Economic Impacts of Timber Product Outputs in Ohio across Timber Market Regions

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Input-output models were constructed to describe the economic impacts of timber product outputs in Ohio and its three timber market regions - the Northeast, West, and Southeast - for 2012. Impact Analysis for PLANning was used to describe these impacts in terms of employment, output, and value added based on 1) the total value of outputs delivered to market by each region's logging sector and 2) a per-unit change in the regionalized delivered value of one million board feet (MMBF) of hardwood sawtimber. Direct impacts of timber products were greatest in the Northeast (for output and value added) and Southeast (for employment). The total economic impacts of timber products in Ohio were 2,880 employees, $287 million in output, and $147 million in value added. The per-unit impact results were more varied due to regional differences in economies and timber price determinants. Employment and output economic impacts per MMBF were both highest in the Southeast. The employment levels directly and indirectly associated with each MMBF in the West were higher than the Northeast. Value added per MMBF was highest in the Northeast across impacts.

Keywords: Economic multipliers; Forestry; Forest products; Input-output model; Sawtimber

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INTRODUCTION

Agricultural production via crops, livestock, and timber provides billions of dollars annually to the American economy (McKeever and Howard 1996). Including harvested timber in the crop category placed its value second only to corn receipts (Haynes 2003). The recent housing collapse and subsequent global recession, though, resulted in a significant downsizing and restructuring of the national forest products industry (Woodall *et al.* 2011a). These changes affected forest-based industries across the U.S., including in the South (Hodges *et al.* 2011), West (Keegan *et al.* 2011), and North (Woodall *et al.* 2011b). Falling demand for hardwood products made the 2007 to 2009 recession the first since World War II for which appearance-grade hardwood lumber prices of all species declined (Hardwood Review 2007-2009).

Stumpage prices in Ohio actually reached their peak three years prior to the recession in 2004, before falling by 50.0% or more in some cases (McConnell 2013; Luppold *et al.* 2014). The magnitude of these large declines contributed to a long-term slowing of the annual percentage rates of change in stumpage prices for Red Oak (*e.g. Quercus rubra*) and White Oak (*e.g. Quercus alba*), which are the two key commercial timber species in Ohio (Duval *et al.* 2014a). Product prices have since been recovering, but Appalachian hardwood lumber prices and sawlog and stumpage prices in Ohio were recently found to have been uncorrelated in the three year period following this most recent recession (Luppold *et al.* 2014). This differed from the price relationships seen following past recessions, where Ohio stumpage and sawlog prices were highly correlated to lumber price during periods of economic recovery.

The structural changes in the national forest products industry along with the recent lumber/log/timber price movements occurring locally prompted our assessment of the current conditions of forestry and forest products manufacturing in Ohio. We found the forest products industry in 2011 employed 47,200 people and contributed $13.6 billion of output, including $4.00 billion of value added, directly to Ohio's economy (Coronado *et al*. 2014). Compared to Hushak's (2005) analysis of the state's forest products industry in 2001, we learned inflation-adjusted output and value added (in 2011 dollars) declined $3.83 and $1.98 billion respectively, while 23,800 jobs were lost.

Economic impacts generated by timber are often spatially specific, varying based on the regionalized structure of the forest products industry and the economic base to which it contributes. For example, the industrial base for timber could be dependent upon whether an area is located in a softwood region, where structural lumber production may predominate, or a hardwood region, where secondary manufacturing sectors can further process appearance-grade lumber into furniture, flooring, millwork, *etc*. Primary processors are often located in rural areas, while secondary manufacturers tend to locate nearer large towns or cities. Regional variations in the timber resource can also play a role in product markets and price. Red oak lumber, for example, is comprised of a number of individual tree species. Trees from higher quality, select red oak species, such as northern red oak (*Quercus rubra*), will generally yield a greater relative amount of high grade red oak lumber (Hanks 1976). A greater percentage of red oak lumber sawn from non-select red oak species, such as southern red oak (*Quercus falcata*), will on average be of lower grade (Hanks 1976). Red oak lumber price trend differences between the U.S. South, Appalachia, and North were attributed to the number of select and non-select species comprising the red oak group as well as the regional differences in physical traits occurring within a species (Luppold 1997).

Cox and Munn (2001) compared the forest products industries of the Pacific Northwest and South, which are dependent upon Douglas-fir (*Pseudotsuga menziesii*) and southern pine (*Pinus* spp.), respectively. Economic impacts in terms of dollars of total output along with the multiplier effects of forest products industries were larger in the South as compared to the Pacific Northwest. Total economic activity per unit of output due to forest products industry demand for Douglas-fir stumpage, however, was 61% higher than the impact generated for an equal amount of southern pine. Thus, the shift in softwood timber harvest volumes from the Pacific Northwest to the South resulted in greater losses to the Pacific Northwest than gains by the South due to the regional price differences in costs of inputs.

Forest inventories, timber and site quality, and the costs of harvesting, hauling, and processing are all, among others, spatially influenced. While Cox's and Munn's (2001) work is beneficial for comparing forested regions on a national scale, the economic feasibility of transporting roundwood dictates timber markets be of a more local nature (Cubbage and Davis 1986). Determining the economic impacts of timber product outputs across timber market regions, though, is not a well explored topic. This is true in Ohio, where three distinct timber market regions exist (Ohio State University Extension [OSUE] 2012, Fig. 1).

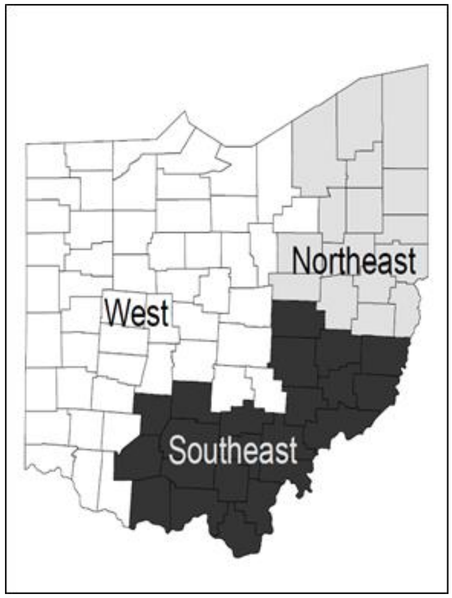

Fig. 1. Timber market regions of Ohio

The Southeast and Northeast regions are more forested, located south and east of the glacial line in the Appalachian foothills, while a large portion of the land area in the West timber market is glaciated. The Southeast is the most rural of the three and contains no major cities. It does, though, possess the greatest regional concentration of sawmills producing at least 5 million board feet of lumber (MMBF) annually, 18 of the 23 facilities qualifying for this category (Wiedenbeck and Sabula 2008). Primary processing is most intensive in this region. The Northeast is also largely rural but includes the Cleveland metropolitan area. This region contains the greatest number of sawmills (Wiedenbeck and Sabula 2008) and is also known for its Amish wood-producing communities, which are centered in and around Holmes County. Bumgardner *et al.* (2007) estimated that Ohio's Amish furniture industry used over 43 MMBF annually, approximately 10% of the hardwood lumber produced in Ohio. The West is mostly farmland but contains several urban areas. It has the fewest primary wood processing facilities, the lowest total timber product consumption, and the lowest average consumption per mill (Wiedenbeck and Sabula 2008).

This study used IMpact Analysis for PLANing (IMPLAN), an economic impact software system, to construct input-output models for the state of Ohio and its three intrastate timber market regions: the Northeast, West, and Southeast (Fig. 1). One set of four models calculated the economic impacts of delivered timber products based upon the total output produced by the Commercial Logging sector in each respective area for the year 2012. Timber products were defined here as roundwood harvested and transported to its first point of delivery for the production of consumer and industrial products (McKeever and Howard 1996). This included veneer logs, sawlogs, pulpwood, and other roundwood products (*e.g.* handle stock). A second set of four models then calculated the associated 2012 economic impacts of timber product outputs on a per-unit of output basis, with one MMBF of delivered hardwood sawtimber representing one unit. Price per unit was developed from five hardwood species' prices described in the Ohio Timber Price Report, White Oak (*e.g. Quercus alba*), Red Oak (*e.g. Quercus rubra*), Hard Maple (*e.g. Acer saccharum*), Soft Maple (*e.g. Acer rubrum*), and Yellow-poplar (*Liriodendron tulipifera*)

(OSUE 2012). Economic impacts were evaluated based on three measures – employment, output, and value added.

EXPERIMENTAL

The Input-Output Model

IMPLAN is an economic impact modeling system that uses input-output analysis to quantify economic activities of an industry in a predefined region. IMPLAN was designed in 1976 by the Minnesota IMPLAN Group Inc. under the direction of the U.S. Forest Service to help meet the reporting requirements for Forest Service land management programs. IMPLAN is now widely used to quantify the economic impacts of various industries, such as agriculture; projects, such as new plant construction; and policy, such as harvesting restrictions; among others. The IMPLAN system is now managed by IMPLAN Group LLC of Huntersville, North Carolina.

IMPLAN quantifies the economic impacts of a predefined region in terms of dollars added in to the economy and jobs produced (IMPLAN Group LLC 2004). Data are obtained from various government sources. These include agencies and bureaus within the Departments of Agriculture, Commerce, and Labor.

The IMPLAN system's input-output model defines 440 unique sectors in the U.S. economy (which are North American Industry Classification System [NAICS] sectors, except in some cases where aggregates of multiple sectors are used) and uses its database to model inter-sector linkages, such as sales and purchases between forest-based industries and other businesses. The transactions table quantifies how many dollars each sector makes (processes to sell) and uses (purchases). The table separates processing sectors by rows and purchasing sectors by columns; every sector is considered to be both a processor and purchaser. Summing each row quantifies an industry's output, which includes sales to other production sectors along with those to final demand. The total outlay of inputs includes purchases from intermediate local production sectors, those from local value added, and imports (both intermediate and value added inputs) from outside the study region. A sector's economic relationships can be explained from the transactions table by the value of the commodities exchanged between the industry of interest and other sectors.

A sector's fixed coefficient production function represents how dependent an industry is on other industries to produce one dollar of its output in order to satisfy final demand. Leontief (1936) defined the relationship between output and final demand using Eq. 1,

$$x = (I - A)^{-1} y \tag{1}$$

where x is the column vector of industrial output, I is an identity (unit) matrix of 1 s, A is the matrix of fixed coefficient production functions (which is a 440 by 440 matrix relating input to output), and y represents final demand. The term $(I - A)^{-1}$ is the total requirements matrix. Each element of the matrix describes the amount needed from sector i (row) as input to produce one unit of output in sector j (column) to satisfy final demand. The output multiplier for sector j is the sum of its column elements, or sector j's total requirements from each individual sector i. Employment and value added multipliers are also derived from summing the respective column elements (Horowitz and Planting 2009).

Employment in IMPLAN is represented as the number of both full and part time jobs an industry creates to meet final demand. Value added is composed of labor income, which includes employee compensation and sole proprietor (self-employed) income, other property type income (OPI), and indirect business taxes[1]. OPI in IMPLAN includes corporate profits, capital consumption allowance, payments for rent, dividends, royalties, and interest income. Indirect business taxes primarily consist of sales and excise taxes paid by individuals to businesses through normal operations. Output is the sum of value-added plus the cost of buying goods and services to produce the product (IMPLAN Group LLC 2004).

Economic Impacts of Timber Product Outputs

First, economic impacts of timber products were determined by region and for the entire state. For this set of models, the input-output analyses were focused on the total value of timber products delivered by the Commercial Logging sector (NAICS sector 113310; IMPLAN sector 16). Four models were constructed, with the direct contributions of the Commercial Logging sector determined from the database. Economic multipliers were used to quantify the spillover effects, the indirect and induced impacts. Here, Type I and Type Social Accounting Matrix (SAM) economic multipliers were applied to describe these effects.

Indirect effects result from inter-industry purchasing to meet final demand. The Type I multiplier defines this linkage, which is described by dividing the direct effect into the sum of the direct and indirect effects (U.S. Department of Commerce Bureau of Economic Analysis 2013). Differences in employee spending within inter-linked industries produce the induced effects. Induced effects are those assumed to be endogenous to a study region, where the changes in value added inputs (which includes labor income) and consumption are fed back into the economy of interest.

Type II multipliers are defined as the sum of the direct, indirect, and induced effects divided by the direct effect. Type II multipliers differ by how they define value added and account for any of its potential endogenous components. A particular Type II multiplier, the Type SAM multiplier, considers portions of value added to be both endogenous and exogenous to a study region. Type SAM multipliers are generally the preferred Type II multipliers used in input-output analysis (Tilley and Munn 2007) and were used in this study to estimate total economic impacts.

Determining the effects of timber product outputs in Ohio, we adjusted our Type I and Type SAM multipliers - for employment, output, and value added - to discount Commercial Logging's input of its own output to meet final demand. Doing so reflected the measured impact of a per unit change in timber product output versus a per unit change to final demand, which paralleled Hushak's (2005) methodology in an earlier input-output analysis of forestry and forest products manufacturing in Ohio. Calculating this adjustment required dividing each of Commercial Logging's multipliers by its associated diagonal element found in the total requirements matrix, which is illustrated in Eq. 2.

$$\text{Adjusted Multiplier}_{\text{Commercial Logging}} = \text{Multiplier}_{\text{Commercial Logging}} \;/\; a_{\text{Commercial Logging}}. \quad (2)$$

The diagonal element's value, the term $a_{\text{Commercial Logging}}$ here, for any sector is at least 1.00 due to the requirement of itself to produce one unit of output at minimum. The diagonal

[1] IMPLAN refers to value added in this context as "total value added."

element exceeds 1.00 when a sector's output is required to produce its product. Accounting for this effect resulted in Adjusted Type I and Type SAM Multipliers for timber products that were less than or equal to the original multipliers calculated from the total requirements matrix. The magnitude of any reduction was dependent upon the logging sector's need for its own production in the manufacturing of output in each respective region.

Economic Impacts per Unit of Timber Product Output

To calculate the per-unit economic impacts of timber products by market region in Ohio, we first accessed the U.S. Forest Service's Forest Inventory and Analysis (USFS FIA) website. We used the Forest Inventory Data Online tool to create reports for the volumes of sawtimber removals from timberland in 2012 (USFS FIA 2014). We generated four separate reports, one for the entire state and one for each of our three regions (Northeast, West, and Southeast). From each, the volume of timberland sawtimber removals of white oak, red oak, hard maple, soft maple, and yellow-poplar were obtained. These five species are main drivers of Ohio's timber market, representing approximately 65% of the sawtimber harvest in 2006 (Wiedenbeck and Sabula 2008). The prices obtained for these species are also used in calculating the Ohio Timber Price Indices for a typical stand of hardwood timber (McConnell 2013).

Weights were developed based upon each species' relative contribution to the total volume of sawtimber removals for all five species in each respective area (Table 1). Prices for the five species were obtained from all returned 2012 price surveys for delivered hardwood sawlogs from the Ohio Timber Price Report (OSUE 2012). The Ohio Timber Price Report dates to 1960 (Duval *et al.* 2014b). The report is compiled from biannual surveys sent to foresters, loggers, mills, and timber buyers in Ohio in Spring and Fall, respectively. Gathering prices from a number of sources helps provide an overall picture of the marketplace that reflects differing perspectives. Typically a small but consistent response rate, ranging from 20.0% to 40.0%, is received per survey.

Delivered sawlog prices are gathered for four log grades – Prime, #1, #2, and Blocking - within ten hardwood species (Duval *et al.* 2014b). Prime is the highest grade, and Blocking is the lowest. Respondents also provide an All Grades price, which is in their judgment the average price paid for all logs of the specified species. The price report publishes the average and median prices paid (dollars per thousand board feet, Doyle) per log grade within each species.

The surveys are coded by region; thus all of the entries for a specific report are region-specific. From these surveys, we were able to use seven responses from the Northeast, four from the West, and five from the Southeast, and sixteen for the state. We used respondents' All Grades sawlog price for all five of our examined species.

The weighted price for each survey response was calculated by

$$\sum \text{(Price of species * Species Weight) = Weighted price.} \tag{3}$$

The weighted prices were then averaged for each area and multiplied by 1,000 to determine an average price per MMBF of delivered sawtimber. Using the regional input-output models and their associated adjusted economic multipliers described previously, we determined the economic impacts per unit of timber product output based upon a change in the regionalized value of one MMBF of hardwood sawtimber delivered by the Commercial Logging sector in 2012.

Table 1. Weights Used to Calculate Regional Delivered Sawtimber Prices

Region	White Oak	Red Oak	Hard Maple	Soft Maple	Yellow-poplar	Average weighted price per MMBF
Northeast	0.09	0.36	0.06	0.30	0.20	$401,000
West	0.22	0.18	0.17	0.11	0.32	$394,000
Southeast	0.28	0.27	0.09	0.04	0.33	$493,000
Ohio	0.20	0.29	0.09	0.13	0.28	$425,000

Weights were based upon each species' relative contribution to the total volume of sawtimber removals for all five species in each respective area. Weights should be summed across rows and may not sum to 1.00 here due to rounding.

RESULTS AND DISCUSSION

Economic Impacts of Timber Product Outputs

The direct employment, output, and value added produced from harvesting and delivering timber in each Ohio timber market area are displayed in Table 2. Also contained in Table 2 are the relative contributions of timber to total agriculture in each respective area. Timber harvesting employed 1,851 people in Ohio in 2012, while creating $73.4 million in value-added and $162 million in output. Most of these impacts were generated from the more forested Northeast and Southeast regions. The Northeast employed 105 less people than the Southeast, but produced $11 million more in output and $15 million more in value-added. The highest relative contribution of timber products to total agriculture was in the Northeast, where 7.03% of the region's value-added from agricultural products was provided by timber. Timber-related employment, output, and value-added in the Northeast and Southeast contributed at least 4.88% to the total direct contributions of all agriculture industries; in the West this was only 0.20% or less in all cases. At the state level, between 1.50% and 1.87% of total agricultural employment, output, and value-added was timber-related.

Table 2. Direct Impacts of Timber Products in Ohio by Region, and their Associated Percentage Contributions to Total Agriculture

Region	Description	Employment	Output, $MM	Value Added, $MM
Northeast	Timber Products	805	$81.5	$42.8
	% of Total Agriculture	4.88%	5.26%	7.03%
West	Timber Products	137	$10.3	$3.74
	% of Total Agriculture	0.20%	0.13%	0.13%
Southeast	Timber Products	910	$70.7	$26.9
	% of Total Agriculture	5.18%	5.87%	6.56%
Ohio	Timber Products	1,851	$162.6	$73.4
	% of Total Agriculture	1.80%	1.50%	1.87%

The unadjusted and adjusted Type I and Type SAM economic multipliers associated with timber products for each region and the state are listed in Table 3. The Type I adjusted multipliers ranged from 1.14 to 1.34. Across regions, employment Type I adjusted multipliers ranged from 1.14 to 1.15; those for output ranged from 1.17 to 1.23; while those for value added ranged from 1.17 to 1.34. The highest adjusted Type I multiplier was value added in the West region at 1.34. Both output and value-added adjusted Type I multipliers in the West were higher than those for the state.

Adjusted Type SAM multipliers ranged from 1.37 to 2.15. The ranges across regions were 1.37 to 1.62 for employment; 1.50 to 1.77 for output; and 1.74 to 2.15 for value added. The highest individual value was again found in the West (2.15), which was also for value added. This and the adjusted Type SAM employment multiplier in the Northeast were higher than their associated state-level multipliers. The Southeast region had the lowest adjusted Type SAM employment, output, and value added multipliers.

Table 3. Type I and Type SAM Economic Multipliers for Each Region and Each Economic Measure

Region	Impact	Type I Multipliers		Type SAM Multipliers	
		Unadjusted	Adjusted	Unadjusted	Adjusted
Northeast	Employment	1.21	1.15	1.70	1.62
	Output	1.23	1.17	1.80	1.71
	Value Added	1.23	1.17	1.93	1.83
West	Employment	1.15	1.14	1.45	1.44
	Output	1.24	1.23	1.72	1.71
	Value Added	1.35	1.34	2.17	2.15
Southeast	Employment	1.19	1.14	1.43	1.37
	Output	1.23	1.18	1.57	1.50
	Value Added	1.27	1.21	1.82	1.74
Ohio	Employment	1.20	1.15	1.62	1.55
	Output	1.27	1.21	1.84	1.77
	Value Added	1.30	1.24	2.09	2.01

Types I and SAM economic impacts by region and state are displayed in Table 4.

Table 4. Total Contributions of Timber Product Outputs to Ohio's Economy 2012

Region	Impact type	Employment	Output, $MM	Value Added, $MM
Northeast	Direct Impacts	805	$81.5	$42.8
	Type I Impacts	928	$95.5	$50.2
	Type SAM Impacts	1,305	$139.7	$78.4
West	Direct Impacts	137	$10.3	$3.74
	Type I Impacts	156	$12.7	$5.00
	Type SAM Impacts	197	$17.6	$8.05
Southeast	Direct Impacts	910	$70.7	$26.9
	Type I Impacts	1,033	$83.3	$32.6
	Type SAM Impacts	1,243	$105.8	$46.8
Ohio	Direct Impacts	1,851	$162.6	$73.4
	Type I Impacts	2,128	$197.2	$91.4
	Type SAM Impacts	2,879	$287.1	$147.2

Contributions were reported by region and for the state as a whole. Employment was the number of full and part time jobs. Output and Value Added are reported in millions of dollars.

Type I impacts are the sum of the direct and indirect impacts, while Type SAM impacts are the direct, indirect, and induced impacts summed together. As expected here, the regional level results were higher in the more forested areas of the state. Employment Type I impacts were highest in the Southeast, while output and value added Type I impacts were highest in the Northeast. The total Type I economic impacts for the state were 2,100 jobs and $197 million in output, including $91.4 million in value added. The Northeast had the highest regional Type SAM impacts across all three economic measures. The Northeast and Southeast were over 5 times higher than the West in Type SAM impacts in all cases. The total Type SAM economic impacts for the state of Ohio were $287 million of output, including $147 million of value added, while creating nearly 2,900 total jobs.

Economic Impacts per Unit of Timber Product Output

Employment, output, and value added economic impacts produced per MMBF of delivered hardwood sawtimber for the state and each market region are listed in Table 5. The average weighted prices entered into these models were regionally specific due to forest composition and prevailing market conditions. The direct output of the regions and state represented the average weighted delivered price of hardwood sawtimber per MMBF. Direct employment represented the number of loggers employed to harvest one MMBF while direct value added was the new wealth generated from that harvest.

Table 5. Per-unit Contributions of One Million Board Feet of Hardwood Sawtimber, Delivered

Region	Impact	Employment	Output	Value Added
Northeast	Direct Impacts	3.9	$401,000	$209,560
	Type I Impacts	4.5	$469,950	$246,000
	Type SAM Impacts	6.3	$687,560	$384,400
West	Direct Impacts	4.8	$394,000	$141,150
	Type I Impacts	5.5	$485,980	$188,680
	Type SAM Impacts	6.9	$672,120	$303,850
Southeast	Direct Impacts	6.3	$493,000	$187,450
	Type I Impacts	7.2	$580,340	$226,920
	Type SAM Impacts	8.6	$737,730	$325,400
Ohio	Direct Impacts	4.8	$425,000	$191,110
	Type I Impacts	5.5	$515,640	$237,770
	Type SAM Impacts	7.5	$750,600	$383,220

Dollar figures were rounded to the nearest ten dollars.

Sawtimber delivered to market in 2012 was valued highest in the Southeast, $493,000 per MMBF, followed by the Northeast and West. Statewide the value of one MMBF was $425,000 in 2012. The Southeast also had the highest direct employment per MMBF of output followed by the West and Northeast. The Northeast had the highest direct value added per MMBF.

Type I impacts for employment and output were again highest in the Southeast, with value added also greatest in the Northeast. However, employment and output impacts generated directly and in support of timber resources were higher in the West than in the Northeast. Statewide, each MMBF of timber generated direct and indirect impacts equaling

5.5 jobs and $515,000 in output, including $237,000 in value added. Of those totals the indirect effects of the timber supply chain amounted to 0.7 jobs, $90,000 in outputs, and $46,000 in value added.

Accounting for the adjusted Type SAM economic multiplier effects of each MMBF of timber in Ohio resulted in total impacts of 7.5 jobs, $750,000 in output, and $383,000 in value added. This included induced impacts of 2.0 jobs, $235,000 in output, and $145,000 in value added. Each MMBF of timber product output in the Southeast produced more total jobs and output across that region's industries than in the West and Northeast. The West generated nearly seven total jobs per MMBF, followed by the Northeast at 6.3. On the other hand, the Type SAM output impact was greater in the Northeast than in the West. The Northeast was able to capture the greatest amount of value added, followed by the Southeast and West, respectively.

Discussion

Hardwood species comprise 96.0% of the forest volume in Ohio, and timber production there is almost wholly hardwood-based. In 2012, timber receipts contributed 1.50% to the total output of all agricultural products (Table 2). Much of that occurred in the two regions occupying the Appalachian foothills. Timber production in those areas each eclipsed 5.00% of total agricultural output. Timber harvested from the farm woodlots of the West contributed very little to regional agricultural receipts there.

Describing timber's economic impacts in terms of total output, the effects generated in the Northeast and Southeast were much larger than the West (Table 4). Mills require timber be appropriate, available for harvest within the procurement radius, affordable, and accessible. The availability of greater timber volumes in those regions logically explained why approximately 94.0% of the direct, Type I, and Type SAM economic impacts of total timber production outputs were contained in those areas. Of the three, timber generated the greatest economic activity monetarily in the Northeast.

The value of timber production in this case was measured in terms of dollars generated. The findings in Tables 2 and 4 were based on the total values of delivered timber products and the associated multiplier effects in each region. The adjusted multipliers in Table 3 described a per dollar change in timber product output. The value of each dollar was assumed to be equal across timber market regions in 2012.

However, the results in Table 5 were based on a per unit change in timber product output, one MMBF. The value of this unit of timber (price per MMBF) in 2012 was not equal across Ohio's timber market regions. Our finding at the state level parallels the greater regional differences in input and output values for Douglas-fir and southern pine stumpage, which led to the varying economic impacts found in Cox's and Munn's (2001) study. Hunter (1982) concluded southern pine sawtimber delivered prices were greater in market regions with higher mill capacity and a greater number of large diameter trees (≥ 19.0 inches). Southern pine sawtimber stumpage prices increased as delivered log prices and timber stocking increased (Hunter 1982). Similarly, Duval (2013) found Ohio red oak stumpage price trends were increasing at a higher rate from 1960 to 2011 in the Southeast, where the forest resource and primary processing are most concentrated, than in the Northeast or West.

The ranking in values in the per-unit analysis varied from those based on total timber product outputs. The West and Northeast were somewhat similar in direct output relative to the price per MMBF due to the costs of regional inputs, though both were over $90,000 lower than the Southeast (Table 5). Additionally, the West directly employed almost one more logger, 4.8 people per MMBF of timber produced, than the Northeast at 3.9 per MMBF. While timber's contribution to the agricultural economy of the West was small, it was a more labor-dependent commodity there than in the Northeast. The number of loggers needed in the West to harvest and deliver one MMBF to market in 2012 equaled the number needed in the state as a whole. Thus, an initiative that stimulated (or limited) timber production would have a greater positive (or negative) effect on direct employment in the West's logging industry than in the Northeast's, relative to the size of the sector in each region. But timber products in the Northeast had a much higher direct value added per MMBF than the West. Value added per MMBF in the Northeast was in fact the largest of the three intrastate regions.

Economic multipliers give meaning to the widespread economic benefits any industry, or product, provides. For the timber markets of Ohio, the adjusted economic multipliers varied by type and region. Type I adjusted multipliers ranged from 1.14 to 1.34. The Type SAM adjusted multipliers ranged from 1.37 to 2.15. Adjusted Type I multipliers describe the inter-industry linkages – the supply chain effects – associated with producing industrial outputs, while adjusted Type SAM multipliers account for household spending being fed back into the regional economy (Hushak 2005). Higher multipliers suggest an increase in regional timber product output would provide spillover effects of greater magnitude. If timber production were restricted, though, the impact of the spillover effects would be less in a region with lower multipliers.

For both output and value added the adjusted Type I and Type SAM economic multipliers in the West were equal to or greater than those from the more forested timber market regions. The West likely had equal or larger adjusted Type I and Type SAM economic multipliers in these cases for at least two reasons. The West's overall economy is much larger than the other two regions, and secondly the area contains more large cities than the other market regions. This provided the opportunity for a greater turnover of dollars associated with timber product outputs' multiplier effects in the West before they leaked out of the economy. On the other hand, the adjusted Type SAM multipliers in the more rural Southeast were the lowest of the three timber market regions. This suggests that the Southeast's economy was less able to capture the induced impacts of employee spending by the logging sector and its supply chain.

The higher output per MMBF obtained for the Southeast was explained by delivered sawtimber prices being at least 23% higher there in 2012 than the other regions. The Southeast consumes the greatest amount of wood of the three regions, as it contains a concentration of large sawmills in the area (Wiedenbeck and Sabula 2008). These large facilities could have been procuring timber more aggressively as lumber prices began rising from their low points in 2009 (Luppold and Baumgras 1998).

The Southeast directly employed more loggers on a per-unit of output basis than both the Northeast and West. This was due to our study's representative unit of timber production, one MMBF of delivered sawtimber, and its associated price in each region. Per MMBF the Southeast had the highest Type I employment and output economic impacts, but it trailed slightly behind the Northeast in Type I Value added. The Southeast also had the highest Type SAM employment and output economic impacts per MMBF, but its Type SAM value added impact was less than the Northeast (Table 5). The Northeast had the lowest Type I employment and output economic impacts per MMBF. The large gains in value added in the Northeast were possibly associated with the region's ability to maximize its use of local resources relative to the costs of input and labor. The Northeast was found to have been the greatest consumer of the local timber supply in its respective region

(Wiedenbeck and Sabula 2008). A lesser reliance on imports by a sector would result in greater payments to value added, assuming intermediate input costs and the total outlay of inputs remained the same.

Cox and Munn (2001) discussed the need for lawmakers to recognize that national forest policy decisions could have varying effects across the country's timber-producing regions by highlighting the differences in the forest-based economies of the U.S. South and Pacific Northwest. An implication of our research is that a "one size fits all" approach to forest policy at the state level may also be inadequate in Ohio. This could be true in other states as well where economies, land use, and the cost of inputs vary significantly between timber market regions.

Examining economic impacts based on the total value of timber product outputs provides decision makers information on the economic activities generated by annual timber receipts in their respective community. Impacts from this point of view, while valuable, cannot account for the differences between market regions that determine timber price. As importantly, they do not illustrate the changes that may occur relative to the level of production in each region. The per unit of output approach to studying the economic impacts of timber maintains the regional differences in timber prices by scaling the analysis to a unit of equal volume, one MMBF (Cox and Munn 2001). This perspective provides information on how events occurring at broader levels, state and national policy decisions or economic upswings and downturns, can have regionally specific impacts within local economies. Both methods can provide interested parties- industry participants, advocates, and lawmakers- needed information when discussing environmental, economic, and social issues, particularly in areas where timber's contributions may not be fully appreciated or understood.

CONCLUSIONS

1. Direct impacts of timber product outputs: Timber product outputs directly contributed \$162 million to Ohio's economy in 2012. Timber accounted for over 5.00% of the direct receipts to total agriculture in the Northeast and Southeast regions of the state. Employment, output, and value added were all the lowest in the West (Table 2).
2. Economic impacts of total timber product outputs: Total economic activity associated with timber in the state, based upon the Type SAM impacts, was just over \$287 million. Direct and Type I employment economic impacts of timber product outputs were highest in the Southeast, while Type SAM employment impact was highest in the Northeast. Direct, Type I, and Type SAM impacts for both output and value added were all highest in the Northeast. Timber receipts in the West generated the lowest impacts in all cases (Table 4).
3. Economic impacts per unit of timber product output: Each MMBF of delivered hardwood sawtimber in Ohio generated outputs of \$425,000 directly, \$90,300 indirectly, and induced an additional \$235,000. Direct, Type I, and Type SAM economic impacts for employment and output per MMBF were highest in the Southeast. Employment impacts per MMBF were all higher in the West than the Northeast. The West also generated a higher Type I output impact than the Northeast. The Northeast employed the least amount of loggers per MMBF of production, but value added was highest in that region across impacts.

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