Investments in Timberland and Softwood Timber as Parts of Portfolio Selection in the United States: A Cointegration Analysis and Capital Asset Pricing Model

Xianchun Liao, Yaoqi Zhang, and Changyou Sun

Abstract: In this article we investigated the financial performance of investments in timberland and timber and their correlations with nonforestry financial assets in the United States. Cointegration analysis and the capital asset pricing model were used to examine the long-run and short-run correlations with quarterly data from January 1992 to June 2006. The results of the cointegration analysis revealed that investment return on timberland tended to increase by 1.3% as Southern softwood stumpage price increased by 1%, indicating that a shift from pulpwood to sawtimber production might increase timber price and thus benefit timberland investment. The results also indicated that there were positive correlations between farmland return and Southern softwood stumpage price and between the stock market and timberland, indicating that treatments such as high-intensity site preparation might increase land quality and, hence, enlarge timber size and increase timber price. However, investors need to be cautious with the stock market because any change in the stock market has a potential effect on the timberland market. The results of the capital asset pricing model showed that timberland generated significant excess returns over the study period, but softwood timber did not. Timberland or softwood did not reduce systematic risk in a portfolio with stocks in the short run. In the short run, abnormal returns on timberland did occur, and timberland would be a desirable investment vehicle mixed with real estate. FOR. SCI. 55(6):471–479.

Keywords: cointegration, capital asset pricing model, portfolio selection, softwood timber, timberland investment

INVESTMENT IN TIMBERLAND or timber in the United States has long been recognized as a means of portfolio diversification because of the relatively high return, low level of financial risk, and low correlation with other financial assets (Hotvedt and Tedder 1978, Redmond and Cubbage 1988, Thomson 1989, Washburn and Binkley 1993, Sun and Zhang 2001). This statement coincides with the recent trend of selling many productive timberlands to timber investment management organizations. The timber investment management organizations have largely acted as fiduciaries for using timberland as an investment instrument (Clutter et al. 2005). In 2005, nearly $30 billion worth of American forestland were sold to institutional investors (Browning 2005). A recent report predicted that more than 44 million acres of private forestland would be sold over the next 25 years (Eilperin 2006).

The diversification benefits associated with forestry-related assets may have been overstated. If the approach to estimating mean, variance, and covariance is based on historical data of, for instance, 30 years, the previous conclusions are still based on short-run indicators (Heikkinen and Kanto 2000), because harvesting decisions of forest stands are typically subject to long time horizons. For example, a pine rotation may be more than 60 years for sawtimber. In addition, from a financial perspective, it is doubtful that timberland could have relatively high return with low risk in the long run. There is no such asset like timberland that always generates higher return with lower risk because the abnormal return in the short run will be absorbed to achieve a long-run equilibrium under the zero-profit condition.

The capital asset pricing model (CAPM) has been widely used to evaluate timberland performance during the last three decades. The CAPM has been used to evaluate the performance of five forestry industry firms (Hotvelt and Tedder 1978), to examine the risk and returns from individual tree species based on historical regional timber prices (Redmond and Cubbage 1988), and to evaluate financial uncertainties of a west coast Douglas-fir tree improvement program (Thomson 1989). Washburn and Binkley (1993) estimated the correlation between forest assets and inflation. Most of these studies analyzed financial performance of forestry assets based on stumpage price change and timber growth dividend. Few studies used investment return from timberland to explicitly assess the financial performance of forestry-related investment vehicles by comparing the CAPM with the arbitrage pricing theory (Sun and Zhang 2001). These previous studies concluded that timberland investments earned higher risk-adjusted return with lower risk and had a low level of correlation with other financial assets. Although these studies provided essential information from forestry investments, they were merely short-run

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indicators and ignored possible long-run correlation (Heikkinen and Kanto 2000).

Recently a few studies have examined the long-run correlations between the timber market and other financial market instruments using cointegration analysis. Heikkinen and Kanto (2000) reformulated a conventional market model by considering the long-run characteristics of forestry investment, whereas Heikkinen (2002) examined the long-run correlation between Finnish forestry assets and financial market instruments. The results showed that the Finnish stumpage prices and bond and deposit rates were cointegrated in the long run. However, these studies included limited investment vehicles. They also assessed timberland performance based on historical stumpage price as a proxy for timberland return. This treatment could be improved considering that the stumpage price is just one source of investment returns from timberland.

The objective of this study was to examine the financial performance of the investments in timberland or Southern softwood timber and their correlations with nonforestry financial instruments in the long and short run using multivariate cointegration analysis and the CAPM. Each approach had its own merits. The cointegration analysis measured the long-run economic correlations, while the CAPM enabled us to examine the short-run correlations. The dual-track approach should allow us to draw more accurate and robust conclusions. All data were quarterly and the time series covered from January 1992 to June 2006 with 58 observations. This article is organized as follows. First, the methods for both cointegration analysis and the CAPM are presented. Then, the data sources are presented and the empirical results are interpreted. This study ends with a discussion and conclusion.

Methods

Cointegration Analysis

Following the Johansen multivariate cointegration analysis (Johansen 1988, 1991; Johansen and Juselius 1990), a vector autoregressive (VAR) model for asset returns is expressed as

$$X_t = \Gamma_1 X_{t-1} + \cdots + \Gamma_k X_{t-k} + \varepsilon_t, \quad (1)$$

where X represents a vector of variables, t is time index, k denotes the number of lags in the model, Γ is a matrix of parameter coefficients, and ε_t is a vector of error terms. If all variables are stationary, an unrestricted VAR system in level form can be used. If all variables are nonstationary, but no cointegration relationship exists, an unrestricted VAR system in first difference form can be used. However, if all variables are nonstationary and cointegrated, the estimates obtained by the standard VAR model cannot be consistently specified (Engel and Granger 1987). To solve this problem, a vector error correction model can be used (Harris and Sollis 2003). Thus, Equation 1 is further reformulated as

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \cdots + \Gamma_k \Delta X_{t-k} + \Pi X_{t-1} + \varepsilon_t, \quad (2)$$

where Γ is a matrix of parameter coefficients for the short-run dynamics and Π represents a matrix of parameter coefficients. $\Pi = \alpha\beta'$, where α can be interpreted as the speed of adjustment to disequilibrium and β represents a matrix of the long-run coefficients. If all variables are integrated of order one $I(1)$, they are stationary in the first difference form. The series $\beta' X_t$ is required to be stationary to obtain consistent estimates. Although X_t is nonstationary, the existence of cointegrating correlations indicates that the linear combinations of $\beta' X_t$ are indeed stationary. Because the columns of β form r distinct cointegrating vectors, the rank of Π is equal to the number of the cointegration vectors. Thus, cointegration tests are needed to find the number of r linearly independent columns in Π. The concept of cointegration indicates the existence of a long-run equilibrium to which an economic system converges over time (Harris and Sollis 2003).

Before the implementation of the cointegration analysis, we need to examine whether individual variables are nonstationary and integrated of the same order. The Augmented Dickey-Fuller (ADF) test is used for this purpose. The lag length for the ADF test is determined by the Akaike information criterion (AIC). Unless the time series are nonstationary and integrated of the order of 2, cointegration analysis can be conducted in a mix of stationary variables $I(0)$ and nonstationary variables $I(1)$ (Harris and Sollis 2003, p. 112).

Another requirement before the cointegration analysis is performed is to determine the optimum lag length for the model because the Johansen method for cointegration analysis is sensitive to changes in lag structure. A number of VAR lag selection criteria and diagnostic tests can be used to determine the optimum lag length. The selection criteria include log likelihood ratio (LR), final prediction error (FPE), AIC, Schwarz information criterion (SIC), and Hannan-Quinn information criterion (HQ). The diagnostic tests (Lagrange multiplier test for residual serial correlation, residual heteroskedasticity test, and residual normality test) are then conducted to make sure that the lag length satisfied the minimum requirement of no residual serial correlation.

In this study, three VAR models are estimated. Model 1 includes timberland (NTI) and FIN. FIN consists of seven financial assets: farmland (FR), real estate (NPI), stock market (SP500), gold (GP), 3-month treasury bills (TB3M), 3-month certificate of deposit interest rates (CD3M), and 30-year government bond (GB30Y). Model 2 consists of stumpage price of Southern pine softwood (SWP) and FIN. Model 3 includes nine variables: NTI, SWP, and FIN. Overall, model 1 focuses on timberland, model 2 on timber, and model 3 on both of them.

Johansen's multivariate cointegration analyses are conducted to determine the number of the cointegration vectors for each of the three models. This study assumes that only constants are included in the cointegration regression. Trace and maximum eigenvalue tests are used to detect the number of the cointegrating vectors, r, as the indicator of the number of the long-run correlations among the variables.

After the cointegration rank is determined, the long-run exclusion tests for each of the three models are conducted to see if any variable can be excluded from the cointegration space. The null hypothesis of a long-run exclusion test states that an individual instrument can be excluded from the cointegration space. The tests are conducted by imposing restriction zero on $\beta_{\gamma,k}$ of the rth cointegrating correlation, representing the corresponding kth variable equation in the cointegration space. The likelihood ratio statistics have a χ^2 distribution with the degree of freedom equal to the number of the cointegrating vectors.

After the cointegration rank is determined, another test of weak exogeneity for each of the three models is conducted to examine whether there are some driving forces in the systems in the long run. We can test this by examining the weak exogeneity of each variable (Heikkinen 2002). Weak exogeneity means that a variable drives the system away from the long-run equilibrium but cannot be driven by the other variables. In other words, the variable dominates and plays a leading role in the system. The null hypothesis states that there is a weak exogenous variable. The weak exogeneity for each of the three models is examined by placing restrictions zero on the adjustment coefficient, $\alpha_{k,\gamma}$, of the rth cointegrating correlation in the kth vector error correction equation. Like the long-run exclusion tests, the likelihood ratio statistics also have a χ^2 distribution with the degree of freedom equal to the number of the cointegrating vectors.

It is necessary to consider whether these cointegration vectors are identified and consequently if they reveal any long-run economic relationship (Johansen and Juselius 1994, Harris and Sollis 2003). For this purpose, several restrictions motivated by economic arguments (e.g., homogeneity restriction, zero restriction, and normalized restriction) are imposed on the cointegration space, β. Because economic theory is not particularly informative on the restrictions on these correlations in this study, general hypotheses (e.g., homogeneity restriction between treasury bills, deposit interest rates, or government bond) are tested to examine whether a particular economic relationship holds. In addition, zero restriction is imposed if a variable is left out of the model. Moreover, some zero restrictions are placed on the cointegration space because the joint restrictions have to identify all cointegrating vectors and the likelihood ratio statistic is available for the binding restrictions. If these restrictions are not rejected, then the long-run correlations can be identified for each of the three models. The long-run coefficients (β) do explain the correlation of these instruments in terms of elasticities because all variables are expressed in percent change.

If cointegration vectors exist in the model system, all estimates with traditional regression (ordinary least squares) are superconsistent (Stock 1987, Heikkinen and Kanto 2000). Thus, the CAPM can be used to evaluate the financial performance of the investments in timberland or timber and their correlations with nonforestry financial vehicles in the short run.

CAPM

The CAPM is chosen in this study because it is a simple and robust method to estimate financial risk and marketwide effects, although it is not without critiques (Roll 1977, Ross 1978). The basic idea of the CAPM is that the expected return on an investment should be equal to the return on a riskless investment plus a premium for the assumption of the market risk. Based on the portfolio theory (Markowitz 1952, Sharpe 1964, Lintner 1965), the CAPM is specified as

$$R_i = R_f + \beta_i(R_m - R_f), \tag{3}$$

where R_i represents the rate of return for investment i, R_f denotes the risk-free rate of return measured by US T-bills (TB3M), β_i is investment i's risk premium, and R_m represents the rate of return of a market portfolio. In this study, SP500 is used as a proxy for the market portfolio.

Because the CAPM is proved to be consistent with a regression equation (Jensen 1969), it is further reformulated as

$$R_i - R_f = \alpha_i + \beta_i(R_m - R_f) + \varepsilon_i, \tag{4}$$

where α_i signifies the appreciation of an asset due to the factors other than the overall market (Redmond and Cubbage 1988). If α_i is positive and significantly greater than zero, then an expected return on the asset is greater than what the market requires for the asset in the risk class and thus indicates a superior risk-adjusted return. β_i is a relative measure of systematic risk, reflecting an asset's price movements caused by changes in the market as a whole. If β_i is greater than one, the asset fluctuates more than a corresponding change in the market, so the asset is more risky than the market, and the asset is said to have a higher correlation with the market. If β_i is negative, a mix of the assets can lower the correlation of the assets in the total portfolio, thus causing the overall portfolio variability to decrease (Markowitz 1952, Brealey and Myers 1981, Reilly 1982). In addition, to evaluate the financial performance of forestry assets (NTI and SWP) with other financial assets directly, each asset in FIN except for TB3M is used as a proxy for the market portfolio. Mathematically, the formula is specified as

$$R_t - R_f = \alpha_i + \beta_i(R_e - R_f) + \mu_t, \tag{5}$$

where R_t denotes rates of return on timberland or softwood and R_e represents each asset in FIN except for TB3M.

Data

A summary of data description and statistics of the selected variables is reported in Table 1. Two of the nine investment instruments are related to forestry. The Timberland Index (NTI) from the National Council of Real Estate Investment Fiduciaries (NCREIF 2006) is chosen to represent institutional timberland investment. NTI is an index based on actual property performance, and it separates total return into income and capital components. It covers more than 75% of all institutionally managed timberlands in 2003 (Binkley et al. 2003). The average stumpage price of Southern pine pulpwood and sawtimber (SWP) is chosen to represent the timber market because 68% of the NTI value in 2003 was in the South (Binkley et al. 2003). The data are obtained from Timber Mart-South (2006).

Considering timberland and farmland are closely related and they may be influenced by each other, total leased return from farmland (FR) is included in this study. The data are taken from NCREIF (R. B. Webb [UBS AgriVest LLC,

Table 1. Definition and data summary for the selected nine variables

Variable	Definition (unit)	Mean	SD	Minimum	Maximum
NTI	NCREIF timberland index (%)[a]	2.29	4.31	−6.28	22.34
SWP	Softwood price (%)[b]	0.36	6.07	−11.70	15.36
FR	Farmland return (%)[a]	1.68	1.83	−0.56	10.66
NPI	Real estate index (%)[a]	1.64	1.51	−2.81	4.90
SP500	Standard & Poor's 500 (%)[c]	1.53	5.62	−16.03	12.42
GP	Gold price (%)[c]	0.41	4.96	−7.30	13.50
TB3M	Treasury bills for 3 months (%)[d]	0.29	0.57	−1.22	1.02
CD3M	Certificate of deposit interest rates for 3 months (%)[d]	0.36	0.59	−1.19	1.12
GB30Y	Government bond for 30 years (%)[d]	0.83	0.50	−0.40	1.97

Data sources: [a]NCREIF (2006); [b]Timber Mart-South Inc. (2006); [c]The Financial Forecast Center (2006); [d]Federal Reserve Bank (2006).

Hartford, CT] and R. Vendl [National Council of Real Estate Investment Fiduciaries, Chicago, IL], Total leased farmland data, pers. communication, Sept. 15, 2006). Real estate (NPI) is included in the portfolio because of considerable changes in timberland ownership from timber processors to real estate investment trusts. The data are also from NCREIF (2006). Stock market index (Standard and Poor's 500 [SP500]) is included in the portfolio because it is often used as a proxy for the market portfolio and reflects returns of major financial assets. SP500 is a composite indicator of the broad market, which is computed as quarterly averages from monthly closing values of the SP500 stock market index. The sixth variable is gold price (GP), which is chosen to represent precious metals because it may have an impact on the timber or timberland market (Sun and Zhang 2001). The data for both SP500 and GP are obtained from the Financial Forecast Center (2006). The last three variables are the US treasury bills for 3 months (TB3M), the certificate of deposit interest rates for 3 months (CD3M), and the 30-year government bond (GB30Y) (Federal Reserve Bank 2006).

To have a consistent measure of the asset returns as percentages, the SWP, SP500, and GP are converted into percent change first. For comparing investments in terms of purchasing power, we deflate all of these variables by the U.S. Consumer Price Index for all urban consumers by all items (US Bureau of Labor Statistics 2006) (1992 = 100). All data are quarterly time series for the period from January 1992 to June 2006 (58 observations). The time period coverage is mainly constrained by the data availability of the leased farmland index from NCREIF.

Results

Cointegration Analysis

Figure 1 shows each series of the nine variables (NTI, SWP, FR, NPI, SP500, GP, TB3M, CD3M, and GB30Y) from January 1992 to June 2006. The results from the ADF

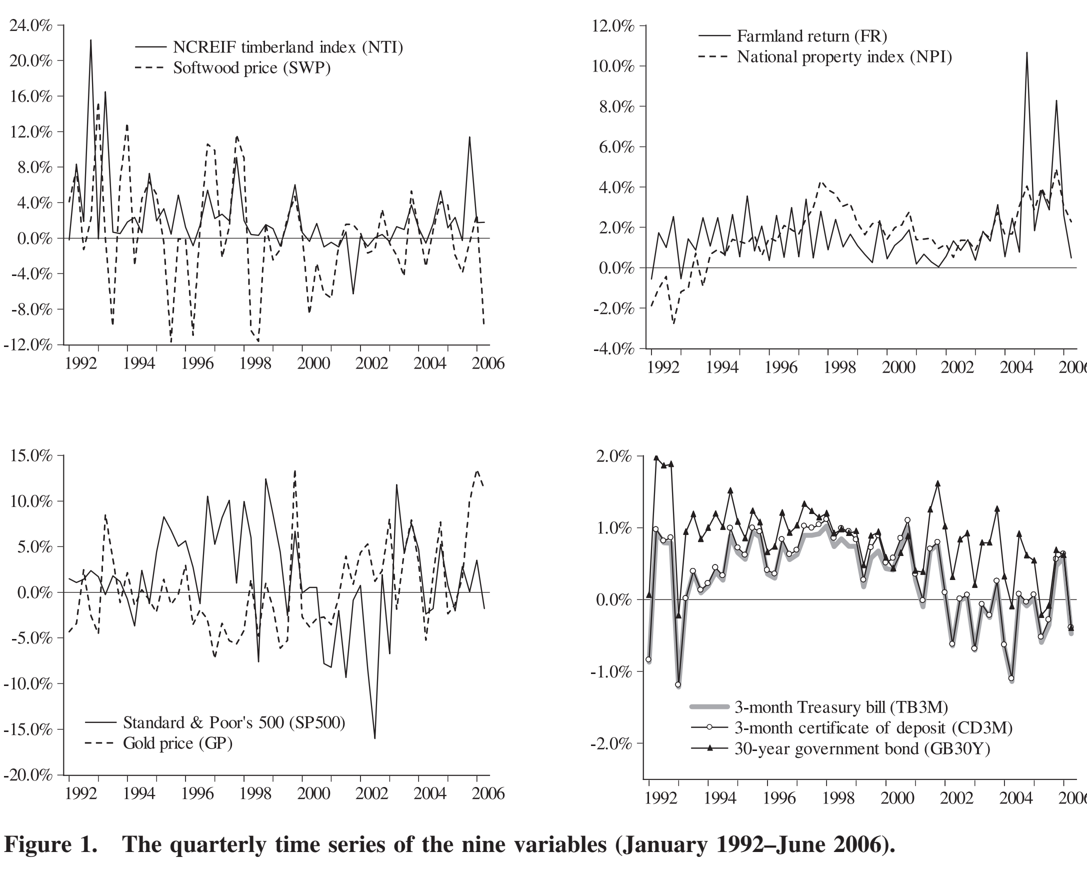

Figure 1. The quarterly time series of the nine variables (January 1992–June 2006).

Table 2. Results of the ADF unit-root tests

Series	Level	Lags	First difference	Lags	Conclusion
NTI	−3.65**	3	—	—	$I(0)$
SWP	−4.14**	5	—	—	$I(0)$
FR	−1.66	5	−10.95**	2	$I(1)$
NPI	−2.32	7	−2.67*	7	$I(1)$
SP500	−3.53**	1	—	—	$I(0)$
GP	−1.53	2	−6.78**	2	$I(1)$
TB3M	−1.36	5	−3.83**	4	$I(1)$
CD3M	−1.42	5	−3.66**	4	$I(1)$
GB30Y	−1.90	3	−11.04**	2	$I(1)$

$I(0)$ indicated that a variable had no unit root and was stationary. $I(1)$ indicated that a variable had a unit root and was integrated of order 1. The null hypothesis of a unit root was rejected at the **5% and *10% significant levels, respectively. The 5% and 10% critical values for the ADF including a constant were −2.92 and −2.60.

test are presented in Table 2. These results indicate that NTI, SWP, and SP500 are stationary $I(0)$, but all other six variables are nonstationary and integrated of order one $I(1)$.

The optimum lag length for the three VAR models is determined by the five lag selection criteria (LR, FPE, AIC, SIC, and HQ) and diagnostic tests as stated earlier. For model 1 (NTI and FIN), LR, FPE, AIC, and HQ suggest two lags, but SIC indicates one lag. For model 2 (SWP and FIN), the results are similar to these for model 1. LR, FPE, AIC, and HQ conclude the presence of two lags, but SIC indicates one lag. Similarly for model 3 (NTI, SWP, and FIN), LR, FPE, AIC, and HQ conclude two lags, but SIC suggests no lag as optimal. The results of diagnostic tests on the residuals of the three VAR models indicate that the null hypothesis of no serial correlation cannot be rejected at the 5% significant level using three lags for model 1, two lags for model 2, and two lags for model 3. The results of heteroskedasticity reveal that the null hypothesis cannot be rejected at the 5% level of confidence. However, residuals are not normally distributed due to excess kurtosis. This result is similar to the findings in Finland (Heikkinen 2002). Because cointegration results appear robust to excess kurtosis (Gonzalo 1994), we accept the models for further analysis. If we couple the results of the diagnostic tests with the results of the five lag selection criteria, three lags are set to model 1, two to model 2, and two to model 3.

The results of the cointegration analysis are presented in Table 3. Both tests reveal that in each model all investment vehicles are cointegrated in the long run. The two cointegration tests report slightly different results about the number of the cointegrating vectors. For models 1 and 3, the numbers of the cointegrating vectors are three by the trace test and two by the maximum eigenvalue test. For model 2, both tests report two cointegrating vectors. The trace test leads to a consistent test procedure, whereas the maximum eigenvalue test does not (Doornik and Hendry 2001). Therefore, three cointegrating vectors are finally chosen for model 1, two for model 2, and three for model 3.

The results of the long-run exclusion tests for each of the three models are presented in Table 4. Except for real estate (NPI) in model 2, the null hypotheses are rejected in all other cases. Therefore, NPI in model 2 is excluded by imposing zero restriction on the cointegration space, whereas all other variables cannot be left out from the variable space. These findings conclude that forestry assets cannot be excluded from the models. We can further obtain their long-run correlations in the systems after identifying economic relationships.

The results of the weak exogeneity tests are reported in Table 5. The results reveal that SP500 and GP are weakly exogenous in the three models at the 5% significant level. Meanwhile, TB3M, CD3M, and GB30Y are weakly exogenous in model 3. These findings suggest that investments

Table 3. Trace and maximum eigenvalue tests for cointegration rank

	Model 1†		Model 2		Model 3	
H_0	Trace	Maximum eigenvalue	Trace	Maximum eigenvalue	Trace	Maximum eigenvalue
$r = 0$	232.45**	78.40**	202.67**	62.99**	252.58**	64.65**
	(159.53)	(52.36)	(159.53)	(52.36)	(197.37)	(58.43)
$r = 1$	154.05**	58.12**	139.68**	51.68**	187.93**	61.35**
	(125.62)	(46.23)	(125.62)	(46.23)	(159.53)	(52.36)
$r = 2$	95.93**	31.52	88.00	33.57	126.59**	43.46
	(95.75)	(40.08)	(95.75)	(40.08)	(125.62)	(46.23)
$r = 3$	64.42	24.62	54.43	19.04	83.12	31.92
	(69.82)	(33.88)	(69.82)	(33.88)	(95.75)	(40.08)
$r = 4$	39.80	16.86	35.39	16.69	51.21	18.50
	(47.86)	(27.58)	47.86	27.58	(69.82)	(33.88)
$r = 5$	22.94	14.41	18.70	11.20	32.71	13.76
	(29.80)	(21.13)	(29.80)	(21.13)	(47.86)	(27.58)
$r = 6$	8.53	8.25	7.50	6.27	18.95	11.00
	(15.49)	(14.26)	(15.49)	(14.26)	(29.80)	(21.13)
$r = 7$	0.28	0.28	1.23	1.23	7.95	6.23
	(3.84)	(3.84)	(3.84)	(3.84)	(15.49)	(14.26)
$r = 8$					1.71	1.71
					(3.84)	(3.84)
r	3	2	2	2	3	2

Model 1 contained NTI and the group variable of FIN (i.e., FR, NPI, SP500, GP, TB3M, CD3M, and GB30Y). Model 2 contained SWP and FIN. Model 3 contained NTI, SWP, and FIN. The critical values for trace and maximum eigenvalue tests are reported in parentheses. Significance at the **5% and *10% level.

Table 4. Results from the long-run exclusion test

Variable	Model 1: $\chi^2_{(3.5\%)} = 7.81$	Model 2: $\chi^2_{(2.5\%)} = 5.99$	Model 3: $\chi^2_{(3.5\%)} = 7.81$
NTI	17.26**	—	14.86**
SWP	—	20.39**	28.91**
FR	14.41**	13.96**	15.59**
NPI	9.45**	0.69	10.38**
SP500	17.49**	7.25**	23.29**
GP	25.89**	21.15**	21.30**
TB3M	43.35**	11.95**	16.03**
CD3M	42.35**	12.59**	17.11**
GB30Y	48.64**	10.77**	7.28**

For explanation of models and of * and **, see Table 3.

Table 5. Results from the likelihood ratio tests of weak exogeneity

Variable	Model 1: $\chi^2_{(3)} = 7.81$	Model 2: $\chi^2_{(2)} = 5.99$	Model 3: $\chi^2_{(3)} = 7.81$
NTI	16.14**	—	14.48**
SWP	—	16.47**	18.91**
FR	15.45**	15.08**	21.55**
NPI	6.51*	13.38**	17.93**
SP500	3.90	0.31	3.70
GP	5.47	1.81	1.77
TB3M	13.89**	6.52**	4.83
CD3M	12.76**	7.28**	6.07
GB30Y	19.56**	8.54**	4.22

For explanation of models and of * and **, see Table 3.

in timberland and softwood do not play leading roles in the three models.

After imposing economic arguments or restrictions, three likelihood ratio statistics are obtained for each of the three models. For model 1, it is hypothesized that there are one normalized restriction ($\beta_{11} = 1$) and three zero restrictions ($\beta_{15}, \beta_{16}, \beta_{18} = 0$) on β_1, a homogeneity restriction ($\beta_{26} = -\beta_{28}$) and one zero restriction ($\beta_{27} = 0$) on β_2, and a homogeneity restriction ($\beta_{37} = -\beta_{36}$) and one zero restriction ($\beta_{38} = 0$) on β_3 as

$$\beta = \begin{bmatrix} 1 & * & * & * & 0 & 0 & * & 0 \\ * & * & * & * & * & 1 & 0 & -1 \\ * & * & * & * & * & -1 & 1 & 0 \end{bmatrix}, \qquad (6)$$

where $*$ indicates a parameter to be estimated freely. The likelihood ratio statistic is 0.57 with a P value of 0.45, while holding homogeneity relationships between TB3M, CD3M, and GB30Y on β_2 and β_3. For model 2, one normalized restriction ($\beta_{11} = 1$) and two zero restrictions ($\beta_{13}, \beta_{15} = 0$) on β_1 and two zero restrictions ($\beta_{22}, \beta_{23} = 0$) where $\beta_{13} = \beta_{23} = 0$ because NPI is left out from the model and a homogeneity restriction ($\beta_{26} = -\beta_{27} = -\beta_{28}$) on β_2 are imposed as

$$\beta = \begin{bmatrix} 1 & * & 0 & * & 0 & * & * & * \\ * & 0 & 0 & * & * & 1 & -1 & -1 \end{bmatrix}. \qquad (7)$$

The likelihood ratio statistic is 2.43 with a P value of 0.66, while holding the same homogeneity relationships on β_2. For model 3, one normalized restriction ($\beta_{11} = 1$) and three zero restrictions ($\beta_{16}, \beta_{17}, \beta_{19} = 0$) on β_1, two zero restrictions ($\beta_{21}, \beta_{28} = 0$) and a homogeneity restriction ($\beta_{27} = -\beta_{29}$) on β_2, and a homogeneity restriction ($\beta_{38} = -\beta_{37}$) and one zero restriction ($\beta_{39} = 0$) on β_3 are placed as

$$\beta = \begin{bmatrix} 1 & * & * & * & * & 0 & 0 & * & 0 \\ 0 & * & * & * & * & * & 1 & 0 & -1 \\ * & * & * & * & * & * & -1 & 1 & 0 \end{bmatrix}. \qquad (8)$$

The likelihood ratio statistic is 2.79 with a P value of 0.25 for model 3, while also holding the same homogeneity relationships between TB3M, CD3M, and GB30Y on β_2 and β_3. Overall, the likelihood ratio tests indicate that these restrictions placed on the cointegration vectors are acceptable.

The results of the long-run cointegration correlations between these investment vehicles are presented in Table 6. Note that only the results of β_1 are presented because they are related to this study objective (examining the financial performance of the investments in timberland and softwood timber). Once the cointegration vectors are transformed into the equations by shifting the normalized variable to the left-hand side, the long-run equations are obtained. For example, the equation for model 3 is

$$\mathrm{NTI} = 1.30\mathrm{SWP} + 0.24\mathrm{FR} - 0.82\mathrm{NPI} + 0.55\mathrm{SP500} - 3.07\mathrm{CD3}M. \qquad (9)$$

The likelihood ratio tests reveal that 9 of 15 variables for the three models are significant at the 5 or 10% significant level. The elasticity of SWP has an expected positive sign in model 3. The investment returns from timberland (NTI) tend to increase by 1.30% as the SWP increases by 1%, ceteris paribus. This result reveals that the softwood timber price largely drives the timberland value, which confirms the common impression that stumpage price is one of the major sources for investment returns from timberland. The results also indicate that there is a significantly positive correlation between the farmland return and the stumpage price of Southern pine softwood. An intuitive explanation for this is that the higher agriculture return means higher land quality in general, while holding others equal. So, the

Table 6. Results from the cointegration analysis

Variable	Model 1	Model 2	Model 3
NTI	−1.00	—	−1.00
SWP	—	−1.00	1.30**
			(7.77)
FR	0.43	0.38**	0.24
	(1.00)[a]	(5.80)	(0.41)
NPI	−0.57	0.00	−0.82
	(−2.12)		(−1.87)
SP500	0.32**	−0.24	0.55**
	(4.09)	(−2.67)	(4.56)
GP	0.00	0.00	0.00
TB3M	0.00	−13.73**	0.00
		(−5.18)	
CD3M	−0.65**	13.52**	−3.07**
	(−6.59)	(5.58)	(−5.35)
GB30Y	0.00	5.35**	0.00
		(13.84)	

For explanation of models and of * and **, see Table 3.
[a] Distributed as $\chi^2_{(1)}$ with the critical values of $\chi^2_{(1,10\%)} = 2.71$ and $\chi^2_{(1,5\%)} = 3.84$.

Table 7. Estimated results from the CAPM using SP500 as a proxy for market portfolio

Asset	α Coefficient	α t ratio	β Coefficient	β t ratio	R^2
NTI	1.89**	3.38	0.09	0.87	0.01
SWP	−0.20	−0.25	0.22	1.54	0.04
FR	1.33**	5.34	0.05	1.04	0.02
NPI	1.32**	6.61	0.02	0.58	0.01
GP	0.17	0.24	−0.04	−0.32	0.01
CD3M	0.07**	11.54	0.00	1.52	0.04
GB30Y	0.54**	11.50	0.00	0.57	0.01

For explanation of * and **, see Table 3.

larger size timber can be produced in the land with the higher quality and the timber price for the large size can be higher correspondingly. Moreover, the results show that there is a significantly positive correlation between SP500 and timberland. This result implies that timberland is not a good vehicle in a portfolio in terms of risk reduction in the long run because any change in the stock market does have a potential effect on the timberland market. Finally, we find that there is a significant and negative correlation between CD3M and investment return from timberland (NTI), whereas a significant and positive correlation exists between GB30Y and the SWP in model 2.

CAPM

The results of the CAPM using SP500 as a proxy for market portfolio are presented in Table 7. Except for SWP and gold, all α coefficients are significantly different from zero at the 5% level. These results reveal that except for SWP and GP, all other assets have significant excess returns than SP500. No β coefficient is significantly different from zero at the 5% level. This implies that these assets do not significantly reduce systematic risk. The results also indicate that these assets have no close relationship with the market portfolio of SP500 in the short run. The results are consistent with the findings in the literature by others (Redmond and Cubbage 1988, Thomson 1989, Washburn and Binkley 1993, Sun and Zhang 2001).

The results of regression using each asset in FIN, except for TB3M, as a proxy for the market portfolio are reported in Table 8. The first panel in Table 8 shows the regression results for NTI. When the market portfolio is SWP, NPI, or GP, the α coefficient is significantly different from zero at the 5% level but not significantly different from zero for the others. When the market portfolio is SWP, FR, or NPI, the β coefficient is significantly different from zero at the 5% level. These results reveal that timberland has significantly greater excess returns than SWP, NPI, and GP and lower risk than SWP, FR, and NPI. The second panel in Table 8 shows the relationship between SWP and each asset in FIN except for TB3M. The α coefficient when GB30Y is used as the market portfolio is negative and significant at the 10% level but is not significant in other cases. The β coefficients are positive and significantly different from zero at the 5% level for NTI and GB30Y. These results reveal that softwood has significantly lower returns and higher risk than GB30Y.

Discussion and Conclusion

This study focused on the forest sector and examined the financial performance of investments in timberland or timber and their correlations with nonforestry financial vehicles in the United States. The multivariate cointegration method and the CAPM were used to investigate the long- and short-run correlations. The study covered these assets between January 1992 and June 2006, using 58 observations. The results from the two approaches revealed that the selected nine assets were cointegrated in the long run, whereas these assets' short-run correlations were not as close as we had expected. Our results implied that an asset should have either high return with high risk or low return with low risk in the long run, but in the short run abnormal returns (high return with low risk) did occur.

The cointegration analysis painted a long-run picture of structural economic correlations among the nine financial assets. Specifically, the results of the long-run exclusion tests revealed that forestry-related investments were not left out from the cointegration space. It is generally believed by economists that the selection of an investment portfolio is a practical issue and we found that the Johansen method for cointegration analysis was sensitive to portfolio selection. The long-run exclusion method was appropriate to exclude some assets from among the portfolio or zero restriction was placed on these assets in the model. In addition, the results of weak exogeneity tests indicated that timberland and softwood timber price did not play leading roles in these portfolios. These results were consistent with the findings in Finland (Heikkinen 2002).

The results of the identification of the long-run correlations revealed that investment return from timberland in the

Table 8. Estimated results from the CAPM using each asset in FIN as a proxy for market portfolio

Asset	NTI α	NTI β	NTI R^2	SWP α	SWP β	SWP R^2
NTI	—	—	—	−0.67 (−0.78)	0.37** (2.00)	0.07
SWP	1.98** (3.74)	0.18** (2.00)	0.06	—	—	—
FR	0.89 (1.39)	0.80** (2.91)	0.13	−0.19 (−0.19)	0.18 (0.43)	0.01
NPI	2.96** (4.14)	−0.72** (−2.01)	0.07	0.84 (0.79)	−0.57 (−1.08)	0.02
GP	1.98** (3.66)	0.14 (1.31)	0.03	0.08 (0.10)	−0.06 (−0.38)	0.01
CD3M	1.64 (1.61)	5.13 (0.42)	0.01	1.64 (1.12)	−22.56 (−1.28)	0.03
GB30Y	0.72 (0.74)	2.37 (1.55)	0.04	−2.93** (−2.13)	5.59** (2.61)	0.11

t ratios are reported in parentheses. For explanation of * and **, see Table 3.

long run was largely driven by softwood price. This finding implied that a shift from pulpwood to sawtimber production might increase timber prices and thus benefit timberland investment. The results also indicated that there is a positive correlation between farmland return and the stumpage price of Southern pine softwood, implying that treatments such as high-intensity site preparation might increase land quality, which would then enlarge timber size and increase timber price. However, investors need to be cautious with the stock market because the results revealed that any change in the stock market did have a potential effect on the timberland market. After an examination of the economic correlations, we further found that there is a significant and negative correlation between deposit interest rates and timberland return. This finding is critical for policymaking because any policy intended to reduce interest rates might be helpful for landowners or investors in the beginning of establishing a timberland plantation.

Further analysis with the CAPM delivered some interesting results with respect to short-run returns. The results of the CAPM revealed that timberland produced significant excess returns over the study period of 1992–2006, but softwood timber price did not. The results also indicated that both timberland and timber did not hedge against systematic risk with the stock market in the short run nor had a close correlation with it. The results of using each asset in financial assets (FIN), as the market portfolio further revealed, were that timberland alone had significantly greater excess returns than softwood, real estate, and gold and lower risk than softwood, farmland, and real estate. These results confirmed the common impression that timberland was worth more as real estate than as a source of timber. In particular, there was a significant and negative correlation between timberland and real estate, indicating that timberland would be a desirable vehicle mixed with real estate because the mix could increase return and reduce systematic risk dramatically. The results also revealed that softwood did not provide risk-reducing benefits in a portfolio with other assets in the short run.

In this study we concluded that timberland did generate excess return in the short run but that the abnormal return would be reduced to achieve the long-run equilibrium under the zero-profit condition eventually. The stumpage price of Southern pine softwood did not have similar characteristics in the short run. In addition, both timberland and timber did not reduce systematic risk in a portfolio with the stock market in the long and short run. Overall, these results based on the cointegration analysis and the CAPM were consistent with the findings in the literature by others (Redmond and Cubbage 1988, Thomson 1989, Washburn and Binkley 1993, Lausti and Penttinen 1999, Heikkinen and Kanto 2000, Sun and Zhang 2001). However, it should be kept in mind that the results from this study need to be interpreted with caution. The findings were based on a relatively short time period. The relatively low frequency of 58 observations might also weaken our inference power, although it is typically hard to obtain all variables that have a long time span with high frequency, particularly in the forest sector (e.g., Hetemäki et al. 2004, Baek and Yin 2006). In addition, the findings were constrained by the empirical analysis technology. Nevertheless, this study is helpful in understanding the difference between long- and short-run performance of investments in timberland or Southern softwood stumpage, and the results should be interesting to those who are interested in a portfolio selection of timberland or softwood timber as an investment vehicle. Further research is needed to examine the long- and short-run correlations between forestry assets and nonforestry financial assets at regional level, considering the large variations in asset investments in the United States.

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