Market Model with Long-term Effects – Empirical Evidence from Finnish Forestry Returns

Veli-Pekka Heikkinen and Antti Kanto

Heikkinen, V.-P. & Kanto, A. 2000. Market model with long-term effects – empirical evidence from Finnish forestry returns. Silva Fennica 34(1): 61–69.

The aim of the study is to reformulate the conventional market model by considering also long-run characteristics of forestry returns. Finnish stumpage prices and the stock market index are found co-integrated. Co-integration relationship between timber and stock market indicates that there are factors in timber market like high transaction costs, illiquidity or temporal lack of information, and in the Finnish case, price recommendations that are priced by market. The presence of long-run effects may make the short-term market model mis-specified and it may give misleading and incomplete results concerning the expected risk and return of forestry. In our case, the market model risk beta was only slightly biased. This study indicates that an error-correction model is more appropriate model than the market model.

Keywords Forest risk returns, market model, co-integration
Authors´ address Helsinki School of Economics, P.O. Box 1210, FIN-00101 Helsinki, Finland **E-mail** vheikkin@hkkk.fi
Received 22 February 1999 **Accepted** 24 January 2000

1 Introduction

In this paper we reformulate the conventional market model (Lintner 1965) by considering also long-run characteristics of forestry returns. The market model is appropriate under quite stringent statistical conditions. Recent econometric literature suggests that time series properties of the data should be studied before choosing the final statistical model. Financial literature includes a number of more general models than the market model, but in forestry literature they are not used except Washburn and Binkley (1993). In the case of insufficient model the conclusions concerning expected risk and return of an asset may be misleading or incomplete.

During recent decade, several North American researchers have used the Capital Asset Pricing Model (CAPM) (Sharpe 1964, Lintner 1965, Sharpe 1963) to test the informational efficiency of timber markets or in measuring the systematic risk of forest investments (Redmond and Cubbage 1988, Washburn and Binkley 1990a, Zhang and Binkley 1993, Binkley et al. 1996). There has also been growing interest shown in forest risks and returns in Finland (Tilli 1995, Penttinen et al. 1996, Lausti and Penttinen 1998).

The CAPM and the single-index market model use only one benchmark asset (Sharpe 1964, Sharpe 1963, Lintner 1965), this being a theoretical market portfolio. The proxy of market portfolio has usually been a value-weighted stock index or a broad based market portfolio.

According to the US studies, forestry has reduced the systematic risk of portfolio whether the market portfolio was either stock market index or broad-based market portfolio, the CAPM beta being nearly zero or negative (Redmond and Cubbage 1988, Washburn and Binkley 1990a, Binkley et al. 1996). A zero beta indicates that the expected return for forestry is equal to risk free interest rate. Negative beta indicates lower forestry return than risk free interest rate and positive beta higher return than risk free interest rate. In the Finnish case, forest ownership provides risk reducing benefits in a portfolio with stocks, but does not reduce risk with other asset classes (Penttinen et al. 1996, Lausti and Penttinen 1998). Comparisons of the earlier results have to be made with caution, because they are based on different time intervals (monthly, quarterly, yearly) and different type of calculation of forestry return. Primarily, forestry seemed to reduce the systematic risk of portfolio.

Although the risk beta is essential information from forestry investments, it includes some shortcomings. The beta is a short-run indicator. It is based on price difference, which indicates short-run co-movements and ignore possible long-run correlation and is thus incomplete. Wang et al. (1997) show using co-integration analysis that although real estate lacks close relationship with other type of assets in the short run, in the long run there is correlation. They studied direct and indirect property investments in UK. They conclude that short-run correlation analysis leads to information loss. The use of long-run analysis helped to find a stronger price discovery mechanism and helped to analyze and predict direct investments. Ely and Robinson (1997) studied using co-integration analysis whether stocks are hedge against inflation in the US. They found that using only short run model gives misleading results from the relationship between stocks and inflation. Puttonen (1993) found co-integration between stock markets and stock index derivative markets. He concluded that derivative markets and derivative are more efficient than stock markets, because transaction costs are lower on the derivative markets and derivative markets are more liquid. Similarly transaction costs seemed to cause co-integration relationship between unrestricted and restricted stocks in Finland (Booth et al. 1994).

Binkley et al. (1996) pointed out that the CAPM estimates for risk and return may be under or overestimates, because the CAPM is a single factor model, and there might be also other omitted factors that are priced by asset markets. They might increase or decrease the riskiness and required return for an asset. Binkley et al. (1996) considers 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. In the Finnish case, price recommendation may also have caused frictions to timber market. Binkley et al.(1996) do not produce any other evidence than low R^2 values from the omitted factors. In this paper we produce further evidence from these omitted factors and show that, a more general model than the market model will produce substantially higher R^2 values indicating that the market model really omitted relevant factors. 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 than the paper of Washburn and Binkley (1993). They included the inflation into the model. Our paper extends forestry literature towards more general asset pricing models.

The traditional form of the market model is appropriate only under quite stringent conditions (Mills 1995), and this may cause estimation bias. If the stumpage price and the stock market index are co-integrated, the estimation of the market model using only the first differences may lead to a biased estimation of beta (Greene 1993, p.246). The estimated model will be seriously auto-correlated, and thus the t-values may be incorrect. In such a case, conclusions drawn concerning the parameters may also be incorrect. In fact, Mills (1995) suggests that co-integration between the price levels should be tested before attempting to estimate a model linking returns. All of the earlier forest economics literature has estimated the market model without considering time series properties of the data.

2 Methods and Data

2.1 An Equilibrium Model

We used a model in which the stumpage price change depended on the benchmark capital cost (Washburn and Binkley 1990a). Called a market model, this depicts the relationship between equilibrium returns on individual assets and the value of a common market factor (index) affecting the return on all assets so that

$$E[r_t^i] = \alpha + \beta\, E[r_t^m] \quad (1)$$

r_t^i = then return of a single asset
r_t^m = the return of a market portfolio
β = systematic risk
α = intercept

We followed Washburn and Binkley (1990a) and defined the return on forest as the sum of the stochastic price change and the physical exponential growth. The use of exponential growth helped us also to formulate the total returns for forest asset i. Let us denote the stumpage price at time t as $\tilde{P}_{t,i}$. The total returns of asset i are thought to include the stochastic price change from $\tilde{P}_{t,i}$ to $\tilde{P}_{t+1,i}$ added to by the deterministic physical growth g_t. The returns from logarithmic price changes are $r_t^i = \ln \tilde{P}_{t+1,i} - \ln \tilde{P}_{t,i}$. Then the expected total returns $\tilde{R}_{t,i}$ for asset i are

$$E\left[\tilde{R}_{t,i}\right] = E\left[\ln \tilde{P}_{t+1} - \ln \tilde{P}_t + g_{t,i}\right] \quad (2)$$

$$E\left[\tilde{R}_{t,i}\right] = E\left[r_t^i + g_{t,i}\right] \quad (3)$$

The expected mean is the sum of price changes and growth, but growth has no effect on the covariance. Physical growth could affect the regression alpha parameter, but not the beta coefficients. In this study we were interested in the price returns of different timber assortments, and we ignored physical growth in the statistical analysis.

2.2 Statistical Testing of Short-run and Long-run Equilibriums

The market model could be estimated by ordinary least squares regression using the normal regression assumptions that the residual is not autocorrelated, its variance is finite, and that it is normally distributed. The return of one forest asset r_t^i depends on stock market return r_t^m as follows:

$$r_t^i = \alpha + \beta r_t^m + \varepsilon_t \quad (4)$$

where index t is related to time. The market portfolio used here is the general stock market index HEX. The test of this model is also the test of the mean-variance portfolio, which is specified as the benchmark. If the benchmark is incorrectly specified, we could falsely reject the asset pricing model. It may never be possible to test the CAPM because of the difficulty in identifying the market portfolio, but the efficiency of the given benchmark can be tested (Roll 1977). To test the CAPM correctly, for example, we should have a broad-based index in Finland also including forest, but this is unfortunately missing in monthly basis.

Next, we studied whether the stumpage prices and HEX stock market index were stationary using the augmented Dickey-Fuller test (Dickey and Fuller 1979). The application of OLS with nonstationary data may lead to spurious regression and fatal errors (see. Banerjee et al. 1993, 70–81). In co-integration estimation, we used the conventional Engle and Granger (1987) procedure. In its basic form, this approach proceeds in two steps. Firstly, a regression model is estimated using level series (in this case not returns but instead prices) as follows

$$\ln P_t^i = \nu + \lambda \ln P_t^m + \zeta_t \quad (5)$$

where P_t^i is the stumpage price and P_t^m is the stock price. The error term ζ_t may be interpreted as a deviation from the long-term equilibrium between P_t^i and P_t^m.

Let z_t be the estimated error term. Note that in the case where a co-integrating relation exists, that neither the regression assumptions nor the common t-values apply. Instead, the estimates are super-consistent and their standard deviations approach zero even more rapidly than the ordinary OLS results would suggest.

The second step regression estimation uses differences, in this case returns, and the lagged error term of the first equation is included into the second regression

$$\Delta \ln P_t^i = \alpha + \beta \Delta \ln P_t^m + \gamma z_{t-1} + \varepsilon_t \qquad (6)$$

Note that if returns are measured as logarithmic differences, this formula corresponds to a modified version of the market model

$$r_t^i = \alpha + \beta r_t^m + \gamma z_{t-1} + \varepsilon_t \qquad (7)$$

If the coefficient γ is significantly negative, there exists an error correction mechanism, and the original non-difference variables (prices) are co-integrated, i.e. they possess a common trend. In the error correction model, the past difference in the price equilibrium between stocks and stumpage prices affects the current returns on forest. In this case, the second step regression is the market model regression corrected by an error-correction term. It has been shown that the two-step procedure produces asymptotically super-consistent estimates (Engle and Granger 1987).

If the price levels are co-integrated, and there is an error-correction representation, the conventional OLS estimation of the market model (4) will give improper results. To be more specific, omitting the co-integration term leads to a biased estimate in the following way

$$E\left(\hat{\beta}\right) = \beta + \frac{\mathrm{cov}(r_m, z_{t-1})}{\mathrm{var}(r_m)} \cdot \gamma \qquad (8)$$

2.3 Data

We used the monthly average volume-weighted national stumpage prices for the following wood assortments: pine sawlogs (PSL), spruce sawlogs (SSL), birch sawlogs (BSL), pine pulpwood (PPW), spruce pulpwood (SPW), and birch pulpwood (BPW). The time series covered the period from October 1985 to December 1995, including a total of 123 monthly observations. These data were obtained from the Finnish Forest Research Institute (METINFO). The stock market indexes were computed as monthly averages from the daily closing values of the HEX index (see the discussion about calculation of the stock market index in Washburn and Binkley 1990b). Because the HEX index was computed from the beginning of 1991, the Berglund WI index (general stock market index calculated by Berglund) was used for the period 1.10.1985–28.12.1990, and the HEX index thereafter. This change caused a jump in the stock index series, which was captured by a dummy variable in the regression estimations. During the period examined, there was a structural change in business conditions on the Finnish timber markets. Price recommendations were in effect during the period 1985–1995 for each timber assortment in Finland (except for the period 1991:4–1993:12). Financial literature shows that β may change over time, and it should therefore be re-estimated at least when the business conditions change (Knif 1989). The superscript *r* in the tables refers to the price-recommendation period while *n* refers to the non-recommendation period.

3 Results

3.1 Single Index Models

The stationarity of the logarithmic level series and their differences (returns) were first tested with Augmented Dickey Fuller unit root tests. The results indicated that all level series were clearly of integrated order one, and the returns series were stationary (Table 2). Unit root test results concerning the timber prices were consistent with earlier findings (Toppinen 1996).

The correlation between the forest-risk returns and stock returns was found to be dependent on estimation period (Table 1). In the course of both price recommendation periods, the correlation was negative, and in free market conditions it was positive, indicating that forest has been a better hedge for stocks during price recommen-

Table 1. The correlation matrix for forest returns and the general stock-market index HEX returns.

	PSL	SSL	BSL	PPW	SPW	BPW
HEX 1985:10–1995:12	–0.02	–0.02	0.09	–0.06	0.00	–0.01
HEX 1985:10–1991:03	–0.13	–0.04	0.08	–0.14	–0.04	–0.01
HEX 1991:04–1993:12	**0.36**	0.13	0.24	0.27	0.32	0.28
HEX 1994:01–1995:12	–0.26	–0.22	–0.13	–0.36	**–0.40**	**–0.41**

Note: Characters in **bold** indicate statistical significance at the 5 % level. PSL = pine sawlogs, SSL = spruce sawlogs, BSL = birch sawlogs, PPW = pine pulpwood, SPW = spruce pulpwood and BPW = birch pulpwood.

Table 2. The Augmented Dickey Fuller (ADF) test for the unit roots of individual time series.

	ADF-test
HEX Stock market index	–1.81 (c,t)
PSL Pine sawlog price	–1.10 (c,t)
SSL Spruce sawlog price	–1.29 (c,t)
BSL Birch sawlog price	–1.29 (c,t)
PPW Pine pulpwood price	–1.21 (c,t)
SPW Spruce pulpwood price	–1.51 (c,t)
BPW Spruce pulpwood price	–1.34 (c,t)
Δ HEX	***–7.56*** (c)
ΔPSL	***–6.36*** (c)
ΔSSL	***–5.54*** (c)
ΔBSL	***–6.95*** (c)
ΔPPW	***–6.38*** (c)
ΔSPW	***–5.7*** (c)
ΔBPW	***–7.03*** (c)

Note: In the test, one lag was used for the price level or the first difference series. The constant (c) and the trend (t) were included for the price levels and the constant (c) for the first difference series. Characters in **bold** indicate statistical significance at the 5 % level, while the characters in ***italics bold*** indicate the same at the 1 % level

Table 3. The parameter estimates of the single-index model for sawlog returns.

Parameter	PSL	SSL	BSL
Constant	0,00 (0.48)	0,00 (1.07)	0.00 (0.62)
Δ HEX ^{r}	–0,05 (–1.22)	–0.03 (–0.82)	–0.03 (–0.80)
Δ HEX ^{n}	**0.10** (2.14)	0.02 (0.53)	0.07 (1.39)
$\bar{R}^2$	0.03	0.02	0.00
$\chi^2_{ARCH(1)}$	0.00	1.63	0.02
$\chi^2_{Q(1)}$	**7.36**	**28.26**	0.05
$\chi^2_{J\&B}$	**120.83**	**47.14**	**82.84**
KURT	4.81	2.97	3.86
SKEW	–0.45	0.36	–0.62

Note: t-values in parantheses. **Characters in bold** indicate statistical significance at the 5 % level, those in ***italics bold*** at the 1 % level. Superscript *r* refers to the price-recommendation period. Superscript *n* refers to the non-recommendation period. N = 123. PSL = pine sawlogs, SSL = spruce sawlogs and BSL = birch sawlogs.

dations than at other times.

We estimated a stock-based, single-index model for Finland for the period 1985:10–1995:12 for six timber assortments. Because the correlations were observed to be dependent on price policy, the beta-coefficients were estimated separately for the recommendation and the non-recommendation periods. The beta for pine sawlogs during the non-recommendation period indicated a small systematic risk as did the beta for spruce pulpwood, which was statistically significant only at the 10 % level. In the cases of the other assortments, the estimations did not indicate any systematic risk (Tables 3 and 4). The residuals of the models were autocorrelated according to the results of the Box-Pierce test and

Table 4. The parameter estimates of the single-index model for pulpwood returns.

Parameter	PPW	SPW	BPW
Constant	0.00 (0.30)	0.00 (0.45)	0.00 (1.24)
D HEX ^{r}	–0.08 (–1.40)	–0.04 (–0.73)	–0.11 (–1.55)
D HEX ^{n}	0.08 (1.24)	0.10 (1.80)	0.10 (1.27)
$\bar{R}^2$	0.01	0.01	0.01
$\chi^2_{ARCH(1)}$	0.90	0.62	0.00
$\chi^2_{Q(1)}$	**14.27**	**19.26**	**5.05**
$\chi^2_{J\&B}$	**241.31**	**97.33**	***723.62***
KURT	6.89	4.39	11.57
SKEW	0.30	0.06	1.55

Note: t-values in parantheses. **Characters in bold** indicate statistical significance at the 5 % level, those in ***italics bold*** at the 1 % level. Superscript *r* refers to the price-recommendation period. Superscript *n* refers to the non-recommendation period. N = 123. PPW = pine pulpwood, SPW = spruce pulpwood, BPW = birch pulpwood.

Table 5. The parameter estimates of the Engle-Granger first-step model for sawlogs.

Parameter	PSL	SSL	BSL
Constant ^{r}	4.62	4.56	4.39
Constant ^{n}	5.21	5.66	5.79
HEX ^{r}	0.10	0.08	0.14
HEX ^{n}	0.01	–0.09	–0.06
ADFz_t	**–2.59**	**–2.19**	**–2.31**

Note: **Characters in bold** indicate statistical significance at the 5 % level, those in ***italics bold*** at the 1 % level. Superscript *r* refers to the price-recommendation period. Superscript *n* refers to the non-recommendation period. N = 123. ADF is the Augmented Dickey Fuller test (no constant, no trend) for the unit roots of the error term z_t. Lags 1,2 and 12 were used.

Table 6. The parameter estimates of the Engle-Granger first-step model for pulpwood.

Parameter	PPW	SPW	BPW
Constant ^{r}	2.99	3.01	3.05
Constant ^{n}	5.49	5.69	4.62
HEX ^{r}	0.20	0.22	0.17
HEX ^{n}	–0.18	–0.17	–0.06
ADFz_t	***–3.32***	**–2.02**	–1.69

Note: **Characters in bold** indicate statistical significance at the 5 % level, those in ***italics bold*** at the 1 % level. Superscript *r* refers to the price-recommendation period. Superscript *n* refers to the non-recommendation period. N = 123. ADF is the Augmented Dickey Fuller test (no constant, no trend) for the unit roots of the error term z_t. Lags 1,2 and 12 were used.

extremely abnormal according to the Jarque-Bera test (see tests Greene 1993). According to the ARCH (1) test there was no heteroscedasticity. The residuals were so far away from white noise that it encouraged us to study the co-integration between the timber prices and the HEX index.

3.2 Co-integration Estimation

The long-run equilibrium was tested using the Engle-Granger first-step model, according to which a long-run equilibrium exists if the error term of the regression is stationary. According to the results of Augmented Dickey-Fuller tests, all the error terms were stationary except for the error term of birch pulpwood first-stage model (Tables 5 and 6).

The parameters were estimated separately for the recommendation period and the non-recommendation period using the Engle-Granger first-step estimation (Tables 5 and 6). The F-test for different parameter estimates for the subperiods suggested that the parameters have to be estimated separately for the recommendation period and the non-recommendation period. The stock price elasticity of the stumpage prices changed depending on the market conditions. During the recommendation period, the elasticity for pulpwood changed within the range 0.17–0.22 and that for logs within the range 0.08–0.14. During the non-recommendation period, elasticity was statistically significant only for coniferous pulpwood, for which it was between 0.17 and 0.18. It should also be noted that part of the reason for the different kinds of market mechanisms could be in the different business cycles: the first years of the price-recommendation period were mainly boom years, but the period ended in the recession in 1991. During the free market period, there was a recession in Finland. The price recommendations were negotiated again in 1994 when the economy was on the way up.

The orders of autocorrelation in error-correction models were specified using backward elimination by starting from as general a model as possible and dropping insignificant lags using F-test. All parameters were estimated separately for the recommendation period and for the non-recommendation period.

The error-correction term was statistically significant in all the models (Tables 7 and 8). The coefficient for coniferous species varied within the range of –0.04…–0.08, indicating that a long-run equilibrium is reached between 12 1/2 and 25 months. The F-test showed that the error-correction term was independent on the market conditions.

We observed autocorrelation in the return series, which were similar to those in earlier studies (Toppinen 1996). This problem was handled in our study by using lagged, dependent variables as the exogenous variables. First we tried 13 lags in all estimations, but only those lags, which were statistically significant at least in one model were left in the final estimations. To be more specific, the autoregressive return was used with both one and 12 lags, and separately for the

Table 7. The parameter estimates of the error-correction model for sawlogs.

Parameter	PSL	SSL	BSL
Constant	0.00 (1.64)	0.00 (1.86)	0.00 (0.72)
z_{t-1}	***–0.06*** (–3.06)	**–0.04** (–2.47)	***–0.08*** (–3.21)
r^r_{t-1}	0.06 (0.57)	**0.24** (2.04)	0.03 (0.27)
r^n_{t-1}	***0.68*** (4.72)	***0.71*** (4.97)	0.22 (1.39)
r^r_{t-12}	***0.28*** (2.76)	0.16 (1.37)	0.21 (1.50)
r^n_{t-12}	–0.00 (–0.03)	0.18 (1.16)	0.10 (0.78)
$\bar{R}^2$	0.38	0.30	0.13
$F_{n \neq r}$	***6.12***	2.89	0.52
$\chi^2_{ARCH(1)}$	1.00	0.04	1.37
$\chi^2_{Q(1)}$	0.32	0.01	0.29
$\chi^2_{J\&B}$	**79.15**	**109.57**	**16.37**
KURT	3.97	3.97	1.92
SKEW	0.73	1.51	0.04

Note: t-values in parantheses. **Characters in bold** indicate statistical significance at the 5 % level, those in ***italics bold*** at the 1 % level. Superscript *r* refers to the price-recommendation period. Superscript *n* refers to the non-recommendation period. N = 123.

Table 8. The parameter estimates of the error-correction model for pulpwood.

Parameter	PPW	SPW	BPW
Constant	0.00 (1.00)	0.00 (1.77)	0.00 (1.11)
z_{t-1}	***–0.06*** (–3.13)	**–0.04** (–2.27)	**–0.06** (–2.41)
r^r_{t-1}	0.14 (1.32)	0.09 (0.78)	0.17 (1.55)
r^n_{t-1}	***0.54*** (4.25)	***0.85*** (6.61)	0.22 (1.19)
r^r_{t-12}	***0.43*** (3.05)	0.22 (1.75)	**0.34** (2.57)
r^n_{t-12}	0.21 (1.75)	0.07 (0.60)	–0.03 (–0.17)
$\bar{R}^2$	0.40	0.40	0.08
$F_{n \neq r}$	**3.02**	***8.17***	1.25
$\chi^2_{ARCH(1)}$	0.00	0.11	0.16
$\chi^2_{Q(1)}$	0.98	0.00	0.37
$\chi^2_{J\&B}$	**123.16**	**92.47**	**779.66**
KURT	4.53	3.53	12.63
SKEW	1.35	1.46	2.07

Note: t-values in parantheses. **Characters in bold** indicate statistical significance at the 5 % level, those in ***italics bold*** at the 1 % level. Superscript *r* refers to the price-recommendation period. Superscript *n* refers to the non-recommendation period. N = 123.

recommendation period and the non-recommendation period. The equality of the autocorrelation structure between the periods was tested using the F-test, which rejected the equality hypothesis, and the parameters had to be estimated separately for both sub-periods. The results indicated that the autoregressive process of returns during recommendation period was mostly 12 months long, but during the non-recommendation its length was one month. This indicates that the markets were more efficient during the non-recommendation period. Spruce logs was the only exception, which had AR(1) also during the recommendation period and a non-statistically significant AR(12). Finally, it should be noted that the models worked clearly better for coniferous timber than for birch.

The risk beta (the coefficient for the first difference of HEX) was statistically insignificant in all of the error-correction models, and so it was set to zero in the final model. In the single-index model, however, the beta for pine sawlogs was statistically significant, and for spruce pulpwood almost significant during the recommendation period. In this Finnish case, two market model beta coefficients were biased because the cointegration relation was omitted from the model. Also, it seems to us that the main impact of the capital markets on forest returns makes itself felt through the error-correction mechanism. The significant autoregressive process and the error-correction mechanism indicate that the expected return on forestry differs from that of CAPM.

There were two exceptional observations in the data: (i) the stock-index change from Berglund WI index to the HEX index in 1991:1, and (ii) the outlier in 1991:10. Because of this, two additional dummies were applied, both of which were found to be statistically significant.

Diagnostic tests run on the error-correction models did not show any problems other than the high kurtosis of the residuals, which is often observed in financial series. In financial econometrics, the problem has often been handled with the use of autoregressive conditional heteroscedasticity (ARCH) models. We did not use an ARCH model, but we did run an ARCH heteroscedasticity test. According to the results of our ARCH(1)-test, there was no statistically significant autoregessive conditional heteroscedasticity in the error term. Although we believe that there still would be room for further modeling, we considered it irrelevant for the purpose of this study: to test how appropriate the market model is for estimating the forest beta and describing data-generating process of forestry returns.

4 Conclusions

We first estimated similar to earlier studies the market model for the forest-risk returns. Risk returns were defined to be returns on stumpage price changes. Forestry returns were calculated from the stumpage prices ignoring physical growth and the general stock market index HEX was used as a proxy for the market portfolio. The beta coefficients were estimated for six timber assortments and separately for the recommendation period and the non-recommendation period.

Two of the market model beta coefficients indicated a small systematic risk while the rest indicated no systematic risk. The residuals of the models were seriously autocorrelated. The market model was not sufficient to describe data-generating process of forestry returns.

We found that the error term of the Engle-Granger first step estimation was stationary, which was an indication of co-integration. If the stumpage price and the stock market index are co-integrated, the estimation of the market model using only the first differences may lead to a biased estimation of beta. Finally, we estimated the error-correction model and compared the risk beta coefficients of the market model and the error-correction model.

In the error-correction model all risk beta coefficients were insignificant. Our results showed that two beta coefficients estimated using the market model were positively biased estimates of the true beta because of an insufficient model.

Although beta was insignificant, the short run forestry return was not independent on stock markets changes because of the error correction mechanism. The adjustment process to equilibrium appeared to last a couple of years. We also found a statistically significant autoregressive process that also indicated slow adjustment to the equilibrium. The adjustment was slower during price recommendation period than during non-recommendation period, which indicates more efficient markets if there is no price recommendation. The error-correction mechanism was, however, similar in both periods.

The Finnish data showed that the market model is not sufficient for describing forest return dynamics and it may give misleading and incomplete result concerning the expected risk and return of forestry. We found an error-correction model a more relevant model. The results also indicated that using only the market model may lead to biased estimation of the beta coefficients.

Our main findings are as follows.

– There are frictions like higher transaction costs, illiquidity or temporal lack of information and, in the Finnish case, price recommendations that are priced by market. We believe that the co-integration relationship between timber and stock market is an evidence from these frictions similar to earlier findings in capital markets (Puttonen 1993, Booth et al. 1994), although we did not specify other frictions than price recommendation in the estimated model. Because of these frictions timber market adjust slower to the equilibrium than stock market.
– A misspesified model will give incorrect information from the expected forestry return.
– The conventional market model led to a slightly biased estimate of the risk beta.

We notice that Finnish economy differs from other economies: forests consist a large share of the total economy, transaction costs are different as well as information flow in raw material and financial market. We, however, argue that our main findings are not caused by these facts and that they can be confirmed on other markets as well. Further evidence is clearly needed.

Acknowledgements

We thank Richard Brazee, David Newman and Anne Toppinen for comments on earlier version of this paper. We also thank Matti Keloharju and Teppo Martikainen for useful discussions. The paper was presented in the Workshop of Forestry Decision-Making in an Uncertain World, March 1998, Athens, USA and in various workshops in Finland. We thank participants of those workshops for useful comments. Financial support from Helsingin kauppakorkeakoulun tukisäätiö, Marcus Wallenbergin liiketaloudellinen tutkimussäätiö, Kyösti Haatajan säätiö and Säästöpankkien tutkimussäätiö is acknowledged.

References

Banerjee, A., Dolado, J., Galbraith, J.W. & Hendry, D.F. 1993. Co-integration, error-correction, and the econometric analysis of non-stationary data. Oxford University Press.

Binkley, C.S., Raper, C.F. & Washburn, C.L. 1996. Institutional ownership of US timberland. History, rationale and implications for forest management. Journal of Forestry 94(9): 21–28.

Booth, G.G., Chowdhury, M. & Martikainen, T. 1994. The effect of foreign ownership restrictions on stock price dynamics. Weltwirtschaftliches Archiv 130(4): 730–746.

Dickey, D.A. & Fuller, W.A. 1979. Distribution of estimates for autoregressive time series with unit root. Journal of American Statistical Association 74: 427–431.

Ely, D.P. & Robinson, K.J. 1997. Are stocks a hedge against inflation? International evidence using a long-run approach. Journal of International Money and Finance 16(1): 141–167.

Engle, R.F. & Granger, C.W.J. 1987. Cointegration and error correction: Representation estimation and testing. Econometrica 55(2): 251–276.

Greene, W.H. 1993. Econometric analysis. Macmillan Publishing Company. New York.

Knif, J. 1989. Parameter variability in the single factor market model. An empirical comparison of tests and estimation procedures using data from the Helsinki stock exchange. Commentationes Scientiarum Socialium 40. Helsinki.

Lausti, A. & Penttinen, M. 1998. The analysis of return and its components of non-industrial private forest ownership by forestry board districts in Finland. Silva Fennica 32(1): 75–94.

— & Penttinen, M. 1998. Forest ownership and forest industry investments analysed in a risk return and capital asset pricing model framework. Working papers W-201. Helsinki School of Economics and Business Administration.

Lintner, J. 1965. The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. Review of Economics and Statistics 47: 13–37.

Mills, T.C. 1995. The econometrics of the market model: cointegration, error correction and exogeneity. International Journal of Finance Economics 1: 275–286.

Penttinen, M., Lausti, A., Kasanen, E. & Puttonen, V. 1996. Risk and returns in forest investments in Finland. Liiketaloudellinen aikakauskirja 1996(1): 111–124.

Puttonen, V. 1993. The efficiency of the Finnish stock index derivatives markets. Acta Wasaensia 31. University of Vaasa.

Redmond, C.H. & Cubbage, F.W. 1988. Portfolio risk and returns from timber asset investment. Land Economics 64(4): 325–337.

Roll, R. 1977. A critique of the asset pricing theory's tests – part 1. On past and potential testability of the theory. Journal of Financial Economics 4: 129–176.

Sharpe, W.F. 1963. A simplified model of portfolio analysis. Management Science 2: 277–293.

— 1964. Capital asset prices: A theory of market equilibrium under condition of risk. Journal of Finance 19: 425–442.

Tilli, T. 1996. Valtakunnallisen puun hintasopimusjärjestelmän purkautumisen vaikutus metsäpääomaan sisältyvään riskiin: Puun ennustamaton hintavaihtelu riskin mittarina Suomessa vuosina 1985–91 ja 1991–93 (In Finnish). Licenciate thesis, University of Helsinki.

Toppinen, A. 1996. Cointegration and causality of monthly stumpage prices in Finland. Paper for SSFE Meeting, March 19–21, 1996.

— 1997. Testing for Granger-causality in the Finnish roundwood market. Silva Fennica 31(2): 225–232.

Wang, P., Lizieri, C. & Matysiak, G. 1997. Information asymmetry, long-run relationship and price discovery in property investment markets. The European Journal of Finance 3: 261–275.

Washburn C.L. & Binkley, C.S. 1990a. Informational efficiency of markets for stumpage. Amer. J. Agr. Econ. 394–405.

— & Binkley, C.S. 1990b. On the use of period-average stumpage prices to estimate forest asset pricing models. Land economics 66(4): 379–393.

— & Binkley, C.S. 1993. Do forest hedge against inflation? Land economics 69(3): 215–224.

Zhang, D. & Binkley, C.S. 1993.The informational efficiency of the Vancouver log market and the financial risk of holding logs in storage. Canadian Journal of Forest Research 24: 550–557.

Total of 26 references