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Portfolio diversification potential of Finnish Timberland Funds

Mean-variance analysis on the diversification potential of timberland funds and REITs

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ABSTRACT:

This study examines the diversification benefits of the Finnish timberland funds and US timberland Real Estate Investment Trusts (REITs) for a mid-size institutional investor whose investment portfolio is exclusively composed of Finnish stocks and bonds. The study will utilize the mean-variance framework and will analyse the efficient frontiers, tangency, and minimum variance portfolios for each timberland fund asset.

The timberland investments have gathered a spreading interest among Finnish institutional investors during the last decade. The timberland funds started to emerge in the beginning of 2010's and since then, the funds have witnessed a substantial growth in assets under management, now reaching a scale measured in the hundreds of millions. The investors interest has further enhanced the appeal of the fund units and as the funds have reported increasing returns, there appears to be no sign of diminishing interest. The academic research on the funds is limited partly due to the short time of existence of the funds and the limited announcement obligations of the funds. The timberland funds on the scope of the study are OP Metsänomistaja, UB Metsä and S-Pankki Metsä. The study also examines the diversification potential of the timberland REITs, Weyerhaeuser, Rayonier, and Potlatch Deltic Corp.

The study delves into the theoretical foundations of the mean-variance framework. The development of the mean-variance theorem is examined and portrayed in detail to comprehensively understand the mean-variance optimizations. The study also provides a comprehensive background for the emergence of the timberland funds and timberland REITs. The difference on the investment vehicles of the study objects, timberland funds and timberland REITs, is also presented.

With the mean-variance framework this study examines the diversification benefit of the timberland funds and REITs. Due to their similar characteristics, Finnish timberland funds are treated individually in portfolio optimization calculations. This approach acknowledges their distinct attributes and allows for a more nuanced analysis of their potential impact on the overall investment portfolio. The results show that the timberland funds do offer significant diversification benefits to a Finnish investor obtaining a portfolio of stocks and bonds. The diversification benefit is most robust if the investor is risk adverse. The timberland REITs offer diversification benefits but only if the investor is prepared to embrace greater levels of risk. The different return characteristics of the funds are also affected by the different structures of the investment vehicles and the geographical landscape of the assets.

KEYWORDS: Portfolioteoria, metsärahasotot, metsäsijoitusrahasto, metsä REIT, metsäsijoittaminen, hajautushyöty, optimaalinen portfolio.

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Tiivistelmä:

Tämä tutkimus tarkastelee suomalaisten metsäsijoitusrahastojen ja Yhdysvaltain metsäkiinteistö-sijoitusrahastojen (REIT) hajautushyötyjä keskikokoisen institutionaalisen sijoittajan näkökulmasta, jonka sijoitussalkku koostuu yksinomaan suomalaisista osakkeista ja joukkolainoista. Tutkimuksessa käytetään portfolioteorian periaatteita, joiden avulla analysoidaan tehokkaan rintaman, tangentti portfolion ja minimi keskihajontaportfolioin avulla metsärahastojen tarjoamaa hajautushyötyä.

Metsäsijoitukset ovat herättäneet kasvavaa kiinnostusta suomalaisten institutionaalisten sijoittajien keskuudessa viimeisen vuosikymmenen aikana. Metsäsijoitusrahastoja alettiin perustaa 2010-luvun alussa ja ovat siitä lähtien kasvattaneet merkittävästi hallinnoitavia varojaan. Nykypäivänä metsärahastojen koot mitataankin sadoissa miljoonissa. Sijoittajien kiinnostus on edelleen lisännyt rahasto-osuuksien kiinnostavuutta ja rahastojen ilmoittaessa houkuttelevia tuotteita, ei kiinnostuksen laantumista ole merkkejä. Rahastoihin liittyvä akateeminen tutkimus on rajoittunutta osittain rahastojen lyhyen olemassaoloajan ja rahastojen vähäisten ilmoitusvelvoitteiden vuoksi. Tutkimuksessa tarkasteltavat metsäsijoitusrahastot ovat OP Metsänomistaja, UB Metsä ja S-Pankki Metsä. Tutkimus tarkastelee myös metsäkiinteistö-sijoitusrahastojen (REIT), Weyerhaeuserin, Rayonierin ja Potlach Deltic Corpin, hajautusmahdollisuuksia.

Tutkimus syventyy modernin portfolioteorian viitekehyksen teoreettisiin perusteisiin. Modernin portfolioteorian kehitystä tutkitaan ja kuvataan yksityiskohtaisesti, jotta viitekehys ymmärretään perusteellisesti. Tutkimus tarjoaa myös kattavan taustan metsäsijoitusrahastojen ja metsäkiinteistö-sijoitusrahastojen kehitykselle. Tutkimuksessa esitetään myös tutkimuskohteiden, metsäsijoitusrahastojen ja metsäkiinteistö-sijoitusrahastojen, rakenteiden eroavaisuudet.

Modernin portfolioteorian avulla tutkimus tarkastelee metsäsijoitusrahastojen ja REIT:ien hajautushyötyjä. Suomalaisten metsäsijoitusrahastojen samankaltaisten ominaisuuksien vuoksi ne käsitellään erikseen salkun optimointilaskelmissa. Tämä lähestymistapa tunnustaa niiden erityispiirteet ja mahdollistaa monipuolisemman analyysin niiden potentiaalisesta vaikutuksesta kokonais-sijoitussalkkuun. Tulokset osoittavat, että metsäsijoitusrahastot tarjoavat merkittävää hajautushyötyä suomalaiselle sijoittajalle, jonka portfolio sisältää yksinomaan osake- ja joukkovelkakirjoja. Hajautushyöty on vahvimmillaan, jos sijoittaja on riskiä välttävä. Metsäkiinteistö-sijoitusrahastot tarjoavat hajautushyötyä, mutta vain jos sijoittaja on valmis ottamaan suurempia riskejä. Rahastojen eriäviin tuotto-odotuksiin vaikuttavat myös sijoitusvälineiden erilaiset rakenteet ja maantieteellinen sijainti.

Avainsanat: Portfolioteoria, metsärahastot, metsäsijoitusrahasto, metsä REIT, metsäsijoittaminen, hajautushyöty, optimaalinen portfolio.

Contents

1	Introduction	9
1.1	Purpose of the study	11
1.2	Hypotheses of the study	12
1.3	Motivation of the study	13
1.4	Contribution of the study	15
1.5	Structure of the study	15
2	Theoretical background	17
2.1	Diversification	18
2.2	The portfolio selection theoretical foundations	20
2.2.1	Mean-variance portfolio selection	22
2.2.2	Mean-variance portfolio selection with one riskless asset	24
2.2.3	Efficient frontier	25
2.2.4	Further progress of mean-variance theory	27
2.3	Timberland investment return drivers	30
2.4	Unsmoothing approach	32
3	Literature review	35
3.1	Timberland and mean-variance analysis	35
3.2	Finnish timberland as the subject of diversification	38
3.3	Timberland REITs literature	43
4	Timberland funds and timberland REITs	47
4.1	Finnish timberland development to institutional asset class	47
4.2	Basic structure of Finnish timberland funds	49
4.2.1	Closed Fund	51
4.2.2	Open Fund	53
4.2.3	Valuation of the forest funds	56
4.2.4	Pricing of the fund unit	57
4.2.5	Liquidity	57
4.3	US timberland REITs	59

4.4	Characteristics of timberland investing in the USA	61
4.4.1	REIT	62
4.4.2	TIMO	64
5	Data and methodology	65
5.1	Data	65
5.1.1	Finnish Timberland Funds	66
5.1.2	Timberland REITs	67
5.1.3	Stock index OMX Helsinki 25 Growth Index	67
5.1.4	Bonds and risk-free rate	68
5.2	Descriptive statistics	69
5.2.1	Descriptive statistics OP Metsänomistaja B II time series	70
5.2.2	Descriptive statistics UB Metsä I time series	71
5.2.3	Descriptive statistics S-Pankki Metsä C time series	71
5.3	Potential bias	72
5.4	Methodology	73
5.5	Mean-variance optimization	73
6	Results	76
6.1	Risk and return combinations of different assets	76
6.2	Portfolio optimization benefits of timberland assets	80
6.2.1	Three asset portfolios with stocks, bonds and timberland funds	81
6.2.2	Four asset portfolios with stocks, bonds, timberland funds and REITs	86
7	Conclusions	92
7.1	Conclusions	92
7.2	Further research	96
	References	98
	Appendices	114
	Appendix 1. Timberland fund observations	114
	Appendix 2. Timber price index in Finland 2014-2023	115

Figures

Figure 1. Efficient frontier, capital market line and tangency portfolio.	26
Figure 2. Development of the fund size of three open forest funds (Suomen sijoitustutkimus, 2024).	49
Figure 3. The business model a closed forest fund (Interview, 14.2.2022).	52
Figure 4. Weighting between industries of the OMXH25GI index in 4.3.2024.	68
Figure 5. Annualized returns of the Finnish timberland funds between 2015 - 2023.	77
	77
Figure 6. Annualized returns of the U.S timberland REITs between 2015 - 2023.	77
Figure 7. Expected returns and volatilities of timberland funds and REITs, 2015 - 2023.	78
	78
Figure 8. (1) Efficient frontier of three asset portfolio with timberland asset OP Metsänomistaja B II.	83
Figure 9. (2) Efficient frontier of three asset portfolio with timberland asset UB Metsä I.	84
	84
Figure 10. (3) Efficient frontier of three asset portfolio with timberland asset S-Pankki C.	85
	85
Figure 11. Portfolio weightings with 3 assets. Tangency and minimum variance portfolios.	85
	85
Figure 12. (1) Four asset portfolios and efficient frontier of four asset portfolio with timberland asset OP Metsänomistaja B II.	88
Figure 13. (1) Portfolio weighting between 4 assets with different expected variance. OP Metsänomistaja B II as timberland fund asset	88
Figure 14. (2) Four asset portfolios and efficient frontier of four asset portfolio with timberland asset UB Metsä I.	89
	89
Figure 15. (2) Portfolio weighting between 4 assets with different expected variances. UB Metsä I as timberland fund asset.	90
Figure 16. (3) Four asset portfolios and efficient frontier of four asset portfolios with timberland asset S-Pankki Metsä C.	91

Figure 17. (3) Portfolio weighting between 4 assets with different expected variances. S-Pankki Metsä C as timberland fund asset. 91

Tables

Table 1. Finnish open forest funds (Suomen sijoitustutkimus, 2024).	54
Table 2. Finnish open forest funds fees (OP, 2023; UB, 2023; S-Pankki, 2023; Dasos Capital, 2022b).	55
Table 3. Public timber REITs and market capitalization (Yahoo! Finance, 2022).	63
Table 4: Data sources for the observations	69
Table 5: Names of the variables and abbreviations. UB Metsä I.	70
Table 6: Descriptive statistics of the variables used in portfolio optimization. OP-Metsänomistaja B II fund unit.	70
Table 7: Names of the variables and abbreviations. UB Metsä I.	71
Table 8: Descriptive statistics of the variables used in portfolio optimization. United Bankers Metsä I fund unit.	71
Table 9: Names of the variables and abbreviations. S-Pankki Metsä C.	72
Table 10: Descriptive statistics of the variables used in portfolio optimization. S-Pankki Metsä C fund unit.	72
Table 11. Sharpe ratios of the timberland assets. Finland 2-year bond as risk-free rate, 2015 – 2023.	79
Table 12. Correlation matrix of the Finnish timberland funds, Euribor and OMX25 index.	80
Table 13. Correlation matrix of the Finnish timberland funds and timberland REITs.	80
Table 14. Tangency portfolios of average 2 asset portfolios, and 3 asset portfolios including (1) OP Metsänomistaja B II fund unit, (2) UB Metsä I fund unit, (3) S-Pankki Metsä C fund unit respectively.	81
Table 15. Minimum variance portfolios of average 2 asset portfolio, and 3 asset portfolios including (1) OP Metsänomistaja B II fund unit, (2) UB Metsä I fund unit, (3) S-Pankki Metsä C fund unit respectively.	82

Table 16. Tangency portfolios of average 3 asset portfolios of timberland funds, stocks and bonds, and 4 asset portfolios including the previous and timberland REITs. The calculations are divided into (1) OP Metsänomistaja B II fund unit, (2) UB Metsä I fund unit, (3) S-Pankki Metsä C, which represent a portfolio including the respective unique timberland fund units. 86

Table 17. Minimum variance portfolios of average 3 asset portfolios of timberland funds, stocks and bonds, and 4 asset portfolios including the previous and timberland REITs. The calculations are divided into (1) OP Metsänomistaja B II fund unit, (2) UB Metsä I fund unit, (3) S-Pankki Metsä C, which represent a portfolio including the respective unique timberland fund unit. 87

Abbreviations

OP metsänomistaja B II	OP B II
UB metsä I	UB I
S-Pankki metsä C	S-Pankki C
Weyerhaeuser	WY
Potlatch Deltic Corp.	PCH
Rayonier	RYN
OMX Helsinki 25 growth index	OMXH25
Finland 2-year bond yield	FINB2
12-Month Euro Interbank Offered Rate	EURIBOR
Modern portfolio theory	MPT
Real estate investment trust	REIT
Capital Asset Pricing Model	CAPM
timber investment management organisation	TIMO
Net asset value	NAV
Discounted cash flow	DCF
Timberland Performance Index	TPI
forestry board districts basis	FBD

1 Introduction

Timberland as an investment has been proven to be an extensive diversifier for investors as it has several key financial characteristics that diversify it from more traditional investments. Firstly, timberland investments have a low correlation with other financial classes. This is a result of limited exposure to daily pricing in open markets which results in relative illiquidity and exposure to end-use markets that are not typically correlated with the domestic economic outlook (Wan et.al., 2015) (Busby, Binkley & Chudy, 2020). Secondly, the risk-adjusted returns of timberland have been detected as compelling. Thirdly, timberland investments have been indicating positive hedging abilities against inflation (Wasburn & Binkley, 1993) (Wan et.al., 2013).

Timberland as an asset class has a unique character that differs from other real estate investments. As an investment, it has only a little exposure to the overall economic outlook. If the markets are headed into a regression, it does not affect the biological growth of the trees. The harvesting operations can be postponed up to 5 years without significant net present value losses if the investor sees that the wood price can be more compelling in the near future and wishes to carry out harvesting operations then.

Timberland investment can be accomplished with a direct acquisition of timberland or through equity markets. The most common channel in U.S equity markets to make investments is timber real estate investment trusts (REIT) stocks (La & Mei, 2015). These investment vehicles have grown to be appealing to investors as they are easy to acquire and sell compared to direct timberland investments. These stocks are publicly traded on the New York Stock Exchange (NYSE) under the names of Weyerhaeuser (NYSE: WY), Rayonier (NYSE: RY) and Potlatchdeltic (NYSE:PCH).

In Finland, the common practice of timberland investing has been through direct timberland investments. Timberland funds started to emerge after the financial crisis as institutional investors sought alternative investment classes for low-yielding government bonds. The first funds were typically closed-end funds, constructed as limited

partnerships. In 2014 OP Financial Group introduced an open-end fund OP Metsäno-mistaja, which was constructed as a special-purpose investment fund. The introduction of open-ended funds enabled medium-sized institutions and individuals to invest and diversify their investments also to timberland investments more easily than previously. Currently, four different open-end funds are operating in Finland. The financial institutions that are providing the funds are United Bankers, OP Financial Group, S-Pankki and Nordea Oyj in collaboration with Dasos Oy. The funds are not traded in an exchange but operated and the valuations are reported by the fund management company (Viitala, E-J., Finer, S., Hietanen, S., Korhonen, O., Nykänen, P., Urpilainen, M., & Valonen, M., 2022).

The diversification problem of an investor is based on the simple acknowledgement that can be phrased as “do not put all eggs in one basket”. This principle is in essence what diversification in financial assets is. The diversification has been later modelled into numerical analysis and this has allowed the investor to make more rational decisions on the allocation of assets within a portfolio. The traditional portfolio includes stocks and fixed income, and the typical distribution has been 40 percent on stocks and 60 percent on a fixed income. The basic principle of including an additional asset class in a portfolio that consists of these two basic assets is that it would alter the risk exposure and include an additional source of income. Another common definition for the diversification of a portfolio is to construct a portfolio that includes a considerable number of securities. The variance of the return in a portfolio constructed to include numerous securities is lower than any single security unless the correlation between the securities is perfect (Markowitz, 1952).

This study will delve deeper into the diversification benefits of the modern portfolio theorem or by its other name, the mean-variance theorem selected as the main diversification strategy. The introducer of the modern portfolio theory was Markowitz (1952, 1959). He described the modern portfolio theory and formulated the portfolio optimization problem for the first time in his article and book. In his article, Markowitz (1952) formulated the portfolio problem to be a choice of the mean return and variance of a portfolio

of assets. He further provided the fundamental evidence of the theorem for the construction of the mean-variance portfolio theory. His two principles for the theory were that by holding a constant variance, one should maximize the expected return and by holding a constant expected return, one should minimize variance. These two principles also provided the fundamentals for the efficient frontier theory, where an investor could choose a preferred portfolio from the efficient frontier of risk-return equilibrium. By addressing the mean-variance analysis on the portfolio investors can seek to determine what is the maximum expected return on a given level of risk or vice versa, what is the risk of a given level of return.

The mean-variance theorem has been the subject of studies regarding timberland investments since the timberland investment started to gather the interests of the investors. From the early work onwards, timberland has shown strong evidence of the diversification potential of the asset. Mills and Hoover (1982) introduced the mean-variance theorem to timberland investing as a part of a portfolio. Their work presented that timberland as part of a mixed asset portfolio that included farm options, stocks and bonds, provided diversification benefits. Thomson (1997) investigated investments in coniferous tree species in the USA with a modified mean-variance method and concluded that by investing in timberland in a limited and consistent matter, the investor obtains lower overall portfolio risk. In 1998 Claufield (1998) examined timberland investments with efficient frontiers. For the financial performance of timberland management companies, he used the timberland performance index. His work described how the timberland provides desirable risk-reducing and return-enhancing characteristics to institutional portfolios.

1.1 Purpose of the study

Timberland funds have experienced increasing popularity since their establishment, attracting both domestic and foreign investors due to their lower commitment requirements. This study aims to investigate the potential benefits of adding timberland to a

traditional portfolio diversified with 40 percent stocks and 60 percent fixed income. The focus is on mid-size institutional investors with portfolios ranging from five to fifty million euros, who may lack the resources to establish a direct timberland investment portfolio. By investing in open funds, these investors gain access to a broader timberland portfolio, leveraging economies of scale.

In today's investing landscape, diversification has become essential, with investors seeking to optimize their portfolios with available assets. This study seeks to determine whether the Finnish forest fund can offer diversification benefits to domestic institutional investors in Finland. Using mean-variance theory, the study calculates the efficient frontier for portfolios comprising domestic asset classes. Additionally, the examination extends to include US REITs to assess their potential diversification benefits for mid-size institutional investors in Finland looking to expand their timberland investments and venture into new geographical locations.

1.2 Hypotheses of the study

Investment horizons in timberland typically span from 20 to 50 years in direct investments, while timberland funds suggest a minimum investment horizon of 5 years. Throughout this investment period, it's essential for investors to gain diversification from the investment. Timberland investments essentially possess characteristics that offer this diversification benefit. Timberland funds managed and valued by professionals with diverse backgrounds in finance and forestry, are expected to capitalize on this diversification potential. This expectation has contributed to the formulation of the two hypotheses in this study.

H_1 : Timberland funds offer diversification benefits for domestic institutional investors, that has solely invested in Finnish stock and fixed-income markets.

This hypothesis investigates how a Finnish investor can gain diversification benefits from a timberland fund. The hypotheses are constructed to determine are the risk-return characteristics of timberland investments detected in the value changes of a timberland fund. The theory and characteristics of timberland investments are widely recognised but are these characteristics displayed on the timberland fund values and do the management organizations emphasize or devastate these special features.

H_2 : A Finnish investor with a portfolio containing domestic stocks, bonds and timberland funds do not gain diversification benefit by further investing in timberland REITs.

The second hypothesis pertains to the investment vehicle type of REITs. It posits that since REITs are publicly traded and exposed to daily market fluctuations, their correlation with stock markets increases, thereby diminishing the diversification benefits. Additionally, REITs are involved in final commodities markets as lumber manufacturers (Mei, 2019). Nevertheless, timberland REITs may offer potential diversification benefits through geographical diversification.

To investigate this hypothesis, the study will analyse the historical performance of timberland REITs and funds, aiming to assess the correlation between timberland funds, stock markets, and timberland REITs.

1.3 Motivation of the study

The study seeks to provide empirical evidence regarding the diversification attributes of timberland funds, which have gained increasing popularity. Notably, existing literature has yet to explore timberland funds from a financial standpoint in terms of their diversification potential. Previous investigations into the diversification potential of Finnish timberlands have relied on an index derived solely from timber prices in Finland. However, this approach overlooks the influence of management actions on timberland returns.

The acquisition of a timberland asset constitutes a pivotal aspect of investment. This process entails a meticulous evaluation of the timberland's future harvesting potential, including on-site measurement of current stock. Accuracy in measuring current stock is paramount during fieldwork, as any inaccuracies can negatively affect the acquisition's outcome. This evaluation process is integral to understanding how timberland funds generate returns.

Furthermore, timberland funds have the capacity to generate income from alternative revenue streams, such as leasing areas for wind energy farms. Additionally, timberland funds benefit from economies of scale compared to timber price indexes, which typically represent average prices over specific timeframes. It is important to note that timber markets exhibit regional variations, influenced by factors such as the opening or closure of mills, which can impact wood consumption regionally.

Timberland REITs have undergone extensive examination in various studies, yet there is a noticeable gap in the literature regarding the integration of Finnish timberland investment with timberland REITs. Fundamentally, timberland investing shares similarities across nations. However, disparities arise when considering factors such as tree species and harvesting techniques. Moreover, investment vehicles vary significantly between regions. Timberland REITs, for instance, exhibit distinct differences from their Finnish counterparts, particularly in terms of exposure to daily pricing fluctuations. Understanding the risk-return profiles of these diverse funds and their potential synergies is crucial for investors seeking to engage in timberland investments.

To enhance the study's contribution, the research aims to delve deeper into uncovering the genuine return characteristics of Finnish timberland investments and analyse in detail whether Finnish timberland funds may be perceived as overly promising. The critical investigation of the historical financial performance is significant as the funds are also marketed for non-professional investors.

1.4 Contribution of the study

As stated in the previous sections the Finnish timberland funds are a relatively new subject of academic study and the contribution of the study lies in the employment of academic research methodologies as well as investigating the funds at a more practical level. The focus on deploying the mean-variance framework on the Finnish timberland funds has been selected as the mean-variance framework is a widely acknowledged and recognized portfolio optimization method. With a comprehensive analysis, the study aims to investigate the timberland funds' desirability for an institutional investor. The study also adds depth to the Finnish timberland investment sector. Timberland investing has lacked an open-source indicator of timberland returns which now the timberland fund provides.

This study also aims to clarify the reasoning behind the exceptional returns of the timberland funds and which characteristics of the fund structure have further enabled the immense returns of a traditionally low-risk asset such as forest land. In conclusion, this study will investigate the timberland funds as a part of a portfolio, the gains and risks of timberland funds, the difference in timberland investment vehicles and represent the results of the mean-variance analysis framework including efficient frontiers, tangency portfolios, minimum variance portfolios and optimal portfolio weightings.

1.5 Structure of the study

The structure of the study is constructed as follows. The first chapter represented the study's objectives, hypotheses and aims, providing a clear framework for the ensuing research. The second chapter of the study will delve into the theoretical development and framework the study will implement in the calculations. The section will also investigate the mean-variance framework development, implications and present the formulas on how the mean-variance framework can be used to calculate the optimal portfolio.

The third chapter represents the most relevant previous studies on the subject. The following chapter clarifies the development of the funds and REITs. This chapter will thoroughly investigate the structural aspects of the fund investment vehicles. The fifth chapter will describe the data and methodology that has been used in the mean-variance analysis. In the sixth chapter, we present our empirical findings derived from the mean-variance analysis, offering insights into optimal portfolio configurations and their implications. The final chapter will conclude and offer a discussion on the hypotheses and findings of the optimizations. The final chapter will also include suggestions for future research topics.

2 Theoretical background

In this chapter, diversification is examined through the theoretical background of the modern portfolio theory. The modern portfolio theory is the leading theorem and extension of diversification and thus it has been selected to be examined more extensively. The theoretical background of modern portfolio theory started with the research of Markowitz in the 1950's. The work of Markowitz has been followed by numerous other literature, but the principles of Markowitz are robust to this day. Understanding the basic principles of the modern portfolio theory enables to delve more deeply into the research topic. The motives, methodologies and implications of modern portfolio theory lay the foundation for a more nuanced understanding of the empirical analyses. To understand the diversification benefits of an asset such as a forest, the basic overlayer of forest investments theorem is represented.

This chapter provides a comprehensive background on the theorem of diversification and the principles behind timberland investing. Firstly, the diversification principles and general assumptions are described to comprehensively understand the underlying benefits of diversification. Diversification benefits have been acknowledged by the majority of portfolio managers and the motivations for diversification are examined in this chapter. The second chapter introduces the modern portfolio theorem. In this chapter, diversification is examined with the mean-variance theorem and how an investor can enhance diversification with it. The mean-variance or modern portfolio theorem is inspected in a structured manner chronologically. The mean-variance theorem starts with the description of the Markowitz (1952) theorem and what the latter implications have understood of the usage of the mean-variance theory. The third chapter moves to the principles of timberland investing. Timberland investing has been a profitable asset class for numerous years, but the theorem of timberland investing is much borrowed from other asset classes. Timberland as such has unique characteristics which are not reflected in the principles of real estate investing. The final chapter describes an unsmoothing approach for the Russel National Council of Real Estate Investment Fiduciaries index, composed by Fisher et al. (1994). The unsmoothing approach gives interesting viewpoint on how

the timberland fund returns could be altered to reflect a direct exposure market value, i.e. daily trading.

2.1 Diversification

Diversification has established an important role when constructing a portfolio. Literature has produced different theories and methods to help in the construction of risk diversified portfolio, or optimal portfolio. Diversification is in essence a process where one by allocating to different types of securities decreases the variance of the mean expected return of the portfolio (Markowitz, 1952). By investing in different types of securities the investor can secure the mean expected return of the portfolio with a certain risk level. The ideology is that by evaluating the respective securities' mean return and variance, one can obtain optimal weighting between the securities and ensure maximum return on a desired level of risk or vice versa minimising the level of risk on a desired expected return.

Diversification has been the focus to reduce the risk of the portfolio. The common understanding is that there is idiosyncratic risk, that a specific company faces and systematic risk in the financial markets (Liu, 2016). With diversification, portfolio management can reduce the idiosyncratic risk of the portfolio. The systematic risk or market risk is considered to be significant because not even a well-diversified portfolio can reduce the systematic risk. In other words, if an investor would construct a portfolio by minimizing the idiosyncratic risk, the portfolio would include all the available stocks in the exchange meaning it would be a market portfolio. The remaining risk is a systematic risk that cannot be excluded by diversification.

Other types of securities do not specifically mean that one should invest in a different type of investment vehicle i.e. stocks and bonds. For example, REITs are traded as stocks on the New York Stock Exchange but have different characteristics than common stock. Diversification between different asset classes is the main objective of the diversification.

The common asset classes from where the investor seeks diversification have traditionally been commodities, foreign exchange, and real estate. Commodities have been an efficient diversification asset class due to their low correlation with stocks and bonds (Bodie & Rosansky, 1980). Foreign exchange has been a tool for investors to hedge against currency exposure in their domestic investments by acquiring foreign currency as part of a portfolio (Campbell, et al. 2010). Much research has been done on the diversification potential of real estate for example, Zebrast & Cambon (1984) and Lee (2005) found a negative correlation between real estate holdings and stocks and bonds.

One can invest in real estate by buying commercial real estate directly, through a mutual fund, or a stock of a REIT. The diversification which can be benefitted between investment vehicles is a subject that has inspired recent literature (Akhtaruzzaman et al. 2020; Goetzmann & Kumar, 2008; Kuang, 2021; Lee & Lee, 2023; Patel, 2021). The integration of the financial markets has increased the discussion on the diversification benefits of the alternative asset classes. As the market dynamics evolve, the different asset classes have become more liquidity and may increase the correlation with the financial markets. Diversification has also started to obtain decreasing abilities due to globalization.

The benefit obtained from geographical diversification has started to present decreasing value due to globalisation, increasing international trade, development of megatrends and systemic crises of the financial markets. This again may hinder the portfolio diversification obtained by geographical distribution (Bekaert et al. 2016; Koren, 2003). The same factors have decreased the diversification benefit from emerging markets. Emerging markets have traditionally offered diversification benefits as they have lacked a strong correlation towards major financial markets, as highlighted by early studies (Bekaert & Urias, 1996; Li, et al. 2003; Phylaktis & Ravazzolo, 2005; Vos, 1988). The maturing of the financial markets of the developing countries will likely expose them more to the mainstream financial markets and decrease the diversification benefit in a portfolio. An increasing amount of investigation has been done to examine the diversification abilities

of the new innovative asset classes (Migliavacca, et al. 2023). The recent developments in literature will be examined more extensively in chapter 3.1.

Ground for the modern diversification theorem was constructed by Markowitz (1952) with his modern portfolio theory (MPT). The mean-variance theorem is the main subject of this chapter and will be investigated further in the coming pages. The work of Markowitz has inspired many different theoretical models that have formulated the diversification problem and solution with additional moments and different assumptions (see Chapter 2.1.5.). The portfolio diversification theorem has also been the inspiration for Sharpe (1977) and his widely known theorem behind the Sharpe ratio, which indicates the risk-adjusted return of a security. The Capital Asset Pricing Model (CAPM) has also been built upon the foundations of the Markowitz theorem (Sharpe, 1964; Lintner 1965; Mossin; 1966).

2.2 The portfolio selection theoretical foundations

In 1952 Markowitz formulated and solved the problem of portfolio selection which marks the beginning of the modern portfolio theory (Markowitz, 1952; Constantinides & Malliaris, 1995). Compared to earlier researchers Markowitz was able to focus on explaining the phenomenon of portfolio diversification. As part of his findings, he had to discredit the prevailing principle of the time that an investor assembles a portfolio by selecting between assets that maximize the discounted expected returns. Markowitz argued that if one should obey this principle the selected portfolio would only contain one asset, the one with the highest expected return. This is of course contrary to the phenomenon of diversification. The researchers of diversification before Markowitz did not ignore the notion of risk in their work, they were simply unsuccessful in developing a sufficient theory to portray investors' behaviour under conditions of risk (Keynes, 1936; Hicks, 1939).

The modern portfolio theory has since been the cornerstone for the latter research on portfolio diversification. The main cornerstone of the Markowitz theorem was that investors should not select the assets for a portfolio based only on the unique characteristics of an asset. Investors should rather consider how the assets co-move within the portfolio. By considering this co-movement an investor could obtain the same level of expected return but with a lower risk than one who would ignore these interactions between the assets (Markowitz, 1952). The measurement for risk in Markowitz's work was the mean-variance of a return. The variance of return is also tractable in a combined portfolio of assets which allows the investor to seek diversification. The mean-variance of expected returns or M-V Rule suggests the investor for diversification and further implies the investor to conduct diversification with the right reasons. Reducing the mean-variance of a portfolio cannot be succeeded only by acquiring many securities, rather one should acquire securities which have low return covariances between each other (Markowitz, 1952).

The theory of mean-variance portfolio theory has inspired risk measures that have evolved since the Markowitz theorem. Professional investors have learned that to understand the impact of adding an asset to a portfolio, one must understand the correlations, means and variances between the assets (Elton & Gruber, 1997). The mean-variance theory work has resulted in risk measures such as beta, which has been developed based on mean-variance analyses.

The mean-variance portfolio theory has been developed to find the optimal portfolio structure in a situation in which the investor is interested in the return distributions over a single period (Elton & Gruber, 1997). The investor is expected to estimate the mean return and variance of return for each asset class during a single period. The mathematical framework of mean-variance theory is that on a given level of risk, the portfolio should be assembled with assets that increase the expected return. The mean variance theory is of course a simplification of the portfolio returns and additional moments can

describe the distributions of the returns more precisely. When we consider the mean return and variance of a return, they do not completely describe the return distribution between the assets within a portfolio. Tobin (1958) and other early researchers began to develop the mean-variance theory further and towards more optimization. The early work on the theory introduced the utility function of investors and the return distribution of assets. Lee (1977) and Kraus & Lizenberger (1976) started to investigate the possibility of offering alternative portfolio theories by including more moments to the theorem, such as skewness and more realistic return distribution descriptions. Despite the alternatives presented in the early work, the mean-variance theory has remained the cornerstone of the portfolio theory. Elton & Gruber (1997), describe two reasons why the early work of Markowitz, despite new alternatives, held its persistence in modern portfolio theory. Firstly, there is no evidence that adding additional moments to the mean-variance theory, which already has large data requirements, has an improbable impact on the desirability of the portfolio selected. Secondly, mean-variance portfolio theory implications are widely known and have great intuitive appeal.

2.2.1 Mean-variance portfolio selection

The key objective of the mean-variance theory framework is to determine the optimal portfolio weighting between different securities. The objective is also to minimize volatility on an acceptable baseline of expected return. In Markowitz's theorem, the variance of the rate of return is taken as a substitute for its volatility. Constantinides and Mallaris (1995), formulate the portfolio selection problem in the Markowitz spirit as follows:

$$\begin{aligned}
 & \text{minimize } \sigma_p^2 = x^T V x \\
 & \text{subject to } \begin{cases} x^t \mathbf{1} = 1 \\ x^t R = R_p \end{cases}
 \end{aligned} \tag{1}$$

where x is an n -column vector whose components x_1, \dots, x_n denote the weight or proportion of the investor's wealth allocated to the i th asset in the portfolio with $i = 1, 2 \dots n$. The sum of weights is understandable 1, i.e. $\sum_1^n x_i = 1$; $\mathbf{1}$ is an n -column vector of ones and superscript T denotes the transpose of a vector or a matrix. R is an n -column vector of mean returns R_1, \dots, R_n if the n assets, where it is assumed that not all elements of R are equal. V is the $n \times n$ covariance matrix with entries $\sigma_{ij}, i, j = 1, 2 \dots n$. It is assumed that V is non-singular. To achieve this, it is needed that none of the asset returns are perfectly correlated with the portfolio constructed of the remaining assets and that none of the selected portfolio assets are riskless (Constantinides & Malliaris, 1995). It should be observed that V is symmetric and positive definite being a covariance matrix. Constantinides and Malliaris (1995) formulate that V is in the $n \times n$ positive definite, if for any nonzero n -vector x , it follows that $x^T V x > 0$. In the mean-variance portfolio selection problem (1) the property of positive definiteness of V follows from the fact that variances of a risky portfolio are strictly positive. Lastly, the p denotes the portfolio and its variance is denoted by σ_p^2 . The portfolio is calculated from $x^T V x$ and the portfolio mean is denoted by R_p and is calculated from $R_p = x^T R$.

In the mean-variance portfolio selection problem (1) the objective is to minimize portfolio variance σ_p^2 subject to two constraints. Firstly, the wealth should be fully invested and secondly, the portfolio's expected rate of return must be equal to R_p . Technically the formula minimizes the convex function subject to the linear constraints. It should be observed that $x^T V x$ is convex because V is positive definite and two linear constraints define a convex set. When this is considered, the equation has a unique solution, and first-order conditions are only to be obtained. This formula by Constantinides and Malliaris (1995) does allow short sales which Markowitz's formula did not include to ensure the simplicity of the analysis. This allows the weight of an asset to be negative.

2.2.2 Mean-variance portfolio selection with one riskless asset

The mean-variance portfolio selection problem (1) does not include a riskless asset, unlike Tobin (1958) who explicitly considered cash. Formulating and solving the portfolio selection problem with n risky assets and one riskless is sufficient. In total the number of assets is $n + 1$ assets. With the assets $n + 1, i = 0, 1, 2, \dots, n$, note that the 0 marks the riskless asset and the return for the riskless asset is R_0 . Expected returns are defined as a vector of $r_i = R_i - R_0, i = 1, 2, \dots, n$, and r denotes it. The weighting of the wealth among the assets $n + 1$ assets is denoted by w_0, w_1, \dots, w_n . In the calculations, the vector of weights should be denoted as w from $w_0 = 1 - w^T \mathbf{1}$. For a portfolio p the mean excess return is calculated from the equation:

$$r_p = w^T R + (1 - w^T \mathbf{1})R_0 - R_0 = w^T r \quad (2)$$

The variance of the portfolio p can be calculated from

$$\sigma_p^2 = w^T V w \quad (3)$$

In the equation (2) and (3) the R and V are as in equation (1). It is notable that the risk-free asset does not contribute to the variance in equation (2). From here, the mean-variance portfolio selection problem with one riskless asset is stated as follows by Constantinides and Malliaris (1995),

$$\text{minimize } w^T V w \quad (4)$$

$$\text{subject to } w^T r = r_p$$

Solving the problem in (4) one needs to minimize the variance of the n -risky assets as subject to the given excess return r_p . Unlike the equation (1), $w^T \mathbf{1} = 1$ is not a constraint because not all the weight should be allocated to the n -risky assets.

These equations, firstly formulated by Markowitz do make assumptions that expose the simplicity needed from the investor to obey as the theorem suggests. The Markowitz assumptions which he noted in order to solve the portfolio selection problem are,

- I) Investor consideration is on only the two first moments of probability distribution of returns.
- II) When the mean return of a portfolio is given, the investor chooses a portfolio with the lowest variance of returns.
- III) The horizon for the investment is one period.
- IV) The individual decisions an investor makes do not affect the market prices.
- V) A fraction of a share can be purchased.
- VI) There are no transaction costs or taxes, and
- VII) Investors can sell assets short (Markowitz, 1952) (Constantinides and Malliaris, 1995).

2.2.3 Efficient frontier

By solving the mean-variance portfolio selection problem, it is possible to construct an efficient frontier (EF) of portfolios. The efficient frontier can also be described as the Pareto frontier of all risk-return optimal portfolios (Markowitz, 1952). Theoretically, the most appealing portfolio on the efficient frontier is one which maximizes the Sharpe ratio. Sharpe ratio was named after its founder William Sharpe (1966). The Sharpe ratio describes the ratio of the excess return towards standard deviation. Sharpe ratio can be stated as:

$$S = \frac{E(R_p) - R_f}{\sigma_p} \quad (5)$$

Where S is the Sharpe ratio, $E(R_p)$ is the expected portfolio rate of return, R_f is the Risk-free rate and σ_p is the standard deviation of portfolio returns (Sharpe, 1966).

In Tobin's (1958) work, the portfolio with a maximum Sharpe ratio is called a tangency portfolio, which by definition is the point where the efficient frontier is tangent to the highest possible point of the line drawn by the portfolios with optimally combined risk and return ratios. This line is known as the capital market line (CML). The capital market line includes the portfolios which minimize the risk on a given return level or maximize the return of a given level of risk.

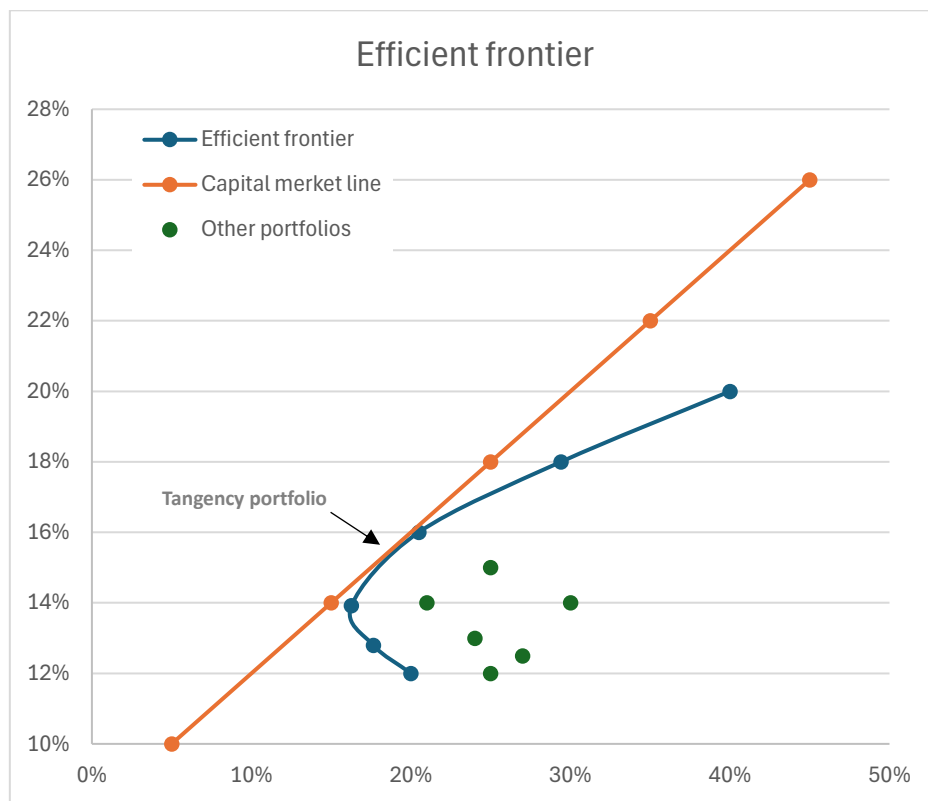


Figure 1. Efficient frontier, capital market line and tangency portfolio.

The following remarks can be done from the efficient frontier. Firstly, the risk-averse investors' optimal choice of portfolio is the minimum variance portfolio. Secondly, portfolios with lower returns than the portfolios on the capital market line will have higher risk resulting in to lower Sharpe ratio and are therefore inefficient.

2.2.4 Further progress of mean-variance theory

The implementation of new alternative models has been the partly result of the underlying simplifying assumptions of Markowitz (1952, 1959). The assumptions made by Markowitz (1952) enabled him to formulate and solve the portfolio optimization problem. The extensions of modern portfolio theory have been investigated to relax these assumptions and bring the model closer to practice. For example, Davis and Norman (1990) introduced transaction costs to the mean-variance optimization framework. Fama (1970), Mossin (1969), Merton (1990) and Hakansson (1970, 1974) all concentrated on expanding the assumption of a one-period investment horizon to a more practical multi-period framework. The shrinkage methods, robust estimators and Bayesian techniques were constructed based on the Markowitz theorem. This chapter will discuss the development of the mean-variance theory and chapter 3.1. will continue to explore the mean-variance theory literature.

After the publication by Markowitz, the development of the theory concentrated on the problematic assumption of a single period and how the analysis should be developed to assess investors' diversification problems in a multi-period environment. The work of Fama (1970), Mossin (1969), Merton (1990) and Hakansson (1970, 1974) were all concentrated on analysing the multi-period environment in different circumstances. The findings suggest that under several reasonable assumptions, the problem of multi-period can be solved with a sequence of single-period problems. The usage of a sequence of single-period problems did result in different optimum portfolios, compared to if only one period were examined. The difference occurs due to the appropriate utility function of a multi-period problem being derived from a single-period utility function and considering multiple periods and this differs from the appropriate utility function for decision-making over a single period (Elton & Gruber, 1997). Most multi-period portfolio analyses depend on the underlying assumption of independent returns between periods. Fama

and French (1989) showed with their research that mean returns and variances are related over time and their relation is a function of easily observable variables.

Thomson (1997) investigated the multi-period mean-variance optimization further. He had previously examined the diversification benefit of timberland assets with a single-period model and concluded that the strict execution of single-period model suggestions may result in a poor rate of return on a long-term investment. Samuelson (1989) noted the importance of rebalancing a portfolio when entering the next investment period. As new information occurs of the realized return one should adjust the mix of assets in a portfolio to better correspond to the next period of diversification. If the rebalancing is not conducted between the periods, the investor may find that the realised return has altered the optimal portfolio weighting, and the current portfolio may not be consistent with the risk tolerance of the investor. In general, the portfolio weighting is calculated based on the expected return of an asset, which is derived from the information on historical returns. As the portfolio has been held for one period, the realized return will be earned which generally differs from the expected return. After one period the assets may not follow the optimal weighting and a rebalancing of weight is appropriate.

In addition to the multi-period models, other alternative models have been developed. The alternative models have been introducing the additional moments to the mean-variance theory, mostly called higher-order moments optimization. As the mean-variance theory focuses mainly on two main characteristics, mean and variance, the higher-order optimization models include in addition skewness and kurtosis of the return distribution. In both cases, the model emphasizes illustrating the empirical risk measures and risk-adjusted return measurements that the historical data provides (Khaki, et al. 2023).

The Markowitz (1952, 1959) assumptions do expose weaknesses when applied without rationality in practice (Haugh, 2016). By naively applied in practice the Markowitz theorem has the tendency to produce extreme portfolio weighting with short selling and longs. In general, these problems are typically caused by the errors in the input

estimations. Typically, the errors occur in the mean return vector and covariance matrix. In practice, the investors do not have the knowledge of the efficient frontier at the moment they are making the investment decision. The portfolio weighting has been proved to be sensitive to small changes in the expected returns (Best & Frauer, 1991). A change in one of the asset's mean expected returns can alter the optimal allocation of the portfolio. When the ratio between the maximum and minimum eigenvalues of the covariance matrix increases it causes more sensitivity on the portfolio weighting. When the number of observations is held fixed, a large portfolio with multiple assets is most likely to observe errors as the observation number is relatively low. The problematic extreme portfolios can be mitigated partly by implementing constraints to exclude short sales.

The literature has also investigated the possibility of developing more robust estimations to produce a more accurate implementation of the modern portfolio theory. The Shrinkage estimator of the variance matrix was developed to decrease the estimation error in situations where the number of assets is greater than the number of samples (Ledoit & Wolff, 2003). By estimating the risk of a portfolio matrix with a weighted average of sample variance matrix and single index covariance matrix it was demonstrated that the shrinkage estimator yields lower out-of-sample variance than the set of existing estimators. Black and Litterman (1992) introduced a framework for implementing the Bayesian techniques for developing the estimators for the return vector and covariance matrix. This model combines two priors as the inputs, views provided by the markets and views provided by the investor. The Black-Litterman model requires the investor to input their own market estimates and uncertainty which is a progress and yet complicating feature. The estimates are determined external to the model and inputted as matrices and vectors. By implementing their own subjective view of the markets, the investor may have more room to steer the model in the direction preferred but it also makes it more laborious to use the model as an investor needs to form their own estimates of development. The mean-variance model is most sensitive to the return vector estimates and still the improved covariance matrix does not provide superior estimates (Alexander, Scherer & Thompson, 2023).

2.3 Timberland investment return drivers

As the financial markets have progressed the curiosity towards timberland has increased. Towards the millennium investors began to be more interested in this asset class which in previous calculations indicated low yields and internal rates of return but despite the calculations had thousands of individuals who operated forests for investment purposes (Mills, & Hoover, 1982). The asset class emerged in the U.S. by the latest in the 1970s when institutions such as insurance companies, pension funds and endowments began to acquire timberland in order to achieve diversification and long-term stable returns. This endorsed the academic literature to begin examining the diversification benefits of timberland investments.

The return of a timberland investment is mainly a function of harvesting operations, i.e. income and silvicultural operations, i.e. expenses. In addition, the land value has an impact on the return as in real estate investments. Biological risks can decrease the investment return, for example, storms that damage the timber. Harvesting operation income is a function of the price paid for the sold wood and the quantity of sold wood, if the wood sale is conducted as a standing trade. The harvesting possibilities in a forest property are determined by the growing stock amount at the start of the period and the growth rate of the trees. The growth rate of the sold wood is determined by the soil quality which is a productive measure, tree species and the maintenance history of the growing stock. The growth rate is decreased with naturally occurring mortality and for example, insect damage to the timber. These subjects are the objective for the silvicultural operations to minimize. The value of the sold wood is determined by the diameter of the harvested log. If the diameter of the log is above a certain level measured from the top, the log is considered logwood and the diameters under the log requirements are consumed as pulp wood. Logwood has typically three times more value than pulp wood (Mills & Hoover, 1982). In summary, timberland returns are driven by three key factors, biological growth, which is more or less constant, timber prices and land

appreciation. (Healey et al. 2005). In some reflections, inflation is named among the return drivers, but inflation can be calculated as part of the timber price movement, as the inflation hedging abilities are sufficient (Washburn & Binkley, 1993).

As mentioned above the return features of timberland assets are unique and thus, have been recognised as an efficient asset class among alternative investments. Wan et al. (2013) describe the unique characteristics as (1) high-risk adjusted returns (Cascio & Clutter 2008; Newell & Eves, 2009), (2) Low or negative correlation with other financial assets (Lundgren, 2005) (3) Portfolio diversification (Mills & Hoover, 1982; Caulfield, 1998) (4) Inflation hedging (Washburn & Binkley, 1993; Lausti, 2004), (5) biological growth (Healey et al. 2005; Mei et al. 2010), and (6) land value appreciation (Caulfield, 1998).

High risk-adjusted returns of timberland asset investments were extensively demonstrated by Cascio and Clutter (2008). Their analysis of The National Council of Real Estate Fiduciaries produced a Timberland index of the timberland asset returns including estimations of market risk sensitivities and required return rates. With the CAPM model, they analysed 19 years of data on timberland returns and concluded that the CAPM beta coefficient was not significantly different from zero, meaning that private equity timberland investments have substantially less risk than the financial markets. The CAPM alpha coefficient was observed to be significantly different than zero meaning that the timberland investments have performed above the level expected by their market risk.

A low correlation between Swedish timberland investments and financial markets was measured in the research of Lundgren (2005). He investigated the diversification potential of the Swedish timberland with CAPM. Using the Sharpe ratio, he concluded that the Sharpe ratio for Timberland was 1.29 and for the reflecting market portfolio 0.3, meaning that timberland had a significantly higher risk-adjusted return. The CAPM beta coefficient was again not significantly different than zero. The analysis also suggested that the inflation hedging potential of the timberland assets was efficient. The inflation

parameter of his analysis suggested that an increase of 10 percent in inflation would result in a 14.4 percent increase in timberland returns. The inflation hedging ability was previously investigated in the U.S. and results were positive on the hedging ability of timberland (Washburn & Binkley, 1993). In more recent studies, the hedging ability has been noted to be affected by the investment vehicle. The privately held timberland assets have shown hedging ability on expected, unexpected and actual inflation (Mei et al. 2013). The inflation hedging ability is also increased when the investment horizon is extended. The publicly traded timberland assets have been less sufficient as inflation-hedging vehicles. The weaker hedging ability is partly caused by the turbulent inflation of the 2000's affecting the time series of the analysis.

The unique characteristic of timberland as an asset class is its natural growth. The natural growth increases every year with the growing stock and by growing the standing stock shifts towards more valuable merchantability classes. This mechanism is due to the more valuable end products that can be manufactured from greater-diameter trees. In financial markets, similar financial asset class characteristics are unrepresented (Healey et al. 2005).

2.4 Unsmoothing approach

The unsmoothing approach was first proposed by Fisher et al. (1994) to unsmooth the Russel National Council of Real Estate Investment Fiduciaries index which describes the appraisal-based value index of the U.S. real-estate markets. The purpose of the paper was to construct a real-estate value index that would be cleared from the smoothing which occurs due to the appraisal method structure of the index. The Russel-NCREIF index was introduced in 1978 and has been the leading real estate index since. At the time of the study, the index included over 1800 properties which were valued at 23 billion USD. The insolvencies with the index were noted in the late 1980s when the commercial real estate values were sharply declining and further causing insolvencies among

commercial real estate holding companies. Later it was noted that the index failed to register these declines of values.

The problems with the index were later analysed and discovered to be understandable when the nature of the appraisal methods-based index was considered (Fisher et al. 1994). The appraisal values, which are relatively stable through time, upon which the index is constructed are submitted by the asset managers. It is also noteworthy that during the period between 1978 and 1992, the number of transactions upon which the appraisal valuations were based was 569. On average that is 38 properties per year, less than 5 % of the properties in the index. From the appraisal's perspective, this all leads to the need to filter out random transaction noises. The transactions on which the appraisal estimates the values of the subject properties include possible errors in observation, asymmetric negotiation skills or unique motivations of the individual participants of a given transaction. This implies that the systematic disaggregation of property level values will conclude in smoothed appraisal valuation over time. In addition, the nature of the submitted appraisals further disaggregates the time relevance of the index. The appraisals are based on the previous quarter values which result in a moving average of spot values. In addition, the index is most efficient on an annual basis as for parts of the underlying assets the assessment is produced once or twice in a fiscal year. For these properties, the quarterly value is unchanged between the valuations. This results in an annual index that is partially updated quarterly. This results in severe positive autocorrelation within the index (Fisher et al. 1994).

The writers also refer to arguments that real estate markets are not informationally efficient in the same manner as a securities market. When the markets are not informationally fully efficient it reduces the peaks and valleys in the values. The constructed model is assumed to reflect the weak-form information prices. They are therefore the closest approximation of the full informed prices that reflect all the available information at the time of the appraisal. The unsmoothed formula simplifies reality as it assumes stationarity and fails to allow purely random error in the index. Nevertheless, it captures much

of the essence of the aggregate level smoothing of the assessment basis index. The smoothing formula can be stated as

$$r_t^* = w_0 r_t + w(B) r_{t-1} \quad (6)$$

Where r_t^* denotes the smoothed index during the period t . r_t denotes the underlying index or corresponding asset value during period t . Weighting between 0 and 1 is denoted by w_0 and $w(B)$ is a polynomial function in the lag operator, where which is formulated as:

$$w(B) = w_1 + w_2 B + w_2 B^2 + \dots w_n \quad (77)$$

B notes one lag ($B r_{t-1} = r_{t-2}$), B_2 notes two lags $B^2 r_{t-1} = r_{t-3}$, and so forth.

This phenomenon can be assumed to be implied in the timberland fund valuations in Finland. The valuation parameters, as described in section 4.1 are based mostly on average historical wood prices to assumably reduce variation. The timber market is relatively fast-moving compared to the long investment horizon on timberland assets, hence the average of historical wood prices is a rational assumption. Nevertheless, this smoothens the variation in the valuations. In some funds, the historical timberland property transactions and the discounted cash flows are mentioned as valuation methods. Combining these two is most likely reasonable in a manner where the discount rate is determined by the recent transactions. These methods are similar to inefficiency moments as in the NCREIF index and an unsmoothing method can be applied to estimate the effect of direct exposure to market valuation i.e. stock markets.

3 Literature review

This chapter will focus on the previous literature on the diversification benefits of timberland asset classes. The focus of the literature review will be on applications of the mean-variance theorem to measure diversification benefits. The mean-variance theorem has been the subject of timberland investment studies starting from Mills and Hoover (1982). The literature review scope is also broadened to examine the literature regarding the diversification benefits of the Finnish timberland. Research on Finnish timberland funds is fairly limited thus the literature review will examine the literature of mainly private equity Finnish timberland at hand. This chapter will focus on the second research objective of the thesis, timberland real estate investment trusts REITs. The timberland REITs differ from the Finnish timberland fund as an investment vehicle and how the literature has observed the difference between a REIT-type of timberland investment compared to a private equity investment will be one main point of focus. Delving into the Finnish timberland investment literature will concentrate on expressing the main points of assumptions of the current literature and enable the reader to understand the differences between timberland fund performance and theoretical timberland investment performance. This will result in the ability to form a view of how the Finnish timberland fund may differ from the private equity investments in Finland at the end of this study. Although there are only a few investigations on Finnish timberland funds, the existing literature from the U.S. can offer insight into how the vehicles differ in the framework of the mean-variance theorem.

3.1 Timberland and mean-variance analysis

Mills and Hoover (1982) introduced the mean-variance framework to timberland investments. By using the Markowitz, (1952, 1959) mean-variance optimization approach they investigated the diversification potential and the pricing of forest land. The case study investigated a portfolio containing four traditional financial investments, four farmland investments and timberland investments. Their estimation of the annual return of a

forest investment was estimated from stumpage prices, i.e. standing price for timber. The historical data on stumpage prices were not available, hence the estimation was derived from lumber futures. Changing attributes were considered, timber prices, biological growth, changes in quality and land value. Their findings were the first in academic circles to prove that the timberland did offer diversification benefits for an investor that possesses traditional financial assets.

Zinkhan et al. (1992) investigated the risk-averse nature of timberland with the single period mean-variance portfolio optimization methods. Their work demonstrates that adding timberland assets to a portfolio is a rational choice for most investors. The result is not unexpected as such, because when adding an asset with a reasonable rate of return and imperfect correlation with other asset classes, it is only reasonable that in a single period optimization, the efficient frontier is pushed further. The same subject was also examined by Caulfield (1998) and the findings were in line with the previous literature. The previous literature had based their estimations of timberland asset returns on hypothetical return indexes, mainly derived from lumber prices. Caulfield (1998) introduced a Timberland Performance Index (TPI), which was a pooled quarterly return index of the TIMCOs at the time, to measure the return of timberland assets. As mentioned, he had a similar outcome as the previous literature on the diversification benefits of timberland assets. He investigated the diversification benefits with a single-period mean-variance optimization model.

The diversification potential of timberland assets was examined by Thomson (1997) with a multi-period mean-variance portfolio approach. His work estimated the inflation adjusted (real term) returns of a direct investment in timberland real estate. The properties in the scope were dominated by Douglas fir and Southern Pine. The additional assets on the portfolio optimization included common stocks, corporate bonds, U.S. Government bonds and U.S. government treasury bills. The period of the study was fifty-eight years from 1937 to 1994. The study indicated that during this period the timberland investments accumulated value either as a part of a portfolio or held solely. The solely held

timberland assets had strong negative correlations with financial markets. Interestingly they suggest that when timberland is held as a part of a portfolio, the weighting should be held fixed during the investment period. The portfolio's other assets should be re-balanced as the periods change.

Waggle and Johnson (2009) analysed the impact of timberland, farmland, and commercial real estate in asset allocation decisions. Their analysis employed Markowitz's (1952) mean-variance framework to determine optimum portfolio combinations. Their work focused on determining the effect of the alternative asset classes on an optimum portfolio. As input data, they used two different approaches, smoothed and unsmoothed returns of farm, real-estate, and timberland assets. In addition, two asset allocation alternatives were implemented, constrained and unconstrained portfolio weighting. The timberland return estimates were based on the National Council of Real Estate Investment Fiduciaries (NCREIF) timberland index. The NCREIF collect the returns of timberland assets in a private equity context. The private equity context allowed the timberland returns to have low return correlations with other asset classes and thus timberland entered all portfolios, as farmland entered only low-risk portfolios.

The difference between private equity and public timberland holdings was investigated also by Scholtens and Spierdijk (2010). Their work implied the mean-variance framework on publicly traded timberland and private equity timberland holdings to thoroughly investigate the diversification potential of each. The publicly traded timberland was represented by three REITs, Rayonier, Plum Creek and Potlatch. For the private equity timberland NCREIF timberland index was used. The initial results were that the private equity timberland holdings did have a greater improvement on the mean-variance frontier, even if the portfolio contains publicly traded forestry and paper indices. Introducing the private equity timberland asset to the investment set increased the tangency portfolio risk-adjusted excess return by 10 basis points.

After the initial findings, the work was focused on the potential biases caused by the NCREIF timberland index. The index is appraisal method-based, meaning that the index is constructed of the appraisals for timberland properties at a given time. The appraisals for the timberland properties are evaluated based on previous comparable actualized transactions, meaning the NCREIF index may suffer from appraisal smoothing bias and may contain certain inertia. The major concern of Scholtens and Spierdijk (2010) was that the index would not reflect the true volatility of timberland. By unsmoothing the index, they increased the volatility, but the expected return stayed unchanged. This significantly reduced the effect private equity timberland had on the mean-variance frontier. They later investigated the significance of the timberland as an addition to the portfolio with spanning tests. They concluded that the unsmoothed private equity timberland index nor the publicly traded timberland assets offered investor diversification benefits. Their data included 55 quarterly observations for both private and public timberland.

3.2 Finnish timberland as the subject of diversification

The previous literature on Finnish timberland as a source of diversification benefit has been studying the relationship between the stumpage prices in various regional distributions in Finland compared to the stock and bond markets (Heikkinen, 2002; Lausti & Penttinen, 1998). Their work has logically derived timberland return indexes from stumpage prices to estimate the return characteristics of timberland investments. Their work depended on an approximation of forestry returns as for example, the open Finnish timberland funds were not published at the time. At the time the U.S. counterparts investigating the return characteristics of timberland employed the assessment-based index. The index by Lausti & Penttinen (1998) estimated the return of forest ownership in general, with net increment and stumpage price change being the core drivers of the model.

The methodology to estimate non-industrial private forest ownership return was claimed by Lausti & Penttinen (1998). They used the data from the national forest inventory of Finland and estimated the return based on the increment of standing stock, Commercial fellings, and wood assortment price development. The bare land value is not considered in the formula. The returns were calculated for the period from 1972 to 1996, on a yearly and forestry board districts basis (FBD). They measured risk as the standard deviation of the yearly calculations. The result showed that the average annual return of the privately held forest land was in the 19 forestry board districts 3 percent pre-tax and 2.5 percent post-tax in real terms. During 1972 – 1996 inflation was measured to be on average 7 percent per annum, hence the nominal return was near 10 percent per annum. The nominal returns varied between 11.5 percent p.a. in northern Ostrobothnia and 9.4 percent p.a. in Helsinki FBD. The standard deviation of the returns was 17.6 percent and 14.4 percent for respective FBDs.

Using the same formula Penttinen & Lausti (2004) continued to evaluate the timberland ownership in Finland from a portfolio perspective. The period was extended to include returns from 1972 to 2003. The estimation of the competitiveness of the timberland asset return was conducted with the Sharpe ratio (Sharpe, 1977). The portfolio allocation problem included commercial real-estate assets, stocks, forest industry stocks, corporate debentures, housing assets, timberland ownership and government bonds which were considered riskless assets. The timberland assets secured a 15.5 percentage share of the total market portfolio with a Sharpe ratio of 0.01. The expected rate of return for timberland was measured at 8.4 percent and the standard deviation of it was measured at 13.4 percent. The tangency portfolio of the assets had a 12.9 percent expected return, 14.2 percent expected variation and 0.32 Sharpe ratio. The greater allocation was in housing assets 37.3 percent and the least in corporate debentures 2.1 percent. The results were not in line with the U.S. counterparts on the return levels (Penttinen & Lausti, 2004).

Penttinen and Lausti (2004) concluded that timberland ownership does not offer risk-decreasing measures for portfolios. By their calculations, the systematic risk was as high as 0.91 percent. The real return, 2.4 percent p.a. was lower than in the U.S. studies with a similar period. The index constructed for the ownership of timberland had stumpage price change as a component, which during this period 1972 - 2003 was, against the expectations, 1.2 percent p.a. lower than the inflation. This has a critical effect on the desirability of the timberland as a part of the portfolio. The results as such suggested that the widely acknowledged inflation-hedging ability of timberland assets was not fulfilled. Lausti (2004) further investigated this with a time series from 1973 to 2003 with the Fisher (1930) methodology. Again, the forest ownership returns were estimated with the formula introduced by Lausti & Penttinen (1998). During this period the ownership of Finnish timberland has not been offering a hedge for actual inflation in their analysis. However, the analysis shows that timberland ownership has offered hedging abilities for unexpected inflation. On the contrary, the stocks did not offer hedging abilities at all, so for institutional investors the forest asset does offer hedging abilities differing from the common stock investment.

The correlation between stumpage prices and stock markets and the usability of the stumpage prices as an indicator of forest-owning income was further investigated by Heikkinen & Kanto (2000). The Finnish stumpage prices and the stock market index were found to be co-integrated which indicated that the pricing of the stumpage prices by the timber markets does consider the high transaction costs, illiquidity, or temporal lack of information. Their analysis is based on a market model similar to Washburn and Binkley (1990) in which the stumpage prices change depending on the benchmark capital cost. The model depicts the relationship between the value of a common market factor and the equilibrium returns of an individual asset. Their time series covered the monthly timber prices for six different assortments from October 1985 to December 1995. Their results were that the market model they applied to estimate expected timberland ownership returns based on timber prices is not sufficient in describing the characteristics of

timberland holdings. The timber price model may give misleading and incomplete results for the expected risk and return of timberland.

Heikkinen (2002) continued to estimate the co-integration of stumpage prices and stock market movements. He first implied a multivariate co-integration method for the data in advance before introducing the Vector Autoregressive Model (VAR) to examine the systematic variability between asset returns. He then discovered that, unlike the previous studies on timberland asset returns and common financial securities which have established that these assets do not correlate, found a correlation between the stumpage price derived Finnish timberland return index and the financial securities as the period is lengthened. The time frame of his analysis was from January 1988 to September 1999. His work shows that the estimated model and the underlying data on which the model is constructed do cause great variation in the expected means of asset returns. The stationarity assumption without a relevant unit root test may lead to an incorrect model estimation. His work shows that if the modelled returns are extended to the subsequent year the possibility for differences in modelling are greater than expected. The model based on the historical stumpage prices indicated a return of 6.0 percent for the year following and the co-integration model suggested only a return of – 2.0 percent. Understandably a timberland holder could react to this information as they decide the cuttings for the next year. This is also one element that the return indexes based on the historical stumpage prices do not consider. The forest owner has unlike other financial securities holders the possibility to adjust the timing of the harvests if, for example, the timber prices are attractive one or two years prior to the planned harvest or vice versa, the timber prices are unattractive, and the timberland owner wishes to further grow the forest in pursue of better stumpage prices.

A similar form of operational problem optimization was previously examined by Heikkinen (1999) as he analysed the attractiveness of a harvest for a private forest owner by using the mean-variance framework. His work applied the single-period optimization model to the timberland owner's choice to harvest a stand and then invest the return in

stocks or postpone a harvest and benefit from the natural growth. A similar topic was examined by Hyytiäinen & Penttinen (2006). Their analysis was concerned with understanding how the modern portfolio theorem could be used to optimize the management activities of the investor. The management problem they formulated as should one conduct a commercial harvest and invest the revenue into an alternative asset class. Their results show that the MPT framework can be used in optimizing the clear-cutting procedures within the timberland holdings.

Another perspective has risen with the alternative income sources that have gathered increasing amounts of interest within the forest owners and people who enjoy forests in their leisure time, and ecosystem services. The effect of the additional revenues on the diversification benefits one gain from a timberland investment was examined by Mathies et al (2015). In this study, the ecosystem services impact on forestry was indicated as a lengthened rotation period of stands, either 10 or 20 years, carbon sequestration compensation, and biodiversity index. Their investigation of the risks and returns of ecosystem services was conducted with the mean-variance framework to determine would the ecosystem services alter the mean-variance of the expected return and further the efficient frontier. The timberland income was yet again estimated with the stumpage price historical information. The mean-variance framework was introduced for two sets of observations, the period from 1995 to 2005 and 2005 until 2012. They concluded that the alternative income resources may offer diversification benefits to individual forest owners in Finland. The alternative income would decrease the investor's exposure to the fluctuations in stumpage prices. They also recognize that these types of services require vast and heterogeneous forests, which are not exactly common, and that the diversification benefit is still vastly limited as the sale of timber is still the dominant source of income for the forest owner.

3.3 Timberland REITs literature

Different types of research on timberland REITs have been conducted throughout the years with different methodologies. One of the most active researchers has been Mei (2015a, 2015b) together with Clutter (2010, 2020), Yao (2015, 2014), Wan et al. (2013, 2015), Lei (2013) and La (2013, 2015). His work has been focused on understanding the timberland REITs return and risk relationship. Mei's personal work (2015a, 2015b) analysed the quarterly prices of Weyerhaeuser (NYSE: WY), Potlatchdeltic Corp (NYSE: PCH), Plum Creek Timber Company Inc (NYSE: PCL) and Rayonier (NYSE: RYN) from 1987Q1 to 2012Q4 with regression-based and pure-play approaches, the analysis showed that independent and identically distributed public-equity timberland assets, returns, risk and average periodic return, remain almost constant during the given period.

Mei and Clutter (2020) also later investigated the quarterly returns of RYN, PCH, WY and CTT from 1991Q1 to 2017Q4 with an augmented CAPM and Bivariate vector autoregression model. The major findings were again that there were only insignificant positive abnormal returns. The analysis showed also that the REIT returns predict Timberland - Investment Management Organizations (TIMO) returns and that timber REITs do have higher systematic risks than TIMOs. In 2013 La together with Mei investigated the information efficiency of the REITs to determine could the abnormal returns be a factor of the inefficient information utilization. They analysed the daily returns of PCL, RYN, PCH and WY from July 1999 to December 2012 using entropy measurement. Key findings were that REITs are less efficient in incorporating information than forest product industries and the S&P500 index. By observing this they concluded that a sophisticated investor may be offered arbitrage possibilities by the timberland REITs.

Mei and Lei (2013) investigated a similar topic on how an investor could note the inefficient information obtained by the REITs. They collected information on internet search volumes of 20 keywords to demonstrate investor's attention. Their results showed that investor attention to the lumber market, global climate change, the utilization of biomass and the manufacturing industry seems to drive the private-equity timberland

abnormal returns. Their work found a correlation including lag, between the search numbers and timberland valuations. Logically the investors who have insight are searching for the development and for example, a new industry plant gives more value to the entire value chain and thus is seen in timberland valuations as increased demand for raw timber. Thus, they concluded that their work offered some evidence that the hypothesis of efficient markets does not to a great extent apply to the timberland sector.

Baral and Mei's (2020) investigations were based on previous studies on timberland REITs and the focus was on the development and performance of timber REITs in the United States. The analysis showed that among others the timberland REITs returns are driven by housing markets. 50 – 70 percent of the timber REIT's revenues are from wood supply to homebuilding purposes. The study indicates that there is some evidence of REITs as beneficial to diversification in the long run but offer no excess returns. Also, the timber REITs offer better liquidity compared to traditional private-equity timberland holdings.

Previously conducted studies found abnormal returns when investigating timberland REITs. Medell et al. (2008) conducted an event study analysis of the daily stock price of PCL, RYN, LFB and PCH for the event period of 11 days. The study found statistically significant abnormal positive returns. In 2010, Mei and Clutter (2010) investigated the quarterly returns of PCH, PCL and Rayonier RYN from 1987Q1 to 2008Q4. The analysis was carried out by using parametric CAPM and Fama-French three-factor models and non-parametric approaches. The study revealed high excess returns and performance similar to the markets, lower returns and higher risk of public timber companies than the pure-play index.

Abnormal returns were also found in a study conducted by Yao and Mei (2015) as they analysed quarterly returns of PCL, RYN, PCH and WY from 1988Q1 to 2011Q4 with inter-temporal CAPM model. The key findings were that REITs do have more variations in

cross-sectional returns explained by the intertemporal CAPM model. Also, REITs have significant positive excess returns from public-equity timberland assets over 1988-1999.

In 2017 Piao et al. (2017) investigated the monthly financial data of PCL, RYN, PCH and WY for an event period of one to three years with buy and hold abnormal returns (AR), cumulative AR which was based on the CAPM model and zero investment portfolio approach with rolling regression, which was based on the Fama-French three-factor model. The analysis showed abnormal returns in the long term. In previous research, Piao et al (2016) found that intertemporal CAPM is more capable of explaining the cross-sectional returns of timber REITs. Also, larger market capitalization does not generate excess returns and REITs are insensitive to recessionary shocks. This analysis was conducted with the intertemporal CAPM model and Multivariate GARCH model on the daily returns of PCL, RYN PCH and WY for an event period of one to three years.

In 2014 Yao et al (2014) used CAPMM and arbitrage pricing theory (APT) models to analyse the quarterly value-weighted returns of PCL, RYN, PCH and WY from 1998Q1 to 2011Q4. The analysis showed that REITs generate higher mean excess returns than public equity timberland assets. Also, REITs have more variations in returns explained by APT than the CAPM. On the other hand, in 2010 Scholtens and Spierdijk (2010) estimated the quarterly returns of PCL, RYN and PCH from 1994Q4 to 2007Q3 with a mean-variance approach. The study did not indicate significant improvement in the mean-variance frontier.

In La and Mei's (2015) investigation on daily prices of PCL, RYN, PCH and WY from December 2009 to December 2013 with co-integration analysis, the findings showed that REITs have diversification potential over the long run. The REITs did not show followable trends between each other and neither with the S&P500 index. Thus, the timberland REITs do offer diversification potential also as unique candidates for the portfolio. Wan et al. (2013) also found improvement in the hedging ability of forest products companies after REIT conversions as they estimated the quarterly returns of PCL, RYN, PVH and WY

from 1981Q1 to 2009Q4 with CAPM under inflation and FAMA-French three-factor model. Sun et al. (2013) conducted an event study analysis on REIT announcements using GARCH model analysis on the daily returns of PCL, RYN LFB, PCH, and WY between 1997 and 2010. The major findings were also that the REITs have increased volatility and statistically significant abnormal returns when a REIT conversion is announced. In another research by Sun (2013a, 2013c) the key findings were also that REITs have positive return-volume relation and a high value at risk during a recession. The study investigated the daily returns and trading volumes of PCL, RYN and PCH between 1999 and 2010 with generalized autoregressive conditional heteroscedasticity model (GARCH) and extreme valuation models.

Clements et al (2017) had a different type of topic as they analysed the lumber futures contract prices and quarterly prices of PCL, RYN, PCH, and WY from 199Q3 to 2014Q4 with vector error correction model and GARCH model. The analysis showed that lumber futures and timber REITs have positive long-run and short-run relationships. Rastepo et al. (2020) found in their investigation that weights on timberland in the mixed asset portfolio vary with time. They investigated annualized returns of RYN, PCH, WY and CTT from 1978 to 2018 with a mean-variance approach and mean conditional value at risk method.

4 Timberland funds and timberland REITs

This chapter will give background for timberland investments in Finland and the United States. The chapter starts from the beginning of the timberland funds and what were the drivers for their emergence. The chapter investigates thoroughly the individual structures of the forest funds to fully understand the unique characteristics of the fund that enable the diversification benefit to thrive. The chapter is gathered from various references but as the funds are a relatively new investment vehicle in Finland the references are collected more from the marketing materials of the funds and open sources. The Natural Research Institute published a distinguished study by Viitala et al. (2021) on Finnish timberland funds which provides a backbone for the chapter.

The latter part of the chapter twelves into the U.S. timberland investment vehicles and their development to the current form. The timberland REITs have a similar path to their current state as the Finnish counterparts. The similarities between the development of the REITs and timberland funds are observable, and this may indicate the future development of the Finnish timberland funds.

4.1 Finnish timberland development to institutional asset class

The Finnish ownership of forest land is efficiently divided. Over 500.000 private landowners own 43,4 percent of the forestland area of Finland (Metsäkeskus, 2022). The long tradition of private landowners traces back to the independence of Finland. The Lex Kallio, which enabled the common farmer to purchase the grounds that were formerly owned by the monarch or aristocrats, meant that the normal farmer now had his land to farm. In 2022 Companies owned 7.1 percent of the forestland area and the investment funds owned 0.9 percent (Metsäkeskus, 2022).

UPM-Kymmene Oyj started to sell its timberland assets in the early 2010s. This meant that big collective areas of well-managed timberlands were available on the forestland

markets. The timberland assets gained interest due to the small economic growth in Finland and the low interest rates that dominated the markets. As the investors were scouting new low-risk asset classes the first Finnish forest funds for private persons emerged. These funds were formed heavily dependent on the forest land sold by UPM-Kymmene Oyj (Taaleri Oyj, 2015; UPM Kymmene Oyj, 2016).

UPM-Kymmene Oyj announced the shutdown of its Kajaani paper mill in 2008 (Rönty, 2018). As the paper mill was closed the company still had vast areas of timberlands in the Kainuu region. The restructuring of the company and the demands of the stockholders meant that it would be beneficial to sell these timberlands and use the gained assets to strengthen the capital structure of the company and invest in future ventures as the demand for paper was declining. The areas surrounding the Kajaani paper mill were remote compared to the remaining production facilities of UPM. The first Finnish forest funds marketed to private persons and mid-size institutions were based on these timberlands.

The first funds were structured as Limited partnership business entities. The funds by Dasos Capital started to operate in the mid-2000s (Dasos Capital, 2022a). These funds raised capital mainly from institutional investors. Since 2010 the funds have begun to gain interest also in private persons. After the demand for forest funds kept on growing the open funds began to emerge. The first open fund began to operate in 2014 by OP Financial Group (Op, 2022). Since then, the forest funds have grown even further, and they have started to acquire forest land from the open markets. The open markets consist mainly of timberland sold by private owners. The mean timberland property size declined after the move to the private owner's markets. The timberlands sold by UPM were big entities that were over 1000 hectares, and as timberlands, they were concentrated regionally. As the mean timberland property size in Finland is 10 hectares the funds have begun to acquire smaller entities from the public markets. (Metsäkeskus, 2022). The shift towards the public timberland markets has meant that the private owners now have the option to sell their forests to professional investors. This has further

liquidated the timberland markets and escalated the prices of the timberland assets (Holteri, 2022).

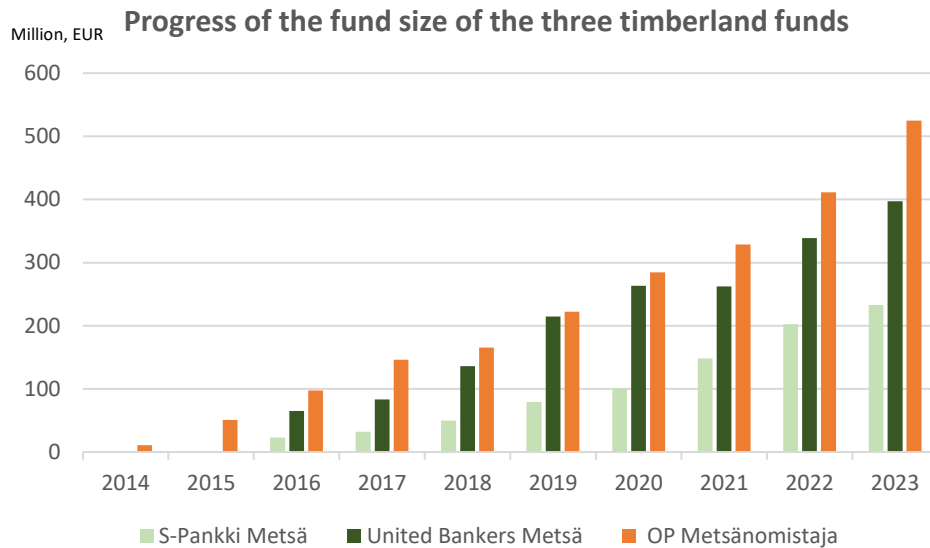


Figure 2. Development of the fund size of three open forest funds (Suomen sijoitustutkimus, 2024).

4.2 Basic structure of Finnish timberland funds

The funds inspected in this chapter are registered in Finland and are operated by fund management companies. The analysis is focused on timberland properties and the main source of cashflow in the funds is generated by the sales of timber from the fund-owned properties. The fund management company is an entity that collects assets from private and institutional investors. The fund then invests the raised capital into asset classes which then forms an investment fund (Financial Supervisory Authority, 2023a). The assets in the investment fund are not the property of the fund management company. The assets are the property of the investor that possesses the fund unit (Financial Supervisory Authority, 2023a).

The funds that are marketed for private persons and private communities are under the regulation of the Alternative Investment Fund Directive (AIFM-Directive) and

undertakings for the collective investment in Transferable Securities Directive (UCITS-Directive) (Financial Supervisory Authority, 2023b). The funds that are marketed for professional investors are under the regulation of the AIFM Directive and Euro Venture Capital Funds Directive (EuVECA-directive). The AIFM directive is focused on regulating the alternative funds managers and the UCITS regulates the special purpose funds. In addition to these, the funds are regulated nationally by the law regarding investment funds and the law on the alternative fund managers (Viitala, et al. 2021).

Viitala et al. (2021) interviewed forest fund managers about fund management. In the survey, the managers had a united opinion on the benefits of the funds in comparison to private forest owners. In the same survey, the managers stated that the forest management and forest treatments do not significantly differ from private forest owners. The funds invest in forest management and the managers stated that it is important for the funds to operate the forest respectively and by the frames that the fertility of the soil generates. The managers state that all the forests are PEFC certified and some of the forests are FCS certified. The certifications give the wood sold from the forest a higher price and indicate that the funds are managed responsibly.

The basic structure of a Finnish forest fund can be divided into two separate entities. The closed funds are the first group and open funds are the second. The closed funds are typically closed after the raise of capital into the fund, hence the closed name. The open funds are open for investments during the operational period, hence the open name. In total 15 forest funds are operating in Finland in the first quarter of 2022 (The Bank of Finland, 2022). Of these four are open funds and 11 are closed or feeder funds used to operate the closed funds. The data does not indicate the funds that have been shut down or sold to other investors before 2021. For example, the Taaleri metsärahassto I was sold in 2017 to the French pension fund AXA (Taaleri Oyj, 2017).

The fund management companies can also collect funds via feeder funds (Viitala et al, 2021). Then the feeder fund invests or feeds the operative funds with the assets

gathered in the feeder fund by purchasing the fund units. The feeder fund can be structured as a mutual fund or an AIF. By the investment fund law (Sijoitusrahastolaki, 213/2019) the fund is obligated to invest 85 percent of its assets into the targeted fund.

As the closed funds are closed for new investments the information regarding their assets and operational functions is not public. The open funds are raising capital continuously and the information about their actions is more accessible. The next chapter is based on multiple interviews with fund managers conducted by Viitala et al (2021) and the author of this thesis.

4.2.1 Closed Fund

The first forest funds in Finland were structured as a limited responsibility business entity. These funds raised capital only once during the establishment of the fund (United Bankers Oyj, 2023). After the capital raising, the portfolio manager acquires the timberland needed for the fund to operate. The investing period usually is also determined in the establishment agreement (Viitala et al. 2021). The investors are represented as silent entity members and the fund manager is the spokesman of the business entity. This gives the fund manager the decision-making authority on the fund and its operational activities (Viitala et al. 2021). The silent partner's liability is limited to the capital contribution of that investor (HE 94/2013).

The legal structure of the closed forest funds is limited responsibility business entities. In some cases, the operating structure of the fund includes common forest. The common forest income tax rate is 26.5 per cent hence the decision to operate the forest fund through the common forest. The closed funds may be operated as a limited responsibility partnership entity as such. The limited responsibility business entity is taxed at the partnership level and therefore the investor does not pay income tax on the profits (Viitala et al. 2021).

If the fund is constructed to use the common forest as a part of the fund it operates as follows. The business entity gives the raised capital as a credit to the newly formed common forest. The common forest acquires, maintains, and manages the forest. The common forest tax rate is 26.5% of its profit (Verohallinto, 2022). The income from the common forest is tax-free for the shareowner. Once the profits are taxed the common forest pays the credits back to the limited partnership business entity that returns the yield in the form of a dividend to the investors (Interview, 2022).

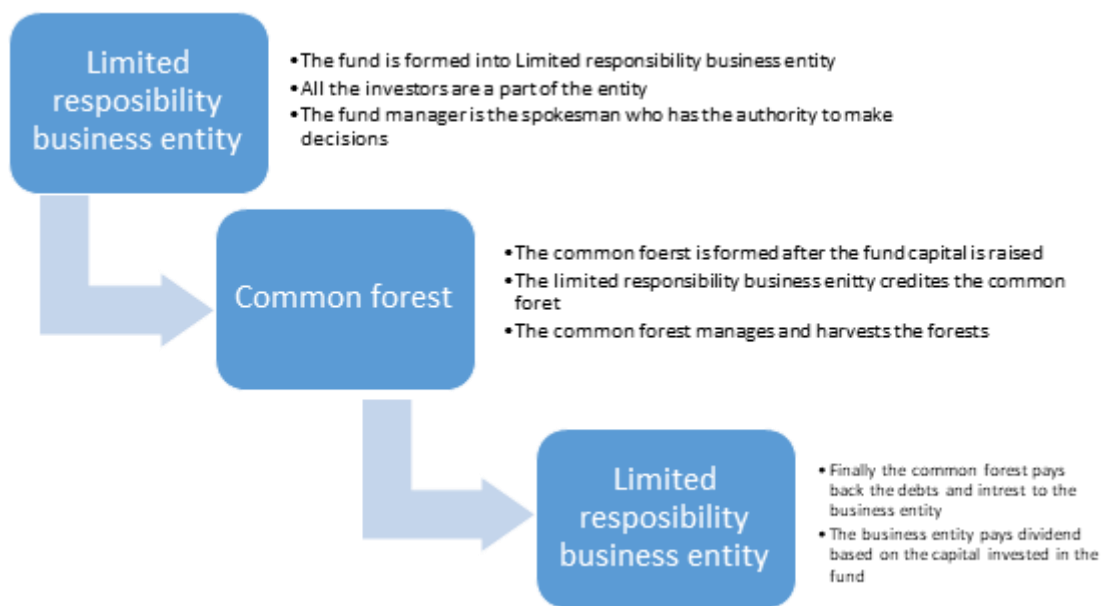


Figure 3. The business model a closed forest fund (Interview, 14.2.2022).

Finnish based closed forest funds are or have been Taaleri metsärahassto III, UB Nordic Forest Fund I, II, III & IV, and Dasos Capital Habitat Fund Ky (Dasos Capital, 2022b, Taaleri Oyj, 2022, United Bankers Oyj, 2023). Dasos Capital has also five other funds that are investing in forest properties, but they are registered in other countries than Finland (Suomen Pankki, 2022; Dasos Capital, 2022b). Also, the Evli Impact Forest Fund I Ky is a limited responsibility business entity that is a fund-on-fund. The Evli fund invests in unlisted carefully picked funds that are investing in forest properties globally (Evli, 2022). The targeted fund size is 100 million. The fund is targeted at institutional and professional investors. The minimum investment is 100.000 euros (Evli, 2022). The closed

funds actively manage forest assets, but the market capitalization is not frequently reported. The market capitalization varies between 15-150 million euros (United Bankers Oyj 2024; Taaleri, 2022). These forest funds have higher minimum capital requirements in comparison to open funds. The number of investors is smaller in a closed fund than in an open fund (Finder, 2022; S-Pankki, 2022). Typical investors are people with great financial abilities and institutional investors.

Some of the funds have been sold prematurely to international investors. Taaleri I in 2017, UB Nordic Forest Fund I in 2020 and UB Nordic Forest Fund II in 2024 were all sold to foreign institutional investors (United Bankers Oyj, 2024; Taaleri Oyj, 2017). Also, Taaleri sold its second fund to the open forest fund UB Metsä in 2023 (United Bankers Oyj, 2023). The funds have been an interesting purchasing possibility for international investors who have been interested in investing in Finnish forests as they are big and well-managed entities. It has been also lucrative for investors to sell portions of the funds (Taaleri, 2017).

The limited responsibility business entity is regulated by the limited responsibility business entity law (389/1988). The business entity can apply to be regulated by the real-estate fund law (1173/1997) if it conducts investing operations that are targeted into real estate and it is marketed publicly and if it is under the same regulation as a public limited liability company (Valtonen et al. 2021; HE 175/2008).

4.2.2 Open Fund

In Finland, four open funds are managed professionally by a fund management company. The fund management company and the fund manager conduct the acquisitions of the forest lands and organize the harvests and forest maintenance tasks. The open fund collects investments from private investors and institutional investors. The funds operate as special-purpose funds. As they are listed as special-purpose funds, they do not have to follow the asset diversification rules that apply to mutual funds (S-Pankki, 2022). The

suggested investing period for these funds in their catalogues varies from 5 years to 50 years.

The four major forest funds are operated by OP Financial Group, United Bankers (UB), S-Pankki (previously FIM) and Dasos Capital Oy.

Table 1. Finnish open forest funds (Suomen sijoitustutkimus, 2024).

MANAGING COMPANY (FUND NAME)	Net asset valuation 31.12.2023	2022 Return%
OP FINANCIAL GROUP (OP-METSÄNOMISTAJA B II)	€525,1 million	10,9 %
UNITED BANKERS (UB METSÄ I)	€397,1 million	10,3 %
S-PANKKI (METSÄ C)	€232,8 million	6,8 %
DASOS CAPITAL (METSÄ JA PUU III)	€209,3*	7,04 %

*29.9.2023

The Metsä ja Puu III fund is marketed to non-professional investors by Nordea. The Metsä ja Puu III was founded in late 2021 and due to the few observations, it is not at the centre of this study.

The regulation regarding the special purpose funds is included in the mutual fund law but it is possible to conduct different kinds of policy on the investing objectives and liquidations of the fund unit. The special purpose fund structure means that it cannot be legally regarded as a real estate fund, but it has the possibility to invest in real estate assets (HE 94/2013). By the definition of the real-estate law (1173/1997), a real estate fund is structured as a public limited company whose purpose by the corporate by-laws is to invest in real estate and manage real estate assets, also it must be defined as an AIF as the AIF directive states. By the Investments Fund law (213/2019) the funds must have rules which define the investing policies, permitted investing objectives, and the fees that are collected from the fund.

The fund rules are stated in a brochure that can be found on the website of the fund management companies. For example, in the brochure for the rules of the UB Metsä special purpose fund, the manager of the fund is UB Rahastoyhtiö Oy (UB, 2021). The

investing objective is stated in the fifth section of the brochure. In the section, it is stated that the fund is allowed to use leverage up to 100 percent of its net asset value. The same paragraph is formulated in the S-Pankki fund rules that the fund is allowed to use leverage to conduct its investing activities and maintain its assets the amount that is no more than 50 percent of its gross asset value (S-Pankki, 2021). In addition to this, both funds are allowed to take leverage up to one-third of the gross asset value for special reasons. These reasons are the need for short time and temporary leverage to maintain the operative activities of the fund. The Op-Metsänomistaja fund has the same formula for leverage as the S-Pankki Metsä-A (OP, 2021). The Dasos Metsä ja Puu III has the same principles that S-Pankki and Op have, but the percentages are calculated based on the net asset value rather than gross asset value. (Dasos Capital, 2022b).

The fees collected in the UB Metsä fund consist of entry fees, brokerage fees, management fees, performance-based fees and custodian fees (UB, 2021). The fees collected in the S-Pankki Metsä C fund unit class are entry fees, brokerage fees, management fees and running fees (S-Pankki, 2021). For the OP-Metsänomistaja and Dasos Capital Metsä ja Puu III funds the fees consist of entry fees, brokerage fees and management fees (OP, 2022; Dasos Capital, 2022b).

Table 2. Finnish open forest funds fees (OP, 2023; UB, 2023; S-Pankki, 2023; Dasos Capital, 2022b).

MANAGING COMPANY (FUND NAME)	Entry fee	Management fee	Running fees	Brokerage fees	Exit fee
OP FINANCIAL GROUP (OP-METSÄNOMISTAJA B II)	4.0 %	1.50 %	1.72 %	0.40 %	5.0 %
UNITED BANKERS (UB METSÄ I)	2.0 %	1.35 %	1.65 %		3.0 %
S-PANKKI (METSÄ C)	2.0 %	1.50 %	1.58 %	0.32 %	4.0 %
DASOS CAPITAL (METSÄ JA PUU III I)	0.0 %	1.60 %	1.92 %		5.0 %

The open forest funds resemble in many ways mutual funds. Their revenues are based on the management fees that the fund manager receives from the investments. The funds are not constructed as a company as REITs but as special-purpose funds. The

owner of the share of the fund is entitled to a part of the returns generated by timber harvesting and other value creation.

The owner of the fund unit is entitled to the profits generated by the fund. The United Bankers Metsä fund has targeted that it could return 75 percent of its profit made during a fiscal year (United Bankers Oyj, 2024). 75 percent is calculated from the realized profits made by the fund. Hence the increase in the asset's value is not included in the share of the return. The OP metsänomistaja and S-Pankki Metsä A funds have targeted also a 75 percent rate of return on the profits made by the fund (OP, 2022). The fourth open fund has a different approach to distributing the profits. The key information brochure states that the fund distributes the returns by the percentage that the board of the fund decides. The motivation behind this is to generate as stable a flow of return to the investor as possible (Dasos, 2022b).

4.2.3 Valuation of the forest funds

The funds calculate the net asset value (NAV) value typically once a quarter. The calculations are the sum of the forest assets, other financial assets held by the fund, and cash assets, reduced by the short-term liabilities. Timberland assets are the biological value of the forest assets and other assets such as plots and agricultural land that often are included in the acquisitions. The biological value of the timberland assets can be calculated in multiple ways. OP-metsänomistaja uses a regenerated version of the sum method. UB Metsä uses the discounted cash flow (DCF) methodology but does not indicate the variables used in the method. S-Pankki fund uses a combination of both. The transaction method is used as a key method, but the DCF method is supportive. Dasos Oy does not state the methodology behind its valuations.

4.2.4 Pricing of the fund unit

The pricing of the fund unit is calculated by dividing the net assets of the fund by the outstanding amount of the fund units (UB, 2022). The valuation of the fund is done usually four times in a fiscal year, in every quarter in the open funds. The valuation of the forest properties is done following good accounting manners and therefore, for example, UB announces that the valuation is done by a third-party member (UB, 2022).

The price of a fund unit changes over time as the value of the fund's assets varies. The marking of the fund unit is done on a specific date. The marking is done in the current value of the fund unit. For example, if the value of the fund unit is at 210 euros and the investor wants to mark one unit, the 210 euros is added to the value of the fund and the number of outstanding numbers of the fund units is added by one. As the investor marks the fund, the invested money is transferred into the fund and in return the investor gets the specific amount of unit shares. The number of unit shares calculated for a specific amount of currency is indicated in one of ten thousand (1/10000) accuracy (UB, 2022). Under this logic, the fund unit value does not change when new unit owners mark the fund. The marking can be halted if the current forest land markets are in distress and the fund for example cannot buy new land for the fund.

4.2.5 Liquidity

The liquidity of the open forest fund unit can be regarded as better than the closed one. Open funds have a responsibility to purchase the fund unit that an investor is selling (United Bankers Oyj, 2024). The investor must give a withdrawal note during the valuation dates of the fund. The purchases of the unit are done on the next valuation date six months from the withdrawal note (S-Pankki, 2020; United Bankers Oyj, 2024; Op-metsänomistaja, 2022). The closed forest fund does not offer the possibility for the fund unit owner to sell the unit to the fund. The fund unit or part of the limited responsibility business unit can be sold to another investor. There are no public aftermarkets for the

closed fund units and hence the liquidity is problematic to evaluate. The funds from an investor's point of view can be lucrative investments also in the later stages of the fund. The valuation of the closed fund unit can be done similarly to bonds and obligations and the fund unit may get a fair price for the seller and buyer to trade upon. The liquidation of a closed fund unit is still poorer than one of an open fund. The closed funds are therefore usually marketed for institutions and investors with great financial capabilities. The fund unit is also marketed to be held for the entire fund operating period (Viitala et al. 2021).

As the modern asset evaluating methods suggest, the value of an asset is generated by the cash flow that it is expected to generate. Although the price of the asset can vary from the valuation. The price of an asset depends on the valuation of the expected cash flow and the underlying liquidity of the market where the asset can be traded. In times of abundant liquidity, the fundamentals of pricing models prevail. In times when the markets are stressed the price of an asset reflects more of the liquidity shortage than the asset's intrinsic expected cashflows (Clerc, 2008).

Change in the value of an asset is shown quickly in a balance sheet in mark-to-market accounting. The change of an asset has an immediate effect on the net worth of the components of the financial system (Clerc, 2008). The change in the net worth of the assets follows that the equity base of a financial operator can vary, and the liquidity shock may transform into a solvency shock. The change in equity base may reduce the possibility for the operator to access funding.

Liquidity risk comes from the equilibrium needed in an economic situation (Clerc, 2008). The risk is that when the equilibrium moves, does the liquidity move with it. for example, in a stable economic situation, the liquid assets do not have to be so great but in a more turmoil situation the fund may need more liquidity to meet the needs of the fund. Therefore, the liquidity risk comes from the change from one equilibrium to another.

Liquidity is a key factor in the management of the fund. In timberland investing the cash-flows are concentrated at the end of the investing period and at the start of the forest cycle there are many expenses. The investments made to the soil may generate cash-flows first after 40 years. The withdrawal of the investors can put pressure on the liquidity of the fund unit. In the closed funds, the withdrawal does not apply directly to the funds because the fund is not obligated to buy the fund unit from the investor wishing to sell it. In the open funds, the fund must purchase the fund unit in six months (S-Pankki, 2022). The timberland assets are seen as illiquid assets (Valtonen et al. 2021). If the open fund must purchase many withdrawals from the fund the limited liquidity of the fund's assets can be a negative factor for the returns for the fund. The funds have a six-month withdrawal period and during that time the funds can reorganize the investments and gather the assets needed for the purchase of the fund units. If the funds must sell many of their assets during a short period to counter the amount of the withdrawals it most likely is going to affect the price that the assets are sold at.

4.3 US timberland REITs

Timberlands in the U.S. were in the early nineteenth hundreds mainly a source of timber for forest products companies (Mei, 2019). The main role of the timberland was to provide raw materials for the factories producing forest products such as lumber and paper. The assets were integrated vertically into the company, and this ensured the supply of the facilities. This meant also that the production line was not dependable on the open markets and the variables of economic situations (Mei, 2019). The owner base of U.S. timberland was in the late 1970s roughly the same as in the early 20 century. The timberland assets were owned majorly by farmers and large forest product companies. These owners were not particularly active in managing the timber assets (Zinkhan & Cabbage, 2003). In the past decades, the industrial users of the raw wood material have outsourced the management and harvesting of timber to other participants in the production line. This has been one of the major key points in the emergence of timberland asset managers and timberlands as a financial asset class.

The major reasons for the reorganizing of the timberland assets in the 1980s in the United States related to the overall financial situation and the advance of the forest product companies. Mei (2019) has recognized five major reasons for the transformation. Firstly, the production of the forest product companies shifted from diversification to specification. This meant that the raw wood users did not use a broad selection of timber from various tree species and cut lengths. Secondly, the timber markets were evolving and hence the insurance value of our supply of raw wood was declining. Thirdly the forest product companies were under the influence of double taxation. The corporations are called c-corps, where the entity of the company and the owners are taxed separately creating a double taxation situation. As a fourth major reason, Mei (2019) presents the undervaluation of timberland assets. Under the generally accepted accounting standards in the US, the book values of the timberlands were undermined and referred to the acquisition price rather than to the fair market price. Finally, the fifth main reason for the transformation was the growing demand for timberland generated by the TIMOs and REITs (Healey et al., 2005; Mei et al., 2009). The transformation of the industry and the declining demand for paper products have meant that forest product companies have been investing in new product lines and technologies. This has increased the financial leverage of the companies. The liquidation of timberland assets has been a possibility to reduce debt. These major factors have separated timberland asset management in the US into its field of business (Mai, 2019).

As the forest product companies have been the major sellers of timberlands the major buyers have been the institutional investors. The regulations for institutional investors have generated a demand for alternative and low-risk investments such as timberland. Some of the former forest product companies changed the structure of the company into a REIT model and continued to operate as earlier. At the end of the 1980's the value of timberland assets managed by TIMOs was roughly 1 billion USD. The growth of the assets under management has been vast. In 2015 TIMO managed timberland for over 40 billion USD. In addition to the Timos, the public timber companies, mostly REITs, managed another 35 billion USD worth of timberlands. (Hood et al., 2015).

Forest product companies such as International Paper and Georgia-Pacific first started to generate letter stocks and limited partnership subsidiaries as the institutional investors expressed their interest in timberland assets. The restructuring of business segments and timberland assets into Master limited partnerships (MLP) and letter stocks was favoured by the financial markets at the beginning of the transformation of the timberland ownership. Since then, TIMOs and REITs have gained more popularity and are now the main structure for forest investing companies (Mai, 2019).

4.4 Characteristics of timberland investing in the USA

The ownership of timberland in the US has variable patterns. In the east side of the country, much of the forestland is dominantly owned by private ownership and by the government in the west (Sass et al., 2021). These patterns are rooted in the development of land settlement, land allocations and other socioeconomic factors. The forestland represents 34 percent (310 million ha) of the total land area of the United States. This area of about 280 million hectares is referred to as commercial timberland. The market value of this area is 460 billion USD. The ownership of this timberland is primarily under private ownership, with 58 percent of the forest and woodlands. This group can be divided into two different entities. Firstly, the biggest group that holds forest lands are families, individuals, estates and trusts which hold 38 percent of the timberland. The second group is the corporate owners which hold an additional 20 percent. This group includes timber real estate investment trusts (REITs) timber investment management organizations (TIMOs) and companies that produce forest-associated products (Sass et al., 2021).

In this study, the focus of the US forest investing markets is concentrated in timber real estate investment trusts (REITs) and a review of the timber investment management organizations (TIMOs) is presented. In the US there are three publicly traded timber REITs and two non-REIT public timber management companies. In addition to REITs, there are over 30 TIMOs (Mei, 2019). By 2007 the TIMOs owned over 9,1 million hectares of

timberland and the estimated value of the timberland held by TIMOs is more than 18 billion USD (Harris, 2007). This makes TIMOs the most prominent institutional timberland investor. REITs are the second major group of timberland holdings. REITs owned by 2007 5,5 million hectares of timberland for a market value of 11 billion USD (Harris, 2007). The combined timberland area of TIMOs and public timber companies is roughly 12 percent of the private timberland area of the US (Mendell et al. 2008).

4.4.1 REIT

REITs are companies that invest in real estate assets or real estate-related assets as their primary business. REITs have been established in 1960 by the congress (Securities and Exchange Commission, 2011). This allowed private investors and households to invest in large-scale and income-producing real estate. REITs differ from other real estate companies by the length and custom of the investments. The REITs must acquire and operate the real estate as a part of their investment portfolio rather than resell the properties after development (Securities and Exchange Commission, 2011). The REITs are publicly listed stocks that entitle the owner to a share of the profits made by the REIT company. The shares of the companies can be traded on the stock exchange as any other publicly listed stock. In the New York Stock Exchange, there are four publicly listed stocks of timber REITs.

The requirements for a company to be qualified as a REIT are as follows (Securities and Exchange Commission, 2011). Firstly, the company must invest at least 75 percent of its total assets in real estate or related assets and cash. Secondly, the taxable income generated by the REIT must be distributed back to the share owner annually in the form of dividends. Thirdly, the REIT must be an entity that is taxable as a corporation. The REIT must be managed by the board of directors or trustees. The shares of the REIT must be fully transferable, and the minimum number of shareholders must succeed 100 shareholders after the first operating year. Finally, the number of shares held by the five biggest shareholders cannot reach 50 percent of the total number of shares.

Timberland REITs are special-purpose REITs that generate cash flow from timber harvests on the timberlands owned by the REIT. After the company meets the requirements needed to be listed as a REIT company it does not need to pay corporate income tax. This is not affected by the amount of profit made (Frankel, 2019). As of 28.4.2022 by market capitalization the largest publicly traded timber REIT was Weyerhaeuser (NYSE: WY) 30.3 billion USD. Other timber REITS were in declining market capitalization order, Rayonier (NYSE: RYN) 6.5 billion USD, Potlatchdeltic Corp (NYSE: PCH) 3.8 billion USD and Catchmark Timber Trust (NYSE: CTT) 410 million USD which merged with Potlatch Deltic Corp in 2023 (Yahoo! Finance, 2022).

Table 3. Public timber REITs and market capitalization (Yahoo! Finance, 2022).

COMPANY (STOCK SYMBOL)	Market Capitalization 2022	5-year Average Dividend Yield
WEYERHAEUSER (NYSE: WY)	\$30.3 billion	3.76
RAYONIER (NYSE: RYN)	\$6.5 billion	3.40
POTLATCHDELTAIC CORP (NYSE: PCH)	\$4.1 billion	3.56

Most of the REITs are publicly traded in stock exchanges but in addition, there are non-traded REITs. The non-traded REITs are not publicly traded on a stock exchange but do report to the U.S. Securities and Exchange Commission (SEC), as do the public timberland REITs (Securities and Exchange Commission, 2011). The public timberland REITs are more liquid as an asset than the non-traded due to the public stock exchange functioning as a marketplace. The non-traded REITs are not traded on public stock exchanges. The timberland REITs may have a redemption program where the investor may be able to sell the shares or wait until the REIT is listed on a public stock exchange or the company decides to liquidate its assets.

The brokerage fees for a public timberland REIT are the same as buying a stock from a stock exchange (Securities and Exchange Commission, 2011). The non-public timberland REITs have typically a 9-10 percent brokerage fee when buying a share of the REIT. The management who operates the public timberland REITs and the assets are typically

employees of the company. In non-public the management is outsourced to a third party and the company does not have any employees. The minimum investment amount for a public timberland REIT is one share of the company. For the non-public, the amount typically varies from one thousand to two and a half thousand USD. The corporate governance in the public timberland REIT is conducted via specific stock exchange regulations whereas non-public REITs are subject to the state and North American Securities Administrators Association (NASAA). The publicity gives a real-time platform for monitoring the value of the share. Also, the public REITs are followed by numerous analysts who offer valuable information about the stock movement. On non-public REITs, there is no independent information about the share value (Securities and Exchange Commission, 2011).

4.4.2 TIMO

TIMOs are purely management organizations and do not own the timberland itself. The management is conducted on behalf of the investors who own the assets. The difference between TIMOs emerges through the ownership distribution. TIMOs can be constructed into one separate account if only one investor is responsible for the timberlands. In the case of multiple investors, a commingled fund can be constructed. Usually, these types of investors include universities, pension funds and foundations (Gunnøe & Gellert, 2010). As TIMOs only manage the timberlands it is possible to combine the number of investors under one TIMO. This allows multiple investors to form a large portfolio that can be effective through large quantities of forest land and geographically diversified to ensure risk management. In comparison to the public-equity timber asset management companies the TIMOs have higher requirements of minimum invested capital but the pressure for capital returns by dividends is smaller (Mei, 2019).

5 Data and methodology

In this chapter, the data used in the mean-variance optimization of a portfolio is clarified. The first sections clarify the source, reliability, and collection of the data. The second chapter represents the descriptive statistics. The potential bias of the data is discussed in the following chapter. The methodology section clarifies the methods of how the study examines the diversification potential of the Finnish timberland funds and the timberland REITs. Finally, the unsmoothed index is represented and discussed as a method to express the true risk-return characteristics of timberland funds.

5.1 Data

The data of the study is all calculated from daily values, adjusted with dividends. The Finnish timberland funds have published their valuations once a quarter or less frequently. The observation dates in the time series are therefore determined by the valuation dates of the respective funds. The value of the return is annualized to make values comparable to each other as the period is not constant. Each fund has conducted its valuations on its schedule and the data has been collected separately for each fund, making three data sets in total. All the daily values are corrected to take dividends into account, making them a true returns index. All the return measures are formed with the natural logarithmic values of the indexes. The return is calculated as, $LN\left(\frac{v_t}{v_{t-1}}\right)$ where v_t is the value of the index at the end of the period and v_{t-1} is the value of the index at the start of the period. The return is then formed in logarithmic form. The return indexes are in nominal form and do not consider taxes or other expenses. The other potential risks such as illiquidity risks of the investment vehicle, are not examined in the analysis as the Markowitz mean-variance model intercepts the risk to be variance of the returns. All the values are represented in euros, and thus implement the currency diversification of the timberland REITs.

5.1.1 Finnish Timberland Funds

The data for the Finnish timberland funds was gathered from Suomen sijoitustutkimus database (Suomen sijoitustutkimus, 2024). Their database consists of values submitted by the fund management companies. The Finnish timberland funds do their valuations quarterly. The fund values per fund unit class and the fund size are submitted to Suomen sijoitustutkimus. This study is concerned with the fund unit class marketed towards institutional investors. In OP metsänomistaja timberland fund the institutional fund unit class is II B. In United Bankers Metsä the institutional fund unit class is UB METSÄ I and in S-Pankki metsärahassto, the institutional fund unit class is METSÄ C.

The returns of a timberland fund consist mainly of raw timber sales, but also hunting lease income, income on rental land for different types of infrastructure, lease income of windmill locations and additional investments. For example, the biggest single investment in OP-Metsänomistaja fund is Tornator Oyj, which is a timberland investment company that owns over 683,000 hectares of forest land in Finland (Tornator Oyj, 2024). The main source of revenue is reported in all funds to be raw timber sales and land value appreciation.

The historical values for the Finnish timberland funds are strictly constrained due to the short period of existence of the funds and the principle of quarterly valuations. The quarterly valuation is calculated on the last date of the quarter by UB and OP. S-Pankki calculates it to the 15th of the last month of the quarter. The first valuation of the OP-Metsänomistaja B II fund unit marketed for institutional owners was on 28.9.2019. Before this date, the only fund unit was the B unit. On 28.6.2019 the valuation of both fund units was the same exact price. Hence the study calculates the return of OP Metsänomistaja fund unit B II from Metsänomistaja B from 31.12.2014 until 29.3.2019. From 28.6.20219 until 29.12.2023 the change is calculated from the values of Metsänomistaja B II fund unit. In total, the return series for OP Metsänomistaja B implemented by the study includes observations from 9 years extending from 31.12.2014 to 29.12.2023.

United Bankers METSÄ I historical values extend from 31.12.2015 to 31.12.2023, 8 years and for S-Pankki METSÄ C 15.12.2016 – 31.12.2023, 7 years. Tables 8, 9 &10 represent the descriptive statistics of the Finnish timberland funds.

5.1.2 Timberland REITs

The study performs portfolio optimization for determining the diversification potential of different timberland assets including the possibility to invest in US timberland REITs. As the individual characteristics of the REITs are not the object of the study the REITs are investigated as pooled index. The timberland REITs are represented by an index constructed of the historical changes of the timberland REITs. The return index of the REITs is an arithmetic mean of the annualized changes of the individual REITs in the time series. The historical values of the timberland REITs are collected from the Yahoo finance database (Yahoo! Finance, 2024). The historical values are reformed comparable with the Finnish timberland funds by introducing the corresponding value from the timberland fund valuation date, or the previous business day. The historical values are also reformed as total return indexes by including the dividends. The data for the timberland REITs starts on the 15th of December in 2014 and ends on the 31st of December 2023. The daily values of the timberland REITs are converted into euros with the respective date exchange rate.

5.1.3 Stock index OMX Helsinki 25 Growth Index

The stock investments in the constructed portfolio are portrayed with the OMXH25GI stock index. The OMXH25GI index consists of the 25 most actively traded stocks of the Helsinki Stock Exchange (Nasdaq, 2024). The index is a marked weighted total return index. The maximum weight of one company is limited to 10 per cent. The composition is revisited twice a year. The OMXH25GI index was first constructed on December 30, 2013. The period used in the study is from 31.12.2014 to 31.12.2023, 9 years. To make

the index comparable with the timberland funds, the data for the stock index is collected from the same dates as the timberland funds have calculated their valuations. As the bond yield has been negative, a constant of 10 is added to the observation value to enable calculation of the annualized changes with logarithm.

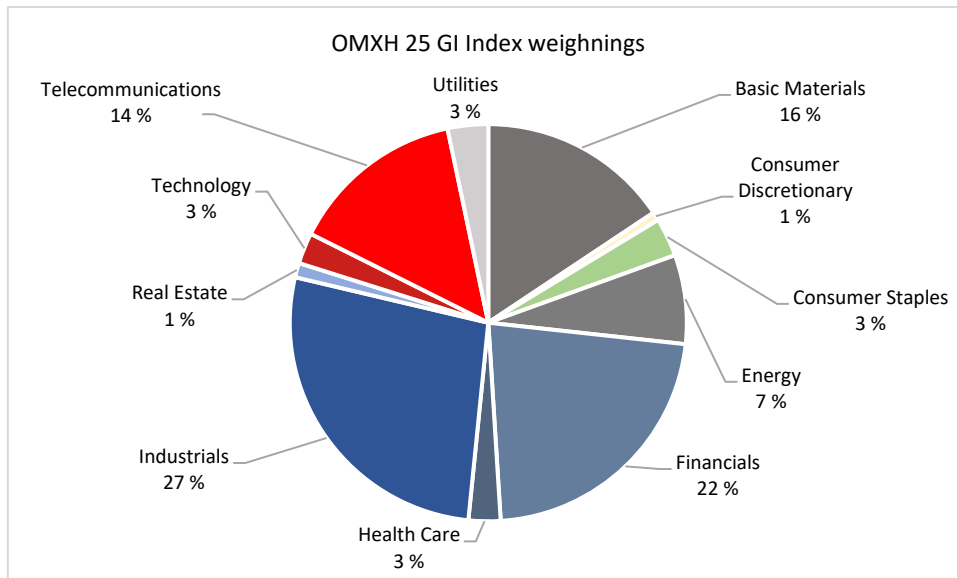


Figure 4. Weighting between industries of the OMXH25GI index in 4.3.2024.

5.1.4 Bonds and risk-free rate

The risk-free rate for the Sharpe formula returns is displayed by the 2-year bond yield of the Finnish government bonds. This is collected from the Bank of Finland database (Bank of Finland, 2024). The bond yield period starts on 15.12.2014 and ends on 31.12.2023. The data is collected on a daily frequency. The bond yield rate is portrayed by the 12-month Euribor rate, collected from the Bank of Finland database, for the same period. The Euribor rate is collected on a daily frequency.

5.2 Descriptive statistics

As mentioned above the data for the other variables has been collected separately for each fund to match the valuation dates of the funds. This results in three separate portfolio optimization models. All the data for each of the data sets are collected from the same resources. The sources of the variables are presented in Table 1.

Table 4: Data sources for the observations

Variable	Abbreviation	Source
OP metsänomistaja B II	OP B II	Suomen sijoitustutkimus Ltd.
UB Metsä I	UB I	Suomen sijoitustutkimus Ltd.
S-Pankki metsä C	S-Pankki C	Suomen sijoitustutkimus Ltd.
Weyerhaeuser	WY	Yahoo! Finance
PotlatchDeltic	PCH	Yahoo! Finance
Rayonier	RYN	Yahoo! Finance
OMX Helsinki 25 growth index	OMXH25	Nasdaq Nordic Ltd.
Finland 2-year bond yield	FINB2	Bank of Finland
12-Month Euro Interbank Offered Rate	EURIBOR	Bank of Finland

Table III represents the descriptive statistics for the variables with the OP metsänomistaja B II fund unit valuation dates. In total, the number of observations is 30 starting from 15.12.2014. As the analysis is performed on a change basis the number of observations of change is in total 29. The descriptive statistics are based on figures of annualized return. The annualization of the returns is performed with the formula number (4):

$$R_a = (1 + R_n)^{\frac{365}{t-t-1}} - 1 \quad (4)$$

Where R_a denotes the annualized return, R_n , the return on a given period. t denotes the start of the period in days and t_{-1} , is the last day of the period.

5.2.1 Descriptive statistics OP Metsänomistaja B II time series

The table below illustrates the abbreviations of the variables and the expected return and volatility in percentages. The figures are calculated based on the annualized return of the percentage change between the valuation dates indicated by the OP asset management for the timberland fund OP metsänomistaja and the fund unit B II.

Table 5: Names of the variables and abbreviations. UB Metsä I.

<i>Asset</i>	<i>Abbreviation</i>	<i>Expected return (%)</i>	<i>Volatility (%)</i>
(1) OP Metsänomistaja II B	(1) OP BII	8.77	8.71
(2) EURIBOR 12kk	(4) EURIBOR	4.86	15.34
(3) OMXH 25 GI Index	(3) OMX25	10.04	26.25
(4) Timberland investment trusts	(4) REITS	12.90	38.91

The table below shows the descriptive statistics of the variables used in the portfolio optimization mean-variance model with the OP metsänomistaja B II as representing the Finnish timberland funds. The number of observations as annualized changes in the data set is twenty-nine and the time series starts from 31.3.2015 and ends at 29.12.2023.

Table 6: Descriptive statistics of the variables used in portfolio optimization. OP- Metsänomistaja B II fund unit.

	<i>Observations</i>	<i>Mean (%)</i>	<i>Median (%)</i>	<i>Std. Dev. (%)</i>	<i>Min (%)</i>	<i>Max (%)</i>
(1) OP BII	29	8.77	6.64	8.71	0.84	36.35
(2) EURIBOR	29	4.86	-0.17	15.34	-12.99	56.64
(3) OMX25	29	10.04	8.86	26.25	-40.82	77.28
(4) REITS	29	12.90	22.32	38.91	-66.18	79.67

5.2.2 Descriptive statistics UB Metsä I time series

The table below illustrates the abbreviations of the variables and the expected return and volatility in percentages. The figures are calculated based on the annualized return of the percentage change between the valuation dates indicated by the United Bankers asset management for the timberland fund UB Metsä and the fund unit I.

Table 7: Names of the variables and abbreviations. UB Metsä I.

<i>Asset</i>	<i>Abbreviation</i>	<i>Expected return (%)</i>	<i>Volatility (%)</i>
(1) United Bankers Metsä I	(1) UB I	5.41	3.83
(2) EURIBOR 12kk	(4) EURIBOR	2.95	15.04
(3) OMXH 25 GI Index	(3) OMX25	13.03	43.08
(4) Timberland investment trusts	(9) REITs	12.41	39.93

The table below shows the descriptive statistics of the variables used in the portfolio optimization mean-variance model with the United Bankers I fund unit representing the Finnish timberland funds. The number of observations as annualized changes in the data set is thirty-six and the time series starts from 15.3.2016 and ends at 15.12.2023.

Table 8: Descriptive statistics of the variables used in portfolio optimization. United Bankers Metsä I fund unit.

	<i>Observations</i>	<i>Mean (%)</i>	<i>Median (%)</i>	<i>Std. Dev. (%)</i>	<i>Min (%)</i>	<i>Max (%)</i>
(1) UB I	36	5.41	5.24	3.83	-0.19	12.05
(2) EURIBOR	36	2.95	-0.25	15.04	-25.70	59.77
(3) OMX25	36	13.03	15.02	43.08	-79.66	179.50
(9) REITs	36	12.41	14.72	39.93	-99.95	93.51

5.2.3 Descriptive statistics S-Pankki Metsä C time series

The table below illustrates the abbreviations of the variables and the expected return and volatility in percentages. The figures are calculated based on the annualized return of the percentage change between the valuation dates indicated by the S-Pankki asset management for the timberland fund S-Pankki Metsä and the fund unit C.

Table 9: Names of the variables and abbreviations. S-Pankki Metsä C.

<i>Asset</i>	<i>Abbreviation</i>	<i>Expected return (%)</i>	<i>Volatility (%)</i>
(1) S-Pankki Metsä C	(1) S-Pankki C	9.25	9.80
(2) EURIBOR 12kk	(4) EURIBOR	5.16	15.27
(3) OMXH 25 GI Index	(3) OMX25	14.61	43.68
(4) Timberland investment trusts	(4) REITs	13.29	36.46

This table shows the descriptive statistics of the variables used in the portfolio optimization mean-variance model with the S-Pankki C fund unit representing the Finnish timberland funds. The number of observations as annualized changes in the data set is twenty-nine and the time series starts from 15.12.2016 and ends at 15.12.2023.

Table 10: Descriptive statistics of the variables used in portfolio optimization. S-Pankki Metsä C fund unit.

	<i>Observations</i>	<i>Mean (%)</i>	<i>Median (%)</i>	<i>Std. Dev. (%)</i>	<i>Min (%)</i>	<i>Max (%)</i>
(1) S-Pankki C	29	9.25	7.64	9.80	-8.99	42.60
(2) EURIBOR	29	5.16	0.08	15.27	-14.30	59.77
(3) OMX25	29	14.61	17.16	43.68	-79.66	179.50
(4) REITs	29	13.29	16.18	36.46	-83.59	93.51

5.3 Potential bias

The data used are possible to cause statistical bias to the results. The period of the Finnish timberland funds is quite short, 29 – 36 observations. As they are indicated by the fund management company there may be an extent of bias, but nevertheless, the fund unit can be sold at that price, making the value sufficient for this analysis. The values of other variables are taken from the daily values of the data in hand, hence there may be alternations on the data dates as the business days do not fall into the same dates in Finland and the U.S.

5.4 Methodology

The methodology applied to determine the diversification potential of timberland funds and timberland REITs has been the mean-variance framework generated by Markowitz (1952). This framework allows for the optimization of portfolio allocation by balancing the trade-off between risk and return. A more detailed analysis of the methodology, including the mathematical formulation and underlying assumptions can be found in Chapter 2.

To conduct the optimization of potential portfolios, Microsoft Excel was utilized along with its data analysis tools. Microsoft Excel provides a user-friendly platform for performing complex calculations and conducting optimization tasks. Specifically, the Solver add-in within Excel was employed to solve the mean-variance optimization problem and identify the optimal portfolio allocations.

5.5 Mean-variance optimization

The mean-variance optimization of a portfolio is a process where the individual weights of the portfolio assets are optimized to produce the maximum expected return on a given risk level. The optimization was constructed to four extents, firstly optimization of the expected standard portfolio of a medium-sized institution with two assets, stocks, and bonds. Second, the portfolio was introduced to the Finnish timberland fund to determine the diversification benefit of the asset. Thirdly, the US REITs are introduced to determine does an investment in foreign timberland assets allows further diversification benefits for a medium-sized institutional investor. Finally, the optimization is conducted for a theoretical investor who would like to diversify only to US timberland to determine the diversification potential of the timberland REITs alone. Each of the three Finnish timberland funds forms its own dataset and optimization procedures.

The optimization of the asset weights is conducted with the Microsoft Excel solver tool. The input data consists of annualized returns calculated from the valuation dates of timberland funds. The optimization is conducted in total for 12 different portfolios. The input data consists of United Bankers 36 observations, for S-Pankki and OP, the number of observations was 29. The covariance matrix is formulated using the Microsoft Excel data analysis tools from each data set annualized return series. The mean expected rate of return is calculated as the arithmetic average of the historical annualized returns. Each asset contribution to the portfolio variance is portrayed in the covariance matrix. The optimization tool is used to determine the maximum Sharpe ratio portfolio, and minimum variance portfolio to later determine the diversification potential of the timberland assets. The variables of the optimization process are the individual asset weights of the portfolio. The constraints of the optimization include firstly that the sum of weights must equal one and that the individual weight of the asset cannot be negative, meaning that short selling is not prohibited. In the Markowitz mean-variance framework the optimal portfolio weights can be found by utilizing the formula (5):

$$w_i = \frac{\frac{1}{\sigma_i}}{\sum_{j=1}^n \frac{1}{\sigma_j}} \quad (5)$$

Where, w_i is the weight of the asset i . The standard deviation of the asset i is noted by σ_i and n is the total number of assets in the portfolio.

The study utilizes the mean-variance framework of one period optimization described in the chapter 2.2.1. The portfolio optimization was constructed to include the one-period optimization model, due to the vast literature and usage of the model. Also, the fund characteristics suggests the use of the one period model. The rebalancing of the multi period model is comprehensive method with liquid stock and bonds, but due to the characteristics of the timberland funds the rebalancing would not be as efficient as the model suggests. In practice, the rebalancing would require the fund management company to

redeem the fund unit from the investor. The redeeming period is typically 6 months meaning that the investor should wait or redeem in advantage the fund unit.

In the study, the efficient frontier is constructed by maximizing the Sharpe ratio at different risk levels, which are imposed as constraints. The Efficient Frontier is displayed in chapters 6.2.2 and 6.2.3 by calculating 10,000 random portfolios that are plotted on a scatter chart. The efficient frontier is represented by the portfolio with the highest possible return figure at a given variance level. As a result, it appears on the far right and far upper portion of the chart. While the exact frontier is not explicitly highlighted, it is easily observable from the scatter plots illustrating each portfolio optimization problem. This graphical representation offers a clear depiction of the trade-off between risk and returns for various portfolio compositions, enabling investors to identify optimal portfolio allocations along the efficient frontier.

The figures of efficient frontiers for the four asset portfolio optimizations also portray the capital market line. The Capital market line is the tangent line that is drawn from the risk-free rate to the efficient frontier. Theoretically the portfolios that fall on the capital market line optimize the risk and return relationship, meaning the tangency portfolio (Constantinides & Malliaris, 1995) The capital market line, r_{CML} is presented and calculated with the following formula:

$$r_{CML} = r_f + \beta \times \sigma \quad (6)$$

Where r_f is the return of risk-free rate and σ denotes the desired variance level. The β is calculated as,

$$\beta = \frac{r_{p,MaxSR} - r_f}{\sigma_{p,MaxSR}} \quad (7)$$

Where $r_{p,MaxSR}$ is the expected return and $\sigma_{p,MaxSR}$ is the expected variance of the tangency portfolio.

6 Results

This chapter will present the results of the portfolio optimization calculations. The chapter will be divided into four sections. The first section describes the risk-return combinations of the different assets. This includes the stocks which are represented by the OMXH25 GI-index, bonds that are represented by the EURIBOR 12-month rate, timberland REITs and each timberland fund separately. The second section presents the effect of the Finnish timberland as it introduced to the portfolio with two assets, stocks and bonds. The minimum risk portfolio, tangency portfolio and efficient frontiers are presented for portfolios constructed to obtain one timberland fund asset. The impact of the timberland fund asset is evaluated for each fund separately. In total 3 portfolios are constructed, all including stock, bond, and a timberland fund asset. The final chapter distinguishes the diversification benefit to be gained by obtaining both Finnish timberland funds and timberland REITs.

6.1 Risk and return combinations of different assets

The nominal return series of the timberland fund's annualized returns is presented in Figure 5. The daily observations are converted into monthly observations. The only negative annualized returns between valuation dates are indicated by S-pankki, at the start of the fund, in June 2019 (-2 %) and in December 2019, (-1 %). Neither OP nor UB have indicated a negative return during the existence of the fund. The highest mean return of the three funds is measured by S-Pankki, 9.25 percent. OP fund's mean return is 8.74 percent and UB Metsä I has a measured return of 5.4 percent slightly differing from the others. The greater increase of OP-Metsänomistaja B II in late 2022 was due to the relatively large investment in Tornator Oyj, which altered its valuation methods and thus increased the value of the timberland fund as well (Tornator Oyj, 2022).

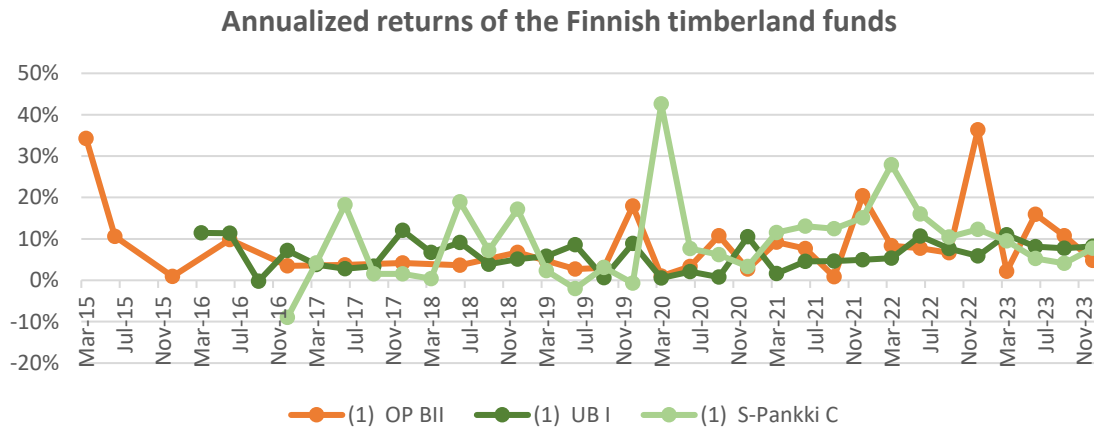


Figure 5. Annualized returns of the Finnish timberland funds between 2015 - 2023.

Figure 6. represents the annualized nominal returns of the timberland REITs. The time series is based on the same intervals between observations as in OP metsänomistaja B II fund unit valuation dates, totalling 29 observations. As expected, the volatility of the REITs is much greater than in the timberland funds. The mean expected returns are 14 percent for Weyerhaeuser, 11.3 percent for Rayonier and 13.4 percent for Potlatch Deltic Corp.

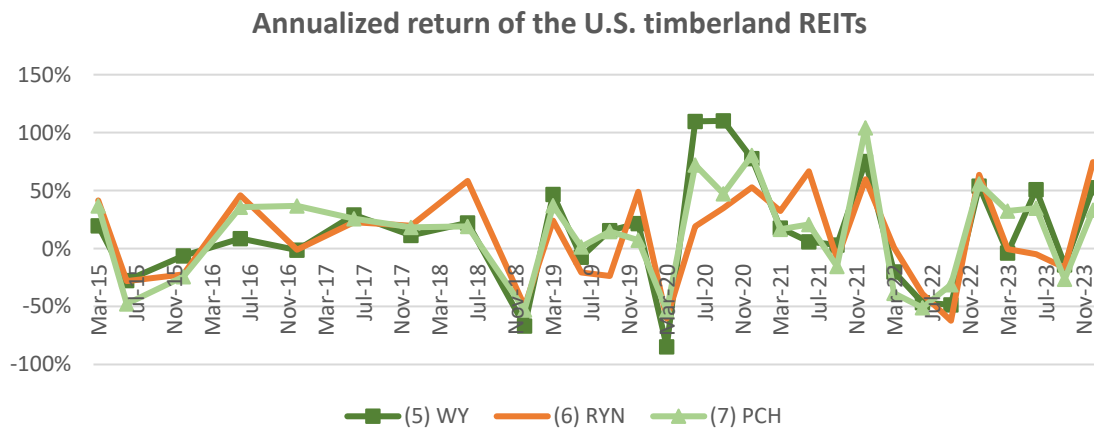


Figure 6. Annualized returns of the U.S timberland REITs between 2015 - 2023.

The market efficiency of timberland REITs has been examined by La & Mei (2013). The timberland funds were discovered to be partly sufficient in displaying the available information in their stock prices. Timberland REIT returns illustrate two major fluctuations in the markets during the observation period. Firstly, at the beginning of 2020, the global

COVID-19 pandemic fragmented the global stock markets and decreased heavily on returns. For the sawmilling industry, the following years were very lucrative as the do-it-yourself movement began to increase the demand for lumber. The lockdowns continued until 2021 and kept the demand for lumber and further timber on a great level and this can be observed in the return series of the timberland REITs. In 2022 the markets were fragmented again as Russia began its invasion of Ukraine. The turbulence is again visible in the returns of the REITs. Since then, the restrictions on the Russian sawn-wood industry have caused turbulence in the end-use markets for which timberland investments produce raw materials.

The two timberland assets have different characteristics and the timberland funds do have unique characteristics compared to other asset classes observed in the study. For a Finnish investor, the REITs seem to have greater volatility than the Finnish stock markets with a greater expected return as presented in Figure 7. The expected returns and expected volatilities are calculated from the observations of the OP metsänomistaja time series.

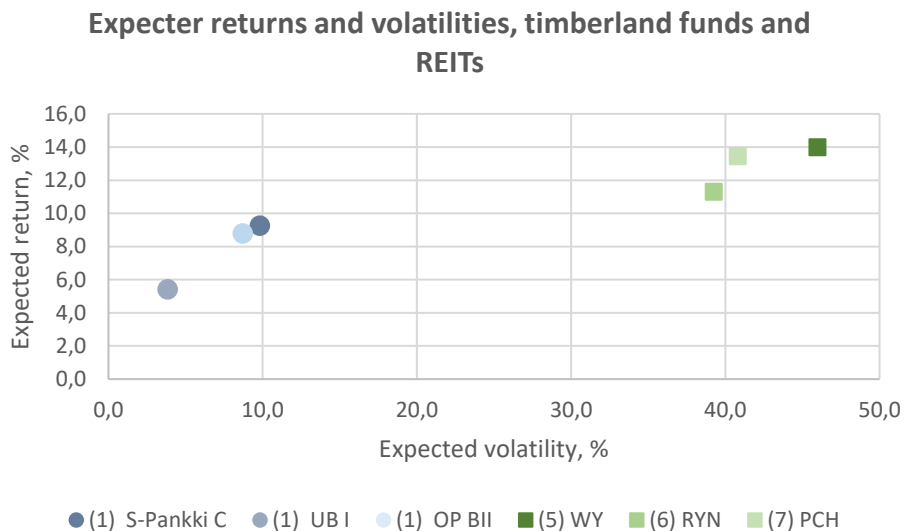


Figure 7. Expected returns and volatilities of timberland funds and REITs, 2015 - 2023.

The highest rate of expected return is displayed by Weyerhaeuser. Logically it has the greatest expected volatility. Timberland funds tend to have very different characteristics.

When the Sharpe ratios are calculated the timberland funds tend to have 0.3 units greater rate of excess return on each unit of risk taken as displayed in Table 11.

Table 11. Sharpe ratios of the timberland assets. Finland 2-year bond as risk-free rate, 2015 – 2023.

<i>Asset</i>	<i>expected return, %</i>	<i>Volatility, %</i>	<i>Sharpe</i>
(1) S-Pankki Metsä C	9.3	9.8	0.45
(2) United Bankers Metsä I	5.4	3.8	0.66
(3) OP Metsänomistaja II B	8.8	8.7	0.50
(4) Weyerhaeuser	14.0	46.0	0.21
(5) Rayonier	11.3	39.2	0.18
(6) Potlach Deltic	13.4	40.8	0.22

The covariance of an asset return is an important determining factor affecting the variance of a portfolio and further the optimal portfolio of a number of risky assets. The covariance is calculated from the correlation coefficients. The correlation together with covariance, is a measure of linear relationship of two asset returns (Luenberg, 1998). The correlation coefficient is not dependable on the units of the measured variables but scaled to represent values between negative 1, absolute opposite movement and positive 1, absolute identical movement.

The correlation matrix for the Finnish forestland funds, Euribor and OMX25 index is displayed in Table 12. The correlation matrix displays the low correlation of the timberland funds. UB I and S-Pankki C fund units seem to have quite a strong negative correlation of -0.3. The highest correlation of the timberland funds with the stock markets portrayed by the OMX25 index was with OP metsänomistaja B II fund unit, 0.14. Nevertheless, the correlations of the assets are relatively weak compared to observed correlations of the timberland REITs. The timberland REITs correlations ranged from 0.72 between WY and RYN, 0.88 between WY and PCH, and 0.76 between RYN and PCH. The correlation is significantly greater than between the Finnish counterparts.

Table 12. Correlation matrix of the Finnish timberland funds, Euribor and OMX25 index.

	(1) <i>OP BII</i>	(1) <i>UB I</i>	(1) <i>S-Pankki C</i>	(7) <i>EURIBOR</i>	(8) <i>OMX25</i>
(1) <i>OP BII</i>	1	0.02	-0.03	0.14	0.10
(1) <i>UB I</i>	0.02	1	-0.30	0.28	0.04
(1) <i>S-Pankki C</i>	-0.03	-0.30	1	0.15	-0.36
(7) <i>EURIBOR</i>	0.14	0.28	0.15	1	-0.26
(8) <i>OMX25</i>	0.10	0.04	-0.36	-0.26	1

Table 13. represents the correlation matrix between the timberland funds and timberland REITs. The correlation between the timberland funds and timberland REITs ranges from – 0.43 to 0.39. S-Pankki c correlates negatively with all three REITs. The strongest correlation between timberland funds and REITs is between OP Bii and Weyerhaeuser, 0.39. The correlation between the OMXH25 index and the timberland REITs vary from 0.56 with Weyerhaeuser, 0.59 with Potlach Deltic and 0.70 with Rayonier.

Table 13. Correlation matrix of the Finnish timberland funds and timberland REITs.

	(1) <i>OP BII</i>	(2) <i>UB I</i>	(3) <i>S-Pankki C</i>	(4) <i>WY</i>	(5) <i>RYN</i>	(6) <i>PCH</i>
(1) <i>OP BII</i>	1	0.02	-0.03	0.24	0.39	0.29
(2) <i>UB I</i>	0.02	1	-0.30	-0.12	0.13	0.02
(3) <i>S-Pankki C</i>	-0.03	-0.30	1	-0.42	-0.22	-0.43
(4) <i>WY</i>	0.24	-0.12	-0.42	1	0.72	0.88
(5) <i>RYN</i>	0.39	0.13	-0.22	0.72	1	0.76
(6) <i>PCH</i>	0.29	0.02	-0.43	0.88	0.76	1

6.2 Portfolio optimization benefits of timberland assets

This section will display the results of portfolio optimization with the mean-variance theorem. This section will answer the question, does the timberland fund offer diversification benefit for a Finnish institutional investor with a traditional set of investments in their investment portfolio. The section is divided into two subsections. First, the diversification benefit from the Finnish timberland funds is examined. All three optimizations with different Finnish timberland funds are represented. In the second subsection, each

of the previous optimizations are introduced to timberland REIT index, to determine does the timberland REITs offer further diversification potential to a Finnish investor who has a three-asset portfolio containing stocks, bonds and timberland funds. The portfolio optimizations are based on each own time series based on the timberland fund at hand.

6.2.1 Three asset portfolios with stocks, bonds and timberland funds

The 2 asset portfolios were calculated from the three time series as the observation dates of the timberland funds were unique. The average weighting between the two assets in the tangency portfolio was 36 percent of stocks and 64 percent of bonds. The average Sharpe ratio of the tangency portfolios of the two assets was 0.23. The risk-free rate of the three time series was on average 4.05 percent p.a. By adding the timberland fund asset, OP metsänomistaja B II fund unit, to the portfolio, the maximum Sharpe ratio increased to 0.53. The expected return decreased by 0.85 percentage units and the expected variance decreased by 15.74 percentage units.

When UB Metsä I fund unit was introduced to the two-asset portfolio the maximum Sharpe ratio increased to 0.75. The expected return of the tangency portfolio decreased by 3.89 percentage units and the variance decreased by 20.40 percentage units from the two-asset tangency portfolio. The tangency portfolio of a three-asset portfolio with S-Pankki Metsä C fund unit obtained a Sharpe ratio of 0.62. Compared to two-asset portfolios the expected rate of return increased with 0.30 percentage units and portfolio variance decreased with 15.89 percentage units. Table 14. presents the measured Sharpe ratios, expected returns, and expected variances on tangency portfolios.

Table 14. Tangency portfolios of average 2 asset portfolios, and 3 asset portfolios including (1) OP Metsänomistaja B II fund unit, (2) UB Metsä I fund unit, (3) S-Pankki Metsä C fund unit respectively.

<i>Tangency portfolio</i>	<i>Average 2 asset portfolio</i>	<i>(1) OP-metsänomistaja</i>	<i>(2) UB-Metsä I</i>	<i>(3)S-Pankki Metsä C</i>
Sharpe ratio	0.23	0.53	0.75	0.62
Expected return, -%	9.72	8.87	5.74	10.02

Expected variance, -%	24.19	8.45	3.79	8.30
Portfolio weight of timberland, -%	-	88.91	95.70	85.72

The average minimum variance portfolio of the two asset portfolios had a variance of 12.89 percent. The Sharpe ratio was 0.13. All three asset portfolios increased the Sharpe ratio significantly. When OP-Metsänomistaja b II fund unit was introduced to the optimization it decreased the portfolio variance with 5.33 percentage units and the Sharpe ratio was increased to 0.47. As expected UB Metsä I decreased the portfolio variance of most of the three timberland fund assets, by 5.33 percentage units. The Sharpe ratio was increased to 0.74. S-Pankki Metsä C fund unit again decreased the portfolio variance by 5.48 percentage units and increased the Sharpe ratio to 0.55. the minimum variance portfolio key figures are represented in Table 15.

Table 15. Minimum variance portfolios of average 2 asset portfolio, and 3 asset portfolios including (1) OP Metsänomistaja B II fund unit, (2) UB Metsä I fund unit, (3) S-Pankki Metsä C fund unit respectively.

<i>Minimum variance portfolio</i>	<i>Average 2 asset portfolio</i>	<i>(1) OP-metsänomistaja</i>	<i>(2) UB-Metsä I</i>	<i>(3) S-Pankki Metsä C</i>
Sharpe ratio	0.13	0.47	0.74	0.55
Expected return, -%	5.75	7.98	5.59	8.94
Expected variance, -%	12.89	7.56	3.69	7.41
Portfolio weight of timberland, -%	-	66.80	97.68	68.73

The expected return of the average, calculated from the three time series, two asset minimum variance portfolio was 5.75 percent and the expected variance 12.89 percent. By introducing the timberland asset and obtaining the same rate of return, the expected variance decreased to 3.8 percent with the UB I representing the timberland funds. By obtaining the same level of variance, 12.89 percent, the expected return increased to 7.7 percent with the same assets. With S-Pankki as the timberland fund, the expected variance increased to 13.4 when the expected return was held constant. When the variance was held constant the expected rate of return increased to 11.1 percent. With OP-Metsänomistaja, when the rate of return was held constant the expected variance was

decreased to 12.1 and when the expected variance was held constant the return decreased to 5.6 percent.

The efficient frontiers of the three-asset portfolios are portrayed by Figures 8, 9 and 10. The efficient frontiers reflect the trade-off between the risk and return measures. The efficient frontier displays the portfolios that maximize the return on a given level of risk. The return levels vary between 4.87 percent and 10.04 percent on the efficient frontier of the three-asset portfolio with OP B II fund unit as the timberland asset. The standard deviations vary from 7.6 percent to 26.2 percent. Figure 7 also displays the efficient frontier of the two-asset portfolio. The maximum and minimum return and variance are untouched when the timberland asset is introduced. The effect of the timberland asset is that the same level return can be achieved with much less risk. As mentioned in Chapter 2, the difference in the tangency portfolio between the two portfolios portrays the increase the added asset enables for the investor.

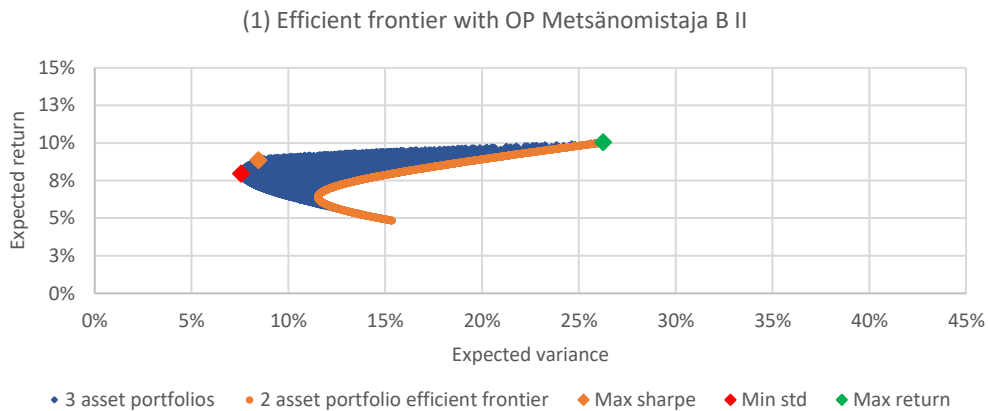


Figure 8. (1) Efficient frontier of three asset portfolio with timberland asset OP Metsänomistaja B II.

The efficient frontier with the UB Metsä I portfolio optimization model is represented in Figure 8. The efficient frontier extends to a greater maximum return than the OP-Metsänomistaja portfolio maximum return. The maximum return of both optimizations is the portfolio with 100 percent weight in the OMX25 index. The difference in the maximum return values is due to the different observation dates. OP metsänomistaja was

established a year earlier and the observations were less frequent during 2014 - 2019. The observation series in UB Metsä I and S-Pankki Metsä C are more equivalent.

Nevertheless, the efficient frontiers in portfolios with UB Metsä I and S-Pankki C Figure. 10 are similar regarding the diversification benefit that the timberland asset provides. Again, the same level of return can be obtained with less risk. The UB Metsä I returns varies from 2.90 percent to 13.02 percent. The return in the efficient portfolios of the portfolio with S-Pankki C fund unit varies from 5,16 percent to 14.6 percent. Variances vary from 3.76 percent to 43.10 percent for a portfolio with UB Metsä I and 7.46 percent to 43.7 percent for a portfolio with the S-Pankki Metsä C fund unit.

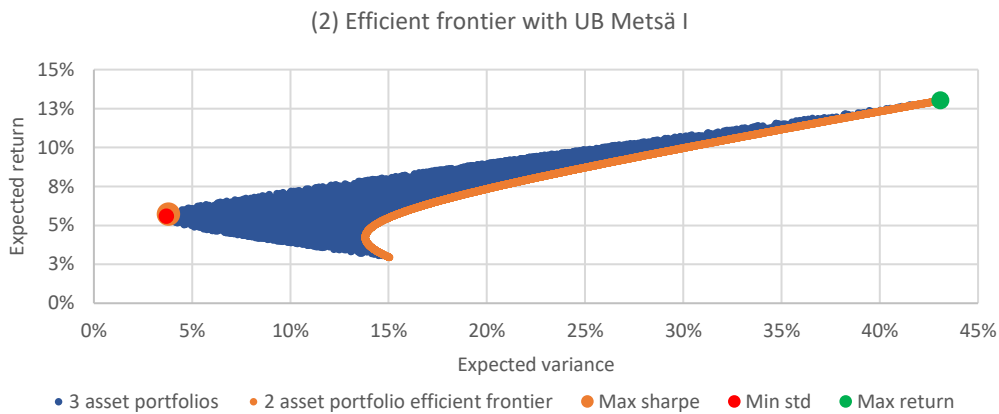


Figure 9. (2) Efficient frontier of three asset portfolio with timberland asset UB Metsä I.

The portfolio which is furthest to the right on the figures is the minimum variance portfolio. The portfolio with the maximum Sharpe ratio or tangency portfolio, is located on the point that crosses the market capital line. The timberland funds are suitable for investors who are more risk-averse. The timberland fund assets relocate the efficient frontier to the left quite drastically, meaning that one can obtain the same value of expected return with a decreased expected volatility. The effect on the efficient frontier is particularly great with UB Metsä I, where an investor can decrease the expected variance by over 10 percentage units and retain the same expected return of 5 percent annually on their investments. The maximum returns portfolios obtained in all three portfolio optimizations solely stock assets.

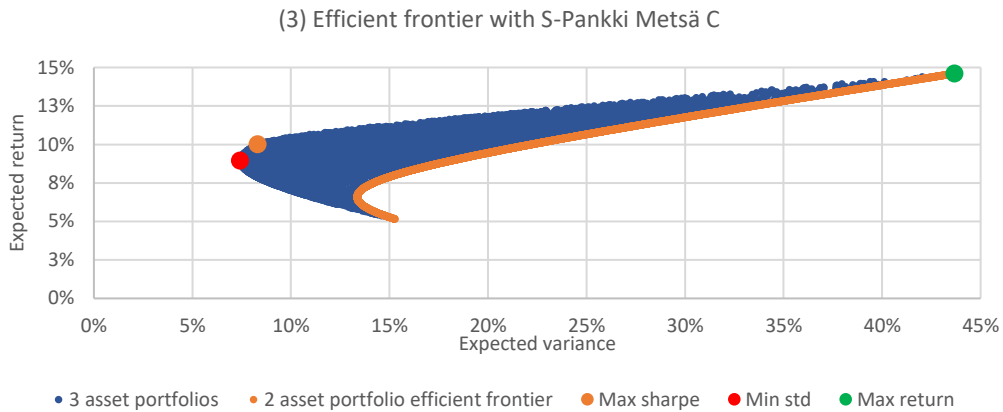


Figure 10. (3) Efficient frontier of three asset portfolio with timberland asset S-Pankki C.

The timberland assets gain a significant portion of the tangency and minimum variance portfolios. The weighting of timberland funds in tangency portfolios varies from 86 percent (S-Pankki) to 96 percent (UB). The minimum variance portfolios of S-Pankki and OP are similar in weightings and the minimum variance portfolio with UB consists of 98 percent of timberland. Only one tangency portfolio had the bond asset as a part of the weighting. The portfolio with OP metsänomistaja B II as the timberland asset employed 1 % to bond assets. The bond was included in the minimum variance portfolios with OP and S-Pankki. The portfolio weightings are portrayed in Figure 11.

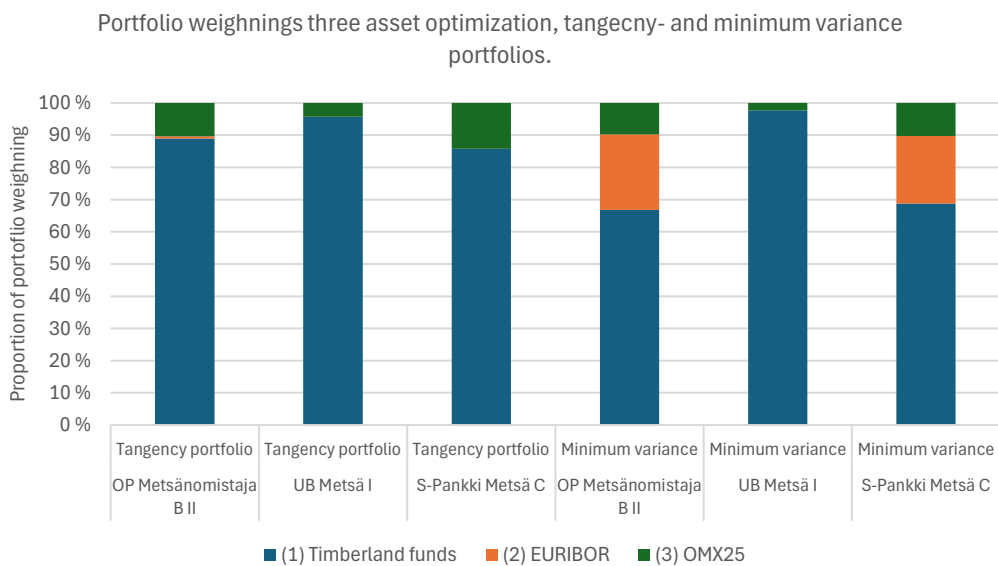


Figure 11. Portfolio weightings with 3 assets. Tangency and minimum variance portfolios.

6.2.2 Four asset portfolios with stocks, bonds, timberland funds and REITs

The portfolio optimization with four asset portfolios indicated that the REITs could offer diversification benefits to a less risk-averse investor. The return characteristics of the timberland REITs offer greater returns, with more variance, than the Finnish counterparts. When the Timberland REIT asset was included as a fourth asset in the portfolio optimization it was only included in the tangency or minimum variance portfolios if the timberland fund asset selected was S-Pankki Metsä C. Portfolio optimizations with OP-metsänomistaja and UB Metsä I did not include timberland REITs in the tangency or minimum variance portfolios. Table 16. represents the tangency portfolios of the portfolio optimization with four assets, stocks, bonds, timberland funds and timberland REITs. The REITs were represented by a REIT index constructed from the three individual timberland REITs.

Table 16. Tangency portfolios of average 3 asset portfolios of timberland funds, stocks and bonds, and 4 asset portfolios including the previous and timberland REITs. The calculations are divided into (1) OP Metsänomistaja B II fund unit, (2) UB Metsä I fund unit, (3) S-Pankki Metsä C, which represent a portfolio including the respective unique timberland fund units.

<i>Tangency portfolio</i>	<i>Average 3 asset portfolio</i>	<i>(1) OP-metsänomistaja</i>	<i>(2) UB-Metsä I</i>	<i>(3) S-Pankki Metsä C</i>
Sharpe ratio	0.63	0.53	0.75	0.69
Expected return, -%	8.21	8.87	5.74	9.98
Expected variance, -%	6.85	8.45	3.79	7.43
Portfolio weight of timberland funds, -%	90.11	88.91	95.70	79.88
Portfolio weight of timberland REITs, -%	-	-	-	12.40

The introduction of Timberland REITs increased the Sharpe ratio of the portfolio optimization with S-Pankki Metsä C from 0.62 to 0.69. The expected variance decreased by 0.9 percentage units. The expected return did not significantly increase, 0.04 percentage units. In the minimum variance portfolios, the optimization with S-Pankki Metsä C was

the only optimization to include the timberland REITs as a part of the portfolio. The minimum variance portfolios are portrayed in Table 17.

Table 17. Minimum variance portfolios of average 3 asset portfolios of timberland funds, stocks and bonds, and 4 asset portfolios including the previous and timberland REITs. The calculations are divided into (1) OP Metsänomistaja B II fund unit, (2) UB Metsä I fund unit, (3) S-Pankki Metsä C, which represent a portfolio including the respective unique timberland fund unit.

<i>Minimum variance portfolios</i>	<i>Average 3 asset portfolio</i>	<i>(1) OP-metsänomistaja</i>	<i>(2) UB-Metsä I</i>	<i>(3)S-Pankki Metsä C</i>
Sharpe ratio	0.59	0.47	0.74	0.62
Expected return, -%	7.50	7.98	5.59	9.07
Expected variance, -%	6.22	7.56	3.69	6.73
Portfolio weight of timberland funds, -%	77.74	66.80	97.68	66.13
Portfolio weight of timberland REITs, -%	-	-	-	12.40

The addition of timberland REITs increased the possibilities of the investor to gain greater expected returns on a desired variance level. Figure 12. presents the efficient frontier for 4 asset portfolio optimization calculations with OP metsänomistaja B II representing timberland funds. The maximum return portfolio in three asset optimizations consisted solely of the OMX25 index. During the time series of OP metsänomistaja, the timberland REITs annualized greater return and hence the maximum return portfolio in four asset optimizations consists solely of timberland REITs. The timberland REITs also enabled the four-asset portfolio to gain greater returns on the same levels of variance than the three-asset portfolio. For example, with an expected variance of 20 percent the three-asset portfolio generated an expected return of 8.9 percent. By adding the timberland REITs asset, the expected return rose to 10.7 percent. When the desired expected variance decreased towards the tangency portfolio, the diversification benefit from adding a timberland REIT decreased. For example, when the desired level of risk was set to 10 percent, the expected return on three asset portfolios was 9.1 percent per annum and with REITs, the expected return was 9.3 percent. When the expected variance was set to 25 percent, the expected return with three assets was 10.0 and by adding timberland REITs to the portfolio, the expected return increased to 11.3 percent.

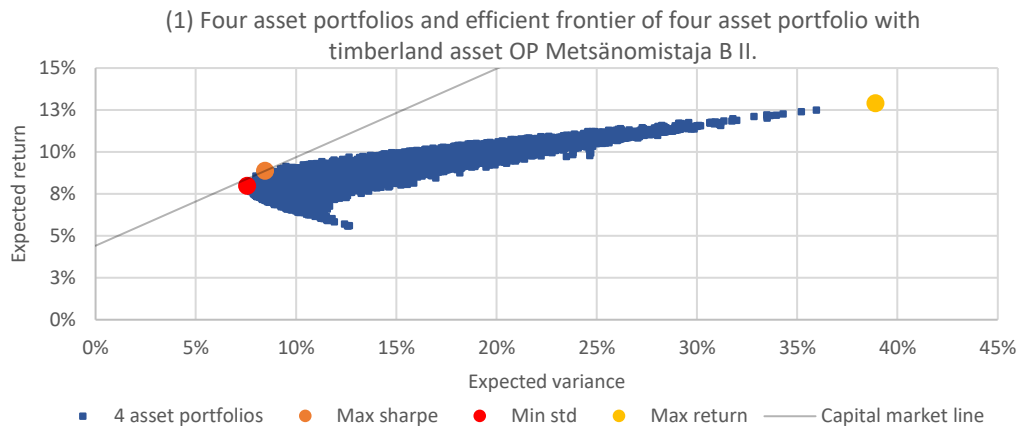


Figure 12. (1) Four asset portfolios and efficient frontier of four asset portfolio with timberland asset OP Metsänomistaja B II.

The four asset portfolio allocations with the OP metsänomistaja representing timberland funds are portrayed in Figure 13. The timberland funds remain the dominant part of the portfolios as the desired expected variance is below 17 percent. The red and orange lines represent the minimum variance and tangency portfolios respectively. When the desired variance is increased, the share of the timberland REITs increases parallel.

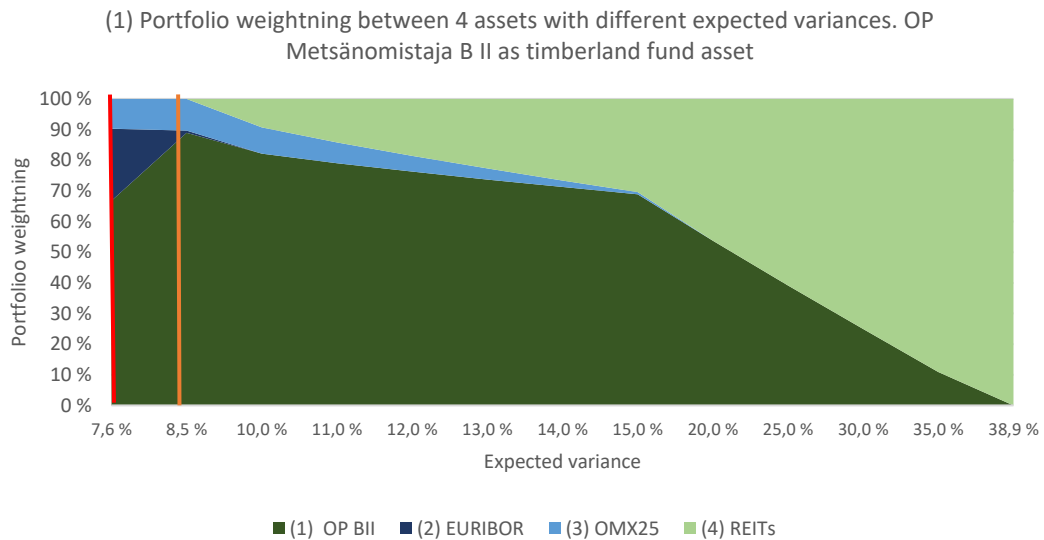


Figure 13. (1) Portfolio weighting between 4 assets with different expected variance. OP Metsänomistaja B II as timberland fund asset

With the exact same principles, the efficient frontier of the portfolio optimization with UB Metsä I fund unit is portrayed in Figure 14. As in three asset optimizations, the tangency or maximum Sharpe portfolio and minimum variance portfolios are nearly tangent. The timberland REITs increased again the mid risk-return relationship as in OP metsänomistaja optimization. However, the increase was not as significant as in OP metsänomistaja optimizations, which is partially caused by the timeseries of the observations and the OMX25 returns. In the OP metsänomistaja optimization the maximum return was generated by timberland REITs index. More logically with UB and S-Pankki time series, the maximum expected return based on the historical annualized changes was generated by the stock index, OMXH25.

The risk efficient frontier increased slightly by adding the REITs in to the optimization problem with UB Metsä I. As the desired risk was set to 10 percent the three-asset portfolio generated a maximum return of 7.2 percent and when REITs were added to the optimization problem the return increased to 7.3 percent. With a desired variance level of 20 percent, the corresponding figures were 9.0 percent and 9.3 percent respectively, and variance level of 30 percent the corresponding figures were 10.7 and 10.8 percent respectively.

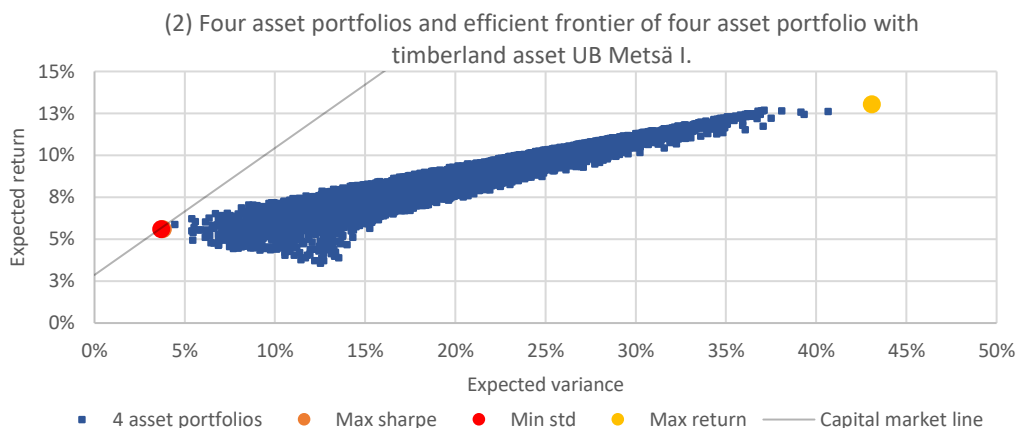


Figure 14. (2) Four asset portfolios and efficient frontier of four asset portfolio with timberland asset UB Metsä I.

The weighting of the portfolio is much alike to the OP metsänomistaja portfolio. The timberland funds dominate the portfolios with smaller levels of expected variances. The

timberland REITs are represented in the portfolios with expected variance above five percent as the figure 15. represents. The red and orange lines represent again the minimum variance and tangency portfolios.

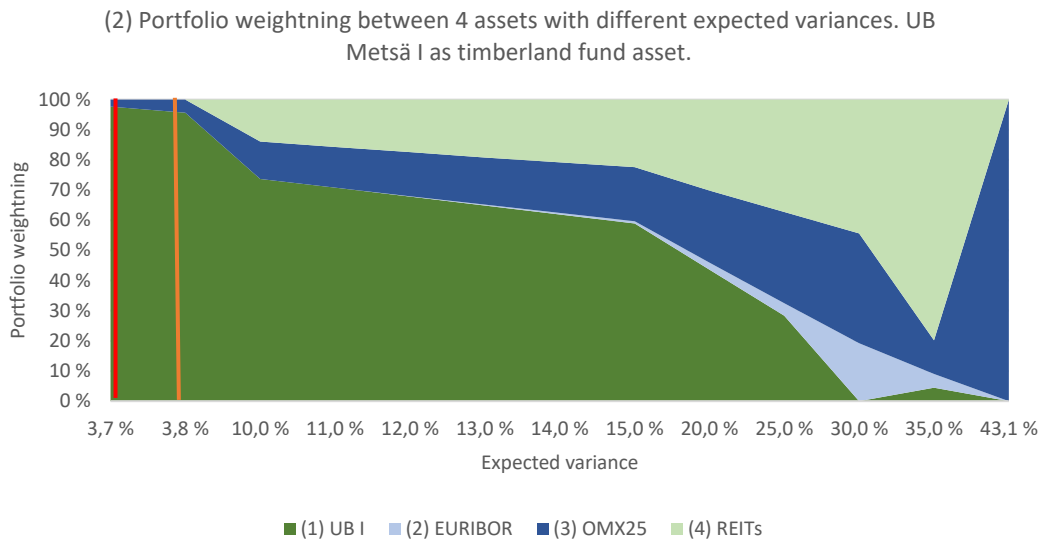


Figure 15. (2) Portfolio weightning between 4 assets with different expected variances. UB Metsä I as timberland fund asset.

The efficient frontier of four asset portfolio optimization with S-Pankki Metsä C fun unit is represented in figure 16. The introduction of timberland REITs increased the expected return on a desired variance level of 10 percent from 10.5 percent to 10.7 percent. As the expected level of variance was increased to 20 percent the return figures were 11.9 percent and 12.0 percent and with 30 percent as desired expected level of variance the figures were 13.1 percent and 13.2 percent.

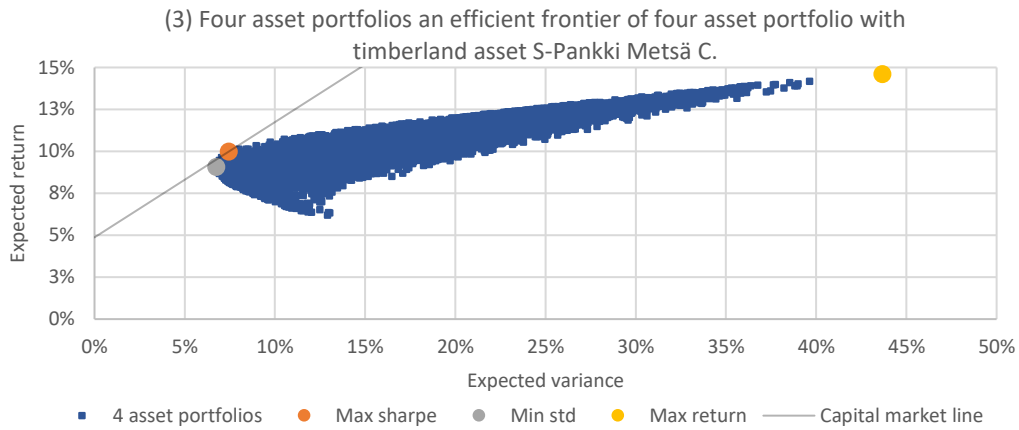


Figure 16. (3) Four asset portfolios and efficient frontier of four asset portfolios with timberland asset S-Pankki Metsä C.

The portfolio allocations of a four-asset portfolio on a desired level of expected variance are portrayed in Figure 17. As in optimization with UB Metsä I the share of timberland funds decreases as the expected variance increases. In the optimization with the S-Pankki Metsä C fund unit, the timberland REITs are represented also in the tangency and minimum variance portfolios. The share of timberland in the portfolio is at its maximum when the expected variance is 35 percent.

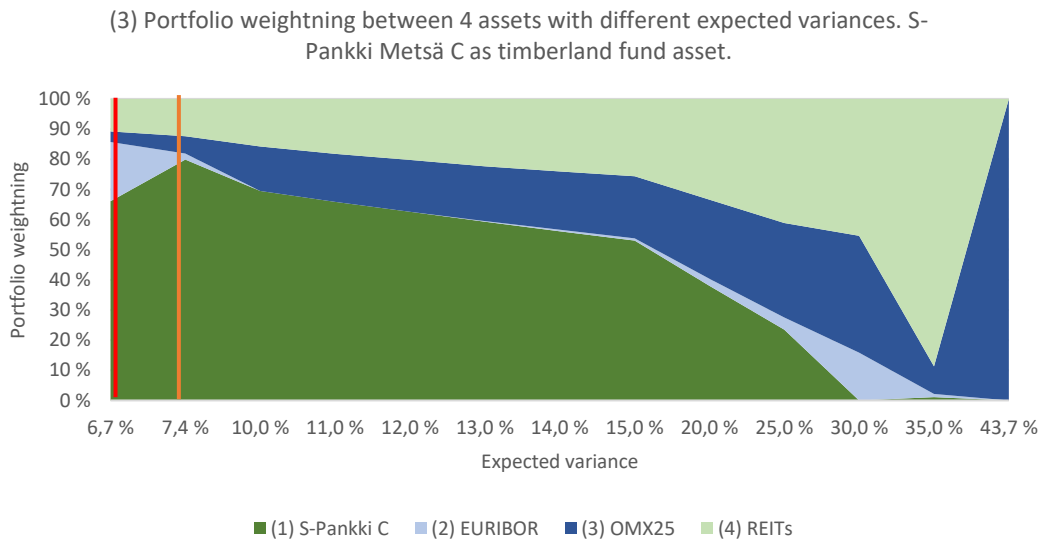


Figure 17. (3) Portfolio weighting between 4 assets with different expected variances. S-Pankki Metsä C as timberland fund asset.

7 Conclusions

This chapter will first focus on analysing the data of the research, applied methodology, the results of the portfolio optimizations and which factors have been significant for the historical returns of the timberland funds and timberland REITs. The discussion section will also analyse the impact that the investment structure or vehicle has on the return represented by the assets included in the analysis. Conclusions will summarise the findings in a broader spectrum and will represent the final insight the study has provided the reader and the industry.

The research objective of the study was to determine the diversification benefit that a timberland fund and timberland REIT can offer a Finnish investor with traditional asset classes stocks and bonds. The study examined the diversification benefit with mean-variance theorem first introduced by Markowitz (1952). The two hypotheses of the study were formulated as:

H_1 : Timberland funds offer diversification benefits for domestic institutional investors, that has solely invested in Finnish stock and fixed-income markets.

And,

H_2 : A Finnish investor with a portfolio containing domestic stocks, bonds and timberland funds do not gain diversification benefit by further investing in timberland REITs.

7.1 Conclusions

The timberland fund assets included in the study can be categorized into the same group. They are marketed to the same investor group, they have the same strategy on investing the timberland markets, they compete on the same individual timberland estates and the structures of the funds are identical. The data gathered for the analysis does have its

differences due to the different valuation dates of the funds. This meant that the annualized returns have a slightly different values in terms of expected return and expected variance as highlighted in chapter 5.1. As the mean-variance framework relies on the correlations between the assets, it was crucial to be robust on the dates of observations and as they are not unanimous among the timberland funds, they were not subject to a united optimization. Nevertheless, the study represented comprehensive figures that indicate the results of the timberland funds and REITs possible diversification benefits.

As expected, the introduction of timberland assets to a portfolio with risky assets does offer investors diversification benefits. The mean-variance optimizations indicate that as the timberland funds are introduced to the portfolio optimization, they are much represented in the low-risk portfolios. As the Figure 11. shows that in the tangency portfolios on 3 asset portfolios, the weighting on the timberland assets was at a maximum 95.7 percent in UB I optimisation and at a minimum 85.7 percent. By including the timberland asset, the Sharpe ratio increased by 0.40 on average, meaning that the Sharpe ratio nearly doubled from 0.23.

By including the timberland asset to the two-asset portfolio the efficient frontier was lifted, especially in the lower variance and return levels of 8 - 15 percent of variance and 4 - 9 percent of return. This is indicating that an improved risk- return ratio was achievable. The timberland funds were much represented in these portfolios, weighting ranging from 70.1 to 95.4 percent. As the result shown in the chapter 6.2.1 the return characteristics of the timberland funds, have the greatest impact on the lower end of the portfolio return-risk ratio. The timberland fund extensively decreases the expected variance as the return figures are conservative.

The minimum variance portfolio of two asset obtained on average an expected return of 5.8 percent with a 12.89 percent of expected variance. As the expected rate of return was relatively high compared to the expected rates of return of the timberland funds, UB metsänomistaja was the only fund unit that enabled to significant decrease in the

variance to 3.8 percent when the expected return was held at 5.8 percent. When the variance was held constant the UB and S-Pankki increased the rate of expected return to 7.7 percent and 11.1 percent respectively. OP metsänomistaja B II fund unit did not increase or decrease the rate of return or rate of variance significantly in either case. The expected return of OP metsänomistaja was 9 percent and thus the low rate of return of the 2-asset minimum variance portfolio increased the share of the EURIBOR asset on the portfolio up to 80 percent.

It can be concluded that the findings of the study confirm the first hypotheses that the timberland fund do offer diversification benefits to a Finnish institutional investor with two asset portfolios. The main point of benefits lies on the lower end of the risk-return ratio, as expected when the characteristics of the timberland assets are considered. The efficient frontiers represent extensively how the efficient portfolio are shifted toward right and enable for example in S-Pankki Metsä C optimization to obtain the same level of return, 10 percent with 8 percent of variance, when with two assets the variance is 22 percent.

By further investing to timberland REITs a domestic investor can partially increase the diversification benefit provided by the timberland investments. As the result on chapter 6.2.2 shows the efficient frontiers are not pushed towards right any more than with the three-asset portfolios. The timberland REITs benefit more risk obtaining investors. The timberland REITs have, as typical to a stock investment, a higher return-risk ratio. When the efficient frontiers of four-asset portfolios are examined, the two timberland assets give the investor benefits in different areas of the risk-return matrix. If an investor is willing to increase the expected variance to obtain greater expected returns, by investing in a timberland REIT asset the investor can increase the expected return in comparison to a portfolio with three-assets. The S-Pankki I fund unit has stronger evidence of the optimization benefits of the Timberland REITs as they are also represented in the minimum variance and tangency portfolios.

All this concluding, the second hypothesis is not supported by the results of the study. The investor can gain diversification benefits by investing into timberland REITs especially if the investor is more risk tolerant. For a risk adverse investor, the timberland REITs do not offer further diversification benefits compared to a portfolio containing Finnish timberland funds, stocks, and bonds.

The Figure 7. Describes the return-risk ratios of the timberland REITs and timberland funds. The different financial characteristics are the result of, among others, different exposure to market pricing, different geographical location, and operating type. In the end, both timberland funds and Timberland REITs are subject to similar characteristics of the timberland investments, for example the little impact on return if a harvest is for example postponed due to poor timber prices. Due to the different structures and operation types, the timberland characteristics are either concealed or observable.

Firstly, due to the investment vehicle of timberland REITs they are subject to the daily pricing, where the fluctuations of the macroeconomics are represented more effectively. The REITs also employ a vast number of personnel, which causes that the operating expenses are not as elastic as the timberland funds, which employ at maximum a handful of people (Weyrehouse, 2022; Rayonier, 2024; Potlatch Deltic Corp, 2024) Secondly, the REITs operate on the U.S. and grow different tree species than the Finnish counterparts. The Finnish timberland funds are operating on the efficient Baltic Sea region timber markets where prices have been steadily increasing during the observed period, see appendix 2. The timberland REITs operate on a different market standard. For example, Weyerhaeuser have its own sawmills and produce sawn wood of nearly half of its yearly harvests. Potlatch Deltic operates facilities producing lumber and plywood and sell mainly these products to end users. Rayonier do not manufacture lumber to similar extent. In summary, the greater rate of return in the study implies that the REITs are efficient in harnessing the lucrative times of the industry, with its vast resources of employees, operations, mills, and end-use products, but are also a subject to riskier environment due to the vast organization and exposure to end-use markets.

The timberland fund on the other hand only produces timber which is then sold to the saw- and pulp mill industry. Hence, they do not carry the end use product risks and nor can benefit from the more lucrative times of the industry as efficiently. The organization structure is light, and the costs are elastic, containing mainly silvicultural works, which like the timber harvests can be postponed or be conducted in advantage, without compromising the return of the investment.

7.2 Further research

For further research, the diversification benefit of the timberland REITs could be examined further. The diversification benefit of the timberland REITs could be partially an effect of the geographical stock exchange diversification and less concentrated to the timberland investing. The diversification benefit gained from the timberland REITs could be obtained also by investing in other common stock on the New York Stock Exchange. The previous literature has provided much of results stating the diversification benefits of the timberland REITs (Mei & Clutter, 2019). Nevertheless, the Finnish stock exchange correlation with the REITs is on the range between 0.56 and 0.70 meaning that a lower number would indicate better diversification benefit than with the REITs.

The unsmoothing index tool described in the chapter 2.4 could be applied to the timberland fund returns to expose the true volatility of the investments. The unsmoothing index requires underlying data which can expose the true variation of the smoothed index. In forestry the main source of income is the selling of raw timber, hence the underlying data could be constructed from the monthly raw timber prices published by Luke. Luke publishes raw timber prices for each assortment of wood, 3 log, 3 pulp and 2 small log assortments in total. It is published on a regional and country level. The study could use the country level data for all harvesting types combined. The assortments are weighted with the respective harvesting levels to determine the index value for each last month

of the quarter. The monthly prices could then be weighted with the respective harvesting volumes to calculate quarterly price index.

The unsmoothing would also be an interesting proxy for the future if a similar type of investment vehicle as timberland REIT would be introduced to Finland or the current timberland funds would transform to such vehicles. The unsmoothing would indicate how the diversification characteristics would alter if the fund units would be exposed to daily market pricing. By assuming the more liquid investment vehicle it would also be more natural to investigate the diversification benefits with a multi-period mean-variance optimisation tool as the re-balancing would be more effortless to conduct.

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Appendices

Appendix 1. Timberland fund observations

The valuation dates of the different timberland funds, which are on the basis of the time-series gathered for the optimizations (Suomen sijoitustutkimus, 2024).

<i>(1) OP BII</i>	<i>(1) S-Pankki C</i>	<i>(1) UB I</i>
31.3.2015		
30.6.2015		
31.12.2015		
30.6.2016		15.3.2016
30.12.2016	15.12.2016	15.6.2016
30.6.2017	15.3.2017	15.9.2016
29.12.2017	15.6.2017	15.12.2016
29.6.2018	15.9.2017	15.3.2017
31.12.2018	15.12.2017	15.6.2017
29.3.2019	15.3.2018	15.9.2017
28.6.2019	15.6.2018	15.12.2017
30.9.2019	17.9.2018	15.3.2018
31.12.2019	17.12.2018	2.5.2018
31.3.2020	15.3.2019	15.6.2018
30.6.2020	17.6.2019	17.9.2018
30.9.2020	16.9.2019	17.12.2018
31.12.2020	16.12.2019	15.3.2019
31.3.2021	16.3.2020	2.5.2019
30.6.2021	15.6.2020	17.6.2019
30.9.2021	15.9.2020	30.6.2019
31.12.2021	15.12.2020	16.9.2019
31.3.2022	15.3.2021	16.12.2019
30.6.2022	15.6.2021	16.3.2020
30.9.2022	15.9.2021	15.6.2020
30.12.2022	15.12.2021	15.9.2020
31.3.2023	15.3.2022	15.12.2020
30.6.2023	15.6.2022	15.3.2021
29.9.2023	15.9.2022	15.6.2021
29.12.2023	15.12.2022	15.9.2021
	15.3.2023	15.12.2021
	15.6.2023	15.3.2022
	15.9.2023	15.6.2022
	15.12.2023	16.6.2022
		15.9.2022
		15.12.2022
		15.3.2023
		15.6.2023
		15.9.2023
		15.12.2023

Appendix 2. Timber price index in Finland 2014-2023

The timber price index calculated on the basis of the Luke (2024) prices per assortment and harvest type. Regional distribution is consolidated by Luke.

Date	Index value	Date	Index value	Date	Index value
31.12.2014	32,3	31.1.2018	34,2	28.2.2021	38,5
31.1.2015	30,4	28.2.2018	35,6	31.3.2021	38,7
28.2.2015	31,9	31.3.2018	36,5	30.4.2021	42,1
31.3.2015	32,9	30.4.2018	36,7	31.5.2021	45,4
30.4.2015	33,3	31.5.2018	39,4	30.6.2021	46,0
31.5.2015	35,3	30.6.2018	41,4	31.7.2021	40,7
30.6.2015	34,4	31.7.2018	39,4	31.8.2021	41,2
31.7.2015	31,5	31.8.2018	39,3	30.9.2021	39,8
31.8.2015	33,5	30.9.2018	39,2	31.10.2021	38,9
30.9.2015	32,7	31.10.2018	39,9	30.11.2021	38,0
31.10.2015	32,5	30.11.2018	40,3	31.12.2021	38,6
30.11.2015	32,7	31.12.2018	39,2	31.1.2022	38,0
31.12.2015	32,7	31.1.2019	36,3	28.2.2022	39,0
31.1.2016	30,0	28.2.2019	35,1	31.3.2022	38,8
29.2.2016	32,3	31.3.2019	33,6	30.4.2022	39,5
31.3.2016	32,2	30.4.2019	34,3	31.5.2022	42,8
30.4.2016	34,0	31.5.2019	34,4	30.6.2022	45,8
31.5.2016	34,4	30.6.2019	34,6	31.7.2022	47,7
30.6.2016	34,3	31.7.2019	33,2	31.8.2022	46,0
31.7.2016	32,6	31.8.2019	34,3	30.9.2022	44,7
31.8.2016	32,3	30.9.2019	33,8	31.10.2022	45,1
30.9.2016	33,0	31.10.2019	33,3	30.11.2022	42,4
31.10.2016	33,4	30.11.2019	31,5	31.12.2022	43,3
30.11.2016	33,4	31.12.2019	32,0	31.1.2023	43,5
31.12.2016	32,9	31.1.2020	31,4	28.2.2023	45,8
31.1.2017	32,0	29.2.2020	32,7	31.3.2023	47,2
28.2.2017	33,9	31.3.2020	35,4	30.4.2023	49,7
31.3.2017	34,8	30.4.2020	35,7	31.5.2023	53,2
30.4.2017	35,9	31.5.2020	34,9	30.6.2023	51,9
31.5.2017	36,2	30.6.2020	35,7	31.7.2023	48,5
30.6.2017	35,7	31.7.2020	34,6	31.8.2023	47,0
31.7.2017	34,2	31.8.2020	34,6	30.9.2023	45,5
31.8.2017	33,6	30.9.2020	35,2	31.10.2023	43,6
30.9.2017	34,9	31.10.2020	35,9	30.11.2023	42,8
31.10.2017	34,7	30.11.2020	36,8	31.12.2023	44,3
30.11.2017	35,5	31.12.2020	39,1		
31.12.2017	36,0	31.1.2021	37,9		