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The competitiveness of forest ownership analysed by various market portfolio proxies

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Abstract

A new market wealth portfolio index for Finland using stocks, bonds, debentures, offices, private housing and non-industrial private forests in 1972–2008 has been constructed for capital asset pricing model (CAPM) analyses.

First, normality, autocorrelation, heteroscedasticity, model fitness and functional misspecification were tested. Second, outliers were identified using Cook's distance measure recognising years 1973, 1991 and 1999. Third, possible breaks between 1972–2008 were analysed using the rolling Chow tests, which suggested a break after 1983. Fourth, correlation study demonstrated that forest correlated significantly with private housing and also with stocks delayed by one year. Fifth, a CAPM was studied with evolving market portfolio proxies.

With the stocks-only market portfolio proxy, the systematic risk (beta) of forest ownership was 0.12 and the risk-adjusted return per annum (alpha) -0.29, but the explanatory power remained only at 7%. With the market value weighted portfolio proxy including all asset classes, the beta was 0.60, significantly different from zero, and the alpha declined to -2.2, but did not, however, differ significantly from zero. The explanatory power of regression jumped to 44%. Moreover, high betas and low alphas persisted with other proxies such as one entirely without forests (0.50 and -2.0), even without forests and after removing the outlier years 1973, 1991 and 1999 using dummy variables (0.60 and -2.5). The shorter period 1984–2008 suggested a slightly lower alpha -2.9, but with inclusion of the dummy years 1991, 1994 and 1999 even better alpha -2.1. Finally, the prerequisites for applying CAPM and model residuals were systematically analysed.

Keywords

Forest ownership, competitiveness, market portfolio proxy, capital asset pricing model (CAPM), systematic risk

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1 Introduction

Constructing the market portfolio is a cornerstone of applying the capital asset pricing model (CAPM). Moreover, there are also many theoretical reasons for analysing the market portfolio. Even a minor misspecification of the composition of the market portfolio proxy can lead to the wrong conclusion (Roll 1977, p. 158). For example, a change in the US market portfolio resulted in a substantial reduction of corporate leverage (Ibbotson and Fall 1979, p. 83).

We can never observe the exact composition of the true market portfolio, but the CAPM theory is not testable unless all individual assets are included in the sample, according to Roll (1977, p. 130). Additionally, a misspecification of the market portfolio would create bias and non-stationarity even if there were a constant riskless return (Roll 1977, p. 131). Brown and Brown (1987), however, found that since any market portfolio without stocks is worthless in measuring the CAPM performance of funds invested primarily in corporate securities, it is useful to construct comprehensive market portfolio proxies in estimating their CAPM performance.

In the US studies, the stocks-only proxy is typically the benchmark case in applying the CAPM to forestry (Washburn and Binkley 1990b, Cubbage et al. 1989, Zinkhan 1990, Zinkhan et al. 1992) in spite of Roll's criticism. Previous results in Finland are based on stocks only as well. The present study analyses the impact of extending market portfolio proxies from stocks only to various broad proxies in CAPM performance benchmarking of forest ownership; something which has not so far been done in the Finnish case.

Section 2 surveys previous findings covering both the impact of market portfolio studies and contributions applying the CAPM to forestry, and outlining the test methodology. Section 3 explains data both covering the asset classes and market portfolio proxies. Section 4 provides the empirical results, while Section 5 considers the findings and draws conclusions.

2 Theoretical background

2.1 Market portfolio and CAPM forestry studies

The role of a market portfolio in applying CAPM is considered first. Roll (1977) states that a correct and unambiguous test of the CAPM is impossible because we can never observe the exact composition of the true market portfolio. Moreover, empirical evidence suggests that the CAPM is invalid or that proxies account for at most two-thirds or perhaps only half of the variation in the true market return (Shanken 1987). The market portfolio of all investable assets should represent the ultimate index fund according to Ibbotson and Fall (1979), who constructed the United States market wealth portfolio by including stocks, corporate securities, farms, residential housing and bonds. Elton and Gruber (1984) extended the work of Roll (1977) by analysing the impact of assets that have been excluded from the market portfolio, including non-marketable and international assets, inflation, taxes and heterogeneous expectations. They showed that the differences between most non-standard forms of the CAPM arose from a difference in which *the market portfolio is assumed to be efficient*, and an assumption about how to change from the *definition of returns* used to define the market portfolio in the usual sense of returns (dividends plus capital gains). Brown and Brown (1987) measured the effects of various specifications of the market portfolio, the stocks only portfolio producing the highest return and standard deviation. The risk and return declined considerably as the market portfolio broadened. The average alpha was not positive when real estate was omitted, but was markedly negative when it was included. Moreover, the market portfolio without stocks was worthless for measuring the performance of funds invested in corporate securities. Thus, the "true" market portfolio can be seen to consist of the observable benchmark portfolio and the unobservable latent portfolio, the benchmark portfolio being a perfect proxy of the market portfolio whenever its correlation with the unobservable one is unity (Eun 1994).

The CAPM has mainly been applied to forestry in the US studies. Olsen and Terpstra (1981) have already analysed risk, return and competition in a log market using the CAPM. Their models provided positive 'degrees of competition' (alpha) and systematic risks (betas) close to zero. Redmond and Cubbage (1988) could demonstrate only low explanatory powers, but their systematic risk betas were negative and the risk-adjusted returns alphas positive. Cathcart and Klemperer (1988) reviewed risk and uncertainty reports in the forestry literature, including US CAPM studies, while Zinkhan (1988) reported negative betas for timberland-oriented projects. Cubbage et al. (1989) suggested that timber price betas have been zero or even negative while the alphas have tended to be positive, but their explanatory powers were very low. Washburn and Binkley (1989) estimated betas for different tree species and different areas and found that betas varied considerably from -0.3 to 1.5, but mostly around 0.5. They recognised that lacking good data on growing stock, bare land value and the cost of holding forest assets, it is difficult to estimate the risk-related return alpha.

Zinkhan and Mitchell (1990) showed that the Southern Timberland Index Fund (STIF) statistically significantly outperformed the Standard & Poor's 500 stock index. Binkley and Washburn (1990) found very low systematic risks and in most cases surprisingly lucrative risk-adjusted returns. Negative systematic risks and positive abnormal returns were reported by McKillop and Hutchinson (1990), but very low explanatory powers. Washburn and Binkley (1990a) obtained most betas close to zero, but the explanatory power remained low in all cases. Both betas and alphas were also close to zero in the CAPM analysis by Washburn and Binkley (1990b). Wagner and Rideout (1991) obtained mainly positive alphas and betas of roughly 0.5, but only a small percentage of total variation in forestry assets could be explained. Wagner and Rideout (1992) analysed forest investments, finding that the parameters of both nominal and real CAPM were unstable, and that the explanatory power was low. Moreover, they demonstrated that there was irregular behaviour in the 4^{th} quarter of 1976, and that the systematic risk beta might be different for these two stable periods. Caulfield (1994) constructed a timberland performance index (TPI) and reported its negative correlation with most assets, especially real estate. Zinkhan et al. (1992, p. 100–104) report several results, some unpublished, in which betas range from -0.21 to 0.57 and alphas from 1.6% to 6.2%. Zhang and Binkley (1994) estimated CAPM coefficients using monthly, quarterly and annual series for five log species in Vancouver log market. They found negative alphas for monthly and quarterly series but positive alphas for annual series. Betas varied according to tree species and series being in case of spruce 3.1 for annual series but -0.3 for quarterly series.

Wagner et al. (1995) obtained mainly negative betas and positive alphas, but these suffered from low explanation power. Timberland, according to Binkley et al. (1996) was the most competitive asset class of all, being clearly above the security market line. Heikkinen and Kanto (2000) found statistically significant systematic risk beta in the Finnish context only for spruce pulpwood. Sun and Zhang (2001) found that arbitrage pricing theory (APT) models yield more robust results than the CAPM, but that the APT can explain a larger proportion of return variation. Cheung and Marsden (2002) estimated betas in the range of 0.5 to 0.8 within the New Zealand market. Lundgren (2005) based forest property valuation on taxation values and obtained a small negative beta (-3.4%) and a clearly positive alpha, (6.9%), which differed significantly from zero.

2.2 Test methodology

Sharpe's notion (1964) was that the return of an asset *a* depends linearly on the market portfolio return. He called the regression coefficient of this relation the systematic risk β_a. and the regression relation itself the nominal CAPM. Jensen (1969) generalised this CAPM for **ex post** studies by introducing the alpha value, α_a for risk-adjusted so-called excess or abnormal return, so that the return on asset *a* could be expressed as

$$(R_{at} - R_{ft}) = \alpha_a + \beta_a(R_{mt} - R_{ft}) + \varepsilon_{at} \qquad (1)$$

where R_{at} is the nominal return on asset a, R_{ft} is the nominal return on a risk-free asset, R_{mt} the nominal market portfolio return and ε_{at} the residual term at time t. [1]

The competitiveness of forest ownership is the question of this study. A market wealth portfolio for Finland consisting of stocks, bonds, debentures, offices, housing, and non-industrial private forests (NIPFs) will be constructed, and its effect on the CAPM estimation analysed. The broad value-weighted and equally-weighted market portfolios as well as a broad portfolio without non-industrial private forests (NIPFs) will be applied. The contribution we make is to investigate the competitiveness of NIPFs with evolving portfolios incorporating other asset classes as a proxy for a true market portfolio. The particular purpose is to determine the impact of extending market portfolios on the CAPM results. The extent of the change in systematic risks (betas) of NIPFs and the risk-adjusted so-called abnormal returns (alphas) as well as the explanatory power of the model is the key research question. All the returns used in the present study are annual, nominal and logarithmic.

[1] The beta values β_j are the statistical estimates of the true betas. Alphas (also called Jensen's performance index) measure ex-post superior abnormal returns. Theoretically, the CAPM rests on the efficient market hypothesis, by which investors correctly price assets with the knowledge of all publicly available information. The alpha values in CAPM regression should thus be zero if the efficient market hypothesis holds. Recall that the real CAPM requires the removal of the effect inflation response coefficients where the variance of inflation is not zero (see Lee et al. 1988, Wagner and Rideout 1991, 1992, Lundgren 2005). Moreover, Leland (1999) included skewness in addition to the mean and variance in power utility functions, and lognormal returns for the market portfolio. Even kurtosis was incorporated into Hwang and Satchell's (1999) CAPM model with logarithmic utility. The assumptions of the CAPM have been summarised by Copeland et al. (2005).

3 Data

3.1 The asset classes in Finland

This study includes assets classes such as private housing, offices and forest ownership, whose holding period is long, typically some years. The NIPF return estimate will utilize all national forest inventory (NFI) data, as well as the forest statistics such as stumpage prices, silvicultural and other forestry costs and subsidies. Private housing, offices, bonds, debentures and stock return estimates will be based on the most comprehensive data available from Statistics Finland, the Bank of Finland, the Helsinki Stock Exchange, Sampo Bank and the Finnish Institute for Real Estate Economics. The most comprehensive return series data available is used for all asset classes. If there is a new index for a return series, this is used to estimate asset class returns as early as possible.

The main asset classes of the total market portfolio in Finland thus are, in market value order, 1) private real estate, 2) offices and other real estate 3) non-industrial private forests (NIPFs), 4) stocks, 5) government bonds and 6) corporate debentures. At the end of 2008 (the 1972–2008 period in parentheses), the average weight of private housing was 33.4% (36.2)%, commercial offices and other real estate 22.5% (27.0%) non-industrial private forest ownership (NIPF) 8.4% (14.5%) , stocks 24.2% (15.0%), government bonds 11.5% (5.5%) and corporate debentures only (1.8%). The market value estimate of the total value of all asset classes was €479 billion in Finland at the end of 2008. [2]

3.1.1 The non-industrial private forest (NIPF) ownership asset class

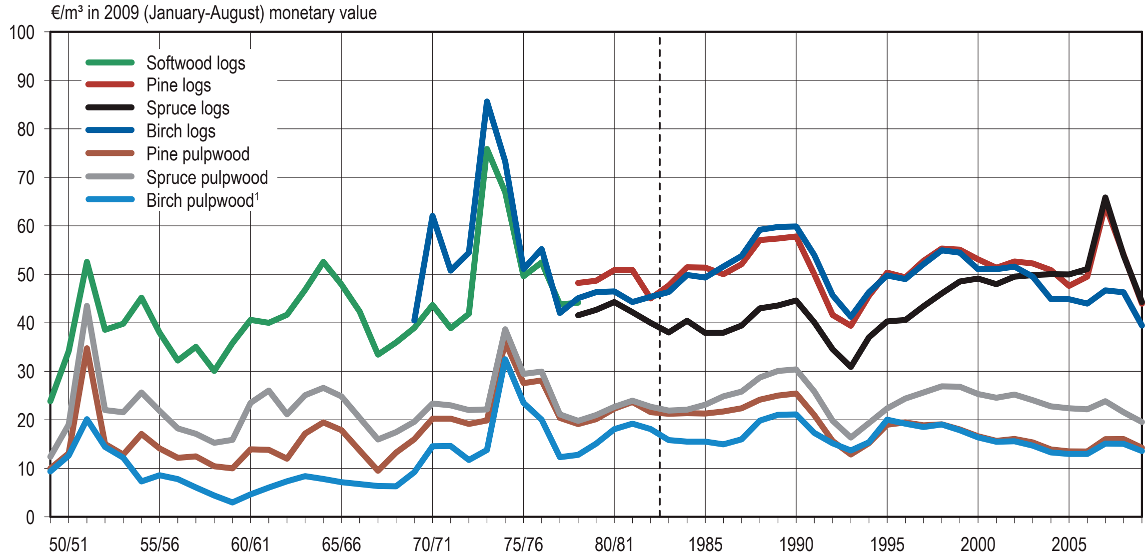
In previous applications of CAPM to forestry, stumpage prices, silvicultural and other costs, and timber performance indices have been used, but forest inventories have been excluded. In the present study, even the systematic national forest inventory (NFI) data of the Finnish Forest Research Institute (FFRI) has been included. The evaluation of the NIPF asset class is based on (i) roundwood assortment volume and (ii) net roundwood assortment increment. [3]

In the five inventories, NFI6, NFI7, NFI8, NFI9 and NFI10, there are thus five measured growing stocks for all six roundwood types and net increment point estimates for three tree species - pine, spruce, and broadleaves. The six roundwood assortments are: (1) pine logs, (2) spruce logs, (3) broadleaf logs, (4) pine pulpwood, (5) spruce pulpwood and (6) broadleaf pulpwood (FFRI 2009). These estimates are for all nineteen (19) Forestry Board Districts (FBDs) in 1972–1981 and for all thirteen (13) Forest Centres thereafter. [4] The methodology developed to tackle the

[2] The Finnish market portfolio does not include the short-term money market instruments, which mature in under a year. Households had 70 billion euros in bank deposits, and their bank loan base exceeded 93 billion (Bank of Finland 2009a, 2009b).

[3] In order to provide net increment volume estimates, natural losses were subtracted from gross increment volumes (see the United Nations 1992, p. 67).

[4] The organisation into 19 FBDs has now changed, a new regional organisation for 14 Forestry Centres having been established on March 1, 1996. Forestry Centres have been reduced to 13 in March 1, 1998.



[1] Until felling season 1968/69 birch fuelwood.
Year 2009 January–August average.
Prices deflated using wholesale price index (1949=100).

Figure 1. Real stumpage prices in non-industrial, private forests, 1949/50–2009 (FFRI 2009).

separate estimation problems of growing stock, net increment, roundwood assortment and commercial roundwood fellings has been outlined in Lausti and Penttinen (1998a) and Penttinen and Lausti (2004).

The roundwood assortment stumpage price matrix $\mathbf{P} = \{ p_{yw} \}$, where y stands for year and w for roundwood type, forms a cornerstone of the process of estimating return on NIPF ownership (Figure 1).

The other cornerstone is the volume matrix of the roundwood assortment growing stock, $\mathbf{V} = \{ v_{yw} \}$. The change in the growing stock over a year is based on the net volume increment matrix after natural losses $\mathbf{I} = \{ i_{yw} \}$, also called the net growing stock increment, and the fellings matrix $\mathbf{F} = \{ f_{yw} \}$. [5]

The return on NIPF ownership $r_{y,NIPF}$ during year y at the national level is produced here by estimating the sum of the growing stock, the change in the growing stock, and felling values across the roundwood assortment (Binkley and Washburn 1990 and Penttinen and Lausti 2004, cf. Lausti and Penttinen 1998a, 1998b) [6]

5 Thomson (1989, p. 1386) has also suggested a return formula based on stumpage prices, growing stock index, harvesting volume, and cost. However, he assumes a constant growing stock index, which is actually constant only for a fully regulated forest. This limitation does not fit the empirical Finnish NFI evidence.

6 Penttinen & Lausti (2004) examined the estimation of return on forest ownership and developed a return disaggregation into (i) stumpage price change, (ii) silvicultural costs and (ii) the growing stock net increment components, which were also divided into (iv) fellings and (v) growing stock value change components. Caulfield (1998a) disaggregated the total return using a return driver. He found that biological growth represented 61% and stumpage price change 33% while the land price change was only 6%.

$$r_{y,NIPF} = LN\left(\frac{\sum_{w=1}^{6} s\{\, p_{yw}(v_{y,w} + i_{yw} - f_{yw}) \,\} + \sum_{w=1}^{6} p_{yw} f_{yw} - c_y}{\sum_{w=1}^{6} s(\, p_{y-1,w}\, v_{y-1,w} \,)}\right) \tag{2}$$

y = the year considered, y = 1972, 1973, …, 2008,

w = roundwood type w, $w = 1, 2, \ldots, 6$,

s = the sensitivity coefficient changing the felling value of the growing stock to forest market value, $0 < s \leq 1$,

p_{yw} ($p_{y-1,w}$) = roundwood type w stumpage price € / m^3 at the end of year y (at the end of year $y-1$)

v_{yw} ($v_{y-1,w}$) = roundwood type w volume m^3 at the end of year $y-1$

i_{ya} = net increment m^3 of roundwood type w during year y

f_{yw} = commercial fellings m^3 of roundwood type w during year y.[7]

c_y = silvicultural and forest improvement costs € reduced by state subsidies during year y.

3.1.2 Private housing and offices

Private housing data includes a large sample, covering the 20 largest cities in Finland as well as smaller cities that have been combined into larger regions.[8] The return on private housing $r_{y(h)}$ and office $r_{y(o)}$ investment includes capital appreciation and the rent component minus the cost component:

$$r_{y(h)} = LN\left(\frac{p_y + n_y - c_y}{p_{y-1}}\right) \quad , \tag{3}$$

where p_y = price of private housing per square metre €/m^2 at the end of year y, n_y = yearly rent per square metre €/m^2 of private housing, c_y = yearly cost per square metre €/m^2 of private housing. The cost side includes the maintenance and capital charges on private housing. Cost statistics have been compiled by Statistics Finland. [9]

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7 The commercial fellings are only needed for the sensitivity analysis section.

8 The statistics are based on some 10,000 or more real annual trades ; e.g., at least 12,000 trades in 1983.Buying quotes without actual trades have been excluded. The private housing rent data includes a considerable sample each year, such as 7473 in 1994. The cost side included some one thousand housing corporations located throughout Finland; 1387 corporations in 1994, and 797 in 1982. The cost side includes the private housing maintenance and capital charges. Rents are gathered as a divided sample, the population being divided by size, location, type of finance and type of private housing. Rent and cost statistics have been compiled by Statistics Finland.

9 The returns on offices are only available for Central Helsinki in 1972–1997. However, a comprehensive index that includes all the major cities in Finland has been used for 1998–2008. This index includes offices and other commercial real estate as well. Since the returns have been constructed by the KTI Institute for Real Estate Economics, the market values of commercial real estate (offices) have thus been overestimated to some degree. The market values of commercial estates include other kinds of estates as well (not private real estate).

The depreciation of capital stock is included in the statistics, and the net fixed capital stock of private real estate has been used as a proxy for market values.

3.1.3 Bonds and debentures

The returns on public bonds were derived from government tax-free and non-indexed bonds, the bond sample size fluctuating between one and three bonds before 1992. There is no comprehensive bond or debenture index available in Finland for the period before 1992.

The return on taxable corporate debentures is calculated as the arithmetical mean of the effective yields on fixed-rate ordinary bonds, debentures and other bonds issued by all issuers except the central government. These monthly figures were converted into yearly returns Market values have been derived from the "Joukkovelkakirjat" publication by Statistics Finland covering the period 1976–2001. Previous market values are from "Suomen joukkovelkakirjalainat", published by the Bank of Finland. [10]

Market values of bonds and debentures include all the issues of Finnish and foreign institutions which took place in Finland. [11] Debt bases have been derived by Statistics Finland as follows:

$$Debtbase_t = Debtbase_{t-1} + Issues_t - Amortizations_t \tag{4}$$

3.1.4 Stocks

The return on the WI index has been used as a proxy for the stock return over the 1972–1989 period. The Helsinki Stock Exchange Hex Total-Return index from 1990 to 2008, also a market-value-weighted index, has been used. All the stock returns include the dividend payments and share issues of the companies, in addition to the price trend.

The market values of the total stock class include stocks listed on the Helsinki Stock Exchange, but not OTC stocks or the stocks on the broker's list. The market values for 1972–1989 were

[10] The yield series of debentures can be found in the monthly Bulletin of the Bank of Finland. The bond and debenture series are yields that do not take the price changes in assets into account. The bond return index was derived by using an approximate average bond and debenture maturity of four years. It was assumed that debentures had a 12% coupon rate and bonds an 8% coupon rate. A one-month-holding period return was calculated for bonds and debentures. These returns were converted into annual levels. The bond and debenture return indices derived in this study do include price and interest changes for assets. These have been calculated by the authors. This asset class (debentures and bonds) has yielded a steadier return than any other asset class in the market portfolio. One reason for a fairly large gap between the debenture return and bond return is that the corporate debenture asset class is taxable, but the public bond asset class is tax-free

[11] This asset class (debentures and bonds) has yielded a steadier return than any other asset class in the market portfolio. One reason for a fairly large gap between the debenture return and bond return is that the corporate debenture asset class is taxable, but the public bond asset class is tax-free.

Table 1. Average composition of the different market portfolio proxies in 1972-2008

Market portfolio proxy	Private housing	Offices	Stocks	Bonds	Debentures	Forest ownership
STOCKS		-	100.0%	-	-	-
VWALL	36.2%	27.0%	15.0%	5.5%	1.8%	14.5%
EWALL	16.7%	16.7%	16.7%	16.7%	16.7%	16.7%
ALLBUTFORESTS	43.0%	32.2%	16.5%	6.1%	2.2%	-

derived by the Kansallis-Osake-Pankki investment unit, and those for 1990–2003 are from the Financial Statements of the Helsinki Stock Exchange OMX. [12]

3.2 The market portfolio proxies

The first market portfolio proxy (STOCKS) consists of stocks only as in Brown and Brown (1987), for instance. The broadest proxy (VWALL) consists of all the asset classes as a value-weighted market portfolio. The third market portfolio proxy (EWALL) also consists of all the asset classes of the study, but is an equally-weighted portfolio. Although the CAPM suggests that the market portfolio should be value-weighted, it is often hard to obtain the market values of all asset classes, and this EWALL has been formed as a sensitivity measurement in order to determine differences between the market-value-weighted and equally-weighted portfolios.

The reduced market portfolio proxy ALLBUTFORESTS is the same as VWALL, except that the forests have been omitted. ALLBUTFORESTS has also been formed for sensitivity analysis. The average composition of the market portfolio proxies is stated in Table 1.

4 Empirical Results

The competitiveness of forest ownership is the question in the analyses. The various relations between forest ownership and other asset classes as well as the statistical properties of the asset class market portfolio returns will be considered as well.

We now consider the effect of applying different market portfolio proxies to the performance measurement. The systematic risk beta of an asset a, β_a depends as much on the proxy selected to present the universe of assets as the unique attributes of that asset, according to Roll's criticism (1977), which suggests that analysis to determine whether the systematic risk β_a and the superior and inferior performance α_a of an asset class a consists of the bias caused by the market portfolio proxy applied. The government bonds asset class is used as a risk-free rate in this study.

[12] The WI index has been calculated by the Swedish School of Economics and Business Administration and is described in greater detail in Berglund et al. (1983). The market values of the stocks include the market values of the companies on the main board of the Helsinki Stock Exchange from 1972 to 1993, companies on the main board, companies on the Investors list, and new market lists from 1994 onwards.

4.1 Descriptive analysis

4.1.1 Asset returns

In spite of the severe depression at the beginning of the 1990s, stocks have provided the second highest return of all classes at 13.0% in 1972–2008. Their risk measured by volatility was also high at 33.5%. Surprisingly, offices produced the highest average return at 14.2% with a lower risk of 14.9%, and their return was exceptionally high during the high inflation period of 1972–1984. The nominal return on forest ownership was 8.1%, while the real return reached only 2.8%, the risk of 12.9% being less than that of offices but slightly more than that of housing at 10.7%. (Table 2)

The normality of any asset class could not be rejected according to the Bera-Jarque test (p values > 0.05) except for bonds; however, the non-autocorrelation hypothesis up to a lag length of 3 could be rejected according to the Godfrey autocorrelation test only in the case of offices and apartments ($p < 0.02$). Moreover, the ARCH behaviour of the asset returns could also be rejected by Engle's ARCH test up to a lag length of 3 years except for offices and bonds ($p < 0.02$).

Offices and stocks form the high-return high-risk asset classes, while housing and NIPF ownership represent medium return and medium risk. Government bonds and corporate debentures represent obvious low-risk classes.

4.1.2 Asset correlation

The correlation both between forest ownership and private housing (0.54) and between forest ownership and the value weighted market portfolio VWALL (0.53) is statistically significant.[13] In fact, private housing correlates very significantly with the market portfolio at 0.71 and even with offices at 0.55, but only significantly with stocks at 0.46. Forest ownership correlated negatively

Table 2. Descriptive statistics of the asset classes 1972–2008.

Asset	Mean	Std	Normality1	Autocorr.2	ARCH 3
Stocks	13.0	33.5	0.892	0.095	0.832
Offices	14.2	14.9	0.838	0.001	0.010
Debent.	10.9	3.3	0.796	0.760	0.586
Apartm.	10.1	10.7	0.056	0.015	0.193
Forest	8.1	12.9	0.634	0.363	0.453
Bonds	7.8	5.4	0.044	0.928	0.017
Inflation	5.3	4.6	0.045	<0.0001	0.001

[1] The p value of the Jarque-Bera normality test
[2] The p value of Godfrey autocorrelation test with three delays
[3] The p value of the Engle autoregressive conditional heteroscedasticity (ARCH) test with three delays

[13] The standard test statistic for the significance of the Pearson sample correlation coefficient is

$$c = \frac{\hat{r}\sqrt{n-2}}{\sqrt{1-\hat{r}^2}},$$

where $\hat{r}$ is the correlation coefficient estimate and n the number of the observations. This statistic approximately follows t distribution with n-2 degrees of freedom and a null hypothesis '$\hat{r} = 0$'.

Table 3. Correlation matrix of different asset classes 1972–2008.

	Forest	Apartments	Stocks	Debentures	Offices	Bonds	VWALL
Forest	1.00						
Apartments	0.54***	1.00					
Stocks	0.22	0.46**	1.00				
Debentures	-0.43*	-0.42*	-0.21	1.00			
Offices	0.37*	0.55***	0.06	-0.23	1.00		
Bonds	-0.26	-0.24	0.03	0.64***	-0.23	1.00	
VWALL	0.53***	0.71***	0.72***	-0.39+	0.56***	-0.31+	1.00

The notations +, *, **, *** describe p values 0.1, 0.05, 0.01 and 0.001, respectively
Variables with block letters such as VWALL stand for market portfolio proxies.

Table 4. The cross-correlation coefficient of forest ownership returns vs. different asset classes 1972–2008: The effect of lag.

	Lag in years			
Asset	0	1	2	3
Apartments	0.54***	0.32+	-0.12	-0.38*
Stocks	0.22	0.50**	0.17	-0.16
Debentures	-0.43*	-0.26	0.46*	0.37+
Offices	0.37*	-0.01	-0.26	-0.22
Bonds	-0.26	0.05	0.41*	0.14
Inflation	0.27	0.089	-0.13	0.05
VWALL	0.53***	0.19	-0.15	-0.27

The notations +, *, **, *** describe p values 0.1, 0.05, 0.01 and 0.001, respectively

with debentures at -0.43 and with bonds at -0.26. Moreover, debentures and bonds correlate very significantly, 0.64, but demonstrate negative or no correlation with other asset classes and the market portfolio. In all, private housing showed statistically significant pairwise correlation with offices, forest ownership and stocks. These form a group of similar asset classes with systematic risk close to that of the market, the correlation with the value weighted market portfolio (VWALL) being 0.53–0.72 (Table 3).

The correlation between forest ownership and stocks was low (0.22), [14] which indicates that forest ownership might reduce risk only in a portfolio with stocks (STOCKS). It does not efficiently reduce the risk with other investments like housing. [15]

The lagged variables showed that only the cross correlation between stocks and forests strengthened dramatically, from 0.22 to 0.50 with a one-year lag (Table 4).

[14] Caulfield (1998b) used the Timberland Performance index (TPI) as a proxy for forest returns, finding that the correlation coefficient between TPI and Large-Cap stocks (S&P 500) was 0.15 during the 1982–1996 period, which is about the same as above (0.22) for Finnish data.

[15] In contrast to the US, the NIPF class represents a significant asset in Finland, accounting for 14.5% of the market portfolio (average 1972–2008). Like the USA, housing and offices correlate even better with the market portfolio (0.71 and 0.56), but these classes account for 36.2% and 27.0% of the total market portfolio.

Table 5. Descriptive statistics of the forests asset class and the market portfolio variables 1972–2008.

Asset	Mean	Std	Skewness	Kurtosis	Normality	Autocorr.	ARCH
Forest	8.1	12.9	-0.03	1.06	0.634	0.363	0.453
STOCKS	13.0	33.5	-0.07	0.60	0.892	0.095	0.832
VWALL	12.0	14.2	0.33	1.65	0.210	0.075	0.937
EWALL	10.5	9.1	-0.72	0.11	0.225	0.015	0.483
ALLBUTFORESTS	12.5	14.7	0.38	1.84	0.133	0.049	0.912

This jump in the correlation coefficient suggests that the stock return is clearly a leading indicator for forest ownership returns.

4.1.3 The market portfolio proxies

The average annual return of the first market portfolio proxy STOCKS, 13.0%, drops to 12.0% of that of VWALL, the value-weighted broadest proxy, the standard deviation dropping even more, from 33.5% to 14.2%. However, the returns and standard deviations of VWALL, the equally-weighted broadest proxy EWALL and VWALL without forests, ALLBUTFORESTS, are fairly close to each other. Only the "artificial" equally-weighted test portfolio EWALL exhibits negative skewness and VWALL and ALLBUTFORESTS excess kurtosis (Table 5).

According to Black (1995) equally-weighted and value-weighted portfolios are strongly correlated, as are even broader and narrower market indices. Here, the correlation coefficients between market portfolios proxies were very high, exceeding 0.89 between VWALL, EWALL and ALLBUTFORESTS. The greater distinction is between STOCKS and other market portfolio indices, as the correlation with stocks is at a lower level (0.72, 0.85, 0.74). This may suggest that the stocks do not describe the characteristics of the market portfolio properly. The high correlation between the value-weighted (VWALL) and equally-weighted market portfolio (EWALL), 0.90, may be deceptive (cf. Eun 1994) as this will make it seem that the exact composition is unimportant. However, it may produce quite different inferences in the CAPM analysis.

4.1.4 CAPM model variables

The risk-free rate of return was deducted from all return series, and the resulting excess return series modelled. Thus all relevant statistical diagnostics were performed within the limits of the 1972–2008 annual data.

The correlation between the excess return on forest ownership and all excess return market portfolio proxies and even with delayed market portfolio proxies up to a lead-time of 3 years were tested. Its correlation was significant ($p < 1\%$) with the VWALL, EWALL, ALLBUTFORESTS portfolios with no lag, and the correlation with lag 1 was significant ($p < 1\%$) with stocks (STOCKS) and almost significant ($p < 5\%$) with the equally-weighted portfolio proxy (EWALL) (Table 6).

Table 6. Correlation between the excess return on forest ownership and the different unlagged and lagged market portfolio excess returns 1972–2008.

	Lag in years			
Asset	0	1	2	3
STOCKS	0.26	0.54**	0.14	-0.12
VWALL	0.66**	0.21	-0.19	-0.22
EWALL	0.70**	0.38*	-0.10	-0.26
ALLBUTFORESTS	0.56**	0.21	-0.20	-0.20

The notations +, *, **, *** describe p values 0.1, 0.05, 0.01 and 0.001, respectively

4.2 CAPM estimation results on the competitiveness of forest ownership

First, with the STOCKS proxy, the explanatory power of the regression remained very low at 7%. Neither the risk-adjusted return alpha -0.29% nor the systematic risk beta 0.12 differed statistically significantly from zero, which corresponds with the results reported in the US studies. However, when the most comprehensive observed value-weighted market portfolio proxy (VWALL) was used, the results changed dramatically, the alpha dropping to -2.2% and the beta jumping as high as 0.60 on average. The beta estimate also become statistically significant ($p<0.02$) and the model's explanatory power increased from 7% to as much as 44% (cf. Lausti and Penttinen 1998b), Moreover, when the equally-weighted market portfolio proxy (EWALL) was used, the risk-adjusted return alpha was roughly at the same level as before while the systematic risk beta increased to as much as to 0.99.

Finally, the forest ownership asset class was eliminated from VWALL in order to compose the market portfolio proxy ALLBUTFORESTS. The effect of forests in the market portfolio composition was fairly strong, because the explanatory power declined from 44% to 32%, this still remaining at a relatively high level. The alpha of -2.0 increased and the beta of 0.50 of NIPF ownership declined only slightly from the most comprehensive observed market portfolio (VWALL) values, the last of which being still statistically significant (Table 7).

In all, explanatory power was high with broad proxies, but only 7% where stocks were the 'stocks only' proxy. These findings corroborate US forestry results.[16] Contrary to the US studies, betas

Table 7. CAPM regression results for the forest ownership return 1972–2008.

	Alpha			Beta			Fit	Normality	Heteroskedasticity	
Regressor	Estimate	t value	p value	Estimate	t value	p value	R^2	JB	White	BP
STOCKS	-0.286	-0.12	0.911	0.119	1.62	0.082	0.069	0.714	0.790	0.900
VWALL	-2.223	-1.13	0.215	0.603	5.21	0.016	0.437	0.892	0.0002	0.002
EWALL	-2.380	-1.27	0.191	0.991	5.79	<0.00001	0.489	0.663	0.014	0.042
ALLBUTFORESTS	-2.032	-0.93	0.312	0.503	4.05	0.024	0.319	0.978	0.045	0.025

The p values for the coefficient estimates are here robust t values (Davidson and MacKinnon 1993). Whites' heteroscedasticity test tests general heteroscedasticity without specifying its structure. Breusch-Pagan tests a hypothesis according to which the heteroscedasticity depends on a constant and an explaining variable.

[16] The US studies have very low explanatory powers and betas; e.g., 4%–28% and from -0.93–0.07 in Redmond and Cubbage (1988).

were high and alphas very low with our broad proxies. Surprisingly, alpha did not differ statistically significantly from zero with *any* of the proxies.

4.3 CAPM model diagnostics

Analysis of the diagnostics of the CAPM regressions showed that the normal distribution hypothesis of the residuals could not be rejected using the Jarque-Bera test ($p > 0.66$). Autocorrelation could not be found with the Godfrey LM test ($p > 0.19$). However, White's tests found heteroscedasticity for VWALL, EWALL and even for ALLBUTFORESTS ($p < 0.05$) and so did the Breusch-Pagan tests, too ($p < 0.05$) (Table 7). Moreover, function misspecification could be found using Ramsey's reset test for VWALL with powers up to four ($p < 0.02$).

A graphic analysis of scatter plots suggested inclusion of dummy variables for the outlier years 1973, 1991 and 1999. The outliers were also identified using Cook's distance measure (Cook 1977, 1979), which recognised these outlier years. Recall that an outlier is a term referring to either a contaminant or a discordant observation (Beckman and Cook 1983). Dummy variable inclusion eliminated both heteroscedasticity ($p > 0.39$), and functional misspecification ($p > 0.10$)

The ordinary least squares (OLS) without dummies produced similar results to OLS with dummies for systematic risk beta and risk-adjusted return performance alpha. The betas differed very significantly from zero except for the STOCKS market portfolio proxy. The betas tended to approach 0.8 after inclusion of these dummy variables for the VWALL and ALLBUTFORESTS proxies. Alphas tended to decrease slightly.

The t- and p-values of alpha were close to a nearly significant difference from zero with the value weighted and "artificial" equally-weighted market portfolio proxies (Table 8).

Incorporating dummies improved model fitness slightly, but completely eliminated heteroscedasticity.

Even the basic structure of the Finnish economy has changed dramatically since the 1970s. The possible breaks between 1972 and 2008 were analysed using the rolling Chow tests (Lütkepohl 2004, p. 49). Chow values dropped sharply from 1983 to 1984 and remained at the lower level after 1984, which suggests a study of the shorter 1984–2008 period. Moreover, the test also indicated a break also in 1995, but the 1995–2008 period was considered too short for a sensitivity analysis. Evaluations for the future development could primarily benefit from the shorter 1984–2008 period (Table 9).

Table 8. CAPM regression results with dummy variables for the years 1973, 1991 and 1999.

	Alpha		Beta		Fit	Normality	Heteroskedasticity	
Regressor	Estimate	p value	Estimate	p value	R2	JB	White	BP
STOCKS	-0.228	0.918	0.061	0.351	0.359	0.968	0.605	0.391
VWALL	-2.441	0.157	0.727	< 0.0001	0.614	0.478	0.695	0.859
EWALL	-2.517	0.158	0.989	< 0.0001	0.590	0.698	0.724	0.951
ALLBUTFORESTS	-2.523	0.197	0.598	0.0001	0.506	0.657	0.667	0.824

Table 9. CAPM estimates for period 1984–2008 with and without inclusion of the dummy variables years for the years 1991, 1994 and 1999.

	No dummies		With dummies	
Regressor	Alpha	Beta	Alpha	Beta
STOCKS	-2.473	0.109*	-0.410	0.040
VWALL	-2.902	0.461*	-2.061	0.541***
EWALL	-2.802	0.806***	-2.220	0.730***
ALLBUTFORESTS	-2.988	0.425*	-2.198	0.498***

The significance for the ‘No dummies’ model estimates was here decided by using robust t values (Davidson and MacKinnon 1993). Similar calculations were not possible for the dummy models.

Coefficients for different CAPM regressions show especially that the inclusion of dummy variables increases alpha but hardly changes beta. Ignoring the outlier years suggests the option in which recessions would not be expected. The value weighted portfolios with (VWALL) and without forests (ALLBUTFORESTS) can be considered the relevant market portfolios for further analysis.

Empirical evidence of the market values of forest holdings suggested that the sensitivity parameter s in formula (2) should be roughly 0.8, which would increase the return level by +0.72 in 1983–2008 (+0.68 in 1972–2003 according to Penttinen and Lausti 2004). This decrease in calculated property values would increase the alpha by +0.7 but only slightly change the beta, the analysis of which remains for further research. In recent years, these market values have, however, increased.

5 Discussion and conclusions

This study was designed to analyse the competitiveness of forest ownership, applying the capital asset pricing model (CAPM) and using the new market wealth portfolio of Finland, which consists of non-industrial private forests (NIPFs), private housing, offices, stocks, bond and debenture asset classes. The market-value estimate of the total market wealth portfolio was €479 billion at the end of 2008. At the same time, households had bank deposits of €70 billion, and total household debt exceeded €93 billion (Bank of Finland 2009a, 2009b).

Unexpectedly high systematic risk beta, 0.60 ($p<0.02$) and a low risk-adjusted return alpha of -2.2 ($p>0.2$), for forest ownership, contradict previous results. This resulted when a comprehensive choice of value-weighted asset classes was used to proxy market portfolio returns. Using the equally-weighted-market portfolio proxy, however, overestimated the systematic risk of forest ownership by 0.99 ($p<0.0001$) and underestimated alpha by -2.4 ($p > 0.19$). Even excluding forests from the comprehensive portfolio still maintained a high systematic risk, 0.50 ($p < 0.03$), and inferior competitiveness, -2.0 ($p > 0.31$), for forest ownership. Although betas differed significantly from zero with all these broad proxies, alphas, however, did not differ statically significantly from zero in any one of these cases.

Results reveal that a stocks-only portfolio proxy leads to severe underestimation of the systematic risk beta, 0.12, and overestimation of the risk-adjusted return alpha, -0.29. as well as a poor fitness of 7%. However, stocks seemed to anticipate the trend in forest ownership by a year, a correlation of 0.50 being statistically significant.

All in all, the systematic risk beta of 0.60 and the risk-adjusted return alpha of -2.2 of the broader market-value-weighted portfolio proxy VWALL could be preferred in estimating the competitiveness of non-industrial private forest ownership. Moreover, using the VWALL proxy and ignoring the years 1973, 1991 and 1999 with dummy variables increased the beta to 0.73 ($p<0.0001$) and decreased the alpha slightly to –2.4 ($p = 0.16$). The explanatory power of the dummy regression increased from 44% to 61% as well. However, a shorter period 1984–2008 slightly decreased beta, but increased alpha to -2.0 with dummies and decreased it to -2.9 without dummies.

Betas have been found to vary a lot depending upon whether the domestic stock index or global stock index was used (Reilly and Akhtar 1995). In Finland, however, since both NIPFs and private housing are local investment compared to stocks, a market portfolio consisting only of Finnish asset classes can be applied as the first step in analysing the competitiveness of non-industrial forest ownership. Empirical evidence suggests that in order to cope with the market values of forest holdings the sensitivity parameter in formula (2) should be roughly 0.8, which would increase the return level by +0.72 (+.68 according to Penttinen and Lausti 2004). It would slightly increase alpha but not necessarily change beta.

The recent recession and problems of forest industries support the forecast of Hetemäki and Hänninen (2009) according to which the domestic roundwood consumption of the Finnish forest industry will decrease from 59.4 M m^3 in 2007 to 49.9 M m^3 in 2015. This forecast also decreases the expectation of risk-adjusted returns alpha. On the other hand, individual forest holdings can be better than these average results, and the owner can even optimise his/her wealth including forest (see Hyytiäinen and Penttinen 2008). Moreover, every forest owner can improve the profitability of his/her forest holding by own activities, the profitability impact of which have been described in the covering literature of business economics of forestry.

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