

Tracking the Economic Contributions West Virginia's Forest Products Industry During the COVID-19 Pandemic Era: A Look at 2019 Through 2022 Data

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Abstract

West Virginia's forest products industry's (FPI) contributions to the state's economy have historically been influenced by factors such as increasing global competition, increasing automation, recessions, the shale gas boom, and more recently, the COVID-19 pandemic. However, there are limited data regarding the impact of the pandemic on the industry and state economy. Given its importance to the state economy, it is therefore important to examine the effect of the pandemic on the industry and the state economy and its recovery postpandemic. This study quantifies the impact of the COVID-19 pandemic on West Virginia's FPI from 2019 through 2022, highlighting significant recovery postpandemic. As expected, during the peak of the pandemic spanning the periods of 2019 and 2020 marked a decline in the West Virginia FPI performance across all measures of economic contributions. However, the magnitude and length of the adverse impact is not as significant as the impact of the Great Recession. The forestry sector experienced the largest decline in terms of direct and total economic contributions while the furniture sector remained relatively resilient. By 2021, the industry already experienced recovery which continued through 2022. In fact, 2022 levels were higher than the prepandemic levels except for employment and direct employee compensation. In general, most sectors of the industry have shown recovery and are even performing better than before the pandemic, except for the logging sector. The West Virginia FPI has proven its resiliency during the pandemic and capitalized on opportunities to respond to the changing demand for forest products.

The COVID-19 outbreak, declared a worldwide pandemic by the World Health Organization (WHO) as a worldwide pandemic on March 11, 2020 (WHO 2021), wreaked havoc on global, national, state, and local economies. During the height of the pandemic, state and local governments across the United States scrambled to contain the spread of the virus by dramatically reducing capacity at in-person gatherings at both business and social events, resulting in some business closures (Dreger and Gross 2021). These measures resulted in significant reductions in employment across industry sectors and as a result, unemployment rate soared both nationally and statewide. The pandemic significantly disrupted various sectors of the state, national, and global economies. One area profoundly affected was the forestry sector, affecting forests, forest-dependent people, and the forest products industry (Stanturf and Mansuy 2021). It caused short-term disruptions in forest products industry supply chains (Food and Agricultural Organization of the

United Nations [FAO] 2020) and changed trends in wood consumer behavior (International Labour Organization 2020; Lund

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et al. 2020). Additionally, it led to mill closures, halted production, and impacted employment globally and nationally (Stanturf and Mansuy 2021).

Although the pandemic inflicted numerous short-term negative impacts on the forest products industry, with some sectors experiencing significant slowdowns, other sectors underwent a boom (Gagnon et al. 2022). The lumber industry in the United States and Canada, as an example, experienced a boom as consumers invested in home improvement projects (Stanturf and Mansuy 2021), with prices rising by as much as 400 percent (Popken 2021). However, few studies have examined the pandemic impact in the forestry sector. The Food and Agriculture Organization of the United Nations (FAO 2020) completed a study at the global level, through a survey on the impacts of the COVID-19 pandemic on wood value chains and recovery measures from the forest sector. The survey results indicate that wood value chains were hard hit by the COVID-19 pandemic, but the direction and intensity of the impacts were not uniform across sectors. For example, the pulp and paper sector reported a positive impact while the logging sector has been negatively impacted. The study concludes that the wood sector in the long term “may emerge from the crisis with higher social and operational standards and social measures; and head towards digitalization, in response to the disruption that operations, workforce and finance have faced to date.” (FAO 2020) Stordal et al. (2021) examined performance of the forest products industry in the initial phase of the pandemic by employing data for publicly traded companies in the global industry. Their findings showed that the forestry subsector was impacted more than the paper subsector in the early stages of the pandemic, and this effect was most prominent in North America. Specifically, systematic risk for the forestry subsector tended to increase during 2020 while the impact on the paper subsector was more stable. The impact of the pandemic on the Canadian wood pellet industry was relatively small because of the integrated nature of the industry and its reliance on long-term supply contracts and feedstock availability (Gagnon et al. 2022). However, the pandemic seriously affected the forest products supply chain in central and southeast European countries, particularly that of the solid wood and engineered wood products (Kuzman et al. 2022). The critical issues contributing to this included increased prices of materials, increased transportation costs, extended delivery times, limited quantities of materials, and total disruption of supply chains. Timber prices globally were also affected by the pandemic. A study by Hlavackova et al. (2024) showed that prices sharply declined early (i.e., first and second quarters of 2020) in Canada and the United States, while price declines occurred later and persisted longer in Europe. Notably, the pandemic’s effects were more pronounced in depressing softwood timber prices, while hardwood remained largely unchanged.

There were also a few studies that examined the impact of the pandemic in the US forest industry. For example, Hancock Natural Resource Group (2020) examined the impact of the pandemic on US timberland investing and concluded that timberland investors should expect to see reduced cash flows as a result of disruptions in the forest product sector and depressed demand, particularly in the highest-value market segments, such as the solid wood products sector. This will translate into increasingly competitive timber markets and downward pressure on sawtimber prices. The pandemic also caused a significant decline

(23%) in forest products exports in Tennessee in 2020, but exports in the state experienced a recovery in 2021 (27%) (Muhammad et al. 2023). Dahal (2021) examined the impact of the pandemic on the economic contribution of the forest products industry in Wisconsin’s economy using Impact Analysis for Planning (IMPLAN) software, which is based on input–output (I-O) models. The study showed that the Wisconsin forest products industry lost about 4.8 percent of its direct jobs (over 3,000) and 9.6 percent of direct industry output (US\$2.4 billion). More recently, Chizmar et al. (2023) examined the effect of mandatory-stay-at-home policies on employment on the forest products sector in the southern United States. The study showed that lockdown policies had limited effects on forest-based employment but some negative effects on employment in the aggregate forest sector and wood products manufacturing, about 4 to 11 percent reduction in employment.

It is presumed that, like other forest products industries globally and nationally, West Virginia’s forest products industry (FPI) was also significantly affected by the COVID-19 pandemic. However, there are limited data relating to the impact of the pandemic on the industry and state economy. This lack of data is concerning as this forest-dependent industry has long been considered important to the state’s economy. West Virginia is the third most heavily forested state in the United States, with over 12 million acres of forestland making up 78 percent of the state’s total land area. Of this forest acreage, 11.72 million acres are classified as timberland, which can be a significant source of merchantable timber. About 210 million cubic feet were harvested from the state’s forests in 2020 (US Department of Agriculture Forest Service 2021), providing a significant source of raw materials for the forest industry. Overall, the state has maturing forests and increasing in volume by an average of 240 million cubic feet. West Virginia’s forest resources therefore provide a solid foundation for a thriving forest industry. West Virginia forest products sectors are therefore poised for further economic growth. The industry is also benefitting from the state’s close proximity to a large portion of the US population and its access to global markets through several nearby international ports (West Virginia Department of Forestry 2020). From commercial (e.g., green lumber, kiln-dried lumber, rustic rail fence, moulding, millwork, cross-ties, pallets, veneer) to consumer products (e.g., custom cabinets, furniture, flooring, log homes), products derived from West Virginia hardwoods play a vital role in the broader state economy.

Overall, the West Virginia FPI contributed about 19,000 total jobs and US\$3.4 billion in total output in 2017 (Gabbert et al. 2020). It is the only natural resource industry that provides jobs in all of the state’s 55 counties. In some counties, the industry accounts for almost 20 percent of the workforce. In fact, the forest industry is considered as the largest employer in a number of counties in the state (West Virginia Department of Forestry 2020). West Virginia is one of the top wood-producing states in the nation, producing 75 billion board feet of timber inventory (West Virginia Economic Development 2021). Wood products manufacturing is the fifth largest manufacturing sector in the state in terms of output, providing an output of US\$381.3 million, which represented approximately 5 percent of the state’s total manufacturing output in 2017 (National Association of Manufacturers 2019). However, West Virginia’s FPI has historically been sensitive to major economic events. Gabbert et al. (2020) examined the historical performance of

the industry in the state spanning the years 2006 to 2017 and showed how the industry was affected by various factors such as the housing market collapse of the mid-2000s, various recessions, increasing global competition, a natural gas boom, and other macro-economic trends or shocks. The COVID-19 pandemic is another major global event that has affected the industry. Given its importance to the state economy, it is therefore important to examine the magnitude of the effect of the pandemic on the industry and the state economy and its recovery postpandemic. Despite extensive studies on economic impacts of the pandemic, there is limited research on specific recovery patterns within the forest products industry. In addition, sector specific performance is lacking, particularly in West Virginia.

This study quantifies the impact of the COVID-19 pandemic on West Virginia's FPI and evaluates its postpandemic performance by examining its economic contributions from 2019 through 2022. Specifically, it aims to answer the following research questions: (1) What was the impact of COVID-19 on West Virginia's FPI? (2) How did the industry as a whole and different sectors within the industry respond and recover? The period 2019 through 2022 was chosen to illustrate the effects of the pandemic and the performance of the industry after the pandemic's peak, allowing an assessment of potential signs of recovery. This study also extends the analysis conducted by Gabbert et al. (2020) by providing key information in tracking industry performance over time to address key economic issues faced by the industry.

This research can provide baseline information on the effect of the pandemic on the industry that will be useful for future work that examines long-term performance of the industry and recovery. As such, this research will provide a basis for policy recommendations because the impacts of the pandemic will be long term and will be entangled with other drivers and ongoing trends that affect the forest products industry (Stanturf and Mansuy 2021).

Methodology

Economic contribution analysis and IMPLAN

The prevailing method for estimating an industry's economic contribution is I-O analysis. Developed by Nobel Laureate Wassily Leontief in the 1930s, I-O models are built upon the economic linkages that exist among the different industries within an economy. The development of a Leontief I-O model involves estimating these linkages based on observed supply chain activity with each sector being both a producer and consumer of goods (Miller and Blair 2009). Through these interindustry linkages, the model can quantify the level of output each industry in an economy must produce in order to satisfy an estimated or given total demand for final production (Berman and Plemmons 1979).

IMPLAN, an I-O analysis modeling software, was used in estimating the economic contributions. This modeling software is routinely used in conducting economic contribution analysis. This section provides an overview of the process and key parameters. Through the construction of I-O models, IMPLAN allows users to estimate the impact or contribution of potential, foregone, or existing economic activities within a user-defined region. IMPLAN makes use of the social accounting matrix (SAM), which underlies the I-O model. The SAM is an I-O matrix that represents the

market (interindustry) relationships that exist in an economy as well as the nonmarket (institutional) relationships that are present (Cheney 2018). The inclusion of institutions allows IMPLAN to not only account for the economic activity brought about by interindustry activity, but also that which is brought upon by institutional (e.g., household, governmental) spending. Results of economic contribution analyses are reported by IMPLAN in a number of economic measures by direct, indirect, and induced effects. Direct effects are those contributions that are made through the primary industry of study's operations in order to meet final demand for its output and are the starting point in IMPLAN. Indirect effects are those contributions that arise through interindustry activity that occurs as secondary industries respond to the demand for inputs by the primary industry's operations. Induced effects are those contribution that arise from the spending of personal income by the employees and proprietors of businesses within the primary and secondary industries. The sum of these effects makes up the total contribution, or the gross change in a region's economy that can be attributed to the primary industry or shock of study. Through its SAM, IMPLAN I-O models are built upon Type SAM multipliers, a Type II multiplier. Type SAM multipliers represent the relationship the industry has with the broader overall economy of the model region. These multipliers take into account not only the direct and indirect effects of an industry's operations, but they also include the induced effects that arise from spending of income that originates from the industry by institutions such as households or governments. These multipliers are a more comprehensive representation of the magnitude of the "ripple effects" that are created through the broader economy by the direct industry activity. Direct, indirect, and induced effects are reported using the following measures:

- Employment: The number of full time and part time jobs.
- Employee Compensation: Wages and salaries, including benefits and payroll taxes.
- Output: The value of total production or sales with a region associated with an industry or shock.
- Value Added: The difference between an industry's output and cost of its intermediate inputs, which consists of employee compensation, proprietor income, indirect business taxes, and other property-type income.

Data

IMPLAN state-level datasets for West Virginia for the years 2019 through 2022 were used in the study. The 2019 data represent the prepandemic conditions, while the 2020 data reflect the pandemic conditions. Postpandemic conditions are captured in the 2021 and 2022 data sets. IMPLAN's US industry data are primarily from the Bureau of Economic Analysis benchmark I-O tables. IMPLAN data for 2019 through 2022 contains 546 industries and commodities.

Analysis

The cloud version of the IMPLAN software was used in the analysis. Specifically, the built-in industry contribution analysis function was used to estimate the economic contributions of the industry. This estimates the value of an industry or groups of industries in a region and looks at backward linkages but the purpose differs from the standard economic

analysis (IMPLAN 2023). It shows the relative extent and magnitude of the “event” in the study area. Calculations are based on Method 1 proposed by Parajuli et al. (2018) for calculating economic contribution analyses.

The West Virginia FPI in the study is comprised of seven major forest products sectors: (1) forestry; (2) logging; (3) primary solid wood products; (4) secondary solid wood products; (5) wood furniture; (6) pulp, paper and paperboard; and (7) secondary paperboard and other paper products. These categories are based on those used by Gabbert et al. (2020) for West Virginia FPIs as well those proposed by Joshi et al. (2017). These sectors were created by aggregating 30 individual IMPLAN sectors (Table 1). It must be noted that there are cases where the region of study did not experience activity in all identified sectors. Following Gabbert et al. (2020), Sector 19 (support activities for agriculture and forestry) was adjusted to only account for the portion that is forestry-related. Economic contributions of the seven major sectors are estimated as well as the combined contribution of the industry for all the data years under consideration. All dollar values are reported in 2022 constant US dollars. Results are reported in terms of output, employment, employee compensation, and value added. Type SAM multipliers are also calculated by dividing the total effect by the direct effect.

Results

West Virginia FPI as a whole

Figures 1 through 4 highlight the changes in total economic contributions of the West Virginia FPI during the pre-pandemic period (2019), the peak of the pandemic (2020), and the post-pandemic period (2022). Overall, the industry suffered a decline in total economic contributions for all measures during the peak of the pandemic. However, post-pandemic, the industry performed better regarding its total economic contributions to the state compared to the pre-pandemic levels in all categories except for total employment. Key findings indicate a 12 and 8

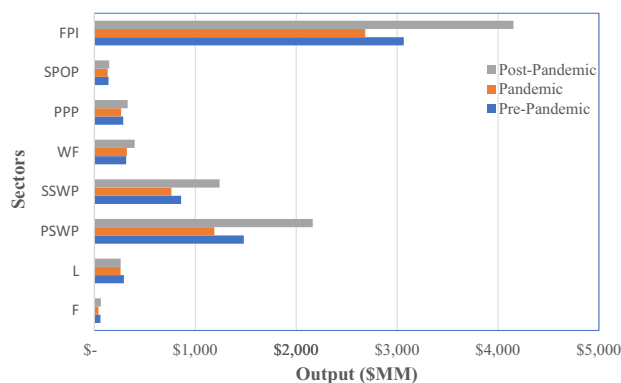


Figure 1.—Prepandemic, pandemic, and postpandemic total output levels for the West Virginia forest product industry and individual sectors.

percent reduction in total output and employee compensation, respectively, during 2020, with significant recovery in 2022 surpassing prepandemic levels.

More detailed information on the economic contributions of the West Virginia FPI from 2019 through 2022 are presented in Table 2. Comparing the data from 2019 to 2020, economic contributions of the forest products industry as a whole declined for all measures. The decline ranged from 5 to 14 percent. Direct contributions in terms of employment declined by 7 percent from the 2019 level, with about 678 lost jobs. Direct value added and employee compensation also declined by about the same rate or 5 and 4 percent, respectively. However, the West Virginia FPI direct output showed a more dramatic decrease from 2019 to 2020, declining by about 12 percent or a loss of US\$250 million. Secondary industries, employees and proprietors of businesses within the primary and secondary businesses, were more affected during the peak of the pandemic as shown by a higher rate of decline in indirect and induced contributions. The rate of decrease ranged from 8 to 14 percent.

Table 1.—Forest product industry (FPI) major sectors included in Impact Analysis for Planning (IMPLAN) analysis. Model sector abbreviations and IMPLAN sector numbers are in parentheses.

FPI model sectors	IMPLAN sectors
1. Forestry (F)	(15) Forestry, forest products, and timber tract production; (19 ^a) support activities for agriculture and forestry
2. Logging (L)	(16) Commercial logging
3. Primary solid wood products (PSWP)	(132) Sawmills; (133) wood preservation; (134) veneer and plywood manufacturing; (136) reconstituted wood product manufacturing
4. Secondary solid wood products (SSWP)	(135) Engineered wood member and truss manufacturing; (137) wood windows and doors manufacturing; (138) cut stock, resawing lumber, and planing; (139) other millwork, including flooring; (140) wood container and pallet manufacturing; (141) manufactured home (mobile home) manufacturing; (142) prefabricated wood building manufacturing (143) all other miscellaneous wood product manufacturing
5. Wood furniture (WF)	(365) Wood kitchen cabinet and countertop manufacturing; (366) upholstered household furniture manufacturing; (367) nonupholstered wood household furniture manufacturing; (369) institutional wood furniture manufacturing; (370) wood office furniture manufacturing; (371) custom architectural woodwork and millwork manufacturing; (373) showcase, partition, shelving, and locker manufacturing
6. Pulp, paper, and paperboard (PPP)	(144) Pulp mills; (145) paper mills; (146) paperboard mills
7. Secondary paperboard and other paper products (SPOP)	(147) Paperboard container manufacturing; (148) paper bag and coated and treated paper manufacturing; (149) stationary product manufacturing; (150) sanitary paper product manufacturing; (151) all other converted paper product manufacturing

^a Denotes partial sector inclusion.

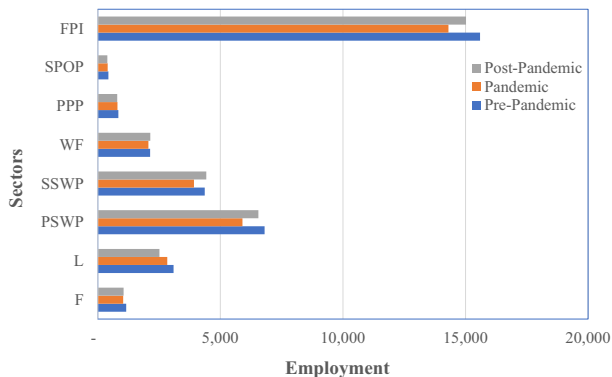


Figure 2.—Prepandemic, pandemic, and postpandemic total employment levels for the West Virginia forest product industry and individual sectors.

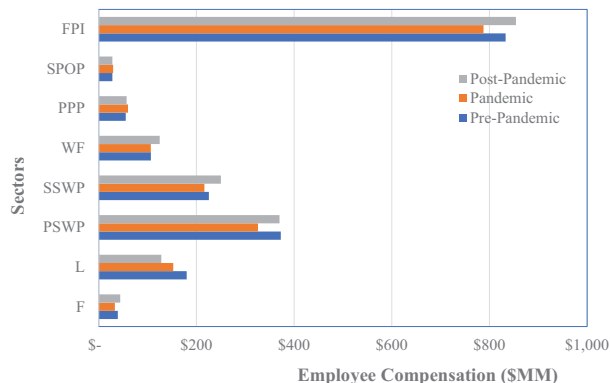


Figure 4.—Prepandemic, pandemic, and postpandemic total employee compensation levels for the West Virginia forest product industry and individual sectors.

Total contributions also declined for all measures. Total output declined by 12 percent or about US\$382 million while total employment and total employee compensation declined by 8 percent from 2019 levels, with 1,288 jobs lost and US\$45.8 million loss in employee compensation.

Comparing the data from 2020 to 2021, the West Virginia FPI started to exhibit considerable improvement. Direct and total industry value added showed the highest relative gain, increasing dramatically by 46 percent (US \$266 million) and 27% (US\$273 million), respectively. This is followed by direct and total output, increasing by 22 percent (US\$411 million) and 16 percent (US\$442 million), respectively. Direct and total employment also increased but at a much lower rate. Direct employment increased by 3 percent, or about 305 jobs, from 2020 to 2021 and by only less than 1 percent in total contribution, or about 15 jobs. Direct employee compensation only increased slightly (1%) but continued to decline in indirect, induced and total effects. However, a recovery from secondary industries and employees and proprietors of associated businesses remains elusive. Except for output, indirect and induced effects continue to decline by less than 1 to 7 percent.

From 2021 to 2022, the West Virginia FPI exhibited continued recovery from the start of the pandemic in 2020. All measures of economic contributions showed an increase

from 2021 levels except for direct employment, which declined slightly (0.5%, or about 45 jobs). The highest gain is from output, exhibiting a 34 percent (US\$779 million), 45 percent (US\$205 million), 10 percent (US\$41 million), and 33 percent (US\$1 billion) increase in direct, indirect, induced, and total contributions, respectively. In fact, in 2022 output levels were even higher than the prepandemic (2019) period. Value added contributions also continued to improve considerably. It increased by 13 percent (US\$106 million) in direct contributions, 42 percent (US\$93 million) in indirect contributions, 11 percent (US\$26 million) in induced contributions, and 17 percent (US\$225 million) in total contributions. Employee compensation in secondary industries associated with the West Virginia FPI have experienced significant recovery from 2021 to 2022 compared to the previous period, increasing by about 36 percent from 2021 level, or about US\$49 million. Overall, a large portion of the West Virginia FPI's growth during 2021 to 2022 came from activities of industries that provide inputs for its operations. This indicates that the West Virginia FPI sourced more of its inputs from West Virginia businesses.

West Virginia FPI: Individual sectors

Historical performance during the prepandemic and postpandemic era for the seven major sectors that make up the West Virginia FPI was also examined to track sector level recovery from the pandemic. Direct and total economic contributions of each sector are presented in Table 3. Prepandemic, pandemic, and postpandemic total economic contributions for the different sectors are also highlighted in Figures 1 through 4. Key findings indicate that total output declined for all sectors except for the wood furniture sector in 2020, with the forestry sector suffering the largest decline, followed by the primary solid wood products sector. Total employment declined for all sectors. Total value added and employee compensation declined for all sectors except for wood furniture and paper-based sectors. All sectors experienced significant recovery in 2022 surpassing prepandemic levels except for the logging sector.

Forestry.—While not a huge component of the FPI sector, the forestry sector had largest decline in direct and total output from 2019 to 2020 compared to other sectors. Direct and total output both declined by about 33 percent. The second largest

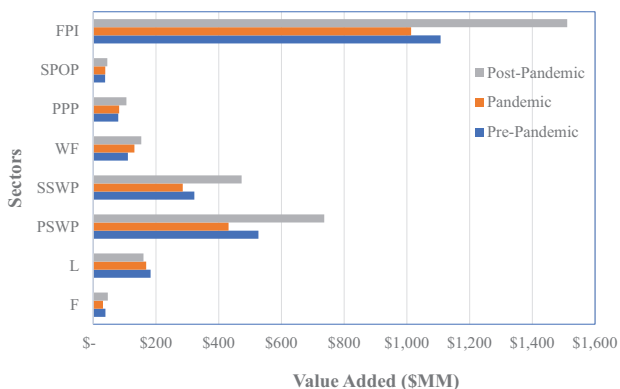


Figure 3.—Prepandemic, pandemic, and postpandemic total value added levels for the West Virginia forest product industry and individual sectors.

Table 2.—The economic contribution of the West Virginia forest products industry and associated social accounting matrix (SAM) multipliers for 2019 through 2022. Dollar amounts reported in 2022 dollars.

Contribution type	2019	2020	2021	2022
Direct				
Output (US\$MM) ^a	2,101.4	1,851.4	2,262.4	3,041.8
Employment	9,545.0	8,867.0	9,172.0	9,127.0
Value added (US\$MM)	605.8	575.6	841.4	947.7
Employee compensation (US\$MM)	537.7	516.3	520.0	533.1
Indirect				
Output (US\$MM)	524.1	449.3	459.5	666.4
Employment	2,979.0	2,788.0	2,580.0	3,197.0
Value added (US\$MM)	254.4	220.5	218.0	310.7
Employee compensation (US\$MM)	157.1	143.9	134.9	184.0
Induced				
Output (US\$MM)	439.9	383.0	403.1	444.5
Employment	3,067.0	2,647.0	2,567.0	2,696.0
Value added (US\$MM)	247.3	217.3	226.8	252.8
Employee compensation (US\$MM)	138.2	127.6	127.5	137.0
Total				
Output (US\$MM)	3,065.4	2,683.6	3,125.0	4,152.7
Employment	15,592.0	14,304.0	14,319.0	15,021.0
Value added (US\$MM)	1,107.5	1,013.4	1,286.3	1,511.2
Employee compensation (US\$MM)	833.0	787.8	782.4	854.2
Type SAM multipliers				
Output	1.46	1.45	1.38	1.36
Employment	1.63	1.61	1.56	1.64
Value added	1.82	1.76	1.60	1.59
Employee compensation	1.55	1.52	1.50	1.60

^a Million dollars.

decline in direct and total contributions came from value added, declining by 14 and 20 percent, respectively. By 2021, this sector showed improvement in both direct and total contributions from 2020 levels, with the largest increase coming from direct and total output, increasing by 27 and 31 percent, respectively. Direct and total output continued to improve through 2022. Direct output increased by 34 percent or US\$10 million and total output increased by 22 percent or US\$12 million. In fact, the magnitude of these contributions is higher compared to the prepandemic levels. Overall, although there was a decline in total economic contributions across all measures from prepandemic to the peak of the pandemic in 2020, by 2022, total economic contributions had surpassed 2019 levels, except for total employment (Figs. 1 through 4).

Logging.—The logging sector also experienced a decline in direct and total contributions from 2019 to 2020 except for direct value added, which showed a slight improvement of about 1 percent. Overall, the immediate effect of the pandemic was moderate compared to other sectors, with direct output declining by about 3 percent or US\$5 million and total output declining by 11 percent or US\$32 million. The largest decline in direct and total contributions came from employee compensation, declining by about 14 to 15 percent. While the immediate effect of the pandemic was modest in this sector, most measures of direct and total contributions continued to experience a decrease from 2020 to 2021. Only direct employment and total output increased, but only by less than 1 percent. Even through 2022, the industry continued to suffer. Although direct output and direct value added improved by 4 to 5 percent, all other metrics of direct and total economic contributions continued to decline. In contrast to other sectors, logging has continued to decline since the onset of the pandemic. Notably, it stands as

the sole sector that has yet to exhibit comprehensive recovery three years after the pandemic's peak, with its current state even lagging the prepandemic levels. As shown in Figures 1 through 4, total economic contributions for all measures in 2022 were lower than the prepandemic levels.

Primary solid wood products.—Prior to the pandemic, the primary solid wood products sector was the largest FPI sector in terms of direct and total economic contributions for all measures. Just like the industry as a whole, this sector showed a decline in economic contributions for all measures from 2019 to 2020. In fact, this sector experienced larger losses compared to the broader industry for direct and total contributions. This sector also suffered the second largest losses compared to the other sectors. Direct and total output and value added had the largest decline. Direct and total output declined by about 20 percent while direct and total value added declined by 20 and 18 percent, respectively. Just like the overall industry, this sector started to see improvement from 2020 to 2021 in direct and total contributions except for total employee compensation, which continued to decline but only by less than 1 percent. The largest improvement was in total value added, increasing by 45 percent from 2020 levels. This is followed by direct output, which increased by 42 percent. Direct and total employment also showed improvement but only by less than 1 percent. By 2022, the sector exhibited continued recovery for all measures of economic contributions. In terms of direct and total contributions, the largest growth is in direct and total output, increasing by 45 and 42 percent, respectively, from 2021 levels. This sector continued to be the largest sector of the FPI in 2022. Direct and total output make up about 50 and 51 percent of the state's FPI direct

Table 3.—The economic contribution of the West Virginia forest product industry sectors: 2019 through 2022. Dollar amounts reported in 2022 dollars.

Year and sector	Output (US\$MM) ^a		Employment		Value added (US\$MM)		Employee compensation (US\$MM)	
	Direct	Total	Direct	Total	Direct	Total	Direct	Total
2019								
F ^b	35.1	59.1	996.0	1,160.0	25.5	38.8	31.8	39.1
L	160.0	291.5	1,551.0	3,091.0	107.9	182.8	132.2	180.1
PSWP	909.1	1,480.4	2,720.0	6,806.0	214.7	526.7	143.4	372.8
SSWP	524.4	858.8	2,393.0	4,362.0	162.3	322.3	121.5	225.5
WF	196.0	314.4	1,418.0	2,136.0	50.9	110.2	70.6	106.8
PPP	171.8	285.3	231.0	840.0	24.8	79.6	20.8	55.4
SPOP	105.1	139.8	234.0	434.0	19.6	37.6	17.3	27.9
2020								
F	23.5	39.8	923.0	1,036.0	21.8	31.0	27.8	33.1
L	155.1	258.7	1,444.0	2,835.0	109.0	168.7	113.2	152.5
PSWP	722.5	1,187.8	2,485.0	5,902.0	171.7	431.3	136.8	326.0
SSWP	479.4	762.6	2,193.0	3,923.0	146.0	285.3	122.2	216.4
WF	211.6	321.1	1,388.0	2,065.0	74.9	131.1	71.1	106.7
PPP	161.7	264.2	221.0	804.0	31.2	82.5	26.6	60.0
SPOP	97.6	130.4	209.0	403.0	20.9	38.2	18.7	29.4
2021								
F	30.0	52.2	987.0	1,130.0	26.3	38.8	34.1	41.8
L	152.4	260.1	1,450.0	2,809.0	98.2	160.4	99.2	141.0
PSWP	1,026.9	1,525.3	2,494.0	5,919.0	356.2	623.6	139.7	325.2
SSWP	582.5	891.9	2,331.0	3,989.0	128.5	377.7	129.6	220.3
WF	219.3	340.8	1,456.0	2,127.0	74.5	136.2	76.2	112.3
PPP	153.2	246.3	235.0	710.0	34.7	80.2	23.1	50.3
SPOP	98.0	132.5	215.0	401.0	22.8	40.6	17.5	28.0
2022								
F	40.3	63.8	910.0	1,052.0	33.1	46.2	34.3	41.4
L	159.4	259.8	1,406.0	2,515.0	102.2	160.1	92.8	128.2
PSWP	1,488.6	2,163.2	2,568.0	6,553.0	384.6	736.5	145.3	370.2
SSWP	786.1	1,239.9	2,372.0	4,427.0	271.9	472.9	133.4	250.2
WF	252.6	398.5	1,412.0	2,141.0	81.6	152.9	84.9	124.9
PPP	206.5	328.7	256.0	794.0	49.0	105.6	25.4	57.2
SPOP	108.2	146.1	200.0	391.0	25.3	44.8	17.0	28.0

^a Million dollars.

^b See Table 1 for definitions.

and total output, respectively. In summary, although total economic contributions dropped across all measures during the peak of the pandemic compared to prepandemic levels, this sector fully recovered by 2022 (Figs. 1 through 4). Total economic contributions postpandemic were higher compared to prepandemic levels across all measures.

Secondary solid wood products.—The secondary solid wood products sector is the second largest component of West Virginia’s FPI. This sector experienced decline in all economic contribution measures from 2019 to 2020 except for direct employee compensation, which increased, but by only less 1 percent from the 2019 level. The decline in this sector pretty much mirrored the decline in the West Virginia FPI as a whole. In terms of direct contributions, the largest decline was in value added. Direct value added declined by US\$16 million or about 10 percent from 2019 levels. Direct output and employment both declined by 8 percent while employee compensation only declined by less 1 percent. In terms of total economic contributions, output, employment, and value added declined by 10 to 11 percent while employee compensation declined by only 4 percent. For the period 2020 and 2021, direct value added continued to decline by another 12 percent or US\$16 million. The rest of the economic measures showed improvement from 2020

levels with largest increase coming from total value added. It increased by 32 percent or about US\$92 million. This indicates a reduction in the cost of intermediate inputs. For the period of 2021 and 2022, the results showed that this sector has continued to improve since the pandemic. In terms of direct and total contributions, the largest gain was in total output, increasing by 39 percent or US\$342 million from 2021 to 2022 followed by direct output increasing by 35 percent or US\$204 million. The least improvement was in direct employee compensation, which grew by only 3 percent. In summary, regarding total economic contributions, all measures declined during the peak of pandemic from prepandemic levels but postpandemic levels surpassed prepandemic levels (Figs. 1 through 4).

Wood furniture.—Unlike the other sectors, the wood furniture sector did not experience an across-the-board decline from 2019 to 2020. In fact, direct output, value added, and employee compensation gained by 8, 47, and 1 percent, respectively. Total output also showed an increase in economic contribution as well as total value added. The decline in the other measures were relatively small compared to the industry, ranging from 2 to 8 percent. For example, direct and total employment only declined by 2 to 3 percent. From 2020 to 2021, direct and total employment showed a

slight improvement, increasing by 3 to 5 percent. Output continued an increasing trend from the prepandemic era for all measures. Direct value added however started to decline while total value added continued to increase during this period. For the period of 2021 to 2022, output continued to increase for all measures, ranging from 13 to 26 percent. However, direct employment declined by 3 percent. Overall, total economic contributions had slightly decreased and in some measures even increased between prepandemic and the peak of the pandemic. By 2022, total economic contributions were higher compared to prepandemic levels (Figs. 1 through 4).

Pulp, paper, and paperboard.—Just like the furniture sector, the pulp, paper, and paperboard sector did not experience an across-the-board decrease from 2019 to 2020. Both the direct and total value added and employee compensation showed improvement from prepandemic levels. Direct value added went up by 26 percent or about US\$6 million and total value added went up by 4 percent or US\$2 million. Direct and total employee compensation went up by 28 and 8 percent, respectively. Both direct and total output and employment were negatively affected by the pandemic but by a smaller percentage (4 to 7%) compared to the other FPI sectors. While the initial impact of the pandemic was not significant for this sector, total economic contributions experienced a decline for all measures from 2020 to 2021. Only direct employment and value added showed improvements, increasing by 6 to 11 percent from 2020 levels. By 2022, this sector has shown recovery, increasing economic contributions for all measures. The largest increase was in direct and total output, increasing by 35 and 33 percent, respectively, from 2021 levels. Overall, the impact of the pandemic was mixed for this sector but the magnitude of total economic contributions was higher in 2022 compared to the prepandemic levels except for total employment (Figs. 1 through 4).

Secondary paperboard and other paper products.—Similar to the pulp, paper, and paperboard sector, the secondary paperboard and other paper products sector also showed a higher direct and total value added and employee compensation in 2020 compared to 2019. Direct and total output and employment showed a decline of 7 to 10 percent during the peak of the pandemic. For the period of 2020 and 2021, direct and total output improved by less than 1 to 2 percent and value added continued to increase by 6 to 9 percent. However, direct and total employee compensation declined 5 to 6 percent during this period. For the period of 2021 and 2022, direct and total contributions improved or did not change for all measures except for employment, which showed a decline of 2 to 7 percent. Overall, results of the pandemic either resulted in an increase (e.g., value added, employee compensation) or decrease (e.g., output, employment) in total economic contributions. Postpandemic levels for total output, total value added, and total employee compensation were higher than prepandemic levels while total employment continued to decline at a level lower than the prepandemic value (Figs. 1 through 4).

Discussion

The global FPI has historically exhibited sensitivity to major economic downturns. A notable example is the Great Recession, which resulted in the loss of 1.1 million jobs across six of the industry sectors (Woodall et al. 2011). Akin to other industries, the FPI was significantly impacted

by the pandemic, with certain sectors experiencing more profound effects than others. The West Virginia FPI's contributions to West Virginia's economy have historically been influenced by factors such as increasing global competition, increasing automation, recessions, and the shale gas boom (Gabbert et al. 2020). The present study examines the effect of the pandemic on the West Virginia FPI's economic contribution and postpandemic recovery trajectory.

West Virginia FPI performance during the pandemic

As expected, the peak of the pandemic, spanning the periods of 2019 and 2020, marked a decline in the West Virginia FPI's performance across all measures of economic contributions. The results of this study corroborate the assessment that governmental and individual actions to curtail the spread of the virus negatively affected the industry, with the largest decline being observed in direct and total output. Direct and total output each declined by 12 percent. The results of this study are also consistent with other studies at the global, national, and state levels that also show a negative impact of the pandemic in the forest industry (e.g., Dahal 2020, FSAO 2020, Hayes and Morgan 2020, Kuzman et al. 2021, Stordal et al. 2021, Muhammad et al. 2023). These results confirm that measures that were implemented to curb the spread of the virus had economic repercussions for the industry. Specifically, these declines can be attributed to the disruptions in forest products supply chains (Stanturf and Mansuy 2021) and reductions in the labor force that were a direct result of governmental measures to mitigate the effects of the pandemic. The pandemic led to labor shortages not only due to governmental measures that forced businesses to shut down but due to illnesses and quarantine measures. This highlights the vulnerability of the industry to such interventions and the importance of labor force to the industry. The forest industry has traditionally been labor-intensive and relies heavily on a skilled labor force. Thus, disruptions in labor supply can have an immediate impact on its performance.

While the broader FPI experienced a decline during the pandemic, the gravity of the impacts are not as bad as those related to the Great Recession and the housing market crisis in the mid to late 2000s. Gabbert et al. (2020) showed a decline of 36 and 28 percent in the West Virginia FPI total and direct output, respectively, during the Great Recession. This study shows that total output only declined by 12 percent during the peak of the pandemic. Overall, the decline experienced ranged from 8 to 14 percent, depending on the economic measure, which is relatively lower than the impact of the housing market crisis. The pandemic both affected both the supply and demand side of forest products so while labor shortages and supply chain disruptions negatively affected the industry, the shift in consumer behavior that drove demand could have lessened the impact. Other studies have also shown a relatively minimal impact of the pandemic in terms of economic contributions. For example, Wisconsin's FPI suffered about 5 to 10 percent decline in direct employment and output (Dahal 2021). The economic implications of the pandemic in central and southeastern Europe forestry sectors and the Canadian wood pellet sector have also been relatively small (Gagnon et al. 2022, Kuzman et al. 2022). The effect on southern US employment in essential forest

industry sectors such as wood-based manufacturing was also limited (Chizmar et al. 2024). The US Department of Homeland Security has identified the FPI as an essential workforce in the country's response to the pandemic, which could have lessened the negative impact on the industry, providing insights into the resilience of the industry to short-term economic shocks (Chizmar et al. 2024). A study by Stanturf and Mansuy (2021) on the impact of the pandemic in Canada and the United States indicates that the forest sector as whole—forest management, industry, and communities—had demonstrated remarkable resilience to the pandemic.

Fiscal and monetary policies implemented by the government to address the economic impacts of the pandemic could have contributed to lessening the negative impact of the pandemic. In Europe, government support curtailed worker layoffs or reduction in wages (Kuzman et al. 2022). The federal government in the United States provided financial relief to some sectors of the economy through the Coronavirus Aid, Relief, and Economic Security Act and Emergency Coronavirus Relief Act of 2020 (US Congress 2020, US Senate 2020). These measures included US\$200 million in funding for logging and log trucking businesses that saw a greater than 10 percent loss in revenues in 2020 related to the pandemic (American Loggers Council 2020). In addition, over 35,000 Paycheck Protection Program loans were acquired by forest products companies during the pandemic, which translated into US\$200 million worth of payments to industry workers. As such, direct and total employment only declined by 7 to 8 percent compared to 20 to 35 percent during the Great Recession (Gabbert et al. 2019).

Postpandemic recovery by the West Virginia FPI

Recovery was already in sight from 2020 to 2021, with the largest improvement coming from direct and total output and value added, increasing from 16 percent to as much as 46 percent. With the stay-at-home mandates, people working from home had pushed the demand for forest products. For example, with extremely low interest rates coupled with the need to work more from home, some decided to expand their living spaces by purchasing larger homes, pushing the demand for home construction. In addition, others invested in home improvements and purchased new furniture, pushing the demand for lumber and related wood products (van Kooten and Schmitz 2021) such as pulp-and-fiber-based personal protective equipment, personal hygiene products, packaging materials (Liu et al. 2020, Sen 2020). Regarding employment, improvements in direct and total employment are minimal. Direct employment increased by 3 percent and total employment by less than 1 percent. The FPI faced significant challenges in rehiring workers, despite the uptick in forest products demand. This predicament was exacerbated by the fact that direct employee compensation only increased by less than 1 percent while total employee compensation continued to decrease, although by only less than 1 percent. Notably, both direct and total employment and direct employee compensation still remained below prepandemic levels. For example, direct and total employment were about 2 to 4 percent lower than the prepandemic levels while. Improvements continued through 2022 compared to 2021 levels, with the exception of direct employment, which continued to decline by about 1 percent. This results indicate that the industry's labor force continues to face challenges in its recovery, which could

be attributed to the aging workforce and specialized skills and training required to enter the workforce.

Looking at the magnitudes of the West Virginia FPI's economic contributions, 2022 levels were higher than the prepandemic levels except for employment and direct employee compensation. Total output and total value added were 35 to 36 percent higher than the prepandemic levels. However, total employment was about 4 percent lower than the prepandemic level. Even with fewer employees, the industry managed to increase production and value added. In fact, 2022 economic contributions have surpassed the levels prior to the Great Recession reported by Gabbert et al. (2006). Total output and value added in 2022 were US\$4.1 billion and US\$1.5 billion, respectively. In 2006, total output was US\$3.6 billion, and value added was US\$1.3 billion (Gabbert et al. 2020). There are a number of reasons why the industry has performed well in spite of the continued reduction in the labor force. Government interventions in the form of financial assistance to businesses and measures to stabilize supply chains might have contributed to increase in performance. Better market conditions such as increasing forest product prices due to increasing demand from consumer activities such as home improvement is also a contributing factor. The results also indicate that the industry is becoming more efficient, probably from increased automation and other technological improvements in the production process. The pandemic compelled the industry to adopt measures aimed at enhancing efficiency and reducing reliance on physical labor. As a result, a noticeable shift has emerged toward digitalization, automation, mechanization, and other innovations to improve resilience by reducing costs and risks associated with manual labor (Kline et al. 2021, Kuzman et al. 2022). Automation not only allows for cost reduction and improved safety, but also enables effective management labor shortages (Amishev 2023). In addition, digitalization facilitates FPI implementation of climate-smart solutions that can minimize emissions while simultaneously reducing maintenance costs and improving safety. The pandemic underscored the importance of supply chain resilience and diversification as a means to mitigate the impact of future crises including relying more on in-state suppliers as shown by the improvement in indirect and induced effects. The pandemic has been a catalyst for the industry to shift its practices and accelerate the adoption of innovations.

Impact of the pandemic on individual FPI sectors and recovery

The responses of the various subsectors of the West Virginia FPI to the pandemic were varied. This variability in response can be attributed to the inherent diversity of the industry and its interconnectedness with different markets on both demand and supply-side value chains. (Stordal et al. 2021). For instance, the forestry sector experienced the largest decline in terms of direct and total contributions, declining by about 33 percent in 2020. However, it is noteworthy that the forestry sector only accounted for less than 2 percent of the total output and 7 percent of the total employment within the West Virginia FPI in 2019 and 2020. Thus, the magnitude of the impact did not have a substantial effect on the industry. Total employment declined by 11 percent, but still not as much as the sector's performance across the United States. This sector suffered a 44 percent employment reduction across the United States (Damicis 2020). As mentioned earlier, the state is highly dependent on

this industry, which not only provides jobs in all of its 55 counties but is also the biggest employer in many of these counties. Thus, measures may have been put in place to minimize the pandemic's impact. By 2021, this sector showed considerable improvement in both direct and total contributions. By 2022, the magnitudes of direct and total contributions surpassed prepandemic levels across all measures, by as much as 19 percent from prepandemic levels, with the exception of employment, which was still 9 percent below prepandemic level.

The logging sector was similarly impacted by the pandemic, as shown by the change in economic contributions from 2019 to 2020, declining by 3 to 15 percent. This outcome was anticipated, given the sector's heavy reliance on demand from downstream industries, such as wood-based manufacturing and other sectors of the West Virginia FPI, which were also affected by the pandemic. These results are also supported by a global survey of this sector conducted by FAO (2020) that reported a significant negative impact of the pandemic. While the logging sector in West Virginia experienced modest reduction in economic contributions, it is the only sector that has not recovered from the pandemic with total employment and total employee compensation 10 to 11 percent lower than the prepandemic levels. Even prior to the pandemic, this sector was already experiencing reduction in workers in the United States due to mechanization and a lack of successful recruitment or retention of employees (Knight et al. 2023). The impacts of the pandemic on the logging sector are expected to be long lasting. Loggers possess highly specialized skills related to timber harvesting and transportation, which are challenging to replace once they leave the industry (Pelkki 2020). Given high transferability of these skills, this sector faces significant labor competition from occupations that require skill sets such as truck drivers, freight and material movers, machine operators, etc. Moreover, logging businesses are typically small, but they face significant start-up costs. Recent inflationary trends have further intensified the challenges they encounter in maintaining their survival. A survey conducted in 2022 highlighted the most pressing issues for loggers, including fuel, labor, insurance, and trucking costs, all of which have been significantly affected by inflation (Knight et al. 2023). During this same time, mills were experiencing increased sales revenues (Prestemon and Guo 2022). However, these revenues generally did not flow down the supply chain to the loggers, resulting in loggers not receiving higher prices on their products (Hilsenroth et al. 2021). This situation could have impacted the recovery for this sector.

The primary and secondary solid wood products sectors experienced significant impacts due to the pandemic, as indicated by the changes in the direct and total contributions from 2019 to 2020. A study by Kuzman et al. (2022) in central and southeastern Europe showed that most significant changes occurred in solid and engineered wood products during the pandemic. These sectors had a high exposure index to COVID-19 pandemic, which is measured based on trade with China, supply chains, and the business environment (Damiciis 2020). The construction demand collapse coupled with labor restrictions resulted in a downturn in these sectors during the peak of the quarantine. These sectors also produce products with price-elastic supply and income-elastic demand, which

makes them more volatile and react more to catastrophic events. Additionally, production from this sector tends to be more cyclical and is highly affected by economic crises (Stordal et al. 2021). For West Virginia, these sectors saw a decline of as much as 20 percent. While is this concerning, as these sectors make up a significant portion of the West Virginia FPI, by 2022, most measures of economic contributions have surpassed the prepandemic levels by as much as 47 percent.

The furniture sector was relatively resilient during the pandemic, in contrast to other FPI sectors. In fact, it experienced an improvement in direct and total economic contributions from 2019 to 2020 by as much as 47 percent. Other studies have highlighted the pandemic's positive impact on this sector. Kuzman et al. (2022) for example, found that central and southern European wooden furniture manufacturers maintained employment, experiencing minimal disruptions. During the peak of the pandemic, furniture production operated at full capacity due to surging demand from home remodeling and the need for home office setup due to stay-at-home orders. This upward trajectory continued through 2022, with the sector's total economic contributions exceeding the prepandemic era.

West Virginia FPI paper-related sectors (i.e., pulp, paper, and paperboard; secondary paperboard and other paper products) only experienced minor reductions in total economic contributions from 2019 to 2020 in terms of output and employment while still showing improvements in total value added and employee compensation. The highest decline was at only 10 percent while improving by as much as 27 percent in some measures. These sectors showed more resilience, just like the wood furniture sector, due to the surge in consumer product demand coming from these sectors during the pandemic. This resilience aligns with findings from a global survey of the forest sector conducted by FAO (2020), which indicated a positive pandemic impact due to increase in sales. The surge in demand for hygiene products such as toilet paper, fueled in part by consumers' panic buying when they were forced to work from home (Wieczner 2020), likely buoyed these sectors. Demand for paper-based packaging due to an uptick in home deliveries also contributed to this. Moreover, pulp and paper production are capital intensive and operate via more continuous processes compared to sawmills, rendering these sectors less susceptible to disruptions (Stordal et al., 2021).

Conclusions

While the West Virginia FPI has experienced a decline in economic contributions during the pandemic, the magnitude and length of the adverse impact is not as significant as the impact of the Great Recession. This study also highlights how the pandemic affected each individual sector differently, with some sectors faring well (e.g., wood furniture) while others were more negatively affected (e.g., logging). This information can be useful for policy makers and forest industry stakeholders in determining where efforts should be directed with respect to industry assistance. For example, the impact of the pandemic on the logging sector will likely be long-lasting, which is exacerbated by the state's aging workforce and labor competition from other industries (e.g., construction). Thus, the state should focus on initiatives such as recruiting a younger workforce and providing training.

In general, the FPI as whole and most sectors within the industry have shown recovery and are even performing better than before the pandemic. The West Virginia FPI has

proven its resiliency during the pandemic and capitalized on opportunities to “build back better.” In fact, the US forest industry as a whole demonstrated remarkable resilience (Stanturf and Mansuy 2021). A major contributing factor was the increased demand for forest products. The pandemic highlighted the needs for forest products for personal protective equipment, construction materials, sanitary needs, packaging, and energy, underscoring the industry’s role in sustainable forest consumption and production (Pepke et al. 2020). This underscores the importance of adapting to evolving consumer behavior to better prepare for future catastrophic events or economic shocks. The FPI was also compelled to innovate and adapt practices to overcome production challenges. However, the FPI must continue innovating and remaining flexible, as supply chain challenges and labor shortages will likely continue into the future. This study has shown that labor shortage will continue to be an ongoing issue. Thus, aside from implementing innovations to improve performance, the forest industry must consider implementing measures to address labor shortages. This could include enhancing recruitment efforts and training, and improving wages and benefits, etc.

The ability to quickly adapt to changing landscapes is necessary for the industry to emerge as stronger and more resilient. This study highlights the resilience of West Virginia’s FPI, offering insights for policy makers to support future economic stability and growth.

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Literature Cited

American Loggers Council. 2020. Loggers celebrate passage of emergency coronavirus relief act of 2020. <https://www.amloggers.com/news/loggers-celebrate-passage-of-emergency-coronavirus-relief-act-of-2020>. Accessed March 20, 2024.

Amishev, D. 2023. Forests on challenging terrain. Canadian Forest Industries (CFI). <https://www.woodbusiness.ca/forests-on-challenging-terrain/>. Accessed April 20, 2024.

Berman, A. and R. J. Plemmons. 1979. Input-output analysis in economics. In: *Nonnegative Matrices in the Mathematical Sciences*. pp. 243–270. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA.

Cheney, P. 2018. Explaining the type SAM multiplier. <https://mplanhelptest.zendesk.com/hc/en-us/articles/115009674768-Explainingthe-Type-SAM-Multiplier>. Accessed November 11, 2018.

Chizmar, S., R. Parajuli, S. Bruck, G. Frey, and E. Sills. 2024. Forest-based employment in the southern United States amidst the COVID-19 pandemic: A causal inference analysis. 2023. *Forest Sci.* 70:23–36. <https://doi.org/10.1093/forsci/fxad042>

Dahal, R. 2021. Impact of COVID-19 on Wisconsin forest products industry. https://dnr.wisconsin.gov/sites/default/files/topic/ForestBusinesses/economicImpact_covid19.pdf. Accessed January 22, 2024.

Damicis, J. 2020. Economic and market trends in forestry and lumber industries under COVID-19. <https://www.expansionsolutionsmagazine.com/forestry-lumber-industries-under-covid-19/>. Accessed April 22, 2024.

Dreger, C. and D. Gross. 2021. Lockdowns and the US unemployment crisis. *Econ. Disaster Clim. Change* 5(3):449–463.

Food and Agricultural Organization of the United Nations (FAO). 2020. Impacts of COVID-19 on wood value chains and forest sector response: Results from a global survey 2020. Policy Brief. <https://www.fao.org/3/cb1987en/CB1987EN.pdf>. Accessed January 10, 2024.

Gabbert, C. C., K. A. Gazal, and J. McNeel. 2020. Economic contribution of West Virginia’s forest products industry over time: a look at 2006, 2010, 2015 and 2017 data. *Forest Prod. J.* 70(2):200–212.

Gagnon, B., H. MacDonald, E. Hope, M. J. Blair, and D. W. McKenney. 2022. Impact of the Covid-19 pandemic on biomass supply chains: the case of the Canadian wood pellet industry. *Energies* 15:3179. <https://doi.org/10.3390/en15093179>

Hancock Natural Resource Group. 2020. COVID-19: Impacts across the forest sector. <https://htrg.com/wp-content/uploads/sites/2/COVID-19-Impacts-Across-the-Forest-Sector.pdf>. Accessed January 31, 2024.

Hayes, S. and T. A. Morgan. 2020. Forest products: Montana wood products in the time of COVID-19. *Mont. Bus. Q.* 58:35–37.

Hilsenroth, J., K. A. Grogan, R. M. Crandall, L. Bond, and M. Sharp. 2021. The impact of COVID-19 on management of nonindustrial private forests in the southeastern United States. *Trees People* 6:100159. <https://doi.org/10.1016/j.tfp.2021.100159>

Hlavackova, P., J. Banas, and K. Utbik-Banas. 2024. Intervention analysis of COVID-19 pandemic impact on timber prices in selected markets. *For. Policy Econ.* 159:103123. <https://doi.org/10.1016/j.forpol.2023.103123>

Impact Analysis for Planning (IMPLAN). 2023. ICA: Introduction to industry contribution analysis. <https://support.implan.com/hc/en-us/articles/360025854654-ICA-Introduction-to-Industry-Contribution-Analysis>. Accessed February 4, 2024.

International Labour Organization. 2020. Impact of COVID-19 on the forest sector. ILO Sectoral Brief. <https://www.ilo.org/resource/brief/impact-covid-19-forest-sector>. Accessed February 2, 2024.

Joshi, O., J. E. Henderson, S. M. Tanger, L. A. Boby, M. H. Pelkki, and E. L. Taylor. 2017. A synopsis of methodological variations in economic contribution analyses for forestry and forest-related industries in the US south. *J. Forestry* 115(2):80–85.

Kline, K. L., V. H. Dale, and E. Rose. 2021. Resilience lessons from the southeast United States woody pellet supply chain response to the COVID-19 pandemic. *Front. Forests Glob. Change* 4:674138.

Knight, C. R. D., M. C. Bolding, J. L. Conrad, and S. M. Barrett. 2024. Log truck transportation challenges and innovative solution: Evaluating the perspective of truck drivers, logging business owners, and foresters. *Int. J. Forest Eng.* 35(1):113–121. <https://doi.org/10.1080/14942119.2023.2273123>

Kuzman, M. K., L. Oblak, B. Glavonjic, A. P. Barcic, M. Obucina, E. Haviarova, and P. Groselj. 2022. Impact of COVID-19 on wood-based products industry: an exploratory study in Slovenia, Croatia, Serbia and BiH. *Wood Mater. Sci. Eng.* <https://doi.org/10.1080/17480272.2022.2109210>

Liu, K., H. Wang, S. Nie, H. Du, and C. Si. 2020. COVID-19: Challenges and perspective for the pulp and paper industry worldwide. *Bio-Resources* 15(3):4638–4641.

Lund, S., B. Hancock, K. Ellingrud, J. Manyika, and A. Dua. 2020. Lives and livelihoods: Assessing the near-term impact of COVID-19 on US workers. McKinsey Global Institute. <https://www.mckinsey.com/industries/public-and-social-sector/our-insights/lives-and-livelihoods-assessing-the-near-term-impact-of-covid-19-on-us-workers>. Accessed January 22, 2024.

Miller, R. E. and P. D. Blair. 2009. Input-output analysis: Foundations and extensions. 2nd ed. Cambridge University Press, New York. 784 pp.

Muhammad, A., C. H. Hellwinckel, S. Nzayirama, and A. Taylor. 2023. Economic impact of Tennessee forest products export in 2021. Extension reports 330847. University of Tennessee, Department of Agricultural and Resource Economics, Knoxville, TN. <http://dx.doi.org/10.22004/ag.econ.330847>

National Association of Manufacturers. 2019. 2019 West Virginia manufacturing facts. <https://www.nam.org/state-manufacturing-data/>. Accessed January 21, 2024.

Parajuli, R., J. E. Henderson, S. M. Tanger, O. Joshi, and R. P. Dahal. 2018. Economic contribution analysis of the forest product industry: A comparison of the two methods for multisector contribution analysis using IMPLAN. *J. Forestry* 116(6):1–7.

Popken, B. 2021. How the lumber industry misread Covid and ended up with a global shortage and sky-high prices. NBC News. <https://www.nbcnews.com/business/economy/how-lumber-industry-misread-covid-ended-global-shortage-sky-high-n1272542>. Accessed 22, 2024.

- Pelkki, M. 2020. Logging production falls off due to Covid-19 impacts. Arkansas Money Politics. <https://armoneyandpolitics.com/logging-production-falls-off-due-to-covid-19-impacts/>. Accessed April 20, 2024.
- Pepke, E., K. Fernholtz, J. Bowyer, G. Erickson, H. Groot, M. Jacobs, and A. McFarland. 2020. COVID-19 impacts on the forest sector: 2020 and beyond. Dovetail Partners. <https://dovetailinc.org/upload/tmp/1609428627.pdf>. Accessed January 6, 2024.
- Prestemon, J. P., J. Guo. 2022. COVID-19 and the forest products sector in 2020–2021. *ORMS Today* 49(1). <https://doi.org/10.1287/orms.2022.01.16>
- Sen, M. 2020. United Nations Department of Economic and Social Affairs. Policy Brief #80: Forests at the heart of a green recovery from the COVID-19 pandemic. https://www.un.org/development/desa/dpad/wpcontent/uploads/sites/45/publication/PB_80.pdf. Accessed March 23, 2024.
- Stanturf, J. A. and N. Mansuy. 2021. COVID-19 and forests in Canada and the United States: Initial assessment and beyond. *Front. Forest Glob. Change* 4. <https://doi.org/10.3389/ffgc.2021.666960>
- Stordal, S., G. Lien, and E. Tromborg. 2021. Impacts of infectious disease outbreaks on firm performance and risk: The forest industries during Covid-19 pandemic. *J. Risk Financial Manag.* 14:318. <https://doi.org/10.3390/jrfm14070318>
- US Congress. 2020. Emergency Coronavirus Relief Act of 2020. Washington, DC. <https://www.congress.gov/116/bills/hr748/BILLS-116hr748enr.pdf>. Accessed July 10, 2024.
- US Department of Agriculture Forest Service. 2021. Forests of West Virginia, 2020. Resource Update FS-339. US Department of Agriculture, Forest Service, Madison, WI. 2 pp. <https://doi.org/10.2737/FS-RU-339>.
- US Senate. 2020. Guide to the Coronavirus Aid, Relief, and Economic Security (CARES) Act. Washington, DC.
- Van Kooten, G. C. and A. Schmitz. 2021. COVID-19 impacts on U.S. lumber markets. *Forest Policy Econ.* 135:102665. <https://doi.org/10.1016/j.forpol.2021.102665>.
- Wieczner, J. 2020. The case of the missing toilet paper: how the coronavirus exposed U.S. supply chain. Fortune. <https://fortune.com/2020/05/18/toilet-paper-sales-surge-shortage-coronavirus-pandemic-supply-chain-cpg-panic-buying/>. Accessed January 13, 2024.
- West Virginia Economic Development. 2021. Forest Products. https://westvirginia.gov/wp-content/uploads/2021/08/Pub_ForestProductsMap_2021_WEB.pdf. Accessed on July 9, 2024.
- West Virginia Division of Forestry. 2020. West Virginia 2020 State Forest action plan. <https://www.stateforesters.org/wp-content/uploads/2021/02/WV-2020-SFAP-Final.pdf>. Accessed on July 9, 2024.
- Woodall, C. W., R. J. Piva, K. E. Skog, P. J. Ince, and W. G. Luppold. 2011. An assessment of the downturn in the forest products sector in the northern region of the United States. *Forest Prod. J.* 61(8):604–613.
- World Health Organization (WHO). 2021. WHO Director-General's opening remarks at the media briefing on COVID-19—11 March 2020. <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020>. Accessed January 13, 2024.