FINANCIAL ANALYSIS OF TIMBERLAND INVESTMENT IN THE UNITED STATES

by

WENJING YAO

(Under the Direction of Bin Mei)

ABSTRACT

Timberland assets, due to their unique return drivers, have attracted much attention in the past decades. In the United States, timberland assets can be both privately and publicly owned. The first part of the dissertation aims to price the timberland investments in the United States using the arbitrage pricing theory (APT). Results show that public-equity timberland assets have higher mean excess returns in general. Compared with the capital asset pricing model (CAPM), a larger portion of the variations in timberland returns are explained by the arbitrage pricing theory because more causal factors are considered. Moreover, the expected returns of timberland assets are declining over time. This may imply an improved efficiency of the timberland market. The second part assesses the risk-return relationship between forestry-related assets and innovations in state variables using the intertemporal capital asset pricing model (ICAPM). Results show that the ICAPM that includes the market excess returns and innovations in the SMB and HML factors, interest rate, term spread, default spread and aggregate consumption as risk factors explains about 80% of the variation in cross-sectional returns of 16 forestry-related assets. In addition, beta loadings on innovations in HML, interest rate and term spread induce significant risk premiums. In general, average excess returns of the forestry-related assets decrease from period of 1988Q1-1999Q4 to period of 2000Q1-2011Q4. Significant positive excess returns are obtained for private- and public-equity timberland assets in the first sub-period but the second. Insignificant excess returns are obtained for forest products and timber products in the whole period. The last part examines the relationship between investor sentiment and timberland investment returns. Results show that current investor sentiment is an important factor that determines the one-quarter future returns of timberland investment. The predicting power is persistent over the next 1-5 years. Both the short- and long-term studies obtain negative coefficients on investor sentiment. In addition, significantly different return variances and insignificantly different average returns of timberland investment are obtained between low- and high-sentiment periods. This further confirms the ability of earning long-term stable returns by timberland investment.

INDEX WORDS: Asset Pricing, APT, CAPM, ICAPM, Timberland Investments, Time Series

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Timberland Investment in the United States

As an investment vehicle, timberland has attracted much attention due to its unique return drivers: biological growth, timber price change and land value appreciation. Among which, biological growth differentiates timberland assets from other types of real estate assets. It contributes more than 50% to the total timberland investment returns and is independent of the financial market conditions (Caulfield 1998). Timberland is an illiquid asset with the length of investment horizons typically being 10 to 15 years (Clutter et al. 2005).

In the past several decades, timberland ownership in the United States has changed dramatically. Forest products companies used to be vertically integrated with both large land holdings and processing facilities. Nonetheless, the integration business model was undervalued by analysts on Wall Street because the value growth of timberland assets is not recognized in the corporate financial statements (Binkley et al. 1996). Moreover, timberland assets managed under the C-corporation structure are subjected to double taxation and mergers and acquisitions have increased the companies' debt levels. Accordingly, more than a half of the forest products companies sold or restructured their ownership of timberland since the late 1980s. At the same time, the Federal Employee Retirement Income Security Act (ERISA) as well as other similar legislations required pension plans, endowments and foundations to diversify their investments from traditional financial assets such as stocks and bonds. Seeking alternative opportunities, institutional investors with large amounts of capital became new forest landowners. The total value of timberland properties held by institutional investors increased from approximately $1 billion in 1989 to about $30 billion in 2010 (Harris et al. 2010).

Ways of Timberland Investment

Large amounts of timberlands owned by institutional investors stimulated the emergence of timberland investment management organizations (TIMOs), which are responsible for achieving adequate returns for investors by purchasing, managing and selling timberlands on their behalf. Two styles of managements are commonly used by TIMOs: separately managed accounts and commingled funds. Separately managed accounts are used for a single portfolio for one investor, whereas commingled funds are used when capital is collected from multiple investors and allocated to a timberland portfolio (Zinkhan 2008).

Timberland investment through TIMOs requires large amounts of capital, and the length of the investment horizon is fixed to 10 to 15 years (Clutter et al. 2005). Therefore, it inhibits general public to partake and is regarded as private-equity timberland investment. Alternatively, investors who are interested in forest investment can invest though publicly-traded timber firms. The major form of timberlands securitization transfers from the master limited partnerships (MLPs) in the 1980s to the timber real estate investment trusts (REITs) in recent years (Sun 2013). Since 1999, four publicly-traded forest products firms converted themselves from traditional C-corporations into REITs for tax efficiency purpose. Other potential benefits from public-equity timberland investments include access to well-regulated and rather diversified timberland portfolios with a small amount of capital allocation and more liquidity (Zinkhan et al. 1992).

Besides aforementioned means, investors can also participate in timberland investments via exchange-traded funds on timber assets, direct ownership, timberland lease, timber-based loans and various specialized arrangements (Zinkhan et al. 1992). Investing in the forest products industry, such as the paper, lumber, and furniture industries, are alternatives of getting involved in forestry-related assets.

Brief Review of Studies on Timberland Investment

Previous studies on timberland investments demonstrated that timberland investments could provide opportunities for portfolio diversifications because of their relatively low correlations with the financial market and low levels of systematic risk (Lonnstedt and Svensson 2000, Zinkhan and Cubbage 2003, Healey et al. 2005, Newell and Eves 2009, Waggle and Johnson 2009). In contrast, Scholtens and Spierdijk (2010) removed the appraisal smoothing in the data and found less evidence of an improved mean-variance efficiency by including timberland assets. To investigate the inflation hedging ability of timberland investments, Wagner and Rideout (1991) combined an Income Growth Model with a nominal and real CAPM to examine two Ponderosa Pine plantations forestry assets between 1963-1988 and found that they were inferior inflation hedges. However, using different methods on varying geographic regions, Washburn and Binkley (1993), Martin (2010), and Wan et al. (2013) found that timberland was a good hedge against anticipated and/or unanticipated inflation. The studies on the financial performance of timberland investments by Sun and Zhang (2001) applied both the CAPM and the APT and found that institutional timberland investments and timberland limited partnerships had low risk levels and high excess returns compared with a variety of other forestry-related assets. Cascio and Clutter (2008) used the CAPM to estimate the risk and risk-adjusted returns for timberland investments based on the NCREIF Timberland Index and synthetic timberland return series. Liao et al. (2009) and Clements et al. (2011) used cointegration analyses on a number of assets and argued that timberland returns were correlated with other assets in the long run. Mei and Clutter (2010) and Rockemann and Schiereck (2010) compared private- and public-equity timberland investments and concluded that the former had significant abnormal returns. However, the results should be interpreted with caution because of the relatively small and insignificant betas estimated from the CAPM. Lastly, the early studies of market efficiency found timberland market to be inefficient (Caulfield 1998). However, this situation tends to be improved in recent years (Zinkhan 2008).

Three Issues to Be Investigated in Timberland Investment

With increasing attention from the investors, the financial performance of timberland assets needs to be evaluated. Given the different investment structures between TIMOs and timberland REITs, the expected returns may vary from each other. Moreover, required with more rigorous audit and appraisal procedures in recent years, the timberland market tends to become more transparent and competitive. Therefore, timberland investments may have different performance over time. Chapter 2 examines the financial performance of private- and public-equity timberland assets using the arbitrage pricing theory (APT). Distinct from the single factor CAPM, the APT considers multiple factors which incorporates information from related fields.

It has been claimed by many studies that the commonly used asset pricing models, such as the CAPM, are static factor models which assume that investors have homogeneous expectation and ignore the time variation in expected returns (Merton 1973, Roll 1977, Campbell 1996). However, investors face stochastic investment opportunity set. This is particularly true for long-term investments in forestry-related assets. To hedge against unfavorable shifts in the future investment opportunity set, investors adjust their investment decisions accordingly (Bali 2008). Merton (1973) developed the multi-factor intertemporal capital asset pricing model (ICAPM), which assumes that investors trade continuously and maximize their expected utility of lifetime consumption. Therefore, besides the market risk, risk of unfavorable shifts in the investment opportunity set, as approximated by the changes of the so-called state variables, will induce additional risk premiums and should be compensated. In Chapter 3, we investigate the intertemporal risk-return relationships of forestry-related assets under the multi-factor ICAPM framework.

Most of previous studies on timberland investments relied on traditional financial and time series models, which assume that only systematic risks affect asset returns. However, empirical results of significant abnormal returns indicate that those systematic risk factors have limited predicting power on timberland investment returns. Recent studies on behavioral finance argue that irrational investors in the market have important impact on stocks prices. Investor sentiment, which captures the irrationality in the naive and individual investors, has been found to be significantly related to stock returns (Brown and Cliff 2005, Baker and Wurgler 2006, Schmeling 2009). In Chapter 4, we examine the predicting power of investor sentiment on the short- and long-term timberland investment returns by using an indirect sentiment index. The performance of timberland investment in low- and high-sentiment periods are studied and compared.

The dissertation is organized as follows. The aforementioned three issues are addressed in Chapters 2-4. Each chapter is formatted as a journal article, which includes abstract, introduction, literature review, methodologies, data, empirical results, and conclusions and discussions. Chapter 5 summarizes the conclusions of the dissertation.

CHAPTER 2

PRICING TIMBERLAND ASSETS IN THE UNITED STATES BY THE ARBITRAGE PRICING THEORY[1]

[1] Yao, W., Mei, B., Clutter, M.L., 2014. *Forest Science*. 60:943-952. Reprinted here with permission of publisher, 04/15/2015.

Abstract

Using quarterly data 1988Q1-2011Q4, we assess the financial performance of timberland investments in the United States by the arbitrage pricing theory. Private-equity timberland returns are approximated by various indices reported by the National Council of Real Estate Investment Fiduciaries and public-equity timberland returns are approximated by a dynamic portfolio of publicly-traded timber firms. The results show that public-equity timberland assets have higher mean excess returns in general. Compared with the capital asset pricing model, a larger portion of the variations in timberland returns are explained by the arbitrage pricing theory because more causal factors are considered. In order to evaluate the performances of timberland assets over time, two sub-periods, 1988Q1-1999Q4 and 2000Q1-2011Q4, are studied separately. The results indicate that the expected returns of timberland assets are declining over time. This may imply an improved efficiency of the timberland market.

Introduction

Timberland, as an investment vehicle, has attracted much attention because of its special characteristics. Among the three drivers of timberland investment returns, i.e., biological growth, timber price change and land value appreciation, biological growth differentiates timberland assets from other types of real estate assets. It contributes more than 50% to the total timberland investment returns and is independent of the financial market conditions (Caulfield 1998). Timberland investments are also long-term investments. For a typical southern pine plantation, it takes 20-30 years for trees to mature financially. Therefore, timberland investors are usually patient investors with long investment time horizons.

Timberland ownership in the United States has changed substantially in the past several decades. Forest products companies used to be vertically integrated with both large land holdings and processing facilities. Nonetheless, the integration business model was undervalued by analysts on Wall Street because the value growth of timberland assets is not recognized in the corporate financial statements (Binkley et al. 1996). Moreover, timberland assets managed under the C-Corp structure are subjected to double taxation and mergers and acquisitions have increased the companies' debt levels. Accordingly, more than a half of the forest products companies sold or restructured their ownership of timberland since the late 1980s. At the same time, the Federal Employee Retirement Income Security Act (ERISA) as well as other similar legislations required pension plans, endowments and foundations to diversify their investments from traditional financial assets such as stocks and bonds. Seeking alternative opportunities, institutional investors with large amounts of capital became new forest landowners. The total value of timberland properties held by institutional investors increased from approximately $1 billion in 1989 to about $30 billion in 2010 (Harris et al. 2010).

Because of the lack of timberland management skills by those institutional investors and the dramatic increase of timberland investments, timberland investment management organizations (TIMOs) have emerged in the past 20 years (Healey et al. 2005). The responsibility of TIMOs is to find proper timberland investment properties for their investors and manage them to achieve adequate returns. Two styles of managements are commonly used by TIMOs: separately managed accounts and commingled funds. Separately managed accounts are used for a single portfolio for one investor, whereas commingled funds are used when capital is collected from multiple investors and allocated to a timberland portfolio (Zinkhan 2008). Investment through TIMOs is regarded as private-equity timberland investment because it requires large amounts of capital that inhibits the general public to partake.

To engage in the timberland business, general investors can buy stocks or bonds of publicly-traded timber firms. Contrasting to the TIMO models, ownership in publicly-traded timber firms is usually referred to as public-equity timberland investments. Between 1999 and 2010, the public-equity timberland market has witnessed a process of conversions. Four publicly-traded forest products firms converted themselves from C-Corporations to real estate investment trusts (REITs). Timber REITs pay out 90% of the taxable income to shareholders and owe no corporate tax, which attracts investors who favor relatively more tax-efficient stocks (Mendell et al. 2008). Other potential benefits from public-equity timberland investments include access to well-regulated and rather diversified timberland portfolios with a small amount of capital allocation and more liquidity (Zinkhan et al. 1992). Besides aforementioned means, investors can also participate in timberland investments via exchange-traded funds on timber assets, direct ownership, timberland lease, timber-based loans and various specialized arrangements (Zinkhan et al. 1992).

Given their different investment structures, the arbitrage pricing theory (APT) is used in this study to examine the financial performance of private- and public-equity timberland assets. The results reveal that public-equity timberland assets have higher excess returns in general and the expected returns of timberland assets tend to decrease over time.

Literature Review

Previous studies on timberland investments can be classified into the following categories: 1) role in a mixed portfolio, 2) inflation hedging ability, 3) financial performance, and 4) market efficiency. In the first category, Lonnstedt and Svensson (2000), Zinkhan and Cubbage (2003), Healey et al. (2005), Newell and Eves (2009), and Waggle and Johnson (2009), among others, demonstrated that timberland investments could provide opportunities for portfolio diversifications because of their relatively low correlations with the financial market and low levels of systematic risk. In contrast, Scholtens and Spierdijk (2010) removed the appraisal smoothing in the data and found less evidence of an improved mean-variance efficiency by including timberland assets. In the second category, Wagner and Rideout (1991) combined an Income Growth Model with a nominal and real CAPM to examine two Ponderosa Pine plantations forestry assets between 1963-1988 and found that they were inferior inflation hedges. However, using different methods on varying geographic regions, Washburn and Binkley (1993), Martin (2010), and Wan et al. (2013) found that timberland was a good hedge against anticipated and/or unanticipated inflation. In the third category, Sun and Zhang (2001) applied both the CAPM and the APT and found that institutional timberland investments and timberland limited partnerships had low risk levels and high excess returns compared with a variety of other forestry-related assets. Cascio and Clutter (2008) used the CAPM to estimate the risk and risk-adjusted returns for timberland investments based on the NCREIF Timberland Index and synthetic timberland return series. Liao et al. (2009) and Clements et al. (2011) used cointegration analyses on a number of assets and argued that timberland returns were correlated with other assets in the long run. Mei and Clutter (2010) and Rockemann and Schiereck (2010) compared private- and public-equity timberland investments and concluded that the former had significant abnormal returns. However, the results should be interpreted with caution because of the relatively small and insignificant betas estimated from the CAPM. In the fourth category, early studies found timberland market to be inefficient (Caulfield 1998). However, this situation tends to be improved in recent years (Zinkhan 2008).

This study extends the literature by applying multi-factor asset pricing model on timberland investments. The evaluation of expected returns over time can also provide empirical evidence of the efficiency of timberland markets. The rest of the paper is organized as follows. The next two sections explain the methods and data. Section V reports the results and the last section concludes the paper.

Methods

Capital Asset Pricing Model

Proposed by Sharpe (1964) and Lintner (1965), the CAPM is widely used in asset pricing because it is easy to understand and implement. Based on Markowitz's (1952) portfolio theory, the CAPM assumes that the expected return of an asset is proportional to its covariance with the market portfolio. Specifically, the expected return is equal to the risk-free rate of return plus a premium that depends on the asset's β_i and the expected risk premium of the market portfolio

(2.1) $$E[R_i] = R_f + \beta_i (E[R_m] - R_f) \, ,$$

Where $E[R_i]$ is the required return on asset *i*, R_f is the risk-free rate of return which is usually represented by the returns of short-term Treasury Bills, β_i measures the market risk of asset *i*, and $E[R_m]$ is the expected return of the market portfolio. Jensen (1969) proved that the CAPM was consistent with the following regression equation

(2.2) $$R_i - R_f = \alpha_i + \beta_i\left(R_m - R_f\right) + \mu_i,$$

where ex post realized returns R_i and R_m are used instead of ex ante expected returns $E[R_i]$ and $E[R_m]$. Intercept α_i is called Jenson's alpha and signifies appreciation of asset *i* due to factors other than the overall market. A positive α_i suggests that asset *i* has a higher expected return than what the market would require for the asset in that risk class, and thus indicates a superior risk-adjusted return. The opposite is true if α_i is negative. Therefore, Jensen's alpha becomes a commonly used measure of abnormal performance. Parameter β_i measures the sensitivity of asset *i* with respect to the market portfolio and therefore is an index of systematic or non-diversifiable risk (Babcock 1972). If β_i is greater (less) than 1, asset *i* is more (less) risky than the market. If β_i is equal to 1, asset *i*'s risk is considered equivalent to the market. The CAPM is used as a benchmark model in this study.

The assets' expected returns from the CAPM can be estimated using equation (2.1). Firstly, the beta coefficient is obtained by regressing the excess returns of an asset on the market risk premium using equation (2.2). Next, the estimated beta coefficient is plugged into equation (2.1) to obtain the point estimate of the expected return, where R_f and $E[R_m]$ are the average values across the sample period. To provide a reliable estimate of the expected return, a confidence interval of the estimate is generated by assuming that the beta coefficient follows the *t* distribution with mean $\hat{\beta}_i$ and standard error $\frac{\hat{\sigma}_i}{\sqrt{T}}$.

Because the expected return calculated by equation (2.1) is a linear function of $\hat{\beta}_i$, the expected return is *t*-distributed with mean $\bar{R}_f + \hat{\beta}_i(\bar{R}_m - \bar{R}_f)$ and standard error $\frac{\hat{\sigma}_i(\bar{R}_m - \bar{R}_f)}{\sqrt{T}}$. Furthermore, the confidence interval of the expected return is

(2.3) $$\bar{R}_f + \hat{\beta}_i(\bar{R}_m - \bar{R}_f) \pm t_{(1-\alpha)/2,(T-2)} * \frac{\hat{\sigma}_i(\bar{R}_m - \bar{R}_f)}{\sqrt{T}},$$

where $t_{(1-\alpha)/2,(T-2)}$ is the upper $(1-\alpha)/2$ critical value for the *t* distribution with $T-2$ degrees of freedom, and T is the sample length.

Arbitrage Pricing Theory

The APT was developed by Ross (1976) and enriched by others (Roll and Ross 1980). It is gradually replacing the CAPM in pricing assets because less restrictive assumptions are required. The APT is based on the law of one price, which asserts that, in an efficient market, all identical assets should have only one price. Unlike the CAPM that uses the market risk as a single factor, the APT derives factors in a more intuitive manner (Ross et al. 2002). It assumes that asset returns are linearly related to a set of industry- and market-wide factors which are called common factors.

The identification of the common factors can be achieved via factor analysis. It is a dimension reduction technique that describes the variance relationships among many variables in terms of a few unobservable random factors. Givenan observable p -dimensional random vector $\mathbf{X}$ with a mean $\boldsymbol{\mu}$ and a covariance matrix $\mathbf{\Sigma}$, an orthogonal factor model states that $\mathbf{X}$ is linearly dependent on n ($n \leq p$) common factors $\mathbf{F}' = (F_1, F_2, ..., F_n)$, and p additional specific factors (errors) $\boldsymbol{\varepsilon}' = \varepsilon_1, \varepsilon_2, ..., \varepsilon_p$ (Johnson and Wichern 2007),

(2.4)
$$\begin{aligned} X_1 - \mu_1 &= l_{11}F_1 + l_{12}F_2 + \cdots + l_{1n}F_n + \varepsilon_1 \\ X_2 - \mu_2 &= l_{21}F_1 + l_{22}F_2 + \cdots + l_{2n}F_n + \varepsilon_2 \\ &\vdots \\ X_p - \mu_p &= l_{p1}F_1 + l_{p2}F_2 + \cdots + l_{pn}F_n + \varepsilon_p \end{aligned} .$$

In matrix notations, the relationship can be expressed as

(2.5)
$$\mathbf{X} - \boldsymbol{\mu} = \mathbf{L}\,\mathbf{F} + \boldsymbol{\varepsilon} ,$$

where $\mathbf{L}$ is a $p \times n$ matrix of factor loadings, $E[\mathbf{F}] = \mathbf{0}$, $\text{cov}(\mathbf{F}) = E[\mathbf{F}\mathbf{F}'] = \mathbf{I}$, $E[\boldsymbol{\varepsilon}] = \mathbf{0}$, $\text{cov}[\boldsymbol{\varepsilon}] = E[\boldsymbol{\varepsilon}\boldsymbol{\varepsilon}'] = \mathbf{\Psi} = diag(\psi_1, \psi_2, ..., \psi_p)$, and $\text{cov}(\boldsymbol{\varepsilon}, \mathbf{F}) = E[\boldsymbol{\varepsilon}\mathbf{F}'] = \mathbf{0}$. In other words, the p deviations $X_1 - \mu_1, X_2 - \mu_2, \ldots, X_p - \mu_p$ can be expressed in terms of $n + p$ unobservable random variables $F_1, F_2, \ldots, F_n, \varepsilon_1, \varepsilon_2, \ldots, \varepsilon_p$.

Provided observed values $\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_n$ on p correlated variables, factor analysis seeks a small number of factors that can adequately represent the data. If $\mathbf{\Sigma}$ significantly deviates from a diagonal matrix, the problem is to estimate the factor loadings l_{ij} and the specific variances ψ_i. The two most widely used estimation methods are the principal component method and the maximum likelihood method. The former uses eigenvalue-eigenvector pairs $(\lambda_i, \mathbf{e}_i)$ of $\mathbf{\Sigma}$ in its spectral decomposition, whereas the latter assumes joint normality of $\mathbf{F}_j$ and $\boldsymbol{\varepsilon}_j$ in maximizing the likelihood function. Once factor loadings are estimated, they are usually further rotated to aid interpretations. Among others, VARIMAX is a commonly used orthogonal rotation method to group variables. Thus, each variable tends to be associated with a small number of factors and each factor represents only a small number of variables (Kaiser 1958). With factor loadings and specific variances obtained, estimated values for the common factors, so-called factor scores, can be constructed and used in subsequent analyses (Johnson and Wichern 2007).

Under the APT framework, asset returns are generated by the following stochastic model

(2.6) $$R_i - E[R_i] = \beta_{i1}F_1 + \beta_{i2}F_2 + \ldots + \beta_{in}F_n + e_i \,,$$

where R_i and $E[R_i]$ are the same as defined in the CAPM and e_i is the error term. Like in the CAPM, β_i 's are interpreted as risk measures for asset *i* corresponding to the common factors. Along with the assumption of zero arbitrage profits, the expected return can be calculated by

(2.7) $$E[R_i] = R_f + \beta_{i1}\lambda_1 + \beta_{i2}\lambda_2 + \ldots + \beta_{in}\lambda_n \,,$$

where λ 's are the risk premiums associated with the *n* risk factors. Empirically, β 's and λ 's need to be estimated first.

Sensitivity coefficients β 's are estimated by the regression model

(2.8) $$R_{it} = \beta_{i0} + \beta_{i1}\delta_{1t} + \beta_{i2}\delta_{2t} + \cdots + \beta_{in}\delta_{nt} + \xi_{it} \,,$$

where β_{i0} is the intercept, δ 's are factor scores associated with the common factors, and ξ_{it} is the error term. After $\hat{\beta}$'s are obtained, λ 's are estimated via cross-sectional regressions

(2.9) $$R_{it} = \lambda_{0t} + \hat{\beta}_{i1}\lambda_{1t} + \hat{\beta}_{i2}\lambda_{2t} + \ \dots \ + \hat{\beta}_{in}\lambda_{nt} + \eta_{it}$$

for $i = 1, 2, \dots, N$ and $t = 1, 2, \dots, T$, where λ_{0t} is the intercept, η_{it} is the error term, *N* is the total number of assets used to derive the common factors, and *T* is the sample length. That is, there is one regression across the *N* assets for each time period and there are *T* such regressions in total. This way, a time series is constructed for each risk premium. Then, averages are taken over the whole sample time period as $\lambda_j = \sum_{t=1}^{T} \lambda_{jt} / T$ for $j = 0, 1, 2, \dots, n$.

Using the estimated sensitivity coefficients and the risk premiums for each period, a total number of *T* expected returns are calculated. Furthermore, the confidence interval of the mean expected return for asset i is constructed using the mean and the standard error of the *T* returns. It can be expressed as

(2.10) $$E(R_i) = \frac{1}{T} \sum_{t=1}^{t=T} \sum_{j=0}^{j=n} \hat{\beta}_{ij} \hat{\lambda}_{jt} \pm t_{(1-\alpha)/2,(T-2)} * \frac{\hat{\sigma}_i}{\sqrt{T}},$$

where $\beta_{i0} = 1$ and $\hat{\sigma}_i$ is the standard error of the *T* calculated expected returns, $t_{(1-\alpha)/2,(T-2)}$ is the upper $(1-\alpha)/2$ critical value for the *t* distribution with *T*-1 degrees of freedom.

As a robustness check, another estimation method, partial least squares, is used to extract factor scores and calculate expected returns. Unlike most multiple regression models that use the covariance structure between the predictor variables only, partial least squares models use the covariance structure of both predictor and response variables (Garthwaite 1994).

Data

Returns of private-equity timberland investments are approximated by various indices reported by the National Council of Real Estate Investment Fiduciaries (NCREIF). The NCREIF Timberland Index (NTI) is reported quarterly and at both national and regional levels (i.e., the South, the Pacific Northwest, the Northeast, and the Lake States). It tracks total returns from a large sample of geographically diverse timberland properties in the United States. As of 2012Q1, the NTI represents over 13 million acres with a market value of about $23 billion (NCREIF 2012). The NTI includes both income return,[2] which comes from operating activities such as timber sales, and capital appreciation, which is from the partial or complete property sales and /or appraisals if the property is not completely sold during the period.

The formulas used to calculate the index are

$$\text{IR}_t = \frac{\text{EBITDDA}_t}{\text{MV}_{t-1} + 0.5(\text{CI}_t - \text{PS}_t + \text{PP}_t - \text{EBITDDA}_t)}, \tag{2.11}$$

$$\text{CR}_t = \frac{\text{MV}_t - \text{MV}_{t-1} - \text{CI}_t + \text{PS}_t - \text{PP}_t}{\text{MV}_{t-1} + 0.5(\text{CI}_t - \text{PS}_t + \text{PP}_t - \text{EBITDDA}_t)}, \tag{2.12}$$

where IR_t and CR_t are the income return and capital return, respectively; CI_t equals the capitalized expenditures (e.g., forest regeneration); PS_t equals the net proceeds from land sales; PP_t equals the gross costs of new land acquisitions; MV_t equals the market value of the property (Binkley et al. 2003). Except for the Northeast and the Lake States,[3] the data go back to 1987Q1.[4] Because these two regions combined represent a small portion of the total value of all properties, they were excluded in the analysis. The NTI for the nation, the South, and the Pacific Northwest are abbreviated as NTI-US, NTI-S, and NTI-PNW, respectively.

TIMOs are fee based organizations. However, the gross returns measured by the NTI are before investment advisory fees. In addition, the NTI excludes the effects of leverage. To deal with these concerns, the NCREIF recently released the Timberland Fund and Separate Account Index (TFSAI). The TFSAI reflects returns of a portfolio of timber funds and accounts and is available both gross and net of feesback to 1988Q1 (NCREIF 2012). The TFSAI is further disaggregated into the commingled fund index (CFI) and the separate account index (SAI). In this study, the TFSAI, the CFI, and the SAI, all net of fees, are used to represent real business returns of private-equity timberland investments.

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[2]Also known as cash return or EBITDDA, earnings before income tax, depreciation, depletion, and amortization.
[3] Data for the Northeast and Lake States start from 1994Q1 and 2006Q4, respectively.
[4] Quarterly NCREIF data may have artificial variations due to unevenly distributed appraisals. We used unsmoothed quarterly NCREIF data because 1) APT analysis requires a relatively large sample size; 2) research has shown that appraisal-based return data can have either enlarged or reduced variance (Cheng et al. 2011).

Public-equity timberland investment returns (PUBLIC) are approximated by value-weighted returns on a dynamic portfolio of publicly-traded timber firms in the United States that had or have been managing timberlands. These firms include DelticTimber, IP Timberlands Ltd., Plum Creek, Pope Resources, Potlatch, Rayonier, The Timber Co., and Weyerhaeuser. Deltic Timber and Pope Resources are natural resources companies focusing on the ownership and management of timberlands; The Timber Co. and IP Timberlands Ltd. are subsidiaries of Georgia-Pacific and International Paper that were separately listed and tracked the values and financial performances of their timberland assets; Plum Creek, Potlatch, Rayonier, and Weyerhaeuser are publicly-traded REITs that invest in timberlands. The value-weighted return of the portfolio is the weighted average of returns of all firms in the portfolio, where the weight of each firm is determined by the ratio between the value of the firm and total value of all firms in the portfolio. Values of these firms are defined by their market capitalizations calculated as the closing stock prices multiplied by the total shares outstanding. These data are obtained from the Center for Research in Security Prices (CRSP).

For the CAPM analyses, market returns and risk-free rates are needed. Market returns (MARKET) are approximated by value-weighted returns on all NYSE, AMEX, and NASDAQ stocks. Risk-free rates (RF) are approximated by returns on one-month Treasury Bills.[5] Data for both proxies come from the CRSP. For the APT analyses, 14 return indices are selected. John Hancock Timber Indices, i.e., US domestic timberland return index (JHTI-US), non-US timberland return index (JHTI-NUS), and global timberland return index (JHTI-G), complied by the Hancock Timber Resource Group represent individual TIMO returns at different regional scales (Hancock Timber Resource Group 2010).[6] Returns of the lumber and wood products industry (WOOD), furniture and fixtures industry (FURNI), and paper and allied products (PAPER) come from French (2012) and represent the overall performance of the forest

[5] Robust results are obtained using the 3-month Treasury bill rate to proxy the risk-free rate. Cascio and Clutter (2008) provided detailed discussions on choices of risk-free rate proxies in the CAPM.
[6] Hancock Timber Resource Group is one of the largest TIMOs in the world. As of 2011, assets under management totaled $9.1 billion. These assets are located in the United States, Canada, Australia, New Zealand, and Brazil.

products industry. Stumpage prices for southern pines in the South (SSP), average values of timber sold on national forests in the Pacific Northwest (PNWSP), and Random Lengths Framing Lumber Composite Prices (LUMBER) represent market conditions for various forest products and are extracted from Timber Mart-South (Norris Foundation 1977-2012), Kling (2008), and Random Length (2012), respectively. Returns on a portfolio of Treasury Bonds (BOND) with maturity periods of 5-10 years represent interest and inflation risk, and come from the CRSP. Exchange rate risk (EXCH) is represented by the broad dollar index, a weighted average of the foreign exchange values of the US dollar against the currencies of a group of major US trading partners. It is included because the United States is a major player of international forest products trade (FAO 2010). These data are available from Federal Reserve Economic Data (FRED 2012). To incorporate the substitution effect of wood and non-wood products, prices for aluminum (ALUM) and steel (STEEL) are collected. Lastly, gold prices (GOLD) are included because both gold and timberland assets are regarded as effective hedges against inflation in the literature. Price data for the three metal products are from the CRB commodity yearbook (Commodity Research Bureau 2011).

To check the robustness of the APT results using the 14 return indices, six more market-wide indices are added to the factor deriving process. These indices include the market return, macroeconomic variables, financial factors and aggregate consumption rates. Market return is the key component to the CAPM. Macroeconomic variables such as risk-free rates and term spreads have some relationship with different risky assets. The term spreads (TERM) are differences in yields between the 10-year Treasury Bond and the 3-month Treasury Bill. These data are obtained from the H.15 database of the Federal Reserve Board (FRB 2012). Financial factors such as size (SMB) and book-to-market (HML) are found important to predict cross-sectional variation of asset returns (Fama and French 1992) and are from French (2012). Lastly, aggregate consumption rates (CONS) are also found to be related to assets' expected returns (Breeden 1979) and are approximated by the quarterly real personal consumption expenditures from the Federal Reserve St. Louise website (FRED 2012). All level indices are converted to returns by taking differences after the logarithm transformations. To balance the sample, all return series are quarterly spanning from 1988Q1 to 2011Q4. In summary, there are seven proxies for timberland investment returns, 14 return series related to timberland assets,[7] and six market-wide indices for robustness check of common factors. The statistical descriptions for the 27 return series are presented in Table 2.1.

Empirical Results

Results for the CAPM

Table 2.2 presents the results from the ordinary least squares estimation of the CAPM. Significant positive α estimates indicate that the private-equity timberland investmentshave superior risk-adjusted returns. The abnormal returns for the NTI-US, NTI-S, NTI-PNW,TFSAI, CFI and SAI are 2.079%, 1.402%, 3.069%, 1.615%, 1.081%, and 1.840% per quarter, respectively. Market β estimates for the above six indices are not significantly different from 0. However, the corresponding R^2 values are very low, meaning that the private-equity timberland investment returns are poorly explained by the CAPM. In contrast, the public-equity timberland investment earns an insignificant abnormal return. However, similar risks as the market and a much higher R^2 value are obtained. Therefore, the CAPM is capable of pricing public- but not private-equity timberland investment. These results are generally consistent with previous findings.

Results for the APT

Because the assumption of joint normality is usually violated with financial time series (Tsay 2005), the principal component method is used to identify the common factors. With respect to what variables to be included in deriving factors and extracting factor scores, there is no consensus in the APT literature. A key concern is whether the assets being priced should be used in this phase (Arthur et al. 1988, Collins 1988, Sun and Zhang 2001). For comparison purposes, factor analysis is conducted with

[7] JHTI indices are not target assets to be evaluated in this study.

and without timberland returns.[8] The number of common factors is first identified. Then, factor loadings are estimated and factor scores are calculated. Next, sensitivity coefficients and risk premiums are estimated. Finally, expected returns are calculated for private- and public-equity timberland investments.

Table 2.3 presents the eigenvalues along with some diagnostic statistics for the covariance matrix of return data with and without timberland assets. As indicated by the last column, about 90% of the total variation is explained by the first five factors in both cases and marginal contributions of additional factors become trivial thereafter. Hence, a total number of five common factors are identified. Factor loadings corresponding to the five factors are reported in Table 2.4. For analyses with timberland assets, factor 1 is highly loaded on private-equity timberland returns and thus should be viewed as a TIMO factor. Likewise, factors 2-5 should be viewed as forest products industry, substitution effects and end product prices. Similarly, for analyses without timberland returns, factors 1-5 should be viewed as forest products industry, inflation, substitution effects and end product prices.

Sensitivity coefficients are estimated via Equation (2.8) with asset returns being the dependent variable and factor scores being the independent variables. Like the one in the CAPM, β coefficients in the APT provide information on the relationship between risks and returns (Table 2.5). For instance, including timberland assets in the factor analysis, the six proxies of private-equity timberland investment returns are highly positively related to the TIMO factor but almost all slightly negatively related to the other four factors. In contrast, the proxy of public-equity timberland investment returns is slightly negatively related to the TIMO factor but positively related to other factors, especially to the forest products industry factor. As indicated by the R^2 values, when timberland assets are included in factor analysis, the portion of their total variations being explained increases dramatically. This is within our expectation because unobservable common factors are linear combinations of the observable variables. Including assets to be evaluated in the factor analysis is equivalent to using information of the response variables as the partial least squares approach does. The results from the three approaches are further

[8] JHTI indices are used in deriving common factors in both cases.

compared in subsequent analyses.

Risk premiums associated with the sensitivity coefficients are estimated with cross-sectional regressions via Equation (2.9). In total, 96 (4 $\times$24) regressions, each with 21 cross-section units, are estimated. For example, including private- and public-equity timberland assets in the factor analysis, the following average risk premiums are estimated: $\lambda_0 = 1.1548$, λ_1=0.5162, λ_2=0.1203, $\lambda_3 = -0.0005$, $\lambda_4 = 0.0752$, and $\lambda_5 = 0.1003$. Therefore, expected returns of timberland investments can be calculated by $E[R_i] = 1.1548+0.5162\hat{\beta}_{i1} + 0.1203\hat{\beta}_{i2} - 0.0005\hat{\beta}_{i3} + 0.0752\hat{\beta}_{i4} + 0.1003\hat{\beta}_{i5}$, for i = NTI-US, NTI-S,NTI-PNW, TFSAI, CFI, SAI, and PUBLIC.

Comparisons

To compare the three common factor deriving approaches as described above, the expected returns from different approaches are compared. Table 2.6 contains the results of pairwise comparisons of the three approaches. The absolute values of *t*-statistics range from 2.55-5.14 when comparing the expected returns using factor analysis with and without timberland assets. The results indicate that the expected returns generated by the two approaches are significantly different. In contrast, there are no significant differences if the expected returns are calculated using factor analysis with timberland assets and the partial least squares method, which are implied by large *P*-values. Moreover, four out of seven small *P*-values indicate that the expected returns are also different when factor analysis without timberland assets and partial least squares method are used. However, the differences are not as significant as the comparison results from factor analysis with and without timberland assets.

As mentioned above, the common factors used in the APT are selected in an intuitive manner, which brings some arguments. As a robust check, sensitivity of the expected returns to different common factors is examined. Besides the 14 return indices, six more market-wide return indices are added to derive new common factors. The sensitivity analysis is conducted by comparing the expected returns using original and new common factors from factor analysis. Results in Table 2.7 show that if timberland assets are included in the factor analysis, *P*-values are greater than 20% for all assets when comparing the original and new expected returns. This indicates that the expected returns are not sensitive to different common factors. Without timberland assets included in the factor analysis, *P*-values are much lower than the previous tests, but still show insensitivity of the expected returns. Based on the results, expected returns from factor analysis with timberland assets included are more robust and therefore used in the following comparisons.

Altogether, the expected returns of timberland investments from different model specifications are compared in Table 2.8. Over 1988Q1-2011Q4, timberland assets have achieved returns of 2.08 - 4.06% per quarter. Using the CAPM, the 95% confidence intervals for the expected returns are between 0.95% and 2.56%. Compared with private-equity timberland assets, however, public-equity timberland assets require much higher returns. Using the APT, the expected returns for private-equity timberland assets grow significantly, ranging from 1.62% to 5.88% per quarter. Overall, with the APT, private-equity timberland assets have much higher expected returns than those with the CAPM.

Substantial changes in the timberland market happened during 2000-2011. Four publicly-traded forest products firms converted themselves from the C-Corporations to timber REITs and the major players of the TIMO industry have been reshuffled at the same time (Harris et al. 2010). Besides, two widely-recognized financial crises hit the overall economy in 2000-2001 and 2007-2009. Following the suggestions made by Johnson and Wichern (2007), we divide the whole sample period into two equal sub-periods of 1988Q1-1999Q4 and 2000Q1-2011Q4. Therefore, the two sub-periods provide a direct comparison with the previous study and incorporate the changes in the timberland market and the overall economic conditions. We then compare the financial performance of timberland investments in the two separate time periods. In each period, new common factors are derived and expected returns are calculated. By and large, the results reported in Table 2.9 show that there is a decreasing trend of expected returns by the APT for both private- and public-equity timberland investments in the last 24 years. The quarterly expected returns for private-equity timberland assets for the first 12 years are from1.78% to 8.47%, whereas for the second 12 years, the expected returns are lower between 0.98% and 1.87%. There is some evidence that private-equity timberland investments have met their expected returns over 2000-2011 but not over 1988-1999. Moreover, the NCREIF Timberland Indexhas higher actual and expected returns in general than the NCREIF Timberland Funds and Separate Accounts Index. For public-equity timberland investments, there is strong evidence of higher than expected returns over the whole sample period.

Conclusions and Discussions

Timberland investments in the United States have developed rapidly in the past three decades. With increasing attention from the investors, the financial performance of timberland assets needs to be evaluated. Most of past research has applied the CAPM on timber price data or the NCREIF Timberland Index to find that little variations of timberland investment returns can be explained. The major reason being claimed is that timberland assets have low correlations with the financial market. Given the fact that the CAPM is a single factor model and more data about timberland investments are now available, this study aims to extend the literature by using multi-factor asset pricing model, i.e., the APT, to a number of proxies of timberland investment returns. Our results show that 1) the APT method is able to explain more variations in timberland investment returns than the CAPM; 2) expected returns for timberland assets have been decreasing over time; 3) the NCREIF Timberland Index has higher expected returns in general than the NCREIF Timberland Funds and Separate Accounts Index; and 4) public-equity timberland assets have substantial higher actual returns than expected returns for the past 24 years, whereas private-equity timberland assets barely earn the expected returns.

Using the APT model, Sun and Zhang (2001) found that NCREIF timberland assets earned very high excess returns during 1987-1997. However, in our study, the expected returns are close to the actual returns in the same period. The different results may be attributed to the various return indices and different methods used to estimate common factors. Instead of evaluating forest-related assets, we mainly focus on the performance of timberland assets, and as many as 10 timberland indices are included in the factor analysis. Therefore, more information about timberland assets is provided, which yield more accurate estimates of the expected returns. Moreover, the maximum likelihood method requires data to be jointly normally distributed, which is always violated by the financial data (Sheikh and Qiao 2010). To avoid the potential problem, the principle component method is used instead. We extend Sun and Zhang's study by using longer period of data, from 1988 to 2011. Accordingly, more precise and stable estimates of common factors are guaranteed. In addition, different sample formation methods and sensitivity of expected return estimates are examined. Since there is no consensus about whether to include the assets being priced in the factor analysis, common factors derived with and without timberland assets are compared. Analyses results indicate that when timberland assets are included in the factor analysis, estimates of the expected returns are more robust. Lastly, the APT model is under controversy because of its intuitive manner of choosing factors. Thus, the stableness of the expected returns is examined. Results show that, if common factors are derived with timberland assets included in the factor analysis, the returns show no significant sensitivity to different common factors. This result again supports that including timberland assets in the factor analysisare robust.

It is well known that as one increases the number of explanatory variables, the overall fitness of a model will increase. Therefore, the decision on asset pricing models is often a compromise between simplicity and overall fitness. Although the APT can price timberland returns more precisely, one must realize that it is a much more complicated approach than the CAPM. Among others, there is no widely accepted criterion on what variables to be included in deriving the common factors. The overall decreasing trend of expected returns of timberland assets may imply improved market efficiency over time. According to the NCREIF, the standing committee has been requiring more rigorous audit and appraisal procedures in recent years and the timberland market tends to become more transparent and competitive. All these can lead to lower risks in investments and thus lower expected returns.

Lower expected returns of private-equity timberland investments at the fund level can result from the management fees. Nonetheless, these return indices are highly correlated with one another but not the financial market. Hence, the newly released fund level return data further confirm the role of private-equity timberland assets as a risk diversifier. It should be noted that various NCREIF timberland indices are mostly based on properties held by tax-exempt institutional investors in a fiduciary environment, and therefore should be benchmarked differentially by individual timberland funds that are allocated at smaller regional scales. Finally, significant excess returns of public-equity timberland assets may reveal investors' confidence in the restructuring activities of timberland business. At least, recent REIT conversions of major timber firms have all generated abnormal returnsin the short run (Mendell et al. 2008). Future research can further calibrate the empirical model of the APT approach and use it to price other real estate assets.

Table 2.1. Statistical descriptions of the 27 return series over 1988Q1-2011Q4

	Mean	Std. Dev.	Min.	Max.
NTI-US	3.06	4.12	-6.54	22.34
NTI-S	2.36	3.24	-5.23	15.09
NTI-PNW	4.06	7.20	-12.54	36.23
TFSAI	2.59	3.61	-4.48	20.03
CFI	2.08	3.59	-4.84	13.37
SAI	2.81	3.92	-4.15	23.33
PUBLIC	3.23	11.50	-37.87	25.40
JHTI-US	3.25	2.91	-1.80	10.84
JHTI-NUS	3.07	3.53	-4.28	11.05
JHTI-G	3.21	2.73	-1.73	10.07
WOOD	2.32	14.37	-46.60	39.70
FURNI	2.93	13.69	-42.51	63.18
PAPER	2.33	10.94	-34.70	32.69
SSP	0.59	6.21	-13.21	19.94
PNWSP	2.89	25.65	-51.61	87.09
LUMBER	-0.53	6.49	-17.86	15.36
BOND	1.90	2.96	-4.29	9.98
EXCH	-0.05	2.50	-6.02	5.76
ALUM	1.77	17.39	-65.64	66.67
STEEL	3.15	19.52	-46.02	94.01
GOLD	1.48	6.48	-10.56	21.64
MARKET	2.68	8.48	-22.09	21.65
RF	0.94	0.58	0.00	2.19
TERM	1.86	1.16	-0.45	3.70
SMB	0.77	5.43	-10.83	19.10
HML	0.51	7.47	-32.01	23.85
CONS	0.69	0.55	-1.30	1.72

Note: NTI-US, NTI-S and NTI-PNW stand for the NCREIF Timberland Index (NTI) at national, South and Pacific Northwest levels. The next three indices represent Timberland Fund and Separate Account Index, commingled fund index (CFI) and the separate account index (SAI). PUBLIC is the return for public-equity timberland investment. The next 14 indices are selected for deriving the APT analyses. JHTI-US, JHTI-NUS and JHTI-G represent John Hancock Timber Indices for US domestic timberland return, non-US timberland return, and global timberland return, respectively. WOOD, FURNI and PAPER stand for returns of the lumber and wood products industry, furniture and fixtures industry, and paper and allied products. SSP, PNWSP and LUMBER represent percentage changes of stumpage prices for southern pines in the South, average values of timber sold on national forests in the Pacific Northwest, and Random Lengths Framing Lumber Composite Prices. BOND is returns on a portfolio of Treasury Bonds with maturity periods of 5-10 years. EXCH is percentage change in the broad dollar index.ALUM, STEEL, and GOLD are percentage changes of aluminum, steel and gold prices. The last six indices are for sensitivity analysis, which represent the market return (MARKET), risk-free rate (RF), term spread (TERM), size (SMB) and value (HML) effects, and aggregate consumption (CONS).

Table 2.2. Estimation of the CAPM using seven proxies of timberland investment returns for 1988Q1-2011Q4

	α	β	R^2
NTI-US	2.079 (5.020)	0.021 (0.440)	0.002
NTI-S	1.402 (4.300)	0.012 (0.310)	0.001
NTI-PNW	3.069 (4.160)	0.031 (0.360)	0.001
TFSAI	1.615 (4.480)	0.019 (0.450)	0.002
CFI	1.081 (2.980)	0.036 (0.850)	0.008
SAI	1.840 (4.660)	0.018 (0.380)	0.002
PUBLIC	0.700 (0.779)	0.914 (8.870)	0.448

Note: Values in the parenthesis are *t*-stats.

Table 2.3. Eigenvalues of the covariance matrix and diagnostic statistics

Number of factors		Eigenvalue		Difference in eigenvalues		Proportion of variance explained		Cumulative proportion of variance explained	
A	B	A	B	A	B	A	B	A	B
1	1	690.88	676.12	91.58	122.22	0.304	0.335	0.304	0.335
2	2	599.29	553.91	202.44	199.83	0.264	0.274	0.567	0.609
3	3	396.85	354.07	200.21	157.74	0.175	0.175	0.742	0.784
4	4	196.64	196.33	89.62	135.94	0.087	0.097	0.828	0.881
5	5	107.02	60.39	44.54	11.77	0.047	0.030	0.876	0.911
6	6	62.48	48.61	6.43	10.84	0.028	0.024	0.903	0.935
7	7	56.05	37.77	17.09	5.54	0.025	0.019	0.928	0.954
8	8	38.97	32.24	4.52	6.61	0.017	0.016	0.945	0.970
9	9	34.44	25.63	8.06	6.03	0.015	0.013	0.960	0.982
10	10	26.38	19.60	7.94	12.57	0.012	0.010	0.972	0.992
11	11	18.44	7.03	3.65	1.77	0.008	0.004	0.980	0.995
12	12	14.78	5.26	2.43	1.28	0.007	0.003	0.986	0.998
13	13	12.36	3.98	5.44	3.98	0.005	0.002	0.992	1.000
14	14	6.92	0.00	2.30		0.003	0.000	0.995	1.000
15		4.62		1.22		0.002		0.997	
16		3.39		0.74		0.002		0.998	
17		2.66		1.24		0.001		0.999	
18		1.42		1.20		0.001		1.000	
19		0.22		0.20		0.000		1.000	
20		0.02		0.02		0.000		1.000	
21		0.00				0.000		1.000	

Note: A and B denote factor analyses with and without timberland assets, respectively.

Table 2.4. Rotated factor loadings through principle component analysis

	Factor1		Factor2		Factor3		Factor4		Factor5	
	A	B	A	B	A	B	A	B	A	B
NTI-US	97		-7		-5		-6		-6	
NTI-S	59		-12		1		-6		-6	
NTI-PNW	91		-1		-5		-1		-4	
TFSAI	92		-6		-10		-6		-9	
CFI	67		2		-10		0		1	
SAI	92		-7		-11		-8		-11	
PUBLIC	-1		90		3		2		4	
JHTI-US	71	-2	3	-35	-2	-1	5	1	2	0
JHTI-NUS	40	1	3	-5	11	10	6	13	12	4
JHTI-G	71	-1	4	-31	1	2	6	5	5	1
WOOD	3	87	92	-36	6	15	-3	4	1	-10
FURN	-2	93	89	-1	-6	2	9	10	9	8
PAPER	2	88	87	22	10	15	-10	-1	-2	-9
SSP	25	10	17	-35	16	19	14	12	9	8
PNWSP	0	-8	-9	-11	-6	-1	99	5	0	99
LUMBER	-22	15	21	-40	14	19	17	13	10	10
BOND	15	-29	-33	1	-32	-35	-1	-10	-7	2
EXCH	1	-23	-19	-47	-11	-9	7	-11	-12	2
ALUM	-2	8	17	6	97	97	3	23	15	-3
STEEL	-2	9	12	2	25	19	5	98	96	-2
GOLD	-1	-11	-17	70	19	12	-7	8	9	0

Note: All values in the table are multiplied by 100. A and B denote factor analyses with and without timberland assets, respectively.

Table 2.5. Estimated sensitivity coefficients

	β_1		β_2		β_3		β_4		β_5		R^2	
	A	B	A	B	A	B	A	B	A	B	A	B
NTI-US	3.989	-0.213	-0.268	-0.111	-0.186	-0.248	-0.235	-0.344	-0.246	-0.207	0.952	0.017
NTI-S	1.913	-0.350	-0.396	0.017	0.017	-0.038	-0.186	-0.245	-0.194	-0.157	0.371	0.020
NTI-PNW	6.584	0.016	-0.057	-0.227	-0.330	-0.389	-0.057	-0.450	-0.313	-0.030	0.840	0.008
TFSAI	3.329	-0.161	-0.224	-0.209	-0.372	-0.406	-0.229	-0.409	-0.312	-0.200	0.878	0.034
CFI	2.390	0.059	0.059	-0.422	-0.357	-0.353	0.006	-0.009	0.053	-0.021	0.453	0.024
SAI	3.612	-0.183	-0.277	-0.114	-0.412	-0.458	-0.325	-0.544	-0.432	-0.273	0.883	0.041
PUBLIC	-0.152	9.536	10.345	-0.686	0.383	1.315	0.190	0.725	0.480	-0.178	0.812	0.708
JHTI-US	2.060	-0.049	0.098	-1.017	-0.066	-0.021	0.141	0.042	0.052	0.012	0.505	0.123
JHTI-NUS	1.422	0.044	0.108	-0.179	0.383	0.355	0.205	0.448	0.433	0.137	0.193	0.030
JHTI-G	1.932	-0.030	0.100	-0.849	0.024	0.054	0.154	0.123	0.128	0.037	0.506	0.099
WOOD	0.430	12.445	13.267	-5.204	0.816	2.214	-0.482	0.542	0.209	-1.441	0.858	0.917
FURN	-0.299	12.685	12.140	-0.188	-0.770	0.228	1.284	1.333	1.176	1.097	0.806	0.875
PAPER	0.218	9.601	9.474	2.421	1.042	1.656	-1.115	-0.083	-0.178	-1.021	0.771	0.851
SSP	1.575	0.595	1.065	-2.189	0.968	1.165	0.891	0.740	0.588	0.500	0.148	0.189
PNWSP	0.049	-1.941	-2.369	-2.744	-1.460	-0.248	25.494	1.358	0.084	25.388	0.999	1.000
LUMBER	-1.399	0.977	1.387	-2.584	0.914	1.216	1.087	0.863	0.633	0.645	0.150	0.244
BOND	0.457	-0.872	-0.987	0.039	-0.953	-1.026	-0.019	-0.298	-0.204	0.072	0.243	0.218
EXCH	0.020	-0.565	-0.462	-1.167	-0.278	-0.214	0.168	-0.285	-0.295	0.059	0.065	0.291
ALUM	-0.333	1.468	2.911	0.973	16.901	16.814	0.489	3.947	2.691	-0.573	0.997	0.997
STEEL	-0.388	1.674	2.285	0.453	4.902	3.693	0.926	19.077	18.720	-0.312	0.999	0.999
GOLD	-0.051	-0.741	-1.126	4.556	1.226	0.790	-0.473	0.522	0.575	0.024	0.079	0.529

Note: A and B denote factor analyses with and without timberland assets, respectively.

Table 2.6. Comparison of expected returns of timberland investments from the APT using different approaches to derive common factors, 1988Q1-2011Q4

	Mean Expected Return			*t*-test					
				A vs. B		A vs. C		B vs. C	
	A	B	C	*t*-stat	*P*-value	*t*-stat	*P*-value	*t*-stat	*P*-value
NTI_US	3.14	2.19	2.79	4.60	0.00	1.75	0.04	3.06	0.00
NTI_S	2.06	2.19	2.23	-5.14	0.00	-0.63	0.26	0.13	0.45
NTI_PNW	4.51	2.20	3.59	4.65	0.00	2.13	0.02	2.99	0.00
TFSAI	2.80	2.19	2.57	4.66	0.00	1.14	0.13	2.02	0.02
CFI	2.40	2.20	2.43	4.81	0.00	-0.14	0.44	1.27	0.10
SAI	2.92	2.20	2.61	4.54	0.00	1.44	0.08	2.14	0.02
PUBLIC	2.38	2.64	2.69	-2.55	0.01	-0.16	0.44	0.97	0.17

Note: Returns are averaged over 1988Q1-2011Q4 and stated as percentage per year. A and B denote factor analyses with and without timberland assets, respectively. C denotes partial least squares.

Table 2.7. Sensitivity analysis of common factors derived from factor analyses with and without timberland investments, 1988Q1 – 2011Q4

	Mean Expected Return				*t*-test			
	A		B		A		B	
	Original	New	Original	New	*t*-stat	*P*-value	*t*-stat	*P*-value
NTI_US	3.14	3.16	2.19	2.09	-0.29	0.38	1.54	0.06
NTI_S	2.06	2.09	2.19	2.08	-0.55	0.29	1.78	0.04
NTI_PNW	4.51	4.52	2.20	2.10	-0.09	0.46	1.43	0.08
TFSAI	2.80	2.81	2.19	2.08	-0.30	0.38	1.55	0.06
CFI	2.40	2.41	2.19	2.09	-0.21	0.42	1.48	0.07
SAI	2.92	2.93	2.19	2.09	-0.28	0.39	1.59	0.06
PUBLIC	2.38	2.42	2.64	2.93	0.40	0.35	-3.19	0.00

Note*:* Returns are averaged over each sample period and stated as percentage per year. A and B denote factor analyses with and without timberland assets, respectively.

Table 2.8. Comparison of expected returns of timberland investments from different model specifications, 1988Q1-2011Q4

	Actual return	Expected return					
		CAPM			APT		
		Mean	Lower 95%	Upper 95%	Mean	Lower 95%	Upper 95%
NTI-US	3.06	0.98	0.96	0.99	3.14	2.32	3.96
NTI-S	2.36	0.96	0.95	0.97	2.06	1.62	2.50
NTI-PNW	4.06	0.99	0.96	1.02	4.51	3.15	5.88
TFSAI	2.59	0.97	0.96	0.99	2.80	2.11	3.49
CFI	2.08	1.00	0.99	1.02	2.40	1.89	2.91
SAI	2.81	0.97	0.96	0.99	2.92	2.17	3.67
PUBLIC	3.23	2.53	2.48	2.56	2.38	0.27	4.50

Note: Lower 95% and Upper 95% indicate the lower and upper 95% confidence intervals for the expected returns.

Table 2.9. Comparison of expected returns of timberland investments by the APT over time

	Actual return		Expected returns					
			88-99			00-11		
	88-99	00-11	Mean	Lower 95%	Upper 95%	Mean	Lower 95%	Upper 95%
NTI-US	4.56	1.55	4.28	3.36	5.20	1.39	1.02	1.76
NTI-S	3.34	1.39	2.15	1.78	2.52	1.37	1.00	1.74
NTI-PNW	6.08	2.05	6.76	5.06	8.47	1.44	1.01	1.87
TFSAI	3.77	1.41	3.98	3.18	4.78	1.34	0.98	1.70
CFI	2.97	1.20	3.04	2.53	3.54	1.37	1.01	1.73
SAI	4.07	1.55	4.32	3.39	5.25	1.33	0.97	1.69
PUBLIC	4.07	2.16	3.12	1.31	4.94	1.52	-1.02	4.06

Note: Lower 95% and Upper 95% indicate the lower and upper 95% confidence intervals for the expected returns.

CHAPTER 3

ASSESSING FORESTRY-RELATED ASSETS WITH THE INTERTEMPORAL CAPITAL ASSET PRICING MODEL[9]

[9] Yao, W. J., B. Mei. 2015. *Forest Policy and Economics*. 50: 192-199.
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Abstract

The intertemporal capital asset pricing model (ICAPM) is used to assess the risk-return relationship between forestry-related assets and innovations in state variables using quarterly returns from 1988Q1-2011Q4. Results show that the ICAPM that includes the market excess returns and innovations in the SMB and HML factors, interest rate, term spread, default spread and aggregate consumption as risk factors explainsabout 80% of the variation in cross-sectional returns of 16 forestry-related assets. Moreover, beta loadings on innovations in HML, interest rate and term spread induce significant risk premiums, and should be priced to determine the cross-sectional expected returns of the forestry-related assets. In general, average excess returns of the forestry-related assets decrease from period of 1988Q1-1999Q4 to period of 2000Q1-2011Q4. Significant positive excess returns are obtained in the first sub-period for private- and public-equity timberland assets but not in the second sub-period. Insignificant excess returns are obtained for forest products and timber products in the whole sample period. The results are robust to different specification tests.

Introduction

The risk-return tradeoff of forestry related assets is an important issue faced by investors who seek alternative investment opportunity. With independent biological growth from the financial market conditions, forestry-related assets distinguish themselves from financial assets or other real estate assets (Caulfield 1998). Forestry-related assets are found to be weakly correlated with the financial markets and have low systematic risk (Lonnstedt and Svensson 2000, Zinkhan and Cubbage 2003, Healey et al. 2005, Newell and Eves 2009, Waggle and Johnson 2009). In addition, Washburn and Binkley (1993), Martin (2010), and Wan et al. (2013) found that forestry-related assets have the ability to hedge against anticipated or unanticipated inflation risk. Most studies on the financial performance of forestry-related assets were based on the capital asset pricing model (CAPM) developed by Sharpe (1964) and Lintner (1965). The CAPM is a static single factor model which states that the expected return of an asset is proportional to its covariance with the market portfolio (Bollerslev et al. 1988). Besides, the CAPM assumes that investors have homogeneous expectation and ignores the time variation in expected returns (Merton 1973, Roll 1977, Campbell 1996). However, investors face stochastic investment opportunity set. This is particularly true for long-term investments such as forestry-related assets. To hedge against unfavorable shifts in the future investment opportunity set, investors adjust their investment decisions accordingly (Bali 2008). Therefore, besides the market risk, forestry-related assets bear the risks from innovations in factors which characterize the future investment opportunity set. With additional risks, investors should obtain additional returns.

Investment in forestry-related assets can be achieved by many means. Institutional investors or wealthy people who are seeking for risk diversification and stable long-term returns have direct ownerships of timberlands. General investors participate in forestry investments via buying stocks from publicly-traded timber firms and exchange-traded funds on forestry assets. Investing in the forest products industry, such as the paper, lumber, and furniture industries, are alternatives of getting involved in forestry-related assets.

The changing history of the forestry industry in the United States dates back to the 1980s, when traditional vertically integrated forest products companies with both large land holdings and processing facilities sold or restructured their timberlands because of the undervaluation of the growth on their financial statements (Binkley et al. 1996). Moreover, managed under the C-corporation structure, forestry assets are double taxed and the companies' debt levels have been increased by mergers and acquisitions. On the demand side, institutional investors such as pension funds, endowments and foundations who were seeking investment diversification became new owners of the timberlands. The value owned by institutional timberland investors grew from approximately $1 billion in 1989 to about $30 billion in 2010 (Harris et al. 2010). Large amounts of timberlands owned by institutional investors stimulated the emergence of timberland investment management organizations (TIMOs), which are responsible for achieving adequate returns for investors by purchasing, managing and selling timberlands on their behalf. Timberland investment through TIMOs requires large amounts of capital, and the length of the investment horizon is fixed to 10 to 15 years (Clutter et al. 2005). Therefore, it inhibits general public to partake and is regarded as private-equity timberland investment. Alternatively, investors who are interested in forestry investment can use publicly-traded timber firms. The major form of timberlands securitization transfers from the master limited partnerships (MLPs) in the 1980s to the timber real estate investment trusts (REITs) in recent years (Sun 2013). Since 1999, four publicly-traded forest products firms converted themselves from traditional C-corporations into REITs for tax efficiency purpose. Public-equity timberland investment provides lower entry barrier and is more liquid than private-equity timberland investment.

Literature Review

To improve the CAPM, Merton (1973) developed the multi-factor intertemporal capital asset pricing model (ICAPM). The model assumes that investors trade continuously and maximize their expected utility of lifetime consumption. It states that, besides the market risk, risk of unfavorable shifts in the investment opportunity set, as approximated by the changes of the so-called state variables, will induce additional risk premiums and should be compensated.

The ICAPM is important in the theoretical standpoint, however, identifying state variables is difficult (Breeden 1979). Theoretically, state variables should be factors that have predicting power of the future investment opportunity set. Empirically, state variables being identified can be categorized into: 1) macroeconomic variables; 2) financial factors; and 3) aggregate consumption rate. Significant macroeconomic state variables include the interest rate, term spread and default spread. Interest rate is observable and time-varying, representing the stochastic characteristic of the investment opportunity set (Merton 1973, Fama and French 1993, Campbell and Vuolteenaho 2004, Hui 2006, Abhyankar and Gonzalez 2009). Brennan et al. (2004) and Petkova (2006) found that innovation in interest rate was a significant factor in predicting the cross-sectional returns of 25 size and book-to-market sorted portfolios; Term spread, calculated as yield difference between long-term and short-term bond rates, is capable of tracking short-term fluctuations in the business cycle (Fama and French 1989). Default spread measures the yield difference between bonds with different credit qualities, reflecting the macroeconomic condition. Empirical research showed that the term spread and default spread had significant impacts on expected returns (Evans 1994, Petkova 2006, Bali 2008, Bali and Engle 2010). In the second category, the SMB and HML factors found by Fama and French (1993) represent the size and value effects of stocks and successfully describe the cross-sectional variation of average stock returns. Kothari and Shanken (1997), Bali (2008), and Bali and Engle (2010) found significant relationships between the SMB and HML factors and the expected returns on stocks. In the last category, the aggregate consumption rate covers a significant fraction of the true consumption and adds explanatory power to the expected returns. Previous studies showed that the aggregate consumption was important in determining investors' investment opportunity set (Breeden 1979, Bollerslev et al. 1988, Hui 2006).

Instead of using the aforementioned state variables directly for the empirical implementation of the ICAPM, Campbell (1996) suggested using innovations in such state variables to forecast the changes in the future investment opportunity set. To estimate innovations in state variables, Brennan et al. (2004) assumed the Ornstein-Uhlenbeck process whereas Petkova (2006) used the first-order vector autoregression model. Both studies observed significant risk premiums induced by innovations in the state variables. As an application of the ICAPM in the natural resources, Dorfman and Park (2011) applied the Bayesian approach and the bivariate GARCH-M model and found significant positive risk-return relation between the agricultural production and food manufacturing industries and the total U.S. stock market.

This study tends to investigate the intertemporal risk-return relationships of forestry-related assets under the multi-factor ICAPM framework. Innovations in the state variables are estimeated via the generalized autoregressive conditional heteroskedasticity model (GARCH) proposed by Bollerslev (1986). The remainder of the paper is organized as follows. In the next section, we describe the ICAPM framework and the method of estimating innovations in state variables. Section IV describes the data. The empirical results and robustness tests are reported in section V and the last section concludes the paper.

Methodologies

ICAPM Framework

In this study, the discrete-time version of the ICAPM is assumed to account for the cross-sectional of asset returns. According to the ICAPM, besides the market risk, risks of unfavorable shifts in the investment opportunity set should also be contained to compensate for expected returns. Therefore, an asset's expected return is a linear function of the market excess returns and innovations in state variables. The unconditional expected excess return can be written as

(3.1) $$E(R_i) - R_f = \beta_{i,M}\lambda_M + \sum_{k=1}^{K}\beta_{i,\varepsilon^k}\lambda_{\varepsilon^k}, \forall i, k = 1, 2, \cdots, K$$

where $E(R_i)$ is the expected return of asset i, R_f is the risk-free rate of return, λ_M is the market risk premium, and λ_{ε^K} is the price of risk for innovation in state variable k. Beta loadings can be estimated through the following time-series regression:

(3.2) $$R_{i,t} - R_{f,t} = \alpha_i + \beta_{i,M}(R_{M,t} - R_{f,t}) + \sum_{k=1}^{K}\beta_{i,\varepsilon^k}\varepsilon_t^k + u_{i,t}, \forall i$$

where $R_{i,t}$, $R_{f,t}$ and $R_{M,t}$ are returns of asset i, risk-free rate of return andreturn of the market portfolio, respectively, ε_t^k is the innovation in state variable k, $u_{i,t}$ is the error term, and subscript t indicates the time.

Innovations in State Variables

Innovations are unexpected shocks to state variables, which can be represented by the difference between actual and expected returns conditional on the past information

(3.3) $$\varepsilon_t^k = r_t^k - \mu_t^k = r_t^k - E(r_t^k | F_{t-1})$$

where r_t^k is the actual return of state variable k at time t, μ_t^k is the conditional mean of r_t^k given the information set F_{t-1} available at time $t-1$. To obtain the dynamics of innovations in the state variables, we assume ε_t^k follows a GARCH (1, 1) model, then

(3.4) $$\varepsilon_t^k = z_t \sqrt{h_t^k}$$

(3.5) $$h_t^k = \alpha_0 + \alpha_1 (\varepsilon_{t-1}^k)^2 + \beta_1 h_{t-1}^k$$

where $\{z_t\}$ is a sequence of independent and identically distributed random variables with mean 0 and variance 1, h_t^k is the conditional variance for the innovation ε_t^k given the information set F_{t-1}, and $\alpha_0 > 0$, $\alpha_1 \geq 0$, $\beta_1 \geq 0$ and $\alpha_1 + \beta_1 < 1$ are restrictions on the coefficients to be estimated. The maximum-likelihood method is applied to estimate the parameters in the GARCH (1, 1) model. In order to make innovations comparable among all state variables, standardized values $\tilde{\varepsilon}_t^k = \varepsilon_t^k / h_t^k$ are used for further analyses.

Cross-sectional Regression

According to equation (3.1), an asset's expected return depends on its exposure to the risk factors and the rewards of bearing such risks. To test the implication of the ICAPM as well as estimating the expected returns, the Fama-Macbeth cross-sectional regression procedure is used (Fama and Macbeth 1973). This method is widely applied to analyze assets' cross-sectional returns. In the first step, ordinary least squares (OLS) approach is used to estimate equation (3.2) for each asset. Assets' beta loadings with respect to the market excess returns and innovations in state variables are obtained. In the second step, the actual excess returns of all assets studied are related to their loadings on the risk factors. In other words, the prices of risk factors are estimated using the following cross-sectional regressions

(3.6) $$R_{i,t} - R_{f,t} = \lambda_{0,t} + \lambda_{M,t}\hat{\beta}_{i,M} + \sum_{k=1}^{K} \lambda_{\varepsilon^k,t}\hat{\beta}_{i,\varepsilon^k} + e_{i,t}, \forall i$$

for $i = 1, 2, \ldots, N$ and $t = 1, 2, \ldots, T$, where $\lambda_{0,t}$ is the intercept, $\hat{\beta}_{i,M}$ and $\hat{\beta}_{i,\varepsilon^k}$ are the beta loadings estimated in the first step, e_{it} is the error term, N is the total number of assets, and T is the sample length. There is one regression across the N assets for each time period and there are T such regressions in total. This way, a time series for each risk premium is constructed. Then, averages are taken over the whole sample time period as $\lambda_{\varepsilon^k} = \sum_{t=1}^{T} \lambda_{\varepsilon_t^k} / T$ for $k = 0, 1, 2, \ldots, K$.

As many studies have indicated, the two-step cross-sectional regression will cause the error-in-variable (EIV) problem. That is, as independent variables in equation (3.6), beta loadings generated from time-series regressions may contain sampling errors. To account for overstating the precision of risk premiums, a correction method provided by Shanken (1992) is applied. Based on the Shanken's correction, the EIV adjustment is yielded from combining the risk premium estimates with the sample covariance matrix of risk factors. The standard error of the risk premium estimates and the associated *t*-statistics are corrected by multiplying and dividing the square root of the EIV adjustment, respectively.

Monte Carlo Simulation

Petkova (2006) pointed out that the estimated innovations used in equation (3.2) may not be accurate estimates of true shocks to state variables. If this is true, the beta estimates from the time-series regression will be downward biased and the subsequent precision of risk premium estimates will be affected. As an indirect way of examining the appropriateness of the innovation proxies, the Monte Carlo simulation approach is conducted to test the unbiasedness of beta loadings. Initially, beta loadings are estimated from time-series regressions and are assumed to be given and correct. Next, 10,000 time-series samples of excess returns are simulated under the model

(3.7) $$R^*_{i,t} = \hat{\alpha}_i + \hat{\beta}_{i,M}(R_{M,t} - R_{f,t}) + \sum_{k=1}^{K} \hat{\beta}_{i,\varepsilon^k} \varepsilon_t^k + e^*_{i,t}, \forall i$$

where $e^*_{i,t}$ is thesimulated residual that is normally distributed with mean 0 and standard error $\hat{\sigma}_i$, $\hat{\sigma}_i$ being the standard error of the time-series regression. Given the 10,000 simulated samples of excess returns, new sets of beta loadings are estimated and the small sample distribution is generated. The unbiasedness of the beta estimates can be further tested using the *t*-test for each asset by comparing the means of the estimates with the given values.

Data

In this study, forestry-related assets include private- and public-equity timberland assets, forest products and timber products. Returns for private-equity timberland investments are provided by the

National Council of Real Estate Investment Fiduciaries (NCREIF) and Hancock Timber Resource Group. The NCREIF Timberland Index (NTI) is a quarterly reported data at the national and regional levels (i.e., the South, the Pacific Northwest, the Northeast, and the Lake States). It consists of income[10] return and capital appreciation. Income return comes from operating activities such as timber and land sales. Capital appreciation comes from biological growth and land value increase based on information from partial or complete sales and/or periodical appraisals. Data for the Northeast and the Lake States are excluded in this study because they start from 1994Q1 and 2006Q4, and the two regions combined represent a small proportion of the total value of all properties. Data for the national, the South and the Pacific Northwest, abbreviated as NTI_US, NTI_S and NTI_PNW, are included to approximate the gross returns of private-equity timberland investments. Besides, in May 2012, NCREIF released the Timberland Fund and Separate Account Index (TFSAI), which reflects returns of a portfolio of timber funds and accounts. This index accounts for the investment advisory fees and excludes the leverage effects. The TFSAI is further disaggregated into the commingled fund index (CFI) and the separate account index (SAI), and is available both gross and net of fees since 1988Q1. The TFSAI, the CFI, and the SAI, all net of fees, are used to represent the net returns of private-equity timberland investments. Moreover, Hancock Timber Resource Group (2010) reports the John Hancock Timber Indices (JHTI) at different regional scales at the individual TIMO level. The indices included are US domestic timberland return index (JHTI-US), non-US timberland return index (JHTI-NUS), and global timberland return index (JHTI-G).[11]

To proxy public-equity timberland assets returns, the value-weighted returns on a dynamic portfolio of publicly-traded timber firms in the United States that had or have been managing timberlands (PUBLIC) is employed. The portfolio includes Deltic Timber, IP Timberlands Ltd., Plum Creek, Pope Resources, Potlatch, Rayonier, The Timber Co., and Weyerhaeuser. Deltic Timber and Pope Resources

[10] It is also known as earnings before income tax, depreciation, depletion and amortization (EBITDDA).
[11] Timber Resource Group is one of the largest TIMOs in the world. As of 2011, assets under management totaled $9.1 billion. These assets are located in the United States, Canada, Australia, New Zealand, and Brazil.

are natural resources companies focused on the ownership and management of timberlands. The Timber Co. and IP Timberlands Ltd. were separately listed as subsidiaries of Georgia-Pacific and International Paper and tracked the values and financial performances of their timberland assets. Plum Creek, Potlatch, Rayonier, and Weyerhaeuser are publicly-traded REITs that invest in timberlands. The weight of each firm is determined by its market capitalization calculated as the closing stock price multiplied by the total shares outstanding. These data are obtained from the Center for Research in Security Prices (CRSP).

In addition, the overall performance of the forest products industry is represented by the returns of the lumber and wood products industry (WOOD), furniture and fixtures industry (FURNI), and paper and allied products (PAPER). Returns for each asset come from French (2012). Moreover, the market conditions for various timber products are captured by the stumpage prices for southern pines in the South (SSP), average values of timber sold on national forests in the Pacific Northwest (PNWSP), and Random Lengths Framing Lumber Composite Prices (LUMBER). These data are extracted from Timber Mart-South (Norris Foundation 1977-2012), Kling (2008), and Random Length (2012), respectively.

Market returns (MKT), as approximated by the value-weighted returns on all NYSE, AMEX, and NASDAQ stocks, come from the CRSP. State variables include the macroeconomic variables (interest rate, term spread and default spread), financial factors (size and value factors) and aggregate consumption rate. Interest rate (RF), as approximated by the one-month Treasury bill rate, is obtained from the CRSP.[12] Term spread (TERM) is the yield difference between the 10-year Treasury bond and the three-month Treasury bill. Default spread (DEF) is the yield difference between the AAA bond rate and BAA bond rate. These data are from the H.15 database of the Federal Reserve Board. The size and value factors are approximated by the Fama-French factors SMB (small minus big) and HML (high minus low). They are constructed using value-weighted portfolios formed by size and book-to-market ratio and come from French (2012). Lastly, the quarterly real personal consumption expenditures obtained from the Federal

[12] Different proxies for interest rate such as prime rate and federal fund rate are also considered. The results are robust using different proxies.

Reserve Economic Data of St. Louis are used to represent the aggregate consumption (CONS). All level indices are converted to returns by taking differences after the logarithm transformations. In summary, quarterly data ranging from 1988Q1 to 2011Q4 is used. There are 16 proxies for returns of forestry-related assets and six proxies for state variables.

Empirical Results

Innovations in State Variables

The innovations in state variable are estimated by the GARCH (1, 1) model. The residuals from the mean equation for each state variable are standardized by their dynamic volatility. Figure 3.1 represents the time-series of standardized shocks to each state variable. The standardized innovations in financial factors SMB and HML have the largest variations among all the state variables, ranging from -3 to +3. Average innovation in SMB factor is around zero across the whole sample period, while it is positive for the innovations in HML factor. Macroeconomic variables such as interest rate, term spread and default spread have relatively smaller variations, ranging from -0.5 to +1.8. In particular, the innovations in interest rate and default spread are always positive during 1988Q1-2011Q4. The innovations in aggregate consumption rate spread from -1 to +1.5. Negative shocks to this rate only happened around 1991 and 2009 when the two well-known financial crises occurred. Although the magnitudes of the innovations among the state variables differfrom each other, all the variables track the shocks during the recent financial crisis around 2007-2009.

Fama-Macbeth Cross-Sectional Regression

The risk-return relationship between forestry-related assets and the innovations in state variables is examined using the Fama-Macbeth cross-sectional regression approach. Initially, quarterly excess returns of 16 forestry-related assets from 1988Q1 to 2011Q4 are regressed on the market excess returns and the innovations in SMB, HML, interest rate, term spread, default spread and aggregate consumption rate. Beta loadings on the market portfolio and innovations in state variable are documented in Table 3.1. Results show that the assets' exposures to innovations in the state variables have wide dispersions and thus have various effects on expected returns. Positive beta loadings are obtained on the market portfolio for almost all the forestry-related assets. However, private-equity timberland assets have much smaller market betas than public-equity timberland assets, forest products, and timber products. For the selected state variables, excess returns of private-equity timberland assets correspond negatively to the innovations in SMB and HML, and positively to the innovations in interest rate, term spread, default spread and aggregate consumption. In contrast, the other forestry-related assets react inversely with respect to the innovations of the state variables. The average value of β_{HML} for public-equity timberland assets is 3.55 higher than that of private-equity timberland assets, and the differences of average values of β_{RF} and β_{TERM} between the public- and private-equity timberland assets are -5.53 and -3.55, respectively.

In the second step, risk premiums associated with each risk factor are estimated and the standard errors of the estimated risk premiums are corrected by the Shanken's adjustment. For comparisons, the widely used CAPM and Fama-French three-factor model are estimated using the same approach. Table 3.2 reports the estimated risk premiums for the three models, along with the *t*-statistics before and after Shanken's corrections. The R^2 shows that the multi-factor ICAPM explains about 80% of the variations in the cross-sectional returns of the 16 forestry-related assets. Compared with the ICAPM, only 37% and 5% of the variations are explained by the Fama-French three-factor model and the CAPM, respectively. The *F*-test suggests rejecting the Fama-French three factor model and the CAPM, but fails to reject the ICAPM. These results indicate that the ICAPM is more capable of explaining the cross sectional returns of the forestry-related assets than the Fama-French three-factor model and the CAPM.

The ICAPM successfully establishes significant relationships between forestry-related assets' cross-sectional returns and risk factors. Even corrected for the sampling error in the beta loadings by the Shanken's adjustment, significant risk premiums of 2.241, 0.728 and −1.324 are obtained for the risks from the innovations in HML, interest rate and term spread, respectively. In contrast, none of the risk factors considered in the Fama-French three-factor model and the CAPM generate significant risk premiums for the forestry-related assets. The market portfolio earns insignificant risk premiums for all three models, which confirms that the cross-sectional returns of the forestry-related assets are weakly related to the market.

Expected Returns

Combining the estimated risk premiums with the beta loadings obtained from the two-step cross-sectional regression, the expected return of each asset can be calculated using equation (3.1). In the first two columns of Table 3.3, the average quarterly actual and expected returns of the 16 forestry-related assets are reported. Excess returns stand for the differences between the actual and expected returns and the associated *t*-statistics represent their significance.

Average expected returns for private- and public-equity timberland assets, forest products and timber products are 1.833%, 1.624%, 1.662 and 0.126% per quarter during 1988Q1 to 2011Q4. The *t*-statistics indicate that private-equity timberland assets in general earn significant positive excess returns. Average excess returns of private-equity timberland assets range from 0.147% to 1.843% per quarter during the whole sample period. Nonetheless, the excess returns earned by public-equity timberland assets, forest products and timber products are not significantly different from zero during the studying period.

To examine the financial performance of forestry-related assets over time with respect to structural changes within the industry, we follow the suggestions of Johnson and Wichern (2007) and divide the whole sample period into two halves. The first half covers the data from 1988Q1 to 1999Q4, and the second half ranges from 2000Q1 to 2011Q4. For each sub-period, beta loadings and risk premiums associated with each risk factor are derived using the same approach. Expected returns for each sub-period are calculated and reported in Table 3.4. It is obvious that actual quarterly returns decrease from the first period to the second for all the forestry-related assets. The average expected returns for private-equity timberland assets and forest products decrease from 1.937% and 2.060% to 1.768% and 1.826% over time. Increases in average expected returns from the first period to the second period are obtained for public-equity timberland assets and timber products. On the other hand, excess returns of all the assets decreased dramatically over time. During 1988Q1 to 1999Q4, both private- and public-equity timberland assets earned significant positive excess returns, averaging 1.761% -3.381% per quarter. However, the significant excess returns disappeared during 2000Q1 to 2011Q4 for almost all the timberland assets. In both sub-periods, the forest products and timber products earn insignificant positive excess returns.

Robustness Tests

With 10,000 simulated samples, new sets of beta loadings are estimated for each sample and the average values are calculated across all samples. Student's *t*-tests are further conducted to compare the average beta loadings with the given values. Table 3.5 presents the small sample distribution of the beta loadings along with the test statistics from the Monte Carlo simulations. Since only innovations in HML, interest rate and term spread induce significant risk premiums to cross-sectional returns of the forestry-related assets, their beta loadings are reported. The average beta loadings are similar to those reported in Table 3.2. The standard errors of beta loadings across simulated samples are very small.[13] These results confirm the accuracy of the beta estimates. Furthermore, the small values of *t*-statistics indicate that the average values of the beta loadings from the Monte Carlo simulation are not significantly different from the given values. Therefore, the beta loadings are unbiased and the subsequent risk premiums estimated using the beta loadings as independent variables are credible.

Concerning the potential misleading inferences from characteristic data when testing asset pricing models (Lo and Mackinlay 1990), the ICAPM is tested on returns of the 49-industrial portfolios using the same approach (French 2012). Table 3.6 contains the estimated risk premiums for each risk factors and associated test statistics. The results show that the *F*-test rejects the CAPM, but fails to reject the Fama-French three-factor model and the ICAPM. The R^2 values are 0.012, 0.233 and 0.448 for each model,

[13]Although not reported here, small standard errors are also found for the market excess returns and innovations in SMB, default spread and aggregate consumption.

indicating that the ICAPM is capable of capturing almost half of the variations in the cross-sectional returns of the 49-industrial portfolios. Additionally, significant risk premiums are induced by risks from the innovations in HML and term spread. Given these results, the empirical implementation of the ICAPM, which incorporates market excess returns and innovations in SMB, HML, interest rate, term spread, default spread, and aggregate consumption as risk factors, is more capable of pricing different assets.

Conclusions and Discussions

Forestry-related assets have become new investment vehicles in the recent decades. In this study, a more complicated but more accurate ICAPM is used to study risk-return relationships between forestry-related assets and several risk factors. Results show that the ICAPM that incorporates innovations in several state variables succeeds to explain about 80% of the variations in cross-sectional returns of 16 forestry-related assets. The ICAPM cannot be rejected by the *F*-test, whereas the widely used Fama-French three-factor model and the CAPM should be rejected. In particular, innovations in HML, interest rate and term spread induce significantly risk premiums so these risk factors should be considered in determining the cross-sectional expected returns of forestry-related assets. Moreover, average excess returns of forestry-related assets decrease from the period of 1988Q1-1999Q4 to the period of 2000Q1-2011Q4. Significant positive excess returns are obtained for private- and public-equity timberland assets in the first sub-period but not in the second sub-period. Forest products and timber products earn insignificant excess returns in both sub-periods. These results are robust according to different tests.

Interest rate is stochastic and important for changing investment opportunity (Merton 1973). During recessions, interest rate is usually lowered to boost the economy. Therefore, negative shocks to interest rate tend to happen during bad economic times. Combined with β_{RF} from the ICAPM, negative shocks to interest rate decrease the expected returns of private-equity timberland assets but increase the expected returns of public-equity timberland assets, forest products and timber products. One possible explanation could be that private-equity timberland assets are seen as hedges against the interest rate risk.

Increased demand of such assets by risk-averse investors during economic downturns would drive up current prices and hence lower future average returns. In contrast, public-equity timberland asset, forest products and timber products do not appear to hedge against unanticipated changes in interest rate. This could be because demand for these assets decreases during recessions, which would in turn lower current prices and raise future average returns.

Many studies have found that term spread with other variables jointly predict long-term corporate bonds or stocks returns (Fama 1976, Startz 1982, Shiller et al. 1983, Campbell 1987, Fama 1990a, Chen 1991). Forestry-related assets, especially timberland assets are long-term investments. Significant term spread risk premiums indicate that long-term investors are rewarded for bearing the duration risk. Fama and French (1989) claimed that short-term fluctuations in business cycles can be tracked by the term spread. That is, positive shocks to term spread are associated with recessions and negative shocks are associated with expansions. Our results of the relationships between the average returns of forestry-related assets and shocks to term spread indicate that private- and public-equity timberland assets correspond differently to business conditions. Smaller magnitudes of β_{TERM} for private-equity timberland assets imply that the returns of such assets are less affected during business cycles than the other forestry-related assets. Finally, our results show that exposures to innovations in HML are significant determinants to the cross-sectional returns of forestry-related assets. These are consistent with previous findings where there existed significant relationships between the value effect and term spread, and book-to-market ratio and an asset's duration risk (Jaehoon and Lee 2006, Petkova 2006). Therefore, the value factor, along with the term spread, explains the duration risk for forestry-related assets under the ICAPM framework.

Table 3.1. Factor loadings on the market excess returns and innovations in state variables from time-series regressions

	β_{MKT}	β_{SMB}	β_{HML}	β_{RF}	β_{TERM}	β_{DEF}	β_{CONS}
NTI_US	0.060	-0.552	-0.066	3.622	0.975	2.160	0.087
NTI_S	0.062	-0.835	-0.111	2.079	0.608	0.825	-0.552
NTI_PNW	0.074	-0.353	0.177	5.704	0.747	4.320	0.741
TFSAI	0.050	-0.397	-0.153	3.055	0.579	2.417	0.048
CFI	0.056	-0.246	-0.069	1.965	-0.154	1.480	0.121
SAI	0.049	-0.408	-0.217	3.251	0.714	2.643	-0.026
JHTI_US	0.062	-0.297	0.113	3.669	1.261	1.627	0.896
JHTI_NUS	-0.008	0.163	0.041	-2.512	-0.237	-4.573	0.479
JHTI_G	0.048	-0.205	0.099	2.434	0.962	0.387	0.813
PUBLIC	0.872	2.949	3.534	-2.948	-2.944	-1.673	-0.738
WOOD	1.125	3.276	6.721	-0.862	1.277	6.394	1.781
FURN	1.199	3.602	5.352	-5.304	-3.489	-8.126	-4.489
PAPER	0.921	1.309	3.073	-3.766	-3.770	-4.470	-3.698
SSP	0.131	-0.945	0.895	0.933	4.878	-1.868	2.027
PNWSP	0.130	-2.616	3.361	-1.245	4.901	6.748	0.906
LUMBER	-0.001	0.525	0.315	-4.314	0.979	-7.645	0.200

Note: NTI-US, NTI-S and NTI-PNW stand for the NCREIF Timberland Index (NTI) at national, South and Pacific Northwest levels. The next three indices represent Timberland Fund and Separate Account Index (TFSAI), commingled fund index (CFI) and the separate account index (SAI). JHTI-US, JHTI-NUS and JHTI-G represent John Hancock Timber Indices for US domestic timberland return, non-US timberland return, and global timberland return, respectively. PUBLIC is the return for public-equity timberland investment. WOOD, FURNI and PAPER stand for returns of the lumber and wood products industry, furniture and fixtures industry, and paper and allied products. SSP, PNWSP and LUMBER represent percentage changes of stumpage prices for southern pines in the South, average values of timber sold on national forests in the Pacific Northwest, and Random Lengths Framing Lumber Composite Prices.

Table 3.2. Estimation results from coss-sectional regressions

	ICAPM			FF 3-Factor			CAPM		
	Estimate	FM *t*-stat	SH *t*-stat	Estimate	FM *t*-stat	SH *t*-stat	Estimate	FM *t*-stat	SH *t*-stat
$\lambda_{\varepsilon^{MKT}}$	-6.359	-2.219	-0.153	1.877	0.930	0.212	0.144	0.221	0.211
$\lambda_{\varepsilon^{SMB}}$	-1.197	-2.151	-1.751	-0.397	-0.915	-0.885			
$\lambda_{\varepsilon^{HML}}$	2.241	3.019	2.131	-0.104	-0.302	-0.302			
$\lambda_{\varepsilon^{RF}}$	0.728	3.086	3.017						
$\lambda_{\varepsilon^{TERM}}$	-1.324	-3.382	-2.965						
$\lambda_{\varepsilon^{DEF}}$	-0.338	-1.815	-1.810						
$\lambda_{\varepsilon^{CONS}}$	0.643	1.613	1.512						
F-stat		4.496			0.370			0.049	
p-value		0.026			0.776			0.828	
R^2		0.797			0.370			0.049	

Note: FM *t*-stat stands for *t*-statistics from the Fama-Macbeth regression directly. SH *t*-stat stands for *t*-statistics corrected by the Shanken's adjustment.

Table 3.3. Quarterly expected returns of 16 forestry related assets from 1988Q1 to 2011Q4

	Actual Return	Expected Return	Excess Return	*t*-stat
NTI_US	3.055	1.745	1.310	3.248
NTI_S	2.361	1.372	0.989	3.111
NTI_PNW	4.063	3.472	0.591	0.822
TFSAI	2.587	1.431	1.157	3.286
CFI	2.083	1.936	0.147	0.413
SAI	2.810	1.140	1.670	4.338
JHTI_US	3.252	2.187	1.065	3.923
JHTI_NUS	3.066	1.223	1.843	5.035
JHTI_G	3.214	1.995	1.219	4.709
PUBLIC	3.227	1.624	1.603	1.361
WOOD	2.324	1.598	0.725	0.494
FURN	2.933	1.607	1.325	0.945
PAPER	2.330	1.782	0.549	0.491
SSP	0.586	-0.600	1.186	1.869
PNWSP	2.895	1.686	1.208	0.461
LUMBER	-0.526	-0.708	0.182	0.273

Note: *t*-stat stands for the *t*-test statistics for excess returns. The null hypothesis under the test is that the excess return is zero.

Table 3.4. Quarterly expected returns of 16 forestry related assets in two sub-periods

	1988Q1-1999Q4				2000Q1-2011Q4			
	Actual Return	Expected Return	Excess Return	*t*-stat	Actual Return	Expected Return	Excess Return	*t*-stat
NTI_US	4.563	2.122	2.441	3.671	1.548	1.533	0.015	0.037
NTI_S	3.337	1.412	1.926	3.986	1.385	1.252	0.133	0.334
NTI_PNW	6.076	3.458	2.618	2.073	2.049	2.595	-0.546	-0.888
TFSAI	3.767	1.876	1.891	3.115	1.408	1.325	0.083	0.256
CFI	2.970	0.803	2.168	3.808	1.196	1.319	-0.123	-0.295
SAI	4.070	2.309	1.761	2.553	1.550	1.190	0.360	1.204
JHTI_US	4.796	2.095	2.700	7.071	1.708	2.343	-0.635	-2.079
JHTI_NUS	3.234	1.404	1.830	3.215	2.898	2.064	0.834	1.795
JHTI_G	4.483	1.956	2.527	6.733	1.946	2.289	-0.343	-1.109
PUBLIC	4.067	0.686	3.381	2.329	2.387	2.416	-0.029	-0.015
WOOD	4.018	2.664	1.353	0.751	0.630	0.537	0.092	0.040
FURN	3.043	0.952	2.091	1.364	2.823	3.112	-0.289	-0.122
PAPER	3.192	2.564	0.627	0.467	1.469	1.828	-0.359	-0.200
SSP	2.220	0.125	2.096	1.930	-1.049	0.895	-1.944	-3.155
PNWSP	1.764	-0.141	1.905	0.506	4.025	3.947	0.078	0.021
LUMBER	-0.043	1.045	-1.088	-1.173	-1.009	-1.078	0.069	0.071

Note: *t*-stat stands for the *t*-test statistics for excess returns. The null hypothesis under the test is that the excess return is zero.

Table 3.5. Mean and standard deviation of beta loadings from the monte carlo simulation

	HML			RF			TERM		
	Mean	Std	*t*-stat	Mean	Std	*t*-stat	Mean	Std	*t*-stat
NTI_US	-0.070	0.461	-0.008	3.594	1.475	-0.019	0.964	1.354	-0.008
NTI_S	-0.109	0.357	0.004	2.091	1.147	0.010	0.602	1.053	-0.006
NTI_PNW	0.161	0.832	-0.018	5.666	2.684	-0.014	0.706	2.424	-0.017
TFSAI	-0.151	0.403	0.005	3.057	1.282	0.001	0.556	1.192	-0.019
CFI	-0.070	0.415	-0.003	1.963	1.342	-0.002	-0.152	1.214	0.002
SAI	-0.213	0.442	0.009	3.235	1.410	-0.011	0.709	1.289	-0.003
JHTI_US	0.116	0.287	0.011	3.672	0.927	0.004	1.257	0.855	-0.005
JHTI_NUS	0.045	0.420	0.010	-2.508	1.354	0.003	-0.213	1.232	0.019
JHTI_G	0.101	0.282	0.007	2.434	0.921	0.000	0.966	0.843	0.004
PUBLIC	3.543	0.914	0.010	-2.938	2.889	0.004	-2.914	2.684	0.011
WOOD	6.718	1.031	-0.003	-0.884	3.332	-0.007	1.272	3.065	-0.001
FURN	5.346	0.813	-0.006	-5.311	2.613	-0.002	-3.524	2.400	-0.015
PAPER	3.068	0.892	-0.005	-3.774	2.837	-0.003	-3.786	2.620	-0.006
SSP	0.888	0.705	-0.010	0.925	2.275	-0.004	4.869	2.092	-0.004
PNWSP	3.378	3.080	0.005	-1.260	9.898	-0.002	4.943	9.052	0.005
LUMBER	0.320	0.760	0.007	-4.335	2.431	-0.008	0.973	2.240	-0.003

Note: Std stands for the standard deviation of the betas from the Monte Carlo simulation samples and *t*-stat stands for the *t*-test statistics for beta means. The null hypothesis under the test is that the mean beta value from the Monte Carlo simulation is the same as the given value.

Table 3.6. Estimation results from cross-sectional regressions for 49 industrial portfolios

	ICAPM			FF 3-Factor			CAPM		
	Estimate	FM *t*-stat	SH *t*-stat	Estimate	FM *t*-stat	SH *t*-stat	Estimate	FM *t*-stat	SH *t*-stat
$\lambda_{\varepsilon^{MKT}}$	0.936	2.250	0.645	0.948	2.382	0.697	0.260	0.733	0.580
$\lambda_{\varepsilon^{SMB}}$	-0.108	-1.681	-1.678	-0.199	-3.085	-3.067			
$\lambda_{\varepsilon^{HML}}$	-0.126	-2.430	-2.427	-0.018	-0.423	-0.423			
$\lambda_{\varepsilon^{RF}}$	0.007	0.171	0.171						
$\lambda_{\varepsilon^{TERM}}$	-0.141	-3.686	-3.682						
$\lambda_{\varepsilon^{DEF}}$	0.024	1.178	1.178						
$\lambda_{\varepsilon^{CONS}}$	-0.034	-0.633	-0.633						
F-stat		4.519			4.353			0.537	
p-value		0.001			0.009			0.467	
R^2		0.448			0.233			0.012	

Note: FM *t*-stat stands for *t*-statistics from the Fama-Macbeth regression directly. SH *t*-stat stands for *t*-statistics corrected by the Shanken's adjustment.

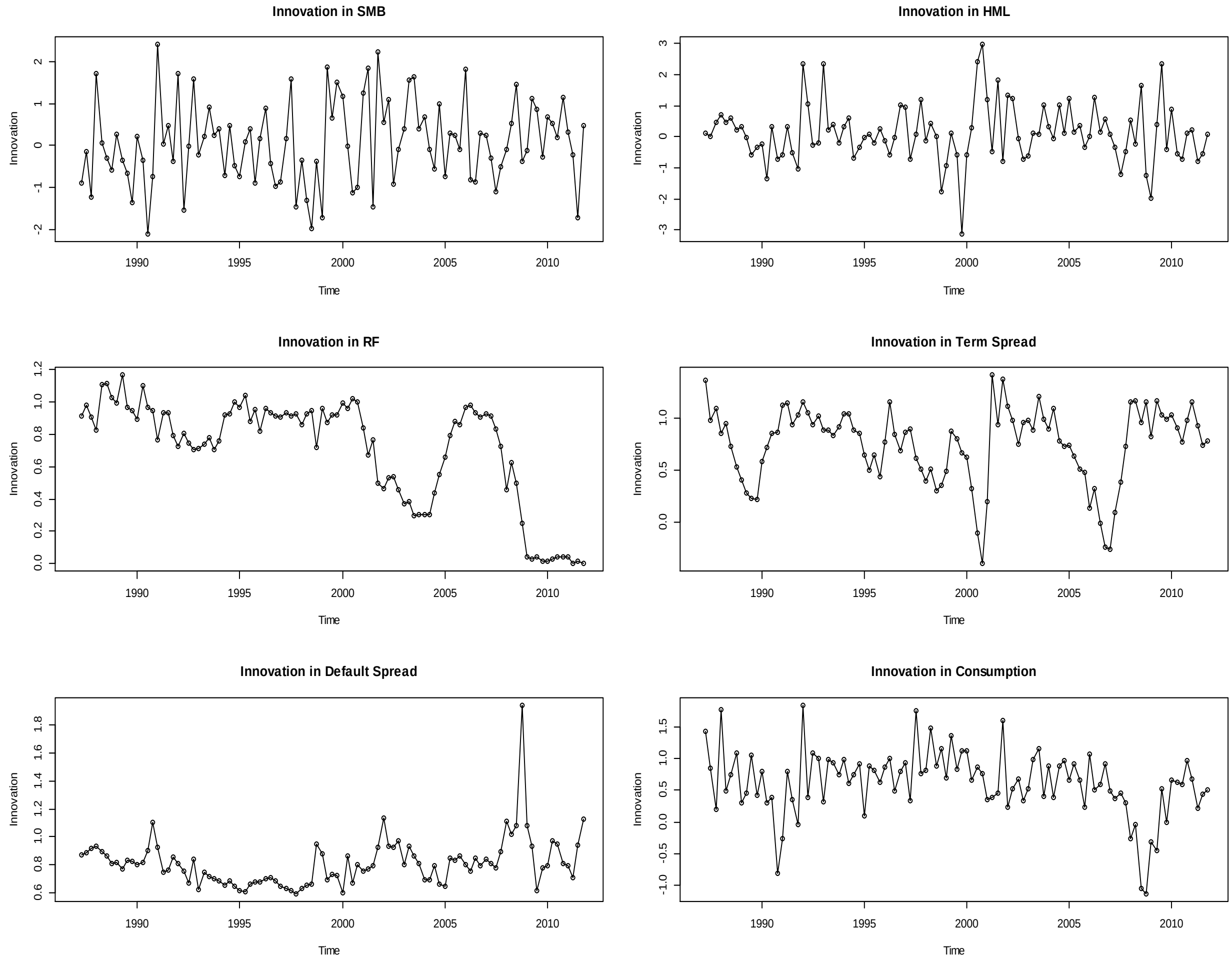

Figure 3.1. Innovations in state variables

CHAPTER 4

INVESTOR SENTIMENT AND TIMBERLAND INVESTMENT RETURNS[14]

[14] Yao, W. and B. Mei. Submitted to the *Forest Products Journal*, 04/01/15.

Abstract

We use the orthogonalized investor sentiment index formed by Baker and Wurgler (2006) to examine the relationship between investor sentiment and timberland investment returns. The empirical results show that current investor sentiment is an important factor that determines the one-quarter future returns of timberland investment and the predicting power persists over the next 1-5 years. Both the short- and long-term studies obtain negative coefficients on investor sentiment, indicating that current increase in investor sentiment drives prices up and lowers future returns. In addition, significantly different return variances and insignificantly different average returns of timberland investment are obtained between low- and high-sentiment periods. The result further confirms the ability of earning long-term stable returns by timberland investment.

Introduction

As an investment vehicle, timberland asset is a good candidate for portfolio diversification because of its weak correlation with the market and low systematic risk (Lonnstedt and Svensson 2000, Zinkhan and Cubbage 2003, Healey et al. 2005, Newell and Eves 2009, Waggle and Johnson 2009). In the United States, institutional investors such as pension funds, investment banks, endowments and foundations have diversified their investments from traditional financial assets to timberland assets for long-term stable returns since 1980s. In 2010, the total value of timberland properties held by institutional investors was approximately $30 billion (Harris et al. 2010).

Institutional investors seek professional management of timberland properties from timberland investment management organizations (TIMOs). TIMOs are responsible for searching proper timberland investment properties and manage them to achieve adequate returns. Timberlands are illiquid assets with the length of investment horizons typically being 10 to 15 years (Clutter et al. 2005). To provide financial information of timberland investment, the National Council of Real Estate Investment Fiduciaries (NCREIF) together with several TIMOs published the NCREIF Timberland Index (NTI) in 1992 (Binkley et al. 2003). Based on the quarterly and yearly NTI data dating back to 1987, the financial performance of timberland assets has been examined by several studies (Sun and Zhang 2001, Cascio and Clutter 2008, Liao et al. 2009, Mei and Clutter 2010, Rockemann and Schiereck 2010, Clements et al. 2011, Yao et al. 2014, Yao and Mei 2015). Most of these studies relied on traditional financial and time series models, which assume that only systematic risks affect asset returns. However, empirical results of significant abnormal returns indicate that those systematic risk factors have limited predicting power on timberland investment returns. Recent studies on behavioral finance argue that irrational investors in the market have important impact on stocks prices. Investor sentiment, which captures the irrationality in the naive and individual investors, has been found to be significantly related to stock returns (Brown and Cliff 2005, Baker and Wurgler 2006, Schmeling 2009).

This study contributes to literature by studying the relationship between investor sentiment and private-equity timberland investment returns. Our goal is to examine the predicting power of investor sentiment on the short- and long-term timberland investment returns by using an indirect sentiment index. The performance of timberland investment in low- and high-sentiment periods are studied and compared. The remainder of the paper is organized as follows. In the next section, the literature on the studies of investor sentiment is summarized. Sections III and IV describe the methodologies and the data. Empirical results are reported in Section V and the last section concludes the paper.

Literature Review

In the classical finance theory, competition among rational investors will lead to market equilibrium where assets prices are determined by the rationally discounted value of cash flows. The modern portfolio theory states that the expected returns of portfolios depend only on systematic risks. However, Baker and Wurgler (2006) presents an evidence that sentiment plays a significant role in determining the cross-sectional changes of stock returns. Sentiment generally indicates an individual's degree of optimism and pessimism about future environment. Investor sentiment, in particular, is the propensity to invest in the financial markets by the optimistic or pessimistic individual investors (Akhtar et al. 2012). Empirical studies have been conducted to explore the role of investor sentiment in the stock market. Some results show that investor sentiment is contemporaneously positively correlated with excess returns in the short term (Lee et al. 1991, Brown and Cliff 2004). In the long run, future returns of stocks are negatively correlated with sentiment (Brown and Cliff 2005). The noise traders model, from the theoretical work of Delong et al. (1990), indicates that changes in the sentiment of noise traders are related to asset pricing. Fisher and Statman (2000) find that changes in the sentiment of individual investors and newsletter writers are highly correlated but not perfectly. However, there is no correlation between changes in the sentiment and institutional investors.

The sentiment proxies can be divided into direct and indirect ones. Direct sentiment proxies of market include the survey conducted by the American Association of Individual Investors (AAII) and the Investor Intelligence (II) (Lee et al. 2002). On the other hand, there are several indirect sentiment proxies. The most widely used one is the closed-end fund discount (CEFD), which is the average difference between the net asset values of closed-end funds and their market prices. It is found to be inversely related to sentiment (Lee et al. 1991, Swaminathan 1996, Neal and Wheatley 1998). The NYSE share turnover is the ratio of reported share volume to the average number of shares listed from the NYSE Fact Book. The share volume, which represents liquidity and is regarded as a sentiment proxy, is found to be able to forecast market returns (Jones 2001, Baker and Stein 2004). Moreover, the first-day returns and number of initial public offerings (IPOs) are good indicators of sentiment because they are sensitive to the stock market (Brown and Cliff 2005, Baker and Wurgler 2006, Cornelli et al. 2006). Other indirect sentiment proxies include measures based on market performance such as the ratio of the number of advancing issues to that of declining issues; type of trading activity (e.g., the percent change in margin borrowing and the percent change in short interest); variables related to derivatives trading activities (e.g., the ratio of CBOE[15] equity put-to-call trading volume); and the dividend premium (Brown and Cliff 2004, Brown and Cliff 2005, Baker and Wurgler 2006). Baker and Wurgler (2006) claim that the current proxies for sentiment are not perfect and controversial. They approximate investor sentiment using the

[15] CBOE: Chicago Board of Exchange.

first principle component of a number of indirect sentiment proxies and find the approximated sentiment index has a significant impact on the cross-sectional changes of stock returns.

To examine the relationship between sentiment and returns, linear regression models are used by Akhtar et al. (2012), Brown and Cliff (2005) and Barberis et al. (2005). Brown and Cliff (2004) use the vector autoregressive (VAR) model to test how sentiment interacts with market returns and identify a causal relationship. Lee et al. (2002) employ the generalized autoregressive conditional heteroscedasticity-in-mean (GARCH-M) specification to test the impact of noise trader risk and find sentiment is a systematic risk factor that should be priced.

Methodology

Short-term return predictability

To investigate the short-term return predictability of investor sentiment on timberland assets, we apply the vector autoregressive (VAR) model. Through the VAR model, the short-term interactions between investor sentiment and timberland investment returns are examined. The model is estimated as follows

(4.1) $$R_t = \phi_0 + \Phi_1 R_{t-1} + \cdots + \Phi_p R_{t-p} + a_t$$

where R_t is a k -dimensional vector of asset return, sentiment index and returns of control variables. ϕ_0 is a k -dimensional vector, Φ_j is a $k \times k$ matrix, $\{a_t\}$ is a sequence of serially uncorrelated random vectors with mean zero and covariance matrix Σ. To determine the number of order p , the selection criterion such as the Akaike information criterion (AIC), Hannan–Quinn information criterion (HQ) and Schwarz information criterion (SC) are used. Under the null hypothesis, behavioral forces have no influence on asset valuations. That is, investor sentiment has no significant impact on asset returns. Under the alternative hypothesis, overreactions caused by current optimism would increase asset prices and thus lower the subsequent future returns. Accordingly, negative coefficients on sentiment are expected. Brown and Cliff (2005) claim that control variables which capture the rational predictability of asset returns should be included because investors' reactions to the market can be a combination of rational reflection of the market and irrational expectation of the future. Sentiment variables may contain information from risk factors that are used to predict assets' future performance. Thus, to examine the predictability of sentiment on asset returns, the irrational part of sentiment variables is tested by incorporating the systematic risks induced by several control variables. On the other hand, investor sentiment may be impacted by market performance. Therefore, the effect of timberland market on the sentiment is also tested by the VAR system.

Long-term return predictability

Intuitively, bullish market attracts more investment, and investors become more optimistic about the market. The impact of sentiment can be persistent. Therefore, investor sentiment may show some importance in predicting the long-term return. The relation between long-term timberland investment returns and investor sentiment is examined by the following regression.

(4.2)
$$(R_{i,t+1} + R_{i,t+2} + \cdots + R_{i,t+k}) / k = \alpha_i^k + \beta_i^k S_t + \sum_{q=1}^{p} \gamma_q^k Z_{q,t} + \varepsilon_i^k,$$

where $R_{i,t+1}, R_{i,t+2}, \cdots, R_{i,t+k}$ are the successive k -period future log returns of asset i; S_t and $Z_{q,t}$ are the sentiment index and control variables at time t; and α_i^k and ε_i^k are the intercept and error term of the regression. Parameters β_i^k and γ_q^k are the sensitivity coefficients on the sentiment index and control variables. Similarly, the null hypothesis indicates that β_i^k is not significantly different from 0; while the alternative hypothesis states that β_i^k is negative.

Nevertheless, the way of generating the multi-period future returns causes an econometric problem. Strong serial correlation in the residuals will be produced after running the OLS regression of overlapping dependent variables so the asymptotic assumptions of the OLS are violated. Although the coefficient estimates are unbiased with serial correlations, the estimated standard errors calculated by the OLS formula are incorrect. To fix the problem, the Newey-West serial correlation consistent standard errors are calculated (Newey and West 1987). For the case $Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i$, the variance for beta estimates is as follows

(4.3) $$Var(\hat{\beta}_1) = \sum_{t=1}^{T} \sum_{t'=1}^{T} \frac{x_t x_{t'}}{\left(\sum_{s=1}^{T} x_s^{\ 2} \right)} \cdot \sigma_{|t-t'|},$$

where $\sigma_{|t-t'|}$ is the variance-covariance matrix for errors. Estimating $\sigma_{|t-t'|}$ requires a big number of covariance estimates. Newey and West (1987) suggest estimating only the most important covariances instead of all of them. As $|t-t'|$ grows larger, the correlation gradually decreases, and $\sigma_{|t-t'|}$ approaches 0. Therefore, the first step in estimating the Newey-West standard errors is to choose a lag L. For all $|t-t'| > L$, we assume $\sigma_{|t-t'|} \approx 0$. If $|t-t'| \leq L$, $\sigma_{|t-t'|}$ is estimated with $e_t e_{t'}$, where e_t are the residuals from the OLS regression. Then, the Newey-West standard errors are estimated by

(4.4) $$s.e.(\hat{\beta}_1) = \sqrt{\sum_{t=1}^{T} \sum_{t'=t-L}^{t+L} \frac{x_t x_{t'}}{\left(\sum_{s=1}^{T} x_s^{\ 2} \right)} \cdot e_t e_{t'}}.$$

The corresponding Newey-West *t*-statistics is calculated as the ratio of the coefficient estimate and the Newey-West standard error.

Asset performance in low- and high-sentiment periods

Previous studies indicate that sentiment investors are reluctant to selling short, and these investors are found to be more active in the run-up market. There is also evidence showing that sentiment investors check their portfolios more frequently during high-sentiment periods than in low-sentiment periods (Karlsson 2005, Yuan 2008). Thus, stocks or portfolios may perform differently with respect to low- and high-sentiment periods. To study the financial performance of timberland investment in different sentiment periods, the average returns of timberland investment as well as the variances of returns are compared. However, the widely used student's *t*-test is not appropriate here because the sizes and variances of the two samples are usually different. To solve the problem, the Welch's *t*- test is adapted to the student's *t*-test (Welch 1947).

Data

The NCREIF Timberland Index

Provided by the NCREIF, the NTI tracks total returns from a large sample of geographically diverse timberland properties in the United States. As of 2014Q2, the NTI represents over 13 million acres with a market value of about $23 billion (NCREIF 2014). The NTI includes both income return,[16] which comes from operating activities such as timber sales, and capital appreciation, which is from the partial or complete property sales and /or appraisals if the property is not completely sold during the period.

The formulas used to calculate the index are

(4.5) $$\mathrm{IR}_t = \frac{\mathrm{EBITDDA}_t}{\mathrm{MV}_{t-1} + 0.5(\mathrm{CI}_t - \mathrm{PS}_t + \mathrm{PP}_t - \mathrm{EBITDDA}_t)}$$

(4.6) $$\mathrm{CR}_t = \frac{\mathrm{MV}_t - \mathrm{MV}_{t-1} - \mathrm{CI}_t + \mathrm{PS}_t - \mathrm{PP}_t}{\mathrm{MV}_{t-1} + 0.5(\mathrm{CI}_t - \mathrm{PS}_t + \mathrm{PP}_t - \mathrm{EBITDDA}_t)}$$

where IR_t and CR_t are the income return and capital return, respectively; CI_t equals the capitalized expenditures (e.g., forest regeneration); PS_t equals the net proceeds from land sales; PP_t equals the gross costs of new land acquisitions; MV_t equals the market value of the property (Binkley et al. 2003).

Due to the fee-based nature of the NTI, the gross returns measured by the NTI are before investment advisory fees. In addition, the NTI excludes the effects of leverage. To deal with these concerns, the NCREIF released the Timberland Fund and Separate Account Index (NTF) in 2012. The NTF reflects returns of a portfolio of timber funds and accounts and is available both gross and net of fees back to 1988Q1 (NCREIF 2012). In this study, the net of fees NTF is used to represent real business returns of timberland investments. For both the NTI and NTF, logarithm is taken for the return data.

[16]Also known as cash return or EBITDDA, earnings before income tax, depreciation, depletion, and amortization.

Investor sentiment

To proxy investor sentiment, the monthly orthogonalized investor sentiment index constructed by Baker and Wurgler (2006) is used and compounded into quarterly data. The composite index of sentiment is formed from the first principle component of six lead or lag underlying proxies for sentiment. The six sentiment measures include the closed-end fund discount (CEFD), the NYSE share turnover (TURN), the first-day returns of IPOs (RIPO), the number of IPOs (NIPO), the share of equity issues in total equity and debt issues (S) and the dividend premium (P^{D-ND}). By principle component analysis, the idiosyncratic noise and non-sentiment-related components are filtered out and common variation is captured. Moreover, to distinguish a common sentiment component and a common business cycle component, the business cycle variation from each sentiment proxies is removed prior to the principle component analysis[17].

Figure 4.1 plots the monthly orthogonalized investor sentiment index from 1988-2010. It is obvious that the index captures some fluctuations in sentiment. In the early 2000s, due to the internet bubble, investor sentiment exploded and reached the highest value. Around 2008-2009, because of the subprime mortgage crisis, people lost their confidence about the market. Therefore, their sentiment dropped from positive to negative.

Control variables

Following the suggestion of Brown and Cliff (2005), to control the information that the sentiment index may contain about the rational reflection of the market, risk factors that are used to predict the future performance are considered. These control variables are motivated by the previous asset pricing literature. Market return (MKT) is a risk factor used in the capital asset pricing model (CAPM) (Sharpe 1964, Lintner 1965). It is approximated by the value-weighted returns on all NYSE, AMEX, and NASDAQ stocks and comes from the CRSP. The size and value factors approximated by the Fama-French factors SMB (small minus big) and HML (high minus low) are considered as significant risk factors and included in the Fama-French three-factor model (Fama and French 1993). They are

[17] Refer to Baker and Wurgler (2006) for more details about the formation of the orthogonalized sentiment index.

constructed using value-weighted portfolios formed by size and book-to-market ratio and are obtained from French (2012). Other control variables include risk-free rate, term spread, and default spread. Risk-free rate is approximated by the one-month Treasury bill rate (Campbell 1991, Hodrick 1992), which is obtained from the CRSP. Term spread (TERM) is the yield difference between the 10-year Treasury bond and the three-month Treasury bill (Fama and French 1989). Default spread (DEF) is the yield difference between the AAA bond rate and BAA bond rate (Keim and Stambaugh 1986, Fama 1990b). These data are from the H.15 database of the Federal Reserve Board. In summary, quarterly data ranging from 1988 to 2010 are used. The descriptive statistics of the data and the correlation matrix of the sentiment index and control variables are reported in Tables 4.1 and 4.2, respectively.

Empirical Results

Results of short-term return predictability

Table 4.3 presents the result from the VAR model, which shows the interactions between the sentiment and timberland investment returns in the short-run. The numbers of lags are determined by the AIC, HQ and SC. AIC and HQ suggest $p = 8$, while SC suggests $p = 1$. For the parsimonious purpose, we stick to a smaller order model. Therefore, the lag of one is chosen. This table only lists the estimation results for the timberland investment returns and sentiment index. From the estimation results in Panel A, we find that the one-lagged investor sentiment index is an important factor that predicts the future returns of the NTI. The coefficient on the sentiment index is negative and significant at the 10% level. Although control variables such as the risk-free rate and term spread also show significance to the future timberland investment returns, they do not affect the significance of the sentiment index. This result confirms the trueness of our alternative hypothesis and suggests that overreactions caused by current optimism would increase the asset price and lower the subsequent one-quarter future returns. The R^2 indicates that by using the lagged variables, 21.5% of the total variation in the timberland investment returns are explained. Moreover, based on the F-test result, the VAR(1) system is a valid model for testing the predictability of sentiment. However, there is no evidence that timberland investment predicts the sentiment but the sentiment predicts itself. Similar results for the NTF are shown in Panel B, which confirms that the current sentiment significantly negatively predicts the future timberland investment returns in the short-run.

Results of long-term return predictability

To examine the long-term predictability of investor sentiment on timberland investment returns, the k -period future return is regressed on the sentiment index and control variables. The results of the long-term return predictability with horizons of 1, 2, 3 and 5 years are presented in Table 4.4. The k -period future return is calculated as the arithmetic average of the log returns. Panels A and B represent the coefficient estimates of the sentiment index and control variables. For all regressions, the dependent variables are the k -period future returns of the timberland assets. The sentiment index and all the control variables considered in the short-term return predictability section are included in the regressions as independent variables. Being reported in Table 4.2, the correlations among the sentiment index and control variables are relatively small. Therefore, multicollinearity is not a concern for the regression model that we fit.

As predicted by the alternative hypothesis, the results from Panel A show that the sensitivity coefficients of the sentiment index are universally negative for all horizons considered, ranging from –0.300 to -0.775. The significance levels are determined by the Newey-West *t*-statistics, which are calculated as the ratio between the coefficient estimates and the Newey-West standard errors with lags of 24. The test statistics show that the current investor sentiment significantly predicts future returns of the NTI over the next 1 to 5 years (5% level for the 1- and 5-year horizons and 1% level for the 2 and 3-year horizons)[18]. Besides the sentiment factor, the market return, value effect, risk-free rate, term spread and default spread are also significant factors that predict the future returns at a certain point of time.

[18] Note that the alternative test is a one-sided test; therefore, the critical values of the *t*-statistics for the 90%, 95% and 99% confidence intervals are 1.282, 1.645 and 2.326, respectively.

Panel B presents the long-run regression results of the NTF. Similar to the results of the NTI, negative coefficient estimates on the sentiment index are obtained. Comparing these results with those in Panel A, current investor sentiment only predicts the 2- to 5- year future returns of the NTF significantly with values of -0.569, -0.512 and -0.217. In addition, control variables such as the value effect, risk-free rate, term spread and default spread are significant in the long-term regression for the 2- to 5-year horizons.

The economic magnitude of the coefficients on sentiment is reported in Table 4.5. The magnitudes are taken by the coefficients on the sentiment index and control variables multiplied by the horizon and the standard deviation of each dependent variable. The standard deviations of sentiment and control variables are reported in the SD column. The values of magnitudes indicate the effect of one standard deviation change of the sentiment index on timberland investment returns. For example, with one standard deviation increase in the current investor sentiment, NTI will decrease by 1.305%, 3.195%, 4.242% per quarter in the first three years and decrease by 3.092% after 5 years. For both the NTI and the NTF, we obtain an increasing trend of the economic magnitudes in the first 3 years and the magnitudes decrease thereafter.

Asset performance in low- and high-sentiment periods

In order to study the performance of timberland assets in different sentiment periods, we compare the average returns of the NTI and NTF in low- and high-sentiment periods as well as their variances. In this study, sentiment is defined as low when the values of the sentiment index are below zero and high when the values are above zero. The average returns, variances, numbers of observations as well as the comparison results are reported in Table 4.6. Due to the different numbers of observations in two samples, the Welch's *t*-test is used to compare the sample means.

The results in Table 4.6 show that during the whole sample period from 1988 to 2010, there are 53 low-sentiment quarters and 39 high-sentiment quarters. Panel A presents the performance of the NTI in each sentiment periods. The variances in low- and high-sentiment periods are 22.252 and 10.749, which are significantly different based on the *F*-test. With higher variance, returns in low-sentiment periods are more volatile than in high-sentiment periods. The average returns are 3.507% and 2.714% during low- and high-sentiment periods, respectively. However, the Welch's *t*-test indicates that the average returns of the NTI in low- and high-sentiment periods are not significantly different. Similar results for the NTF are obtained, which are shown in Panel B. The result confirms the previous finding that timberland investment earns stable long-term returns.

Discussion and Conclusion

The debate about the effect of investor sentiment on asset pricing has been going on in the financial economics for a long time. In this study, we use the orthogonalized sentiment index formed by Baker and Wurgler (2006) to examine the effect of investor sentiment on private-equity timberland investment returns in the short and long runs. The results show that current sentiment is an important factor that determines the one-quarter future returns of both the NTI and the NTF after controlling for other market variables. Moreover, the significant impact of the current sentiment persists over the next 1-5 years. Comparisons of the variances and average returns between low- and high-sentiment periods indicate that different sentiment drives different variances but not average returns for both the NTI and the NTF.

The empirical evidence of this study shows that investor sentiment significantly predicts timberland investment returns in the short run. This may be because the mispricing by irrational behaviors is not eliminated by the arbitrage forces in a short time. The persistent negative impacts of the investor sentiment on the timberland investment returns indicate that current optimism about the stock market leads to an overvaluation of the timberland market over the next few years and vice versa. Accordingly, current high sentiment is an indicator of low cumulative long-run returns as the market price reverts to its intrinsic value. This implies that the irrationality in investors is capable of predicting the returns of timberland assets. Therefore, the importance of sentiment in the asset valuation model cannot be ignored.

Similar average timberland investment returns in low- and high-sentiment periods indicate that returns of timberland investment are relatively stable with respect to the investor sentiment. This is can be explained by the unique return drivers of timberland investment: biological growth, timber price change and land value appreciation. Among the three, biological growth contributes most to the total timberland returns and is independent of the financial condition (Mei et al. 2013). Therefore, this result further confirms that timberland investments are able to earn stable long-term returns and are good candidates of portfolio diversifiers.

Previous empirical studies showed that during economic downturns, investors check their portfolios or stocks less frequently than during economic booms. Hence, variances of returns are larger during high-sentiment periods than during low-sentiment periods. However, we obtain a contrasting result for timberland investment. One possible explanation is that when people are optimistic about the market, they tend to invest more in traditional financial markets. Whereas during economic recessions, timberland assets which has lower risk and more stable returns becomes more attractive to the investors.

It is worth mentioning that results from this study do not necessarily imply a profitable trading strategy. It is well known that the NTI and the NTF represent private-equity timberland investment returns by a large number of institutional investors and wealthy families in a fiduciary environment. As such, timberland transactions in the private market usually take months or even years to complete. Hence, the illiquidity of privately-placed timberland assets may prevent any investment timing arbitrage opportunities implied by the investor sentiment index.

Table 4.1. Descriptive statistics of the quarterly returns for timberland assets, sentiment index and control variables from 1988-2010.

	Mean	Median	Max.	Min.	SD
NTI	1.322	0.870	8.760	-2.940	1.695
NTF	1.131	0.705	7.930	-1.990	1.495
SENT	0.047	-0.055	2.260	-0.830	0.515
MKT	2.781	3.735	21.650	-22.090	8.376
SMB	0.843	0.205	19.100	-10.830	5.463
HML	0.603	0.270	23.850	-32.010	7.594
RF	0.980	1.120	2.190	0.000	0.559
TERM	1.816	1.855	3.700	-0.450	1.167
DEF	2.922	2.690	9.350	1.69	1.281

Notes: NTI and NTF stand for the NCREIF Timberland Index and Timberland Fund and Separate Account Index. Logarithm is taken for the return data. SENT is the quarterly othogonalized investor sentiment index formed by Baker and Wurgler (2006). MKT is the market return. SMB and HML are the size and value factors. The last three variables are the one-month Treasury bill rate, term spread and default spread, respectively.

Table 4.2. The correlation matrix ofthe quarterly orthogonalized sentiment index and control variables

	SENT	MKT	SMB	HML	RF	TERM	DEF
SENT	1.000	-0.265	0.047	0.191	0.129	-0.274	-0.254
MKT	-0.265	1.000	0.418	-0.100	0.063	0.025	0.065
SMB	0.047	0.418	1.000	0.068	-0.317	0.338	0.131
HML	0.191	-0.100	0.068	1.000	-0.135	0.153	0.085
RF	0.129	0.063	-0.317	-0.135	1.000	-0.684	-0.436
TERM	-0.274	0.025	0.338	0.153	-0.684	1.000	0.455
DEF	-0.254	0.065	0.131	0.085	-0.436	0.455	1.000

Notes: SENT is the quarterly othogonalized investor sentiment index formed by Baker and Wurgler (2006). MKT is the market return. SMB and HML are the size and value factors. The last three variables are the one-month Treasury bill rate, term spread and default spread, respectively.

Table 4.3. The short-term return predictability of investor sentiment to the NTI and the NTF with control variables from 1988-2010.

Panel A: Short-term Results for NTI			
Dependent Variable	Lag	Independent variables	
		NTI	SENT
NTI	1	0.012	0.005
SENT	1	-0.847*	0.913***
MKT	1	-0.004	0.005
SMB	1	0.033	-0.001
HML	1	0.011	0.000
RF	1	1.760***	-0.039
TS	1	0.407*	-0.061*
DEF	1	-0.071	0.015
Constant		-0.782	0.089
F-stat		2.807	55.040
p-value		0.008	0.000
R^2		0.215	0.843
Panel B: Short-term Results for NTF			
Dependent Variable	Lag	Independent variables	
		NTF	SENT
NTF	1	-0.207*	0.005
SENT	1	-0.583*	0.912***
MKT	1	-0.010	0.005
SMB	1	0.027	-0.001
HML	1	-0.010	0.000
RF	1	1.557***	-0.038
TS	1	0.406*	-0.061*
DEF	1	-0.116	0.015
Constant		-0.527	0.088
F-stat		2.704	55.030
p-value		0.011	0.000
R^2		0.209	0.843

Note: This table only presents the estimation results for the NTI, NTF and sentiment index. *, **, and *** represent significance at 10%, 5% and 1% level, respectively.

Table 4.4. The long-term return predictability of investor sentiment to the NTI and the NTF with control variables from 1988-2010.

Panel A: Long-term Regression Coefficients for the NTI				
	1-Year	2-Year	3-Year	5-Year
Intercept	-0.908	-0.832	-0.924	-1.505***
SENT	-0.633**	-0.775***	-0.686***	-0.300**
MARKET	0.019*	0.018**	-0.002	-0.011**
SMB	-0.022	-0.005	0.003	0.012
HML	0.013	0.029***	0.023**	0.011*
RF	1.411	1.036**	0.997**	0.948***
TERM	0.506	0.364**	0.356**	0.306***
DEF	-0.041	0.159	0.219	0.466***
F-stat	10.380	23.190	31.450	45.350
p-value	0.000	0.000	0.000	0.000
R^2	0.476	0.681	0.754	0.832
Panel B: Long-term Regression Coefficients for the NTF				
	1-Year	2-Year	3-Year	5-Year
Intercept	-0.625	-0.437	-0.493	-0.976
SENT	-0.372	-0.569***	-0.512***	-0.217**
MARKET	0.016	0.018**	0.000	-0.007
SMB	-0.017	-0.005	0.002	0.008
HML	0.006	0.024***	0.016**	0.008***
RF	1.150	0.778**	0.742**	0.727***
TERM	0.430	0.267**	0.285**	0.244***
DEF	-0.065	0.106	0.139	0.335***
F-stat	8.741	21.120	31.790	52.010
p-value	0.000	0.000	0.000	0.000
R^2	0.433	0.661	0.755	0.851

Notes: Significance levels are adjusted by the Newey-West standard errors. *, **, and *** represent significance at 10%, 5% and 1% level, respectively.

Table 4.5. Economic magnitude of sentiment in the long-term regressions.

Panel A. Economic Magnitude of Sentiment for the NTI					
	SD	1-Year	2-Year	3-Year	5-Year
SENT	0.515	-1.305	-3.195	-4.242	-3.092
MARKET	8.376	0.637	1.206	-0.201	-1.843
SMB	5.463	-0.481	-0.219	0.197	1.311
HML	7.594	0.395	1.762	2.096	1.671
RF	0.559	3.154	4.632	6.686	10.596
TERM	1.167	2.363	3.399	4.987	7.144
DEF	1.281	-0.210	1.630	3.367	11.942
Panel B. Economic Magnitude of Sentiment for the NTF					
	SD	1-Year	2-Year	3-Year	5-Year
SENT	0.515	-0.767	-2.346	-3.166	-2.237
MARKET	8.376	0.536	1.206	0.000	-1.173
SMB	5.463	-0.371	-0.219	0.131	0.874
HML	7.594	0.182	1.458	1.458	1.215
RF	0.559	2.571	3.478	4.976	8.126
TERM	1.167	2.008	2.493	3.992	5.696
DEF	1.281	-0.333	1.087	2.137	8.585

Table 4.6. The performance of the NTI and the NTF in low- and high-sentiment periods from 1988-2010.

	Variance	*F*-stat	*p*-value	Mean	Welch's *t*-stats	Welch's *p*-value	No. Obs.
Panel A: NTI Returns							
Low sentiment	22.252	2.071	0.021	3.507	-0.951	0.344	53
High sentiment	10.749			2.714			39
Panel B: NTF Returns							
Low sentiment	16.689	1.901	0.040	2.903	-0.651	0.517	53
High sentiment	8.779			2.424			39

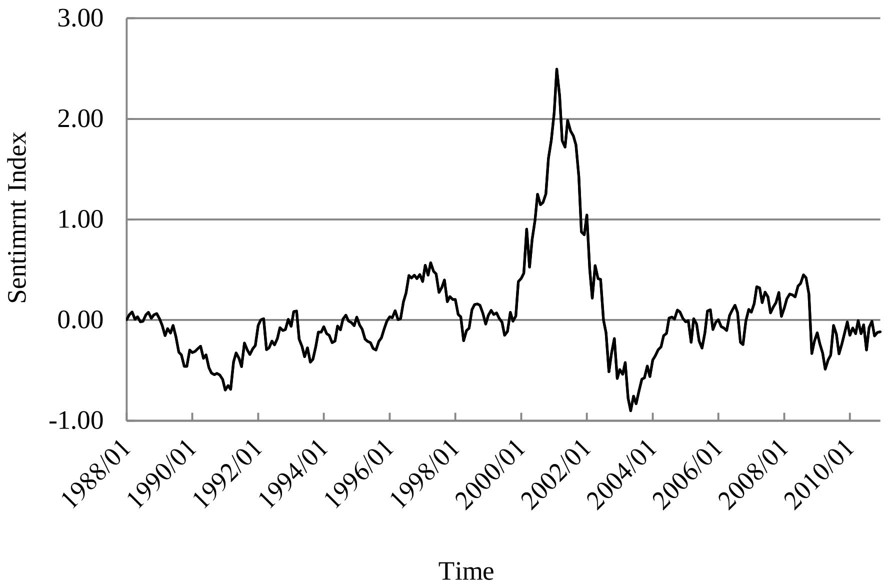

Fig. 4.1. Historical pattern of the monthly orthogonalized investor sentiment index from 1988-2010

CHAPTER 5

DISCUSSIONS AND CONCLUSIONS

In the past several decades, timberland investments in the United States have developed rapidly. Due to the low correlations with the financial market, little variations of timberland investment returns can be explained by past researches which applied the CAPM on timber price data or the NCREIF Timberland Index. Chapter 2 applies the multi-factor asset pricing model, i.e., the APT, to a number of proxies of timberland investment returns. We find that the APT method is able to explain more variations in timberland investment returns than the CAPM. Moreover, expected returns for timberland assets have been decreasing over time. Compared to the NCREIF Timberland Index, the NCREIF Timberland Funds and Separate Accounts Index has lower expected returns in general. Lastly, public-equity timberland assets have substantial higher actual returns than expected returns for the past 24 years, whereas private-equity timberland assets barely earn the expected returns.

In chapter 2, we mainly focus on the performance of timberland assets, and as many as 10 timberland indices are included in the factor analysis. As more information about timberland assets is provided, more accurate estimates of the expected returns are yielded. Moreover, different from many other studies using the maximum likelihood method to derive factors, the principle component method is used due to the non-normally distribution of the financial data. In addition, we examined different sample formation methods and sensitivity of expected return estimates. Since there is no consensus about whether to include the assets being priced in the factor analysis, common factors derived with and without timberland assets are compared. Analyses results indicate that when timberland assets are included in the factor analysis, estimates of the expected returns are more robust. Lastly, the APT model is under controversy because of its intuitive manner of choosing factors. Thus, the stableness of the expected returns is examined. Results show that, if common factors are derived with timberland assets included in the factor analysis, the returns show no significant sensitivity to different common factors. This result again supports that including timberland assets in the factor analysis is robust.

The management fees lowered expected returns of private-equity timberland investments at the fund level. Nonetheless, these return indices are highly correlated with one another but not the financial market. Hence, the newly released fund level return data further confirm the role of private-equity timberland assets as a risk diversifier. It should be noted that various NCREIF timberland indices are mostly based on properties held by tax-exempt institutional investors in a fiduciary environment, and therefore should be benchmarked differentially by individual timberland funds that are allocated at smaller regional scales. Finally, significant excess returns of public-equity timberland assets may reveal investors' confidence in the restructuring activities of timberland business. At least, recent REIT conversions of major timber firms have all generated abnormal returns in the short run (Mendell et al. 2008). Future research can further calibrate the empirical model of the APT approach and use it to price other real estate assets.

In Chapter 3, the risk-return relationships between forestry-related assets and several risk factors are studied using a more complicated but more accurate ICAPM. It is shown that the ICAPM that incorporates innovations in several state variables succeeds to explain about 80% of the variations in cross-sectional returns of 16 forestry-related assets. Compare the three commonly used asset pricing models, the ICAPM outperforms the Fama-French three-factor model and the CAPM. In particular, significantly risk premiums are induced from the innovations in HML, interest rate and term spread, which should be considered in determining the cross-sectional expected returns of forestry-related assets. Moreover, average excess returns of forestry-related assets decrease from the period of 1988Q1-1999Q4 to the period of 2000Q1-2011Q4. Significant positive excess returns are obtained for private- and public-equity timberland assets in the first sub-period but not in the second sub-period. Forest products and timber products earn insignificant excess returns in both sub-periods. According to different tests, these results are robust.

The stochastic interest rate is important for changing investment opportunity (Merton 1973). The results with β_{RF} from the ICAPM imply that private-equity timberland assets are capable of hedging against the interest rate risk. However, public-equity timberland asset, forest products and timber products do not appear to hedge against unanticipated changes in interest rate. Significant term spread risk premiums indicate that long-term investors are rewarded for bearing the duration risk. From our results, private- and public-equity timberland assets perform differently with respect to business conditions. Smaller magnitudes of β_{TERM} for private-equity timberland assets imply that the returns of such assets are less affected during business cycles than the other forestry-related assets. Finally, the exposures to innovations in HML are found to be significant to the cross-sectional returns of forestry-related assets. These are consistent with previous findings where there existed significant relationships between the value effect and term spread, and book-to-market ratio and an asset's duration risk (Jaehoon and Lee 2006, Petkova 2006). Therefore, the value factor, along with the term spread, explains the duration risk for forestry-related assets under the ICAPM framework.

Chapter 4 uses the orthogonalized sentiment index formed by Baker and Wurgler (2006) to examine the effect of investor sentiment on timberland investment returns in the short and long runs. The results show that the current sentiment significantly determines the short-term future returns of both the NTI and the NTF with and without the control variables. The significant impact persists over time. Significantly different return variances and insignificantly different average returns of timberland investment are obtained between low- and high-sentiment periods for both the NTI and the NTF.

The empirical evidence shows that in the short run, investor sentiment significantly predicts timberland investment returns. It is within our expectation because the mispricing by irrational behaviors may not be eliminated by the arbitrage forces in a short time. The persistent negative impacts indicate that current optimism about the stock market leads to an overvaluation of the timberland market over the next few years. Accordingly, current high sentiment is an indicator of low cumulative long-run returns as the market price reverts to its intrinsic value and vice versa. This implies that the irrationality in investors is capable of predicting the returns of timberland assets. Therefore, the importance of sentiment in the asset valuation model cannot be ignored.

Based on the similar average timberland investment returns in low- and high-sentiment periods, returns of timberland investment are relatively stable with respect to the difference in investor sentiment. This may be explained by the unique return drivers of timberland investment: biological growth, timber price change, and land value appreciation. Among the three, biological growth contributes most to the total timberland returns and is independent of the financial condition (Mei et al. 2013). Therefore, this result further confirms that timberland investments are able to earn stable long-term returns and are good candidates of portfolio diversifiers.

Previous empirical studies showed that during economic downturns, investors check their portfolios or stocks less frequently than during economic booms. Hence, variances of returns are larger during high-sentiment periods than during low-sentiment periods. However, we obtain a contrasting result for timberland investment. One possible explanation is that when people are optimistic about the market, they tend to invest more in traditional financial markets. Whereas during economic recessions, timberland assets which has lower risk and more stable returns becomes more attractive to the investors.

It is worth mentioning that results from this study do not necessarily imply a profitable trading strategy. It is well known that the NTI and the NTF represent private-equity timberland investment returns by a large number of institutional investors and wealthy families in a fiduciary environment. As such, timberland transactions in the private market usually take months or even years to complete. Hence, the illiquidity of privately placed timberland assets may prevent any investment timing arbitrage opportunities according to the investor sentiment index.

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