Can Timber Hedge against Inflation? An Analysis of Timber Prices in the US South

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Abstract

The US South is one of the world's leading timber producing regions. This article analyzes stumpage prices, the price a landowner receives for standing timber product, without the influence of growth or consideration of land price. Under the framework of Fisher's hypothesis and the real capital asset pricing model, we investigated stumpage prices' ability to hedge against inflation in 12 US southern timber regions using Timber Mart-South data. Prices for five major timber products, including pine sawtimber, hardwood sawtimber, pine pulpwood, hardwood pulpwood, and pine chip-n-saw, for each individual timber region and all regions combined were analyzed in a system by rolling regression and weighted least squares. Using instantaneous quarterly returns, no uniform conclusion could be drawn for either individual regions or the timber portfolio—the inflation hedging ability varied greatly by product and by time. Using 40-quarter average returns on the timber portfolio instead, it was found that pine pulpwood and chip-n-saw could hedge against both expected and unexpected inflation. Hence, stumpage prices alone should not be viewed as consistent or persistent hedges against inflation unless they are held for a long period.

Inflation is a measure of the overall increase in the level of commodity and service prices. Investors care about inflation because it diminishes their real returns and erodes the purchasing power of their money. Therefore, people seek assets that can provide effective inflation hedges. Physical assets are commonly believed to be effective inflation hedges. Gold, for example, is durable, transportable, universally acceptable, and verifiable, and it has long been viewed as an asset that can hedge against inflation. Since the collapse of the Bretton Woods system in 1971, gold has lost its central role in the monetary system. Although gold still serves as a store of value in many Asian countries, investors have been looking for alternative assets for inflation protection (Lausti 2004, Wang et al. 2011). For instance, Fama and Schwert (1977) found that private residential real estate completely hedged against both anticipated and unanticipated inflation. Bodie and Rosansky (1980) investigated 23 individual commodities and claimed that commodity futures were good inflation hedges.

Timber assets have gained more and more attention from the public in recent years, partly due to the passage of Employee Retirement Income Security Act in 1974, which required pension fund managers to diversify away from stocks and bonds. Concurrently, timberland ownership has changed substantially in the United States. Integrated forest products companies, like International Paper, have divested their timberland properties and concentrated on their core businesses, whereas institutional investors such as pension funds, mutual funds, university endowments and foundations, and families with high net wealth have been active timberland purchasers. In 2010, private-equity timberland assets managed by timberland investment management organizations totaled more than 20 million acres, or $35 billion (Norris Foundation 1977 to 2011). Additionally, there are several publicly traded timber real estate investment trusts or firms that focus on timberland businesses.

Timberland return has three drivers—biological growth,[1] timber price change, and land appreciation. The three return

[1] Biological growth has two key components: one is the physical growth in volume, and the other is the growth into larger (higher value) product classes.

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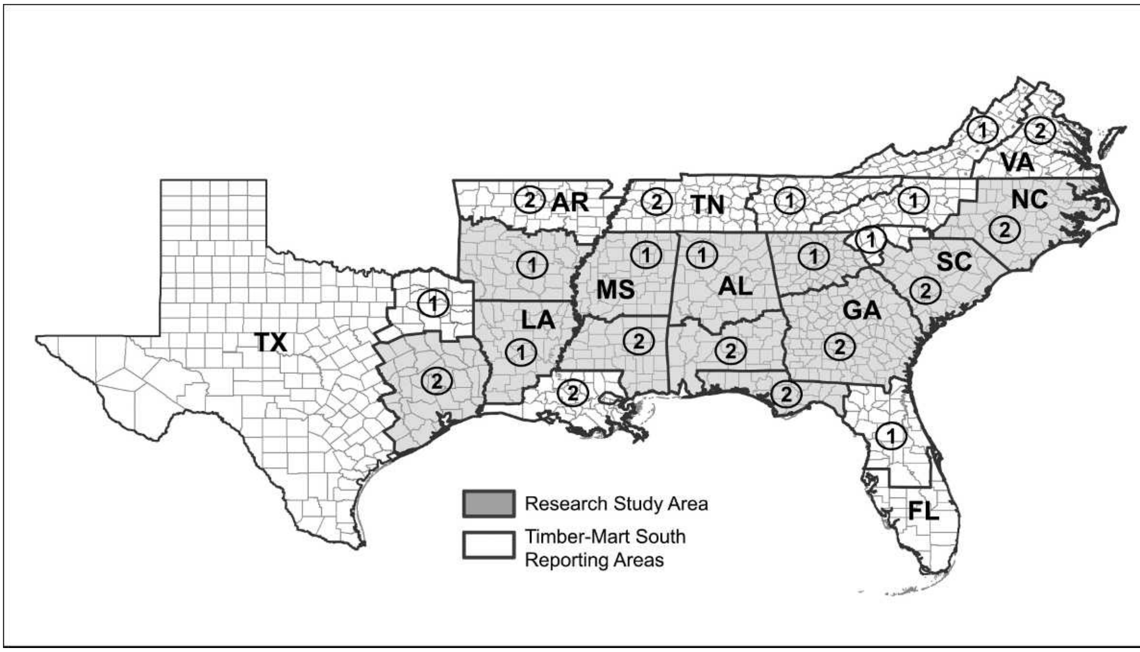

Figure 1.—Timber Mart-South reporting areas in the US South with the 12 areas examined in this study shaded.

drivers determine timberland returns both individually and interactively. Biological growth was identified as the dominant return driver in terms of the percentage of contribution (Caulfield 1998). Due to this unique feature, the volatility of timberland returns has been dampened during economic recessions. Historically, timberland returns have shown a moderate to high correlation with the consumer price index (CPI) so timberland assets have been viewed as good hedges against inflation (Washburn and Binkley 1993, Lundgren 2005). However, it is interesting to test whether or not stumpage prices alone can hedge against inflation.

The economic literature has generated a large number of empirical studies on the effectiveness of gold as an inflation hedge (e.g., Capie et al. 2005, Wang et al. 2011). Research on timber assets and inflation, however, has been sporadic. Redmond and Cubbage (1988) applied modern portfolio theory and the nominal capital asset pricing model (CAPM) in evaluating timber prices of various species, products, and regions. They claimed that the addition of growth to the total returns had little impact on beta estimation and timber assets tended to appreciate more in value during inflationary times. Defining forest assets as timber inventory plus bare land, Wagner and Rideout (1991) identified ponderosa pine plantations in the Pacific Northwest as inferior inflation hedges. Within the same context, Wagner and Rideout (1992) found some evidence of parameter shift in estimating the CAPM by applying stumpage prices. Using rates of change in sawtimber stumpage prices as a proxy for forestry returns, Washburn and Binkley (1993) found that forests in the US West and South had been effective hedges against unexpected inflation. Lausti and Penttinen (1998) showed that the average real timberland return had been 3 percent over high and low inflation periods in Finland. Penttinen and Lausti (2004) found some evidence of inflation-hedging characteristics of forest ownership. Sun and Zhang (2001) compared forestry-related investment vehicles using the arbitrage pricing theory (APT) and the CAPM. They found that results from APT supported previous CAPM studies but the APT findings were more robust. Heikkinen (2002) proved that timber prices and bond and deposit rates are co-integrated in the long run. Lausti (2004) argued that forest ownership in Finland (1973 to 2003) was an effective hedge against unanticipated inflation and that the longer the period, the more effective the hedge. Lundgren (2005) included bare land values, operating cash flows, and timber values to derive timberland returns and found Swedish timberland could hedge against inflation. In summary, the different conclusions in previous research may be due to different measures in timber investment returns,[2] geographic locations, product mixes, and criteria to measure the effectiveness of inflation hedging.

This study isolated the timber component and selected a narrow set of criteria. We chose to examine the stumpage price history of five major timber products,[3] including pine sawtimber, hardwood sawtimber, pine pulpwood, hardwood pulpwood, and pine chip-n-saw, in 12 southern regions (Fig. 1) under the framework of Fisher's hypothesis and real CAPM. The southern timber market was chosen because the majority of mill capacity in the United States is established in the South (Wear et al. 2007), about 60 percent of the nation's timber is produced by the southern states (Prestemon and Abt 2002), and a large portion of commercial timberlands in the United States as well as the world is located in the South (Cascio and Clutter 2008). In contrast to previous studies that examined sawtimber price only (e.g., Washburn and Binkley 1993), we included chip-n-saw and pulpwood prices as well since multi-products are produced simultaneously from a forest plantation. Rolling regression technique was applied to tackle the potential

[2] In the literature, timber investment returns were constructed by using product prices alone, or timber inventory and land, or forest ownership over time (i.e., growing timber plus land).

[3] Product prices only, not including land or biological growth.

instability of the parameters. Heterogeneity among different markets was addressed by the weighted least squares. The major finding was that, using instantaneous quarterly timber returns, there was no uniform conclusion on stumpage prices' ability to hedge against inflation; however, using average timber returns over a longer time period, pine pulpwood and chip-n-saw were found to be effective hedges against both expected and unexpected inflation. In addition, pine sawtimber and chip-n-saw prices were found to be closely related to the overall market, whereas hardwood products had outperformed the market. This study will shed light on our understanding of timber as an asset class.

Data

Stumpage prices came from Timber Mart-South (TMS). TMS compiles and publishes timber prices for 22 US southern market areas on a quarterly basis. The five products examined are pine sawtimber, hardwood sawtimber, pine pulpwood, hardwood pulpwood, and pine chip-n-saw.[4] The 22 regions are coded by the two-letter US Postal Service state abbreviation and the number assigned by TMS (Fig. 1), which are delineated by terrain features, mill types, harvest activities, species mixes, etc. (Norris Foundation 1977 to 2011). There have been two major revisions in TMS reporting regimes since their inception. First, reporting frequency has changed from monthly to quarterly since 1988. Second, reporting areas in most coastal states have changed from three to two since 1992. Researchers had examined the temporal and spatial aggregation issues and the power of different statistical tests on TMS timber prices (e.g., Prestemon and Pye 2000, Prestemon et al. 2004). Accordingly, we used spot-sampling (middle month) quarterly series for 1977 to 1987 and transformed three-region series to two-region series by the TMS conversion method.[5]

Of the 22 TMS timber regions, some have substantial missing values (i.e., LA2, TN2, and TX1), and some are peripheral or have low timber removals (i.e., AR2, FL1, NC1, SC1, TN2, VA1, and VA2). Hence, the following 12 timber regions were studied in our analysis: AL1, AL2, AR1, FL2, GA1, GA2, LA1, MS1, MS2, NC2, SC2, and TX2. Together, these 12 timber regions account for 90 percent of the total annual pine removals in the South (Forisk Consulting and Timber Mart-South 2007) and represent the southern timber market well. Instantaneous quarterly returns for timber assets, calculated as $R_{i,t} = P_{i,t}/P_{i,t-1} - 1$, captures real-time market fluctuations. Nevertheless, considering the long-term nature of timber investment, 40-quarter (10-y) average returns, calculated as $R_{i,t} = (P_{i,t}/P_{i,t-40})^{1/40} - 1$, were also examined in the regression analysis.

Actual inflation is approximated by CPI of all commodities for urban consumers, expected inflation is approximated by the lagged 3-month Treasury bill rate (Fama and Schwert 1977), and unexpected inflation equals actual inflation minus expected inflation. Value-weighted returns of all stocks listed on NYEX, AMEX, and NASDAQ are used as market returns, and 3-month Treasury bill rates are used as risk-free rates. All these data came from Wharton Research Data Service. For illustration purpose, the movement of CPI and pulpwood price in northern Georgia (GA1) is plotted in Figure 2. All three are expressed as indices, with 1977 Q1 equal to 100. There is an overall increasing trend for CPI over time except for economic downturns (e.g., year 2008). Pulpwood price was relatively stable tending to track CPI from 1977 to 1990 but became much more volatile thereafter, especially for hardwood pulpwood price. Causal factors for this price trend include harvest restriction on national forests in the Pacific Northwest, changes in industry capacity and production, and business cycles (Harris et al. 2010).

Methods

Nominal CAPM

Based on Markowitz's (1952) work of mean-variance efficient portfolio, Sharpe (1964) and Lintner (1965) developed its economy-wide implications, nominal CAPM, which states that the expected return on an asset or a portfolio $E[R_i]$ equals a risk-free rate R_f plus a premium that depends on the asset's β_i and the expected market premium $E[R_m] - R_f$:

$$E[R_i] = R_f + \beta_i[E(R_m) - R_f] \quad (1)$$

In empirical regression analysis, ex ante expected returns $E[R_i]$ and $E[R_m]$ are replaced by ex post realized returns R_i and R_m and nominal CAPM can be estimated in the excess return form:

$$R_i - R_f = \alpha_i + \beta_i(R_m - R_f) + \mu_i \quad (2)$$

Intercept α_i, known as Jensen's alpha (Jensen 1968), measures the abnormal performance, and slope β_i, called systematic risk, measures how returns on an individual asset change with the overall market.

Real CAPM

Fisher's hypothesis states that nominal interest rate equals real interest rate plus inflation (Fisher 1930). Similarly,

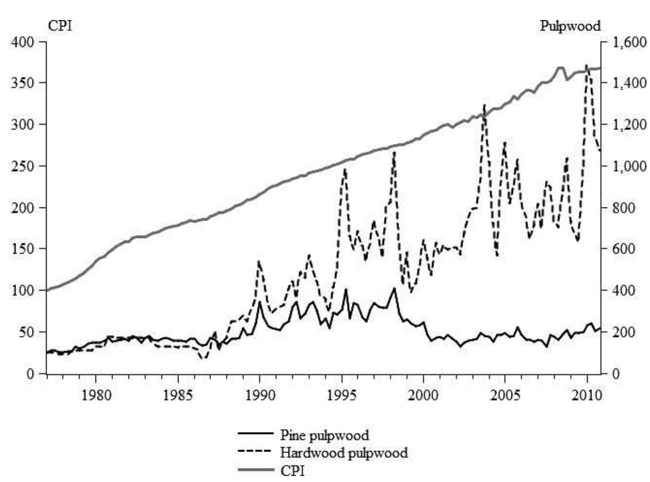

Figure 2.—The trend of pulpwood prices in northern Georgia and consumer price index (CPI).

[4] Hardwood is of mixed species, including ash, black cherry, hard maple, hickory, red oak, sweetgum, walnut, white oak, and yellow poplar (Norris Foundation 1977 to 2011).

[5] Timber price series based on the conversion technique proposed by Prestemon and Pye (2000) were also analyzed. Since similar results were found, these results are not reported separately, but are available from the authors upon request.

nominal rate of return R_i for asset i, be it a security, a portfolio, or a risk-free asset, can be expressed as

$$1 + R_i = (1 + r_i)(1 + \pi)^{\gamma_i} \quad (3)$$

where r_i is the rate of return without inflation, π is the inflation rate, and γ_i is the inflation response coefficient for asset i (Lee et al. 1988). The rate of return without inflation and inflation response coefficient are not observable but can be estimated by

$$\ln(1 + R_i) = \ln(1 + r_i) + \gamma_i \ln(1 + \pi) + e_i \quad (4)$$

and γ_i can be interpreted as the asset's inflation hedging ability in the following three categories: (1) complete inflation hedging with $\gamma_i = 1$; (2) superior inflation hedging with $\gamma_i > 1$; and (3) inferior inflation hedging with $\gamma_i < 1$.

However, investors not only care about hedging inflation but also diversifying their residual risk. Therefore, a two-factor model, i.e., the CAPM in real terms, which accounts for market risk, is more appropriate for examining the marginal ability of inflation hedging (Lee et al. 1988). To get real CAPM, Equation 4 is first linearized using the Taylor expansion (Chen and Boness 1975):

$$R_i = r_i + \gamma_i \pi + e_i^* \quad (5)$$

Then the econometric CAPM (Eq. 2) in real terms can be written as

$$R_i - \gamma_i \pi - r_f = a_i + b_i(R_m - \gamma_m \pi - r_f) + \varepsilon_i \quad (6)$$

Rearranging the terms, Equation 6 becomes

$$R_i - r_f = a_i + b_i(R_m - r_f) + c_i \pi + \varepsilon_i \quad (7)$$

where $c_i = \gamma_i - \gamma_m b_i$. Equation 7 can be viewed as an APT model under inflation (Elton et al. 1983), since c_i signifies how the return generating process relies on inflation (Lee et al. 1988). Actual inflation Equation 7 can be further decomposed into expected inflation π_e and unexpected inflation π_u, which leads to (Lausti 2004)

$$R_i - r_f = a_i + b_i(R_m - r_f) + c_{i,e}\pi_e + c_{i,u}\pi_u + \varepsilon_i \quad (8)$$

Econometric estimation

To account for potential structural changes in the timber markets, the rolling regression technique is applied to generate the estimates of time-varying inflation hedging parameter. A linear rolling regression model can be expressed as

$$\mathrm{Y}_t(n) = \mathrm{X}_t(n)\mathrm{B}_t(n) + \mu_t(n) \quad (9)$$

where t ranges from n to T, n denotes the length of the rolling window, $\mathrm{Y}_t(n)$ is an $n \times 1$ vector of dependent variables, $\mathrm{X}_t(n)$ is an $n \times k$ matrix of explanatory variables, $\mathrm{B}_t(n)$ is a $k \times 1$ vector of coefficients corresponding to the rolling window ($t - n + 1$, t), and μ_t is an $n \times 1$ vector of error terms (Zivot and Wang 2006). In addition, timber prices in adjacent markets tend to be correlated. To incorporate these intercorrelations, a system of 12 equations was estimated simultaneously for Equations 7 and 8 for each timber product under the rolling regression framework. The weighted least squares method was used to address market heterogeneity.

Results

Results using instantaneous quarterly returns

Rolling estimations of Equations 7 and 8 generated R^2 values ranging from 0.01 to 0.19. Residual tests cannot reject the normality assumption. The 10-year rolling estimates of parameter c_i in Equation 7 for pine sawtimber in the 12 southern timber regions are reported in Table 1.[6] The overall effectiveness of inflation hedging was weak except for region AL2 (1991 to 2004), LA1 (1991 to 2003), and SC2 (1984 to 2002). For hardwood sawtimber, inflation hedging was found in region AL2 (1981 to 1991 and 1999 to 2010), AR1 (1994 to 2004), FL2 (2008 to 2010), GA2 (1983 to 1998), SC2 (1981 to 2007), and TX2 (1992 to 2007). For pine pulpwood, inflation hedging was found in AL1 (1983 to 1999), AL2 (1989 to 2004), AR1 (1988 to 2004), FL2 (1989 to 2007), GA1 (1982 to 2000), SC2 (1982 to 2000), and TX2 (1993 to 2005). For hardwood pulpwood, inflation hedging was found in AL2 (1981 to 1993 and 1996 to 2007), AR1 (1977 to 1987 and 1992 to 2002), GA1 (1986 to 2002), SC2 (1981 to 1999 and 1997 to 2007), and TX2 (1994 to 2006). For pine chip-n-saw, inflation hedging was evidenced in AL1 (1977 to 1995), AL2 (1980 to 1991), GA1 (1981 to 2002), GA2 (1980 to 1991), MS1 (1978 to 1989), and SC2 (1982 to 2002). In sum, only timber assets in SC2 showed consistent inflation hedging ability from the late 1980s to the early 2000s. Timber assets in MS2 showed no inflation hedging ability at all during 1977 to 2010. Timber assets in other regions showed some ability of inflation hedging. Overall, the effectiveness of inflation hedging of timber assets varied substantially by product and by time.

Timber investors usually use geographic diversification to minimize risks from natural disasters such as fire, snow storm, icy rain, hurricane, tornado, disease, and insects. To understand the relationship between timber assets and inflation on a broader scale, a hypothetical timber portfolio of the 12 southern regions was formed and equal-weighted returns were evaluated. It was found that hardwood sawtimber (1982 to 1991), pine pulpwood (1988 to 2000), and pine chip-n-saw (1977 to 1990, 1989 to 2000) had hedged actual inflation, whereas pine sawtimber and hardwood pulpwood did not over the whole sample period (Table 2). In addition, in certain time periods, i.e., 1989 to 1998 and 1992 to 2002 for pine sawtimber, 1981 to 1992 for hardwood sawtimber, 1988 to 2003 for pine pulpwood, 1980 to 1989 for hardwood pulpwood, and 1989 to 2000 for pine chip-n-saw, timber assets had been superior hedges against unexpected inflation. Regardless of actual or unexpected inflation, there were times when the magnitude of the hedging parameter was significantly negative, meaning inferior hedges against inflation.

Another finding from the rolling regression was the very low beta estimates, ranging from –0.18 to 0.23 (Fig. 3). This is consistent with previous research (Redmond and Cubbage 1988, Wagner and Rideout 1992), which implies timber assets were insensitive to the overall market and thus had diversification potential for a portfolio. Moreover, after inflation was accounted for, Jensen's alpha, as a measure of

[6] Rolling regressions for the other four products, of different window length, and for Equations 4 and 8 were conducted. Since similar results were found, they are not reported separately. The results, however, are available from the authors upon request.

Table 1.—Ten-year rolling estimation of hedging parameters in Equation 7 for pine sawtimber in 12 southern regions using instantaneous quarterly returns.[a]

Year	AL1	AL2	AR1	FL2	GA1	GA2	LA1	MS1	MS2	NC2	SC2	TX2
1986	1.30	1.30	1.98	0.56	0.90	−0.62	0.89	1.86	0.91	0.36	−0.47	0.43
1987	0.57	0.32	1.27	−0.30	0.36	−1.06	−0.57	0.99	0.14	−0.22	−0.64	−0.77
1988	0.48	0.06	1.24	−0.48	0.14	−0.79	−0.71	−0.72	−0.79	−0.07	−0.79	−0.73
1989	0.43	0.53	1.54	−0.06	−0.19	−0.99	−1.54	−2.08	−1.69	−0.32	−0.83	−1.66
1990	5.33*	1.15	4.60*	2.54	3.97*	1.05	−1.32	−0.23	0.91	3.62	3.52	−1.87
1991	4.78	−0.49	3.57	0.78	2.41	−0.85	−3.65	−4.14	−0.63	2.26	4.36	−5.25
1992	−1.82	−8.77*	−1.53	−3.07	−0.89	−3.20*	−5.05	−4.16	−3.15	−0.43	4.51	−8.29*
1993	−1.72	−10.74*	−1.67	−3.75	−1.48	−1.97	−5.92	−7.87*	−5.13	−2.16	6.57*	−11.19*
1994	−5.26	−10.15*	−1.73	−4.92	−4.11*	−2.75	−4.58	−5.59	−4.37	−3.13	5.27	−10.36*
1995	−2.35	−6.08*	−0.93	−3.70	−2.61	−1.41	−2.70	−1.99	−1.37	−0.80	6.34*	−9.01*
1996	−3.20	−5.24	1.61	−3.85	−2.10	−1.77	−0.16	−6.76	−3.90	2.95	8.12*	−5.89
1997	−3.84	−3.53	−2.57	−5.24	−3.38*	−2.43	0.80	−4.57	−5.56	5.06	8.48*	−7.00*
1998	−0.19	0.02	2.88	−0.25	0.66	−0.81	4.56	−2.44	−1.51	6.44	11.44*	−5.13
1999	−1.30	−0.14	2.08	0.16	2.43	−0.53	5.19	−1.30	−1.44	5.86	13.56*	−5.55
2000	1.05	9.88*	7.50	5.35	4.75	1.14	6.87*	5.95	5.78	3.85	4.66*	−5.39
2001	1.62	7.75*	4.87	3.91	−0.91	−0.14	5.75*	2.84	3.07	2.66	3.30	−0.60
2002	2.21	7.30*	5.52	3.41	−3.07	−0.07	5.01*	1.93	2.70	1.99	3.48*	0.05
2003	0.01	6.06*	−0.65	0.52	−3.09	−1.80	2.22	1.61	−0.07	−0.56	1.85	1.24
2004	1.75	5.01*	−0.30	1.51	−3.24	−1.17	2.07	−0.17	−1.79	−0.05	1.76	−0.24
2005	0.03	1.51	−0.49	0.88	−2.04	−1.11	−0.08	−1.40	−1.73	−1.35	0.66	−0.34
2006	0.60	1.41	−0.28	0.36	−0.90	−0.61	0.25	−0.46	−0.96	−2.33	0.97	−0.29
2007	0.91	1.28	0.20	−0.02	−1.50	−0.16	0.55	−0.89	−1.21	−1.11	1.33	−0.98
2008	0.12	−0.63	−2.01*	−0.27	−0.43	0.07	−1.64*	−1.40	−1.46*	−1.12	−0.24	−2.21*
2009	−0.09	−1.22	−2.13*	−0.70	−0.79	0.02	−1.72*	−1.46	−1.75*	−1.25	−0.43	−2.48*
2010	−0.02	−1.40	−2.00*	−0.86	−0.72	−0.01	−1.61	−1.62	−1.76*	−0.98	−0.42	−2.27*

[a] An asterisk (*) denotes significance at the 10% or better level with a one-tailed test.

Table 2.—Ten-year rolling estimation of inflation hedging parameters in Equations 7 and 8 for the timber portfolio of 12 southern regions using instantaneous quarterly returns.[a]

	Actual inflation					Unexpected inflation				
Year	PST	HST	PP	HP	PCS	PST	HST	PP	HP	PCS
1986	0.78	−0.38	0.30	0.76	2.91*	1.56	0.34	0.52	0.82	1.77
1987	0.01	−0.56	0.10	0.22	1.92*	0.71	0.13	0.25	0.61	1.34
1988	−0.26	−0.77	−0.13	0.12	1.56	0.25	−0.06	−0.13	0.88	1.02
1989	−0.57	−0.39	0.16	0.78	2.03*	0.12	0.74	0.34	2.28*	1.54
1990	1.94	1.66	−0.01	1.35	2.01*	2.41	3.08*	0.13	2.86	1.64
1991	0.26	2.76*	0.36	0.87	1.56	0.64	3.35*	0.51	1.85	1.52
1992	−2.99*	0.45	−0.55	1.70	0.10	−2.57	0.92	−0.40	2.63	0.51
1993	−3.92*	0.11	0.24	3.13	0.26	−3.01	1.26	0.68	4.30	1.04
1994	−4.31*	−0.64	0.75	1.67	−0.14	−3.24	0.88	1.33	2.62	1.35
1995	−2.22	0.51	1.36	3.39	0.58	−1.71	1.80	1.46	3.64	1.56
1996	−1.68	0.81	1.34	−0.46	−0.10	−0.38	2.95	1.36	−1.52	1.02
1997	−1.98	−2.06	3.04*	−2.48	0.23	0.32	0.22	4.13*	−3.97	2.22
1998	1.30	0.31	5.70*	1.21	2.90*	4.32*	3.13	7.33*	0.08	5.23
1999	1.59	0.54	6.23*	−1.36	2.98*	3.77	2.33	6.99*	−1.46	4.50
2000	4.28	−0.74	5.02*	1.17	3.80*	3.77	−0.92	4.88*	1.30	3.56
2001	2.85	1.01	3.36	4.09	1.56	3.76*	1.54	3.81*	3.89	2.24
2002	2.54	0.97	2.64	2.84	0.91	3.29*	1.30	3.33	2.73	1.49
2003	0.61	0.72	2.95	3.86	−0.02	0.96	0.82	3.55*	4.21	0.19
2004	0.43	0.71	1.61	2.16	−0.36	0.53	0.74	1.78	2.12	−0.29
2005	−0.46	0.34	0.47	2.26	−0.83	−0.47	0.34	0.44	2.24	−0.84
2006	−0.19	0.66	−0.05	1.83	−0.55	−0.29	0.63	−0.24	1.72	−0.64
2007	−0.13	0.96	0.63	2.30	−0.47	−0.15	0.95	0.60	2.27	−0.49
2008	−0.93*	0.42	−1.87*	−0.89	−1.92*	−0.79*	0.50	−1.56*	−0.67	−1.66*
2009	−1.17*	0.19	−2.46*	−1.51	−2.21*	−1.05*	0.20	−2.22*	−1.31	−2.01*
2010	−1.14*	0.37	−2.01*	−0.81	−2.12*	−1.10*	0.42	−1.97*	−0.80	−1.95*

[a] PST = pine sawtimber; HST = hardwood sawtimber; PP = pine pulpwood; HP = hardwood pulpwood; PCS = pine chip-n-saw. An asterisk (*) denotes significance at the 10% or better level with a one-tailed test.

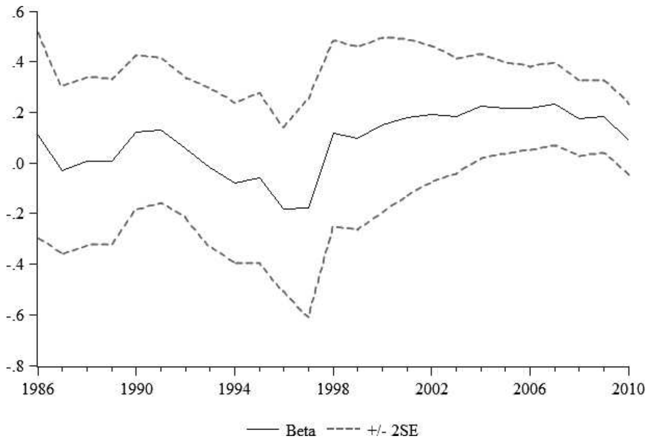

Figure 3.—Ten-year rolling estimations of β for pine sawtimber using instantaneous quarterly returns. Estimations of β for the other four timber products showed similar patterns and thus are not reported separately.

abnormal returns, was no longer significant for most of the time periods.

Results using 40-quarter average returns on a timber portfolio

Calculating 40-quarter average returns generated a balanced sample of 1986 Q1 to 2010 Q4. The regression results for the timber portfolio are reported in Table 3. In the long run, pine pulpwood was found to be a complete hedge of expected inflation and superior hedge of unexpected inflation, while pine chip-n-saw was found to be a superior hedge of both expected and unexpected inflation. In addition, all timber products have positive correlation with the market in the long term, although to different extents. Returns on pine sawtimber and chip-n-saw tied closely to market returns with betas estimated around one, whereas returns on pulpwood products showed lower sensitivity to the market with betas less than 0.2. In terms of abnormal performance, hardwood products outperformed the market by about 1 percent after inflation was adjusted. Pine pulpwood and chip-n-saw, on the other hand, showed underperformance of 1 and 2 percent, respectively.

Discussion and Conclusions

Under the framework of Fisher's hypothesis and real CAPM, this study investigated the ability of timber assets to hedge against inflation in 12 US southern timber regions. Prices for five products, pine sawtimber, hardwood sawtimber, pine pulpwood, hardwood pulpwood, and pine chip-n-saw, for both individual timber regions and all regions combined were analyzed by rolling regression and weighted least squares. When instantaneous quarterly returns were used, no uniform conclusion could be drawn—the inflation hedging ability varied greatly by region and by time. Consistent with previous research, beta estimates for regional timber assets were small and in certain cases negative. However, with real CAPM, less abnormal returns were found. This implies that real CAPM, as a two-factor model, can be a better asset pricing model for timber assets. When timber returns were averaged geographically and over a longer time horizon, pine pulpwood and chip-n-saw were found to be effective hedges against both expected and unexpected inflation. Therefore, timber assets alone should not be considered as consistent or persistent hedges against inflation unless held for a long term. In other words, should timberland returns indeed hedge against inflation, it's the interaction among the three timberland return drivers, i.e., biological growth, timber price, and land value, not simply timber price that matters. Lastly, in the long run, changes in pine sawtimber and chip-n-saw prices were more closely related to the market, and hardwood products' prices had outperformed the market.

There are several other considerations for evaluating timber assets. First, timber is a long duration asset. A typical southern pine plantation has a 25- to 30-year rotation. However, unlike most agricultural products, mature timber can be stored on the stump with minimum costs. This gives landowners the option to delay harvesting when the market is bad and thus improve their returns. Therefore, a one-period asset pricing model like CAPM may not fully explain the managerial flexibility in timber production. Second, timber prices are determined by a variety of factors such as housing start, business cycles, wood utilization technologies, and international trade. For example, the US–Canada softwood lumber trade disputes were found to have a significant impact on the US softwood lumber price volatility (Zhang and Sun 2001). In the short run, timber prices are subject to market shocks, whereas in the long run, they revert to their normal equilibrium level determined by marginal costs of production. Movement of timber prices in the past 30 years is only a snapshot of their stochastic behavior in history. Over the past 90 years, stumpage price in the South has risen more than 5 percent per year (Norris Foundation 1977 to 2011), while inflation has averaged about 4 percent per year over the same time period. Third, besides timber sales, there are other revenue-generating opportunities associated with timber investments such as hunting leases, carbon credits, recreational uses, and woody biomass production. All these may impact the financial performance of timber assets.

Table 3.—Estimation of inflation hedging parameters in Equation 8 for the timber portfolio of 12 southern regions using 40-quarter average returns.[a]

	PST	HST	PP	HP	PCS
α	−0.001 (0.562)	0.011 (0.000)	−0.012 (0.000)	0.014 (0.001)	−0.024 (0.000)
β	0.925 (0.000)	0.507 (0.000)	0.182 (0.084)	0.196 (0.179)	1.031 (0.000)
c_e	−0.945 (0.007)	−1.461 (0.000)	0.973 (0.046)	−1.313 (0.052)	2.227 (0.003)
c_u	0.934 (0.133)	−0.062 (0.914)	2.247 (0.010)	−0.959 (0.424)	4.457 (0.000)
R^2	0.678	0.618	0.077	0.107	0.681

[a] PST = pine sawtimber; HST = hardwood sawtimber; PP = pine pulpwood; HP = hardwood pulpwood; PCS = pine chip-n-saw. *P* values are presented in parentheses. Using south-wide 40-quarter average returns generated similar parameter estimates. The results are available from the authors upon request.

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Literature Cited

Bodie, Z. and V. I. Rosansky. 1980. Risk and return in commodity futures. *Financ. Anal. J*. 36(3):27–39.

Capie, F., T. C. Mills, and G. Wood. 2005. Gold as a hedge against the dollar. *J. Int. Financ. Markets Inst. Money* 15(4):343–352.

Cascio, A. J. and M. L. Clutter. 2008. Risk and required return assessments of equity timberland investments in the United States. *Forest Prod. J*. 58(10):61–70.

Caulfield, J. P. 1998. Timberland return drivers and investing styles for an asset that has come of age. *Real Est. Finance* 14(4):65–78.

Chen, A. H. and A. J. Boness. 1975. Effects of uncertain inflation on investment and financing decisions of a firm. *J. Finance* 30(2): 469–483.

Elton, E., M. Gruber, and J. Rentzler. 1983. The arbitrage pricing model and returns on assets under uncertain inflation. *J. Finance* 38(2): 525–537.

Fama, E. and G. Schwert. 1977. Asset returns and inflation. *J. Financ. Econ*. 5(2):115–146.

Fisher, I. 1930. The Theory of Interest. The MacMillan Company, New York. 566 pp.

Forisk Consulting and Timber Mart-South. 2007. Timber Market Profiles & Rankings: US South. Center for Forest Business, Warnell School of Forestry and Natural Resources, University of Georgia, Athens.

Harris, T. G., S. Baldwin, and J. P. Siry. 2010. Long-term pine sawtimber and pulpwood prices. *Forest Landowner* 69(3):32–34.

Heikkinen, V. P. 2002. Co-integration of timber and financial markets-Implications for portfolio selection. *Forest Sci*. 48(1):118–128.

Jensen, M. C. 1968. The performance of mutual funds in the period 1945–1964. *J. Finance* 23(2):389–416.

Lausti, A. 2004. The inflation-hedging characteristics of forest ownership, private housing and stocks in Finland. *LTA* 4(04):427–451.

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

Lee, C. F., F. C. Jen, and K. C. J. Wei. 1988. The real and nominal parameters in the CAPM: A responsive coefficient approach. *Int. J. Finance* 1(1):113–130.

Lintner, J. 1965. The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. *Rev. Econ. Stat*. 47(1):13–37.

Lundgren, T. 2005. Assessing the investment performance of Swedish timberland: A capital asset pricing model approach. *Land Econ*. 81(3): 353–362.

Markowitz, H. 1952. Portfolio selection. *J. Finance* 7(1):77–91.

Norris Foundation. 1977 to 2011. Timber Mart-South. Warnell School of Forestry and Natural Resources, University of Georgia, Athens.

Penttinen, M. and A. Lausti. 2004. The competitiveness and return components of NIPF ownership in Finland. *Finn. J. Bus. Econ*. 53(2): 141–154.

Prestemon, J. P. and R. C. Abt. 2002. Southern forest resource assessment highlights: The southern timber market to 2040. *J. Forestry* 100(7):16–22.

Prestemon, J. P. and J. M. Pye. 2000. A technique for merging areas in Timber Mart-South data. *South. J. Appl. Forestry* 24(4):219–229.

Prestemon, J. P., J. M. Pye, and T. P. Holmes. 2004. Temporal aggregation and testing for timber price behavior. *Nat. Resource Model*. 17(2):123–162.

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

Sharpe, W. F. 1964. Capital asset prices: A theory of market equilibrium under conditions of risk. *J. Finance* 19(3):425–442.

Sun, C. and D. Zhang. 2001. Assessing the financial performance of forestry-related investment vehicles: Capital asset pricing model vs. arbitrage pricing theory. *Am. J. Agric. Econ*. 83(3):617–628.

Wagner, J. E. and D. B. Rideout. 1991. Evaluating forest management investments: The capital asset pricing model and the income growth model. *Forest Sci*. 37(6):1591–1604.

Wagner, J. E. and D. B. Rideout. 1992. The stability of the capital asset pricing model's parameters in analyzing forest investments. *Can. J. Forest Res*. 22(11):1639–1645.

Wang, K.-M., Y.-M. Lee, and T.-B. N. Thi. 2011. Time and place where gold acts as an inflation hedge: An application of long-run and short-run threshold model. *Econ. Modelling* 28(3):806–819.

Washburn, C. L. and C. S. Binkley. 1993. Do forest assets hedge inflation? *Land Econ*. 69(3):215–224.

Wear, D. N., D. R. Carter, and J. Prestemon. 2007. The U.S. South's timber sector in 2005: A prospective analysis of recent change. USDA Forest Service, Asheville, North Carolina. 30 pp.

Zhang, D. and C. Sun. 2001. U.S.-Canada softwood lumber trade disputes and lumber price volatility. *Forest Prod. J*. 51(4):21–27.

Zivot, E. and J. Wang. 2006. Modeling Financial Time Series with S-PLUS. Springer, New York. 998 pp.