Welfare implications of tax driven industrial timberland ownership change on U.S. timber markets

Mohammad Mahfuzur Rahman[1], Ian A. Munn[2], Changyou Sun[3]

Abstract

In the last two decades, many firms in the U.S. forest products industry have 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 were believed to have consequences on the welfare (i.e. economic surplus) shares of producers and consumers in the U.S. timber markets. This issue has not been adequately addressed in existing literature. Equilibrium displacement models were employed to address welfare implications in U.S. timber markets attributed to timberland ownership changes. Due to the net reduction of timber supply, total social welfare decreased by $43 million in 2006. Compared to over $33 billion U.S. timber markets, this welfare reduction was quite small. This study thus helps justify timberland divestiture decisions of industrial timberland owners, and understand the shifts of welfare share among producers and consumers when timberlands change hands.

Keywords: Divestiture; EDM; REITs; surplus; TIMOs

---

[1] Graduate Research Assistant, Department of Forestry, Mississippi State University, Phone: (662) 769-3014, email: mahfuzusa@yahoo.com

[2] Professor, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762, Phone: (662) 325-4546, email: imunn@cfr.msstate.edu

[3] Associate Professor, Department of Forestry, Mississippi State University, Box 9681, Mississippi State, MS 39762, Phone: (662) 325-7271, email: csun@cfr.msstate.edu

Introduction

Since the late 1980s and early 1990s, there has been an unprecedented change of industrial timberland ownership in the United States. Primary sellers were industrial corporate (IC) landowners (traditionally known as vertically integrated forest products firms) and the largest identifiable group of buyers was timber investment management organizations (TIMOs). Both buyers and sellers of timberlands had grounds for selling and buying timberlands. Primary factors for selling timberlands include poor shareholder returns, debt reduction through the sale of timberland assets, increased tax efficiency through the movement to more efficient tax structures such as real estate investment trusts (REITs), and decreased insurance values of internal timber supplies attributed to mature timber markets (Hickman 2007; Rogers and Munn 2003; Yin et al. 1998). The reasons for buying timberlands by TIMOs and other private organizations were favorable returns and low risk, and timberland values, apparent correlation with inflation thus providing a 'hedge' against inflation (Clutter et al. 2007). Since timberland investments were attractive to nonindustrial corporate (NIC) landowners (i.e., REITs, TIMOs), their investment in timberland increased considerably over this period. Investment in timberland by institutional investors in the U.S. has grown from just under $1 billion in 1985 to $4 billion in 1995, $12 billion in 2003 (Li and Zhang 2007) and $15 billion in 2005 (Clutter et al. 2007).

There is one major difference between IC timberland owners and TIMOs/REITs with regard to tax treatment of timberlands and timber. IC timberland owners are usually classified as Sub-chapter C corporations, and any profits obtained from timber sale are taxed twice – once at the corporate level (usually 35%), and once at the stockholder level when dividends are disbursed (usually 15%). The practical effect of this tax policy is that shareholders of IC landowners can recoup as little as 50% out of every dollar of profit made from a timber sale. In contrast, shareholders of NIC landowners can normally retain about 85% of the profit from timber sales with a 15% tax rate (Block and Sample 2001; Clutter et al. 2007; Hagan et al. 2005; Siegel 2004). As a result, income taxation law has become one of the major driving forces behind timberland sales since the late 1980s and early 1990s. Presumably, this shift in timberland ownership has considerable consequences on stakeholder welfare (i.e., producer and consumer surplus) in U.S. timber markets. Previously, one perceived benefit of owning timberland for a forest products firms was guaranteed timber supplies for their mills. Nonetheless, from the perspective of NIPF landowners, there has been wide concern that internal timber supplies by forest products firms may have negative impacts on timber markets and NIPF landowner welfare (Murray 1995).

Past studies analyzed various issues related to taxation laws (Daughtrey et al. 1987; Sun 2007). For example, Boyd and Daniels (1985a) applied a General Equilibrium Model (GEM) to examine income taxation in forestry. Welfare losses generated by preferential capital gains treatment of timber were much greater than previously imagined. Federal taxation laws applicable to IC timberland owners were one of the major forces pushing them to divest their timberlands. About 37 million acres of timberland was sold between 1981 and 2005. Of this, 15 million acres were sold to TIMOs, 10 million acres to conservation groups, 10 million acres to publicly traded REITs and master limited partnerships (MLPs), and 2 million acres to private forest product companies (Boyd 2006; Hickman 2007).

Large-scale timberland ownership change gave rise to a net reduction in the timber production base. Conservation groups purchased a considerable acreage of timberland and their main objective was environmental conservation rather than timber production. Reduced management intensity for timber production on these lands would reduce timber supply. Also, all timberland owners, including industrial owners and TIMOs, sold tracts that had higher values in other uses such as urban development. These tracts were converted to higher and better uses (HBUs) like house building or urban sprawling. Most lands used for rapidly increasing urban sprawl came from forest land (LaGro and DeGloria 1992). One of the major non-forestry conversions of timberland is real estate development which captured higher land prices (Zinkhan 1993). Thus, the U.S. timber markets suffered a two-way timber supply reduction: (1) reductions to the timberland base through conversion of timberland to HBUs and (2) a reduced supply from land acquired by conservation agencies. This study was designed to address the extent of timber market equilibrium displacement (i.e., displacement of timber price and quantity supplied) and to evaluate its subsequent impact on the welfare shares of producers and consumers in the U.S. timber markets.

Methods

To address the above research issues, an equilibrium displacement model (EDM) was used. EDMs have been widely used to estimate the displacement of market equilibrium caused by external shocks such as adoption of a new policy or imposition of environmental regulations on forest resource use. Displacements of price and quantity as measured by EDMs can be used to estimate the welfare changes for consumers and producers in the market. Thus, EDMs are hailed as a powerful methodology for welfare analysis. Several studies (Boyd and Daniels 1985b; Brown and Zhang 2005; Sun 2006; Sun and Kinnucan 2001) were carried out using EDMs to determine impacts of law and policy shocks on timber markets.

Conceptual Model

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:

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

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

The model is constructed based on following assumptions: (i) timber supply by public ownership is constant over the study period; (ii) timber supply shift is upward and parallel; (iii) supply shift is caused by two different factors - conversion of timberlands to HBUs, and less intensive timber management by conservation groups; (iv) timberlands converted to HBUs constitutes a small percentage of total timberland base; (v) timberland management regimes under corporate industrial owners and REIT and TIMO ownerships were similar; (vi) there is no demand shock over the study period; (vii) timber market is competitive and a common timber price prevails in a certain regional market; (viii) timber economy is closed, i.e., it does neither import nor export timber; and (ix) there is a direct linear relationship between the size of the landbase, and inventory and timber supply although this may only be true in the short run. Assumption (ix) enables using inventory elasticities in this study and deducing following relationship between timberland base (L) and corresponding timber inventory (I) for owners $m\,(=i,n,r,g)$.

$$L_m = tI_m$$

$$dL_m = tdI_m$$

The equation system [1] through [6] can be totally differentiated as follows.

[1a] $\tilde{Q}_i = \varepsilon_i \tilde{P} + \xi_i \tilde{L}_i$

[2a] $\tilde{Q}_n = \varepsilon_n \tilde{P} + \xi_n \tilde{L}_n$

[3a] $\tilde{Q}_r = \varepsilon_r \tilde{P} + \xi_r \tilde{L}_r$

[4a] $\tilde{Q}_s = \lambda_i \tilde{Q}_i + \lambda_n \tilde{Q}_n + \lambda_r \tilde{Q}_r + \lambda_g \tilde{Q}_g$

[5a] $\tilde{Q}_d = \eta \tilde{P}$

[6a] $\tilde{Q}_d = \tilde{Q}_s$

The variables with tildes indicate percentage changes in those variables. For example, $\tilde{L}_i$ equals the remaining industrial timberland acreage after divestiture minus the original timberland acreage before divestiture divided by the timberland before divestiture. The symbols ε's, ξ's, and η are supply, inventory and demand elasticities, respectively, and λ_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}). These parcels went out of timber production. Thus the 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 it was assumed that $l_{HBU} = 0$. Even though substantial acreage 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,

$$\tilde{L}_i l_i + \tilde{L}_n l_n + \tilde{L}_r l_r = 0$$

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

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

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

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

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

Substituting [8] into [5[a]] and solving for $\tilde{Q}$,

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

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, vertical shift of price in supply is needed. 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), vertical shift in supply was calculated with equation [10].

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

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

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

[12] $$\Delta PS_r = P^0 Q_r^0 (1 + \frac{1}{2}\tilde{Q}_r)(\tilde{P} + V_s)$$

[13] $$\Delta PS_n = P^0 Q_n^0 (1 + \frac{1}{2}\tilde{Q}_n)(\tilde{P} - V_s)$$ [Following equation 11]

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

[15] $$\Delta CS = -P^0 Q^0 \tilde{P} (1 + \frac{1}{2}\tilde{Q})$$

U.S. average timber prices and timber supplies in 2006 were used in this study. Displacements of timber prices in softwood and hardwood markets were calculated using equation [8]. Similarly, the overall displacements of equilibrium quantity of hardwood and softwood supply were calculated using equation [9]. Utilizing parameter values reported in Table 2 in equations [11], [12], [13], and [15], welfare changes (i.e., producer and consumer surplus changes) were calculated, respectively, for IC, NIC, NIPF landowners, government, and consumers in softwood and hardwood markets of the U.S. Welfare changes were estimated based on average annual and total size of timberland ownership change from 1987 through 2006.

Welfare changes were estimated based on annual and total ownership changes and are reported in Table 4.

Sensitivity analysis

Since elasticity parameters used in this study were calculated or assumed based on existing literature and timber prices used were not zone-specific, a sensitivity analysis for the elasticities and timber prices was necessary to examine the extents of possible welfare changes for landowners, consumers, and society. There are several ways to perform sensitivity analysis on stochastic parameters. Sun and Kinnucan (2001) carried out a stochastic simulation to place 95% confidence intervals around mean welfare loss borne by southern landowners due their conformity to environmental regulations. In a similar study, Brown and Zhang (2005) increased and decreased elasticity estimates by 50% and examined the changes in welfare range for forest industrial landowners due their conformity to SFI.

In this study, a stochastic simulation was carried out on elasticity estimates and timber prices. Each elasticity parameter was lowered by 25% of its estimated value to obtain its lower bound for a simulation process. Similarly, it was raised by 25% to get the upper bound. The 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 2006 real world markets, these were held constant while the sensitivity analysis was carried out.

Data and data sources

Total and annual average changes of timberland ownership over time

Approximately two thirds of the total forest land in the U.S. are timberland (Fiacco 2011). By 2006, U.S. timberland totaled 517 million acres. Since the late 1980s and early 1990s, there have been large-scale timberland transactions. Rinehart (2001) reported that about 20 million acres of timberlands were divested from 1989 to 2001. Of this, IC timberland owners divested 15.9 million acres accounting for 79.5% of the total acres sold during this period. Boyd (2006) reported that IC timberland owners held 68 million acres of timberland in the U.S. in 1981. By 2005, their holdings dropped just to 21 million acres, 69.1% reduction. In contrast, over the same period, the holdings of TIMOs and REITs grew from just zero to over 25 million acres. By 2006, IC timberland owners had divested nearly 80% of their timberland holdings. Most of this is now owned by NIC landowners (Smith et al. 2010).

As reported in Table 1, from 1987 through 2006, timberland ownership for IC landowners decreased by 68.73%, an average annual decrease of 3.44%. Similarly, the decrease of NIPF timberland ownership was 10.07% in total and 0.50% annually during the same period. Using this information and $\tilde{L}_r = -(\tilde{L}_i l_i + \tilde{L}_n l_n) / l_r$, total and annual values of $\tilde{L}_r$ were estimated to be 0.4802 and 0.0239, respectively.

Table 1. Chronological patterns of timberland ownership in millions of acres by IC landowners (IC), nonindustrial private forest landowners (NIPF) and the public ownership in the United States from 1952 to 2006 and total and annual percentage change rate of timberland ownership from 1987 to 2006.

Owners	Years						Total Change	Annual change
	1952[a]	1962[a]	1977[a]	1987[a]	1992[a]	2006[b]	1987-2006	1987-2006
IC	58.98	61.43	68.94	70.35	70.46	22.00	-68.73%	-3.44%
NIPF	304.44	307.53	285.25	283.56	287.61	255.00	-10.07%	-0.50%
Public	145.45	146.16	138.17	151.03	131.49	156.00	3.29%	0.16%
Total	508.87	515.12	492.36	504.94	489.56	433.00	-10.71%	-0.54%

[a] Powell et al. (1993); [b] Smith et al. (2010).

Timber prices

2006 quarterly prices for softwood and hardwood were collected from multiple online sources accessed through Logprice.com (2010) and USDAFS (2010). Price data were collected for 50% of the states (i.e., 25 states) randomly chosen from six different zones of the United States: Northeast (NE), North Central (NC), Southeast (SE), South Central (SC), Rocky Mountains (RM) and Pacific Coast (PC). Softwood prices for all four quarters of 2006 for a specific state were averaged to obtain the state simple average softwood price for that state. 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.

Demand elasticities

Elasticity values were obtained from the literature. Where more than one value was available, elasticities were averaged to generate one elasticity measure for each owner and timber type. Table 2 depicts the values of all elasticities and other parameters used in this study. Demand elasticities for softwood and hardwood used in this study were -0.45 and -0.24, respectively (Buongiorno 1996).

Supply elasticities

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) and were 0.26, 0.39, 0.47, 0.99, and 0.32, respectively, for the PSW, SC, SE, NC, and NE regions. Based on these values, mean supply elasticity of industrial softwood was calculated to be 0.58. Newman and Wear (1993) estimated supply elasticity for hardwood sawtimber and pulpwood to be 0.27 and 0.58, respectively, for the SE 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 the PSW, SC, SE, and NC (Adams and Haynes 1980). Again, private softwood supply elasticity values as calculated for the regions WW, NOW, and SWO 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 study, 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 study used the average, 0.28, for NIPF hardwood supply elasticity (Table 2). Currently, there is no literature on supply elasticity of NIC landowner timber supply. Since the timber management intensity maintained by this ownership type was similar to industrial owners, their timber supply elasticity was assumed to be closer to that of industrial owners. Thus, the softwood and hardwood supply elasticities from NIC owners were assumed to be 0.55 and 0.40, respectively (Table 2).

Table 2. Estimated or assumed values of elasticity parameters, landbase change rates from 1987 to 2006, land acreage shares, and timber supply shares by timber types and landownership types in 2006 in the United States.

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]	-0.6873[j]
		-0.0344[k]	-0.0344[k]
$\tilde{L}_n$	Change rate of timberland base for NIPF landowners	-0.1007[j]	-0.1007[j]
		-0.0050[k]	-0.0050[k]
$\tilde{L}_r$	Change rate of timberland base for NIC landowners	0.4802[j]	0.4802[j]
		0.0239[k]	0.0239[k]

[a](Buongiorno 1996); [b](Adams and Haynes 1980), (Liao and Zhang 2008), (Prestemon and Wear 2000); [c](Newman and Wear 1993); [d] assumed; [e](Adams and Haynes 1980), (Adams 1983), (Prestemon and Wear 2000); [f](Newman and Wear 1993); [g](Adams and Haynes 1980), (Nagubadi and Munn 2001); [h](Adams and 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;

Inventory elasticities

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 PNWW, PNWE, PSW, SC, SE, NC, and NE, respectively. Nagubadi and Munn (2001) estimated inventory elasticities for hardwood sawtimber and pulpwood to be 1.65 and 1.87 and for the SC region. Thus the mean elasticity values for industry softwood and hardwood inventories were 0.70 and 1.23, respectively (Table 2). 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 PNWW, PNWE, PSW, RM, SC, SE, NC, and NE regions. Thus the average NIPF softwood inventory elasticity was 0.75 (Table 2). Hardwood inventory elasticity value for NIPF, hardwood and softwood inventory elasticities of NIC owners were not readily available in any literature. As mentioned earlier, the timber management intensity maintained by NIC landowners was similar to industrial landowners and thus, their inventory elasticity was assumed to be close to that of IC landowners, 0.60. Although inventory elasticity varies based on stand composition, and substitution between pulpwood and sawtimber harvesting (Brown and Zhang 2005), the inventory elasticities were assumed *a priori* as approximately unitary (Hynes and Adams 1985). Using this piece of information, inventory elasticities for NIPF hardwood, NIC hardwood were assumed to be 1.00 (Table 2).

Timberland and timber supply shares for different landowners

Estimation of inventory elasticities to be used in the study was followed by estimation of timberland and timber supply shares for each owner. Timberland shares (l's) were calculated from acreage of timberland owned by different owners in 2006. Similarly, supply shares (λ's) were calculated from timber supplied by different timberland owners in 2006. All these share values are reported in Table 2.

Results

Displacement of timber market equilibrium

Softwood and hardwood price increases were 0.11% and 0.14%, respectively (Table 3). Initial and displaced quantities of softwood and hardwood timber supply from different landowners are also presented in Table 3. As expected, timber supply decreased from IC landowners and NIPF landowners and increased from NIC owners. For softwoods and hardwoods, IC timber supply declined by 2.34% and 4.17%, respectively, and NIPF supply declined by 0.40% and 0.53%, respectively, on average annual landownership change basis. On the contrary, NIC timber supply increased annually by 1.50% for softwood timber and 2.45% for hardwood timber based on average annual landownership change.

Table 3. Initial and landownership changes driven displaced timber prices (U.S. dollar per MMBF) and timber supply (thousand MMBF) by timber product types and landownership types in the United State in 2006. Price changes and supply changes are based on annual average timberland transactions from 1987 through 2006.

Markets	Price			Landowners	Timber supply		
	Initial [a]	Displaced	Change		Initial [b]	Displaced	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 owners [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 owners [c]	68,095	68,071	-0.03%

[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; 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; [c] data may not add to total due to rounding.

Welfare analysis

Base scenario

Based on annual average timberland sale rate (3.44% of their total land), producer surplus for IC landowners decreased, by $1.75 million, $0.89 million, and $2.64 million, respectively, in softwood, hardwood markets, and both markets. Over 1987 to 2006, IC landowners sold off 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 4). Like industrial corporate landowners, NIPF landowner land base reduction contributed to their surplus loss. Among all timberland owners, NIPF landowners faced the largest welfare losses. 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 their total timberland base reduction (10.07% of their total land) was considered, their welfare reductions were $396.93 million, $201.43 million, and $598.36 million, respectively, in the softwood, hardwood, and both markets (Table 4).

Table 4. Changes in producer, consumer, and total welfare (surplus) in U.S. timber markets based on total and annual average timberland ownership change rate from 1987 through 2006.

Landbase change	Markets	Surplus change (million U.S. dollars) [b]						
		Producer [a]					Consumer	Total [c]
		Public	IC	NIC	NIPF	Net		
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	633.82	-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

[a] IC=IC landowners; NIC=NIC landowners; NIPF=nonindustrial private forest landowners; [b] all values are based on 2006 timber prices and supplies; [c] data may not add to total due to rounding.

Since NIC landowner timberland share increased annually by 2.39%, 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 4). Although timber supply from public timberland was assumed constant over time, the government benefitted from higher timber prices. For average annual 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 4).

Unlike the government, consumers faced reduced consumer surplus in timber markets. Their welfare 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 4). Based on annual average timberland transaction rate, total social welfare 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 social welfare decreased by $448.89 million in the softwood market, $276.77 million in the hardwood market, and $725.67 million in both markets (Table 4).

Sensitivity results

Results of the sensitivity analysis of welfare (i.e., surplus) estimates for producers and consumers are presented in Table 5. 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 timber markets based on annual average land transactions. For total land transactions, the absolute mean for producer surplus increased by 15% and both consumer and producer surplus by 26%, when compared to the original absolute surplus changes.

Table 5. Sensitivity of changes in producer, consumer and total surplus in U.S. timber markets based on total and annual average timberland ownership change rates from 1987 through 2006.

Landbase Change	Markets	Surplus change (million U.S. dollars) [a]						
		Producer [b]					Consumer	Total [c]
		Public	IC	NIC	NIPF	Net		
Total	SW	48.62	-35.13	473.67	-514.26	-27.10	-555.58	-582.68
		(6, 106) [d]	(-78, -5)	(62, 1030)	(-1138, -67)	(-130, 43)	(-1210, -71)	(-1282, -75)
	HW	38.97	-12.70	357.81	-245.22	138.86	-477.41	-338.54
		(-16, 106)	(-34, 5)	(-148, 975)	(-678, 98)	(-59, 386)	(-1300, 193)	(-932, 133)
	Both	87.59	-47.83	831.48	-759.49	111.76	-1032.98	-921.22
		(14, 171)	(-94, -10)	(137, 1607)	(-1472, -160)	(-112, 369)	(-2019, -145)	(-1772, -175)
Annual	SW	2.43	-2.28	20.82	-26.67	-5.70	-27.92	-33.62
		(0.3, 5.4)	(-5.1, -0.3)	(2.8, 46.2)	(-59.4, -3.5)	(-14.4, -0.5)	(-61.8, -3.7)	(-74.9, -4.4)
	HW	1.94	-1.08	14.60	-12.75	2.71	-23.89	-21.18
		(-0.8, 5.4)	(-3.0, 0.4)	(-5.7, 40.6)	(-35.6, 5.0)	(-1.0, 8.8)	(-66.1, 9.3)	(-58.9, 8.2)
	Both	4.37	-3.36	35.41	-39.42	-2.99	-51.81	-54.80
		(0.7, 8.8)	(-6.7, -0.7)	(6.2, 70.9)	(-79.2, -8.4)	(-12.8, 5.4)	(-104.7, -7.8)	(-109.4, -10.3)

[a] All values are based on 2006 timber price and supply; [b] SW=Softwood market; HW=Hardwood market; IC=IC landowners; NIC=NIC landowners; NIPF=Nonindustrial private forest landowners; [c] Data may not add to total due to rounding; [d] Values in the parentheses are the 95% confidence intervals around respective means;

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. 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.

Discussion and conclusions

This study quantitatively examined the welfare consequences borne by timberland owners and consumers for changes in timberland ownership from 1987 through 2006. Producer surplus for NIC owners 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 net decrease of timber supply by all owners. Although timber supply from public ownership was assumed constant during the study period, government welfare share increased due to increased timber price. Although consumers were not any part of timberland ownership changes, they were adversely affected due to increased timber prices and they faced the largest consequences among all involved in the timber markets. Their surplus reduced by a large margin due to increased timber price increased. Although producer surplus increased for some landowners (NIC timberland owners and public ownership), decreased for some landowners (CI timberland owners, NIPF landowners), consumer surplus decreased, overall social welfare decreased due to net reduction in timber supply in U.S. timber markets. 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 was nominal on the U.S. timber market. The price increase over the 20 year divestiture period was $3.64 per MMBF (i.e., $0.18 per MMBF per year) for softwoods and $5.81 per MMBF (i.e., $0.29 per MMBF 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 in total social surplus reduction. Based on the 2006 U.S. average for softwood and hardwood prices and timber supply data (Smith et al. 2010), the U.S. timber market size was estimated as $33.3 billion in 2006. And, estimated total social welfare reduction was about $43 million in the same year. Thus, the social welfare reduction was quite small compared to total timber market size.

This study explains the mechanism of welfare shifts among producers and consumers, and quantifies welfare changes for each of the landowners attributed to timberland ownership changes in the U.S. It also evaluates how consumers and society face consequences for timberland ownership changes. While government loses tax income for timberlands being owned by S corporations like TIMOs and REITs, it earns a positive producer surplus change due to higher timber price. However, this study has not investigated the balance between the two. It is a step forward to justify industrial timberland divestiture decisions. Although IC timberland owners divested timberland and faced reduction in producer surplus, the reduction is presumed to be trivial compared to the potential benefits from divesting industrial timberlands such as profits from timberland sales, avoidance of double taxation, increased capital, and debt reduction. However, these options were not investigated in this study. Further investigations may be carried out to include all of these factors to further resolve the issue of whether industrial timberland divestiture was at all a profitable option for IC timberland owners.

References

Adams, D.M. 1983. An approach to estimating demand for national forest timber. For. Sci. **29**(2): 289-300.

Adams, D.M., and Haynes, R.W. 1980. The 1980 softwood timber assessment market model: structure, projections, and policy simulations. For. Sci. Monogr. **22**: 1-64.

Block, N.E., and Sample, V.A. 2001. Industrial timberland divestiture and investment: opportunities and challenges in forestland conservation. Pinchot Institute for Conservation, Washington, D.C.

Boyd, G.P. 2006. Corporate forest land divestiture: issues & opportunities for companies and communities. International Paper.

Boyd, R., and Daniels, B.J. 1985a. Capital gains treatment of timber income: incidence and welfare implications. Land Econ. **61**(4): 354-362.

Boyd, R., and Daniels, B.J. 1985b. Capital Gains Treatment: of Timber Income: Incidence end Welfare Implications. Land Econ. **61**(4): 354-362.

Brown, R., and Zhang, D. 2005. The Sustainable Forestry Initiative's impacts on stumpage market in the US South. Can. J. For. Res. **35**(8): 2056-2064.

Buongiorno, J. 1996. Forest sector modeling: a synthesis of econometrics, mathematical programming, and system dynamics methods. Int. J. Forecast. **12**: 329-343.

Clutter, M., Mendell, B., Newman, D., Wear, D., and Greis, J. 2007. Strategic factors driving timberland ownership changes in the U.S. South. Southern Region State and Private Forestry and The Southern Research Station.

Daughtrey, Z.W., Bunn, R., and Martin, R.J. 1987. The impacts of the Tax Reform Act of 1986 on individual timber producers. J. Agric. Tax. Law **9**(2): 234-253.

Fiacco, J.B. 2011. National forest harvest. Available from http://thetimberlandblog.blogspot.com/2010/01/national-forest-harvest.html [accessed 01 January 2011].

Hagan, J.M., Irland, L.C., and Whitman, A.A. 2005. Changing Timberland Ownership in the Northern Forest and Implications for Biodiversity. Manomet Center for Conservation Sciences, Report # MCCSFCP-2005-1, Brunswick, Maine.

Hickman, C. 2007. TIMOs and REITs. Research & Development, USDA Forest Service.

Hynes, R.W., and Adams, D.M. 1985. Simulations of the effects of alternative assumptions on demand-supply determinants on the timber situation in the United States. USDA Forest Service, Forest Resource and Economics Research, Washington, D.C.

LaGro, J.A., and DeGloria, S.D. 1992. Land use dynamics within an urbanizing non-metropolitan county in New York State. Landscape Ecol. **7**: 275-289.

Li, Y., and Zhang, D. 2007. An empirical study of industrial timberland ownership and financial performance of forestry products companies. Working paper, 30pp.

Liao, X., and Zhang, Y. 2008. An econometric analysis of softwood production in the U.S. South: a comparison of industrial and nonindustrial forest ownerships. For. Prod. J. **58**(11): 69-74.

Logprice.com. 2010. Family forest landowner. Available from http://www.logprice.com/ [accessed 01 June 2010].

Murray, B.C. 1995. Oligopsony, vertical integration, and output substitution: Welfare effects in U.S. pulpwood markets. Land Econ. **71**(2): 193-206.

Nagubadi, V., and Munn, I.A. 2001. An Econometric Study of the Hardwood Stumpage Market in the South Central United States. the Forest and Wildlife Research Center, Mississippi State University(FO-098): 1-9.

Newman, D.H., and Wear, D.N. 1993. Production economics of private forestry: a comparison of industrial and nonindustrial forest owners. Amer. J. Agr. Econ. **75(**August): 674-684.

Powell, D.S., Faulkner, J.L., Darr, D.R., Zhu, Z., and MacCleery, D.W. 1993. Forest resources of the United States, 1992 (1992 RPA). USDA Forest Service, Forest Inventory and Analysis National Program, available at http://www.fia.fs.fed.us/program-features/rpa/docs/rpa_93_tables1-10.pdf.

Prestemon, J.P., and Wear, D.N. 2000. Linking harvest choices to timber supply. For. Sci. **46**(3): 377-389.

Rinehart, J.A. 2001. An Analysis of Timberland Transactions from 1989 to 2001 and Prognosis for the coming decade. R & A Investment Forestry, San Francisco, CA.

Rogers, W.R., and Munn, I.A. 2003. Forest Management Intensity: A comparison of Timber Investment Management Organizations and Industrial Landowners in Mississippi. S. J. Appl. For. **27**(2): 83-91.

Siegel, W.C. 2004. Tax considerations associated with different types of forest ownership. National Woodland **April Issue**: 22-24.

Smith, W.B., Miles, P.D., Perry, C.H., and Pugh, S.A. 2010. Forest Resources of the United States, 2007: a technical document supporting the Forest Service 2010 RPA Assessment. USDA Forest Service, Forest Inventory and Analysis National Program, available at http://www.fia.fs.fed.us/program-features/rpa/default.asp.

Sun, C. 2006. Welfare effects of forestry best management practices in the United States. Can. J. For. Res. **36**(7): 1674-1683.

Sun, C. 2007. Federal income taxation laws for forest landowners, 1913 – 2006. For. Policy Econ.: (under review).

Sun, C., and Kinnucan, H.W. 2001. Economic impact of environmental regulations on Southern softwood stumpage markets : a reappraisal. S. J. Appl. For. **25**(3): 108-115.

USDAFS. 2010. Timber price on the web. Available from http://www.srs.fs.usda.gov/econ/data/prices/index.htm, [accessed 01 June 2010].

Yin, R., Caulfield, J.P., Aronow, M.E., and Harris, T.G. 1998. Industrial timberland: current situation, holding rationale, and future development. For. Prod. J. **48**(10): 43-48.

Zinkhan, F.C. 1993. Timber Investment Management Organizations and other participants in forest asset market: a survey. S. J. Appl. For. **17**(1): 32-38.