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WELFARE IMPLICATIONS OF TIMBERLAND OWNERSHIP CHANGES IN THE U.S. TIMBER MARKETS

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Abstract

In the last two decades, many forest product firms in the U.S. either divested their timberlands to timber investment management organizations (TIMOs) and conservation organizations or converted their corporate structures from C corporations to real estate investment trusts (REITs). All landowners sold smaller timberland tracts for nonforestry uses. Reduced timber supplies from conservation organizations and timberland loss to other nonforestry uses have consequences on producer and consumer surpluses in the U.S. timber markets. Equilibrium displacement model has been employed to evaluate the welfare changes in U.S. timber markets attributed to timberland ownership changes. Net reduction of timber supply contributed to the reduction of social surplus by $43 million in 2006. Compared to the $33 billion plus U.S. timber markets, this welfare reduction was small. Overall, this article explains the shifts of economic surpluses among producers and net surplus reduction for the society attributed to timberland ownership changes in the United States.

Keywords: *Market equilibrium, Price, Surplus, Tax, Welfare*
JEL Codes: *L73, Q11, Q23, Q28, R13*

1. Introduction

In the United States, industrial corporate owners purchased millions of acres of timberland in 1940s to meet internal timber demands for their mills (G. P. Boyd, 2006). Since the late 1980s, an unprecedented change occurred in the ownership patterns of the timberlands. Firms either sold their timberlands or converted their corporate structures to real estate investment trusts (REITs). Investment in timberland by nonindustrial corporate owners in the U.S. has grown from under $1 billion in 1985 (Li & Zhang, 2007) to $15 billion in 2005 (Clutter, Mendell, Newman, Wear, & Greis, 2005). Primary factors for selling timberlands include poor shareholder returns, debt reduction, higher tax rate on timber profit, development of tax strategies to minimize the impact of large capital gains taxes, decreased significance of internal timber supplies attributed to mature timber markets, and realization of the appreciation value of timberland assets (Hickman, 2007; Rogers & Munn, 2003; Yin, Caulfield, Aronow, & Harris, 1998).

Primary reasons for buying timberland by timber investment management organizations (TIMOs) were favorable returns and low risk, its apparent correlation with inflation thus providing a "hedge" against inflation (Clutter et al., 2005). Hickman (2007) added that passage of the Employee Retirement Income Security Act (ERISA) of 1974 and the Real Estate Investment Trust Simplification Act (REITSA) of 1997 also created a favorable environment for nonindustrial owners to invest in timberlands. The former encouraged nonindustrial corporate owners to seek increased returns by diversifying their investment portfolios to include more than just fixed-income securities like government and corporate bonds and the latter precluded industrial corporate timberland owners from forming timber REITs (Hickman, 2007).

There is a major difference in tax treatments for industrial corporate and nonindustrial corporate (i.e., TIMOs and REITs) timberland owners. Industrial and nonindustrial corporate timberland owners are classified as Sub-Chapter C and S corporations, respectively. Any profits obtained from timber sales by C corporations are taxed twice – once at the corporate level (usually 35%), and again at the stockholder level (usually 15%) when dividends are disbursed. The practical effect of this tax policy is that shareholders of industrial corporate owners can recoup as little as 50% out of every dollar of profit made from timber sales. In contrast, shareholders of S corporations can normally retain about 85% of the profit from timber sales with a 15% tax rate (Clutter et al., 2005; Hagan, Irland, & Whitman, 2005). As a result, taxation laws available to industrial corporate timberland owners were one of the major forces for industrial timberland divestiture. About 37 million ac of industrial timberland was sold between 1981 and 2005. Of this, 15 million ac were sold to TIMOs, 10 million ac to conservation groups, 10 million ac to publicly traded REITs, and 2 million ac to private forest product companies (G. P. Boyd, 2006; Hickman, 2007).

Conversion to REITs or selling timberlands to TIMOs might not adversely affect timber supplies since timber management intensity by REITs and TIMOs was similar to that of industrial corporate owners (Bowyer & Howe, 2007; Rogers & Munn, 2003). The objectives of owning timberland by conservation organizations, however, were different from those of industrial or nonindustrial corporate landowners. While the major objective of owning timberland by industrial or nonindustrial corporate landowners was to maximize profits, conservation organizations owned timberlands to maximize environmental benefits. Also, all timberland owners sold timberlands in smaller tracts that were close to urban or developing areas. Most land being used for rapidly increasing urban sprawl came from forest lands (LaGro & DeGloria, 1992). One of the major non-forestry conversions of timberland is real estate development. This conversion captured higher prices for those parcels compared to regular timberland prices and to increase land value through such conversion (Zinkhan, 1993). Bowyer and Howe (2007) reported concerns about forest land conversion or its parcelization or fragmentation through timberland sales and real estate development activities. Thus, through parcelization a certain portion of timberland, although small compared to the entire timberland base, was leaving timber production.

Thus, timber markets could suffer a two-way reduction in timber supply: (1) reduced supplies from the land acquired by conservation organizations, and (2) reduction of the timberland base through conversion of timberland to higher and better uses (HBUs). This reduction in timber supply presumably could have consequences on consumer and producer surpluses in the timber markets. Past studies (Daughtrey, Bunn, & Martin, 1987; Sun, 2007) only analyzed various issues related to taxation laws. For example, Boyd and Daniels (1985) applied a General Equilibrium Model to examine income taxation in forestry. They reported that welfare losses generated by preferential capital gains treatment of timber were much greater than previously imagined. Thus, welfare implications for timber producers and consumers due to timberland ownership changes have not been adequately addressed in past the studies. This article was designed to address the extent of timber market equilibrium displacement attributed to timberland ownership change and to evaluate its subsequent impacts on producers and consumers in the U.S. timber markets.

2. Methods

The detailed methods are described in the following subsections.

2.1. Conceptual Model

An equilibrium displacement model (EDM) was used in this article. EDMs are a powerful methodology for welfare analysis and have been widely used to estimate the displacement of market equilibrium caused by external economic shocks. Several studies (R. Boyd & Daniels, 1985; Brown & Zhang, 2005; Sun, 2006; Sun & Kinnucan, 2001) used EDMs to determine impacts of law and policy shocks on timber markets. Following Brown and Zhang (2005), Sun and Kinnucn (2001), and Sun (2006), the total timber market has been modeled with the following system of equations:

Timber supply by industrial corporate owners $Q_i = f(P, L_i)$ (1)
Timber supply by NIPF landowners $Q_n = g(P, L_n)$ (2)
Timber supply by nonindustrial corporate and other owners $Q_r = h(P, L_r)$ (3)
Aggregate timber supply $Q_s = Q_i + Q_n + Q_r + Q_g$ (4)
Aggregate timber demand $Q_d = k(P)$ (5)
Market clearance $Q_d = Q_s$ (6)

Where P is the timber price; L_i, L_r, L_n are respectively the acreage of timberland owned by industrial corporate landowners, nonindustrial corporate landowners and NIPF and other private owners; and Q_g is the supply of timber by public ownership. The model has four exogenous variables; L_i, L_r, L_n, and Q_g and six endogenous variables Q_i, Q_n, Q_r, Q_s, Q_d, and P.

The model has been constructed based on following assumptions: (i) timber supply by public ownership was constant over the study period; (ii) any supply shift was upward and parallel; (iii) the supply shift was caused by two factors - conversion of timberlands to HBUs, and less intensive timber management by conservation groups; (iv) timberland management regimes under corporate industrial owners and REIT and TIMO ownerships were similar; (v) there was no demand shock over the study period; (vi) the timber market was competitive and a common timber price prevailed in a certain regional market; and (vii) there was a direct linear relationship between the size of the timberland base, and inventory and timber supply, although this may only be true in the short run.

Assumption (vii) enables using inventory elasticities in this article and deducing following relationship between timberland base (L) and corresponding timber inventory (I) for owners $m(= i, n, r, g)$.

$$L_m = tI_m$$

where, t is positive and a proportional constant. On total differentiation, the relation reduces to,

$$dL_m = tdI_m$$

The equation system (1) through (6) can be totally differentiated as follows.

$$Q_i = \varepsilon_i \tilde{P} + \xi_i \widetilde{L_i} \qquad (1^a)$$

$$Q_n = \varepsilon_n \tilde{P} + \xi_n \widetilde{L_n} \qquad (2^a)$$

$$Q_r = \varepsilon_r \tilde{P} + \xi_r \widetilde{L_r} \qquad (3^a)$$

$$\tilde{Q}_s = \lambda_i \tilde{Q}_i + \lambda_n \tilde{Q}_n + \lambda_r \tilde{Q}_r + \lambda_g \tilde{Q}_g \qquad (4^a)$$

$$\tilde{Q}_d = \eta \tilde{P} \qquad (5^a)$$

$$\tilde{Q}_d = \tilde{Q}_s \qquad (6^a)$$

The variables with tildes indicate percentage changes in those variables. The symbols ε's, ξ's, and η are supply, inventory and demand elasticities, respectively, and $\lambda_m{}'s$ are timber supply shares for each owner compared to the total market supply.

There is an implicit relationship among owner landbases; total timberland is the sum of all timberland and the parcels that were converted by all owners to higher and better non-forestry uses (L_{HBU}). This relationship can be expressed as, $L = L_i + L_n + L_r + L_g + L_{HBU}$ which on total differentiation, gives,

$$\tilde{L} = \tilde{L}_i l_i + \tilde{L}_n l_n + \tilde{L}_r l_r + \tilde{L}_g l_g + \tilde{L}_{HBU} l_{HBU}$$

where, l_m's are the land shares of each owners with reference to the total timberland of all owners. Compared to the total timberland in the U.S., L_{HBU} was small and thus, $l_{HBU} = 0$. Even though substantial acreage of timberland changed ownership, the total timberland area remained almost constant over time which implied that, $\tilde{L} = 0$. According to Smith et al. (2010), the balance between public and private timberland has not changed since 1953. This suggests that private timberland ownership change remained confined within the purview of private owners and the public timberland base remained constant over this period, i.e. $\tilde{L}_g = 0$. Thus the above expression reduces to,

$$\tilde{L}_r = -\frac{\tilde{L}_i l_i + \tilde{L}_n l_n}{l_r}$$

Again, since timber supply from public forest land was not affected either by market forces or by the timber tax policy, $\tilde{Q}_g = 0$. Given these, and substituting equations (1^a), (2^a) and (3^a) into (4^a) yields,

$$\tilde{Q}_s = \lambda_i \varepsilon_i \tilde{P} + \lambda_i \xi_i \tilde{L}_i + \lambda_n \varepsilon_n \tilde{P} + \lambda_n \xi_n \tilde{L}_n + \lambda_r \varepsilon_r \tilde{P} + \lambda_r \xi_r \left(-\frac{\tilde{L}_i l_i + \tilde{L}_n l_n}{l_r}\right) \qquad (7)$$

Substituting equations (7) and (5^a) into (6^a), and solving for $\tilde{P}$ yield equation (8).

$$\tilde{P} = \frac{\lambda_i \xi_i \tilde{L}_i + \lambda_n \xi_n \tilde{L}_n - \lambda_r \xi_r \left(\frac{\tilde{L}_i l_i + \tilde{L}_n l_n}{l_r}\right)}{\eta - \lambda_i \varepsilon_i - \lambda_n \varepsilon_n - \lambda_r \varepsilon_r} \quad (8)$$

Substituting (8) into (5^a) and solving for $\tilde{Q}$,

$$\tilde{Q} = \eta \times \frac{\lambda_i \xi_i \tilde{L}_i + \lambda_n \xi_n \tilde{L}_n - \lambda_r \xi_r \left(\frac{\tilde{L}_i l_i + \tilde{L}_n l_n}{l_r}\right)}{\eta - \lambda_i \varepsilon_i - \lambda_n \varepsilon_n - \lambda_r \varepsilon_r} \quad (9)$$

Equations (8) and (9) are the reduced forms for percentage changes in timber price and equilibrium quantity in the market expressed in terms of elasticity parameters and timberland ownership changes.

To measure the welfare changes for landowners, the vertical shift of price in supply is needed. A vertical shift of price in supply is equivalent to a percentage change in price holding the supply constant (i.e., $V_s = \tilde{P} / _{\tilde{Q}_s = 0)}$). As measured by Sun and Kinnucn (2001), the vertical shift in supply was calculated with equation (10).

$$V_s = -\frac{\lambda_i \xi_i \tilde{L}_i + \lambda_n \xi_n \tilde{L}_n - \lambda_r \xi_r \left(\frac{\tilde{L}_i l_i + \tilde{L}_n l_n}{l_r}\right)}{\lambda_i \varepsilon_i + \lambda_n \varepsilon_n + \lambda_r \varepsilon_r} \quad (10)$$

Again, following Sun and Kinnucn (2001) and Brown and Zhang (2005), welfare changes due to supply shifts were calculated using equations (11) through (15).

$$\Delta PS_i = P^0 Q_i^0 (1 + \tfrac{1}{2}\tilde{Q}_i)(\tilde{P} - V_s) \quad (11)$$

$$\Delta PS_r = P^0 Q_r^0 (1 + \tfrac{1}{2}\tilde{Q}_r)(\tilde{P} - V_s) \quad (12)$$

$$\Delta PS_n = P^0 Q_n^0 (1 + \tfrac{1}{2}\tilde{Q}_n)(\tilde{P} - V_s) \quad (13)$$

(Following equation 11)

$$\Delta PS_G = (P^a - P^0) Q_G^0 \quad (14)$$

$$\Delta CS = -P^0 Q^0 \tilde{P} (1 + \tfrac{1}{2}\tilde{Q}) \quad (15)$$

Parameters with superscript '*0*' and '*a*' indicate values before and after landownership change, respectively. U.S. average timber prices and timber supplies in 2006 were used in this article. Displacements of timber prices in softwood and hardwood markets were calculated using equation (8). Similarly, the overall displacement of equilibrium quantity of hardwood and softwood supply was calculated using equation (9).

This article could be planned to evaluate the impact of a specific year's landownership change on timber economy. Since timberland ownership changed from year to year during the study period varied widely, estimating surplus changes based on annual average timberland ownership change over the study period was more relevant. Thus, producer surplus, consumer surplus and total surplus were calculated based on annual average timberland ownership change from 1987 through 2006. Again, EDMs are partial equilibrium models and, these are used in analyzing short term impacts of exogenous economic shocks. Thus, it may be shaky to measure the impacts of total timberland ownership change throughout the study period using EDMs. Yet, it might be interesting to examine the welfare implications of total timberland ownership change during the study period. With this view in mind, surplus changes were also calculated based on total timberland ownership change from 1987 through 2006.

Annual average and total values for $\tilde{L}_i$ and $\tilde{L}_n$ were used in equations (8), (9), and (10) to calculate two sets of values for $\tilde{P}$, $\tilde{Q}$ and $\tilde{V}_s$. Using each set of values thus obtained and the U.S. softwood price and supply data in equations (11), (12), (13), (14), and (15), producer and consumer surplus changes were calculated, respectively, for industrial corporate timberland owners, nonindustrial corporate owners, NIPF landowners, government, and consumers in the U.S. softwood markets for annual average and total landbase change rates during the study period. In the same way, hardwood prices and supply data were used to calculate producer and consumer surplus changes in the hardwood markets based on annual average and total landbase change rates during the study period.

2.2. Sensitivity Analysis

This article utilized elasticity estimates obtained from existing literatures. Missing price elasticity estimates for supply and demand were assumed to be similar to those for landowners with similar management regimes. One caution was that some estimates were dated and might not be appropriate for 2006. Furthermore, there was no literature on timber supply elasticities with respect to timberland area; hence, timber supply elasticities with respect to timber inventory were used assuming a direct linear relationship among timberland base, inventory, and timber supply. Finally, historical U.S. timber price data showed that, prices varied from state to state and region to region. For these reasons, a sensitivity analysis was necessary to examine the possible extent of changes in the surplus for landowners, consumers, and the society attributed to the changes in the elasticities and timber prices within their stochastic ranges.

There are several ways to perform sensitivity analysis on stochastic parameters. Sun and Kinnucan (2001) evaluated the welfare loss borne by southern landowners due to their conformity to environmental programs. They carried out a stochastic simulation to place 95% confidence intervals around mean welfare estimates for landowners. Brown and Zhang (2005) evaluated industrial landowner surplus loss attributed to their conformity to sustainable forestry initiative. Unlike Sun and Kinnucan (2001), Brown and Zhang (2005) increased and decreased elasticity estimates by 50% and examined the changes in surplus for different landowners.

In this article, a stochastic simulation was carried out to re-estimate the equations (11) through (15). The stochastic variables namely elasticity estimates and timber prices were simulated within their stochastic range and corresponding probability density functions for equations (11) through (15) were estimated. Each elasticity parameter was lowered by 25% of its exsiting or assumed value to obtain its lower bound for a simulation process. Similarly, it was raised by 25% to get the upper bound. These upper and lower bounds of the parameter formed the stochastic range for the parameter to vary in the simulation process. For timber prices, the stochastic range was defined by minimum and maximum average timber prices across the U.S. Each parameter estimate of elasticity and price was simulated with 10,000 iterations. Since timberland divestiture and timber supply data were collected directly from the 2006 markets, these were held constant while the sensitivity analysis was carried out.

3. Data and Data Sources

The article is based mainly on secondary data sources or existing literatures. The following subsections discuss in detail the type of data used in this article and their sources.

3.1. Timberland Ownership Changes Over Time

Boyd (2006) reported that industrial corporate timberland owners held 68 million ac of timberland in the U.S. in 1981. By 2005, their holdings dropped just to 21 million ac, a 69.1% reduction. In contrast, over the same period, the holdings of TIMOs and REITs grew from zero to over 25 million ac. By 2006, industrial corporate timberland owners had divested nearly 80% of their timberland holdings. Most of this is now owned by nonindustrial corporate owners (i.e., TIMOs and REITs). From 1987 through 2006, timberland ownership for industrial corporate landowners decreased by 68.73%, an annual average decrease of 3.44%. Similarly, the decrease of NIPF timberland ownership was 10.07% in total and 0.50% annually during the same period (Powell, Faulkner, Darr, Zhu, & MacCleery, 1993; Smith et al., 2010). Using this information and the relationship, $\tilde{L}_r = -(\tilde{L}_i l_i + \tilde{L}_n l_n)/l_r$, total and annual values of $\tilde{L}_r$ were estimated as 0.4802 and 0.0239, respectively.

3.2. Timber Prices

Factors like high fixed costs for forest industry equipments, and high transportation costs for bulky logs attributed to a few but large processing firms with oligopsonic to strong monopsonic power in purchasing domestic timber (Asinas, 2001; Mei & Sun, 2008). These factors suggest segregated regional timber markets with varying timber prices. Quarterly softwood and hardwood prices for 2006 were collected from Logprice.com (2010) and USDAFS (2010). Price data were collected for 25 states chosen from six different regions of the United States: Northeast, North Central, Southeast, South Central, Rocky Mountains, and Pacific Coast. Quarterly softwood prices for all four quarters of 2006 for a specific state were averaged to obtain the state simple average softwood price. Obtained in this way, the 25 state average prices were further averaged to obtain the U.S. simple average softwood price. The same process was followed to obtain the U.S. simple average hardwood price.

3.3. Timber Demand, Supply, and Inventory Elasticities

In addition to timber price, region-wise elasticity data were needed to complete the article. Elasticity values as obtained from existing literature varied widely from region to region within the United States. All available elasticity values for a specific landowner type and for a certain timber type were averaged to have a single elasticity measure for that owner and timber type. If only one elasticity value was available from the existing literature, it was directly adopted for this article. Table 1 gives the values of all elasticities and other parameters chosen or calculated to complete the EDM.

Table 1. Definitions of Parameters and Their Magnitudes by Timber Types in The U.S. Timber Markets from 1987 to 2006.

Parameter	Parameter descriptions	Timber types	
		Softwood	Hardwood
η	Demand elasticity of timber with respect to price	-0.45[a]	-0.24[a]
ε_i	Price elasticity of timber supply for IC [l] landowners	0.58[b]	0.43[c]
ε_r	Price elasticity of timber supply for NIC [m] landowners	0.55[d]	0.40[d]
ε_n	Price elasticity of timber supply for NIPF [n] landowners	0.24[e]	0.28[f]
ξ_i	Inventory elasticity of timber for IC landowners	0.70[g]	1.23[g]
ξ_r	Inventory elasticity of timber for NIC landowners	0.60[d]	1.00[d]
ξ_n	Inventory elasticity for NIPF landowners	0.75[h]	1.00[d]
l_i	Timberland share for IC landowners	0.04[i]	0.04[i]
l_r	Timberland share for NIC landowners	0.16[i]	0.16[i]
l_n	Timberland share for NIPF landowners	0.49[i]	0.49[i]
l_g	Timberland share for government	0.30[i]	0.30[i]
λ_i	Timber supply share for IC landowners	0.06[i]	0.06[i]
λ_r	Timber supply share for NIC landowners	0.21[i]	0.21[i]
λ_n	Timber supply share for NIPF landowners	0.64[i]	0.65[i]
λ_g	Timber supply share for government	0.09[i]	0.08[i]
$\tilde{L}_i$	Change rate of timberland base for IC landowners	-0.6873[j] -0.0344[k]	-0.6873[j] -0.0344[k]
$\tilde{L}_n$	Change rate of timberland base for NIPF landowners	-0.1007[j] -0.0050[k]	-0.1007[j] -0.0050[k]
$\tilde{L}_r$	Change rate of timberland base for NIC landowners	0.4802[j] 0.0239[k]	0.4802[j] 0.0239[k]

Notes: [a](Buongiorno, 1996); [b](Adams & Haynes, 1980), (Liao & Zhang, 2008), (Prestemon & Wear, 2000); [c](Newman & Wear, 1993); [d] assumed; [e](Adams & Haynes, 1980), (Adams, 1983), (Prestemon & Wear, 2000); [f](Newman & Wear, 1993); [g](Adams & Haynes, 1980), (Nagubadi & Munn, 2001); [h](Adams & Haynes, 1980); [i]calculated from real world data; [j]total change rate of timberland ownership from 1987 to 2006; [k]annual average change rate of timberland ownership in from 1987 to 2006; [l]IC = industrial corporate ; [m]NIC = nonindustrial corporate; [n]NIPF = nonindustrial Private Forest.

Demand elasticities for softwood and hardwood used in this article were -0.45 and -0.24, respectively (Buongiorno, 1996). Liao and Zhang (2008) estimated supply elasticities for industrial softwood sawtimber and industrial softwood pulpwood to be 0.70 and 0.90, respectively for U.S. South. Industrial pulpwood supply elasticities estimated by Prestemon and Wear (2000) was 0.66. Industrial softwood supply elasticity values as calculated by Adams and Haynes (1980) were 0.26, 0.39, 0.47, 0.99, and 0.32, respectively, for Pacific Southwest, South Central, Southeast, North Central, and Northeast regions. Based on these values, mean supply elasticity of industrial softwood was calculated as 0.58. Newman and Wear (1993) estimated supply elasticity for hardwood sawtimber and pulpwood as 0.27 and 0.58, respectively, for Southeast and their average value, 0.43, was taken for industrial hardwood supply elasticity. Private or NIPF softwood supply elasticity values were 0.12, 0.39, 0.30, and 0.31, respectively, for Pacific Southwest, South Central, Southeast, and North Central regions (Adams & Haynes, 1980). Again, private softwood supply elasticity values as calculated for the regions Western Washington, Northwest Oregon, and Southwest Oregon were 0.34, 0.18, and 0.15, respectively (Adams, 1983). Prestemon and Wear (2000) calculated NIPF pulpwood elasticity for U.S. to be 0.12. In this article, the NIPF softwood supply elasticity was 0.24, an average of all of these elasticity values. Newman and Wear (1993) estimated NIPF hardwood sawtimber and pulpwood as 0.22 and 0.33, respectively, and this article used the average, 0.28, for NIPF hardwood supply elasticity (Table 1). Currently, there is no literature on supply elasticity of nonindustrial corporate landowners timber supply. Since the timber management intensity maintained by this ownership type is similar to that of industrial owners, their timber supply elasticity was assumed to be closer to that of industrial owners. Thus, the softwood and hardwood supply elasticities from nonindustrial corporate owners were assumed to be 0.55 and 0.40, respectively (Table 1).

Adams and Haynes (1980) obtained 1.00, 0.46, 1.00, 0.41, 0.49, 0.20, and 0.37 as industry softwood inventory elasticities for the Pacific Northwest (west), Pacific Northwest (east), Pacific Southwest, South Central, Southeast, North Central, and Northeast regions, respectively. Nagubadi and Munn (2001) estimated inventory elasticities for hardwood sawtimber and pulpwood to be 1.65 and 1.87 for the South Central U.S.. Thus, the mean elasticity values for industry softwood and hardwood inventories were 0.70 and 1.23, respectively (Table 1). Adams and Haynes (1980) also estimated NIPF softwood inventory elasticities of 1.00, 1.00, 1.00, 1.00, 0.66, 0.72, 0.35, and 0.28, respectively, for Pacific Northwest (west), Pacific Northwest (east), Pacific Southwest, Rocky Mountain, South Central, Southeast, North Central, and Northeast regions. Thus, the average NIPF softwood inventory elasticity was 0.75 (Table 1). Hardwood inventory elasticity value for NIPF landowners, hardwood and softwood inventory elasticities of nonindustrial corporate owners were not readily available in any literature. As mentioned earlier, the timber management intensity maintained by nonindustrial corporate landowners was similar to that of industrial owners and thus, their inventory elasticity was assumed to be 0.60. Although inventory elasticity varies based on stand composition, and substitution between pulpwood and sawtimber harvesting (Brown & Zhang, 2005), the inventory elasticities were assumed *a priori* as approximately unitary (Hynes & Adams, 1985). Using this piece of information, inventory elasticities for NIPF hardwood, nonindustrial corporate softwood and hardwood were assumed to be 1.00 (Table 1).

3.4. Timberland and Timber Supply Shares for Different Landowners

Land shares (l's) for landowners were calculated from acreage of timberland owned by the landowners in 2006. Similarly, supply shares (λ's) were calculated from timber supplied by timberland owners in 2006. All share values are reported in Table 1.

4. Results

The following paragraphs discuss the extents of displacement of US timber markets resulted from industrial timberland divestitures.

4.1. Displacement of Timber Market Equilibrium

Annual average prices increased by 0.11% and 0.14%, respectively for softwood and hardwood (Table 2). This suggests that large scale timberland ownership change did not greatly impact timber prices in the U.S. timber markets. Initial and displaced quantities of softwood and hardwood timber supplies from different landowners are also presented in Table 2.

Table 2. Initial and Displaced Timber Prices and Timber Supply by Timber Types and Landownership Types in the United States in 2006.

Markets	Price			Supply			
	Initial [a] ($/MBF)	Displaced ($/MBF)	Change (%)	Landowners	Initial [b] (MMBF)	Displaced (MMBF)	Change (%)
Softwood	164.42	164.60	0.11	Public	10,289	10,289	0.00
				IC	6,583	6,429	-2.34
				NIC	25,134	25,510	1.50
				NIPF	76,300	76,034	-0.40
				All [c]	118,306	118,247	-0.05
Hardwood	201.53	201.82	0.14	Public	5,525	5,525	0.00
				IC	3,813	3,654	-4.17
				NIC	14,559	14,916	2.45
				NIPF	44,198	43,995	-0.53
				All [c]	68,095	68,071	-0.03

Notes: [a]Average U.S. timber prices available through Logprice.com (2010) and USDAFS (2010); [b]Modified from Smith et al. (2010); IC=Industrial-corporate owners; [c]Data may not add to total due to rounding; NIC=Nonindustrial corporate owners; NIPF=Nonindustrial private forest land owners; Price changes and supply changes are based on annual average timberland transactions from 1987 through 2006.

As expected, timber supply decreased from industrial corporate landowners and NIPF landowners and increased from nonindustrial corporate landowners. For softwoods and hardwoods, industrial corporate timber supply declined by 2.34% and 4.17%, respectively, and NIPF supply declined by 0.40% and 0.53%, respectively. On the contrary, nonindustrial corporate timber supply increased annually by 1.50% for softwood timber and 2.45% for hardwood.

4.2. Welfare analysis for base scenario

Producer surplus for industrial corporate landowners decreased by $1.75 million and $0.89 million in the softwood and hardwood markets, respectively. Thus, the total annual decrease in producer surplus for these landowners was $2.64 million. Over the entire divestiture period, industrial corporate landowners divested 68.73% of their total timberland. Given this landbase reduction, their producer surplus decreased by $27.18 million, $10.63 million, and $37.81 million, respectively, in the softwood, hardwood, and combined timber markets (Table 3).

Table 3. Changes in Producer, Consumer and Total Surpluses in U.S. Timber Markets Based on Total and Annual Average Timberland Ownership Change Rates From 1987 to 2006

Landbase change	Markets	Surplus change (million U.S. dollars) [a]						
		Producers					Consumers	Total [f]
		Public	IC [b]	NIC [c]	NIPF [d]	Net [e]		
Total	Softwood	37.46	-27.18	366.37	-396.93	-20.28	-428.61	-448.89
	Hardwood	32.10	-10.63	297.46	-201.43	117.50	-394.27	-276.77
	Both markets	69.56	-37.81	663.82	-598.36	97.22	-822.88	-725.67
Annual	Softwood	1.87	-1.75	15.99	-20.46	-4.35	-21.46	-25.81
	Hardwood	1.61	-0.89	12.09	-10.54	2.26	-19.79	-17.53
	Both markets	3.47	-2.64	28.08	-31.00	-2.09	-41.25	-43.34

Notes: [a]All values are based on 2006 timber prices and supplies; [b]IC=Industrial corporate landowners; [c]NIC=Nonindustrial corporate landowners; [d]NIPF=Nonindustrial private forest landowners; [e]Sum of all owners' producer surpluses; [f]Data may not add to total due to rounding.

Like industrial corporate landowners, NIPF landowners' land base reduction contributed to their surplus loss. In 2006, they owned the biggest share (49%) of timberland in the U.S. (Smith et al., 2010) and their timberland base was reduced from 283.56 million ac in1987 to 255 million ac in 2006 (Powell et al., 1993; Smith et al., 2010) with an annual decline of 0.50%. Thus, among all timberland owners, NIPF landowners faced the largest producer surplus losses. Given this average land-base reduction rate, their surplus declined by $20.46 million and $10.54 million, respectively, in the softwood and hardwood markets. Their total surplus loss, when softwood and hardwood markets were combined, approximated $31 million. When the total reduction of their timberland base from 1987 through 2006 (10.07% of their total land) was considered, their surplus reduction was $396.93 million in the softwood market, $201.43 million in the hardwood market, and $598.36 million in both markets (Table 3).

Nonindustrial corporate owners and government, on the contrary, experienced increased producer surplus. Based on annual average timberland purchase rate (2.39% of their total land), their producer surplus increased by $15.99 million and $12.09 million, respectively, in the softwood and hardwood markets. Their total gain in both markets was $28.08 million. When their total land increase rate (through purchase) from 1987 through 2006, 48.02%, was considered, their surplus increased by $366.37 million in the softwood market, $297.46 million in the hardwood market and $633.82 million in both markets (Table 3).

Although timber supply from public timberland was assumed constant over time, the government benefitted from higher timber prices. For annual average timberland transactions among other producers, the government surplus increased by $1.87 million, $1.61 million, and $3.47 million, respectively, in softwood, hardwood and both markets. For total timberland transactions among other landowners, government surplus increased by $37.46 million in the softwood market, $32.10 million in the hardwood market and $69.56 million in both market (Table 3). However, this increase in surplus is expected to be distributed back to the people of the United States.

Unlike the government, consumers faced reduced consumer surplus in timber markets. Their surplus reduction was $21.46 million in the softwood markets, $19.79 million in the hardwood markets and $41.25 million in both markets based on annual average rate of timberland transactions among landowners. When total land transactions were considered, their consumer surplus decreased by $428.89 million, $394.27 million and $725.67 million, respectively, in softwood, hardwood, and combined markets (Table 3). However, this reduction is a little smaller than calculated since the government surplus gains are eventually distributed back to the consumers. Since the government's surplus increased by $69.56 million from both markets, the actual reduction of the consumer surplus loss is reduced from $725.67 million to $656.09 million.

Total surplus decreased primarily due to the reduction in timber supply. This reduction was attributed to net reduction of the timberland base through nonforestry uses of timberland (HBUs) and reduced timber supply from conservation groups. Based on the annual average timberland transaction rate, total surplus reductions were $25.81 million, $17.53 million, and $43.34 million, respectively, in softwood, hardwood and both markets. When total land transactions among all landowners were considered, total surplus decreased by $448.89 million in the softwood market, $276.77 million in the hardwood market, and $725.67 million in both markets (Table 3).

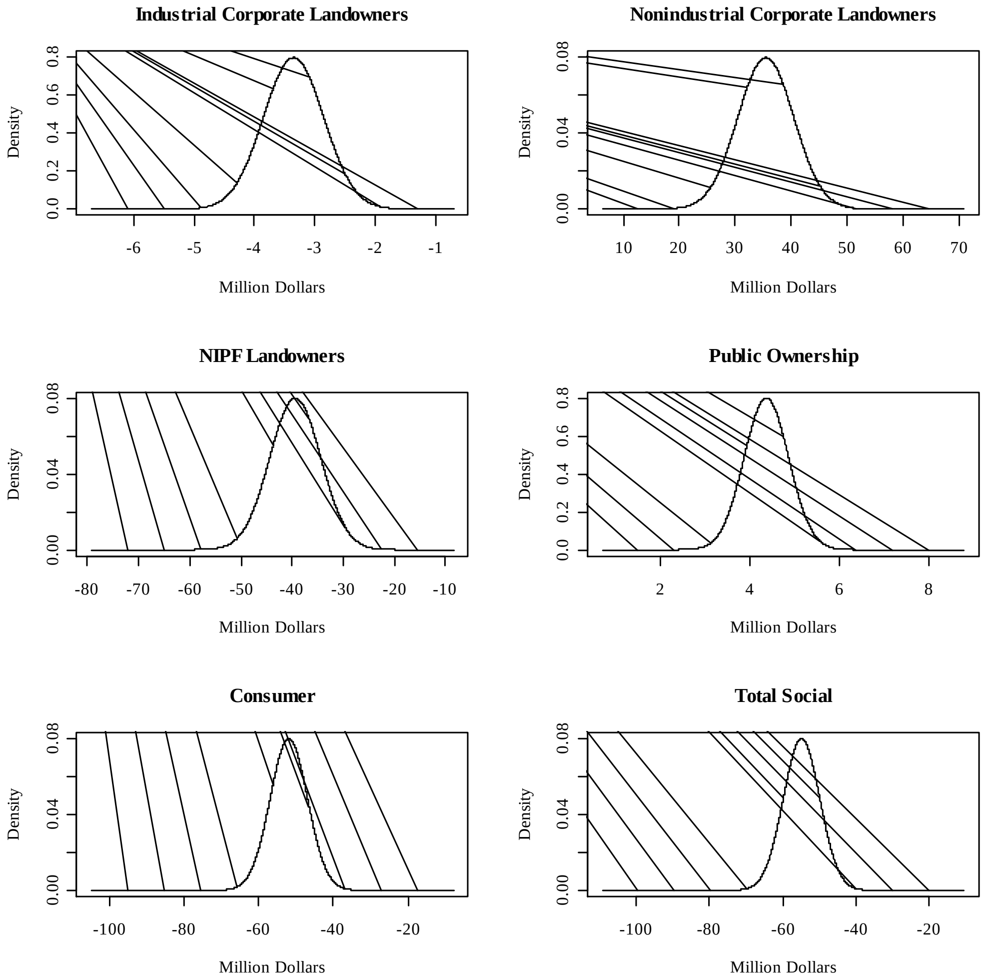

Figure 1. Probability density functions for changes in producer, consumer and social surplus (million U.S. dollars) in U.S. timber markets due to timberland ownership changes.

4.3. Sensitivity Analysis Results

Results of the sensitivity analysis are presented in Figures 1 and 2. Changes are estimated based on annual average acreage of timberland transacted among landowners from 1987 to 2006, 2006 timber supplies (MMBF), and timber prices (dollars per MBF). Values on the horizontal axes indicate 95% confidence intervals around the means of the surplus changes for respective parties. When stochastic parameters were simulated, the absolute mean values of producer (as a group) surplus, consumer surplus and total surplus increased by 43%, 26%, and 26%, respectively, compared to the original absolute surplus change in combined hardwood and softwood timber markets based on annual average land transactions. Since the prices and elasticities were set to their upper and lower bounds in the simulation processes, the values of the surplus changes also tended to follow upper and lower bounds of the stochastic variables which ultimately increased the absolute mean values of the surplus changes for producers, consumers, and the society. Similarly, for total land transactions, the absolute mean for producer surplus increased by 15% and both consumer and producer surpluses by 26%, when compared to the original absolute surplus changes.

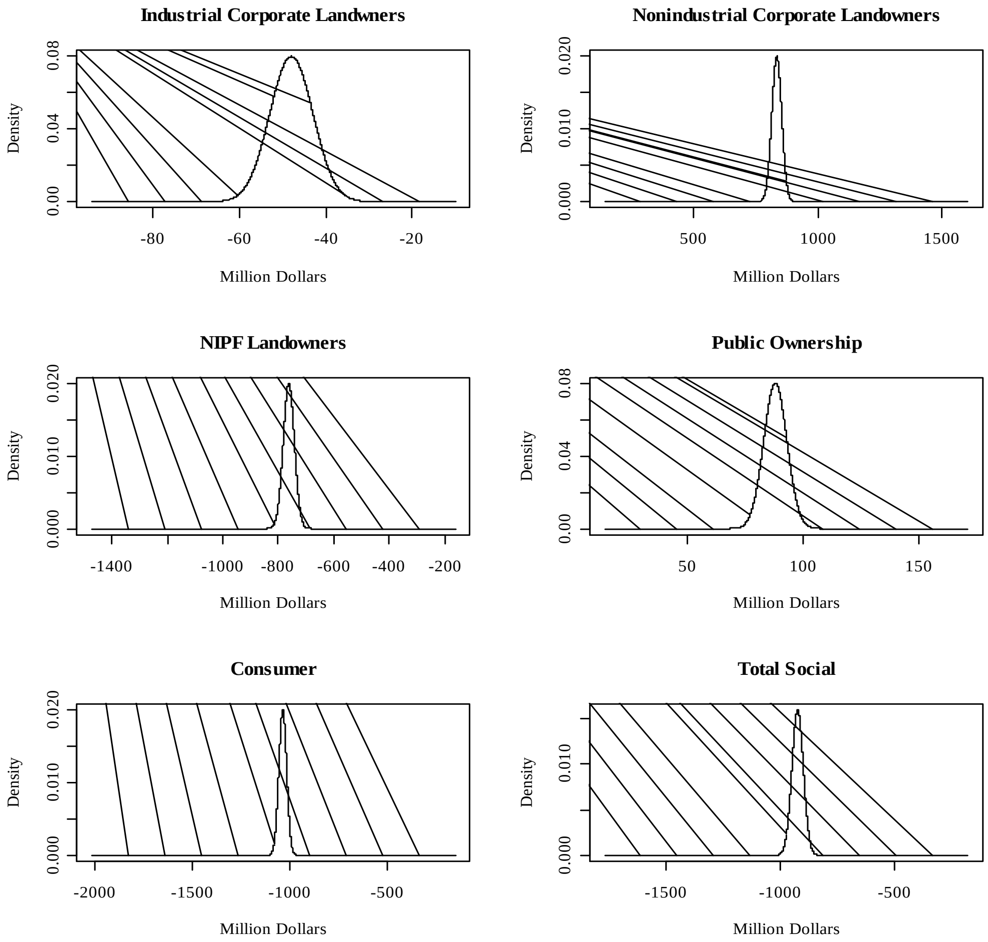

Figure 2. Probability density functions for changes in producer, consumer and social surplus (million U.S. dollars) in U.S. timber markets due to timberland ownership changes.

Based on annual average timberland transactions, surplus change for producers as a group, consumers, and society as a whole ranged between -$12.8 and $5.4 million, -$12.8 and $5.4 million, and -$109.4 and -$10.3 million, respectively (Figure 1). For total land transactions, surplus changes varied between -$112 and $369 million for the producer group, -$2019 and -$145 million for consumers, and -$1772 and -$175 million for society (Figure 2).

5. Discussion and Conclusions

This article examined economic surplus changes borne by timberland owners and consumers due to changes in timberland ownership from 1987 through 2006. For many reasons including a double tax burden, industrial corporate timberland owners sold about 70% of their timberland during this period. After industrial timberlands were divested, the industry share of timber supply reduced considerably. Nonindustrial corporate landowners' share of timber supply increased since they acquired most of the divested industrial timberland. NIPF supply share decreased since NIPF timberland base decreased from 283.56 million ac in 1987 to 255.00 million ac in 2006 (Powell et al., 1993; Smith et al., 2010). Some timberland went out of timber production as HBU parcels. This resulted in a net decrease in timber supply in the U.S. timber markets and increased timber prices. These two effects together changed the economic surpluses of all parties involved in timber markets. Producer surplus for industrial corporate landowners and NIPF landowners decreased after they divested their timberlands. Producer surplus for nonindustrial corporate landowners, on the other hand, increased as they increased their timberland holdings.

Producer surplus for nonindustrial corporate landowners increased for two reasons: (1) their timberland base increased considerably through land purchases which increased their timber supply and, (2) increased timber prices due to a net decrease in timber supply to the U.S. timber markets. Although timber supply from public ownership was assumed constant during the study period, producer surplus share for government increased due to increased timber price. Consumers were adversely affected due to increased timber prices and they faced the largest consequences among all involved in the timber markets. Their surplus was reduced by a large margin due to increased timber price. However, the consumers were expected to gain a little more social welfare through the increased surplus earned by the government. Overall, the social surplus decreased due to net reduction in timber supplies. This reduction is attributed to reduction of timberland base through nonforestry uses of timberlands and a reduced timber supply held back from the markets by conservation groups since their primary objective of owning timberland is environmental conservation.

The overall impact of timberland ownership change on U.S. timber markets was small. The price increase over the 20 year divestiture period was $3.64 per MBF (i.e., $0.18 per MBF per year) for softwoods and $5.81 per MBF (i.e., $0.29 per MBF per year) for hardwoods. Based on total acreage of timberland transactions among landowners over the divestiture period, timberland ownership change did cost society about $726 million as total social surplus reduction. Based on the 2006 U.S. average softwood and hardwood prices and timber supply data (Smith et al., 2010), the U.S. timber market was an estimated $33.3 billion in 2006. Total social surplus decreased by about $43 million in the same year. Thus, the social surplus reduction was quite small compared to total timber market size.

This article explained the mechanism of surplus shifts among producers and consumers, and quantifies the surplus changes for each of the landowner groups attributed to timberland ownership changes in the U.S. from 1987 to 2006. It also evaluated how consumers and the society face financial consequences for timberland ownership changes. Government might lose tax income since timberland holdings were transferred to TIMOs and REITs who were required to pay significantly lower tax rates than their industrial counterparts. However, lower tax rate together with increased timber price raised the producer surplus in the US timber markets. However, this article has not investigated the balance between the gains and losses of the parties involved in timberland transactions. It is a step forward to justify industrial timberland divestiture decisions.

In comparison to the potential benefits from divesting industrial timberlands, the reduction in industrial producer surplus is presumably trivial. A double tax burden on timber profits, poor shareholder returns, and interest on loans were some of the financial liabilities being incurred by corporate timberland owners that led them to divest their timberlands. Through divestiture of these lands, they rid themselves of these burdens. Potential benefits from divesting timberlands include profits from timberland sales, avoidance of double taxation, and increased capital availability. However, these options were not taken into consideration in this article. The economic surplus losses for industrial corporate owners were generated solely by reduction of timberland base of these owners through divestitures. Further investigations may be carried out to include all of these factors to pinpoint clearly whether or not it was financially a better option for the industrial corporate timberland owners to divest their timberlands.

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