Identifying Important Sectors among Michigan's Forest Products Sectors:

Using I-O Coefficients to Measure Comparative Gross and Base Value Added, Competitive Advantage and Structural Path Analyses

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Key words

Forest products, export base, intermediate demand, import substitution, competitive advantage, structural path, supply chain, network analysis

Abstract

In 2013, Michigan's Governor Snyder proposed the goal of increasing the contribution of forest products to the state's economy. The general category of forest products includes logging, primary and secondary wood and paper production and wood furniture. Out of the 535 sectors available in the 2013 IMPLAN data system, forest products sectors make up twenty seven. Which are the important forest product sectors? Which ones offer the best hope of responding positively to state government's efforts to increase exports, value added, employment and output and also works best with the non-forest products sectors in the state?

Three model are used to make this determination. Each model uses coefficients derived from IMPLAN social accounting data—annual data from 2007 to 2013 available for each state with more than 400 sectors of detail. The first model generates measures of gross and base value added for Michigan, which identifies the primarily exporting and import substituting sectors. Then the changing shares of value added by sector in the state are used in a SWOT analysis (strength, weakness, opportunity and threats) to determine changing comparative advantage of each of Michigan's forest products sectors compared to the U.S. over time. Finally, it is possible to identify potential bottleneck sectors in the forest product supply chains with measures of network betweenness centrality. This network analysis builds on structural paths of the decomposed induced effect multiplier, which reveals the network of directed movements of payments from sector production to household consumption.

Ten forest products sectors are best positioned to increase economic activity in Michigan. Three sectors—office and institutional furniture and paper board container manufacturing offer an opportunity to expand exports. In the case of containers, these "exports" include increased sales to non-forest products sectors in the state. Four sectors—paper, paperboard, shelving and veneer manufacturing—can expand both exports and sales to other important forest products sectors in the state. Three sectors—logging, sawmills and pallets—can increase sales primarily to other important forest product sectors in the state. In fact, the lack of increase sales by these important "betweenness centrality" sectors would pose a barrier to the growth in the other important forest product exporting sectors.

1. The Problem: Opportunities for forest product market expansion

In 2013, Michigan's Governor Rick Snyder hosted a Forest Products Industry Summit in an attempt to help improve the rural economy of the state. Representatives from industry, government, finance, and academia identified four goals for the forest product industry. These goals are: 1) to increase forest products economic impact from $14 to $20 billion, 2) to increase their export of value-added by 50 percent, 3) to increase their jobs by ten percent and 4) to encourage industry development regionally (www.michigan.gov/dnr/).

One of the consistent themes expressed by the participants in the Summit was the lack of forest product market and supply chain information. This lack of information was views as an important "impediment" to making informed decisions on how to best foster the growth of the state's important forest products sectors.[1] As a result the Michigan Departments of Agriculture and Rural Development, and the Natural Resources created a request for proposal to answer a set of marketing questions. They asked for help: 1) to identify past and current forest products supply chains, practices and marketing trends, 2) to identify future potential for market growth, and 3) to recommend an integrated sector growth strategy that includes identifying obstacles and their potential solutions.

2. Context

Recent declines in demand for U.S. forest products is attributed to three factors—the decline in housing starts, the recession of 2008, and increased foreign competition in secondary wood products manufacturing (Brandeis and Hodges 2015) (Woodall et al. 2011).

Regarding supply, high quality hardwood timber in the Great North Woods of Northeastern U.S. and Canada has been compared by analogy to oil in Saudi Arabia—as a regional treasure

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[1] http://www.michigan.gov/documents/dnr/Timber_Summit_Notes_Actions_420849_7.pdf

trove (Woodall et al., p. 611). In the late 19th and early 20th century, Michigan's endowment of wood resources were put to good use building the cities of Chicago and Detroit. As the replacement crop of trees grew over the intervening decades, the wood lots became fragmented and the infrastructure such as saw mills and rail lines eroded. Michigan's economy evolved away from natural resources toward auto manufacturing. Today the sum of the twenty seven forest product sectors in Michigan represents about 1.5 percent of the gross state product (Leefers et al. 2013). Currently hard wood growth in Michigan has reach a point in which the growth in harvestable timber supply is threatened by senescence and mortality (Woodall, et al., p. 608).

3. Data

The Alward Institute for Collaborative Science has a contractual agree with IMPLAN Group, LLC to be an archival repository of all the annual IMPLAN data published since the early 1990s (IMPLAN Group LLC 2015). Working in collaboration with IMPLAN Group, the Alward Institute currently has a working set of comparable time series input-output tables for every county and state in the U.S. since 2007 (Olson and Lindall 2004). There is a convergence in the data available to the Alward Institute and the increasingly powerful software such as Microsoft Excel's Power Pivot and Power View that can handle easily in a single data model containing the millions for rows of panel input-output transactions (Ferrari and Russo 2013). Now it is possible to mine past input-output relationships using DAX code written algorithms and present the results with clear and simple Power View tables, bar charts and scatter diagrams. The Institute is using the Michigan forest products analyses as an opportunity to explore some of these new big data mining techniques.

4. Methodology

Three model are used to determine which forest products sectors show the most promise for expanding economic indicators. Each model uses IMPLAN social accounting data available annually for all states from 2007 to 2013.

The first model generates measures of gross and base value added for Michigan, which identifies the primarily exporting and import substituting sectors (Waters, Weber and Holland 1999). In the search for important forest product sectors, the criteria is the extent to which a sector either brings money in or keeps it in the economy. Both roles are important and all sector play both roles—the base and gross measures show the level of each.

The size and number of base and gross sectors change over time as the structure of the economy changes. Ideally, the growth in primarily exporting sectors is accompanied by a similar growth or perhaps even greater growth in the import substitution sectors. Because of its deepening effect on the economic structure, import substitution has a greater long-run impact on the economy than comparable increases in exports (Cooke and Watson 2011, Watson et al. 2015, Watson et al. 2007).

Competitive advantage drives market structure. "If nature endows two regions unequally with factors of production, the relative cost of transforming one commodity into another domestically will probably be different for the two areas … Each [region] will specialize in the commodity in which it has a comparative advantage and export its surplus of that product for imports from [outside the region]" (Samuelson 1970).

To express changing comparative advantage, the change in shares of base and gross value added by sector are presented in a SWOT format—a four quadrant grid, one each for strength, weakness, opportunity and threat. The changes in value added shares can be configured to

convey the substitution effect from changing input prices along with the sector-wide factor bias from the introduction of skill-biased technology (Ferguson 1969) (Diewert 1976) (Finegold and Soskice 1988) (Redding 1996, Scicchitano 2009) (Violante 2008) (Cooke and Kulandaisamy 2010). The criteria that shows competitive advantage is improving is when the growth in a sectors' value added shares is increasing both relative to the competition (the US average share) and over time relative to a previous "personal best" (compared to the 2008 share). Improvements over both the US average and previous years' shares is consider a strength and decreases in both—a weakness. An improvement over time, but lagging the US, is considered an opportunity because continued improvement would result in over taking the US average. Conversely, more growth than the US but decreasing over time is a threat because continued declines would result in falling behind the US average as well.

Defourny and Thorbecke (1984) assert that embedded within a Leontief multiplier matrix, the supply chains of each sector exists. They used a technique called structural path analysis to prove their assertion. Structural path analysis of the forest products sectors starts with the technical coefficients of a 52 sector social accounting matrix, in which half the sectors refer to forest products. The model is closed to also include households. We apply structural path analysis to ten important forest product sectors in Michigan to determine the supply chains as revealed by income moving from these sectors to households (Garcia 2009) (Garcia et al. 2012) (Oshita 2012) (Cooke 2014). Network analysis builds on structural paths of the decomposed induced effect multiplier, which reveals the network of directed movements of payments from sector production to household consumption (Arndt et al. 2012, Gephi Open Source 2015). The criteria for determining the potential bottleneck by a sector in the supply chain is its measure of "betweenness centrality" (Assenov 2013, Golbeck 2013, West 2001). Betweenness centrality is a measure of the extent of the control, in this case, a sector can bring to bear over the other sectors in an interdependent economy (Assenov 2013). The greater the betweenness centrality of a sector, the greater its potential control over the supply chain—another measure of importance.

5. Outcomes, products and deliverables to satisfy the requirement

Export and Import Substituting Sectors

The search for the important forest product sectors begins with an understanding of their base and gross contributions to value added. Wood office furniture manufacturing is the most important wood products sector in Michigan in 2012 using base value added as the criterion with about three billion dollars in base value added and 26 thousand base employment. See Table 1. Wood office furniture is an important exporting sector, primarily to the domestic U.S. market. Adding the related sectors of institutional furniture manufacturing and shelving brings the total base value to four billion dollars and thirty seven thousand jobs. The exports from institutional furniture sector are primarily for the international market.

Paper products are the other major base value added sectors in Michigan. Paper and paperboard mills along with paperboard containers together create about two billion dollars in base value added and seventeen thousand jobs. These sectors perform dual and roughly equal roles of providing exports as well as intermediate inputs to other sectors in the state.

Sawmill, veneer manufacturing, pallets, and commercial logging together make a relatively modest contribution of less than five hundred million dollars in base value added and six thousand jobs. As we will show in the supply chain analysis these sectors play an important but different role in Michigan's forest products economy.

Table 1. Michigan's Ten Important Forest Product Sectors Using Base Value Added Criterion, 2012

	Sector ID and Label	Base Employ.	Gross Employ.	Base TVA	Gross TVA	Base <> Gross
	Michigan--Forest Products Total	75,058	54,614	7,740	5,690	>
1	300 Office Furniture	26,077	12,303	2,895	1,914	>
2	105 Paper mills	8,621	2,512	1,290	909	>
3	299 Institutional furniture manufacturing	5,004	2,046	586	353	>
4	302 Showcase, partition, shelving, locker manuf.	5,866	2,802	583	333	>
5	107 Paperboard container manufacturing	5,365	5,746	497	577	<
6	106 Paperboard Mills	3,398	896	409	242	>
7	095 Sawmills and wood preservation	1,779	2,199	100	101	≈
8	096 Veneer and plywood manufacturing	1,299	1,068	88	75	>
9	016 Commercial logging	2,029	3,180	81	79	≈
10	100 Wood container and pallet manufacturing	1,225	2,071	73	98	<

To determine whether a sector has an improving competitive advantage, the base value added shares should be improving both over time—relative to 2008—and relative to the U.S. average. Of all the forest products sectors in Michigan, the wood office furniture manufacturing sector in 2012 stands out for its performance along both dimensions. See Figure 1. This is a particularly impressive accomplishment given that only two other states—Iowa and Indiana—have wood furniture manufacturing sectors that show improvements—improvements that only begin to rival those of Michigan. Paper, paperboard and paperboard container sectors also show positive though modest improvements in competitive advantage.

Nearly all of the changing competitive advantage is attributable to sector bias rather than from the substitution effect associated with changing input prices. Sector bias is due to the nature of their production technology in which some sectors gain while others are setback from skill-biased technological change. Positive skill-biased technological change is defined as "a shift in the production technology that favors skilled over unskilled labor by increasing its relative productivity and, therefore, it relative demand." (G. Violante, New Palgrave). The average wages in paper, paperboard, paperboard container and wood furniture sectors are significantly greater than in the other important wood product sectors in Michigan. Sector bias that favors high paying wood product sectors contributes to a high-skill equilibrium economy with sectors producing high-quality, specialized goods and services that require a well-qualified workforce capable of rapid adjustment in the work process and continual product innovation" (Finegold, 1988).

**Figure 1. Michigan Sectors with Increasing Competitive Advantage, 2012**
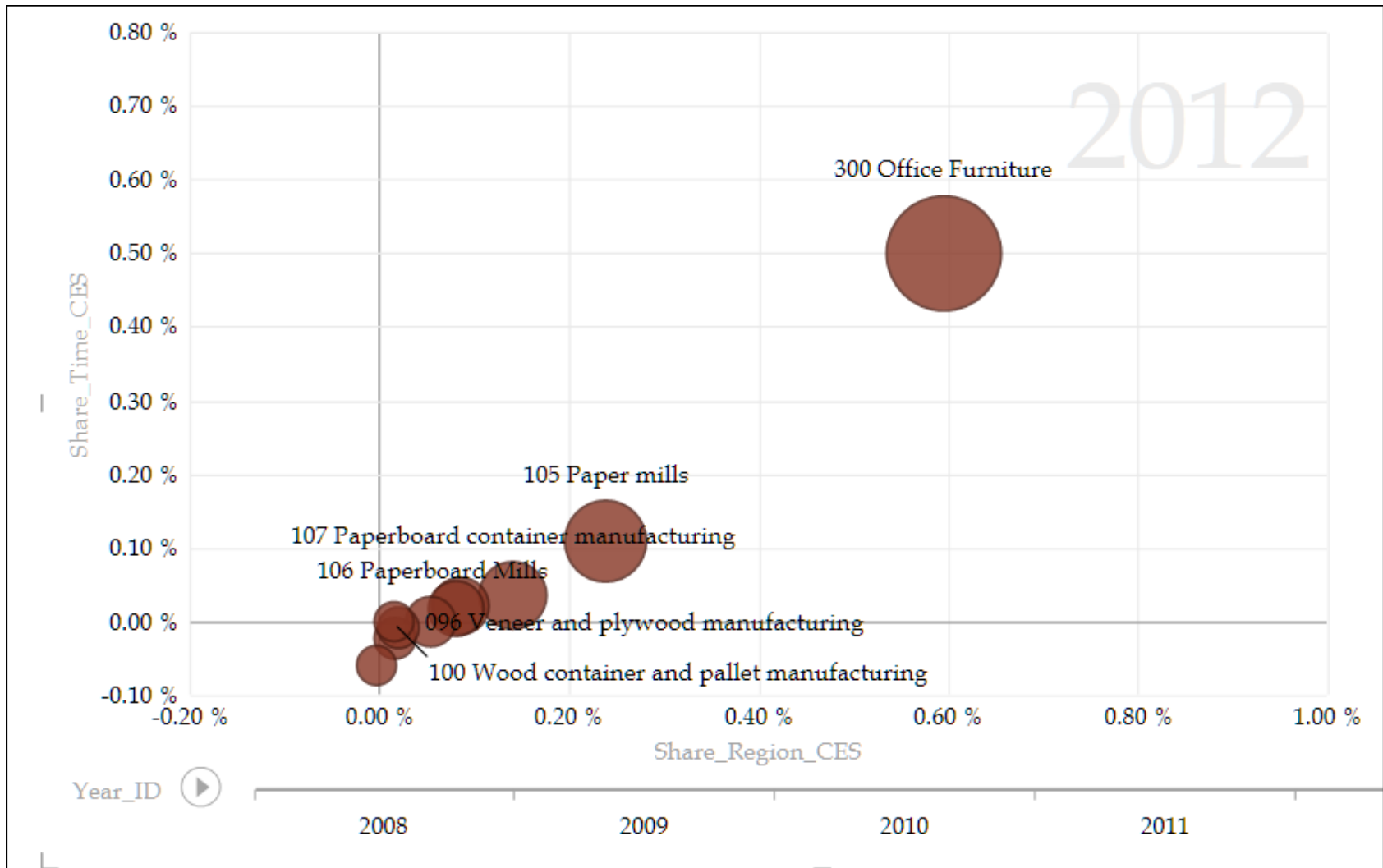
In a social accounting model of Michigan's economy that includes households, the supply chains that track the flow of funds from the ten important wood product sectors to households are explored. The definition of "important" is circular, in that after starting with forest products sectors with high base value added and increases in competitive advantage is was found that other wood products—logging, sawmills, veneer, pallets and shelving were also important in the production of wood office furniture and institutional furniture. Similarly, paper, and paperboard production are important inputs for manufacturing paperboard containers. In effect the process has come full cycle in that the focus on base value added and changing competitive advantage lead to the important role that gross value added forest products play in the supply chain. Their interdependence is complete.

Besides the strong "betweenness centrality" of the important forest product sectors as inputs, there are other key inputs into the forest product exporting sectors as well. These include: labor, capital, wholesaling, utilities and other manufactured goods. For example, the wholesale function in forest products relates to the need for channel masters to organize the flow of timber from small wood lot owners to the sawmill proprietors. By far, labor is the biggest potential bottleneck in the flow of funds between the forest products sectors and households.

Table 2. Michigan's Sectors with Betweenness Centrality

DESTINATION→ SOURCE↓	OFFICE FURNITURE	INSTIT'L FURNITURE	PAPERBOARD CONTAINERS	SAW MILLS	PALLETS	VENEER	PAPER MILLS	PAPERBOARD MILLS
Logging				X	X	X	X	X
Saw Mills	X	X		--	X			X
Pallets					--		X	
Veneer	X					--		
Paper Mills			X				--	
Paperboard Mills			X					--
Shelving	X							

Figure 2. Michigan's Circular Network of Structural Paths Ranked Clockwise by Betweenness Centrality, 2013
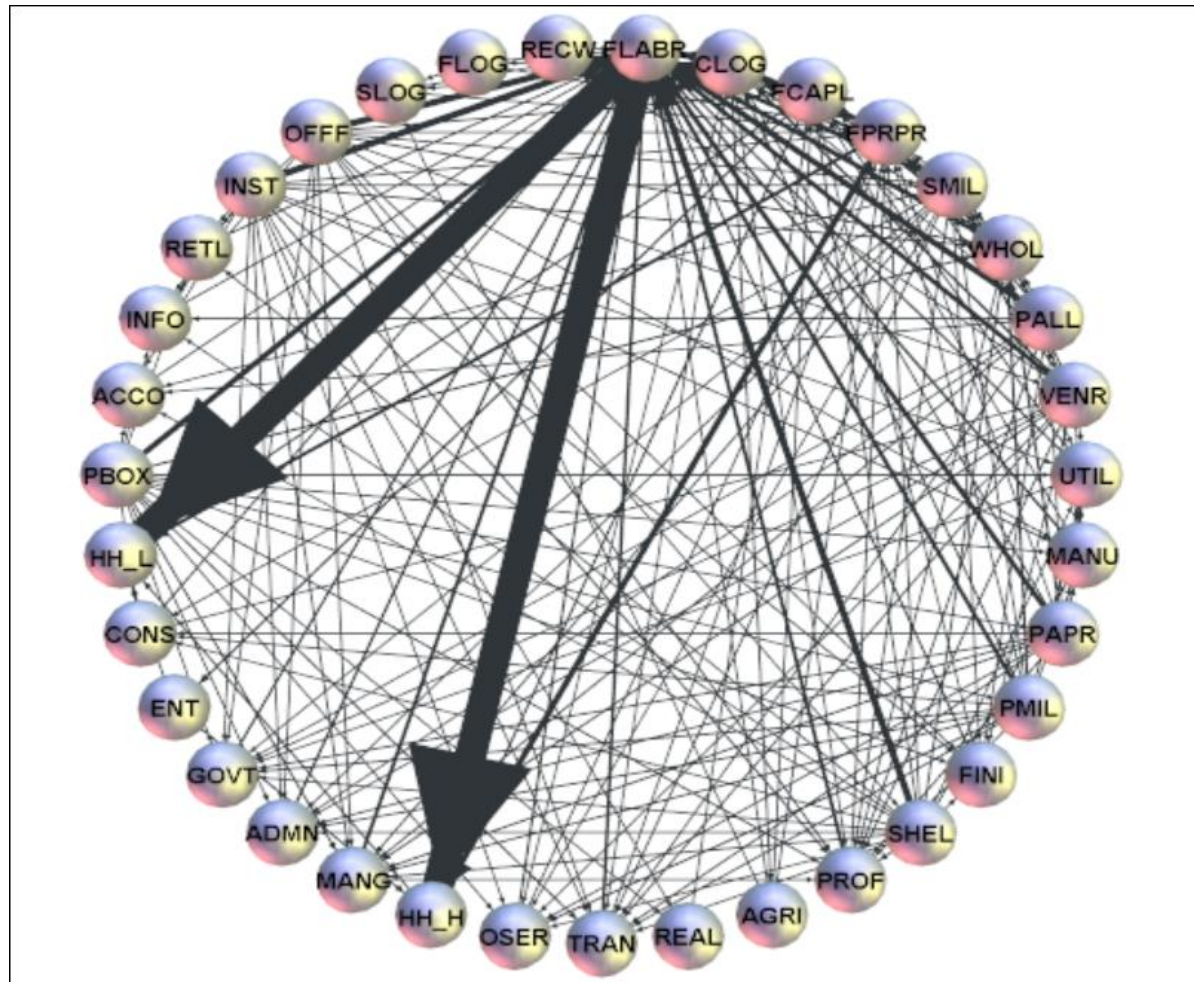
Table 3. Sector Acronyms

aagri	11 Ag, Forestry, Fish & Hunting	aboat	Boat building
aflog	Forestry, forest products, and timber tract production	akitn	Wood kitchen cabinet and countertop manufacturing
aclog	Commercial logging	aupld	Upholstered household furniture manufacturing
aslog	Support activities for agriculture and forestry	anupl	Nonupholstered wood household furniture manufacturing
amine	21 Mining	aoupl	Other household nonupholstered furniture manufacturing
autil	22 Utilities	ainst	Institutional furniture manufacturing
acons	23 Construction	aofff	Wood office furniture manufacturing
amanu	31-33 Manufacturing	amill	Custom architectural woodwork and millwork
asmil	Sawmills	ashel	Showcase, partition, shelving, and locker manufacturing
awpre	Wood preservation	awhol	42 Wholesale Trade
avenr	Veneer and plywood manufacturing	aretl	44-45 Retail trade
atrus	Engineered wood member and truss manufacturing	atran	48-49 Transportation & Warehousing
arecw	Reconstituted wood product manufacturing	ainfo	51 Information
adoor	Wood windows and door manufacturing	afini	52 Finance & insurance
aplan	Cut stock, resawing lumber, and planing	areal	53 Real estate & rental
aomil	Other millwork, including flooring	aprof	54 Professional- scientific & tech svcs
apall	Wood container and pallet manufacturing	amang	55 Management of companies
amobl	Manufactured home (mobile home) manufacturing	aadmn	56 Administrative & waste services
apref	Prefabricated wood building manufacturing	aeduc	61 Educational svcs
amisc	All other miscellaneous wood product manufacturing	aheal	62 Health & social services
apulp	Pulp mills	aarts	71 Arts- entertainment & recreation
apapr	Paper mills	aacco	72 Accommodation & food services
apmil	Paperboard mills	aoser	81 Other services
apbox	Paperboard container manufacturing	agovt	92 Government & non NAICs
apbag	Paper bag and coated and treated paper manufacturing	flabr	Employee Compensation
astat	Stationery product manufacturing	fprpr	Proprietor Income
asany	Sanitary paper product manufacturing	fcapl	Other Property Type Income
aoppr	All other converted paper product manufacturing	ftopi	Tax on Production and Imports

6. Summary and Conclusions

From the base and gross value added analysis, four forest product sectors were identified as making major contributions to Michigan's economy: paper, paperboard, paperboard containers and wood office furniture. The measures of competitive advantage revealed that these sectors were also increasing their share of value added both over time and relative to the U.S. Wood office furniture in particular showed strong increases in competitive advantage. An analysis of the supply chains show that wood furniture, institutional furniture along with paperboard container manufacturing are most identified with exports albeit in the case of paperboard containers these exports are of the intermediate demand type to other non-forest products sectors. Further, these sectors are dependent on the output of smaller forest product sectors that could become bottlenecks in the production of the more important exporting sectors. The potential bottleneck sectors include commercial logging, sawmills and pallets manufacturing. Paper, paperboard, shelving and veneer manufacturing pay a duel role of producing for exports and intermediate demand in almost equal measure.

Policy considerations relate to the key role played of exports by wood furniture manufacturing in the forest product economy of Michigan. Paperboard containers also play a role of producing a key input to other non-forest product sectors in the state. These sectors warrant the close attention of state policy makers to assure their continue retention and expansion. A concern that might prevent this would be issues in key input sectors. These potential bottleneck sectors include commercial logging, sawmills and pallets. In addition, the labor supply to the forest product sector in general needs careful attention.

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