Capital Asset Pricing Model in Forestry: A Review of Methods and Applications

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master in Forest Science
(M.Sc. European Forestry)

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Vienna, October 2008

ACKNOWLEDGEMENTS

I would like to express my first sincere gratitude and deep respect to my thesis supervisor Ao. Univ. Prof. DI Dr. Walter Sekot, Institute of Agricultural and Forestry Economics, Department of Economics and Social Sciences, University of Natural Resources and Applied Life Sciences, Vienna, Austria, for his great contribution from the beginning of development of ideas in the formulation of research topic up to this stage of final completion. Without his constant support, inspiration and encouragement, the final output could not be expected in this shape.

I am grateful to Prof. Hubert Hassenauer, Institute of Silviculture, BOKU/ Austria, who is also the program coordinator of European forestry in Boku. His way of supportive role during my study in Vienna was always inspiring and encouraging.

My special thanks go to Prof. Pavo Pelkonen, University of Joensuu, Finland who guided me during my study at University of Joensuu, Finland. Additionally, I am indebted to European Commission (Erasmus Mundus program)/MScEF consortium for providing me a great opportunity to participate in such a dynamic mobility study program with scholarship as a part of my Master program, which was very encouraging to get a broad exposure in forestry in European countries.

I am also thankful to my colleagues Ananta Ghimire, Basanta Raj Adhikari, Basanta Raj Gautam, Rajesh Rai, Sharad Baral, Sishir Gautam, Sony Baral, Sita Aryal, Sushma Dangol and Sager Subedi for their good accompany in making a homely environment during my study period in Finland and Austria.

Last but not least, I express my deep respect to my mother, father, sister, brothers and all the family members who provided me good care and guidance up to this stage. I am also equally expresses my deep love to my wife Nima and daughter Barada and all those family, who have suffered my long absence in Nepal during my study period in Europe.

ABSTRACT

The Capital Asset Pricing Model (CAPM) is a well established approach for the evaluation of investment opportunities. The growing interest of institutional investors in timberland and wood production has inspired consultants, forest owners, managers of forest companies and economists alike to apply this model also in regard to forestry. The thesis reviews and evaluates respective applications of CAPM where forests are considered as financial assets. The empirical analyses refer to three countries: the US, Sweden and Finland.

CAPM is based on certain assumptions and considers only the non-diversifiable systematic risk measured by beta (β). Alpha (α) and β are the two crucial parameters of the model, explaining the return and risk of an asset. The parameters are derived from linear regression by ordinary least square estimates.

The application of CAPM requires the estimation of returns of the forestry asset, a risk free rate of return and the rate of return associated with the market portfolio. Historical returns on forestry were derived without considering any non-timber values. The estimates were based on several assumptions in regard to stumpage prices, growing stock and the value of the bare land. In the case of the US and Sweden, CAPM-results revealed that forestry investments reduced the systematic risk of the portfolio, β being nearly zero or negative and α being positive. In contrast to these results, positive β and negative α values were found in Finland. Further findings indicate that forestry investments may be useful for hedging against inflation. It is concluded that CAPM is a useful tool also for assessing the potential of timberland investments for reducing total portfolio risk. However, the very restrictive, implicit assumptions and the poor explanatory power of the model as such as well as a lack of accurate historical data on forestry may limit the practical significance of the approach.

Key words: *CAPM, risk and return, systematic risk, forest asset, forestland investment, financial asset, portfolio risk diversification, inflation hedging*

KURZFASSUNG

Das Capital Asset Pricing Model (CAPM) dient im Rahmen der Portfoliotheorie der Analyse von risikoabhängigen Gleichgewichtsbedingungen. Nachdem sich institutionelle Investoren zunehmend auch für Forst-Investments interessieren, ist CAPM auch auf die Forstwirtschaft angewandt worden. Im Rahmen der Arbeit werden die einschlägigen, in der Literatur dokumentierten Erfahrungen zusammengefasst und ausgewertet. Die analysierten Fallstudien stammen dabei aus den USA, Schweden und Finnland.

Der Modellansatz beruht auf einigen, durchaus weitreichenden Annahmen. Im Mittelpunkt des Interesses steht dabei das nicht-diversifizierbare, systematische Risiko, das mit dem Parameter Beta (β) gemessen wird. Alpha (α) und β sind die beiden zentralen Modellparameter, welche die Renditeerwartung sowie das Risiko einer Anlage zum Ausdruck bringen. Diese Parameter werden über ein lineares Modell geschätzt.

Die Anwendung von CAPM erfordert die Abschätzung der Renditeerwartung im Zusammenhang mit einem Forst-Investment, die Bestimmung der Rendite einer risikolosen Veranlagung sowie jener des Marktportfolios. Dabei müssen verschiedene Annahmen getroffen werden, etwa in Bezug auf die Holzpreise und den Bodenwert.

Die Anwendungen mit Bezug auf die USA und Schweden haben gezeigt, dass Forst-Investments durchaus das systematische Risiko verringern können. Mit positiven (β) und negativen α Werten wurden allerdings im Falle Finnlands gegenteilige Ergebnisse erzielt.

Generell wird die Fruchtbarkeit des Ansatzes kontrovers diskutiert. In Bezug auf forstliche Investments kann zudem der Mangel an verlässlichen, historischen Daten die Anwendbarkeit limitieren.

Key word: CAPM, Forstinvestments, Risiko, Kapitalgüter

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ABBREVIATION

APT: Arbitrage Pricing Model

ARIMA: Auto Regressive Integrating Moving Average

CAPM: Capital Asset Pricing Model

CAR: Cumulative Abnormal Return

CAR: Cumulative Abnormal Return

CB: Capital Budgeting

CML: Capital Market Line

CPI: consumer Price Index

CST: Cusum Signal Test

DCF: Discounted cash flow

EEP: Expected Equity premium

ETLA: Research Institute of the Finnish Economy

FAO: Food and Agricultural organization

FRP: Forestry Revitalization Plan

GDP: Gross Domestic Product

HEP: Historical Equity premium

HEX: Helsinki Stock exchange

HTRG: Hancock Timber Resource Group

ICAPM: Intertemporal CAPM

IEP: Implied Equity premium

IGM: Income Growth Model

IRR: Internal Rate of Return

IWC: The International Woodland Company

JHTI: The John Hancock Timberland Index

LEV: Land Expectation Value

LEV: Land Expectation Value

L-FICP: Large Forest Industry Company Portfolio

LLR: Log-likelihood Test

LUMBER: Lumber Futures

M&A: Mergers and Acquisitions

M-FICP: Medium Forest Industry Company Portfolio

MOU: Memorandum of Understanding

MPT: Modern Portfolio Theory

NCREIF: National Council of Real Estate Investment Fiduciaries

NIF: National inventories in Finland

NIPF: Non-Industrial Private Forests

NPV: Net Present Value

OLS: Ordinary least square

PI: Profitability index

PNSPA: Pacific Northwest Stumpage Price Average

PRR: The Project Rate of Return

Q1: First Quarter

REIT: Real Estate Investment Trusts

REP: Risk Equity premium

ROI: The Return on Investment

S&P 500: The Standard and Poor's 500

SEV: Soil Expectation Values

SLA: Softwood Lumber Agreement

SML: Security Market Line

SSPA: Southern Stumpage Price Average

STIF: Southern Timberland Index Fund

SYF: Statistical Yearbook of Forestry

T-bills: Treasury-bills

TIMOs: Timberland investment management organizations

TLP: Timberland Limited Partnership Portfolio

TPI: Timberland Performance Index

US: United States

WACC: Weighted Average Cost of Capital

Chapter 1: Introduction

Forest is a store of wealth, or capital. A forest is somewhat like a certificate of deposit or a stock we buy with the hope that, over time, our financial investment will return more money than we paid for it (Klemperer 1996). Forests, of course, are much more than a financial asset because they provide an array of other benefits with values that cannot be measured in monetary terms. Some of these are extremely valuable to individuals, organizations, and society (Bullard & Straka 1998). Viewing forests as financial assets is a useful framework into which non-monetary values can later be woven (Klemperer 1996). In a financial sense, if trees and land are considered as capital, two of the most important inputs into forestry are capital and time (Klemperer 1996).

Forest is unique resources among other terrestrial ecosystem thus a viable option among other competing land uses. Forest possesses potentiality of diversification, multitude of benefits, goods and services and joint production of wood assortments. Forestry involves most importantly the three resources namely natural, capital and human resources. These resources in proper integration are capable of providing the various goods and services at various levels. The new global resource assessment (FAO 2005) provides statistics how world area is allocated to designated functions of forests; function includes production (wood and non–wood products) (34 %), protection of soil and water (9%), conservation of biodiversity (11%), social services (recreation, tourism, education and conservation of cultural and spiritual sites (4%), multiple purposes (34%) and other no or known function (8%). The benefits and services provided by the forest can be classified into marked based and non market based at private semi private and public levels. Better understanding of the full range of goods and services supplied by forests is essential for optimal utilization of forests, and may provide an economic rationale for sustainable forestry.

To understand the forces behind forestry, one needs to understand business and management in general because forest management is a business, and a segment of the total business community (Davis 1966). Business and market forces also apply to the management of public lands. Raw materials from forest lands are sold and processed, and the final products distributed, in competitive markets. Demands for recreation, wildlife, water, and other non-timber products also stem from the general economy and are part of it. Although forestry affairs are in some sense different or separate from other economic affairs, there are areas of similarity (Davis 1966).

Timberland investment is defined as the equity ownership of forestland and the trees standing on it (Binkley et al. 2005, Binkley & Bever 2004). Investors sometimes own just the land or sometimes just the timber; however, most often, they own both. Investment in forestry can be done by two ways: i) simply purchasing suitable land and manage the land adopting different forest related (planting, thinning, final felling and selling timber products) and activities for forestry. ii) Purchasing shares in an investment plan. Investments in forest management include investments in protection (from wildfire, insects, diseases, and other depredations), in various management practices (e.g., planting trees), in infrastructure such as access roads and recreation facilities, and in developing management information.

Because forestry is a long-term production activity, every management activity (even inactivity) can be construed as an investment (Wear 2000). The most significant investment is usually in the trees themselves, whether they are held for timber production or for other purposes. The value of the investment increases with the age and size of the trees. Most forestry is very capital intensive because of the long time periods involved.

The investment varies depending upon the objective of management. Some forest landowners are interested mainly in financial returns and hold the land for that purpose (Klemperer 1996). With adequate investments to actively manage endowment forest land assets, substantial financial returns may be expected from these lands in perpetuity.

The forest investments involve large and small scale investments at various levels: local national, regional, international and global level. In forestry investment, economic agents of several categories namely, enterprising individuals, private sector enterprises, communities, rural households, governments (both national and local), international funding organizations, and non-governmental organizations (NGOs) have participated. Investors can hold timberland through three different institutional arrangements: various forms of direct, privately traded ownership, publicly traded units of securitized timberland limited 'partnership and publicly traded stock in vertically integrated forest products companies that own substantial areas of timberland (Blinkley 1994)

There is also a growing convergence of interest between leading forest enterprises, financial institutions-including commercial banks, investment funds, export credit agencies and the multilateral development banks-and conservation organizations in responsible investment in sustainable forestry (World Bank 2003).

1.1 History of Institutional investment

The 1990s and onward have produced a substantial number of mergers and acquisitions all over the world, including Canada, Finland, Japan, Sweden, US, which has led to the monetization of nonstrategic assets (e.g., the sale of timberlands) to alleviate debt (Block & Sample 2001). While there are various company-specific reasons for some of the major timberland transactions, there are also some general key drivers for these divestitures. In the US, the removal of the capital gains federal tax advantage for industrial ownership in 1986 is an important reason for the decline in industrial timberland ownership. Yin & Izlar (2001) mention consolidation and globalization, asset realignment and operation concentration (on manufacturing and marketing). The financial performance of the forest products industry has been weak during the 1990s (Lonnstedt 2007, Yin et al. 1998, Yin et al. 2000) as a result, companies looked for ways to improve profits. Butner & Stapley (1997) point out that closeness to primary resource of trees equates with low return. Many companies have started to move capital away from timberlands in their own countries into lower-cost, higher-productivity timberlands in other regions of the world, as well as into investments in biotechnology research. Both strategies would allow companies to produce more fiber on fewer hectares. Furthermore, the latter part of the 1990s has witnessed a strategic restructuring among forest products companies that has led many of them to focus on their core production manufacturing and less on wood supply.

Jenkins (1996) states the two reason of growing interest in institutional investment in timberland in US. The Employment Retirement Income Security Act of 1974 (ERISA) for private pension plans, and subsequent similar state legislation for public pension plans, endowments, and foundations, allowed to diversify their investments. Secondly, some major forest products companies sought to reduce their direct investment in timberland by selling or cashing out part of their timberland assets. One way, short of selling the land, was to create an investment company to hold the land and allow investors to invest in the timberland. These laws encouraged institutional investors (such as pension plan managers) to diversify from their traditional reliance on fixed-income securities such as government and corporate bonds (Binkley et al. 1996).

Many investment entities now recognize timberland as a legitimate investment (Zinkhan & Cubbage 2001). Investment in forestry is expanding and is gaining appreciation from both investors, and researchers and policy makers for its potential. HTRG (2007) estimates Institutional investment in US timberland accounts for more than $40 billion (www.htrg.com). Several timberland investment management organizations (TIMOs) raise capital from institutional and other investors and invest it in timberland. Private equity is labeled as TIMOS- investment advisors who support institutional investment in timberland.

HTRG (2002) classified buyers and sellers in timberland investment transactions into four ownership groups:

- Timberland Investors: includes TIMO both taxable and nontaxable.
- Forest Industry or companies owning both timberland and timber processing facilities. This category includes both public and private companies. These are seller.
- Conservation Groups, including private and public organizations. These are buyer.
- Others, which include real estate developers, energy and rail companies, loggers and the like. These are the buyer.

Institutional timberland-owning investors with fiduciary obligations include pension funds, universities, foundations, and trusts (Zinkhan and Cubbage 2001). Institutional investors are apt to be a bit more patient in their timber sales decisions than forest products manufacturers (Binkley et al. 1996). TIMOs were created to handle these investments on behalf of the institutions. Several institutions began to select timberland for its diversification potential in the early 1980s. Dana (2008) reports that by early 2008, a number of TIMOs had become the largest landowners/managers in the U.S. Several TIMOs manage more than 2.0 million ha and some more than 4.0 million ha.

1.2 Investable forest area in globe

The International Woodland Company (2005) on The Global Forestland Investment Study report has analyzed the Forestland cover, ownership and investable versus non investable status at global level. Private forestland that is investable via fee simple purchase is dominated by North America followed by Europe, South America, Oceania and Central America/Mexico (Fig.1)

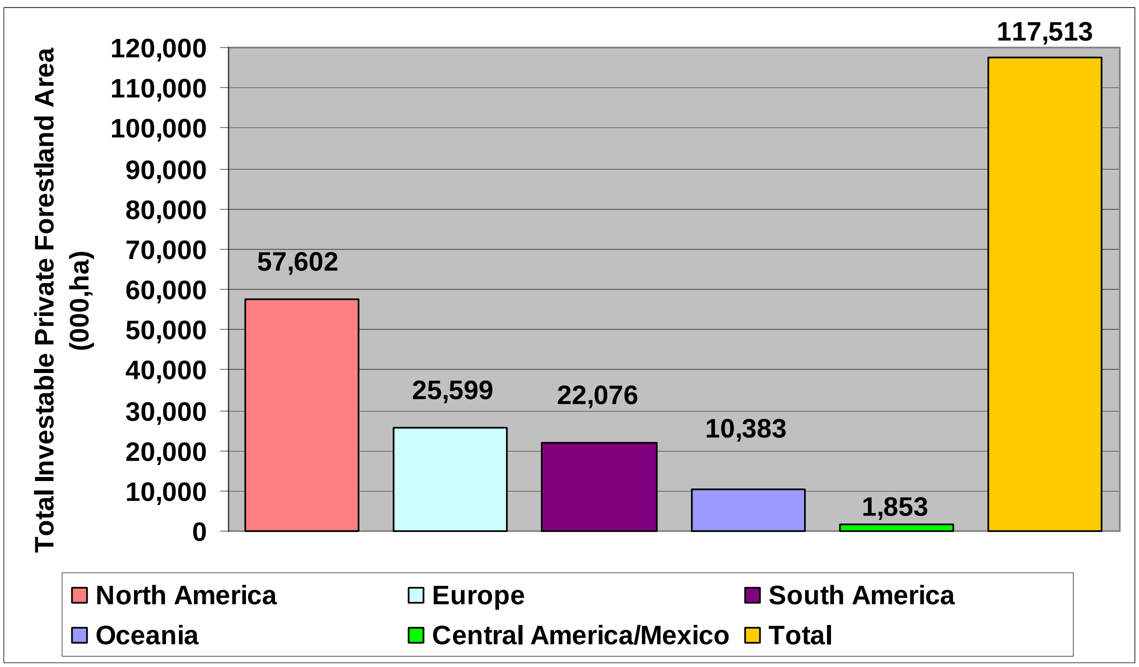

Figure 1: Private investable Forestland area. (Source: IWC 2005)

However, ‘Public’ forestland that is investable via long-term leases is dominated by combined CIS (Commonwealth of Independent States) countries and followed by the countries of Asia, Canada, and the countries of Africa (Fig. 2).

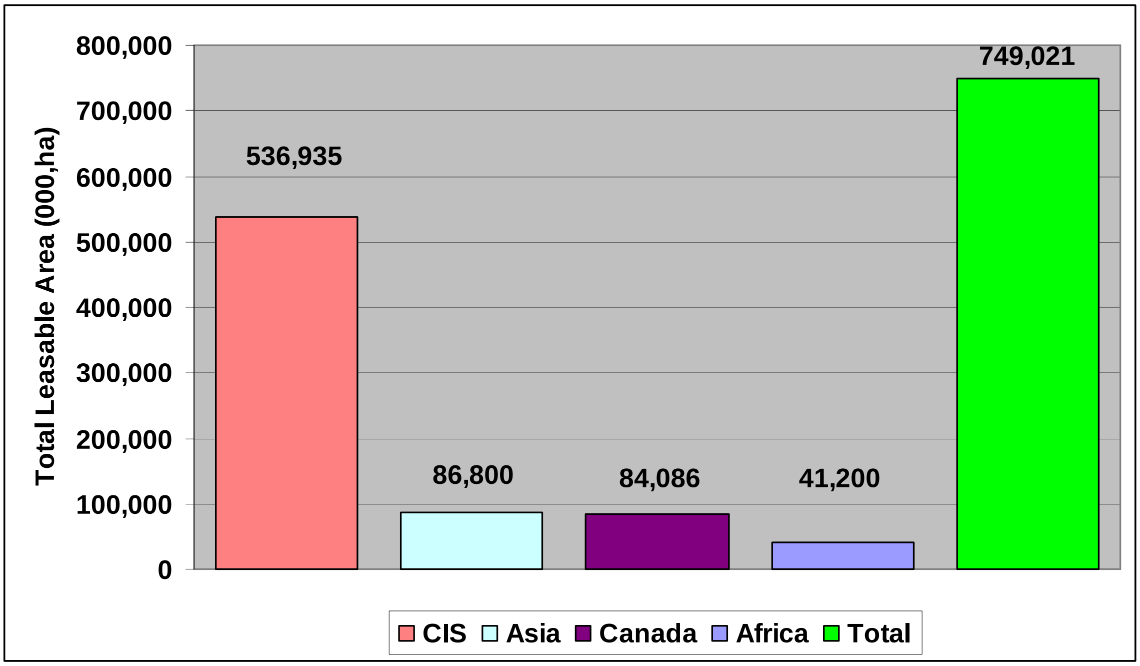

Figure 2: Public leasable Forestland area (Source: IWC 2005)

The cumulative global investable and leasable forestland estate covers about 870 million ha and has a value of nearly $480 billion USD, which represents about 3% and 19% respectively of the world’s forestland area (IWC 2005). Binkley et al. (2005) reported the value of investable universe to about $200 billion with about half of this total in the US and other half widely distributed in Canada, Australia, New Zealand, South America and Europe. They excluded Africa, Russia, and Southeast Asia from the investable universe due to the existing country risk and economic factors with the notion that they may vary with time. On the same way, IWC (2005) concluded that the change in the area and value of forestland will expected to happen due to the dynamic nature of forest policy and management at local, regional, national and global level.

Binkley et al. (2005) identified three reasons of not having all the forest investable: 1) forest in remote areas or under stocked, 2) government owned forest and 3) forest located in those countries that are highly risky for attracting long-term investments in fixed assets.

DANA (2008) analyzed the global investment in forestland and identified more than 600 global players in the timberlands business such as global timberlands owners, funds managers, “fund of funds” managers, listed vehicles and institutional funds in North America, Europe Oceania, Latin America, Africa and Asia.

1.3 Forestry information of selected countries

US

According to USDA (2007), Forest lands in US represent the 33.18% of the land area. Forest land has been classified into two broad categories: public and private. Public ownership includes federal (national forest, bureau of land management and other), state, & county and municipal. Private forestland includes private corporate and private non corporate. 56% (171.1 million ha) of all forest land is privately owned and 44 % (132.8 million ha) is public forest land (USDA 2007).

Timberland in US has been defined as the forest land capable of producing in excess of 20 cubic feet per acre per year and not legally withdrawn from timber production (USDA 2007). Timberland covers an area of about 208 million ha which is more than 68% of total forestland (USDA 2007). Fig. 3 shows type of timberland ownership in US.

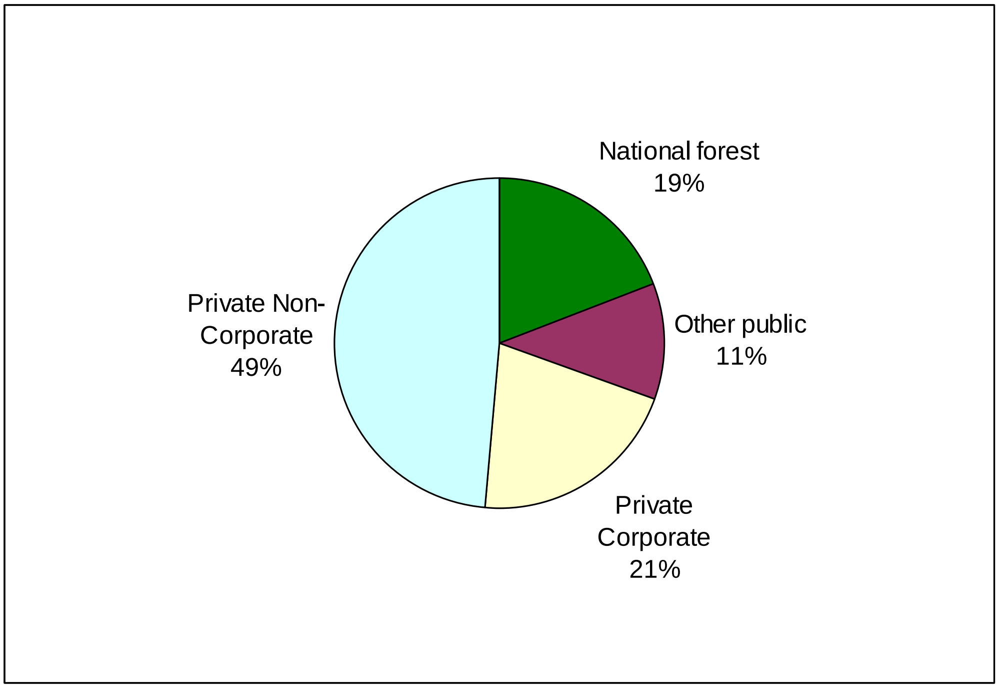

Figure 3: Timberland ownership in US (USDA 2007)

About 69% of the US timberland, 1442.6 million ha, is in private ownership, a slightly lower percentage (0.3%) than ten years ago. Public ownership of timberland has increased about 8% in the US Public ownership of timberland is about is 638.29 million ha. Timberland constitutes plantation and natural origin which is more than 87% and 12% respectively (USDA 2007).

Sweden

According to Swedish Forest Agency (2008), the total land area of Sweden is approximately 41.3 million hectares, out of which 23 million ha (55%) are forest land according to the Swedish definition of forest land. The land area and other forestry information are given in Table 1. Approximately 10% of Sweden's land is protected by some kind of nature conservation legislation.

Table 1: Land area and forestry information (Source: Swedish Forest Agency 2008)

Land area	*Forest land*	*Forest land*	*Growing stock(GS)*	*Annual increment of GS*	*Protected area*
41.3million ha	*23 million ha (55%)*	*20.1mill ha*	*3.0 billion.m³sk (ob)*	*117mill.m³sk*	*10%*

The Fig. 4 shows the Forest land ownership classes in Sweden, which constitute of private individual (51%), private owned companies (25%), state owned companies (14%), other private (6%) and other public owner (1%).

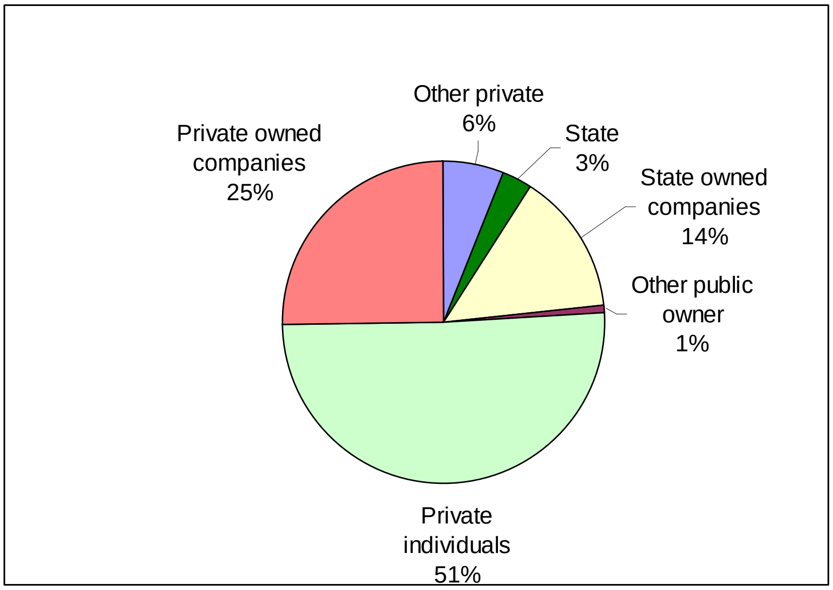

Figure 4: Forest land ownership classes in Sweden (Swedish Forest Agency 2008)

Finland

According to Metla (2007), the following information about forest has been reported. Based on site productivity, forestry land is divided into forest land (20.1 million ha), scrub land (2.8 million ha) and waste land (3.2 million ha of treeless or almost treeless land). The national definitions of the forestry land categories are as follows (Metla 2007):

- Forest land: the potential annual average increment of the growing stock is at least 1.0 m^3/ha.
- Scrub land: the potential annual average increment of the growing stock is less than 1.0 m^3/ha, but at least 0.1 m^3/ha.
- Waste land: the potential annual average increment of the growing stock is less than 0.1 m^3/ha.

The total area of forest and scrub land in Finland amounts to 22.9 million ha, of which 92% is available for wood supply. The remaining 8% is protected.

The land area and forestry related information has been demonstrated in Table 2.

Table 2: Land area and forestry information (Source: Metla 2007)

Land area	*Forest area*	*Forest land*	*Forest land*	*Growing stock(GS)*	*Annual increment of GS*	*Removal (in 2006)*
30.413million ha	*26.3 million ha (87%)*	*20.1million ha*	*20.1million ha (76.42%)*	*2189 million.m³ (ob)*	*98.5 million.m³*	*65.4million m³*

The Fig.5 shows that the forestry land ownership classification in Finland. 52% is under Non-industrial, private ownership is dominant (52%). Other represents forests under municipal, parish, shared or joint ownership.

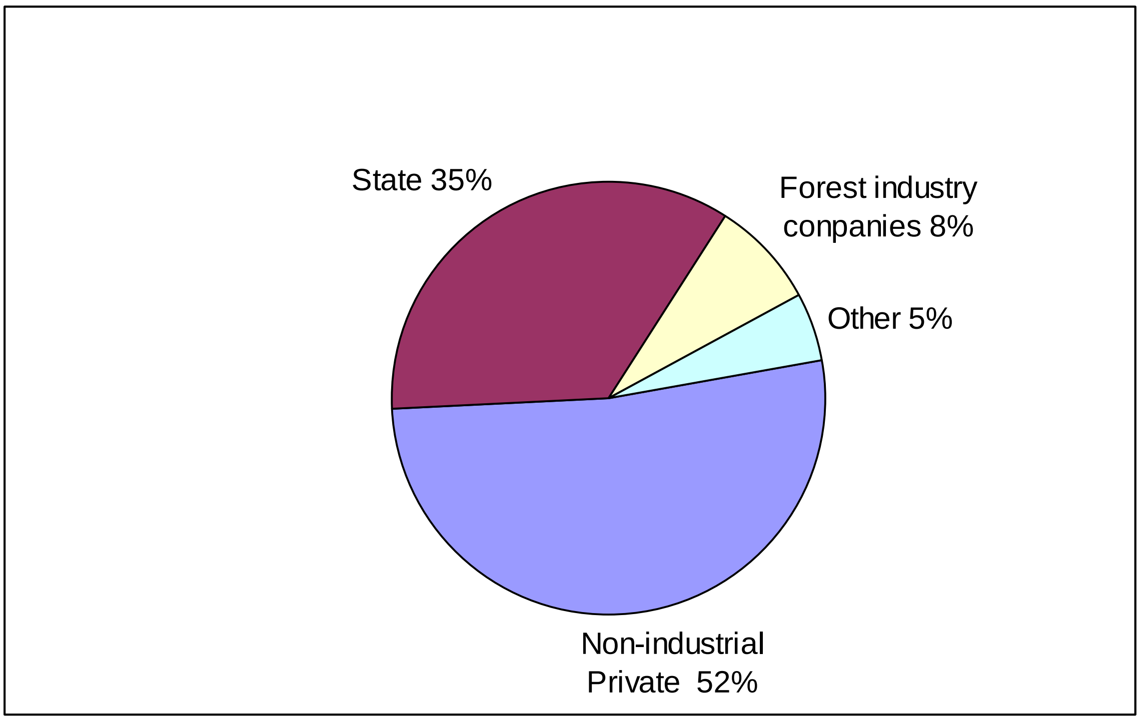

Figure 5: Forestry land ownership classification in Finland (Source: (Metla 2007)

FAO (2005) have ranked US, Sweden and Finland on third, sixth and tenth position under the ten countries with largest area of planted forest.

1.4 Forest production in selected countries

FAO (2005) has outlined forest production basically in 5 different types: Industrial round wood (logs), Sawn wood (lumber), Wood based panels, Wood for pulp and Paper and paper boards. Based on the data from FAOSTAT (2006), on top ten highest countries in all production were used to compare three countries namely, US, Sweden and Finland have been compared in all those forest production. The result ranked US 1st in all production except in wood based panel production. US shares 19.4 % of the world wood based panel production. Finland and Sweden did not fall in largest top ten countries in wood based panel production.

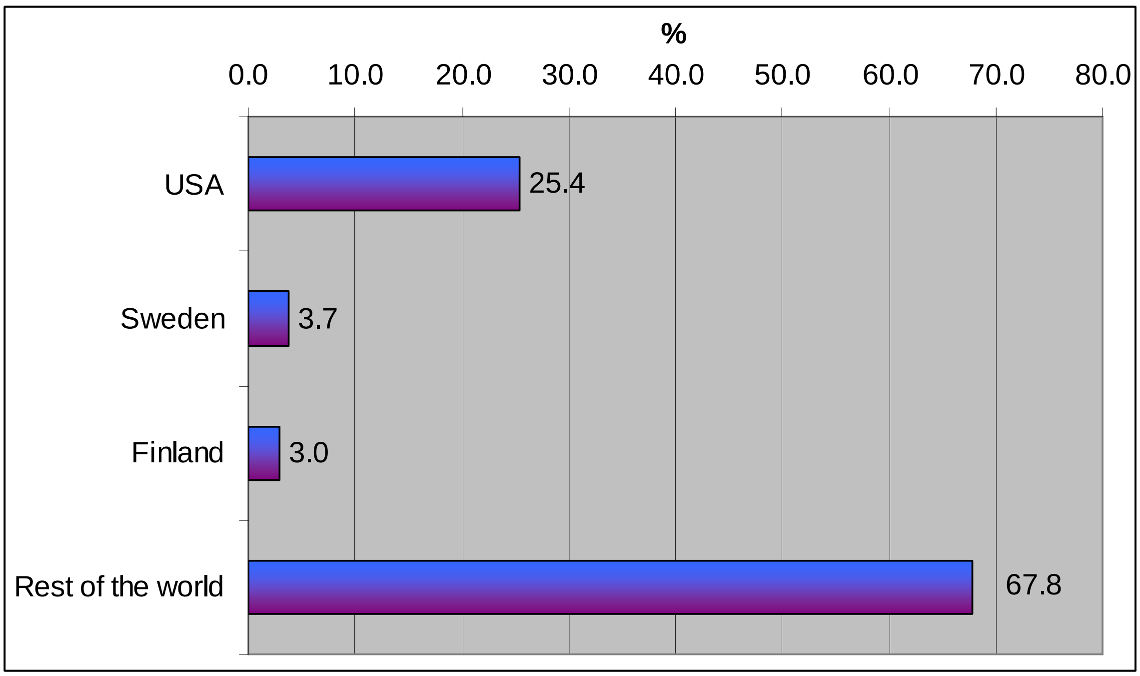

Figure 6: Industrial Round wood (Cum), 2006 FAOSTAT

The Fig. 6 shows that US, Finland and Sweden are the top ten producers of global industrial round wood, producing 25.4%, 3% & 3.7% respectively. US is the highest among all, which produces the just over one quarter of the world's logs. Finland and Sweden share 8th and 6th position respectively.

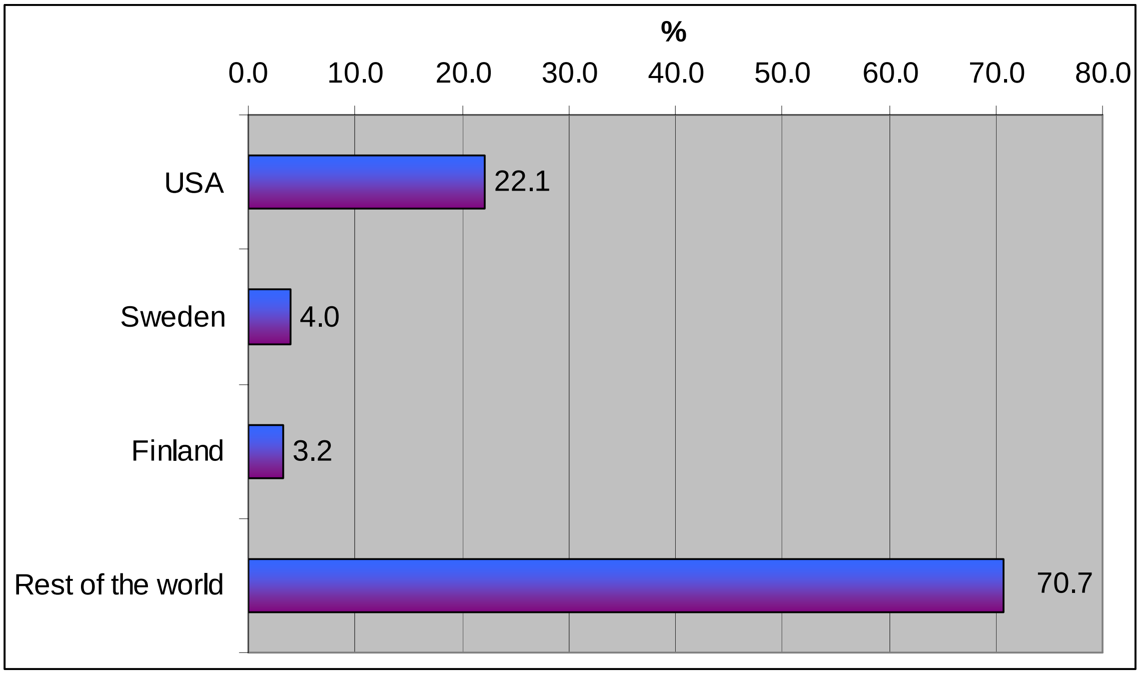

Figure 7: Sawn wood Production (Cu.m), 2006 FAOSTAT

Fig. 7 shows that US, Sweden and Finland are the top ten producers of global sawn wood production sharing 22.1%, 4% & 3.2% respectively. Sweden and Finland ranked 6th and 8th respectively.

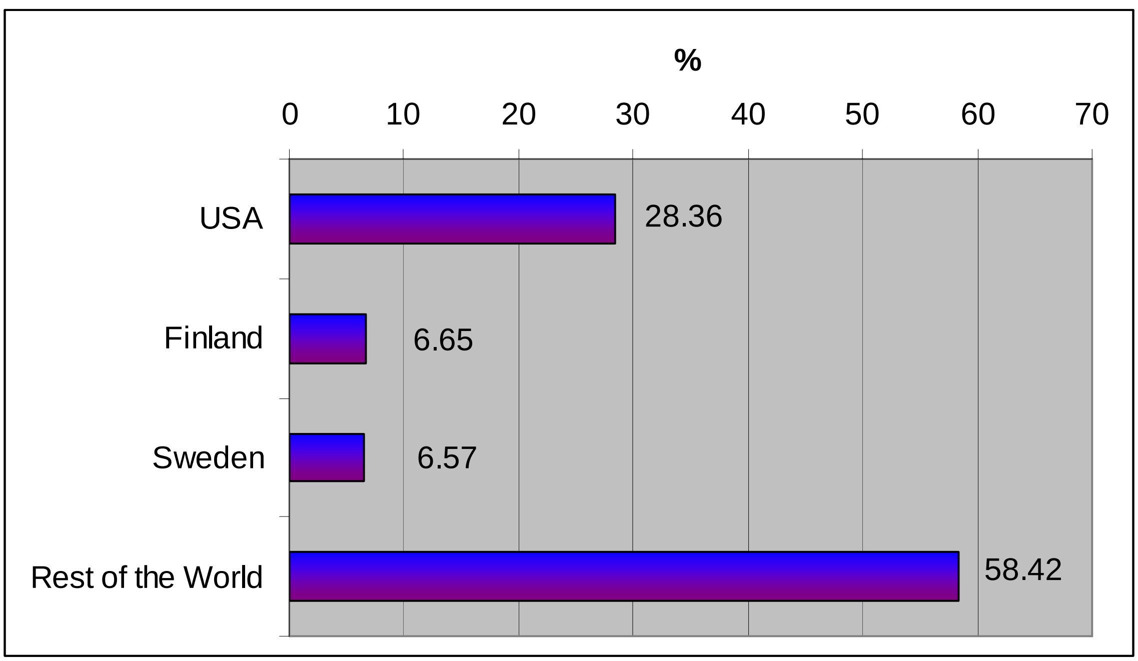

Figure 8: Wood Pulp for Paper production (MT), 2006 FAOSTAT

Fig. 8 shows that US, Finland and Sweden share 28.36%, 6.65% & 6.57% for global wood pulp production respectively. Finland and Sweden ranked 3rd and 4th respectively.

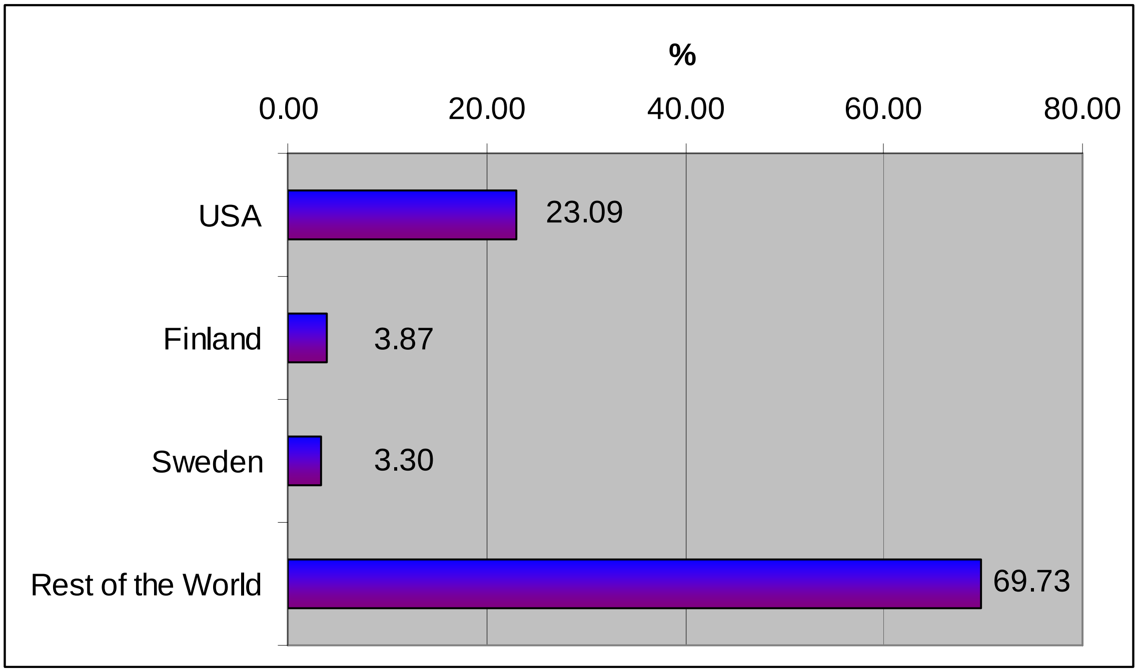

Figure 9: Paper and paper board production, (MT), 2006 FAOSTAT

Figure 9 shows that, US, Finland and Sweden share 23.09%, 3.87% & 3.30% for global paper and paper board production respectively. Finland and Sweden ranked 6th and 7th respectively.

1.5 Research question and objective of the study

This thesis has focused on following questions:

1. What are the forestland investment attribute?
2. What is the forest asset portfolio diversification?
3. How the forest asset return is valuated for estimating CAMP?
4. In which field of forestry CAMP is applied and what is the result?
5. What are the problems of CAMP in general and forestry application?
6. Do forest asset have ability to hedge inflation?

The general objective of this study is to address the research questions based on the available literatures in order to examine the applicability of CAPM in forestry investment in selected countries. The specific objectives are as follows:

- To review the methods of calculating forest returns for estimating CAPM.
- To examine the application of CAPM in forestry.
- To examine the inflation hedging potential of the forest investment.

1.6 Organization of thesis

The thesis has been divided into five chapters. The first chapter provides general introduction of forest investment, history of institutional investment in forestland, forestland investment status in globe, and some forestry information about selected countries. This chapter also includes objectives, organization of thesis, methodology, scope and limitation of the study.

Chapter two deals with the development and of CAPM, detailed description of CAPM and its components: risk premium, risk free rate, alpha and beta. It also includes the description of real CAPM. Chapter three starts with the comparison of forest asset and commercial assets and concentrates on the forest investment attributes especially return driver and risk types in forest investment. Chapter four describes firstly the different approaches in estimating forestry return for the estimating CAPM equation and their implication in beta and alpha parameter. Secondly, this chapter deals with the different fields of application of CAPM in forestry and their results. The limitations of CAPM application in general and forestry specific problem of CAPM application are also presented in this Chapter. Additionally, it also reviews the model used for assessing inflation hedging ability of forest asset. Finally, major conclusions in relevance with research questions are presented in Chapter five.

1.7 Methodology

Data and information used in this study are secondary, which has been collected and reviewed through web searching, literatures (related books, reports, journals and other published articles) to get the context and justify the relevancy of the research. The study is based on the empirical studies carried out in US, Finland and Sweden. Since these countries share large percentage of forestland area and global forest production, they have been considered for the selection of the study.

1.8 Scope and limitation of the study

The findings of the study will be useful for researchers, academicians for further research as a reference material. This study has utilized the finance and forestry literature to review the CAPM and its forestry application. Therefore, this will provide a comprehensive guidance in conducting further study in the risk and return analysis of forest investment. The main limitation encountered during the study is an inability to document sufficiently published literatures in CAPM application in forestry assets especially in Sweden and Finland since there are only one study of CAPM application in forestry in comparing with financial assets in Finland and Sweden and in case of Finland the paper has not been published yet. In this context, the risk return study based on Modern portfolios theory has been utilized. This has limited to make generalization of the CAPM findings.

Chapter 2: Capital Asset pricing model

2.1 Development of CAPM

CAPM is a financial model developed independently by Jack Treynor (1962), William Sharpe (1964), John Linter (1965) and Jan Mossin (1966) as an extension of the portfolio selection theory (also known as Modern portfolio theory) by Harry Markowitz (1952). Jack Treynor and John Linter were independently discovering the same fundamental pricing equation of the CAPM.

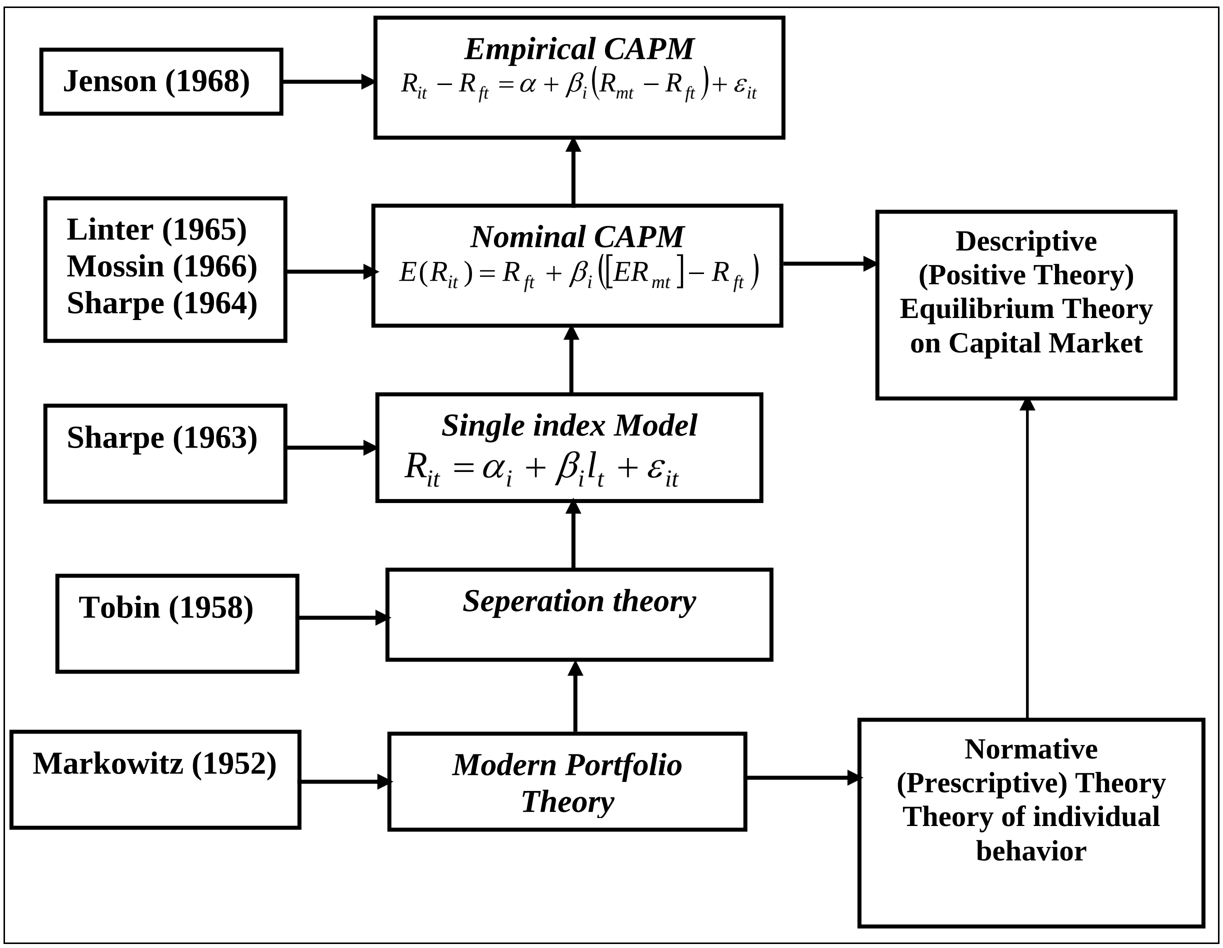

Figure 10: Development of CAPM at different stages

Treynor's work was published later in 1999. Furthermore, Linter's paper also published after Sharpe. Sharpe (1964) and Linter (1965) applied the normative analysis of

Markowitz to create a positive theory of the determination of asset prices. Finally, Sharpe (1964) and Linter (1965) remain the classical citations for the CAPM. Harry Markowitz & William Sharpe were honored Nobel Prize together in Economic Science with Merton Miller in 1990 for their great contribution in financial economics. Fig. 10 explains the different stages of CAPM development.

2.1.1 Modern Portfolio theory

Asset pricing models have attracted considerable attention in the finance literature. Asset pricing theory is a framework developed to identify and estimate risk as well as return for risk bearing (Harvey 2001).The foundations for the development of asset pricing models were laid by Markowitz (1952) and Tobin (1958). Markowitz (1952) observed that (i) when two risky assets are combined, their standard deviations are not additive provided the returns from the two assets are not perfectly positively correlated and (ii) when a portfolio of risky assets is formed, the standard deviation risk of the portfolio is less than the sum of the standard deviations of its constituents. Markowitz was the first to develop a specific measure of portfolio risk and to derive the expected return and risk of a portfolio. The Markowitz model generates the efficient frontier of portfolios and the investors are expected to select a portfolio, which is most appropriate for them, from the efficient set of portfolios available to them.

2.1.1.1 Expected return of an asset and portfolio

According to Markowitz's model, the investor's decision variable is defined as the expected return. The expected return of an asset is a probability-weighted average of its return in all states. Calling p_s the probability of state *s* and r_s the return in state *s*, the expected return of single asset can be expressed as:

$$R_i = \sum_{s=1}^{s} r_s \cdot p_s \text{ .... } (1)$$

Portfolio return is the weighted (by the proportion held) average of the rates of return of individual assets. The portfolio expected return is a linear combination of the expected returns R_i of *N* assets:

$$R_p = \sum_{i=1}^{N} W_i \times R_i \text{..} (2)$$

Where:

w_i = *weight of asset* ***i*** *in portfolio* ***p***

R_i =expected return on asset **i**

2.1.1.2 Risk of an asset and portfolio

Risk of an asset is measured by its variance, which is defined as the expected value of squared return deviations from the expected return. Symbolically,

$$\sigma_i^2 = \sum_{s=1}^{S} \left(r_s - R_i\right)^2 \cdot p_s \text{...} (3)$$

Standard deviation of asset is given by:

$$\sigma = \sqrt{\sigma^2} \text{...} (4)$$

Portfolio risk is measured as the standard deviation of the combined assets. It is a function of the variation in return over time for each assets compared to the variations in returns over time of each of the other assets in the portfolio. As returns of assets in portfolio are not independent, the variance of portfolio has to capture the variability of individual assets σ_i^2 but also the tendency of how they move up and down together σ_{ij}^2 :

$$\sigma_p^2 = \sum_{i=1}^{N} w_i^2 \cdot \sigma_i^2 + \sum_{i=1}^{N} \sum_{J=1, i \neq j}^{N} \sigma_{ij} \cdot w_i \cdot w_j \text{....................................} (5)$$

Where,

$$w_i \geq = 0 \ \& \ \sum_{i=1}^{N} w_i = 1, \ \& \, i = 1, \ldots\ldots, N$$

2.1.1.3 Co- variance

Covariance is defined as the measure which combines the variance (or volatility) of an asset's returns with the tendency of those returns to move up or down at the same time other assets move or up down (Eugene et. al. 1999). Covariance between any two assets ***i*** & ***j*** can be expressed as follows:

$$\sigma_{ij} = \sum_{s=1}^{S} \left[(r_{si} - R_i) \cdot (r_{si} - R_j) \right] \cdot p_s \text{ .... } (6)$$

σ_{ij} represents the measure of return dependency between assets ***i*** & ***j***, and therefore the measure of risk diversification.

2.1.1.4 Total risk

The total risk of an asset can be divided into systematic risk, also called market risk, and unsystematic risk, which is also called unique risk. Systematic risk is risk that correlates with the market portfolio and is affected certain common economy-wide forces such as GNP growth rate changes, interest rate & exchange rates movements, unemployment rate fluctuations, and price level swings (Zinkhan 1988). Unsystematic risk is independent of market fluctuations. It is affected by the companies' individual characteristics. Unsystematic risk reflects factors unique to the industry, company or asset itself, such as research and development, markets, firm management, or capital and labor productivity (Zinkhan 1988, Redmond & Cubbage 1988). Unsystematic risk can be eliminated by portfolio diversification, because the variances due to companies' individual characteristics offset each other. The standard deviation of the portfolio returns is reduced as the number of assets in the portfolio increases. After the diversification only the systematic risk present in the market is left. Because the unsystematic risk can be eliminated, only the systematic risk should affect asset pricing (Brealey et al. 2006). Systematic is the only risk that an investor is rewarded for undertaking, can be reduced by careful selection of assets in a portfolio (Redmond & Cubbage 1988). Total risk if an asset ***i*** can be differentiated into systematic risk and unsystematic risk:

$$\sigma_i^2 = \beta_i^2 \sigma_m^2 + \sigma_\varepsilon^2 \text{ .... } (7)$$

Where, β_i is a measure of systematic risk. $\beta_i^2 \sigma_m^2$ is the component of systematic risk. The unsystematic risk can be expressed as:

$$\sigma_\varepsilon^2 = \sigma_i^2 - \beta_i^2 \sigma_m^2 \text{ .... } (8)$$

2.1.1.5 Correlation coefficient

The competitiveness of different asset classes depends not only on returns and risks but also on their correlation. Correlations are important inputs in asset allocation decisions. The standard deviation of a portfolio depends on the (1) correlation between each pair of assets, (2) proportion of total funds allocated to each asset, and (3) the standard deviation of each asset. Portfolio standard deviation is the sum of the standard deviations of each portfolio asset multiplied by the proportion of funds invested in the asset, plus an interaction term. The magnitude and sign of the interaction term depend on the value of the correlation coefficient for each asset pair. When correlations between two assets are negative, the interaction term is also negative, reducing portfolio standard deviation (Markowitz 1952).

A relatively clear way to show the degree of co-variation between different assets is to study the correlation coefficients for the returns on the different assets (Wonnacott & Wonnacott 1990). The correlation coefficient between two assets ***i*** and ***j*** can be expressed as:

$$\rho_{ij} = \sigma_{ij}^2 / \sigma_i \cdot \sigma_j \text{ ....} (9)$$

On the interval − *1*, *1* standardized form of the covariance, the correlation coefficient allows to compare and easier interpret different covariance. The correlation of *+1* means perfectly positive, *-1* perfectly negative correlated asset, and -1$-1 < \rho_{ij} < 1$ expresses imperfect linear return dependency. The poorer the correlation (as ρ gets closer to - 1), the lower the portfolio risk will be for that combination of investments. Thus, a particular investment's diversification potential is a function of its correlation with other investments.

2.1.1.6 Two asset portfolio model

The risk of two asset portfolio model is given by:

$$\sigma_p = \sqrt{\left[\sum_{i=1}^{N} w_i^2 \sigma_i^2 + 2\left(\sum_{i=1}^{N} \sum_{i=1}^{N} w_i w_j Cov_{ij} \right) \right]} \text{ ....} (10)$$

Where:

σ_p = Standard deviation of portfolio

σ_i^2 = Variance of asset ***i***

w_i = weight of asset ***i***

w_j = weight of asset ***j***

Cov_{ij} = Covariance between assets ***i*** and asset ***j***

DeForest et al. (1989) calculated stumpage price return to a portfolio using a simple two-asset model.

2.2 Capital Market Line (CML)

Markowitz's model of portfolio selection focused only on the choice of risky assets. Tobin (1958) extended the model to include a risk free asset. As a result, he found the set of efficient risk-return combinations in a straight line, called a capital Market line (CML). Tobin (1958) showed that under certain conditions Markowitz's model implies that the process of investment choice can be broken down into two phases: first, the choice of a unique optimum combination of risky assets; and second, a separate choice concerning the allocation of funds between such a combination and a single risk free asset. This is also called Tobin's separation theorem.

The CML specifies the return an individual investor expects to receive on a portfolio. In Fig. 11, CML is the line from R_f to B. X=$E(R_m) - R_f$, which is the market risk premium. This is a linear relationship between risk and return on efficient portfolios that can be written as:

$$E(R_p) = R_f + \sigma_p \left[\frac{E(R_m) - R_f}{\sigma_m} \right] \qquad (11)$$

Where:

R_p = portfolio return,

R_f = risk-free asset return,

R_m =market portfolio return,

σ_p =and standard deviation of portfolio returns,

σ_m = standard deviation (risk) of market portfolio returns and

$\left[\dfrac{E(R_m) - R_f}{\sigma_m}\right]$ = the slope of CML.

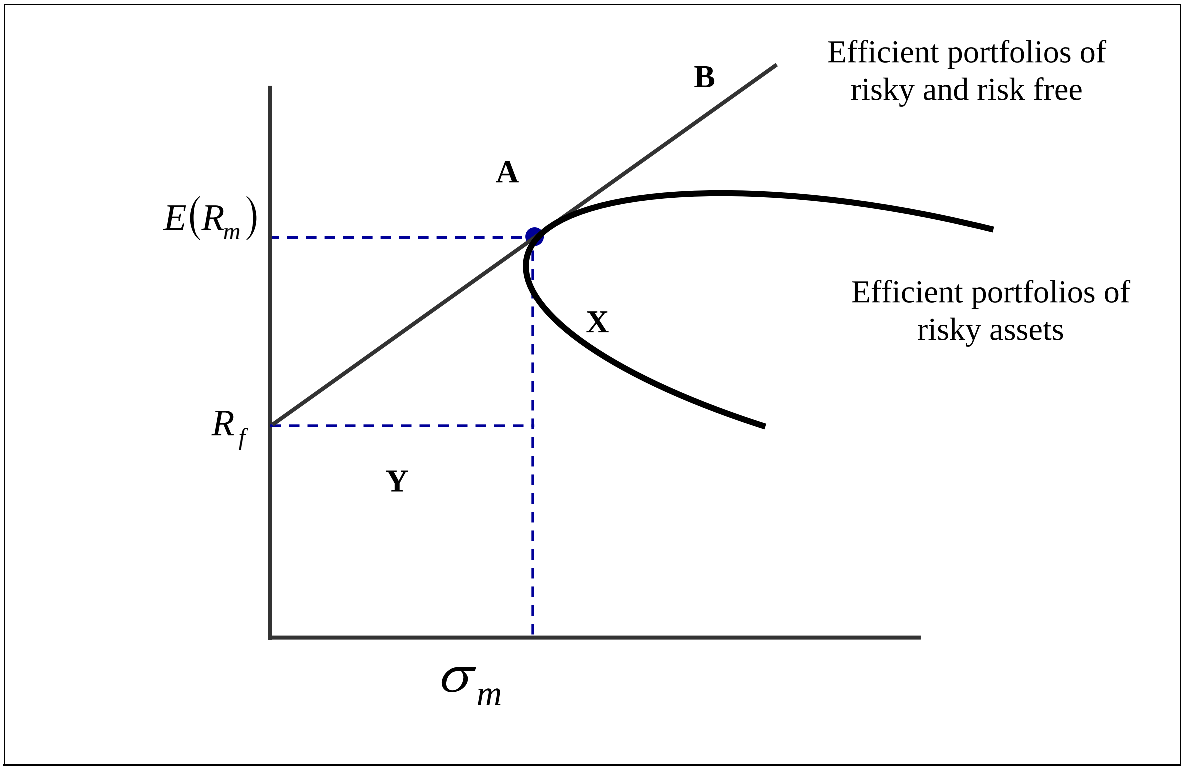

Figure 11: Capital Market Line

The slope of the CML is the market price of risk for efficient portfolios, or the equilibrium price of risk in the market. According to equation 11, the expected return on a portfolio can be thought of as a sum of the return for delaying consumption and a premium for bearing the risk inherent in the portfolio. The CML is valid only for efficient portfolios and expresses investors' behavior regarding the market portfolio and their own investment portfolios.

2.3 Sharpe's Single index model

Sharpe (1963) described the benefit of applying single index model of the relationship among securities based on the Markowitz portfolio technique. He demonstrated that single index measures could be applied in quadratic programming to generate mean variance frontiers that closely approximate frontiers with a full covariance matrix. His effort of developing this model was able to reduce the computational capacity and the cost due to the absence of covariance and possible increases in forecasting accuracy.

Sharpe explored an approach now known as the 'market model' or the 'single factor' model. It assumes that the return on each security is linearly related to a single index, usually taken to be the return on some stock market index such as the Standard and Poor's 500 (S&P 500). Thus the (random) return on asset ***i*** at time ***t*** can be written as:

$$R_{it} = \alpha_i + \beta_i l_t + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(12)}$$

Where, l_i is the value of the market index. ε_t is the error term with expected value of zero. In this equation, α_i is the expected return of the asset if the market is expected to have a zero return, while the parameter β_i measures the sensitivity of the asset to market condition. An asset that has β_i = 1 is just as risky as the market index: if the S&P 500 index increases by 10 percent in a given year, we would expect this asset to increase by α_i +10%. An asset that has β_i < 1 is less volatile than the market index, while one with β_i > 1 is more volatile. If the rate of return on a proxy for the overall market portfolio is used as the index, then the slope coefficient parameter β_i of the market model provides essentially the same empirical measure of systematic risk as the CAPM beta (Brenner 1979). The single-index market model and the CAPM are used interchangeably to measure systematic risk (Washburn & Binkley 1990a). Collins (1988) outlines their different theoretical foundations. Varian (1993) stated that this model formulation assumes most stocks move together most of the time so the model determines of the cross-sectional variation in returns. This linear relationship in this model can easily be estimated by ordinary least squares, and the estimated coefficients can be used to construct covariance, which, in turn, can be used to construct optimal portfolios. Sharpe's approach reduced the dimensionality of the portfolio problem dramatically and made it much simpler to compute efficient portfolios (Varian 1993).

2.4 Contribution of Sharpe, Linter, Mossin and Jensen in formulating CAPM

Sharpe (1964) proposed a market equilibrium theory of asset price under conditions of risk. He demonstrated that the extension of investor behavior model gives the theory whose implications are consistent with the assertions of traditional financial theory and showed the relationship between the price of an asset and the various components of its overall risk. He derived equilibrium in the capital market based on the two assumptions: 1) all investors able to borrow or lend funds on equal terms with a common pure rate of interest, 2) homogeneity of investor expectation. Sharpe's two major contributions, the single factor model and the CAPM, are often confused (Varian 1993). He also pointed that the first one deals with supply side model of how returns are generated; the later one is a demand side model. The models can hold independently, or separately, and both are used in practice.

Linter (1964) discussed the problem of selecting optimal portfolio by risk adverse investors who have the alternative of investing risk-free securities with a positive rectum and who can sell short if the wish. He developed different important equilibrium properties within the risky asset portfolio. He derived a set of stable equilibrium market prices that explicitly reflect the uncertainty per se and derives further implication of these results for the normative aspect of capital decision budgeting decisions of a company whose stock is traded in the market. He examined the complications introduced by institutional units on amounts that either individuals or corporations may borrow at given rates by rising costs of borrowed funds and certain other real world complications.

Mossin (1966) investigated the properties of market for risky assets on the basis of a simple model of general equilibrium of exchange where individual investors seek to maximize preference functions over expected yield and variance of yield on their portfolios. He proposed a theory of market risk premiums and showed that general equilibrium implies the existence of so called market line relating per dolor expected yield and standard deviation of yield. He further discussed the concept of price of risk in terms of the slope of this line.

Jenson (1969) developed a model for evaluating the performance of portfolios of risky assets under the assumptions of homogenous investor horizon periods. He reviewed 1) a theory of rational choice under uncertainty; 2) the normative theory of portfolio selection; and 3) a closely related theoretical model of Capital asset pricing under uncertainty. He defined the market model and the concept of systematic risk and their application to the evaluation problem. He derived measures of portfolio performance under alternative assumptions regarding the finite and infinite variances for the distribution of the finite or infinite variances for the distribution of the returns. He discussed the horizon problem a solution to it and the valuation model to the world in which investors possess heterogeneous horizon periods. He derived a measure of efficiency and examined the relation between the concepts of performance and efficiency. Furthermore, he discussed the concept of systematic risk for 115 mutual funds and the assumptions of the market model and included the results of an application of the model to the evaluation of these 115 mutual fund portfolios.

2.5 Assumption of CAPM

The CAPM is a ceteris paribus model. It is only valid within a special set of assumptions. The main assumptions of the CAPM as listed by Olsen & Terpstra (1981), Redmond & Cubbage (1988) and Lundgren (2005) are:

1. The only two decision parameters are risk and return. Asset returns are normally distributed.
2. Investors are risk averse individuals who maximize the expected utility of their end of period wealth. It implies that the model is a single period model.
3. Investors have homogenous expectations (beliefs) about asset returns. It implies that all investors perceive identical opportunity sets. This is, everyone have the same information at the same time.
4. Investors that are operating in the asset market are price takers.
5. There are a definite number of assets and their quantities are fixed within the one period world.

6. All assets are perfectly divisible, liquid and priced in a perfectly competitive marked. It implies that human capital is non-existing (it is not divisible and it can't be owned as an asset)
7. The investment time horizon is identical for all investors.
8. The capital market is perfect; investors can lend and borrow money at the same interest rate. It implies that the borrowing rate equals the lending rate.
9. There are no market imperfections such as taxes, regulations, information or restrictions on short selling.

Certainly, each and every point of the listed assumptions is difficult to fulfill perfectly by many assets. All these assumptions have been discussed in relevance to forestry by Olsen & Terpstra (1981), Redmond & Cubbage (1988) and Lundgren (2005). The first seven assumptions generally hold fairly well in case of company shares or stocks (Redmond & Cubbage 1988, Lundgren 2005). However, In the case of timberland investments, the first five assumptions should hold as well as they do with stocks (Redmond & Cubbage 1988, Lundgren 2005). Since the quantity of timber on a given patch of land changes as the timber grows, assumption (5) is perhaps more questionable for timber than for stocks (Lundgren 2005). However he adds that a mutual fund that follow a regulated forest with compartments containing timber in each age class could better satisfy assumption (5). Timberland investments would certainly be less divisible as well as less liquid than investments in stocks. Since the forestry investment usually attracts the investors long time-horizons, the seventh assumption (7) also may not hold good. They agree that assumptions, the last assumption (8) & (9) are rarely valid to timber investment than stocks.

Overall, it appears that timberland investments may conform to the CAPM assumptions less well than do stocks (Redmond & Cubbage 1988). With these shortcomings, there is a risk that using the CAPM to analyze timberland returns may generate biased results (Lundgren 2005). But the CAPM approach has been widely applied despite these problems, indicating either its acceptance or robustness (Redmond & Cubbage 1988).

The basic concept of the CAPM specifically was developed for financial assets such as stocks; however, the model has been widely applied in other assets also. CAPM applies a theory of rational investor behavior to the pricing of investments. CAPM assumes that all investors are efficiently diversified and examine the risk and return of any capital asset. A capital asset can be a portfolio, an individual share or security, a portfolio projects or investments made by company or even an individual project (Woolf et. al 1985).

The risk of an asset depends on how its return co-varies with those of other assets, CAPM being the first and widely used financial asset pricing model capture this logic (Binkley et al. 1996). CAPM offers a statistical framework that allows a comprehensive analysis of behavior in capital markets (Omran 2007). CAPM is based on the premise that in competitive equilibrium, assets earn a premium over the riskless rate, and that this premium will increase as risk increases (Redmond and Cubbage 1988). The CAPM specifies an equilibrium relationship between asset ***i***'s expected rate of return $E(R_{it})$, the risk-free rate of return R_{ft}, and the expected risk premium on the market portfolio of all assets in the economy (the expected market rate of return, ER_{mt} minus the risk-free rate, R_{ft}:

$$E(R_{it}) = R_{ft} + \beta_i \left(\left[ER_{mt} \right] - R_{ft} \right) \text{...}(13)$$

Where:

R_{ft} = *the nominal rate of return on a risk-free asset at time* ***t***

β_i = *index of nominal measure the systematic risk of asset* ***i***

$\left[ER_{mt} \right]$ = *the expected nominal return on the overall market portfolio of all assets in the economy at time* ***t***

$\left[ER_{mt} \right] - R_{ft}$ = *the expected nominal risk premium on the market portfolio at time* ***t***

E =expected value operator

2.6 Security Market Line (SML)

Equation (13) is traditionally labeled as the SML and this equation defines the expected or *ex ante* rate of return at time ***t*** for any asset (Haugen 1986) as a function of the risk-free rate and the expected risk premium on the market portfolio, $[ER_{mt}] - R_{ft}$.

SML assumes that portfolio is composed of two assets: 1) An asset that pays a risk free return R_{ft} and 2) A market portfolio that contains some of every risky asset in the market. The SML is applicable to portfolios as well. Therefore, SML can be used in portfolio analysis to test whether assets are fairly priced, or not.

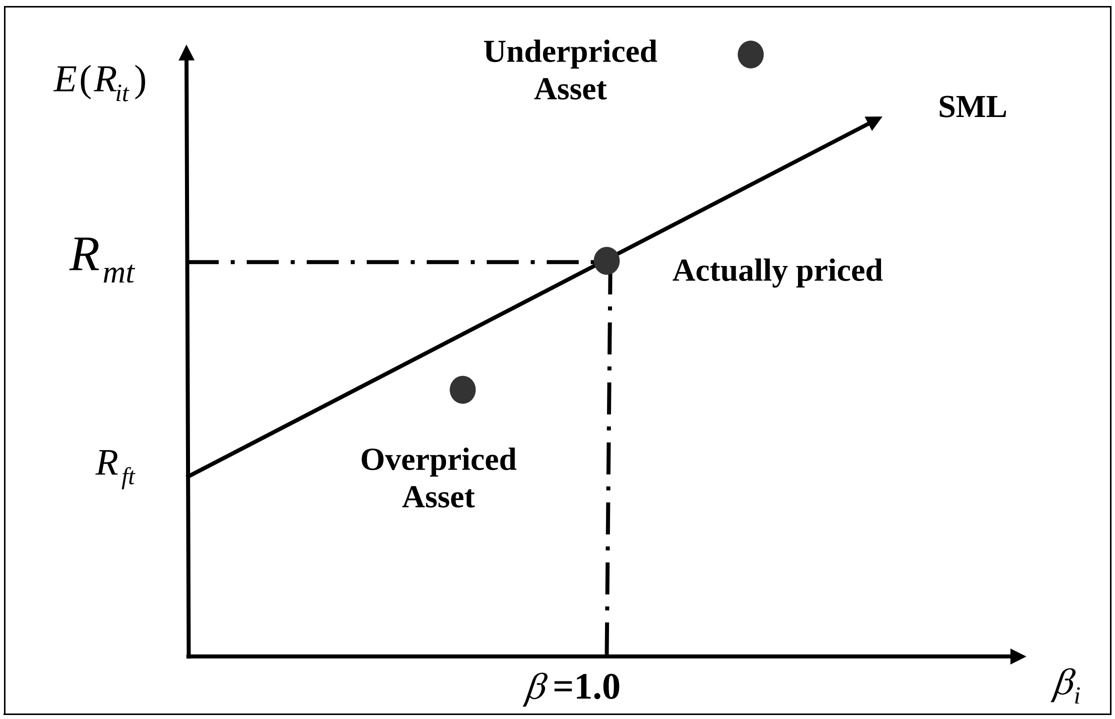

Figure 12: Security Market Line

According to CAPM, if capital markets are in equilibrium, when returns are plotted against risk (as measure by beta), all assets should fall on a straight line-called a security line (Fig.12). If individual asset or portfolio lies above the line, then expected return is too high than the required return and asset is said to be underpriced. In this condition, investors bid up price until expected return falls. If an individual asset or portfolio lies below line, then expected return is too low than the required return and asset is said to be overpriced. In this condition, Investors sell asset driving down price until expected return rises. If an individual asset or portfolio lie along line, then expected return is equal to required return according to CAPM and asset is said to be correctly priced.

As expected or ex-ante returns are not directly observable at time ***t***, it complicates the econometric estimation of equation 14 (Lundgren 2005). Hence, the model must be estimated from ex-post data. Because a return equal to the risk-free rate can be achieved by taking no risk, one should only include the value of returns greater than the risk-free rate in calculating a relevant risk measure. Jensen (1969) showed that the CAPM formulation is consistent with this rationale. It should be adjusted the stated returns by subtracting the risk-free rate from both sides of the CAPM formulation. He demonstrated that CAPM parameter β_i may be estimated using ex-post or realized returns and proved that the following representation is consistent with the regression equation or excess return form:

$$R_{it} - R_{ft} = \alpha + \beta_i \left(R_{mt} - R_{ft} \right) + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Where:

R_{it} = *the realized nominal rate of return of the asset* ***i*** *at time* ***t***

R_{ft} = *the nominal rate of return on a risk-free asset at time* ***t***

α = *CAPM alpha*

R_{mt} = *the realized nominal return on the overall market portfolio of all assets in the economy at time* ***t***

ε_{it} = *Stochastic residual error, a normal random variate with mean zero, constant variance and serial independence*

$R_{it} - R_{ft}$ = *the realized excess return on the asset i at time t*

$R_{mt} - R_{ft}$ = *the realized excess return on market mi at time t*

Estimation of the CAPM equation (14) requires a time series of historical returns for the asset under study.

2.7 Description of Model components

2.7.1 Risk free rate of return (R_{ft})

The risk-free rate is an important parameter of CAPM in calculating expected return of risky asset, excess return on asset and equity premium. It represents the interest an investor would expect from an absolutely risk-free investment over a specified period of time (www.investopedia.com.). Eugene et al. (1999) also added that the risk free rate should strictly mean the interest rate on a totally risk free security without any risk of default, maturity risk, risk of loss if the actual rate of inflation exceeds the expected rate. According to Damodaran (2006), the two conditions must be two conditions to be fulfilled to have an asset with risk free rate: (1) there can be no risk of default associated with its cash flows and, (2) there can be no reinvestment risk.

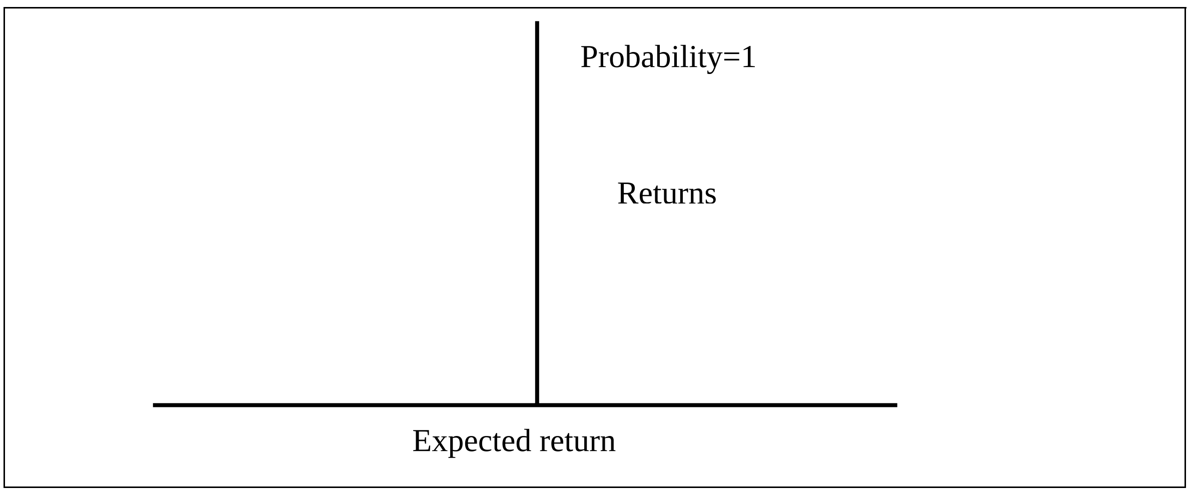

Figure 13: Returns on a Risk free Investment (source: Damodaran 2006)

Fig.13 shows that an investment is risk free because there is no variance around the expected return. For an investment to be risk free in this environment, then, the actual returns should always be equal to the expected return. The investment is considered risk free if there is no is variance around the expected return so that actual return is always equal to expected return. In practice, however, the risk-free rate does not exist because even the safest investments carry a very small amount of risk. Risk free rate can be real and nominal. According to Eugene et al. (1999), nominal risk free rate is the real risk free rate plus a premium for expected inflation.

In USA, Risk free rates of returns are calculated from proxy for a riskless asset, such as 90-days or 13 weeks period US Treasury-bills (T-bills) or Treasury bond rate. In Sweden a short-term government guaranteed type of bond is considered as the nominal risk-free rate of return (Lundgren 2005).

In practice, investors use any number of government bond rates as a proxy for the risk-free rate, each with its own strengths and weaknesses. Those who use T-bills rates argue that the shorter duration and lower correlation of the T-bills with the stock market make it truly riskless. However, because T-bills rates are more susceptible to supply/demand swings, central bank intervention, and yield curve inversions, T-bills provide a less reliable estimate of long-term inflation expectations and do not reflect the return required for holding a long-term asset (Damodaran 2006). For valuation, long-term forecasts, and capital budgeting decisions, the most appropriate risk-free rate is derived from longer-term government bonds. They capture long-term inflation expectations, are less volatile and subject to market movements, and are priced in a liquid market (Damodaran 2006).

2.7. 2 Market rate of return (R_{mt})

Market rate vary according to the economy of the country to be studied. The proxy of market portfolio has usually been a value-weighted stock index or a broad based market portfolio. The model theoretically is based on historical returns for a particular asset vis-à-vis historical returns for an index of all possible assets that an investor may have. The lack of such index have made researchers to use a stock market index such as the S&P 500 and Ibbotson Associates of World Wealth Portfolio in most prior studies of timberland investments in USA (Binkley et al. 1996; Redmond & Cubbage 1988). The market portfolio consists of an investment in each market asset in proportion to its fraction of total value of all assets in the market (Olsen and Terpstra 1981). Most experts consider the S&P 500 one of the best benchmarks available to judge overall U.S. market performance. S&P 500 is the Stock index consisting of 500 individually selected large companies. The S&P 500 isn't exactly 'the market', but it does cover about three-quarters of the total capitalization of the entire U.S. stock market. The expected market rate of return (R_{mt}) is reflected by S&P 500 market index (Francis 1972, Brealey 1969).

Binkley et al. (1996) and Redmond & Cubbage (1988) used S&P 500 as a proxy for the overall market portfolio to represent all possible assets in an economy. However, the appropriate proxy for the market portfolio is arguable (Webb 1990). The market rate of return (R_{mt}) on S&P 500 is calculated as:

$$R_{mt} = \left(\frac{SP_{t+1} - SP_t}{SP_t} \right) \quad \text{..} \quad (15)$$

Where:

SP_{t+1} = *Value of SP index at the end of the time period* ***t*** *and*

SP_t = *Value of SP index at the beginning of the time period* ***t***

The stock market indices were computed as monthly averages from the daily closing values of the Helsinki stock market index (Heikkinen 2002) and Stockholm stock exchange index in Sweden (Lundgren 2005).

2.7.3 Equity risk premium ($R_{mt} - R_{ft}$)

Equity-risk premium or excess return on market ($R_{mt} - R_{ft}$) is one of the most important parameter in CAPM equation. This is the difference between expected return on risky stocks and the risk-free rate, is considered to be one of the most critical numbers and has been extensively investigated in finance literature (Cornell 1999; Dimson et al. 2002). In equity-risk premium computation, the expected return plays a key role since the government treasury rate reliably represents risk-free rate (Cornell 1999). Fernandez (2006) has differentiated Historical equity premium (HEP), Expected equity premium (EEP), Risk equity premium (REP) and Implied Equity premium (IEP) as these are different concepts as follows:

1. HEP: It is the historical differential return of the stock market over risk free rate.
2. EEP: It is an expected differential return of the stock market over risk free rate.
3. REP: It is an incremental return of the diversified portfolio over the risk free rate required by the investor. It is needed for calculating the required return to equity (cost of equity). The CAPM assumes that REP and EEP are unique and that both are equal.

4. Implied EP: It is the required equity premium that arises from assuming that the market price is correct.

According to Fernandez (2006), HEP is easy to calculate and equal for all investors but all others are different for different investors and their magnitudes cannot be directly observed. The parameter has been estimated in a variety of ways, in a variety of markets. The seminal work is that of Ibbotson and Sinquefield (1976), who estimate this parameter for the CAPM in the US. They assume that the parameter is constant over time and therefore estimate it by averaging the ex-post outcomes over a long time period, i.e., by determining the excess of the actual market return for a year over the risk-free rate at the beginning of the year, and then averaging this margin over the period of study. Recent such estimates for the US, using data from 1926 to 1999, are between 0.080 and 0.095 (Ibbotson Associates, 2000).

2.7.4 Beta (β)

Beta is a widely used quantity in investment analysis. β represents the slope coefficient in equation (7, 12, 13 & 14) is also a measure of the slope of the characteristic line; it measures the volatility of an asset's rate of return in relation the market rate of return (Babcock 1972) and therefore as an index of systematic or non-diversifiable risk (Lundgren 2005).

According to CAPM, an asset's returns are correlated to the variability of the market portfolio’s returns. The beta index of the CAPM measures this correlation and defines the ‘systematic’ variability of an asset's returns (Wagner & Rideout 1991). For very well diversified portfolios, non-systematic risk tends to go to zero and the only relevant risk is systematic risk measured by beta (Elton et al. 2003). The tendency of an asset to fluctuate with the market is reflected in its beta coefficient (Eugene et. al. 1999). An asset's sensitivity to changes in the market portfolio is measured by beta. Therefore, beta is the marginal contribution of an asset to the risk of the market portfolio (Lundgren 2005).
Statistically the parameter β_i is defined as:

$$\beta_i = \frac{Cov(R_{it} R_{mt})}{VarR_{mt}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (16)$$

Where, $Cov(R_i R_m)$ is the covariance between the excess returns of an asset and of the market portfolio and $VarR_{mt}$ is the variance of the excess return to the market portfolio. Thomson (1991) stated that the CAPM predicts a linear risk-pricing relationship where the beta as a covariance of returns between an asset of interest and the market portfolio measures the risk.

The level of asset's systematic risk depends on the value of β. The larger the value of β, the greater the assets systematic risk. Investors expect assets with a β of one to earn the overall market rate of return, those with a beta of zero to earn only the risk-free rate of return and those with a negative β to earn even less than the risk free late rate (Washburn and Binkley 1990). If β value is greater (less) than one, the asset moves more (less) than a corresponding move in the market. Thus, such asset is said to be more (less) risky than the market. This value indicates what Francis (1972) calls an "aggressive asset." β< 1 indicates that an asset's rate of return moves counter to that of market as a whole (Blume 1971). Zero β indicates that the expected return for forestry is equal to risk free rate of return. β normally takes a value between 0.4 and 2.5; the higher the β, the more the shares return co-moves with the market (Remmers 2004). For example, an asset with a Beta of 1.15 indicates that if the market rose by 10% then the asset is expected to move up by 11.5%, and the reverse in a falling market. The main drawback of β is that it is retrospective, based on historical data and the historical position of the asset (Gadd 2005). CAPM is also known as unconditional or static CAPM due to the fact that the relation between individual securities and market portfolio, as implied by the betas, is assumed to be time-invariant and stable in this framework (Kayahan & Stengos 2007).

2.7.5 Alpha (α)

In finance literature, alpha has different nomenclatures: Jensen's alpha or Jensen's Performance index or ex-post alpha. It is also known as the abnormal return or the risk adjusted excess return and is the most widely used measure of the risk to return trade-off. This measure was first used in the evaluation of mutual fund managers by Jensen (1968). It has been used as a performance evaluation indicator of any investment. The α is interpreted as a measure of the funds' performance with respect to the market benchmark chosen (Otamendi et al. 2008). It represents Y intercept in CAPM regression, which signifies the valuation of an asset due to factors other than the overall market (Sun and Zhang 2001, Redmond and Cubbage. 1988, Binkley et al. 1996).

The intercept alpha measures the difference between the rate of return that an asset has actually generated and the rate that was justified by that asset's level of systematic risk (β_i). The alpha coefficient of Equation (14) is the Jensen Index of performance (Haugen 1986) which is defined as:

$$\alpha = R_{it} - R_{ft} - \beta_i \left(R_{mt} - R_{ft} \right) \text{…………………………………… (17)}$$

The alpha coefficient has an expected value of zero because the CAPM implies that an asset's returns are determined solely by its systematic variability (Irwin et al. 1988). A positive α_i indicates that the asset has an expected return that is greater than the market required in the risk class (as measured by beta) and thus indicates a superior risk-adjusted return (Sun & Zhang 2001). Therefore, a statistically significant positive (negative) alpha indicates returns are greater (less) than that necessary to compensate for a given level of systematic variability (Irwin et al. 1988, Redmond & Cubbage 1988, Haugen 1986). In other word, asset with positive alpha would not only reduce variability within a portfolio because it is poorly correlated with the market, but would also appreciate at a higher rate than the market would expect, given its risk level (Redmond & Cubbage 1988). An alpha of 0.4 means an asset outperformed the market-based return estimate by 0.4% while an alpha of -0.6 means an asset's monthly return was 0.6% less than would have been predicted from the change in the market alone. For a given set of data, the way we estimate β will have an effect on the consequent value of α: if we underestimate beta, then we shall overestimate alpha (Tofallis 2008).

2.8 Method of estimating α & β

The CAPM equation (14) can be written as:

$$r_{it} = \alpha + \beta_i r_{mt} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (18)$$

Where:

$$r_{it} = R_{it} - R_{ft} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

$$r_{mt} = R_{mt} - R_{ft} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

In general, β is a measure of an expected future value. Expected β is not observable in the market, but is estimated using historical data. The CAPM considers that the intercept α is zero for every asset. According to the CAPM, expected returns vary across assets only because the assets' β are different. The CAPM's prediction for the α is that it should equal to zero and the slope should equal the excess returns on the market portfolio.

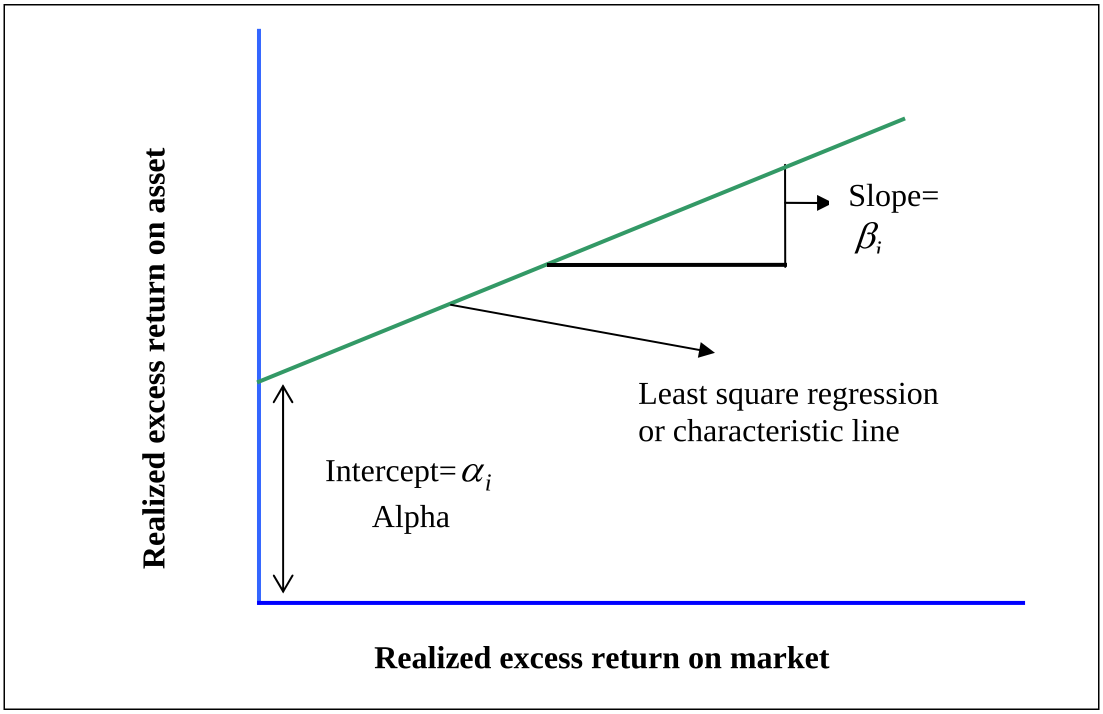

Figure 14: Regression line for α & β estimation

Ordinary least square (OLS) method is used by researchers and practitioners to estimate the characteristic line or regression line (Fig. 15). Therefore, the usefulness of CAPM mainly depends on the authenticity of beta. In equation 19, r_{it} is dependent variable and r_{mt} is independent variable. The figure shows the least square regression or characteristic line, which is obtained by regressing the equation 19. According to Bodie et al. (2002), most commercial providers of beta data do not use the excess return form.

As discussed by Brigham and Gapenski (1985), the time period for calculating beta is arbitrary. However betas of market portfolio return are generally calculated with the use of five years or of monthly rate of return data. Since historical monthly rate of return data is not at present available for any timberland index fund, the available annual data must be utilized (Zinkhan 1988).

In addition to α & β, the regression gives the information about different statistics such as: R^2, standard error of beta estimate. The statistical explanation of the R squared is that it provides a measure of the goodness of fit of the regression, the economic rationale is that it provides an estimate of the proportion of the risk of a firm that can be attributed to market risk; the balance $(1-R^2)$ can then be attributed to firm-specific risk or the percentage of variation not explained by the market. The percentage variation in returns explained by the variation in the market returns, coefficient of determination (R^2), is the ratio of market risk to the total variance of the returns on a particular asset. The final statistic worth noting is the standard error of the beta estimate. The slope of the regression, like any statistical estimate, may be different from the true value; and the standard error reveals just how much error there could be in the estimate. The standard error can also be used to arrive at confidence intervals for the 'true' β value from the slope estimate. Tofallis (2006) proposes an alternative approach to estimate β which is given by:

$$\beta = (sign\,of\,r)\sigma_i / \sigma_m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

Where, ***r*** is the correlation coefficient between asset and market portfolio, σ_i and σ_m is the standard deviation of asset ***i*** and market portfolio ***m*** respectively.

2.9 Test of Normality and autocorrelation

CAPM assumes that return data are normally distributed. Normal distribution of time series asset return data (monthly, quarterly or annualized data) is prerequisite for the model. Researchers have applied T-distribution test, F-Test in their study as a statistical method. They have performed the test of normality of return series by using statistical test such as: W-test. The normality of returns also indirectly supports the hypothesis of market efficiency (Redmond and Cubbage 1988).

Redmond & Cubbage (1988) used W-test to test hypothesis of normality. He observed that few data tended to have most of the bell shaped curve leaning slightly to the left, with a thin-tailed right-hand side. It implied that there was a tendency toward many years of fairly average returns to the stumpage price indices, but there were a few years of exceptionally high returns. The stumpage price series all had more moderate annual price changes, and all were normal based on examination of frequency distributions and the W-test. They concluded that the results of the analysis indicate that the timber price returns followed adequate normality to meet the model assumptions.

The Durbin-Watson test has been used in testing autocorrelation properties of time series data (Lausti 2004; Redmond & Cubbage 1988; Lundgren 2005; Olsen and Terpstra 1981; Binkley and Washburn 1988a, 1988b, 1994, 1988a, 1988b, 1994; Binkley et al.1996; Washburn & Binkley 1989, 1990a, Binkley et al. 2005). D-W statistic tests for first-order serial correlation; that is, the D-W statistic measures the linear association between adjacent residuals from a regression model. This test is appropriate for small samples (Dunn and Clark 1974). The test statistic is:

$$DW = \frac{\sum_{t=2}^{n} (e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^{\,2}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(22)}$$

Where, n is the number of observation, t is the time period and e is the error variable. The D-W Test for serial correlation assumes that the ε is stationary and normally distributed with mean zero. It tests the null hypothesis H_o that the errors are serially uncorrelated is

$H_{o:}$ p=0

$H_{1:}$ p>0

If there is no serial correlation, the D–W statistic will be around 2. If the D–W statistic falls below 2, there is positive serial correlation (in the worst case, it will be near zero). If there is negative correlation, the statistic will lie between 2 and 4.

Redmond and Cubbage (1988) examined autocorrelation in the CAPM regressions using the D-W statistic. Two out of twenty two of the total regressions- Georgia pine saw timber prices and Louisiana pine pulpwood-exhibited significant serial correlation (α = 0.01). Overall, the fairly satisfactory results from the W- test and the D-W test support the statistical validity of using simple linear regression to estimate CAPM parameters for stumpage price risk and returns.

Lundgren (2005) used a non-linear least square minimization estimation method procedure. The method obtains least squares or minimum distance estimated of linear or non-linear equations utilizing a generalized Gauss-Newton type of technique. They did not observe any problem with auto-correlation or heteroskedasticity during regression. He also performed LM (Lagrange multiplier) test for heterogeneity.

Olsen and Terpstra (1981) tested the hypothesis that log returns behave as a random by the examination of estimated serial correlation coefficients up to and including four 3-month lags. In general, the results support the random walk hypothesis. Of the 56 correlation coefficients, only seven were significantly different from zero at the 5% level. In addition, there was not found any pattern among these seven coefficients such as to sign, log type, or lagged period. They also used chi-square goodness-of-fit test of normality for the log return distributions. For each log type the sample mean and standard deviation were used to find the points which would divide a theoretical normal distribution with that mean and standard deviation into octal with equal frequencies in each octal. Sturges Rule was employed to determine the optimum number of distribution divisions in order to maximize the discriminating power of the chi-square test. There would be 5 observations per octal if returns were normal. In only one instance, the hypothesis of normal return distributions could be rejected at the 5% significance level. However, in nine other cases the return distributions appeared to have a tendency toward peakedness. Dusak & Clark (1973) have shown that peaked distributions are consistent with the CAPM. On balance it would appear that most of the log return distributions are probably consistent with the CAPM but that additional examination with larger samples is clearly desirable.

Redmond and Cubbage (1988) concluded that statistical estimation via OLS produced the satisfactory result. However, most of the regressions showed low coefficients of determination and low significance levels for the β.

2.10 Real CAPM

The Sharpe-Linter CAPM focuses on nominal CAPM. The finance literature contains a variety of techniques for calculating an index of real systematic variability using a real CAPM. A recent technique by Lee et al. (1988) expands the opportunity set to include money and also provides a measure of the inflation hedging ability of the asset. Lee et al. (1988) developed the real CAPM assuming the real risk-free interest rate is non-stochastic or the risk-free asset is a complete inflation hedge. The real CAPM parameters of the model defined by Lee et al. (1988) can be estimated using equation:

$$R_{rat} = \alpha_{ra} + \beta_{ra}(R_{rmt}) + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(23)}$$

With

$$R_{rat} = R_{at} - \gamma_a i_t - r_f \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(24)}$$

$$R_{rmt} = R_{mt} - \gamma_m i_t - r_f \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(25)}$$

$$\beta_{ra} = \frac{Cov(R_{ra}, R_{rm})}{V(R_{rm})} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(26)}$$

$$\alpha_{ra} = E(R_{at} - \gamma_a i_t - r_f) - \beta_{ra} E(R_{mt} - \gamma_m i_t - r_f) \ldots \textit{(27)}$$

Where β_{ra} is an index of real systematic variability, R_{rat} and R_{rmt} are the excess ex-ante real return to the asset and the market portfolio (Lee et al. 1988), respectively, γ_a

and γ_m are the inflation response coefficients of the asset and the market portfolio, respectively, i_t is the inflation rate, r_f is the real risk-free interest rate, and ε, is the stochastic residual error assumed $N(0,\sigma^2\varepsilon_t)$. The α coefficient of equation (24) may be interpreted as the Jensen Index of performance (Lee et al. 1988). Lee et al. (1988) defined the inflation response coefficient as:

$$\gamma = \frac{Cov(R,i)}{V(i)} \quad \text{……………………………………………………..} \quad (28)$$

Where, $Cov(R,i)$ is the covariance between the nominal returns of either an asset or a portfolio and the inflation rate and $V(i)$ is the variance of the inflation rate. They used the inflation response coefficient to classify assets according to their degree of inflation hedging ability: (1) $\gamma < 0$ as an inferior inflation hedge (i.e., the asset's price decreases as inflation increases); (2) $0 \le \gamma \le 1$ as a complete inflation hedge (i.e., the asset's price remains unchanged or increases at less than or equal to the inflation rate); and (3) $\gamma > 1$ as a superior inflation hedge (i.e., the asset's price increases faster than the inflation rate). Lee et al. (1988) use the inflation response coefficients to examine whether the nominal beta coefficient (β_{na}) underestimates or overestimates the systematic variability given realized inflation. If γ_a **>(<)** $\gamma_m\ \beta_{na}$, then the nominal beta underestimates (overestimates) the systematic variability. Wagner and Rideout (1991) followed the Real CAPM by Lee et al. (1988) to evaluate two alternative management regimes using a simulation of two fully regulated Pacific Northwest ponderosa pine plantations. Similarly, Lundegren (2005) also estimated real CAPM for timberland and alternative investment based on Lee et al. (1988) and Wagner and Rideout (1991).

2.11 Sharpe Ratio

Sharpe Ratio is simply a risk-adjusted measure of return. Sharp ratio, originally found by Sharpe (1994) has been understood as Sharpe index, Sharpe measures, or reward-to-variability ratio. According to Sharpe 1994, the sum of these differential returns ($R_i - R_f$) divided by the standard deviation of asset (σ_i) is the ex-post, or historic

Sharpe ratio. The Sharpe ratio is often referred to as an excess return to variability measure, and is calculated by subtracting the risk-free rate from the expected rate of return for any particular asset or market portfolio and dividing the result by the standard deviation of the asset or market portfolio returns. Sharpe ratio for any investment/asset (S_i) or market portfolios (S_m) calculated by:

$$S_i = \frac{R_i - R_f}{\sigma_i} \quad \text{……………………………………………… …….} \quad (29)$$

$$S_m = \frac{R_m - R_f}{\sigma_m} \quad \text{…………………………………………………..} \quad (30)$$

Where:

R_i = *mean rate of return for asset class* ***i*** *during a specified time period*

R_m = *mean rate of return for market portfolio* ***m*** *during a specified time period*

R_f = *mean rate of return on a risk free asset during the specified time period (usually measured by 90-day Treasury bills in US or government bond)*

σ_i = *standard deviation of the return for asset class* ***i*** *during the specified time period*

σ_m = *standard deviation of the return for market portfolio* ***m*** *during the specified time period*

The Sharpe Ratio thus measures the excess return for some asset class relative to a measure of total risk, standard deviation. It is a measure of how well the asset performs relative to its risk level. Additionally, Sharpe Ratio gives some indication of how good the portfolio manager is at diversifying away unsystematic risk. Sharpe performance is measured by plotting the standard deviation in x axis and excess return on y axis to determine the price of risk as defined by the CML.

If $S_i > S_m$, the asset earn more than the risk premium required by the capital market line, indicating superior performance by the portfolio manager.

If $S_i < S_m$, the asset earn less than the risk premium required by the capital market line, indicating poor performance by the portfolio manager.

The higher the Sharpe Ratio the larger the excess return per unit of standard deviation. Higher sharp measures are associated with superior performance. Since, Sharpe ratio is based on the historical measurement of return on particular asset or portfolio; it does not guarantee similar performance in future.

Chapter 3: Forest Investment Attributes

The forestland like other types of investments has unique attributes, some positive and some negative. Mills (1988) has analyzed and compared forestland asset with other financial assets and finally proposed a strategy to reduce the negative attributes and enhance the positive attributes of such combined investments. Washburn et al. (2003) compared the timberland with commercial properties such as building and real estate on the context of USA and found the useful differences (Table 3).

Table 3: Comparison of timberland asset and real estate based on Washburn et al. (2003)

Properties	**Timberland Asset**	**Commercial Asset**
Realized Return	Higher and more variable	Lower
Return driver	Diverse	
Required rate of capital	Lower	Higher
Required capital expenditure to maintain or enhance the value	Low	High
capital expenditure leakage from operating income	Substantially less	High
Parcelization	Flexible and allows investor to take Whole sale to retail price spread.	Low flexibility
Operating Cash Yields	More valuable	Less valuable
Harvest-timing , sell decisions	More flexible	Less flexible
Addition to a portfolio	More useful	Less useful

According to Mills (1988), the most commonly recognized attributes of investments are: rate of return and associated level of risk; liquidity or marketability; maturity or length of time it must be held; type of income (capital gain or ordinary) desired for tax purposes; amount of personal time that can be devoted to managing investments; and possible protection from inflation or deflation.

The characteristics of forestland investments vary on greatly depending on the differences in site quality, location, current stocking and species composition, size, and form of investment. However, the attributes of forestland can be discussed on following points:

3.1 Return

An investment's rate of return and riskiness are closely related. Generally, the higher the return, the higher the level of associated risk. The return earned by a long-term investment in forestland is a function of acquisition cost, site productivity, management and associated costs, and markets (Milliken & Cubbage 1985). The return can be calculated for market values alone or can include nonmarket goods and services. Timberland returns derive from a combination of income and capital gains. The income as a cash flow comes mainly from the sale of trees. However, there are other sources of income as well- recreational leases, rental income and the sale of small tracts of land for development. Capital gains arise from the steady biological growth of trees and from the changes in the value of the timber and the underlying land (Binkley and Bever 2004). Careful and sustainable management of the forest can also enhance growth rates and add to investor returns.

The returns from timberland investments can be discussed on three principal components: biological growth, stumpage price changes, and land value changes (Zinkhan 1990, Caulfield 1998a, Mills 1988). The principal costs are property taxes and management expenses, and losses to certain natural hazards. Different sources state that at least half of timberland's expected real return is derived from biological growth, a variable for which there is no logical correlation with general financial asset return proxies. Table 4 shows the different driver of timberland return.

Table 4: Timberland return driver

Return driver	**Data Sources**		
	Summit Timber Advisors, USA	Evergreen Timberland Investment Management	Caulfield (1998a)
Biological Growth (Volume and class)	6-7%	65-75%	60.5%
Timber price	1-2%	25-30%	33.3%
Land values	1-2%	2-5%	6.2%
Total annual Return	8-11%	-	14.3%

3.1.1 Biological growth

Biological growth is it is estimated to be the most important return driver. This unique feature of timberland separates it from other types of financial assets such as real estate (Caulfield 1998a). The resulting change in volume and value over time are largely independent of macro economic or financial market conditions (IWC 2006). Biological growth as a unique feature of timberland provides the protection from inflation and portfolio diversification benefits (Zinkhan & Mitchell 1990). The effect from biological growth on return is two-dimensional resulting increase in volume as well higher valuable merchantability classes (IWC 2006, Zinkhan & Mitchell 1990). Variation in growth occur depending on species, tree, and stand, the age of the timber, the quality of the site, the intensity of forest management, and various other factors. Growth in the size or volume of individual trees, and stands of trees, is a function of the ecological conditions of the site that affect productivity. Site index is a proximate measure of productivity. Other factors affecting timber stand growth are the number and basal area per acre of desirable trees per acre, and the basal area of competing undesirable trees, as well as the age and condition of the stand (Zinkhan et al. 1992).

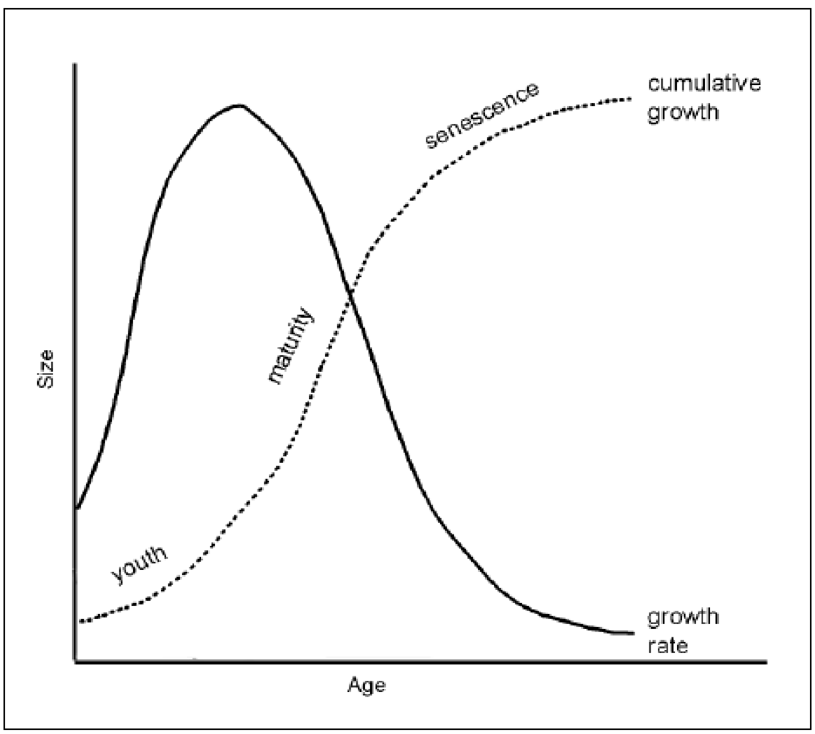

Figure 15: Tree growth curves: cumulative size growth, with life stages (broken line); and rate of growth (solid line). (Source: Husch et al. 1972).

The growth rate curve (Fig. 15 solid line) during the young stage of a tree's life increases rapidly to a maximum at the point of inflection in the cumulative growth curve (Figure 6 broken line). Acceleration of the growth rate first increases and then drops to zero at the point of inflection in the growth curve. During the maturity and senescence stages, the growth rate decreases. Hence, for an even-aged forest, the general relationship between tree growth and age can be represented by sigmoid curve (Caulfield 1998a).

The growth increment may be expressed as an annual growth rate, which will be higher when trees are young and more vigorous. Because tree volume is proportional to cross-sectional area as well as height, one year's growth ring of the same width becomes a smaller percent of the tree volume as tree age and diameter increases (Klemperer 1996).

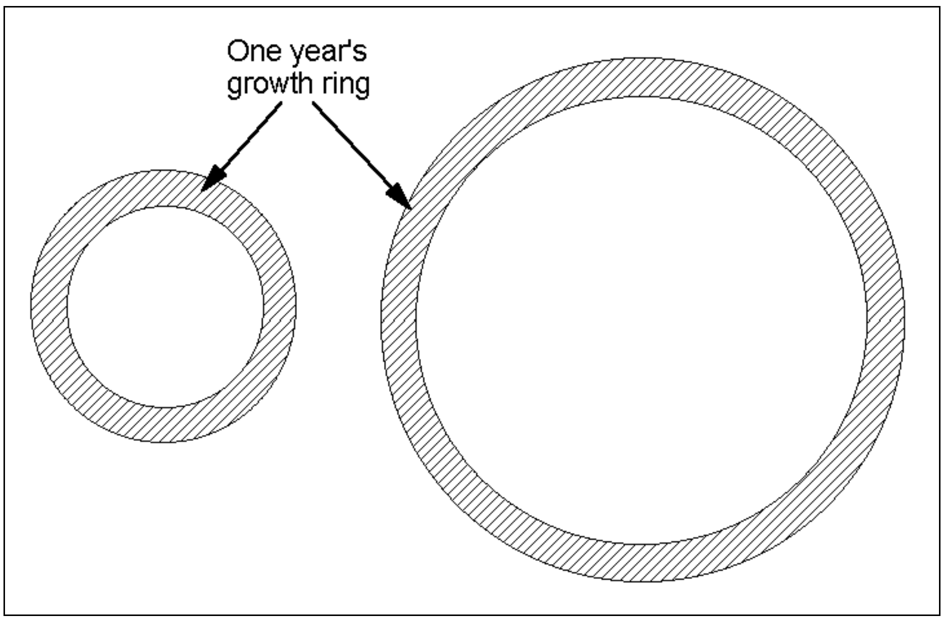

Figure 16: Comparison of two annual growth rings of equal width on a small and large tree. Source: Forest Resource Economics and Finance (Klemperer 1996).

As shown by cross-sectional views of two trees (Fig. 16), a decline in annual growth rate is a result of the way tree growth rates are measured rather than the slight decrease in the width of the annual growth ring as trees age. The hatched areas represent one year's growth ring of the same width. One ring on the larger tree is a much smaller percentage of the cross-sectional area than is one ring on the smaller tree. During a year, the percentage increase in cross-sectional area is roughly the same percentage increase in merchantable tree volume. Thus the volume added by the growth ring represents a smaller percent of tree volume as trees get larger (Klemperer 1996).

The information about growth rate helps managers determine when trees should be cut. Physical volume is converted into value by applying unit values to the accumulated volume. A tree's percentage value growth rate will eventually decline with age, as does the physical growth rate (Klemperer 1996). When this percentage change includes land value and incorporates annual revenues and costs of management, it is called "forest value growth percent." Because forests are capital assets, percentage growth rates in wood volume in the forest and its corresponding value are of considerable importance to investors (Klemperer 1996).

In addition to mature timber and the underlying land, immature timber growing stock is another component of an investment in timberland (Binkley et al. 1996). As the diameter of the immature tree grows, the wood will become valuable when the tree reaches merchantable size. Value also may increase from one product class to another. Value per unit volume increases as a tree grows into the saw timber size class. Unless timber prices are rising sharply, the forest value growth rate percent ultimately declines (Klemperer 1996).

Caulfield (1998a) has outlined the condition at which timberland value growth or investment returns are attached to volume growth: if 1) timber is merchantable from time of planting to rotation age, 2) prices received are constant per unit timber volume regardless of tree size, and 3) there is no product and land price volatility, investment returns would be completely defined by the biological growth rate.

Large-diameter trees have traditionally been worth more per unit of volume than smaller trees because they can be manufactured into higher valued products. When this happens, an investor benefits from two kinds of growth: biological growth in volume and economic upgrading from a lower-value commodity like pulpwood to a higher value commodity like saw timber (Zinkhan et al. 1992).

3.1.2 Stumpage price change

Changes in stumpage prices are the second factor contributing to the return on timber or timberland investment. "Stumpage" is the value of timber as it stands uncut, and is expressed as an amount per unit volume or area (Helms 1998). Timber is the raw material for numerous basic industries, and stumpage is timberland's primary economic output. Stumpage is what buyers pay for standing timber ready for harvest. The potential harvest income from standing timber is called stumpage value (Klemperer 1996). Stumpage prices are a function of demand and supply (Zinkhan et al. 1992). Stumpage price A_t can be explained by following interpretation:

$$A_t = P_t - C \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (31)$$

Where, P_t represent the price of timber at the mill yard in year ***t*** and *C* is the cost of extraction (harvesting and transportation).

A number of micro and macro economic variable are influential in timber price change. Macroeconomic factors include: housing starts, interest rates, population growth, GDP per capita, activity in the construction sector, interest rates, and the overall level of economic activity. Moreover, microeconomic factors affect the stumpage price within regions (Caulfield 1998a). However, the decline is price is compensated by the biological growth, which shows that a timberland investment is naturally inflation hedge properties (IWC 2006).

Timber price change can be interpreted by economic theory. Stumpage price is a function of timber and supply demand. Increase in price level according to economic theory because the demand curve is shifting out, the supply curve is shifting backward, or both shifts are occurring. Changes in stumpage price reflect changes in resource scarcity due to interactions of timber supply and demand in the stock and flow markets (Berck 1979, 1981). Globally we observe real stumpage price increases for quality wood-wood that can be cut into lumber or high-grade plywood. Bentley (2005) discusses the two forces for timber price change: are shifting demand out-increased populations and higher per capita incomes. One force is shifting supply backward-the shrinking inventory of timber suitable for lumber and plywood manufacture. This combination has created a steady price increase for many decades for conifers that have high quality (really high value) characteristics straight, round, and more cubic volume per linear unit of measure (Bentley 2005). However, in the past, demand factors have driven stumpage markets (Gregory 1987).

Analysis of time series trends is useful for describing the historic rate of return component attributable to stumpage price and thus forest value change. Models of timber price dynamics typically view standing timber as a capital asset with owners holding rational expectations with respect to future timber prices (Berck 1979). Timber owners respond to supply and demand shocks by either holding timber off the market (in anticipation of higher prices) or offering it up for sale (in anticipation of falling prices). If timber markets are informationally efficient, then markets adjust freely to new information and no opportunities exist for making excess profits by optimal harvest timing (Berck 1979). The rational expectations model assures us that, following an unpredictable catastrophic shock, agents of timber supply and demand take account of the new information and prices adjust to a new equilibrium that equates supply and demand (Berck 1979).

Fluctuations in timber prices are a key feature of any timberland investment. Hancock (2001) considers this variation in timber price not only the source of risk but also source of value as well and reports that, fluctuations in pine saw timber stumpage prices in the U.S. South have been responsible for about two thirds of the variability in regional timberland values.

3.1.3 Land value

Land value is the most significant single factor influencing timberland investment returns (Zinkhan et al. 1992). Usually, land value only represents a very small percentage of the total timberland investment value (IFC 2006). In addition, price is also partly a function of quality. Increase in land value typically increase overall returns. Land values are related to local supply and demand conditions and therefore vary spatially (Caulfield 1998a). In addition, price of the land component of timberland is also partly a function of quality. If growing timber is the highest and best use for a given tract of land, its price should approach the present value of the estimated future stream of stumpage harvest revenues less periodic expenses discounted at some appropriate cost of capital (Zinkhan et al. 1992). A study by Washburn (1992) demonstrates that the strongest indicators of real value of land over time are the CPI and the nominal risk-free rate of interest. During periods of low inflation and relative timber product price stability, timberland prices tend to change slowly, and vice versa.

3.2 Risk

Effective investment criteria should consider both: return and risk. Risk is the impact of forces that cause the actual return of an investment to deviate from that which was expected. Not all risks are negative. Uncertainty and risk may be distinguished as suggested by Knight (1921), with uncertainty referring to situations in which the likelihood of outcomes is unknown and risk referring to situations in which the likelihood of possible outcomes is known.

Biological uncertainties concerning forest growing stock and merchantable yield constitute an important economic risk that impacts measures of profitability for long-term management (Montgomery, 1996; Erickson et al., 1999). Even with long-term tenure security, market uncertainties concerning future timber preference among loggers and landowners for liquid assets rather than capital investment in long-term forest management (Dequech 2000).

Forest investment risk is usually defined as the historical volatility in an investment return (Weyerhaeuser 2005). By this measure, forestland investments are low risk largely because trees grow at a relatively steady rate. This biological phenomenon dampens the volatility from price fluctuations and other economic factors.

According to www.htrg.com, the primary risks associated with timberland investments are commonly referred to as price risk, volume risk, and asset value risk. Price risk refers to the volatility associated with future timber and timberland prices. Volume risk includes the risk of inaccurately estimating standing inventory, and asset value, or liquidity risk, implies the risk associated with realizing expected disposition values. Baumgartner et al.

(1992) considered price risk as the important risk for the landowner. Weyerhaeuser (2005) classified risk in forestry into investment risk, economic risk and physical risk. Timberland Report (2004) classifies the timberland investment specific risks into physical, financial, operational, and regulatory.

Physical risks include factors affecting the volume and quality of timber such as fire, insects, animals, disease, storms, hurricanes and theft. The degree of risk varies considerably by geographic region due to climate and other factors. These risks are associated with the losses from natural and man-caused events, which can be minimized through active management. Mills (1980) shows that biophysical risks are small compared to the risk of price changes. Geographic diversification is a good way to control this and other sources of physical risk (HTRG 2003a, Mills 1988, Weyerhaeuser 2005). While practice to increase the vigor of forest stands or decrease fuel loadings can decrease some of these risks, the owner can adjust the species mix at the same time (Baumgartner et al. 1992). Even in the extreme case of loss to fire or disease, efficient salvage operations can often capture much of the value (Weyerhaeuser 2005). HTRG (2003a) reported that over the last 12 years, the financial loss from a damaging natural event in all Hancock Timber Resource Group-managed properties have averaged only 0.04 percent (four basis points) per year. One forest products firm that has kept records of such mortality estimates that it averages less than 2% annually, at most (Webb 1987), and most of the timber is salvageable.

Financial risks include those affecting the price of inputs, including fertilizers and seedlings, and outputs, such as pulpwood, saw logs, and the timberlands themselves. Economic risks include such interrelated factors as timber supply and demand, fluctuations in log and stumpage prices, and liquidity. Price changes occur based on supply and demand dynamics including cyclical and seasonal fluctuations. Demand can be affected by various external factors including substitution of non-wood materials such as metal or plastic, imported wood as a substitute for domestic production, or usage factors such as housing starts and recycling rates. Supply risks include such factors as the quality of silvicultural management and increasingly stringent environmental regulations (Weyerhaeuser 2005). Economic risks can be minimized through good management, anticipating regulatory changes, and ongoing monitoring and analysis of markets (timing of harvests and dispositions), policies and other factors likely to impact timber prices (Weyerhaeuser 2005).

According to Timberland Report (2004), operational risks include factors affecting the day-to-day operability on the timberlands, from weather impacts and access issues. Regulatory risks may arise from land use regulations, green certification, and social pressures, all of which have policy implications. These risk categories, influences on returns may be positive or negative.

In estimating expected investment return, generally adjustment is made on expected revenues for these types of risks by incorporating fall-down factors based on historic probability of their occurrence. However, the estimation of the probability of loss from these risks on timber investments in any particular geographic area from historical records is not accurate. Also, the actual levels of loss during any given year are unknown ahead of time.

Other risks like the impact of global warming or new environmental regulations cannot be easily predicted based on historical information. The forestry investments are also associated with many market and political risks.

3.3 Liquidity and transaction cost

Liquidity is a measure of the marketability of an investment (Mills 1980). Negative attributes associated with forestland includes relatively poor liquidity and the need for specialized management expertise. Timberland investing generally requires a commitment of 10 years or more to the asset class and is illiquid relative to stocks or bonds. Timberland, similar to other real estate investments, has high transaction costs and is relatively illiquid. These factors reduce the attractiveness of timberland investments. Another limitation is the indivisibility of timberland; timberland investment requires substantial investments. While this is a constraint for private investors, it is not a constraint for institutional investors.

The liquidity of forestland investments, even limited partnerships, is relatively poor (Mills 1988). Adding to marketability problems is the relatively large amount of capital required to invest in just one tract of land. The development of more limited partnerships and other forestland investment vehicles will result; it is hoped, in a larger market, thus increasing their liquidity. The development of timberland limited partnerships and timberland investment advisory groups should help to reduce these disadvantages (Zinkhan & Mitchell 1990). However, if an investor wishes to liquidate their timber holdings, the disposition process can be initiated quickly.

3.4 Maturity

Except when a forest area can be purchased cheaply just before it grows into a higher merchantability class (e.g., pulpwood to saw timber or saw timber to veneer), the maturity of forestland investments is longer than most other investments (Mills 1988). The value of the asset will increase, but there are periods of low or negative cash flow when trees are not merchantable the scale of operations is sufficiently large, a regular cash flow can be obtained using forest regulation to schedule harvests in different parts of the forest at different times.

3.5 Harvesting flexibility or market timing

A unique characteristic of timber is that it can be stored ‘on the stump’ as it is grown. Forestland managers or land owners often have the option of storing timber on the stump when price conditions are not as favorable as desired.

3.6 Tax advantage

Forestland has significant tax advantages over other types of investments. Considered after taxes, forestland investments can be attractive (Mills 1980). For individual investors, timberland ownership offers tax advantages where income from timber and timberland sales can generally be treated as capital gains. In addition, there are specialized tax deductions and credits that can be utilized for conservation easements, reforestation, and timberland management practices. Therefore, a forestland investment can result in a reduction of current income taxes and in the deferment of taxes due on the annual increase in value or volume. Furthermore, the relatively long duration between harvests often provides investors with the potential for a significant degree of income tax deferment (Zinkhan & Mitchell 1990).

3.7 Personal time

Forestland investments need not require more personal management time than other investments (Mills 1988). Professional forestry assistance can be purchased, much as brokerage and investment advisory services are purchased for other investments. However, if an investor chooses to personally manage the land, the time commitment can be significant.

3.8 Cost

As with almost any investment, owning timberland means management responsibilities and costs. There are annual real estate taxes, legal and administrative expenses and many other forest management expenses (e.g. the development and maintenance of roads, hiring logging contractors, managing leases, and certification).

Chapter 4: Methodology and Application of CAPM in Forestry

4.1 Method of estimating forestry return

A standard method of computing return for financial security as used by Ibbotson and Sinquifield (1982) is:

$$R_t = \left(\frac{V_t + D_t}{V_{t-1}} \right) - 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (32)$$

Where:

R_t = *the rate of return earned in period* ***t***

V_t = *the value (price) of the security in period* ***t***

V_{t-1} = *the value (price) of the security in the previous period* ***t-1***

D_t = *the dividend received in period* ***t***

The market return for stocks represents the stock price appreciation return plus dividends. A similar construct may be derived for the forest ownership. Stands of timber may not simply appreciate or depreciate in price (like a stock), but also offer value appreciation each year because of biological growth, just as a firm issues dividends each year. Thus a measure of a timber stand's actual return is the sum of the stumpage price change plus net increment of the standing timber. This total amount would reflect the total returns on forest ownership (Cubbage et al. 1989).

Binkley et al. (2006) outlines the six key factors on which return from forestry return depends:

- the acquisition cost of asset.
- the natural productivity of the land
- the location of the land in proximity to strong market for manufactured forest products
- the management of land
- the operating economics of land (i.e. harvesting cost, transportation costs)
- exit value of the forest

The return can be calculated for market values alone or can include nonmarket goods and services. However, in CAPM studies, researchers have not included values of non market goods. When returns for actual timberland assets are lacking, analysts have generally combined historical timber prices (which are available for extended periods) with various assumptions about timber growth, historical values of forestland and timber growing stock, and management expenses to reconstruct returns for a model forest.

Most researchers begin with an assumption that their model forest is ‘fully regulated’. A forest is said to be fully regulated if it contains an equal distribution of timber inventory among all age classes. This condition allows an equal volume of timber to be harvested from the model forest each year and ensures that both the timber inventory and the rate of timber growth remain constant over time. Although few individual forests contain an even mix of timber ages, portfolios of several timberland properties can approach full regulation. This assumption provides a useful, stable benchmark for valuation comparisons.

Various researchers have used different methods based on their assumption about stumpage price, growing stocks and bare land value to calculate forestry returns. It is found in the literature that the forest return has been calculated in real and nominal terms. Mills & Hoover (1982) and Grauer & Hakansson (1982) use nominal returns, while Thomson (1991b) calculates in real terms. Mills & Hoover (1982) calculated annual return as a direct return plus the year’s price change for the asset in question, related to the previous year’s price for that asset. Prices alone are often used as a proxy for calculating historical return from forest returns (Redmond & Cubbage 1988; Washburn & Binkley 1990a; Baumgartner et al. 1992). Stumpage price, growing stock and management cost information are needed to compute the annual return for each timber investment. Operating cost associated with managing the forest includes the site preparation, seedlings, planting, property taxes and administration.

In aggregate level studies, forestry returns are calculated for a hypothetical forest land investment, assuming certain management regimes, age class distributions, site qualities, and timber species. It is typically assumed that any amounts of fully regulated forest with given timber species and productivity can be purchased or sold in the forest land market (Thomson & Baumgartner 1988; Thomson 1992). Statistics on stumpage prices (Redmond & Cubbage 1988) or timberland indices (Zinkhan 1990; Sun & Zhang 2001) have typically been employed to estimate series of forestry return. Forestry returns can be calculated for individual timberland funds (Caulfield 1994) or real or hypothetical forest holdings (Lonnstedt & Svensson 2000) or by combining information from regional forest inventories and statistics on prices and costs (Penttinen & Lausti 2004).

A return formula based on stumpage prices, growing stock index, harvesting volume, and cost has also been proposed by Thomson (1989). He assumes a constant growing stock index, which is actually constant only for a fully regulated forest. Thomson (1991b) calculated the real return for growing fully regulated timer stand for producing a timber from selected species (Southern pine, ashes, gums and oaks). He used the historical stumpage price series data from 1960-1980 for the selected studies. These nominal prices were deflated to the common base year of 1967 by using the CPI figures reported in Ibbotson and Sinquifield (1982). The real annual returns computed for timber investments use an annual price series. This annual price series is the composite from averaging prices observed during the year.

$$R_{f,t} = \left(\frac{LEV_t + P_t G + P_t H - C}{LEV_{t-1} + P_{t-1} G} \right) - 1 \quad (33)$$

Where:

R_t = *Real annual return from the timber asset in period **t***

LEV_t = *Real value of bare forest land in period **t***

P_t = *Real stumpage price in period **t***

H = *Constant annual harvest volume from fully regulated forest*

C = *Constant annual cost of managing the forest including all silvicultural expenditures, land taxes, and other costs associated with forest management*

G = *Growing stock index, which is constant from period to period for a fully regulated forest*

He also compares the return from the timber asset of the above equation with the return from the financial security of equation 32, where, P_tG is the current value of growing stock. The sum of the timber plus LEV_t is the value of the growing stock in period t and thus is analogous to the value of the security, V_t . The sum of $P_{t-1}G$ and LEV_{t-1} is the value of the timber plus growing stock in period *t-1* and thus is analogous to the value of security in period *t-1*, (V_{t-1}). The one period earning from managing the forest is the value of the harvest, P_tH , minus the annual forest management costs, C, so P_tH is analogous to the dividend, minus the annual forest management costs D_t ,of a financial security.

Bare land value was calculated by using Fraustmann formula and the growing stock index, G was estimated as the sum of the discounted growing stock for each age class of the regulated forest as the formula below:

$$G = \sum_{t=1}^{T} \frac{H}{(1+i)} \quad \text{(34)}$$

Where:

T= rotation age

i *= discount rate*

H *=1/T*

Baumgartner et al. (1992) defined price return as the percent return earned on a stand over a year due to the change in timber prices and used to estimate the return of the individual tree species of mixed hardwood stand in the Midwest US. They estimated the beta for each species or product in the stand by regressing the price return of each species or product against an index representing the market in general. They assume no net growth and no management costs. They used an unweighted average price return R_t for all saw timber prices for the index.

$$R_t = \frac{P_t}{P_{t-1}} - 1 \text{………………………………………………………………….. } (35)$$

Where:

P_t =*Stumpage price on this year*

P_{t-1} =*Stumpage price on the previous year*

Hotvedt & Tedder (1978) calculated the quarterly return of the five forest products companies to evaluate their common stocks for the holding period 1970-1976 by using the following formula:

$$R_{it} = \frac{D_t + P_{t+1}}{P_t} - 1 \text{……………………………………………………… } (36)$$

Where:

D_t = *Cash dividend for time period* ***t***

P_{t+1} = *Common stock price at the end of time period* ***t+1*** *and*

P_t = *Common stock price at beginning of time period* ***t***

Mills (1988) estimated the average annual rate of return for an uneven aged stand in west central Indiana on an average site for a 20 year period (1959-78). He used simulator to calculate annual net growth by species considering potential mortality from physical losses such as storm damage, oak wilt and other diseases, and wildfire. Annual stumpage value by species was estimated using prices reported in the Indiana Forest Products Marketing and Wood Utilization Report.

Conroy & Miles (1989) calculated historical returns (for the period 1976-1986) for a representative plantation of southern pine in distributed in three geographic region under 25 year harvest strategy assumptions. Using the biological growth model, they calculated the volumes of the commercial timber products and utilizing the price of timber end products (Fiber, Chip- n-saw and Saw timber) from Timber-Mart South, and the cost of management; they calculated the monthly cash flows and monthly values of standing timber. For measuring the rate of change in forest land values, they used the rate of change in farmland values.

$$MR = \left(\frac{TV_t + LV_t + OCF}{TV_{t-1} + LV_{t-1}G} \right) - 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (37)$$

Where:

MR = *Monthly return*

TV_t = *Timber value in period t*

LV_t =*Land value in period t*

OCF =*Operating cash flow*

G = *Growing stock index, which is constant from period to period for a fully regulated forest*

Wagner & Rideout (1991) defined forest asset as the thinning and non thinning management regime. They used growth-and-yield simulator Stand Projection System to calculate yield data and random generator to select quarterly final yields for the years 1963 to 1988 from the 31 possible final yields. The quarterly net ponderosa pine prices for the Pacific Northwest region were obtained from USDA Forest Service Resource Bulletins (USDA Forest Service, Pacific Northwest Research Station 1963-1988). Finally, a constant real long-term cost of capital was used to calculate the quarterly bare forestland's expected value (LEV) and timber inventory. Based on the several assumptions, they used the Fraustmann formula to estimate the bare forestland's expected value (LEV) and the discounted expected future harvest revenues to estimate the value of the timber. Finally they presented nominal return for both forest assets using the formula:

$$R_t = \left(\frac{\Phi_t - \Phi_{t-1}}{\Phi_{t-1}} \right) - 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (38)$$

Where:

Φ_t = *Real quarterly LEV plus the timber inventory of the forestry assets.*

Olsen & Terpstra (1981) calculated quarterly holding period (from July 1968 through september1978) returns on thirteen individual log species and grades and one ‘composite’ log type from actual average log sales prices compiled by the Industrial Forestry Association of Oregon. They state that some researchers have advocated the use of logarithms of returns in order to reduce the magnitude of the standard error under estimation, however, in their case they did not find useful. They used storage costs (including deterioration, theft, and insurance premium) obtained from the US Forest Service and finally return was calculated:

$$R_{it} = \left(\frac{P_{it} - C_{it}}{P_{i\,t-1}} \right) - 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.... (39)$$

Where:

P_{it} =*Average actual sale price per thousand board feet (mbf) of log type **i** during quarter **t***

P_{it-1} =*Average actual sale price per thousand board feet (mbf) of log type **i** during quarter **t-1***

C_{it} =*Estimated storage costs per thousand board feet of log type **i** during quarter **t***

Washburn and Binkley (1989) suggested following formula to estimate the continuous rate of return during period ***t*** for any forest asset ***i*** is given by:

$$R_{i,t} = \ln\left(\frac{H_t P_t - C_t + GSV_t + BLV_t}{GSV_{t-1} + BLV_{t-1}} \right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (40)$$

Where:

H_t = *Volume of stumpage harvested at the conclusion of the period **t***

P_t = *Price of stumpage at the conclusion of the period **t***

C_t =*Cost of holding the asset during the period **t***

GSV_t =*Values of the growing stock at the conclusion of the period **t***

BLV_t = *Values of the bare land at the conclusion of the period **t***

GSV_{t-1} = *Values of the growing stock at the conclusion of the period **t-1***

BLV_{t-1} = *Values of the bare land at the conclusion of the period **t-1***

Washburn & Binkley (1990b) used differences of the natural logarithm when calculating rates of change in stumpage price, stock market value and inflation. Washburn & Binkley (1993) used variation in historical rates of change in the price of saw timber stumpage as a proxy for variation in rates of return for entire forest properties. They believe that the procedure is consistent with an assumption that forestry returns are equal to:

$$R_{for,t} = \ln\left(\frac{P_{stum,t+1}}{P_{stum,t}}\right) + C_{for} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (41)$$

Where:

$R_{for,t}$ = *The continuous rate of nominal return during period **t** for the forest asset.*

$P_{stum,t+1}$ **=** *Stumpage prices for periods **t+1***

$P_{stum,t}$ =*Stumpage prices for periods **t***

C_{for} = *Constant*

This formulation considers the rate of change in stumpage price is only source of variability in forestry returns. Furthermore, Washburn & Binkley (1993) assumes that the other determinants of returns for assets such as timber growth, changes in the value of bare land and timber growing stock, and operating expenses are either perfectly correlated with changes in stumpage price, constant, or of negligible magnitude.

Since, historical rates of return or any other no industry-wide index of appraisal-based returns for or privately traded timberland was not available, Binkley & Washburn (1994) followed a hedonic equation of timberland value. The equation was then used to estimate the capital value of a fully regulated southern pine forest at quarterly intervals from 1977 through 1990. Net income for the forest was estimated from quarterly data on historical timber prices and property management expenses. To annualize the returns, the mean was multiplied by 12 and the standard deviation by the square root of 12. Historical returns for direct ownership of southern pine timberland were calculated from quarterly average data. The standard deviations of quarterly returns were calculated by a factor of 1.225 to correct for smoothing induced by averaging. To annualize the quarterly returns, the mean was multiplied by 4 and the standard deviation by the square root of 4.

Aronow et al. (2004) separates returns from investments in timberland properties into two components: 1) an ‘income’ return, or cash dividend, reflecting the current net operating revenues associated with timber harvesting and the sale of various non-timber outputs that forests produce and 2) an ‘appreciation’ return reflecting the change in the value of the timberland property, including the bare land and timber inventory. The income returns depend mainly on timber prices. They demonstrate that the appreciation returns being volatile, they are quite influensive in changing timberland properties. Hence, the identifying the factors that create this volatility in timberland values is the important consideration in effective management of timberland investment.

They developed a simple model for explaining timberland value for an area regulated forest in US. They concluded that the Timber prices with their influence on operating revenues appear to have a strong effect on timberland values; interest rates do not. According to them, an area-regulated forest is a stable inventory of timber which produces an equal flow of timber harvests, off an equal number of acres, from year to year in perpetuity. The value of an area-regulated forest can be modeled as follows:

$$V_t = \frac{I_t}{r_t} \quad \text{(42)}$$

Where V_t is the value of the forest at the end of year ***t*****,** I_t is the net operating revenue produced by the forest during the calendar year ***t***, and r_t is the real discount rate used by timberland market participants to value timberland properties at the end of year ***t*****.** The model implies that net operating revenues are expected to keep pace with general inflation. In other word, participants in timberland markets are assumed to use the past year’s net operating revenue as an expectation of future levels, in real terms. They demonstrate that with net revenue estimates in hand, one can calculate historical area-regulated forest values that would produce the National Council of Real Estate Investment Fiduciaries (NCREIF) reported total rates of return. The calculation uses the following formula:

$$R_t = \frac{V_t - V_{t-1}}{V_{t-1}} \quad \text{...} (43)$$

Where, R_t is the total rate of return reported by NCREIF for the calendar year ***t.***

Return has been calculated for non industrial forest ownership considering it as an asset class with few species and the round wood assortment in Finland (Lausti & Penttinen 1998a 1998b; Penttinen & Lausti 2004; Lausti 2004). The tree species used in this study are pine, spruce, and broadleaves. The six round wood assortments are pine logs, spruce logs, broadleaf logs, pine, pulpwood, spruce pulpwood and broadleaf pulpwood. They have developed return estimation and return decomposition methodology in NIPF ownership at board district level and national level based on the data form national inventories in Finland (NIF).

Lausti & Penttinen (1998a) defined the return on forest ownership by dividing the sum of the value change in absolute terms caused by (i) the price change and (ii) the net increment, by the estimated value of the stand. The components of the return on NIPF ownership includes such as stumpage price, felling, costs, and change in forest value. The national-level return by splitting it into (i) stumpage price change, (ii) silvicultural costs and (ii) the growing stock net increment components, the last of which are also divided into (iv) fellings and (v) growing stock value change components.

They demonstrate that the split in the return is beneficial in many ways, not only in analyzing factors contributing to the ex-post economic result, but also in evaluating the ex-ante influence of various changes and new features of the today's turbulent forestry world. The return split shows, the variation in return components in different parts of Finland. These findings provide results covering return and risk on NIPF, and provide much background information for price, felling, change of the growing stock and forest improvement considerations. Another advantage is that the price change component can be compared with inflation.

They estimated the logarithm return on NIPF ownership during year y ($r_{y,NIPW}$) at the national level based on the sum of the growing stock, the change in the growing stock and felling values across the round wood assortment:

$$r_{y,NIPW} = LN\left(\frac{\sum_{a=1}^{6} P_{ya}\left(V_{y-1,a} + I_{ya} - F_{ya}\right) + \sum_{a=1}^{6} P_{ya}F_{ya} - C_y}{\sum_{a=1}^{6} P_{y-1,a}V_{y-1,a}}\right) \text{……… (44)}$$

Where:

$r_{y,NIPW}$ =*Return on NIPF ownership* r_y *during year y at the national level*

a = *Round wood type* ***a***

P_{ya} = *Stumpage price of round wood type a at the end of year* ***y***

$P_{y-1,a}$ =*Stumpage price of round wood type a at the end of year* ***y-1***

$V_{y-1,a}$ = *volume of round wood type a at the end of year* ***y-1***

I_{ya} = *Net increment stock of a round wood type a during year* ***y***

F_{ya} = *Commercial felling of round wood type a during year* ***y***

C_y = *Silvicultural and forest improvement costs reduced by state subsidies during year* ***y***

Their decomposition methodology is divided into three phase return structure:

1. **Cost component (**$r_{y(c)}$**)**

$$r_{y(c)} = LN\left(1 - \frac{C_y}{\sum_{a=1}^{6} P_{ya}\left(V_{y-1,a} + I_{ya}\right)}\right) \text{…………………………… (45)}$$

2. **Net value increment component splits into the price change component** $r_{y(p)}$ **and net increment (volume change) component** $r_{y(i)}$

$$r_{y(p)} = LN\left(\frac{\sum_{a=1}^{6} P_{ya}V_{y-1,a}}{\sum_{a=1}^{6} P_{y-1,a}V_{y-1,a}}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(46)}$$

$$r_{y(i)} = LN\left(\frac{\sum_{a=1}^{6} P_{ya}I_{ya}}{\sum_{a=1}^{6} P_{y,a}V_{y-1,a}}\right)$$

3. **The net increment (volume change) component $r_{y(i)}$ further splits into felling component $r_{y(f)}$ and the volume change in the growing stock $r_{y(v)}$ components.**

$$r_{y(f)} = LN\left(\frac{\sum_{a=1}^{6} P_{ya}F_{ya}}{\sum_{a=1}^{6} P_{y-1,a}V_{y-1,a}}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(47)}$$

$$r_{y(v)} = LN\left(1 + \frac{\sum_{a=1}^{6} P_{ya}\left(I_{ya} - F_{ya}\right)}{\sum_{a=1}^{6} P_{ya}V_{y-1,a}}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(48)}$$

Heikkinen (1999) computed forest return series in Finland based on stand growth, price variability and opportunity cost of postponing the harvest. The opportunity cost was found to be insignificantly small and was therefore neglected. However, stand growth was based on percentage growth of timber volume only. The positive effects of transition of timber volume between round wood categories and reduction in unit harvesting were thus neglected.

Lonnstedt & Svensson (2000) calculated the annual normal return on timberland for an even aged non industrial private ownership level in Sweden for the period 1968-1994. The return on timberland was calculated by separately calculating the returns only for two softwood species spruce and pine using the formula and then weighing them together with weights of 0.49 and 0.51, respectively.

$$AVK = \left(\frac{AVN_t + MV_t + RVST_t - C_t}{MV_{t-1} + RVST_{t-1}} \right) \text{……………………. …. } (49)$$

Where:

AVK = *annual normal return on timberland*

AVN_t =*Total net feeling value at period* ***t***

MV_t = *Land value according to traditional Faustmann formula*

$RVST_t$ = *Standing value of the forest at period* ***t***

C_t = *Costs for silvicultural*

Lundegren (2005) estimated forestry return from Swedish timberland according to:

$$R_{T,t} = \frac{\Delta(LV_t + TV_t) + OCF}{LV_{t-1} + TV_{t-1}} \text{ ……………………………………... } (50)$$

Where:

$R_{T,t}$ = *return from timber asset at period* ***t***

LV_t = *the value of bare land in period* ***t***

TV = *the value of standing timber (biomass stock)*

OCF = *net operating cash flow* = $(P_t \times H) - C$

LV_{t-1} = *the value of bare land in period* ***t-1***

TV_{t-1} = *the value of standing timber in period* ***t-1***

P_t = *price of timber, (stumpage price) in period* ***t***

H = *Constant annual harvest volume from fully regulated forest*

C = *cost of harvesting, investment, and maintenance costs.*

$\Delta(LV_t + TV_t)$ is the value change in bare land and growing timber stock between timer ***t-1*** and ***t.*** The value of standing timber was calculated by stumpage price and total growing stock. The operating cash-flow data series OCF was collected from Statistical

Yearbook of Forestry (SYF) an estimate of the net value of total annual felling in Sweden. Total harvest included all different types of tree species that grow in Sweden. The land value per hectare was calculated according to the traditional Faustmann formula.

4.1.1 Timberland Indices in US

Timberland investors always are inquisitive towards the expected return of their investment and the past performance of the investment in forestry. Timberland Report (1999) pointed that calculating the performance of institutional timberland investments and comparing individual investments against industry returns is not as simple as comparing investments in the stock market against leading market indexes such as the S&P 500. Therefore, to address this issue, professional or timberland investment TIMOs since their inception in 1990, have developed index to make it comparable return and volatility between the forestry assets among geographical region and among other non financial assets (Caulfield 1994).

Several TIMOs developed timberland index over the years based on theoretical timberland investments. These indices have been discussed in Zinkhan & Mitchell (1990). Academicians have also created timberland indexes. They are usually based on the performance of hypothetical investments in timberland. Conroy & Miles (1989) constructed a timberland index for southern pine that was dependent upon farmland values.

Zinkhan & Mitchell (1990) highlighted the two most common reasons for a good timberland index. The first reason is to determine asset allocation, and the second is to evaluate the investment performance relative to other investments. Presently two indexes: Timberland Performance Index (TPI) and the NCREIF Timberland Index there exist in US. The NCREIF Timberland Property Index is developed from data supplied by timberland investment managers who report quarterly on appraised value, property income and expenses, and property land transactions. However, TPI has been discontinued since 1999. The comparison of these two indices has been demonstrated in table 3. There is also another index named as The John Hancock Timberland Index

(JHTI), which is published by the Hancock Timber Resource Group. The JHTI uses historical data to extend its timberland performance time series back to 1960. Timberland Report (1999) compared the total annual returns for the two indexes for the period 1987-1998 and found the low correlation coefficient (Just over 19%). However, over time the two indexes showed similar levels of returns. Table 5 presents the comparison of TPI and NCREIF

Table 5: Comparison of TPI and NCREIF (Source: Timberland Report 1999, 2002, Aronow et al. 2004)

Attributes	TPI	NCREIF
Publisher	Jon Caulfield at the Warnell School of Forestry at the University of Georgia	The National Council of Real Estate Investment Fiduciaries
Period	1981 through 1999	1987 through the present
	Fund based performance measure	a property-based index reporting returns for three regions of the United States: the South, Northeast and Pacific Northwest
Contributors	13 timberland funds managed by 3 TIMO	3 TIMO: Hancock Timber Resource Group, Forest Investment Associates, and Forest Systems LLC
Return Component	Consists of returns (weighted by market value) from	Income and capital appreciation returns
Limitation	• Covers primarily the Southern United States • Reports only total returns	• Short duration: returns are only available since 1987 • Use of quarterly appreciation returns • Based largely on appraisals rather than actual market transactions • The timber inventory on each property changes over time due to growth and harvest • All properties are not revalued each quarter • The sample of properties in the Index changes from quarter to quarter

Caulfield (1994, 1998b) reported that a good timberland index should:

1) be based on actual returns from real properties,
2) be weighted by asset value and the weights should include as many timberland properties as possible,
3) have sufficient historical data so that a comparison of average returns and standard deviations with other assets is statistically meaningful,
4) be able to recreate an index from publicly available data, and
5) be separated into regional sub indexes.

Caulfield (1998b) demonstrate the estimation formula of timberland Property Index (TPI) as:

$$TPI_i = TPI_{i-1}\left(1/T_{i-1}\sum_{j=1}^{m} R_{ji-1}W_{ji-1}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(51)}$$

Where:

TPI_i = *Value of the Timberland Performance Index m period* ***i, i = 1 to k***

R_{ji-1} = *Change in value of timberland fund* ***j*** *from period* ***i-1*** *to period* ***i***

W_{ji-1} = *Dollar value of timberland fund* ***j*** *in period* ***i - 1***

T_{i-1} = *Total dollar value of all funds in period* ***i-1***

4.2 CAPM estimation procedure

Once the return on the assets of question and the model parameter is estimated, the model can be employed to derive required rate of return. The Fig.17 shows the different steps involving on the estimation of required rate of return.

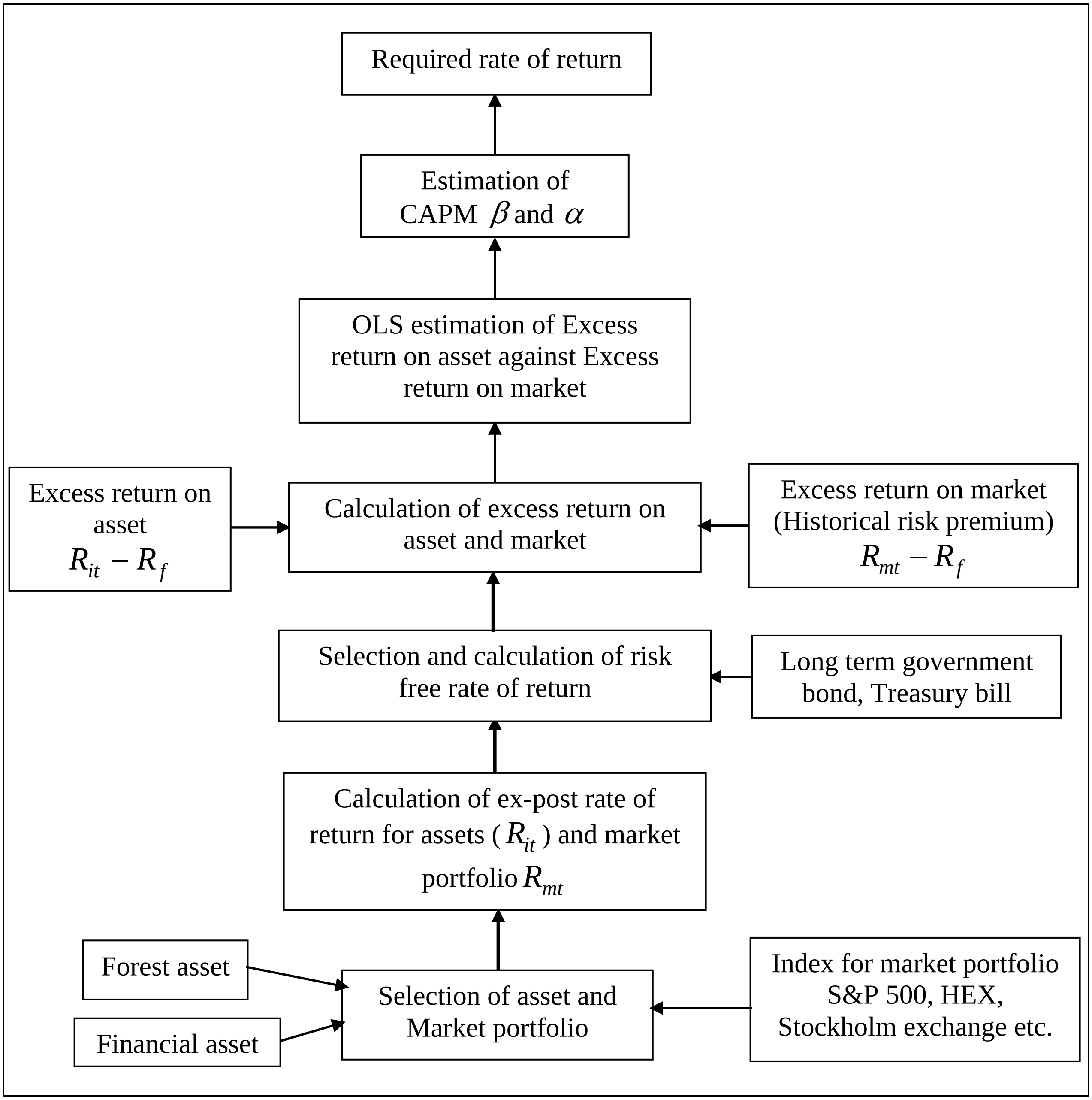

Figure 17: CAPM estimation steps

4.3 Approaches to estimate forestry return and their implication on beta

Washburn and Binkley (1989) examined the approaches in estimating forestry return and application of CAPM to forest assets due to differing assumptions on stumpage price, growing stock and bare land value used in calculating returns.

4.3.1 Stumpage prices

Stumpage prices are the most influential determinant of the value of hypothetical forests (Washburn & Binkley 1989). If one assumes that bare land and growing stock values track stumpage prices, holding costs are negligible, and timber growth is constant, then all of the variation in forestry returns arises from changes in stumpage price. Even when other assumptions are made, changes in stumpage price often account for the bulk of variation in returns (Washburn & Binkley 1989). In such case, β can be estimated to a good approximation from rates of change in stumpage price alone. The other components of forest asset value only affect the estimate of α (Washburn & Binkley 1989).

Cubbage et al. (1989) and Redmond & Cubbage (1988) have estimated the CAPM from rates of change in stumpage price. Thomson & Baumgartner (1988) demonstrate that, given their particular assumptions about growing stock and bare land values and holding costs, market-model coefficients estimated from rates of change in stumpage price alone are nearly identical to those obtained with their detailed series of constructed returns. Washburn & Binkley (1989) states that though the stumpage prices are the most abundant source of data for calculating historical returns to forest assets, their relative availability series of sufficient length or perceived accuracy is making difficulty in the CAPM estimation. When data on stumpage values are not available, or when they are of dubious accuracy, forestry returns must be calculated with some proxy measure for price (Washburn & Binkley 1989). Mills & Hoover (1982) and Mills (1988) used rates of change in log or lumber price as a proxy for rates of change in stumpage price and have calculated forestry returns.

Washburn & Binkley (1989) examined the effects of two important proxies: (i) bid prices for national forest stumpage in the West, and (ii) log or lumber prices to estimate current market value. They compared the mean, standard deviation, correlation with stock market returns, and the CAPM βs calculated from continuous rates of change in annual cut and bid prices for national forest saw timber stumpage in four western regions using the CAPM equation. Cut prices were found much less volatile and lower β value than bid prices for similar mean rates of change. They demonstrated that the bid prices used for national forest saw timber stumpage to measure current market values overestimated price variability and estimated CAPM consequently overstates the systematic risk.

Washburn & Binkley (1989) also examined the consequences of using rates of change in log or lumber price rather than stumpage price to estimate the CAPM. In the case of southern pine, the net result of the differences in volatility and correlation with market returns was surprisingly similar βs for stumpage, logs, and lumber. For Douglas-fir, however, the stumpage, log, and lumber βs were very different, ranging from 0.057 for saw logs to 0.649 for lumber indicating that the use of lumber or log prices to estimate the risk of owning Douglas-fir timber would be very misleading.

4.3.2 Growing stock value

Forestry is a capital-intensive production enterprise (Binkley 1985). Growing stock represents the capital of forestry and shares about three-quarters of the value of a fully regulated forest asset taken as a whole (Washburn & Binkley 1989). Despite of its difficulties in measurement of changes in growing stock over time and to measure the current market value of different ages of growing stock, it is crucial for evaluating the risk and return of timberland investments (Washburn & Binkley 1989).

There are two approaches practiced in US for estimating capital value of growing stock to construct estimates of the returns for forest assets (Washburn & Binkley 1989). Most researchers have assumed, either explicitly (Conroy & Miles 1987; Binkley and Washburn 1988a, 1988b) or implicitly (Redmond & Cubbage 1988), that the market value of growing stock is simply equal to its value if sold for immediate harvest in the stumpage market. Growing stock therefore has no value until it grows to a merchantable size. Other analysts (Thomson 1987, 1991a; Thomson & Baumgartner 1988; Wagner & Rideout 1991) have discounted expected future harvest revenues to obtain an estimate of growing stock value. Both approaches assume that the value of growing stock tracks the price of stumpage.

Washburn & Binkley (1989) compared these two approaches by calculating the value of the growing stock with the use two methods separately method in a 30 acre fully regulated forest of southern pine with certain assumption. They used current market values reported in their survey of southern forestland appraisers for various ages of young southern pine timber as a benchmark for assessing the accuracy of the two approaches. As a result, they demonstrated that the discounted value of future harvest revenues is nearly double the immediate harvest value. The lower capital value given by the immediate harvest approach yields a rate of return of 10.5% compared to 8.1% for the discounted harvest income. According to the appraisers, the immediate harvest value understates the value of growing stock and therefore overstates the return for the forest asset; the discounted harvest revenue overstates growing stock value and understates forest asset return.

Redmond & Cubbage (1988) examined an effect of the addition of growth to the model parameters. The addition of growth to the model simply increased the mean expected annual stumpage returns and the α value by the exact amount of the average annual growth per year but had little impact on β estimation.

4.3.3 Bare land Value

Like the value of growing stock, the current value of bare land is difficult to observe and records of its historical values are nearly nonexistent. As a substitute for actual data, researchers have used three approaches about rates of change in bare land value. Some indexes assume the bare land value of timberland tracks farmland values, timber price changes or inflation.

Some studies (Thomson 1991a, 1991b) included the value of bare land in their forestry return formula. However, Lausti & Penttinen (1998) & Lausti (2004) excluded bare land value in the forestry return estimation because of empirical evidence of market price. They assumed bare land value equal to zero. They found that the felling values of forest holdings have in most cases been higher than the actual market prices. In another study, Hyytiainen & Penttinen (2007) assumed constant bare land value in their return formula. Lundegren (2005) also found that forest estate values are likely to vary far less than actual timber prices.

Redmond & Cubbage (1988) assumed that the value of bare land changes at the same rate as the return for the timber component of the forest asset. Thus their measurement of asset risk such as β that are calculated from timber return (or rates of change in stumpage price) are assumed to apply to the land component as well. This approach finds support in the notion that bare land derives its value from the revenue it generates from timber production (Washburn and Binkley 1989).

Other researchers (Mills & Hoover 1982; Mills 1988; Binkley & Washburn 1988) have used rates of change in farmland values to measure rates of change in forestland values. Past values of bare forestland are back casted from the current value with historical rates of change in farmland value. This approach is valid to the extent that common factors similarly affect farmland and forestland value. The third approach assumed that bare forestland values change at the rate of inflation (Zinkhan 1988; Zinkhan & Mitchell 1988 through their analyses of the STIF constructed by Forest Investment Associates).

Washburn & Binkley (1989) compared these three approaches based on the alternative risk and return characteristics of bare timberland and of a fully regulated southern pine forest asset in Louisiana. They found that substantially lower mean and standard deviation of returns for both bare land and inflation rate assumption than for the rate of change in farmland-value assumption than they were for the timber-return assumption. In addition, same measures for the inflation rate assumption were substantially lower than those for the farmland-value assumption. They concluded that the timber-returns assumption results in a much higher β for bare forestland than and return of a composite timber and land asset, the same patterns emerge, although the effects of the different bare land assumptions are dampened through the addition of growing stock to the valuation exercise.

Applications of the CAPM to forest assets have relied on rates of change in period-average stumpage price. Timber prices are reported as period averages; that is, an average value of prices observed throughout a month, quarter, or year. In contrast, prices of the market and risk-free assets are reported as instantaneous values. Rates of change in period-average stumpage price span two periods of time; rates of change in values of the market and risk-free assets are typically calculated over a single period.

In US aggregate studies, the two approaches prevail in estimating the CAPM. Some researchers (Binkley and Washburn1988a, 1988b) have related annual-average forest returns to market and risk-free returns during the first calendar year. Others (Thomson 1987; Cubbage et al. 1988; Redmond & Cubbage 1988; Zinkhan 1988; Zinkhan & Mitchell 1988) have related forest returns to market and risk-free returns during the second calendar year.

Redmond & Cubbage (1988) used market and risk-free rates measured over the second calendar year to estimate negative βs of -0.2350 and -0.1575 from rates of change in the price of saw timber stumpage and rates of change in the price of pulpwood stumpage respectively. Zinkhan (1988) and Zinkhan & Mitchell (1988) also used second calendar year market and risk free rates to estimate negative β of -0.21 and -0.20, respectively, for a hypothetical, fully regulated Southern Timberland Index Fund (STIF). On the other hand, Binkley & Washburn (1988a) used market and risk-free rates measured over the first calendar year to estimate a positive β of 0.252 for a similar hypothetical forest property.

Washburn & Binkley (1989, 1990a) reports two problems due to the period averaging for analyzing forestry returns:

1) Rates of change calculated from averaged data are less variable than the corresponding rates of change in instantaneous values.
2) Period averaging introduces spurious first-order serial correlation into the rates of change in the averaged series.

To clarify the empirical implications of the two approaches to measuring the CAPM's explanatory variables, Washburn & Binkley (1989, 1990a) used first and second calendar year market and risk-free rates of return to estimate the CAPM for rates of change in eleven of the series of annual average saw timber stumpage prices analyzed by Redmond & Cubbage (1988): bid prices for Douglas fir, western hemlock, ponderosa pine, southern pine, mixed hardwoods, maple, and oak sold from national forests and prices for southern pine, ash, gum and oak sold from private land in Louisiana. The S&P 500 with dividends reinvested for the overall market portfolio, and a series of one-month U.S. T-bills as proxy for the risk-free asset were used and OLS regression was used to estimate the model if the D-W statistic for first-order autocorrelation of the error was within its upper bound for significance at the 0.05 level.

They compared CAPM parameters estimated with first and second calendar year market and risk-free rates to those estimated with properly measured explanatory variables. The results indicate that measurement of market and risk-free rates over the second calendar year (Redmond & Cubbage 1988; Cubbage et al. 1988; Zinkhan 1988; Zinkhan & Mitchell 1988) substantially underestimates the systematic risk of forest assets. Measurement of the explanatory variables over the first calendar year (Binkley & Washburn 1988a, 1988b) overestimates the systematic risk. Furthermore, the α values estimated with market and risk-free rates measured over the first calendar year were substantially lower than those estimated with second calendar year rates.

Washburn & Binkley (1989, 1990a) demonstrate that period-average stumpage prices are typically unbiased estimates of the arithmetic mean of prices at any $\boldsymbol{n}$ regular intervals within the period. They found the procedures for rates of change in the arithmetic average of asset values are directly applicable to estimation of the CAPM for forest assets and the rates of return for forest assets should be related to market and risk-free rates that are calculated as either (i) the geometric mean of true periodic rates, (ii) the arithmetic mean of true periodic rates, or (iii) the rate of change in arithmetic period average values. They conclude that the choice among the three alternatives is not consequential.

DeForest et al. (1989) concluded that the debate over the 'best βs' may be not as important as the fact that forestry investments would reduce the variability of a well-diversified portfolio. They argued that the approach of comparing timber price changes with returns from the first year seems less desirable, because investors are concerned about returns for assets during similar time periods.

4.4 Application of CAPM in forestry

The parameters in CAPM are useful to explain trade-offs relationship between risk and return. In business finance, CAPM is used in investment management which uses the β & α. CAPM is used to estimate the costs of capital useful in discounting and valuation in capital budgeting and valuation. It is also used in risk management used in formulating investment objectives.

During the decade of 80s and 90s, several US researchers have used asset pricing models: either Sharpe's (1963) single index market model (with returns to the overall market portfolio serving as the index) or the CAPM to timberland investments to measure their risk and evaluate their performance (e.g. Thomson 1987; Zinkhan 1988; Zinkhan & Mitchell 1988; Cubbage et. al 1989; Redmond & Cubbage 1988; Binkley & Washburn 1988a, 1988b, Zhang & Binkley 1993, Binkley et al. 1996). Subsequent analysts have examined the diversification potential of timberland investments in other geographic regions (e.g. Thomson 1987; Thomson & Baumgartner 1988; Conroy & Miles 1987; Zinkhan & Mitchell 1988; DeForest et al. 1989). Studies on the optimization of return and variance to determine the composition of portfolios were conducted by, e.g. Mills & Hoover (1982) and Thomson (1991). Some key references based on CAPM are Olsen & Terpstra (1981), Redmond & Cubbage (1988), Cubbage et al. (1989), Thomson (1989), Washburn & Binkley (1990a, b) and Zinkhan et al. (1992).

Several authors have applied MPT and CAPM in forestry. Hotvedt & Tedder (1978) used CAPM to calculate returns and beta values for several forest products firms. Mills & Hoover (1982) used portfolio theory and the calculation of alpha to indicate that total investments in mid-western hardwood forest land (including land, stumpage prices, and growth) provided advantages of improving returns and reducing risk as part of a diversified investment portfolio. Fortson (1986) reviewed CAPM in general and its

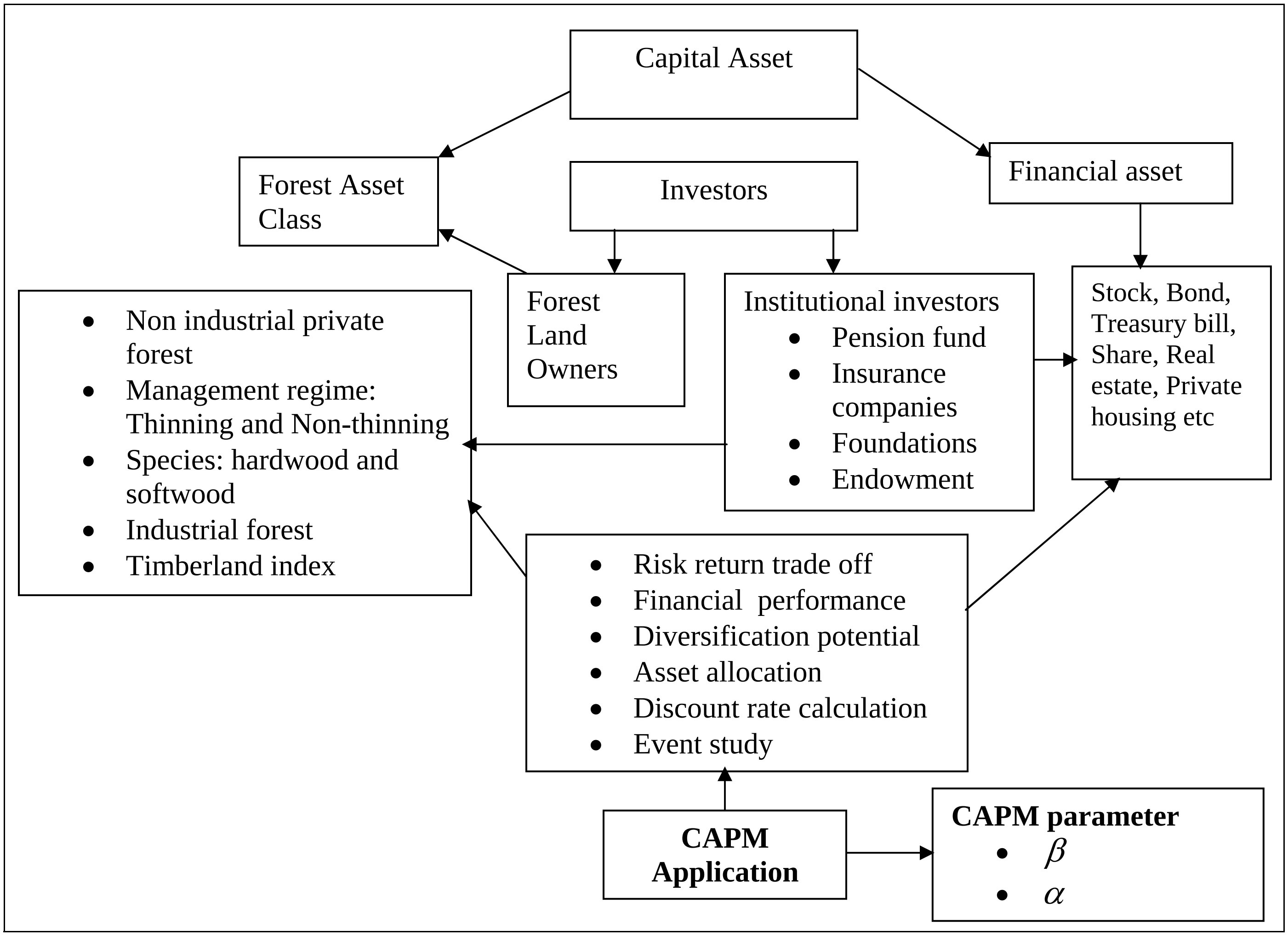

Figure 18: Application of CAPM in forestry

application to industrial forest land investments. He concluded that forest land investments did provide considerable advantages to forest products firms because they are capable of supporting large amounts of long-term debt, and land investments are relatively low risk when used in the production of timber. Olsen & Terpstra (1981) applied CAPM to the spot market for softwood logs in Oregon from 1968 to 1978. Results indicated that the market was competitive and that log investors earned a return approximating that on U.S. T- Bills.

DeForest (1989) examined the impact of the different betas, annual returns, and variability of those returns on a market portfolio incorporating varying percentages of timber investments. Zinkhan et al. (1992) summarize the literature and describe in detail the diversification benefits with respect to other asset classes. In particular, they emphasize how timberland investments have generated low risk-adjusted returns and exhibited low or little correlation with, for example, the stock markets, enhancing their value as a portfolio diversifier.

Literature suggests that MPT and CAPM in forest economics has been used to a very small extent in all of Europe, with the exception of Finland and Sweden. Penttinen & Lausti (1995), and Lausti & Penttinen (1998b) analyzed forest ownership and investments risk and return using CAPM in Finland. They implemented CAPM to Finnish economy during the period 1972-1994 and to study asset allocation of the economy. They included different asset classes such as forestry, real estates as well commercial real estates, shares and bond markets in to the market portfolio.

Penttinen et al. (1996) examined the return and risk of forest ownership based on MPT, and comparing forestry and other investments such as stocks, public bonds, private real estate, commercial real estate, and corporate debentures. The forestry return was based on stumpage prices, commercial felling volumes, silvicultural costs, and the growing stock volumes of the NFI. They included inflation in the analysis.

Penttinen & Lausti (2004) compared stumpage price change and inflation as well as between forests and other assets private housing, offices, bonds, debentures and stock as well as its subset, forest industry stocks. The competitiveness of forest and forest industry stocks was assessed in the framework of the Finnish portfolio using the risk-adjusted Sharpe ratio, correlation.

Lundgren (2005) used CAPM to evaluate the investment performance of Swedish timberland. British researchers McKillop & Hutchinson (1990) used the CAPM to estimate a nominal discount for both private and public forestry investment in the United Kingdom.

The Fig. 18 shows that how the CAPM is linked to investor and land owner to have an understanding of their potential investment in forest asset and other financial asset. The CAPM have been applied in Forestry to study risk and return, evaluation of performance of forest investments, to assess the diversification potential, asset allocation study, determination of discount rate in capital budgeting and even study, which are discussed below with the result:

4.4.1 Performance evaluation

The evaluation of investment performance is of importance for both academics and practitioners. The finding of superior performance will influence the way in which investors allocate their wealth across various professionally managed portfolios and set appropriate management fees (Chang 2004). Different investors considers risk differently, therefore the use of measuring risk is also different (Binkley et al. 1996). Investment managers and investors look at a variety of measures in evaluating and comparing investment asset which includes: α, β, standard deviations, Sharpe ratios, return-risk ratio and correlation coefficients are among the tools in the investor's analysis kit. Researchers also have used these parameters independently to evaluate the return of some asset class relative to some measure of risk in their studies. In this heading, performance of timberland, forest product companies in comparison to other financial assets have been discussed based on the review of literatures in US, Sweden and Finland.

Chambers (1989) shows the visual concept of CAPM (Figure 10). All investments lying on the required rate of return line have met market based investment expectations for the particular asset. All investments lying above the line have provided superior performance relative to the market for the amount of risk taken, and conversely, all lying below the line have provided inferior risk adjusted returns to the total portfolio.

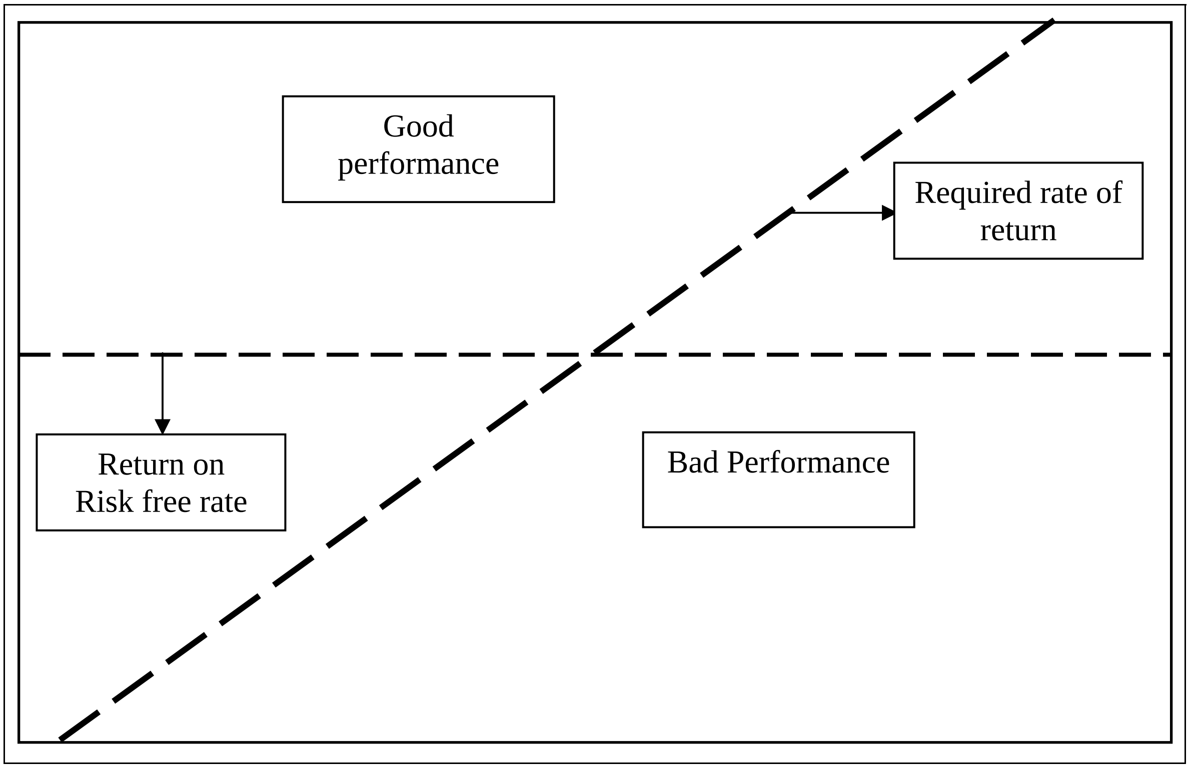

Figure 19: Visual concept of CAPM (Source: Chambers 1989)

US

Binkley & Washburn (1994) analyzed the financial performance of three different investment vehicles on which investors can hold timberland using CAPM. These were direct, privately traded non industrial ownership (southern pine timberland), publicly traded units of securitized timberland limited ‘partnership’ (3 companies included) and publicly traded stock in vertically integrated forest products companies (9 companies in West, South, and Northeast) that own substantial areas of timberland. For the comparison, they also selected other financial assets such as: Common stocks, small company stocks, corporate bonds, and Long-term corporate bonds, long term US bonds interim term US bonds, Treasury bills and inflation. They separately calculated historical return, standard deviation, correlation coefficients, α , β for all these vehicles and financial assets for the period 1977-190 and 1986-1990, except for limited ‘partnership’ the holding period was during the years 1986 through 1990. As an the performance benchmark, they calculated returns for a portfolio of forest product company timberland limited ‘partnership’ weighted by the estimate of the value of their timberland holdings. The result showed that β for privately traded, direct timberland investments were negative. The α s were positive (although not statistically different than zero), indicating that direct timberland ownership had generated excess returns relative to its systematic risk.

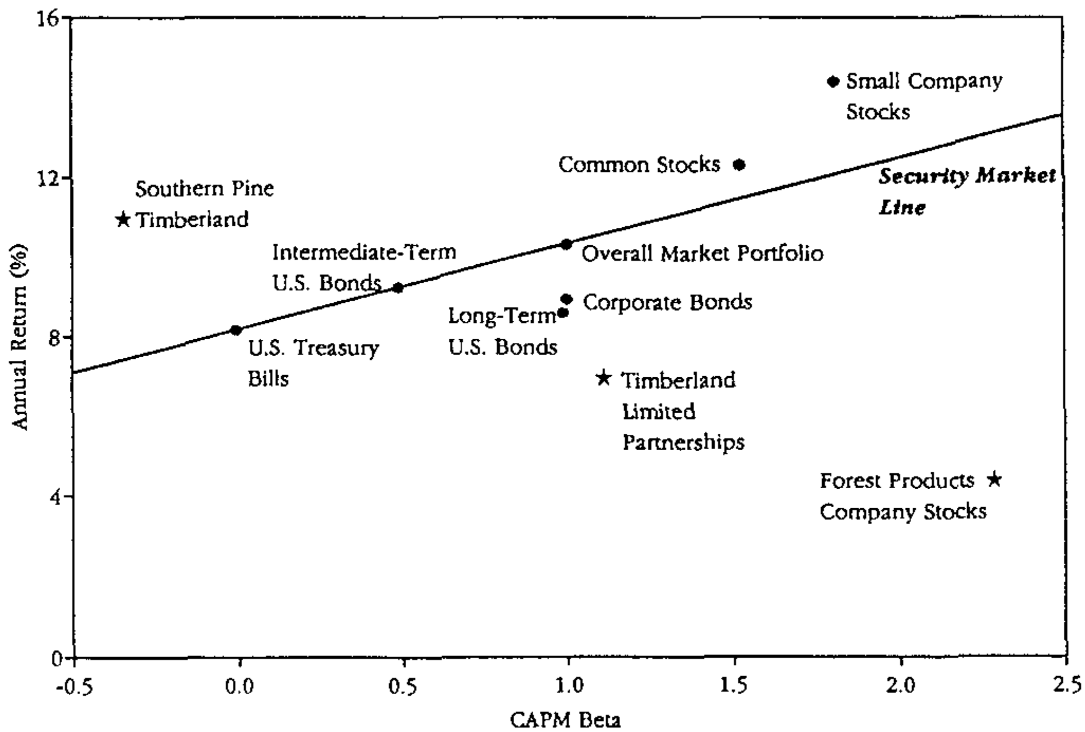

Figure 20: The Security Market Line. (Source: Binkley and Washburn 1994)

On the other hand, Forest products company stocks had high β value, and the α less than zero for the period 1977-1990. The performance of the securitized, publicly traded timberland limited partnerships was intermediate between the other investment alternatives. Returns for forest products companies were highly correlated with returns for stocks and bonds. On the other hand, direct investment in southern pine timberland showed negative correlation with overall market portfolio. Based on these result, they concluded that direct investment in privately traded timberland were preferred effective timberland investment vehicle for portfolio diversification. The Figure 20 shows that a timberland investment is above the security line. Since, timberland investment has positive α, it is either underpriced, have high transaction costs or are subject to some risk factor that is not measured by the CAPM (Binkley & Washburn 1994).

Sun & Zhang (2001) examined CAPM using data consisting of forestry-related assets, a farmland index and other assets, including government bonds. The study was carried out to compare the financial characteristics of all major forest-related investment vehicles as a result obtained from both CAPM and Arbitrage Pricing Theory (APT). They selected 18 investment portfolios or price indexes, eight of which are forest-related, and the rest serve as approximate control and comparison groups for return generation process of all assets. The eight forestry-related assets are Timberland Performance Index (TPI), NCREIF Timberland Index (NCREIF-T), Timberland Limited Partnership Portfolio (TLP), Large Forest Industry Company Portfolio (L-FICP), Medium Forest Industry Company Portfolio (M-FICP), Southern Stumpage Price Average (SSPA), Pacific Northwest Stumpage Price Average (PNSPA), and Lumber Futures (LUMBER). All data have quarterly returns from 1986 to 1997 with 48 observations except the returns for NCREIF timberland index, which have only 44 observations (1987-1997). They calculated α and β regressing the excess return on all forestry related asset against the excess return on S&P 500. The result showed that the α for two timberland indexes, TPI and NCREIF-T were significantly different from zero at the 10% level. There were no significant excess returns for other six forestry-related assets. The β for the large forest industry company portfolio (1.04) was bigger than one and significant at the 10% level. The β for the medium forest industry company portfolio (0.94) was very close to one. The β for the timberland limited partnership portfolio was 0.52 and also significant at the 10% level. These results indicated that timberland alone had a lower risk level than the combining of timberland and timber processing facilities (i.e., forest products firms). The β for other 5 assets were not found significant at the 10% level.

Zinkhan (1988) used the CAPM to determine β for southern pine timberland. He used a privately-constructed price index- STIF, which reflects timberland value appreciation and net returns for harvests from 1956 to 1986. Using simple linear regression, he compared total rate of return data from STIF with the S&P 500 and found β of -0.21.

Zinkhan & Mitchell (1990) used CAPM to determine α and Sharpe index for southern pine timberland. They used privately-constructed price index STIF as a benchmark of comparison for evaluating both timberlands' performance relative to other asset class and given timberland investment manager. They regressed the excess returns of a given asset class STIF relative to the excess return of S&P 500 to derive α as stated earlier by ordinary least square regression. They also calculated Sharpe ratio for both STIF and S&P 500 by using the equation 22 & 23. The result (Table 4) showed that the STIF did not perform well relative to the S&P 500 according to the Sharpe ratio but outperformed the S&P 500 according to the α.

Table 6: Sharpe index and α for STIF and S&P 500, 1977-1987 (Source: Zinkhan and Mitchell 1990)

	Sharpe ratio*	α
STIF	*0.18*	*6.20***
S&P 500	*0.35*	*0****

* Statistical significance is not measured

** Statistically different from zero at 0.05 level of significance

***The market portfolio possess zero alpha by definition

According to Zinkhan & Mitchell (1990), this variation was common and would depend open the investor's judgment and decision. They explained that the institutional investors who hold the diversified portfolios would concern on the α measure for a given investment alternative and the investor who hold few other investment would be more concentrated on Sharpe ratio.

Olsen & Terpstra (1981) applied CAPM to study risk return and competition in a major spot market for softwood logs in Oregon from 1968 to 1978. The α and β approximately equal to zero indicated that that the market was competitive and that log investors earned a return approximating that on 13-week US T-bills. In addition, log returns were not found to be highly related to measures of non diversifiable risk .The result implied that the financial risk associated with the large investment hold by the Oregon wood products manufacturers may be through portfolio diversification. They concluded that the CAPM to the secondary markets for cut timber is promising. They suggested for the better result additional empirical research with larger samples and other log markets, inclusion of transportation cost and appropriate suitable stock market indexes as proxies for the global market portfolio.

Redmond & Cubbage (1988) and Cubbage et al. (1989) regressed 22 stumpage price series against S&P 500 and calculated β and α regression coefficients as measures of the systematic risk and the risk-return efficiency in each price series. They found low or negative β which would mean that that stumpage prices were often opposite market cycles for the S&P 500 and could therefore reduce the volatility of many portfolios.

Baumgartner & Hyldahl (l991) used historical stumpage price data from three Midwestern states to determine the risk, return and efficient portfolios for timberland investments of major commercial species. They found that the lowest risk-return portfolios included hickory, silver maple, sugar maple and black walnut. The study also found a large variation in β for the same species in different states.

Wagner & Rideout (1991) compared the nominal and real α for the two assets: thinning and non-thinning asset as an alternative forest management regime. They found positive α for the non-thinning asset in both nominal and real terms. It indicated that returns were greater than necessary to compensate for the given level of systematic variability. For the thinning asset, the nominal (real) α were negative (positive) indicating returns were lower (greater) than necessary to compensate for the given level of systematic variability. The inflation was influencing the result. They demonstrated that if the management action decreases (increases) the β and increases (decreases) the expected return, there is a potential financial incentive for the management regime to include (exclude) the investment. If the management action has no effect on the β, the decision to include the investment is based on the expected return. In this case, the financial decision concerning thinning would be based on the expected return. They observed majority of the simulated forest assets' variability was nonsystematic or diversifiable. Hence, adding either of these forestry assets to a well-diversified portfolio would increase the portfolio's expected return while not substantially contributing to the variance of the investor's portfolio.

Thomson (1987) calculated mean returns, standard deviations, β, R^2, and significance levels for the S&P 500 and for eight Midwestern and Southern timber-growing investments, represented by stumpage price series. He used annual saw log stumpage price data from 1960- 1980 for pine, ash, oak, and gums in Louisiana. White pine, red pine, aspen, and red oak stumpage prices in Minnesota stood for his Midwestern forestry investments. The timber betas he calculated were all negative, ranging from -0.91 to -0.07. They averaged -0.37 with a standard deviation of 0.3193. None of the estimated β values were statistically significant at 5% level.

A study by HTRG (2003) based on series of historical returns for timberland calculated from the JHTI and the NCREIF Timberland Property Index suggests that timberland investments lie above the capital market line. In other words, the level of timberland returns has been relatively high given their volatility.

Binkley & Washburn (1988a) estimated at Loloblly pine plantations in South Carolina had mean annual returns as high as 11.1% (for the period of 1956 to 1984) and negatively correlated with other assets. Mills (1988) reported that the annual rates of return (between 1959 and 1978) of certain Midwestern timberland tracts were negatively or weakly correlated with 11 of the 14 investments analyzed. The negatively correlated such alternatives were: the S&P 500 common stock average, residential housing, over the counter-stocks, preferred stocks average, no load mutual fund average, preferred stocks, T-bills, Treasury notes, municipal bonds, long term corporate bond, saving deposit S&L associate, Time deposits commercial banks and commercial paper. The result showed the strong potentiality of forest investment for diversifying the risk of investment portfolios. Conroy & Miles (1989) reported negative correlations between their southern pine timberland index and common stocks, small cap stocks, and a long-term Treasury security index.

Caulfield (1998b) compared returns, standard deviations, and correlations between the TPI and the performance of other major assets with large domestic stocks (measured by the S&P 500), small domestic stocks (Russell 2000), bonds (Shearson Lehman Govt.

/Corp. Bond), foreign stocks (MSCI EAFE-Morgan Stanley Morgan Stanley Capital International Europe, Australasia Far East Index), commercial real estate (NCREIF Real Estate) and T- bills (Short term US government bond) for the period between first quarter 1981 to second quarter 1996s. The result showed that only commercial real estate and T-bills had lower standard deviations. Timberland returns exceeded commercial real estate and T-bills returns by a wide margin. Timberland returns were very close to bonds, lower than small stocks, and followed large domestic and foreign stocks substantially. TPI had low correlations with most other assets, ranging from -0.40 with commercial real estate to 0.12 with the S&P 500 (Fig. 21). Commercial real estate and T-bills were found with lower standard deviations. The TPI's standard deviation was less than half of large domestic stocks, and slightly lower than bonds. The risk adjusted ratio (return-risk ratio) for TPI was higher than the entire asset except T-bills- the benches mark 'risk-free asset'.

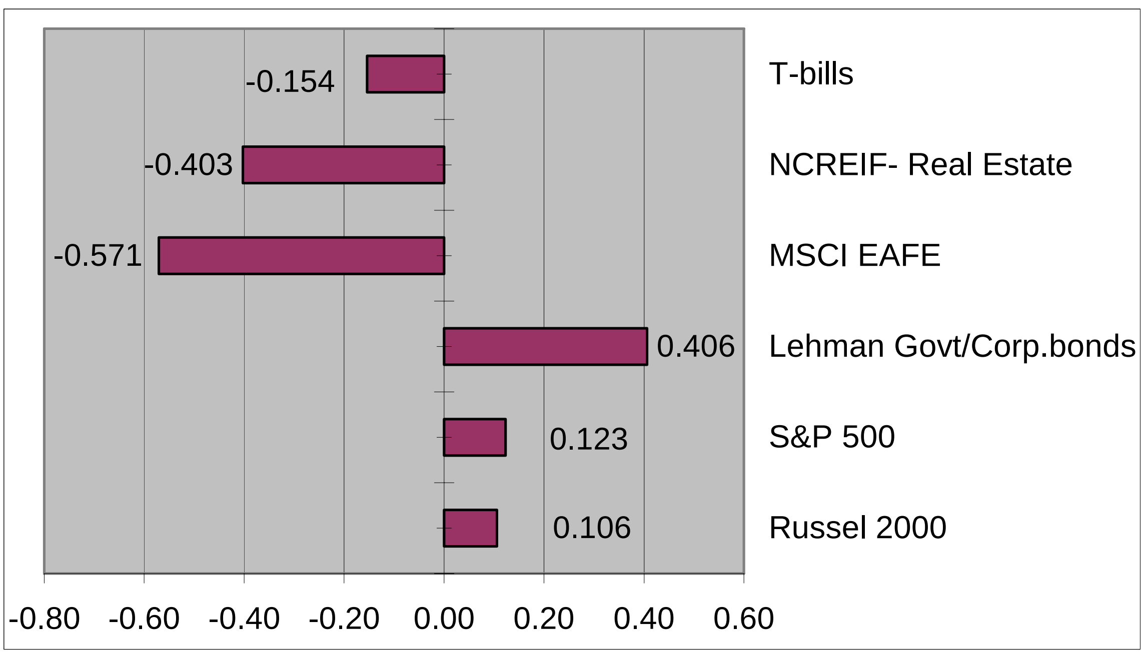

Figure 22: Correlation with TPI for the period Q1 1981-Q2 1996 (Sources: Caulfield 1998b)

Sun & Zhang (2001) observed low correlation coefficients (0.41) between timberland limited partnerships and S&P 500 than the other large and medium forest industry company portfolios, which imply limited partnership has diversification potential than others.

Binkley et al. (2005) found that that timberland returns have had either negatively or significantly positively correlated with other assets, including equities and fixed income but not correlated with the returns from such other alternatives assets as venture capital and direct energy investment (Fig.22)

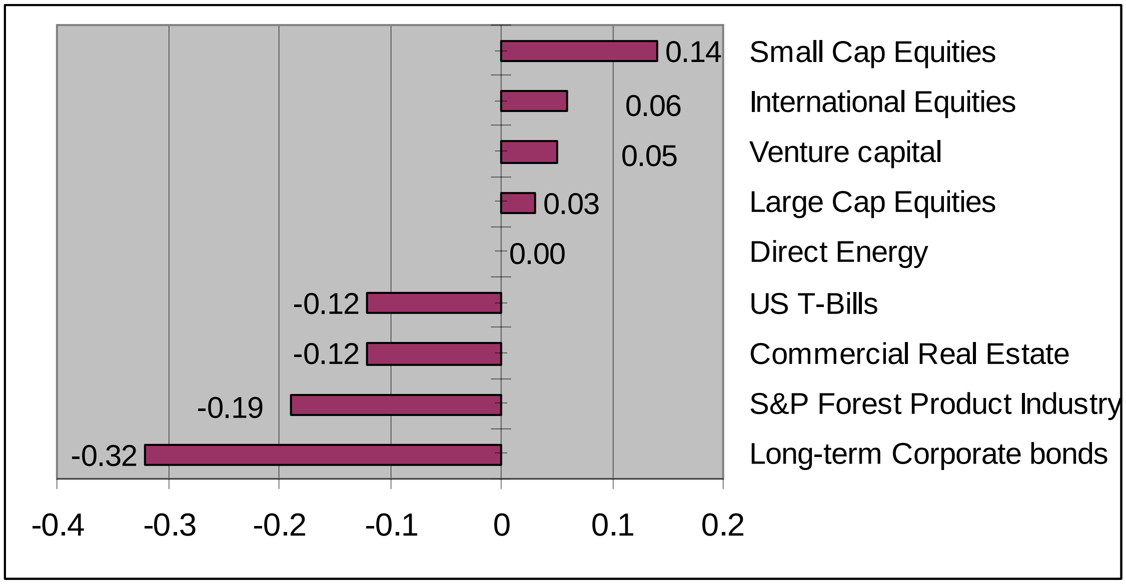

Figure 23: Correlation with timberland returns, 1975-2004 (Sources: Binkley et al. 2005) Note: S&P Forest products Index 1977-2004

IWC (2006) also examined the correlation of timberland investment with other financial investment. The result shows that timberland investments correlate negatively with real estate returns. It implies that the addition of timberland asset in real asset portfolio can provide diversification benefit. On the other hand timberland investments positively correlate with other financial investment stocks and bonds, indicating that there are sizeable benefits to be achieved by including timberland in a diversified portfolio. The result also shows that those timberland investments, to some extent, provide a hedge against inflation (Fig.23).

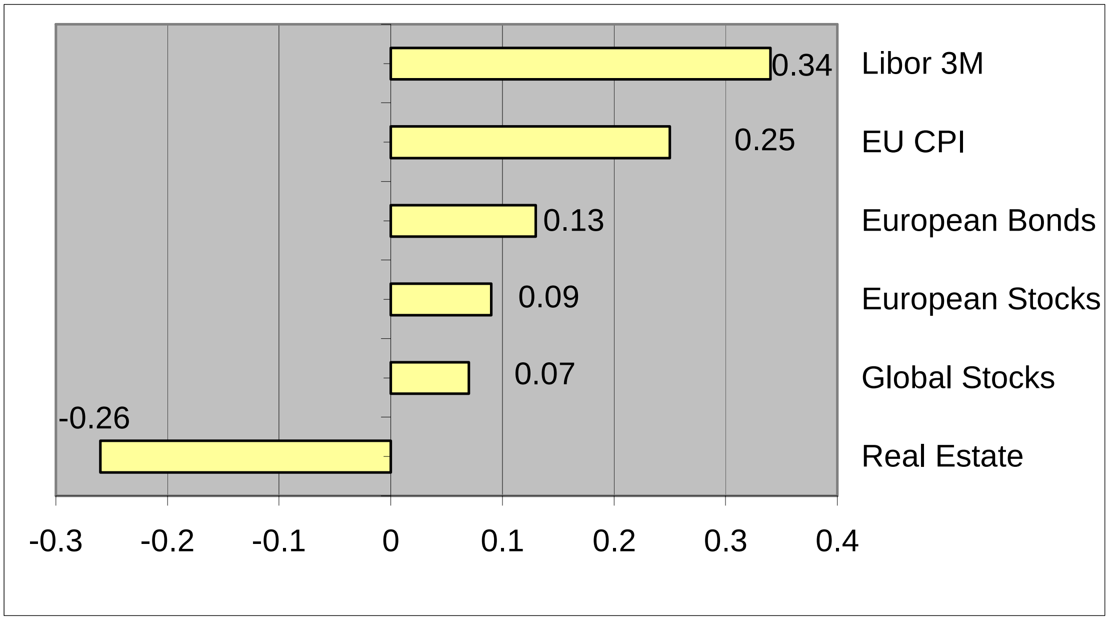

Figure 24: Historical correlations with US timberland returns based on quarterly data between Q1 1987 and Q4 2004. (Source: IWC 2006)

Binkley et al. (2005) compared Sharpe ratio of US timberland with other 8 financial investments. Their result shows that timberland with a Sharpe ratio 0.50, its risk adjusted return performance has been as good as that for large cap and equities and far better than that of either publicly traded forest product companies or such other alternative assets as private equity or direct energy investments (Fig.24).

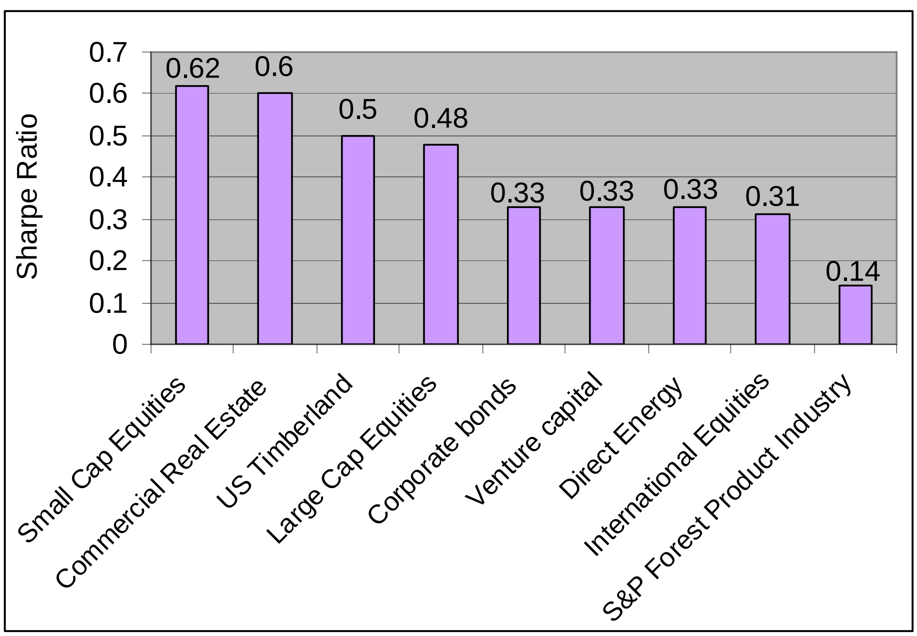

Figure 25: Sharpe ratios 1975-2004 (Sources: Binkley et al. 2006) Note: S&P Forest products Index 1977-2004

IWC (2006) calculated the Sharpe ratio for both the historical data according to NCREIF Timberland Index and the other indexes used by IWC based on the identified risk and return characteristics for the asset in the investable universe.

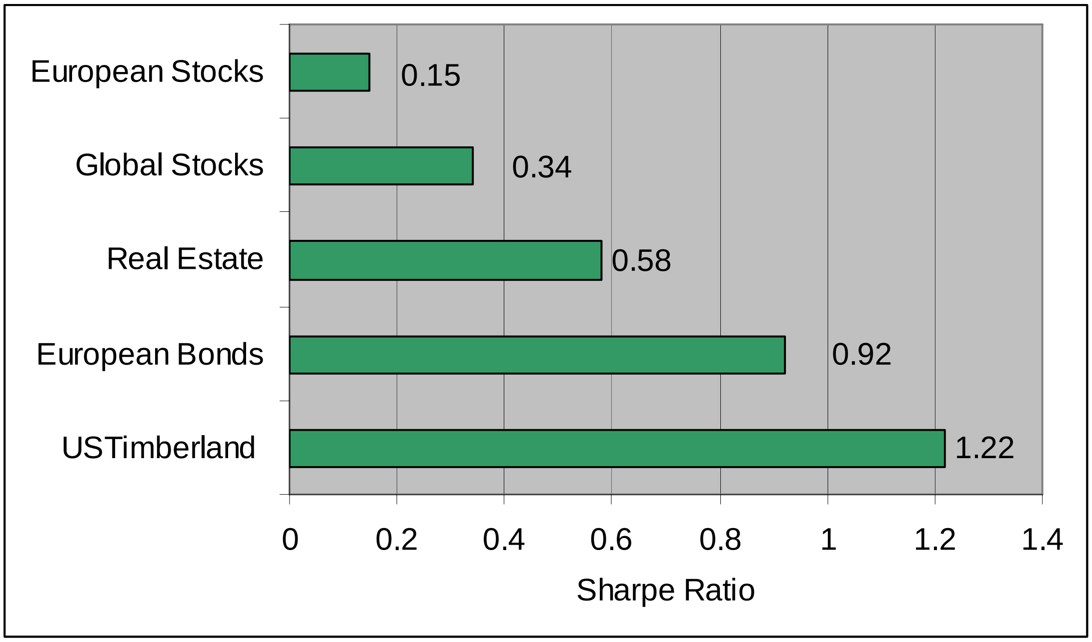

Figure 26: Sharpe Ratio for each asset in the investable universe (Source: IWC 2006)

They used the calculated rate of return from Libor 3M as the risk-free rate of return and the returns based on historical data Q1 1987 to Q4 2004. The Fig. 25 shows that the timberland's performance is very attractive as it holds excess return to variability than other financial assets.

Sweden

Lundgren (2005) evaluated the investment performance of Swedish timberland for thee period 1965-1999 using the CAPM. He measured β, α and Sharpe Ratio (Table 5). Based on his result, Swedish timberland investments well performed its potentiality in diversification potential. He demonstrated that timberland returns has low correlation with the market portfolio and return was higher comparing to other alternative investment in the same risk class indicating diversification potential for Swedish forests. The results are in line with similar studies performed in US.

Table 7: β, α ***for timberland and Sharpe ratio for timberland and market portfolio for the period 1965-1999 (Source: Lundgren 2005)***

	β	α	Sharpe Ratio
Timberland	-0.03	0.06	1.29
Market portfolio			0.30

Result showed β with -0.03 (not statistically different from 1 but not 0) low negative correlation with the market. It implied that the timberland clearly had diversification potential over the study period. The α (0.06) was positive. Given its level of risk, the timberland show positive excess return and outperforms the market portfolio by 6%. This implies that forest assets have a higher return than other investments in the same risk class. Sharpe ratios for timberland and market portfolio were 1.29 and 0.30 respectively. It implied that timberland return outperformed the market portfolio quite strongly when it comes to expected return in relation to risk. However, he concluded that the, construction of the (Land value plus Total value) variable (interpolating between years with data) may underestimate the year to year variance of the return series, and thus overestimate the Sharpe ratio for timberland. Hence, this measure should be interpreted with some caution.

In another study in Sweden, Lonnstedt & Svensson (2000) applied the mean-variance framework based on MPT in to analyze the risk and return in NIPF investment and compared the result with other alternatives: related with grain production, milk production, bank and share for the period 1968–1994. The forest holdings were found a medium-high return and a high risk asset. Shares showed high returns and a relatively high risk. Bank assets showed low returns and a low risk. The lowest returns were seen for agricultural holdings. The observed negative correlations for forest holdings with several other assets imply that the forest can be a potential for portfolio risk diversification (Fig. 26). The result indicated that it would be of interest for NIPF owners to reduce their investments in timberland and increase their share holdings.

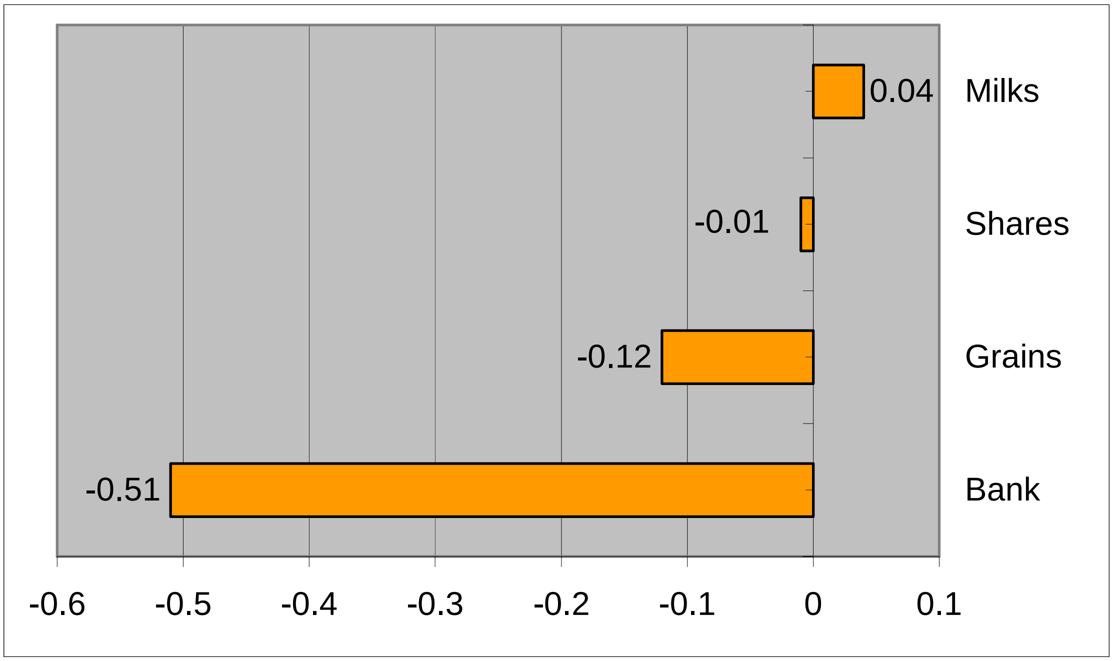

Figure 27: Historical correlations with timberland returns based on annual data between 1968 -1994 (Source: Lonnstedt & Svensson 2000)

Finland

The Finnish empirical evidence revealed a very significant correlation only between forestry and private housing (Penttinen et al. 1996). The systematic risk of forest ownership (β) was found relatively high at 0.6 and α of forestry was negative 0-2.4 (Lausti & Penttinen 1998b). Penttinen et al. (1996) reported negative risk-related Sharpe ratio for forests in 1984-1994. The reason of this result might be due to the influence of the recession at the beginning of the 1990s (Penttinen 2007). The correlation of forest ownership was also found significant with both private housing and commercial real estates for the same period. Penttinen & Lausti (2004) reported a lower real return for forest ownership (2.6%), medium return for housing (4.6%) and higher return for forest industry stocks (7.6%) in the 1972-2003 periods.

In another study by Penttinen & Lausti (2004), Sharpe ratio (Fig.27) of NIPF ownership was found as (0.01) which was lower than that of private housing (0.18), and was well below that of stocks (0.20). They also found that forest ownership has been both a high risk (15.5%) and low return (10.8%) investment in Finland over the period 1972-1994 with average inflation of 7.5%.

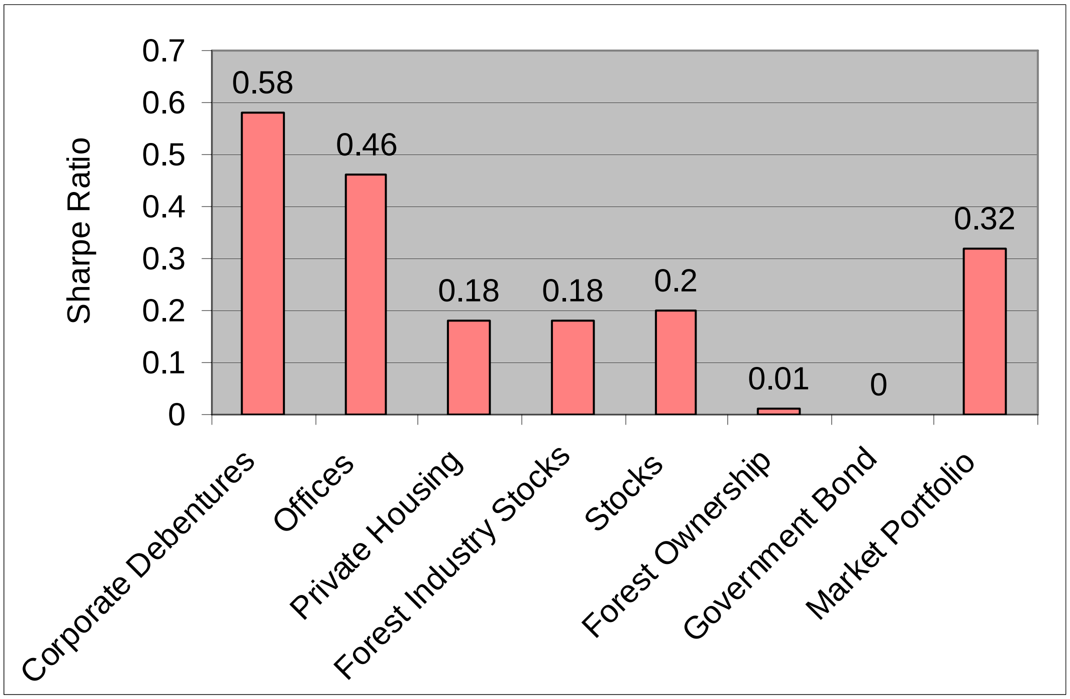

Figure 28: Sharpe ratios of various asset classes in Finland 1972–2003 (Source: Penttinen and Lausti 2004)

A study by Penttinen et al. (1996) showed that the forestry has been both a high risk (15.5%) and low return (10.8%) investment in Finland over the period 1972-1994 with average inflation of 7.5%. Penttinen & Lausti (2004) classified offices and stocks (as the high return-high-risk classes, while investment in private housing and NIPF ownership as medium return and medium risk class and government bonds as low risk-low return classes. In another study, Lausti (2004) reported forest ownership having the lower return and higher risk level than for private housing. He also found that the return to risk relationship of forest ownership has not been as good as that of stocks or private housing over this period 1972–2003.

Penttinen & Lausti (2004) analyzed correlation of forest ownership with other investment and observed only statistically significant correlation between private housing (0.55). They found forests slightly behind housing in competitiveness benchmarking places. The forest ownership was found positive correlation with inflation and negative correlation with corporate debenture and bond (Fig. 29).

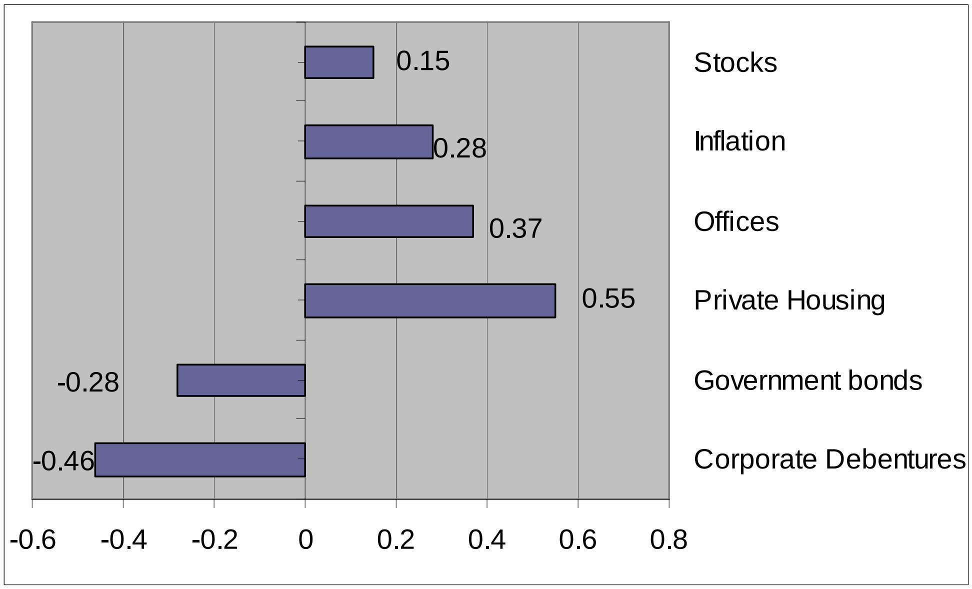

Figure 29: ***Correlation matrix of different asset classes with forest ownership (Annual data 1972-2003, except for corporate debentures 1972–1994). (Source: Penttinen and Lausti 2004)***

Comparison of return and risk in selected countries:

The table 8 shows the nominal, real return and standard deviation of different ownership and index in selected countries. It demonstrates how that the nominal and real return is higher in USA timberland than the Swedish and Finish timberland. Finish timberland was found with the lowest return among other forestland.

Table 8: Comparison of risk and return in Swedish, Finish and US Timberland

Country	Ownership/ Index	Period	Nominal return (%)	SD (%)	Real return (%)	Source
Sweden	NIPO	1968-1994	14.9	7.7	_	Lonnstedt & Svensson (2000)
Sweden	Swedish timberland	1965-1999	16.1	30.2	_	Lundgren (2005)
Finland	NIPO	1972–2003	8.4	13.4	2.6	Penttinen & Lausti (2004)
USA	NCREIF	1987-	15.3 %	8.9	11.6	IWC (2006)

	Timberland Index	2005				Binkley et al. (2005)
USA	TPI	Q1 1981 –Q2 1996	11.06	6.64	_	Caulfield (1998b)

4.4.2 Asset allocations

The result of risk return study can be used in asset allocation decision. Asset allocation is the process of dividing or allocating an investor's portfolio among a number of major asset classes (Sharpe 1992). The purpose of asset allocation is to reduce market risk by diversifying the portfolio. A portfolio or asset allocation that maximizes return for the level of risk is called an efficient portfolio.

The ideal asset allocation differs based on the risk tolerance behavior of the investor. Asset allocation should be consistent with an investor’s goals, constraints and time horizon. The goal of asset allocation is to achieve the highest return for the acceptable level of risk, or alternatively the lowest risk for a required rate of return. By combining assets with different characteristics in a portfolio, an investor can achieve higher returns with lower risk over the long term. Adding high risk asset classes and investments to a portfolio may seem risky, but it’s likely the net effect will be to both higher returns and lower the risk of the portfolio.

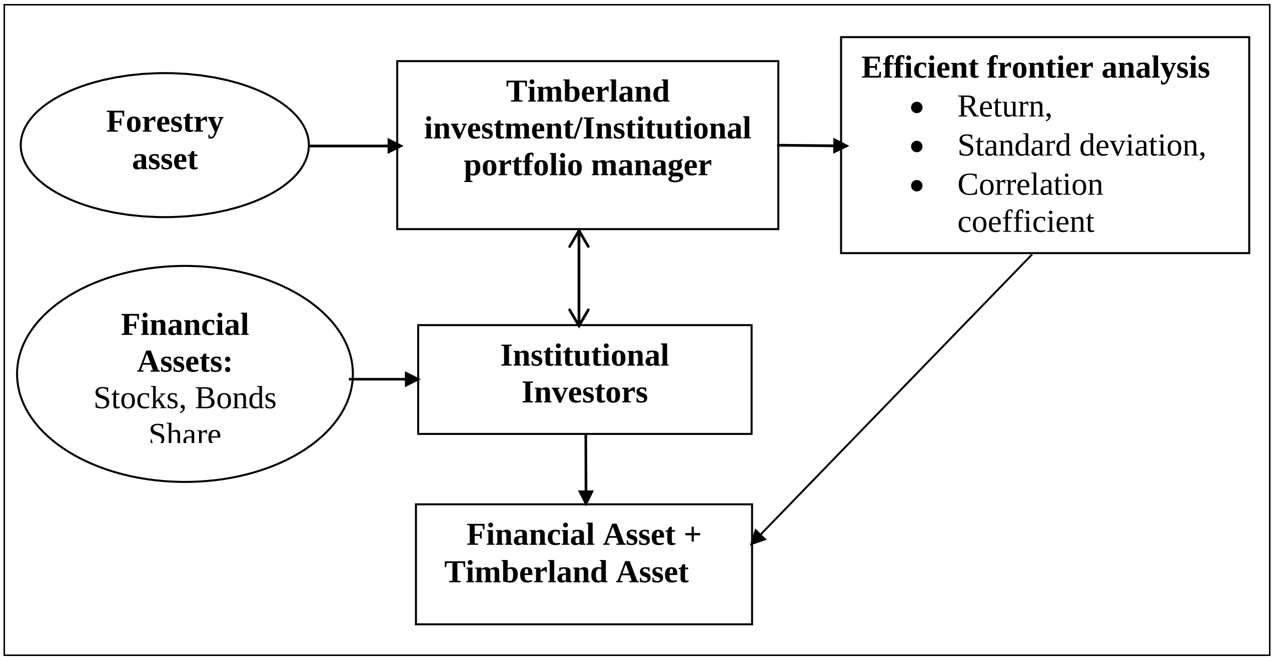

Figure 30: Asset allocation of Forestry asset to investor's portfolio

The Fig. 30 illustrates that how the timberland investment manager helps to investors in identifying timber assets allocation to their portfolio asset. Institutional investors hold the financial asset and they want to seek to diversify the portfolio risk by adding an asset which has a low or weak correlation with their financial assets. Timberland manager helps to identify that asset based on the risk, return and correlation study and perform the efficient frontier analysis. In general terms, the most risk-efficient portfolios are formed by mixing assets with negative or weakly positive correlations. The benefits of including timberland in an investment portfolio have been analyzed through an efficient frontier analysis.

MPT indicates that assets having low correlations with one another, when combined in portfolios, minimize the portfolio risk for a given level of expected returns. Thus, the weak correlations with traditional assets strongly imply that given the competitive returns and risk associated with timberland investments, timberland has been found to be potential to reduce institutional portfolio risks. The CAPM result is more robust in asset allocation of timberland investment through portfolio analysis or following optimization procedure. When the negatively correlated asset (such as timber) possess positive α and negative β, the possibility for inclusion in portfolio will be further enhanced (Redmond & Cubbage 1988).

Because timberland asset offers many advantages to the investor in diversifying portfolio risk, investors are interested in allocating investment's portfolio asset to timberland (Mills 1998; Conroy & Miles 1989; Zinkhan & Mitchell 1990; Redmond & Cubbage 1988; Caulfield 1998b, IFC 2006, Binkley et al 2006, HTRG 2003). However, the amount and the percentage of asset allocation depend on a number of factors, including the desired risk-return profile of the investor (Zinkhan & Mitchell 1990). According to MPT, the prudent investors prefer portfolio with highest (lowest) expected return (risk) for a given level of risk (expected return). The notion of well diversified portfolios implies that the risk of the well diversified portfolio is its variance and the risk of a particular asset is not its variance.

The data input needed for any asset allocation decision study are estimates of risk defined by the standard deviation, rate of return, and correlation of any asset combination represented in the investable universe (IFC 2006; Caulfield 1998b; Zinkhan & Mitchell 1990; Binkley et al. 2005). These researchers have conducted asset allocation studies based on the historical performance of forestry and other financial assets.

Zinkhan & Mitchell (1990) and Conroy & Miles (1989) used indexes based on hypothetical properties to compare the performance of timberland to other financial asset classes and showed how adding timberland to an asset allocation influences risk-return relationships for institutional portfolios. Zinkhan & Mitchell (1990) found that with an addition of 30% of the STIF to a group of financial asset alternatives reduced the risk of efficient portfolios by an average of 43%.

Mills & Hoover (1982) used a linear approximation technique to compute minimum risk portfolios of timber, agricultural and financial assets. They calculated the α to indicate that total investments in mid-western hardwood forest land (including land, stumpage prices, and growth) provided advantages of improving returns and reducing risk as part of a diversified investment portfolio. Their analysis focused on the decision of whether to hold timber assets and they found that although timber assets had a high risk and relatively low rate of return, they were desirable components of some investment portfolios.

Caulfield (1998b) used an asset-based performance measure TPI to evaluate performance of timberland with other asset class and asset allocation purposes. Thomson (1987) used quadratic programming to solve the standard Markowitz mean-variance portfolio problem and analyzed timber investments portfolio with and without inclusion of the S&P. HTRG (2003b) examined the capacity of timberland to diversify a portfolio of stocks, bonds, and commercial real estate.

The role of timberland investments in such 'risk-efficient' portfolios can be assessed by examining the correlation among rates of return for various classes of assets. Efficient portfolios are those with the greatest (lowest) expected return (risk) for a given level of risk (expected return) (Zinkhan & Mitchell 1990). For these resulting efficient frontiers, they described as modified because of the complete reliance on historical data for estimates of the expected returns and risks associated with the investment alternatives-rather than adjusting the figures for current and expected future market conditions.

The inclusion of an asset in an efficient portfolio is highly dependent on its correlation coefficient with other investment alternatives (Zinkhan & Mitchell 1990). Generally two risk-efficient frontiers of diversified portfolios have been calculated for comparison: one with timberland and the other without timberland (HTRG 2003b, Zinkhan & Mitchell 1990, Caulfield 1998b, Conroy and Miles 1989, IWC 2006, Binkley et al. 2005).

Using the timberland in the USA and other three international financial assets European stocks, Global stocks and European bonds, IWC (2006) analyzed the efficient frontier for the period 1987-2005. They analyzed the advantage of including timberland in an investment portfolio through an efficient frontier analysis. The study allocated real stocks to 25% European stocks to 75%, Global stocks to 50%, and European bonds to 75%. The inclusion of optimal allocation to timberland in a portfolio with a target rate of return of 8.5%, the expected standard deviation can be reduced from 5.3% to 3.3%. It is clear from

(Fig. 30) that allowing an allocation to timberland in a portfolio is highly beneficial. A threshold analysis performed by IWC (2006) shows that timberland should be included in the portfolio as long as the expected nominal rate of return from timberland is above 7.5% annually.

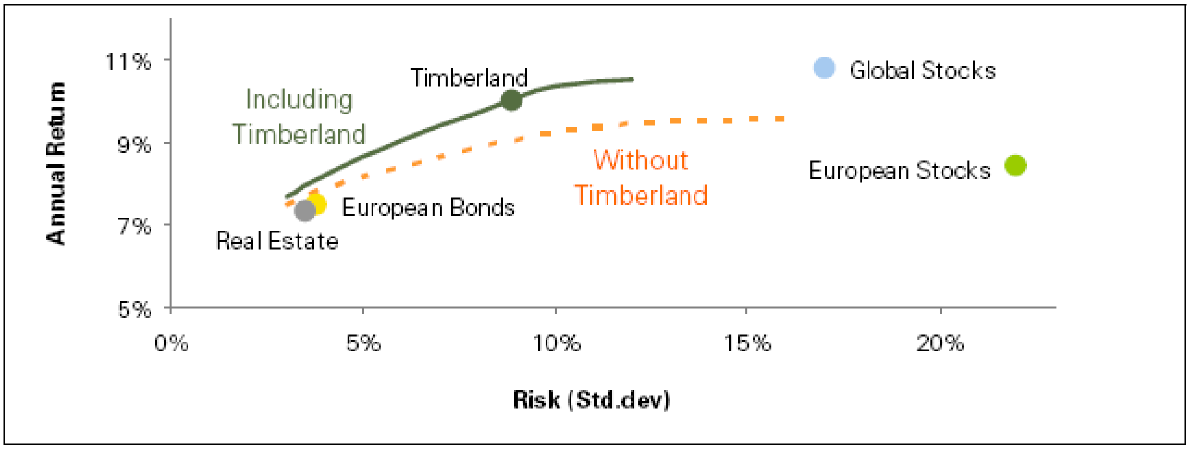

Figure 31: ***Efficient frontier and combination of returns and risks for alternative asset classes (Source: IWC 2006)***

Binkley et al. (2005) presented an efficient frontier (Fig. 31) and stated that modest allocations can produce meaningful improvements in portfolio performance than large allocations.

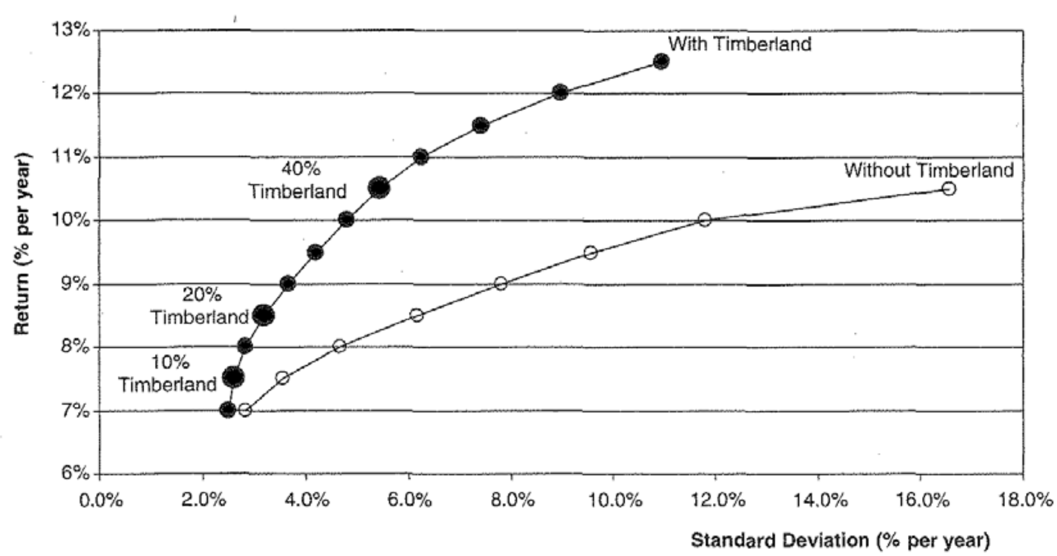

Figure 32: Efficient frontier with and without Timberland (Source: Binkley et al. 2005)

According to Fig.31, if we consider the target return level of 10.4%, then the standard deviation for the risk-efficient portfolio without and with timberland are 11.8 % & 4.8%

per year respectively. Hence a figure assures that with an addition of timberland to a portfolio of stocks, bonds and commercial real estate can substantially reduce its volatility (Binkley et al. 2005).

Thomson (1991a) looked at a portfolio that included investments in Douglas-fir and southern pine over 50 years. The study found that portfolios with timber investments should restrict timber to between 5-20 % of the portfolio in order to maximize returns and minimize risk. Baumgartner & Hyldahl (l991) used historical stumpage price data from three Midwestern states to determine the risk, return and efficient portfolios for timberland investments of major commercial species. They found that the lowest risk-return portfolios included hickory, silver maple, sugar maple and black walnut.

Heikkinen (1999) constructed cutting rules for the timber harvesting planning of a forest holding with four merchantable stands together with stocks, using the portfolio optimization with the estimated returns on both stands and stocks in Finland. Hyytiainen & Penttinen (2007) applied MPT to investigate rational clear cutting decisions at forest holding level in Finland. They observed the average returns and standard deviations for alternative financial and real asset classes based on historical data from 1987 to 2005. Assuming the forest owner's initial non-forest wealth is zero on their estimation, they derived the efficient frontier (Fig. 32). The figure illustrates that the combinations of return and risk fall far below the efficient frontier for most forest stands. The risks caused by fluctuating timber prices are at about the same level as risks on government bonds and apartments, but the average stand returns are lower. They concluded that portfolio optimization as a practical decision making tool for harvesting.

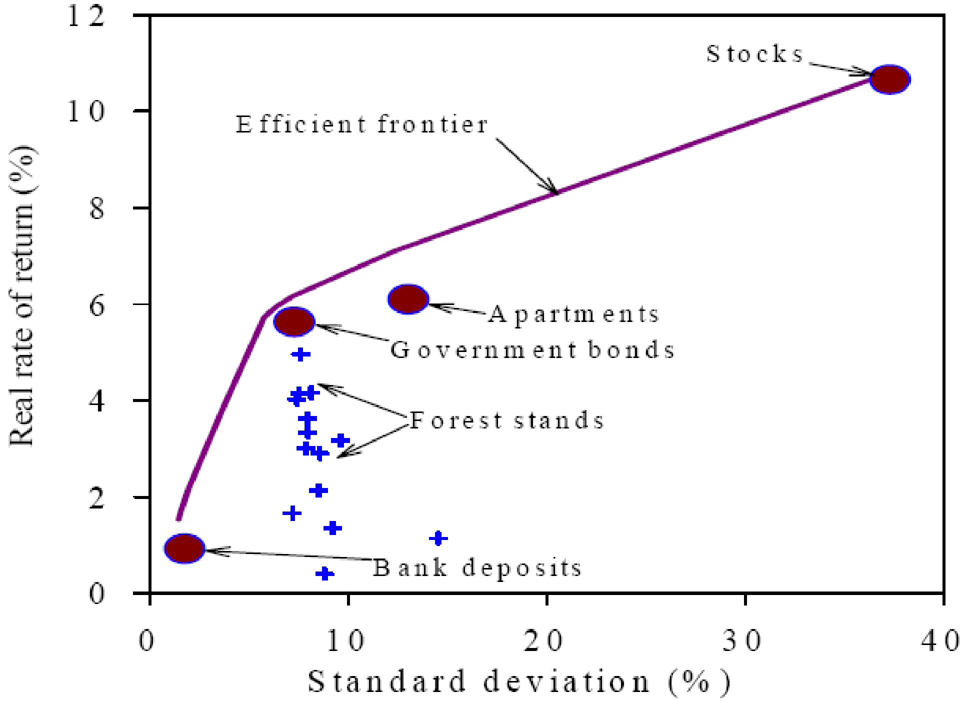

Figure 33: Efficient frontier and combination of returns and risks for alternative asset classes (Source: Hyytiainen & Penttinen 2007)

There are various software programming developed for analyzing asset allocation. Quadratic programming computer software helps to calculate portfolio weights. Conroy & Miles (1989) used the General Interactive Optimizer for the IBM PC developed by Lasdon Waren, LINDO System Inc. to generate efficient frontier. Zinkhan & Mitchell (1990) used computerized version of the traditional Markowitz model (1952) which is the STAND-ALONE software package, published by McGraw-Hill, Inc. Caulfield (1998b) used quadratic programming to generate an efficient frontier. Since historical returns, standard deviations, and correlations are fixed, the quantity varied in the optimization algorithm is the proportion of each asset held (Caulfield 1998b). Thomson (1987) used quadratic programming to solve the standard Markowitz mean-variance portfolio problem and analyzed timber investments portfolio with and without inclusion of the S&P.

Thomson (1991b) compared single-period and multi period portfolio expected returns and standard deviations for portfolios constructed from eight saw timber investments and four financial market investments in US. Portfolios were computed two ways: (1)

maximizing a quadratic utility function, which is inherently a single-period approach, and (2) maximizing a power utility function, which has been shown to be a suitable multi period optimization. He conclude that if timber returns are not well described by the mean and variance then the power utility approach appears safest and if the timber returns appear near normal then, the computational efforts of employing the power utility approach can be avoided by using the quadratic approaches. Hyytiainen & Penttinen (2007) discussed about strength and the limitation of portfolio optimization.

4.4.3 CAPM in Capital budgeting

Capital budgeting (CB) can be broadly defined as the systematic evaluation of how much capital to invest in a project or asset and the specific assets companies should use to meet their investment objectives (Cubbage & Redmond 1985). Capital budgeting techniques based on discounting future cash flows have been the principal methods for analyzing investments in forest land. Discounted cash flow (DCF) is a procedure well suited to the analysis of almost all financial investments, including forestry (Gregory 1987). DCF provide an estimate of the present value of an investment. DCF analysis consists of several steps:

1. All expected inputs and outputs are specified quantitatively.
2. Each input and output is scheduled; i.e., the timing for each input or output is specified.
3. A value is placed on each input and output.
4. Future values of inputs and outputs are discounted to the present time, using a specified interest rate.
5. Discounted values are combined into some measure of profitability (Gregory 1987).

The forestry literature has many examples of how these techniques can be used to determine not only the value of investments in management of the timber asset, but also investments in timberland (Zinkhan & Cubbage 2001). The most often used CB criteria in forestry are the Net Present Value (NPV), Land Expectation Value (LEV), and internal rate of return (IRR). Each technique has advantages and disadvantages (Zinkhan &

Cubbage 2001). The LEV is a variation on NPV, and is useful for appraising asset value based on estimates of future financial costs and returns.

$$NPV = \sum_{t=0}^{T} B_t (1+i)^{-t} - \sum_{t=0}^{T} C_t (1+i)^{-t} \text{ ………………………….. } (52)$$

$$LEV = \frac{\sum_{t=0}^{T} B_t (1+i)^{-t} - \sum_{t=0}^{T} C_t (1+i)^{-t}}{1+(1-i)^{-T}} \text{ ………………………… } (53)$$

The internal rate of return (IRR) is most useful in evaluating individual project investments, rather than overall asset portfolio performance. The IRR is defined as the discount rate (DR) that equates the present value of the benefits with the present value of the costs:

IRR = ***i*** at which:

$$\sum_{t=0}^{T} B_t (1+IRR)^{-t} = \sum_{t=0}^{T} C_t (1+IRR)^{-t} \text{ …………………………… } (54)$$

Where:

B_t = *a benefit at time* ***t***

IRR = ***i*** *= discount rate, in decimal form*

C_t = *a cost at time* ***t***

T = *lifetime of project*

An investment project's IRR is the rate that will make the sum of all discounted project costs exactly equal to the sum of all discounted project revenues, which means it is the DR that makes the NPV of a project equal zero (Gregory 1987). This measure has several names: the profitability index (PI), the project rate of return (PRR), the return on investment (ROI), but is probably best known as the IRR.

The concept of a 'project' is important in financial analysis (Gregory 1987). A project is any planned investment undertaking or proposal that can reasonably be analyzed or evaluated as an independent unit. The project approach provides a general framework for making decisions that have economic content or implications, and this covers most forestry decisions (Gregory 1987).

IRR indicates the annual rate of return that an investment would generate. For individual project-level investments, the IRR is usually compared with some given hurdle or target rate, or with rates other potential investments might earn. Projects with IRR greater than the target rate or other potential alternative rates of return are considered acceptable, given adequate capital (Zinkhan & Cubbage 2001).

As the formulas indicate, these three criteria are closely related. The unifying concept is the discounting of future benefits and costs to the present time with an interest rate, or discount rate. The choice of that DR is an important policy decision. The NPV converts a series of periodic income flows to a single number that can be used to compare mutually exclusive investment alternatives over the same investment horizon at a given DR. For project investment decisions, one would accept an investment that has a positive NPV if enough capital were available. If the NPV were negative, one would reject that investment. In order to compare NPV of different investment lengths (rotation ages in forestry), one would have to convert all those investments to the same horizon, such as the least common denominator of all time horizons (Zinkhan & Cubbage 2001).

LEV were developed by German forester Martin Faustmann (1849) for valuing forest land for tax purposes, and are sometimes called soil expectation values (SEV) (Gregory 1987). Faustmann’s formula is generally called the LEV. It has been a useful in forest management because it can be used to determine the optimal regime for timber growing that maximizes the value of bare land based on its biological productivity and expected response to management.

The LEV uses infinity as the common time. LEV is most often used to value even-aged plantations, where LEV calculates the value of bare land in perpetual timber production (Straka and Bullard 1996).When used as a project-level decision criterion, the LEV is a simple way to compare investments with different time horizons by using infinity as the common time horizon denominator. LEV is applied just like NPV in making investment decisions, with positive LEVs inferring investment acceptability, and negative LEVs suggesting project rejection (Zinkhan & Cubbage 2001).

LEV is most often used to value even-aged plantations, where LEV calculates the value of bare land in perpetual timber production (Straka & Bullard 1996). LEV is also useful in valuation of timber stands cut periodically. It can be used when a tract of land is harvested annually. In this case, the value of land and timber are established concurrently, and one cannot be separated from the other. In effect, this DCF technique is used to value a perpetual timber production 'factory' (Straka & Bullard 1996). In the forest valuation process, land and timber values are estimated jointly rather than separately (Bullard & Straka 1998).

4.4.3.1 Methods of determining discount rates

Whether an asset is performing adequately in the financial sense requires identification of a target rate of return. This is a threshold value for a rate of return criterion, or what Klemperer (1996) calls the minimum acceptable rate of return. This rate of interest would be used to determine which lands are performing above that level, and those which are not. It is also sometimes called a guiding rate of return or an alternative rate of return (ARR), because the chosen rate guides the investor's decisions, and reflects what an alternative investment represents as the opportunity cost of capital (Gregory 1987). It is also a DR used to adjust for timing differences in cash flows over the investment time horizon, again reflecting the opportunity cost of capital (Zinkhan & Cubbage 2001). The DR also includes expectations of future revenues, expressed as financial risk (Klemperer 1996). The target rate is used to discount future cash flows to a present value, in recognition that a dollar received in the future is worth less than a dollar in hand today. As well as an expression of the opportunity cost of invested capital, the target rate is an expression of how much the investor values the future in relation to the present. The higher the target rate, the less the investor values the future. In addition, the longer the payoff period involved in an investment, the lower the associated premium for financial risk will be (Klemperer 1996). Furthermore, the higher the target rate, the lower the timber cutting age and land value.

The DR is used to determine the present value of anticipated future costs and returns through DCF techniques. The results of DCF analysis are used to guide management decisions, including when to cut trees, and for estimating the value of land assets. The discount rate appropriate to any investor is the investor's opportunity cost of the needed capital, and this is seldom either an easy or precise calculation (Gregory 1987).

The DR is crucial for DCF analyses and decisions (Zinkhan & Cubbage 2001). High DR will tend to favor short-term investments with short paybacks, because the future value of something with a large DR will be very small. The higher the DR, the lower the value given future benefits and costs as compared with present ones (Row et al. 1981). The DR represents an organization's opportunity cost of capital for an investment. For private firms this is often calculated as the weighted average of debt (loans) and equity (stock). For public organizations, the cost of capital is usually determined by the government or by an international lending agency. For all investors, the DR is the alternative rate of return that the investor could receive in some other investment (Zinkhan & Cubbage 2001).

Klemperer et al. (1994) argue that risk premiums for forestry investments should be lower, as the long-term nature of forest production implies unreasonably low certainty equivalents for expected values of forestry investments if the risk premium is fixed at a moderate level. Brukas et al. (2001) states that taking risk into account will not necessarily increase discount rates in forestry above that observed in other economic sectors and may even, depending on the actual nature of the risk in the specific case, be considerably lower.

With the help of numerous examples, Price (1993) demonstrates flaws associated with traditional arguments based on opportunity cost of capital and human time preference on consumption. Forston (1986) reviewed the discount rate calculation method. He considered weighted average cost of capital (WACC) and opportunity cost method as a traditional method of calculating discount rate, whereas he categorized CAPM and adjusted present value concept under emerging concept in cost of capital. Emphasizing the importance of matching discount rates to the specific risk of a given project, he concluded that the adjusted-present-value rule is an improvement over the traditional WACC.

Wagner et al. (1995) reviewed the forestry applications of the CAPM and compared it to traditional CB techniques to analyze forestry investments. They did computation of CAPM and CB criteria for several forestry investment alternatives to compare the relative merits of each. However, the R^2 value between the CAPM and traditional investment analysis methods was very low explanation percentages of 0.09% - 27%. They concluded that integration of the methods will help analysts understand how forest assets are correlated to the general economy (as measured by an index of stock market activity) and may earn returns different from those suggested by using only CB analysis.

There are a variety of methods that can be used to determine discount rates. Properly used, discount rates match the specific risk of each particular project. Therefore, risky investments employ higher discount rates, and safer investments lower rates. In using a discount rate, it needs to have the adjustment of the inflation to the discount rate. This rate is referred to as the risk adjusted rate (Thuesen 1986). When conducting financial analysis for timberland investments, as with other asset classes, the challenge with discount rates is that they are not directly observable. In other words, there exists no perfect ‘discount rate reference manual’ that identifies a suitable discount rate for every type of timberland investment (Timberland Report 2006). Rather, discount rates must be estimated despite they vary by the motivations and risk profiles of each investor. The Common approaches to estimating discount rates for timberland investments are listed on table 9 (Timberland Report 2006).

Table 9: Common approaches to estimating discount rates for timberland investments

Approach	Key Assumptions	Data Required
Estimate with CAPM	Market rewards investors for risk, not for failures to diversify	Risk free rate; historical returns of a suitable market index and of the specific asset being considered.
Calculate Weighted Average Cost of Capital (WACC)	Firm/project maintains same debt level over time; firm/project has similar risk profiles; capital cost reflects the marginal cost of capital.	Firm market value of debt and equity, historic returns on equity, marginal cost of debt, and applicable tax rate
Survey active investors	Honest responses; rates estimated independently; they know the market.	Discount rates; specify whether real/nominal, before/after tax, benchmark risk free rate.
Derive from comparable timberland transactions	Buyers seek to maximize profits; winning bid represents market; required data are available	Timberland prices; deal characteristics (such as debt, species, acres, volumes); assumptions regarding forest growth, revenue, management costs.

4.4.3.2 Use of CAPM in DR calculation

American evidence suggests that the adoption of the CAPM in the practice of capital budgeting has been widespread (Graham & Harvey 2001). The use of CAPM is found to be significant also in assessing the risk of cash flows of investment projects, and the discount rate of returns (Jagannathan & Wang 1996; Graham & Harvey 2001). Researchers have used CAPM to estimate discount rate in forestry investment and have found lower than the risk free rate.

The CAPM procedure recognizes that risk and return are directly related and that high-risk projects should be discounted by a rate that reflects the degree of risk. The true cost of capital for a project depends upon the use to which the capital is put, and the CAPM is a useful theoretical approach that enables the analyst to objectively estimate the opportunity cost of funds for a project. CAPM offers a method to obtain an appropriate cost of capital for risky assets that accounts for both the time value of money and market risk. The CAPM form the standard framework managers use to calculate the risk-adjusted cost of capital.

CAPM assumes that all investors hold diversified portfolios and it is a single period model, while forestry projects hold the longer period. Though the CAPM-based approach for selecting a DR is imperfect, it is generally considered by financial theorists to be one of the best approaches available (Zinkhan 1988). CAPM studies in USA and Swedish timberland have shown low or even negative βs (Binkley & Washburn 1988b; Blinkley et al. 2006, 1996; Zinkhan 1988; Thompson 1987; Thomson & Baumgartner 1988; Cubbage et al. 1988; Redmond & Cubbage 1988; Lundegren 2005). These results indicated rationality for using a lower DR to analyze timberland investments than for more traditional assets such as common stocks. Also, various timberland investment projects, whether, land and timber acquisition, tree planting, herbicide application or others, may exhibit low betas to other timberland investments and therefore justify a lower discount rate (Zinkhan 1988; Chamber 1989). However, all timberland investments should not be analyzed with the same discount rate (Forston 1986; Zinkhan 1988; Chamber 1990). Only systematic risk is important in discount rate determination, because unsystematic risk can be diversified away in the total portfolio.

McKillop a& Hutchinson (1990) used the CAPM to estimate a nominal discount for both private and public forestry investment in the U. K. that was less than an expected risk-free interest rate. Zinkhan **(**1988) implemented the CAPM to develop a nominal DR for southern pine projects that was less than the U.S. T-bills rate (table 8), which was found less than the risk free rate. Chambers (1990) also calculated required rate of return for Timberland Fund II in 1988 using regressed β against the S&P 500 according to the CAPM. He calculated the value 0.014, 6.76%, 16.76% for β, risk free rate of return and market rate of return respectively. The required rate of return (the implied discount rate) was 6.62%. This shows that timberland is a low risk investment in relation to broad based market securities such as common stocks.

Table 10: Determination of discount rate of southern timber land projects (Source: Zinkhan 1988)

Discount rate (%)	=	US T-bills [a] rate (%)	+	β [b]	* Expected market [c] premium (%)
4.3	=	6		-0.21	8

a The approximate 90-day rate as of August 5, 1987.

b Calculated using annual rate of return during the period of 1956 to 1986

c $R_m - R_t$ *in equation 1. The value has averaged approximately 8% over the last 50 years.*

The CAPM model used in conjunction with the opportunity cost of capital recognizes that the use of a single discount rate for all projects is, in general, inappropriate (Fortson 1986). Furthermore, Zinkhan (1988) discuss that the main difficulties in using the CAPM in estimating discount rate using the CAPM. However, He addressed four issues associated with the implementation of this DR using the CAPM:

1) The 90-day US T-bills rate-should be updated in a daily basis and the beta value should be modified on at least an annual basis.
2) The discount rate selected according to this process should not be utilized by those individual investors who do not hold diversified portfolios or by those firms with a major portion of their outstanding stock held by individuals without diversified portfolios.
3) Though each timberland oriented project does not necessarily posses the same degree of systematic risk, it is not appropriate to use the CAPM to generate a distinct discount rate for each possible project or firms. However, both the managers of timberland divisions and individuals should utilize single discount rate for all of their timberland-oriented projects.
4) The methodology in calculating a discount rate has ignored the potential financing side effects of investing in a project.

Researchers have used capital budgeting surveys for different types of practiceners in forestry to know the budgeting process, investment criteria used, allowances for risk, and discount rate used. Manley (2003) applied questionnaire survey for a total of 17 forest valuers, mostly from consulting firms in New Zealand. He found that eleven valuers selected discount rate based on market evidence while only two valuers were found using the CAPM to test the rationality of the discount rate used. Four valuers based discount rate on the WACC, the opportunity cost of capital or their estimate of the return required by investors (Manley 2003).

Redmond & Cubbage (1985) and Hogaboam et al. (2001) examined the capital investment practices of publicly owned forest products firms in the U.S.A. According to a survey of 41 forest products firms by Redmond & Cubbage (1985), only 2 of the firms were found using individual project based on the CAPM to estimate discount rate. However, Hogaboam et al. (2001) reported none of the firms out of 20 responded firms were using individual project based on the CAPM to estimate discount rate. Hogaboam et al. (2001) and Redmond & Cubbage (1985) both found the similar result that weighted average cost of capital was the dominant discount rate determination method in their survey. Redmond & Cubbage (1985) and Hogaboam et al. (2001) found in their survey of major forest products firms that only 23% and 39% of the responding firms frequently and infrequently use the CAPM for the purpose of incorporating risk into investment decision respectively. Hogaboam et al. (2001) conclude that firms still rarely use the CAPM. Rather than utilizing the CAPM to adjust for risk in their analyses; firms were found to raise their required rate of return, shorten their payback period, or simply subjectively adjust cash flows, which implied a prevalence of subjective adjustment in risk analysis (Hogaboam et al. 2001).

4.4.4. Event studies application

Another application of the CAPM in forestry is its use in event study. Event studies generally use financial data to examine the economic impact of some event or set of events on the value of assets over a relatively short time period (Campbell et al. 1997). Event analysis methodology provides management researchers a powerful technique to explore the strength of the link between managerial actions and the creation of value for the firm (McWilliams and Siegel 1997). Boardman et al. (1992) states that event study are capable of providing relatively inexpensive estimates of the total impacts of policy changes upon the value of firms traded in relatively efficient financial markets. Mendell et al. (2008) states that event studies can determine whether or not new information resulted in artificially high or low prices for a given security (stock). Campbell et al. (1997) demonstrate that the event study will continue to be a valuable and widely used tool in economics and finance. However, they stated that the event study can face the problem due to non-trading or non-synchronous trading effect and non normality of data. Boardman et al. (1992) show that the most serious problem in event study is the empirical determination of when and how information is revealed to the market.

Event study is a standard methodology in financial economics to determine the impact of specific financial decisions on shareholder returns and expected firm profitability (Bin and Sun). The event analyses theoretically assume that individual stock returns over time can be predicted to some degree. Researchers then observe the actual stock returns over the period of interest and compute the difference between the returns predicted and observed. Though stock returns are subject to some degree of ‘noise’ or random statistical fluctuation, the event analysis is looking for returns that exceed this normal level of variation (Mei & Sun). If the difference is determined to be statistically different from zero, it may be concluded that the event under study did impact stock returns and reflect an investor reaction to the event (Wells 2004).

There are different model have been used in event study, one of them is the CAPM. Others include: multi-factor model based on the APT, mean-adjusted model, the market–adjusted model, and the market model. MacKinlay (1997) in his review of event-study methodology points out that the CAPM imposes questionable restrictions and that a more complex APT model often provides little gain to the simpler market model. However, researchers have used the CAPM in event study in forestry application.

MacKinlay (1997) and Binder (1998) offer comprehensive overviews of the event study. Macey et al. (1991) summarize how event study methodology, a simple empirical technique, can be used to identify statistically significant effects on a firm’s stock price. Campbell et al. (1997) have outlined the seven steps to carry out event study (Fig. 33).

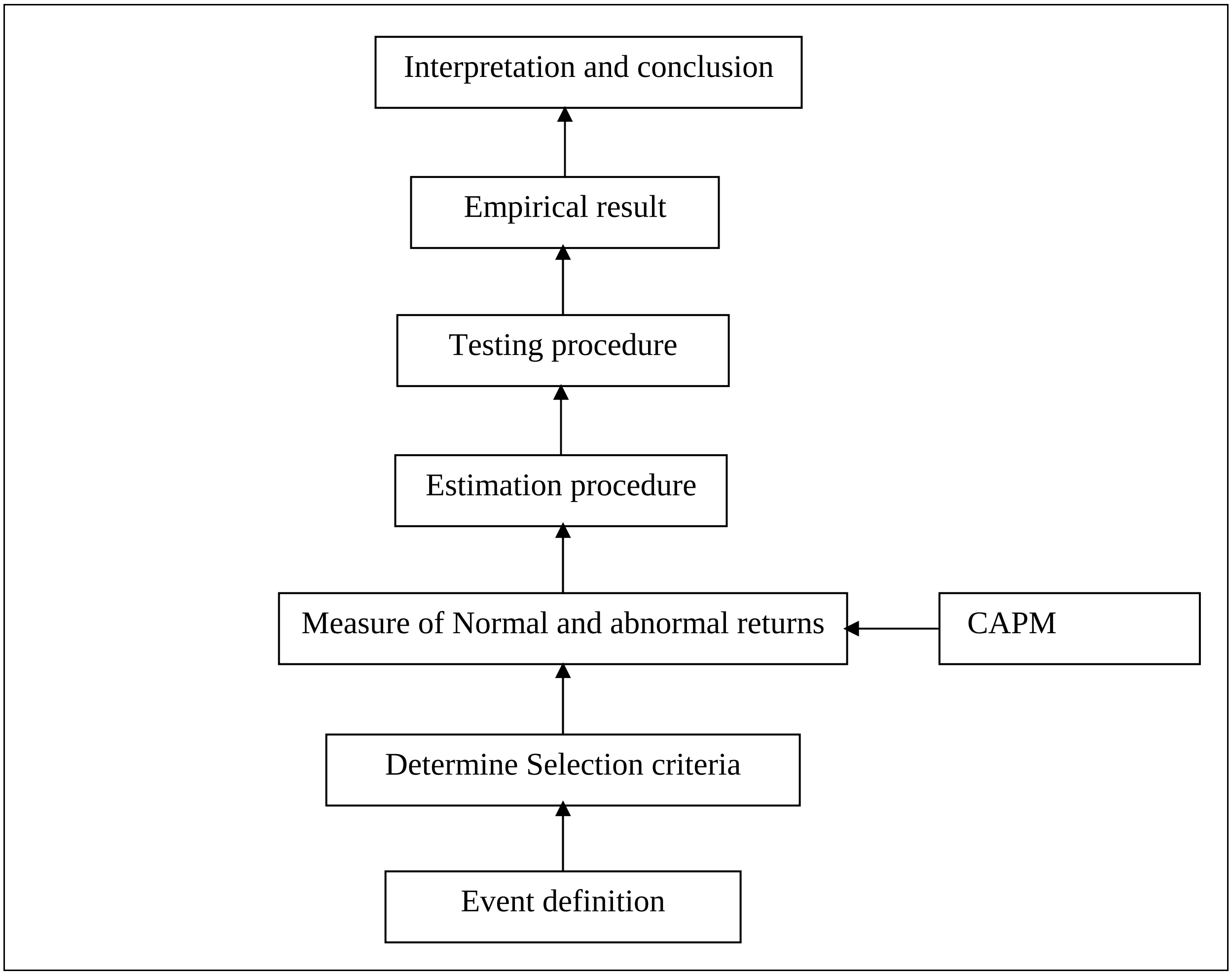

Figure 34: Steps in conducting event study (Source: Campbell et al. 1997)

A comparison of estimation window, event window, and post-event window along a time line for event analysis has been described by MacKinlay (1997). Fig. 34 shows the event window, which is a period over which the event occurs and estimation window over which parameters are estimated (Campbell et al. 1997).

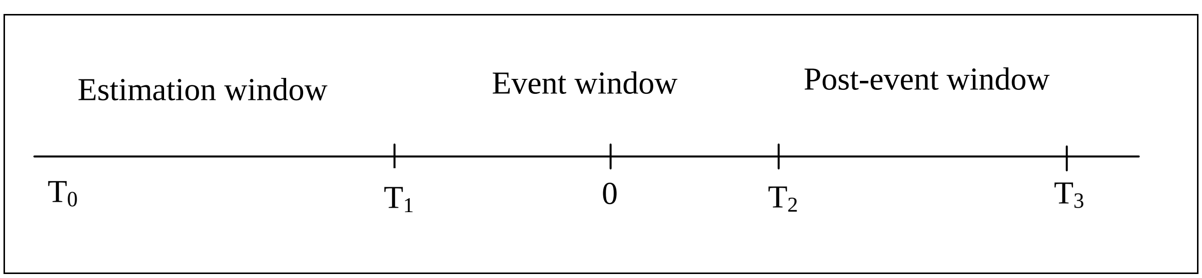

Figure 35: Comparisons of estimation window, event window, and post-event window along a time line for event analysis. Source: MacKinlay (1997)

4.4.4.1 Event study in forestry

Event studies have widely been used by financial economists to study regulatory change, M&A, and earnings announcements. In forestry sector, event study also have been applied to determine the impact of M&A of forest product company (Mei and Sun), to examine the impact of spinoff of forest product company (Zinkhan 1988a, & Mendell et al. 2008) and to analyze the impact of regulatory changes on the expected profits of firms (Zhang & Binkley 1995, Binkley& Zhang 1998, and Niquidet 2007).

Zinkhan (1988a) used the CAPM to control for risk differentials and movements in the market as a whole around the event date. Mei & Sun used the CAPM to estimate two regressions for each firm: one before the Mergers and Acquisitions (M&A) event and the other after M&A event. Mendell et al. (2008) used the CAPM to estimate expected returns, which are being subtracted from actual returns during the event period to determine abnormal return. The abnormal return is the ex post return of the security over the event window minus the normal return of the firm, which is the return that would be expected if the event did not take place (Mei & Sun). The abnormal return can be obtained by subtracting the expected returns according to the CAPM from actual returns during the event period (Mendell et al. 2008).

Zinkhan (1988a) evaluated the impact on shareholders of major timberland restructurings by four publicly traded forest products firms: Masonite Corporation, Pope and Talbot, International Paper, and ITT Corporation. During the period between 1982 and 1985 these four large publicly traded forest products firms spun off 8.05 million ac. of timberland to publicly owned limited partnerships (Zinkhan 1988a). The objective of the study was to determine whether the restructuring of timberland ownership via the establishment of limited partnerships is a negative, positive, or neutral event from the perspective of the forest products firms' shareholders. He found that shareholders benefitted significantly around the announcement date of the event and forest-land divestitures generally increased the value of forest product companies. The results suggest that the share prices of the forest products firms did not adequately reflect the value of their timberland prior to the announcement.

Zhang & Binkley (1995) applied event study in forestry and found little impact of the 1987 changes in British Columbia's forest policy. In another study, Binkley & Zhang (1998) assessed the net effect of the policy decision of stumpage fee increase by the British Columbia government on 14 April 1994.They measured the impact of such major public policy change on 12 publicly traded forest products firms in Canada. They found the aggregate abnormal return for these firms during the event period significantly different from zero. It implied that the shareholders of the forest industry suffered from policy changes of the stumpage increase decision. Binkley & Zhang (1998) and Zhang & Hussain (2004) followed same methodology in event study.

Zhang & Hussain (2004) examined the impact of a series of events related to the US-Canada softwood lumber trade dispute on the stock prices of forest products firms in both countries. They selected the recent four major events: Canadian withdrawal from the MOU (Memorandum of Understanding) on September 4, 1991, Agreement-in-principle reached for the SLA (Softwood Lumber Agreement) on February 16, 1996, Expiration of the SLA on April 1, 2001, and Imposition of a 19.67% preliminary countervailing duty on Canadian lumber imports by US Department of Commerce on August 10, 2001. The study suggest that event specific impacts associated with the US Canada softwood lumber trade dispute have been large enough to be noticeable in stock prices of forest products firms. They concluded that the firm specific impacts vary among firms in both countries. However, both medium and large Canadian forest products companies were adversely impacted by restrictive trade actions. While in US, adverse impacts were confined only to the medium forest products companies and the positive impacts included large companies such as Georgia Pacific Corporation and International Paper.

Mei and Sun assessed a 57 major M&A events in the US forest products industry. They focused on firm-level performance using the financial data from the capital market in order to measure the impact of M&A events on the performance of firms. Their result of abnormal return implied that capital market reacted positively to M&A of forest products industry as a whole, leading to a significant enhancement of the firms' market value. They used the CAPM model to estimate systematic risk before and after the M&A for each firm. The risk analyses for the acquiring firms in the selected 14 M&A events showed that the risk for most of them has experienced limited changes after the M&A events.

Cascio (2006) used short term event study to test the null hypothesis of no shareholder value creation from the mergers and acquisitions of 9 vertically-integrated U.S. forest products companies within the last ten years. He tested the hypothesis that the concept of market efficiency dictates that the reaction of financial markets to new information should be both quick and lasting by the use of long term event study. His result showed a net creation of $4.7 billion of market value upon the announcement of the 9 M&A, which rejected the null hypothesis. Additionally, target firms enjoyed a statistically significant; nearly 15% averages return attributable to the merger announcements. By using calendar-time portfolio approach to estimate long-term post merger performance, it was found that the abnormal returns were strongly insignificant.

Niquidet (2007) studied the impact of regulatory policy called Forestry Revitalization Plan (FRP) of the British Columbian government on the publicly traded forest companies. They used the daily return index on 13 publicly traded forest companies which operated in the province within British Columbia for the period June 24, 2002 to April 1, 2004 (448 trading days). The result showed that the announcement of the FRP generated significant negative abnormal returns for several firms due to new stumpage system and the loss of forest tenure.

Mendell et al. (2008) used event study methodology to analyze equity market responses and subsequent impact to on shareholder value, through changes in the stock price due to four announcements of forest industry firms converting their corporate structures from traditional C-corporations to real estate investment trusts (REIT). These announcements were Plum Creek in 1998, Rayonier in 2003, Potlatch in 2005, and Longview Fiber in 2005. They tested the hypothesis whether that equity markets were indifferent to announced REIT conversions. In other words, the null hypothesis was that each firm's announcement would not correspond with significant or abnormal changes in each firm's stock price and, by extension, market value as measured by market capitalization. Market capitalization is the price per share of the firm at the time multiplied by the number of shares outstanding (Mendell et al. 2008). They followed the event study approach used in Zinkhan (1988a). The result showed that all four announcements were associated with significant abnormal increases in the stock prices of the four firms on the day before, day of, or day after each firm's announced REIT conversion. This indicated investor preference for holding industrial timberlands within an REIT rather than traditional C-corporation structure.

4.5 Limitation of the CAPM application

Limitation of CAPM has been discussed in general in finance and in forestry specific application.

In Finance:

The CAPM has been examined and tested by a great number of authors during the past decades and various anomalies of the CAPM have been documented as a result of these studies. A growing number of studies found that the cross-asset variation in expected returns could not be explained by the systematic risk alone. Therefore, a variety of models have been developed to predict asset returns. In financial literature multi-dimensional asset pricing models such as the arbitrage pricing model (Ross 1976) have been widely used.

The validity of the CAPM has been extensively tested in developed markets especially in the seventies and eighties (Black et al. 1972). They found that the CAPM is that it does not provide a complete description of security returns. Friend et al. (1978) found the erratic nature of the relationship between risk and return for an individual asset and the frequently low explanatory power of the model are also problems. They also indentified a problem that an average returns have been related to diversifiable risk as well as systematic risk (beta), which would be inconsistent with the CAPM.

The CAPM is formulated in a nominal context. The thrust of portfolio theory and the CAPM is that on the average, the capital market is dominated by risk-averters. Nahum (1975) states that if the rate of change in the general price level is not certain, real return considerations may lead to investment decisions which are quite different from those arrived at through nominal considerations.

The single-factor CAPM is rejected when the portfolio used to proxy for the market is inefficient (Roll 1977 & Ross 1977). Roll (1977) argues that the CAPM may not be testable. Roll offers a proof that the relationship between realized returns and betas could turn to be exactly linear if the proxy for the market portfolio is mean-variance efficient. He points out that the most reasonable proxies will be very highly correlated with each other and with the true market portfolio regardless of them being mean-variance efficient. Roll & Ross (1994) show that even very small deviations from efficiency can produce an insignificant relation between risk and expected returns.

Fama & French (1992, 1995, & 1996) have found that the CAPM does not hold empirically. The empirical results against the unconditional CAPM were so strong that it led some authors to conclude that the CAPM is dead. Fama & French (1993, 1996 & 1998) suggest that an overall market factor, firm size, and book-to-market equity help explain the variation in average stock returns better than the CAPM. In this model, size and book to market factors are included, in addition to a market index, as explanatory variables. Fama & French (1996) report that their three-factor model captures most of the average-return anomalies missed by the traditional CAPM. However, Bartholdy & Peare (2005) compared the performance of CAPM and Fama and French three factor model for individual stocks and observed the low explanatory power of both the CAPM and the Fama French model. Based on the result they concluded that neither model is useful for estimation of cost of equity based on the simple OLS estimation technique.

The CAPM suggests that the beta coefficient is the only relevant risk measure for asset pricing. The CAPM and the estimation of expected returns have been widely used for evaluating financial decisions and calculating the cost of capital and the required rate of return (Fletcher 2000). However, the disadvantage is that the beta may be unstable over time and also that CAPM is a single factor model, focusing only on the market risk (Groenewold & Fraser 1997).

CAPM consider that only systematic risk should be priced in the market and that idiosyncratic risks should not be related to stock returns. CAPM assumes that it is rational for a utility maximizing investor to hold a well-diversified portfolio of investments to eliminate unsystematic risk. However, Malkiel & Xu (2000) state that when constrained investors are unable to hold the market portfolio, unconstrained investors will also be unable to hold the market portfolio. They also state that if investors are unable to hold the market portfolio, they will be forced to think about total risk and not simply the systematic or market risk. Malkiel and Xu (1997) found that the idiosyncratic volatility is highly correlated with firm size and that it plays a significant role in explaining the cross-section of expected returns. They refer transaction costs, liquidity constraints, and other exogenous factors as possible reasons for the inability to hold the market portfolio.

Drew et al. (2004) investigated the robustness of a multifactor model incorporating idiosyncratic volatility as an explanatory variable. They found that that (a) idiosyncratic volatility is priced and (b) the multifactor model provides a better description of average returns than the CAPM. They also found that the absolute pricing errors of the CAPM are large when compared with the multifactor model of Fama and French.

Liu (2006) states that neither the capital asset pricing model (CAPM) nor the Fama-French three-factor model can account for the liquidity premium. Using a new measure of liquidity, he documents a significant liquidity premium robust to the CAPM and the Fama–French three-factor model and shows that liquidity is an important source of priced risk. With the presentation of a simple theoretical model to explain how asset prices are affected by liquidity risk and commonality in liquidity, Acharya et al. (2005) found that the liquidity-adjusted CAPM explains the data better than the CAPM in terms of R^2 for cross-sectional returns and p-values in specification tests, even though both models employ exactly one degree of freedom. McCauley & Gunaratne (2003) argues that the CAPM is not, as is often claimed, an equilibrium model because the distribution of returns is not an equilibrium distribution.

Merton's (1973) intertemporal CAPM (ICAPM) derives equilibrium asset premia and suggests that the conditional expected excess return on the stock market should vary positively with the market's conditional variance. In contrast to CAPM, Merton's ICAPM is based on a three-fund theorem. Each rational investor holds the riskless asset, the market portfolio, and a hedge portfolio for a so-called state variable in order to maximize his lifetime expected utility. The state variable is a stochastic term, which affects the asset price processes. The hedge portfolio provides maximum correlation to the state variable, i.e. it provides the best possible hedge against the state variable variance. Ghysels et al. (2005) found a positive and significant relation between risk and return based on Merton's ICAPM.

The APT offers an alternative to CAPM, as it allows more than one generating factor (Roll & Ross 1980). The APT is found to be more capable of explaining the financial performance of securities and portfolios than the CAPM, indicating that some other factors, in addition to the market risk, have a critical role in the assessment of returns (Groenewold & Fraser 1997, Sun & Zhang 2001). The CAPM identifies the systematic factor that comes from the market, while the application of the APT makes clear that there are other factors as well, such as inflation, interest rates, exchange rates and the Industrial Production Index, that affect the securities. Messis & Iatridis (2006) and Sun & Zhang (2001) compared the CAPM and the APT, and found that that, under the Theil's U^2 test, the APT outperforms the CAPM.

In Forestry

Not surprisingly, problems arise in applying CAPM originally developed for financial assets such as stocks to timberlands (Washburn & Binkley 1989, 1990a). Leuschner (1984) states that the use of CAPM is limited by its severe assumptions. Redmond & Cubbage (1988) and Lundgren (2005) questioned the validity of assumption of CAPM such as identical time horizon of investment, liquidity perfect capital market (equal borrowing and the lending rate, taxes, regulations, information or restrictions on short selling). The investment characteristics of forest asset and financial assets differ. Such differences could render models developed to price financial assets, such as the CAPM, unsuitable for pricing timberland investments (Washburn & Binkley 1990).

The CAPM is not widely used in timberland investment analysis primarily due to lack of reliable historical investment performance indices. This has limited the CAPM's usefulness, especially for evaluating alternative forest management investments (Wagner & Rideout 1991). The problems are not surprising while application of CAPM to forestland investment, since it was primarily developed for pricing of financial asset (Washburn and Binkley 1989). Unlike stocks, bonds and other financial assets, timberland does not trade on organized exchanges, nor is its price publicly reported daily. For many years, a challenge that faced potential timberland investors was the lack of a performance benchmark for evaluating timberland performance.

The main limitation of application of the CAPM in forestry is due to the lack of accurate historical market data describing timberland returns (Washburn & Binkley 1989, Chambers 1989). In forestry, there are no historical market data on either the timber inventories or actual land values for most forest assets. Since the lack of historical data on forest assets, researchers have calculated return on forest asset based on several assumptions on stumpage price, growing stock and bare land value. Consequently, various combinations of published and approximated regional timberland or agricultural land indices, output prices, and yield models have been used to generate historical 'market' returns of a forest asset (Conroy & Miles 1989). Therefore, estimating the CAPM parameters from combinations of market and market proxy data is not unique in the forestry or finance literature.

Washburn and Binkley (1989) describe several problems that arise when portfolio theory and the CAPM are applied to timberland investments. Among these are the: choice of an appropriate data series for measuring stumpage value changes; measurement of growing stock and bare land value; and the method by which periodic returns are calculated. In addition, problems with the composition of the true market portfolio, the low explanatory power of the model, and the low accuracy of prediction have been reported in forestry literature, as well as in the analysis of other financial assets (Washburn and Binkley 1989).

The calculation of return and risk for the timberland investment is based on one case, while the data for the other investments are general. This restricts the possibility for general conclusions (Lonnstedt & Svensson 2000). Washburn & Binkley (1989) examined some econometric problems of applying the CAPM to timberland assets due to differing assumptions used in calculating its returns. Binkley et al. (1996) and Washburn & Binkley (1989) pointed out that the CAPM estimates for risk and return may be under or overestimate, because the CAPM is a single factor model, and there might be also other omitted factors that are priced by asset markets. They consider high information and transaction costs and illiquidity as possible additional factors for timberland. They argue that there may logically be a disparity between the level of expected return of timberland and the level the CAPM suggests. They did not produce any other evidence than low R^2 (explanatory power) values from the omitted factors. A particular problem for pricing forest assets could be their relative illiquidity as Collins (1988a) asserts is the case for pricing agricultural investment.

Heikkinen & Kanto (2000) pointed the short coming of risk beta as a short-run indicator. They explained that based on price difference, which indicates short run co-movements and ignore possible long-run correlation and is thus incomplete. They emphasized that the conclusions about the expected risk and return of an asset derived from the use of insufficient model may be misleading or incomplete.

Wagner & Rideout (1992) analyzed the stability of CAPM parameters using the cusum signal test (CST) and the log-likelihood test (LLR). They found that the nominal and real CAPM parameters were unstable; the estimated parameters were insignificant, indicating that the β indices calculated using real returns were stable. DeForest et al. (1989) stated that CAPM is not a panacea for making an investment decision. Wagner & Rideout (1991) indicated that the results of the CAPM should not be the sole criterion for accepting or rejecting an investment. They suggested for the possibility of other linear and non linear models in finance literature such as the arbitrage pricing model or multi-index models could also be used to examine financial variability in forestry examine both linear and nonlinear relationships.

Penttinen (2007) states that the non-conditional CAPM only focuses on correlation in addition to returns and risks, but ignores both Skewness and kurtosis and advanced conditional CAPM models with heteroscedastic variances would benefit from semi-annual and quarterly return series. He also emphasize a need of inclusion of foreign assets such as the return series of the customers of the Finnish forest industry as in a CAPM study or an analysis connecting the returns to national economy using APT.

CAPM studies only examine the short-run relationships between timberland and other financial market instruments (Liao & Zhang 2007). Researchers have also trying to apply the extension of CAPM or more robust methods in investment analysis and timberland portfolios. In financial literature multi-dimensional asset pricing models such as the arbitrage pricing model (Ross 1976) are widely used. It was surprising that there are no other extensions of the CAPM or the market model in the earlier forestry literature. Only one literature is found in Sun & Zhang (2001), who used CAPM and APT to assess the financial performance of eight forestry-related investment vehicles. They found APT more robust than CAPM in explaining the risk and return.

More sophisticated asset pricing models simultaneously recognize multiple sources of asset risk. The simplest of these examines inflation and market risk together such a two-factor model has been applied including inflation into the model in forest investment analysis to demonstrate that timberland appears o be a particularly effective hedge against unexpectedly high inflation (Binkley et al. 2005; Washburn and Binkley 1993, Lausti 2004).

However, recent studies on the long-run relationships between forestry-related investments and financial instruments have also been conducted (Heikkinen and Kanto 2000; Heikkinen 2002; and Liao & Zhang 2007). The recent developments in time series provide a tool to study the long-run relationships, i.e., multivariate co-integration between timberland and other financial assets and incorporate this information in a short-run market model. Co-integration analysis has been used extensively in spatial aspects of the forest economics literature (Jung & Doroodian 1994, Alavalapati et al. 1997, Murray & Wear 1998, Yin et al. 2002). For example, Heikkinen & Kanto (2000) suggest that the

Finnish stumpage prices are co- integrated with stock prices. Furthermore, Heikkinen (2002) shows that the Finnish stumpage prices, bond and deposit rates are co-integrated in the long run. Liao & Zhang (2007) demonstrate that there exist co-integrated relationships between timberland, timber price, and the non-forestry financial assets (farmland, real estate, stock market index S&P 500, T-bills, deposit interest, and gold price) in the long run using quarterly data in US for the period January 1992 to July 2006.

4.6 Inflation hedging potential of forest assets

Inflation is defined as an increase in general price level in the economy over a period of time and it is measured by CPI, GDP (Gross Domestic Product) deflator. A nominal or current rate includes inflation and a real or constant rate excludes inflation. Inflation is generally measured by calculating the inflation rate, which is the percentage rate of change for a price index, such as the CPI, GDP deflator.

$$I_t = \frac{CPI_t}{CPI_{t-1}} - 1 \qquad (55)$$

Where:

I_t = *Inflation rate*

CPI_t = *Consumer price index at time t*

CPI_{t-1} = *Consumer price index at time t*

Inflation is equally important for investors as well as investors. Being forestry is long term investment; protection from inflation is an important characteristic to the institutional investors (Lundgren 2005, Lausti 2004, Binkley et al. 2005, and Washburn & Binkley 1993). In timberland investment analysis, inflation should either be included in the timberland rate of return, or adjusted out of whatever alternative timberland is being compared to, such as stocks or commercial real estate. Unless otherwise stated, all interest rates and price changes will be considered in real terms, excluding inflation. Inflation, or the general rise in prices, is assumed to be zero (Klemperer 1996). Most forestry projects and investments are calculated initially with a before-tax, real (i.e., without inflation) discount rate. Effects of inflation or taxes can be important, and can be added to the analysis as necessary (Zinkhan & Cubbage 2001).

Institutional investors are always looking for alternative investment for inflation hedging attribute. Traditionally, timber has been considered to be a good hedge against inflation. Redmond & Cubbage (1988) envisage that timberland asset could offer inflationary protection because of the negative CAPM β for the stumpage price series. Graham (1985) stated that timberland offers investors such benefits as protection from inflation. However, there are few studies conducted in US, Finland and Sweden to test the inflation hedging potential of timberland assets.

The notion of inflation hedging is that the real return of an asset is independent of the rate of inflation. An asset is a complete hedge against inflation, if and only if the nominal return of the asset changes in a one-to-one relationship with both expected & unexpected inflation (Foo 2000). For measuring inflation hedging ability of timberland assets, researchers have used several approaches: i) use of correlation analysis ii) analysis of relationship between timberland returns and realized inflation using real CAPM and ii) use of model to measure expected and unexpected inflation hedging properties.

Lundgren (2005) estimated inflation parameter for Swedish timberland for thee period 1965-1999. He found the estimates positive and larger than one (1.44) based on real CAPM. This inflation parameter suggest that if inflation goes up by 10%, timberland returns will increase by 14.4%, making it a suitable investment alternative for investors looking for protection against inflation.

Wagner (1990) related the nominal rate of return for investments in ponderosa pine forests in the Pacific Northwest of USA to the realized rate of inflation. He found that the relationship was opposite and concluded that ponderosa pine forests were poor inflation hedges. Wagner & Rideout (1991) combined Income Growth Model (IGM) with a nominal and real CAPM to evaluate two alternative management regimes using a. simulation of two fully regulated Pacific Northwest ponderosa pine plantations. They tested the inflation-hedging ability of the two forest assets (thinning and non-thinning) for the years 1969 to 1979 based on real CAPM. The estimated inflation response coefficients were negative and significant at the 89% and 88% levels of confidence for the non-thinning and thinning assets, respectively. Inflation response coefficients for the same years based only on quarterly net harvest values of the two forestry assets or just output prices were also negative. They concluded from simulation that the forestry assets as inferior inflation hedges. In previous study, Washburn and Binkley (1989) found southern pine saw timber with a poor inflation hedging ability.

Lutz (2008a) analyzed the timberland returns from NCREIF Timberland Index for the period 1987-2006 and the Wilson Model (commonly known as the JHTI) for the period 1960-1986 and the inflation-CPI. They conclude that the US timberland returns are highly positively correlated with inflation rate because timber prices contribute to the inflation rate in the following year. Lutz (2008b) concluded that a diversified timberland portfolio is a better inflation hedge than investments in a single region.

Zinkhan & Mitchell (1990) found positive correlation between the real rate of return from STIF and the inflation rate for the period 1977-1987. However, they suggested for cautiously interpretation of this result in the context of both a lack of statistical significance and the assumption associated with STIF.

Based on the quarterly returns on timberland investments, measured by the NCREIF and the Euro CPI for the period Q1 1987 and Q4 2004, IWC (2006) reported the historically positive correlation (0.25) between them indicating that timberland investments to some extent provide a hedge against inflation.

4.6.1 Measurement of expected and unexpected inflation

Asset pricing theory suggests that investors prefer a portfolio with returns that are insensitive to departures from inflation expectations. This means in an extreme case a portfolio with a regression coefficient of unexpected inflation equal to zero. Such a portfolio can be formed by combining assets that hedge higher than expected (the unexpected inflation regression coefficient is positive) with those that hedge lower than expected (the unexpected inflation regression coefficient is negative). Prior empirical work indicated that most financial assets, including stocks and bonds, have historically hedged lower than expected inflation (Lausti 2004; Washburn & Binkley 1993). Thus the capacity to hedge higher than expected inflation should be priced positively in the asset markets (Washburn & Binkley 1993).

Analyst commonly divides inflation into expected and unexpected components. Expected inflation is commonly measured by the difference between realized inflation and a time series model of the return on short-term US T-bills (Binkley et al. 2005; Washburn & Binkley 1993). Unexpected inflation is the difference between actual and expected inflation. Washburn & Binkley (1993), Binkley et al. (2005) and Lausti (2004) have used a multi factor model based on Fisher hypothesis to measure the expected and unexpected inflation hedging properties of forest asset and other financial assets. The analysis is based on the theoretical foundation that the expected nominal rate of return for any asset is equal to the risk-adjusted real rate that investors expect from the asset plus the expected rate of inflation (Fisher 1930), which is as follows:

$$R_{i,t} = \beta_{0,i} + \beta_{1,i} ER_t + \beta_{2,i} EI_t + \varepsilon_{i,t} \quad (56)$$

Where:

$R_{i,t}$ =*nominal return from asset* ***i*** *in period* ***t***

ER_t = *expectation of real return in period* ***t***

EI_t = *expectation of inflation in period* ***t***

$\varepsilon_{i,t}$ = *an error term assumed to be normal*

$\beta_{0,i}$, $\beta_{1,i}$, $\beta_{2,i}$ = parameters to be estimated for each asset ***i***

4.6.2 Test against unexpected inflation

Washburn et al. (2005) updated the study of Washburn & Binkley (1993). Both study used two-factor model with CAPM beta and unexpected inflation to relate timberland returns to overall market returns and unexpected inflation:

$$R_{i,t} = \gamma_{0,i} + \gamma_{1,i} R_{m,t} + \gamma_{2,i} UI_t + \varepsilon_{i,t} \quad (57)$$

Where:

$R_{i,t}$ = *real returns from asset i in period* ***t***

$R_{m,t}$ = *real market returns in period* ***t***

UI_t = *unexpected inflation at time* ***t***

$UI_t = I_t - instrEI_t$

I_t =*Actual inflation at time* ***t***

$instrEI_t$ = *instrument for expected inflation* $= Y_t - ARIMAEr_{f,t}$

Y_t = *yield on US Treasury bill at time* ***t***

$ARIMAEr_{f,t}$ = *the time-series estimate of the expected real risk free rate of returns during period* ***t***

$\varepsilon_{i,t}$ = *an error term assumed to be normal*

$\gamma_{0,i}$, $\gamma_{1,i}$ *and* $\gamma_{2,i}$ = *parameters to be estimated for each asset* ***i***

The estimates of $\gamma_{1,i}$ is the measures of the CAPM beta or systematic risk of the forest assets (Washburn & Binkley 1993). The coefficient $\gamma_{2,i}$ in equation (57) provides the measure of the relationship between asset returns and inflation-the response of real rates of returns for asset ***i*** to unanticipated inflation. Because investors hedge to insure against unexpected outcomes, $\gamma_{2,i}$ is the appropriate measure of an asset's inflation-hedging properties. i) If $\gamma_{2,i}=0$, then real returns for asset ***i*** have been immune to unexpected inflation; ii) If $\gamma_{2,i} > 0$, then asset ***i*** has hedged higher-than-expected inflation; and iii) if $\gamma_{2,i} < 0$, then asset ***i*** has hedged lower-than expected inflation.

They estimated the model (57) for timberland and other assets over the period 1960-2004 using annual data applying OLS regression for each series of stumpage prices. They measured unexpected inflation (UI_t) as the difference between realized U.S. consumer price inflation (measured by CPI-U) and a measure of expected inflation based on an ARIMA (Auto Regressive Integrating Moving Average) model of the short-term U.S. treasuries. Estimates of the expected real riskless rate were obtained from an ARIMA model based on past realized risk-free rates, themselves calculated as the rate of change in the period-average value of a series of one month T-Bills (calculated from values at the conclusion of each month taken from Ibbotson Associates) less the rate of change in the corresponding period average CPI. The ARIMA model for the expected real riskless rate uses a constant, a first-order autoregressive parameter, and a first-order moving average parameter. Thus, they assume that investors' expectations of the real risk-free rate of interest during year ***t*** are based on a linear combination of both the actual real riskless rate during year ***t-1*** and the difference between thee actual and expected real riskless rates during year ***t-1.***

Using the model equation, Washburn & Binkley (1993) examined the historical relationship between forestry returns and inflation using stumpage price series as a proxy for individual regional tree species returns. The study was carried out in national forests in the West, private forests in the Louisiana and private forests in Maine for the period 1955-1987. They used variation in historical rates of change in the price of saw timber stumpage as a proxy for variation in rates of return for entire forest properties. They measured the inflation-hedging properties of forest assets in a portfolio context with stocks. The study showed that forests in the West and in Louisiana have been significantly effective hedges against higher than unexpected inflation, while the forests in the Northeast have been less effective hedges against unexpectedly high inflation; the estimates of unexpected inflation for the Maine price series, although consistently positive, were not statistically different from zero. They found timberland in the West and South to be overvalued during times of relatively high expected inflation and undervalued when the rate of inflation is anticipated to be relatively low. They also compared the results for forest assets with those for financial assets. The result showed that none of the stocks, corporate bonds, government bonds provided a hedge against higher than-expected inflation. In fact, the estimates for the T-bills and bonds were significantly less than zero indicating that they hedged lower than expected inflation. This suggests that investor can add timberland to portfolio of financial assets to help compensate it against unexpected inflation.

Binkley et al. (2005) updated the study by Washburn & Binkley (1993) for timberland and other financial assets over the period 1960-2004 using annual data. The result was consistent with previous one suggesting that the US Pacific Northwest responded strong hedge against unexpected inflation. The explanatory power of this regression is 18%, 24%, 9% and 17% for aggregate US timberland, US South, US Pacific Northwest and US Northwest respectively.

Lausti & Penttinen (1998b) reported that the average real return of forest ownership has been about 3% over the high inflation period 1972–1983 and low inflation period 1984–1994 in Finland. Penttinen & Lausti (2004) found that the average real return has been 2.6% over the period 1972–2003. This suggests that forest ownership might have some ability to hedge against inflation.

In recent study, Lausti (2004) examined the extent to which forest ownership, private housing and stocks provided a hedge against actual inflation, expected inflation, and unexpected inflation. The inflation-hedging characteristics of forest ownership were also examined in a portfolio context, forest ownership with stocks or private housing. He also analyzed correlation. According to his study, the correlation coefficient between inflation and forest ownership return was 0.28 over the whole period from 1972 to 2003. During the sub period, 1972–1987 and 1988–2003, the correlation coefficient between inflation and forest ownership were 0.18 and 0.03 respectively. Lausti (2004) used following four different models to estimate actual inflation, expected inflation, and unexpected inflation:

1) Test against actual inflation with forest ownership

Lausti (2004) used the following regression model to evaluate the direct relationship between the inflation and the forest ownership return:

$$R_t = \alpha_0 + \alpha_1 I_t + \varepsilon_t \quad \text{......} \quad (58)$$

Where,

R_t = nominal rate of return on the forest ownership at time ***t***

I_t = actual inflation rate at time ***t***

α_0, α_1 = model parameters to be estimated

ε_t = error term at time ***t***

Using change in cost-of-living index, he calculated actual inflation. He tested the regression model and found that the forest ownership has not provided a hedge against actual inflation over the annual holding period 1973–2003. The coefficient α_1 was 0.81(<1) but p-value is 0.12 and the explanatory power of this regression was only 8%. The null hypothesis, that forest ownership has not provided hedge against actual inflation (i.e. $H_0 : \alpha_1 \neq 1$) could not be rejected.

2) Test against actual inflation with forest ownership, and stocks

The inflation-hedging characteristics of forest ownership return within the context of a complete return-generating model was examined by including the return on the stock market could be included in the regression model(Lausti 2004):

$$R_{i,t} = \alpha_0 + \alpha_1 I_t + \beta_t R_{m,t} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(59)}$$

Where:

R_t = nominal rate of return on the forest ownership at time ***t***

$R_{m,t}$ = return on the value-weighted index of the Helsinki Stock Exchange

P_t = actual inflation rate at time ***t***

α_0, α_1 = model parameters to be estimated

β_t = magnitude of response of forest ownership return to general stock-market activity

The result showed that the forest ownership in combination with the stocks in a portfolio could not hedge against actual inflation, but performed better than stocks over the annual holding period 1973–2003.

3) Test against expected and unexpected inflation with forest ownership and stocks

Lausti (2004) used the following regression equation to estimate direct relationship between unexpected and expected inflation:

$$R_{i,t} = \alpha_0 + \alpha_1 E(I_t) + \alpha_2 \{I_t - E(I_t)\} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(60)}$$

Where:

$E(I_t)$ = *expected inflation*

$\{I_t - E(P_t)\}$ =*unexpected inflation*

$\alpha_0, \alpha_1, \alpha_2$ = *model parameters to be estimated*

He used inflation forecasts by Research Institute of the Finnish Economy (ETLA) to compute expected inflation. The regression result showed that over the annual holding period 1978–2003, forest ownership and private housing provided a better hedge against unexpected inflation than stocks. Forest ownership has not provided a hedge against expected inflation.

4) Test against expected and unexpected inflation with forest ownership in a Portfolio Context

Lausti (2004) finally estimated the forest ownership inflation hedging characteristics in a portfolio composed of stocks, forest ownership and private housing based on the following regression model:

$$R_{i,t} = \alpha_0 + \alpha_1 E(I_t) + \alpha_2 \{I_t - E(I_t)\} + \beta_1 R_{m,t} + \varepsilon_t \quad \text{………..} \ (61)$$

Where:

β_1 = *the regression coefficient for stock market return.*

The estimated regression model parameter showed that forest ownership remains an effective asset class to hedge against unexpected inflation, but not against expected inflation. Private housing was found a good substitute for the capital of non-industrial private forest owners. Using five-year and ten-year holding periods, he studied the long-run interactions between forest ownership return and inflation. The result showed that Forest ownership provided a hedge against expected inflation provided to some extent and a very effective hedge against unexpected inflation with much improved than annual holding period. The study concluded that forest ownership and private housing are better assets for the institutional investor in terms of inflation hedging. Both these asset categories have provided effective hedges against unexpected inflation.

Chapter 5: Conclusion

This literature review study describes the concepts and development of CAPM its model components, estimation procedure, estimation methodology used for applied forestry return and the application area of forestry where the CAPM have been implemented. The study focused the three countries for the review the model based on the use of published documents, secondary data, information, academic journal (online) and the library study. The following conclusions are drawn with respect to research question and objectives based on the review of those studies.

The characteristics of forestland investments

The characteristics of forestland investments vary on greatly depending on the differences in site quality, location, current stocking and species composition, size, and form of investment. The forestland like other types of investments has unique attributes, some positive and some negative. Positive attributes includes the biological growth, harvesting flexibility. Negative attributes associated includes relatively poor liquidity and the need for, high transaction cost, specialized management expertise. The study has shown that forestland possess various properties in contrast to commercial assets.

Risk and return and portfolio diversification:

The return earned by a long-term investment in forestland is a function of acquisition cost, site productivity, management and associated costs, and markets. The return can be calculated for market values alone or can include nonmarket goods and services. Timberland returns derive from a combination of income and capital gains. The returns from timberland investments are derived from the three principal components: biological growth, stumpage price changes, and land value changes. The principal costs are property taxes and management expenses, and losses to certain natural hazards.

The primary risks associated with timberland investments are commonly referred to as market risk (change in price of future timber and timberland price) and biophysical risk. Biophysical risks are small compared to the market risk. Geographic diversification is a good way to control this and other sources of physical risk.

Since the return on investment on forestland have been found negatively or weakly correlated with financial assets, the forest assets can reduce the total portfolio risk by adding forest asset in investment portfolio. Forest investments are typically diversified by property location, timber market, tree age, species and end products. Most importantly, by investing in timberland among different regions, investors can offset the risk associated with investing in only one area.

Forestry return calculation

Return on forest asset return for estimating CAPM is based on the time series historical data following a similar approach of standard formula used for calculating financial assets. In aggregate level studies, forestry returns are calculated for a hypothetical forest land investment, assuming certain management regimes, age class distributions, site qualities, and timber species. Stumpage price, growing stock and management cost information are needed to compute the annual return for each timber investment. In US, return on timberland has been calculated i) based on the assumption about stumpage price, growing stock and bare land, b) use of the timberland indices, or individual timberland fund c) real or hypothetical forest holding. In Sweden bare land value has been considered with assumption or growing stock. While in Finland, forest ownership return has been calculated excluding bare land and including the net increment of the growing stock in addition to stumpage prices, i.e. as an actual return index.

The CAPM estimation requires the estimation of risk free rate, rate of return on market portfolio and the asset of in question. Ordinary least square (OLS) method is used by researchers and practitioners for estimating α in CAPM. The usefulness of CAPM mainly depends on the authenticity of beta. Normal distribution of time series asset return data (monthly, quarterly or annualized data) is prerequisite for the model. Researchers have applied T-distribution test, F-Test in their study as a statistical method. They have performed the test of normality of return series by using statistical test such as:W-test. The Durbin-Watson test has been used in testing autocorrelation properties of time series data.

Application results

Based on the review of CAPM study and other risk return study, the following conclusions have been drawn in timberland in USA, Sweden and NIPF ownership in Finland.

NIPF ownership in Finland

- Medium risk- medium return assets class
- Low real return
- Positive beta (β=0.6): high systematic risk
- Negative alpha (α =-0.24): high required rate of return for a given level of risk
- Significantly correlated with both private housing and commercial real estates
- Sharpe ratio: negative, lower than that of private housing, stocks and market portfolio
- Less competitive than private housing
- Capable of effective hedging against unexpected inflation.
- Low diversification potential

Timberland in US

- High real return
- Negative beta (β=0.13,0.37,-0.21) than T-bills, S&P 500, real estate and venture capital: Low systematic risk
- High risk adjusted return than US T-bills
- Positive alpha(α =-0.24,6.20,): high required rate of return for a given level of risk
- Negatively with commercial real estates, common stocks, small cap stocks, and a long-term Treasury security index.
- Timberland limited partnerships weakly correlated with S&P 500 than other large and medium forest industry company portfolios.
- TPI negatively correlated with T-bills, NCREIF-Real Estate, foreign stocks and positively correlated with the S&P 500 and Corporate bonds.
- Midwestern timberland tracts negatively correlated with financial alternatives : the S&P 500 common stock average, residential housing, over the counter-stocks,

preferred stocks average, no load mutual fund average, preferred stocks, T-bills, Treasury notes, municipal bonds, long term corporate bond, saving deposit S&L associate, Time deposits commercial banks and commercial paper.

- Positively correlated with inflation
- Higher Sharpe ratio than European stocks, global stocks, real estate, European bonds, publicly traded forest product companies or such other alternative assets as private equity or direct energy investments.
- Above Security Market line: Southern Pine timberland investment has been found security line
- Above the capital market line: the level of timberland returns has been relatively high given their volatility.
- Capable of effective hedging against unexpected inflation.
- Strong diversification potential

Timberland in Sweden

- Medium risk- medium return assets class
- Negatively correlated with bank, grain, shares
- Low correlation with the market portfolio
- Higher real return
- Higher Sharpe ratio(1.29) than the market portfolio(0.30)
- Negative beta (β=-0.03): Low systematic risk
- Positive alpha(α=-0.06): high required rate of return for a given level of risk
- Strong diversification potential

The findings of the literature review concluded that forestry has reduced the systematic risk of portfolio whether the market portfolio was either stock market index or broad-based market portfolio in USA and Sweden the CAPM β being nearly zero or negative. The negative β indicates that the forestry return is a negative-risk investment and therefore should be required to generate even less than the return earned by a risk-free asset. Positive α suggests that timberland has been undervalued, generating substantial excess returns given its low risk. In contrast to these results, forest ownership in Finland provides risk reducing benefits in a portfolio with stocks, but does not reduce risk with other asset classes. The lower β and higher α implies that they have higher diversification potential to reduce portfolio risk. This benefit of timberland in portfolio's risk's diversification is a useful approach for institutional investors for allocating the amount of forestland to their investment portfolio even if the expected returns on forest land are lower than returns on alternative investment with similar risks.

Performance evaluation

Based on these result, it can be concluded that direct investment in privately traded timberland or timberland alone has a lower level of risk than forest industry companies which combine timberland and timber processing facilities and historical returns in the past are substantially higher than the required returns. This superior performance of these kinds of assets than the medium and large forest product companies suggests that they could be good investment vehicles for some investors for portfolio diversification.

Asset allocation

The result of risk return study can be used in asset allocation decision. Asset allocation is the process of dividing or allocating an investor's portfolio among a number of major asset classes. It is concluded that CAPM result is useful in asset allocation of timberland investment through portfolio analysis or following optimization procedure. When the negatively correlated asset (such as timber) possess positive α and negative β, the possibility for inclusion in portfolio will be further enhanced. One study showed that with an addition of 30% of the STIF to a group of financial asset alternatives reduced the risk of efficient portfolios by an average of 43%. Asset allocation study has not been conducted in Sweden.

Discount rate determination:

Researchers have suggested the integration of the CAPM and CB methods will help analysts understand how forest assets are correlated to the general economy and may earn returns different from those suggested by using only CB analysis. CAPM is a useful theoretical approach that enables the analyst to objectively estimate the opportunity cost of funds for a project. Though the CAPM-based approach for selecting a DR is imperfect, it is generally considered by financial theorists to be one of the best approaches available. Only the risk free rate of return, market risk premium and β is essential for estimating discount rate (required rate of return). CAPM studies in USA and Swedish timberland have shown low or even negative βs indicates the rationality for using a lower DR to analyze timberland investments than for more traditional assets such as common stocks. However, in practice, the study shows that the rather than utilizing CAPM to adjust for risk in their analyses; forests industry firms were found to raise their required rate of return, shorten their payback period, or simply subjectively adjust cash flows, which implied a prevalence of subjective adjustment in risk analysis.

Event study application in forestry

Among different model available in finance literature, the CAPM has also been applied in event study. Event studies generally use financial data to examine the economic impact of some event or set of events on the value of assets over a relatively short time period. In forestry sector, event study also have been applied by in U.S. researchers to determine the impact of M&A of forest product company, impact of spinoff of forest product company and to analyze the impact of regulatory changes on the expected profits of firms. The CAPM has been used in event study to estimate abnormal return. The abnormal return is the ex post return of the security over the event window minus the normal return of the firm, which is the return that would be expected if the event did not take place. The abnormal return can be obtained by subtracting the expected returns according to the CAPM from actual returns during the event period. Event studies have been conducted only in USA.

Limitation of CAPM in forestry application

The result of CAPM is based on the ex-post data so; it cannot predict the future return or risk level on the same way. On other hand, the strong assumption of the model, debate on selection of index as a proxy for market, instability of beta, lack of historical market data describing return on forest are the possible constraints on the successful of the result derivation from CAPM. In addition to this choice of an appropriate data series for measuring timber value changes; measurement of growing stock and the method by which periodic returns are calculated problems with the composition of the true market portfolio; the low explanatory power of the model; and the low accuracy of prediction. Most of the earlier studies have suggested for the cautious interpretation of the result, because they are based on different time intervals (monthly, quarterly, and yearly) and different type of calculation of forestry returns.

Forest investment has an inflation hedging potential

It has been concluded from the study that forest as an asset has an inflation hedging potential on comparison to other financial assets. The inflation hedging characteristic of forestland also observed strong in Sweden, Finland and USA. With a use of model including inflation, researchers have demonstrated that forest as a financial asset demonstrated its strong inflation hedging ability against unexpected inflation in the Finland and USA. This suggests that timberland investments have been an effective vehicle for the preservation of capital during inflationary periods.

It has been concluded from the study that the result of CAPM has an important implication for the institutional investors since the timberland investment has been found more attractive to them to reduce their total portfolio risk. Also, there is a need of development of suitable timberland indices in the country like Sweden and Finland incorporating the non-timber value so that the results could be comparable, attractive, accurate and convincing for the investors. However, with the development of more robust financial models and time series analysis suggest for the use of those methods instead of CAPM for further research.

In US, the timberland investments produced excess returns and timberland alone has been found with a lower level of risk than forest industry companies which combine timberland and timber processing facilities. The CAPM result shows in timberland investment have excess return in US, the forest product industry (medium and large) did not perform well and did not earn risk adjusted return in the past. Timberland alone was found with lower level of risk than forest industry companies which combine timberland and timber processing facilities. Historical returns of institutional timberland investment in the past years were found substantially higher than the required return. These results suggest that investment in forestland will have higher probability of expanding in future.

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