CATALYZING ECONOMIC AND ENVIRONMENTAL INSIGHTS: APPLICATIONS OF IMPLAN'S ENVIRONMENTALLY EXTENDED INPUT-OUTPUT (EEIO) MODELING FOR ENERGY PRODUCTION SCENARIOS

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Abstract

In the United States, regional scientists and economists frequently employ IMPLAN, a proprietary input-output (I-O) software, for assessing the economic ramifications of diverse interventions on the local economy. IMPLAN has recently incorporated the Environmental Protection Agency's (EPA) Environmentally Extended Input-Output (EEIO) modeling as an optional extension within their subscription service. In this paper, we compare coal vs. solar production scenarios in Ohio (a state in the United States) as a case study to illustrate the seamless integration of EEIO modeling with traditional I-O modeling, showcasing its enhanced capabilities for evaluating economic and environmental impacts. In the case of Ohio, we found that the state's plans to increase solar energy capacity and decrease coal energy capacity have a net positive impact on its economy when considering both economic and environmental aspects.

Keywords: Input-output, coal, solar, environmental impact
JEL classification: C67, R15, E01, P18

1. Introduction

Input-output (I-O) modeling is an established technique for measuring the economic impact of changes in a local economy (Clouse et al., 2023). While various software packages exist to support I-O modeling, IMPLAN is commonly used by agricultural economists and regional scientists in the United States to measure economic impact. IMPLAN was developed by the U.S. Forest Service in the 1980s and later spun out as a private company (United States Department of Agriculture, 2023). Examples of I-O modeling using IMPLAN include user guides for interpreting forestry economic contribution analyses (Parajuli et al., 2019) and economic impact studies of 4-H programs (Harder and Hodges, 2011; Hill, 2015), forestry (McConnell, 2013), and other extension programs (Kerna et al., 2015), among others. Other academic journals have published similar IMPLAN studies documenting the economic impact of forestry and related industries (Henderson et al., 2017), agriculture (McKean and Spencer, 2003; English et al., 2014), and fisheries (Steinback, 1999).

Despite its roots in forestry, IMPLAN has been extended to measure impacts outside of the natural resource area, including colleges and universities (Carroll and Smith, 2006; Khalaf et al.,2022; Quddus et al., 2022), tourism Lacher and Oh (2012); Kwon et al.

(2020), transportation infrastructure (Brun et al., 2014; Chen and Haynes, 2015; Gao et al., 2019), and the circular economy (Zendehdel et al., 2021).

In recent years, a host of I-O studies (including some using IMPLAN) have emerged around measuring the economic impact of traditional and alternative sources of electricity and associated green industry sectors like biofuels. I-O modeling was used to estimate the short-term increases in prices across industries should the United States adopt a carbon tax to transition to net zero carbon by 2050 (Kay and Jolley, 2023). As the United States transitions to alternative sources of energy production, recent studies have explored the economic impact of closing traditional coal-fired power plants (Jolley et al., 2019) as well as the emergence of alternative sources of energy such as woody biomass (Perez-Verdin et al., 2008; Lester et al., 2015; Jackson et al., 2018), wind (Greene and Geisken, 2013; Khalaf, 2022), and solar (Bae and Dall'erba, 2016; Smith et al., 2018).

The National Renewable Energy Laboratory (NREL) has also recently introduced its own Jobs and Economic Development Impact (JEDI) models, the free and user-friendly I-O-based tools designed to estimate the economic impact of constructing and operating energy and fuel production plants at the state and local levels. The JEDI model's default data inputs, such as costs and spending patterns, are obtained from surveys and interviews with industry experts and local developers, but users can also modify data inputs for specific projects (National Renewable Energy Laboratory (NREL), 2017). The JEDI models offer various models to estimate local employment impacts of power plants based on specific energy sources such as coal, wind, solar, hydro, and geothermal. As a result, it has been a great complement to the IMPLAN input-output model.

The US energy sector is transitioning from coal to cleaner energy sources such as solar, wind, and hydropower. Coal-generated electricity has declined in the US since its peak in 2011 due to the declining cost of natural gas and the rapid growth of solar and wind power technologies (Feaster, 2023). From 2011 to 2022, the share of coal-generated energy in the US declined from 44% to 20% of the total energy production (Feaster, 2023). The US Energy Information Administration projects that the share of coal-fired energy will continue to drop to 8% of total energy production by 2050 (Tsao, 2023). Natural gas and various sources of renewable energy such as solar, wind, and hydroelectric have become the alternative sources of electricity production as coal-generated electricity phaseout continues.

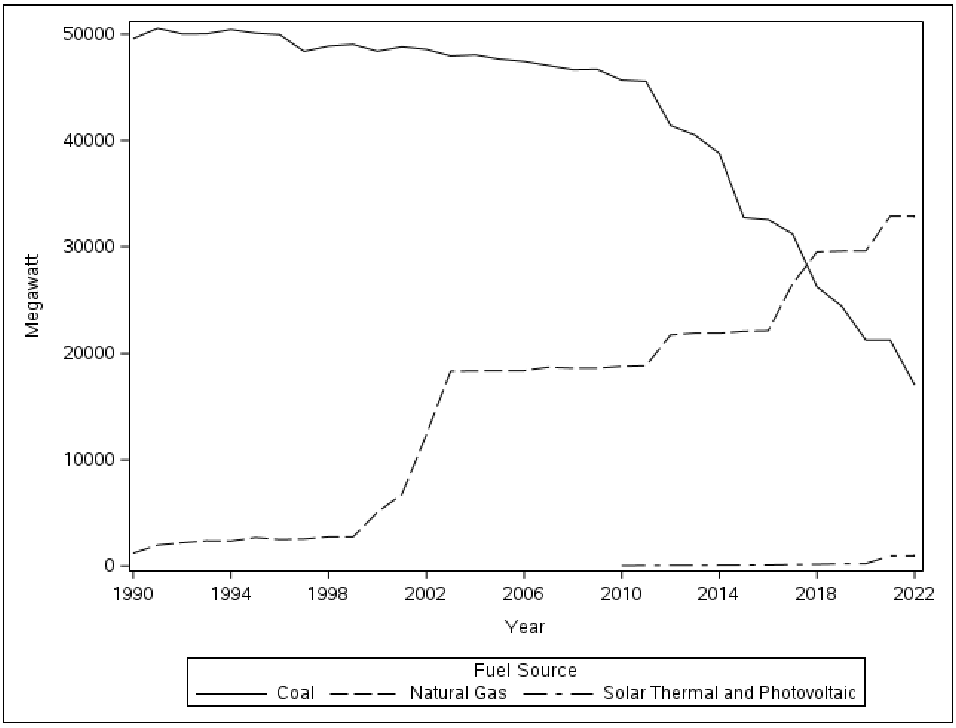
Decision-making about energy production is a complicated process that often involves trade- offs between interdependent factors. The size and composition of the energy infrastructure, the security of the energy supply, the environmental impact of production, and the market response to changes in the sector are interconnected in ways that encourage linking their analysis (Del Granado et al., 2018). In particular, the transition to alternative energy sources creates changes in the structure of the energy sector that can have large regional economic effects (Jenniches, 2018).

In the other direction, economic activity has environmental impacts that extend up the supply chain from the point of consumption through instances of transportation, construction, and material procurement (Nazir et al., 2024). Because of the multi-regional and cross-sectoral nature of supply chains, it can be difficult to fully account for these environmental impacts. EEIO modeling was developed as a tool to track these impacts along the chain of economic activity (Kitzes, 2013). This allows studies implementing EEIO to understand the true environmental impacts of economic activity more fully. Analyses using EEIO have become common and have been used to model impacts on a wide range of topics, including energy transition (de Bortoli and Agez, 2023), economic sector carbon management (Sun et al., 2020), food waste (Reynolds et al., 2015), and health care systems (Eckelman et al., 2020).

2. Economic and Environmental Scenarios in Ohio

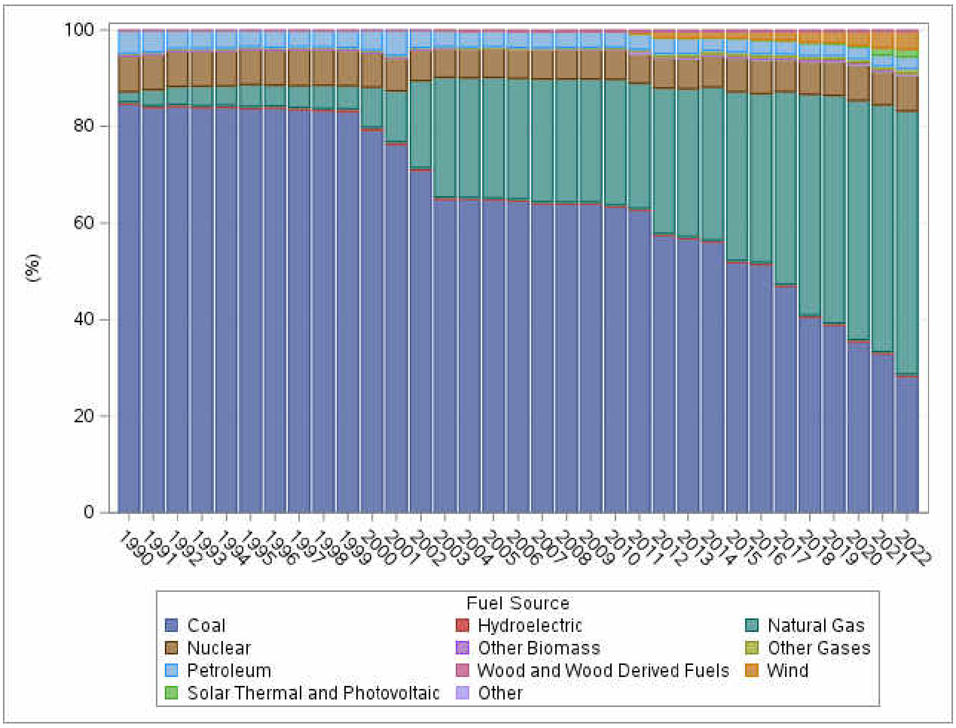
Between 1990 and 2016, coal was Ohio's primary electricity production source, accounting for more than half of the state's total electricity production. Since 2011, however, the capacity for coal-generated energy in Ohio has decreased significantly. Over the last decade, from 2012 to 2022, coal-generated energy has declined by 59%, from 41,438.6 Megawatts (MW) to 17,032.4 MW. Consequently, in 2022, coal-generated electricity only comprised 28.29% of the state's total electricity production (Figures 1 and 2). Two more coal-fired plants in Jefferson and Hamilton Counties in Ohio are scheduled to retire by 2028, further decreasing Ohio's coal-fired energy capacity by 1,765 MW (U.S. Energy Information Administration, 2022).

Figure 1: Ohio's electricity capacity by fuel type 1990-2022



Source: U.S. Energy Information Administration, 2022

Figure 2: Ohio's electricity generation fuel shares 1990-2022



Source: U.S. Energy Information Administration, 2022

Since 1999, electricity from natural gas has rapidly increased in Ohio. In 2017, the capacity of natural gas electricity surpassed that of coal-fired electricity and became the largest source of electricity in the state (Figure 1). As of 2022, natural gas electricity in Ohio has reached a capacity of 32,863.2 MW, making up 54.6% of the state's total electricity production (Figure 2). However, there are currently no plans to expand Ohio's natural gas energy capacity in the near future (U.S. Energy Information Administration, 2022).

Solar energy capacity in Ohio has not increased significantly since the installation of the first solar plants in the state in 2010. In 2010, solar energy capacity in Ohio was only 26 MW, accounting for only 0.4% of the state's total capacity. In 2022, solar energy reached a new capacity of 965 MW, or 1.6% of the state's total capacity (Figures 1 and 2). However, 17 new utility-scale solar projects with a total capacity of 2,498 MW are planned to be completed in Ohio by 2028 (U.S. Energy Information Administration, 2022). When completed, these new projects will bring the total solar energy capacity to 3,463 MW, or 5.7% of Ohio's total energy capacity.

Ohio's plans for a further transition away from coal-fired energy and replacing coal-fired energy with solar energy will have significant impacts on the state's economy and the environment. IMPLAN's recent incorporation of EEIO modeling as an extension of their traditional I-O modeling allows researchers to consider not just the economic impacts (jobs, labor income, value-added, and output) but also the corresponding environmental impacts (pollutants, emissions, greenhouse gases, etc.) associated with these economic activities. To demonstrate the EEIO tool, we compare the economic and environmental impacts associated with the production of 100 MW of energy from coal and solar in the state of Ohio and use the planned increase in solar power capacity and decrease in coal-fired power capacity in Ohio by 2028 to estimate the net impacts they might have on Ohio's economy and environment.

3. Methods and Results

In this study, we first examine and compare the environmental impacts of producing 100 Megawatts of coal-generated electricity and solar-generated electricity. The analysis includes a two-step process. First, we use the National Renewable Energy Laboratory's (NREL) Jobs and Economic Development Impact (JEDI) model to calculate the number of direct jobs and labor income associated with generating 100 MW of power from coal-fired power plants and solar photovoltaic (PV). JEDI has been a common tool to complement and sometimes supplement IMPLAN modeling of energy impacts (e.g., Johnson and Solomon (2010); Bae and Dall'erba (2016)). Second, after obtaining the direct employment and labor income associated with 100 MW of energy production from each source, we then model these direct jobs and labor incomes in each energy production scenario via IMPLAN. This provides both the economic impacts and environmental impacts of each scenario (Table 1).

On average, solar energy supports more direct jobs than coal-fired energy; however, coal plants' employees earn higher incomes than solar plants' employees. The production of 100 MW solar energy supports 18.5 direct full-time jobs a year, while the production of 100 MW coal-fired energy supports 14.0 full-time jobs annually (Table 1). The average labor incomes from solar and coal-fired power plants are \$60,100 and \$89,300, respectively. The total value added and outputs from producing 100 MW of coal-fired energy are higher than that from producing the same amount of energy with solar PV (Table 1).

Solar PV is much more environmentally friendly than coal when considering the environmental impacts. For example, producing 100 MW of coal-fired electricity creates 134,447 metric tons of greenhouse gases, 824 times higher than the amount created by producing 100 MW of solar energy (Table 1). Note that 99.99% of the 134,447 tons of greenhouse gases created by producing 100 MW of coal-fired energy are carbon dioxide (CO_2). Coal-fired power also creates more than twice as much land use, water withdrawal, and pollution, such as waste, air emission, and releases to water and ground (Table 1).

Table 1: Comparison of the direct economic and environmental impacts of 100 MW of solar energy and 100 MW of coal-fired energy.

Direct Economic Impacts	Unit	100 MW Solar PV	100 MW Coal

Employment	Jobs	18.5	14.0
Labor Income	$	1,110,303	1,279,543
Value-Added	$	2,878,465	5,269,512
Output	$	5,021,086	11,113,976
Direct Environmental Impacts	**Unit**	**100 MW Solar PV**	**100 MW Coal**
Commercial Non-Hazardous Waste Excluding Construction Activities	ton	5.53	12.24
Commercial RCRA Defined Hazardous Waste	ton	0.21	0.47
Criteria and Hazardous Air Emissions	ton	24.75	54.79
Greenhouse Gases	ton	163.26	134,447.45
Land Use	m2*a	51,639.84	114,302.73
Point Source Industrial Releases to Ground	ton	0.07	0.16
Point Source Releases to Water	ton	14.52	32.15
Water Withdrawals	ton	1,589,165.34	3,517,554.44

Source: Calculations by authors using IMPLAN

In the next step, we use Ohio's planned transition from coal to solar energy as a case study to demonstrate the trade-offs between interdependent factors when making energy production decisions. By 2028, coal-fired energy capacity in Ohio will decline by 1,765 MW due to two coal-fired plants closing in Jefferson and Hamilton Counties. Also, by 2028, seventeen new solar plants will increase Ohio's solar capacity by 2,498 MW. To capture the net effect of the decrease in coal-fired energy and the increase in solar energy on Ohio's economy and environment, we first employ the same analysis as above to estimate the economic and environmental impacts of producing 2,498 MW of solar energy and 1,765 MW of coal-fired energy, then subtract coal energy's impacts from solar energy's impacts (Table 2).

The new solar capacity in Ohio will support 461 direct full-time jobs annually with an annual labor income of $27.7 million and contribute $85.2 million to Ohio's Gross State Product (GSP) (Table 2). The closures of two coal-fired plants in Jefferson and Hamilton Counties will result in 253 annual job losses, a $22.6 million reduction in direct labor income, and a $84.3 million decrease in Ohio's GSP (Table 2). As a result, the planned changes in Ohio's energy by 2028 will result in a net positive economic impact. The changes will support an additional 208 full-time jobs with a $5.1 million increase in labor income and a $878,836 increase in the state's annual GSP (Table 2). However, Ohio will also see a net loss of $39.5 million in total outputs when switching from coal to solar energy due to the loss in sales of byproducts from coal burning, such as fly ash, gypsum, and slag, which can be sold and used as inputs to other industries like roofing materials, cement, and wallboard manufacturing.

Table 2: Net economic and environmental impacts of the new planned 2,498 MW of solar PV and planned retired 1,764 MW of coal-fired energy.

Direct Economic Impacts	**Unit**	**2,498 MW Solar PV**	**1,765 MW Coal**	**Net Impacts**
Employment	Jobs	461.3	253.0	208.3
Labor Income	$	27,749,911	22,610,282	5,139,629
Value-Added	$	85,189,605	84,310,769	878,836
Output	$	144,144,055	183,660,836	-39,516,781
Direct Environmental Impacts	**Unit**	**2,498 MW Solar PV**	**1,765 MW Coal**	**Net Impacts**
Commercial Non-Hazardous Waste Excluding Construction Activities	ton	158.71	202.22	-43.51
Commercial RCRA Defined Hazardous Waste	ton	6.14	7.83	-1.68
Criteria and Hazardous Air Emissions	ton	710.62	905.43	-194.81
Greenhouse Gases	ton	4,686.81	2,221,773.08	-2,217,086.26
Land Use	m2*a	1,482,463.18	1,888,877.26	-406,414.08
Point Source Industrial Releases to Ground	ton	2.05	2.62	-0.56
Point Source Releases to Water	ton	416.96	531.27	-114.31
Water Withdrawals	ton	45,621,349.03	58,128,343.17	-12,506,994.14

Source: Calculations by authors using IMPLAN

Solar energy is much more environmentally friendly compared to coal-fired energy. For example, the changes in Ohio's energy capacity will result in a reduction of 2.2 million metric tons of carbon dioxide, a reduction of 12.5 million tons of water withdrawals, and a reduction of 406,414 square meters of annual land use (Table 2).

Deciding on energy production is a complicated process that should involve more than one factor. For example, in the case of Ohio, the net economic impacts from the energy transition alone can lead to a biased impression that there will be a significant loss in Ohio's total output. However, when considering the net environmental impacts, replacing coal-fired energy with solar energy can save us the cost of sequestering $2.2 million tons of carbon dioxide. The baseline estimates of reducing carbon dioxide through forest conservation, a considerably cheaper method compared to new cleaning technologies or carbon taxes on fuels (Van Kooten et al., 2004; Obersteiner et al., 2001; Sohngen and Alig, 2000; Chomitz et al., 2000; Dudek and LeBlanc, 1990; Callaway and McCarl, 1996), is between $12.71 and $70.99 per ton (Van Kooten et al., 2004). When considering the opportunity costs of land use, the average cost of sequestering carbon dioxide through forest conservation is between $31.84 and $386.62 per ton (Van Kooten et al., 2004). By reducing coal-fired energy capacity and increasing solar energy capacity, Ohio can save between $70.6 million and $857.2 million annually in sequestering 2.2 million tons of carbon dioxide alone (Table 3).

Table 3: The cost of sequestering 2.2 million tons of carbon dioxide through forest conservation.

	Baseline cost		Appropriate cost	
	Low	High	Low	High
per ton of CO2	$12.71	$70.99	$31.84	$386.62
Total	$28,179,163	$157,390,935	$70,592,018	$857,169,789

Source: Calculations by authors using IMPLAN

4. Discussion

I-O and EEIO models are both common tools for measuring economic and environmental impacts. The new adoption of EEIO modeling within IMPLAN provides an efficient tool for integrating both measures. We have applied this model to the planned changes in Ohio's energy capacity to demonstrate the value in comparing the impacts within each model, as well as between the various scenarios.

From a sustainability perspective, our case study of Ohio shows the importance of integrating the environmental and economic impacts of energy transition. Sustainability requires micro-level changes in how individuals consume goods and services, with macro-level policies that shape production and consumption. Policies are often the product of a political process where information about the environmental and economic impacts is fiercely debated. By integrating these together, policymakers and the public can be better informed about the trade-offs that exist. In this respect, our work contributes to research on how policy can help achieve sustainability (Li and Miao, 2022; Wang and Yu, 2024) and the economic trade-offs involved (Davydenko and Hilbers, 2024).

References

Bae, J. and Dall'erba, S. (2016). The economic impact of a new solar power plant in Arizona: Comparing the input-output results generated by JEDI vs. IMPLAN. Regional Science Policy & Practice, 8(1-2):61–73.

Brun, L., Jolley, G., Hull, A., and Frederick, S. (2014). Infrastructure Investment Creates American Jobs. Alliance for American Manufacturing, Washington DC.

Callaway, J. M. and McCarl, B. (1996). The economic consequences of substituting carbon payments for crop subsidies in US agriculture. Environmental and Resource Economics, 7(1):15–43.

Carroll, M. C. and Smith, B. W. (2006). Estimating the economic impact of universities: The case of bowling green state university. Industrial Geographer, 3(2).

Chen, Z. and Haynes, K. E. (2015). Multilevel assessment of public transportation infras- tructure: A spatial econometric computable general equilibrium approach. The Annals of Regional Science, 54:663–685.

Chomitz, K. M. et al. (2000). Evaluating Carbon Offsets from Forestry and Energy Projects.
The World Bank, Washington DC.

Clouse, C., Thorvaldson, J., and Jolley, G. J. (2023). Impact factors: Methodological standards for applied input-output analysis. Journal of Regional Analysis & Policy, 53(2):1–14.

Davydenko, I. and Hilbers, H. (2024). Decarbonization paths for the Dutch aviation sector. Sustainability, 16(3).

de Bortoli, A. and Agez, M. (2023). Environmentally-extended input-output analyses efficiently sketch large-scale environmental transition plans: Illustration by Canada's road industry. Journal of Cleaner Production, 388:136039.

Del Granado, P. C., Van Nieuwkoop, R. H., Kardakos, E. G., and Schaffner, C. (2018). Modelling the energy transition: A nexus of energy system and economic models. Energy Strategy Reviews, 20:229–235.

Dudek, D. J. and LeBlanc, A. (1990). Offsetting new CO2 emissions: a rational first greenhouse policy step. Contemporary Economic Policy, 8(3):29–42.

Eckelman, M. J., Huang, K., Lagasse, R., Senay, E., Dubrow, R., and Sherman, J. D. (2020). Health care pollution and public health damage in the United States: An update. Health Affairs, 39(12):2071–2079.

English, L., Popp, J., and Miller, W. (2014). Economic contribution of the agricultural sector to the Arkansas economy in 2012. University of Arkansas Division of Agriculture, Fayettville, AK.

Feaster, S. (2023). US on Track to Close Half of Coal Capacity by 2026. Institute for Energy Economics and Financial Analysis, Lakewood, OH.

Gao, L., Saldarriaga, D., You, B., Qiao, F., and Li, Q. (2019). Evaluation of transportation and economic impact of short line railroads in Texas. International Journal of Rail Transportation, 7(3):191–207.

Greene, J. S. and Geisken, M. (2013). Socioeconomic impacts of wind farm development: A case study of Weatherford, Oklahoma. Energy, Sustainability and Society, 3:1–9.

Harder, A. and Hodges, A. W. (2011). Economic impact analysis of 4-H youth livestock projects using IMPLAN. The Journal of Extension, 49(1):26.

Henderson, J. E., Joshi, O., Parajuli, R., and Hubbard, W. G. (2017). A regional assessment of wood resource sustainability and potential economic impact of the wood pellet market in the US south. Biomass and Bioenergy, 105:421–427.

Hill, R. (2015). Using IMPLAN to evaluate the economic contribution of 4-H to Colorado and individual counties. The Journal of Extension, 53(1):4.

Jackson, R. W., Neto, A. B. F., and Erfanian, E. (2018). Woody biomass processing: Potential economic impacts on rural regions. Energy Policy, 115:66–77.

Jenniches, S. (2018). Assessing the regional economic impacts of renewable energy sources: A literature review. Renewable and Sustainable Energy Reviews, 93:35–51.

Johnson, N. H. and Solomon, B. D. (2010). A net-present value analysis for a wind turbine purchase at a small US college. Energies, 3(5):943–959.

Jolley, G. J. and Belleville Jr, D. E. (2021). Economic impact of Ohio Foundation of Independent Colleges. Voinovich School of Leadership and Public Affairs, Athens, OH.

Jolley, G. J., Khalaf, C., Michaud, G., and Sandler, A. M. (2019). The economic, fiscal, and workforce impacts of coal-fired power plant closures in Appalachian Ohio. Regional Science Policy & Practice, 11(2):403–422.

Jolley, G. J., Khalaf, C., Michaud, G. L., and Belleville, D. (2020). The economic contribution of logging, forestry, pulp & paper mills, and paper products: A 50-state analysis. Forest Policy and Economics, 115:102140.

Kay, D. and Jolley, G. J. (2023). Using input–output models to estimate sectoral effects of carbon tax policy: Applications of the NGFS scenarios. American Journal of Economics and Sociology, 82(3):187–222.

Kerna, A., Frisvold, G., Jacobs, L., Farrell, V. A., Houtkooper, L., and Misner, S. (2015). Ap- plication of IMPLAN to extension programs: Economic impacts of the University of Arizona Cooperative Extension SNAP-Ed spending. The Journal of Extension, 53(6):21.

Khalaf, C. (2022). Measuring the Economic Impacts of Wind Projects in Wyoming. Center for Business and Economic Analysis, Laramie, WY.

Khalaf, C., Jolley, G. J., and Clouse, C. (2022). The economic impact of small colleges on local economies: A guide to attainable data and best practices. Economic Development Quarterly, 36(1):17–32.

Kitzes, J. (2013). An introduction to environmentally-extended input-output analysis. Re- sources, 2(4):489–503.

Kwon, Y., Lim, J., and Kim, E. (2020). Diversifying visitor demand and its impact on Las Vegas's tourism industry during recovery from the Great Recession. Regional Science Policy & Practice, 12(2):249–266.

Lacher, R. G. and Oh, C.-O. (2012). Is tourism a low-income industry? Evidence from three coastal regions. Journal of Travel Research, 51(4):464–472.

Lester, T. W., Little, M., and Jolley, G. J. (2015). Assessing the economic impact of alternative biomass uses: Biofuels, wood pellets, and energy production. Journal of Regional Analysis & Policy, 45(1):36–46.

Li, X.-W. and Miao, H.-Z. (2022). How to incorporate blue carbon into the China Certified Emission Reductions Scheme: Legal and policy perspectives. Sustainability, 14(17).

McConnell, T. E. (2013). Using impact analysis to document a forest products sector's contri- butions to Ohio's economy. The Journal of Extension, 51(2):35.

McKean, J. R. and Spencer, W. P. (2003). Implan understates agricultural input-output multi- pliers: An application to potential agricultural/green industry drought impacts in Colorado. Journal of Agribusiness, 21(345-2016-15214):231–246.

Michaud, G. and Jolley, G. J. (2019). Economic contribution of Ohio's wood industry cluster: Identifying opportunities in the Appalachian region. Review of Regional Studies, 49(1):149– 171.

National Renewable Energy Laboratory (NREL) (2017). JEDI: Jobs and Economic Develop- ment Impact Model. National Renewable Energy Labratory, Golden, CO.

Nazir, S., Zhaolei, L., Mehmood, S., and Nazir, Z. (2024). Impact of green supply chain management practices on the environmental performance of manufacturing firms considering institutional pressure as a moderator. Sustainability, 16(6).

Obersteiner, M., Rametsteiner, E., and Nilsson, S. (2001). Cap Management for LULUCF Options: An Economic Mechanism Design to Preserve the Environmental and Social Integrity of Forest Related LULUCF Activities Under the Kyoto Protocol. International Institute for Applied Systems Analysis, Laxenberg.

Parajuli, R., Henderson, J. E., Tanger, S., Joshi, O., and Dahal, R. (2018). Economic contribu- tion analysis of the forest-product industry: A comparison of the two methods for multisector contribution analysis using IMPLAN. Journal of Forestry, 116(6):513–519.

Parajuli, R., McConnell, E., Tanger, S., and Henderson, J. (2019). Interpreting forestry eco- nomic contribution reports: A user's guide. The Journal of Extension, 57(4):2.

Perez-Verdin, G., Grebner, D. L., Munn, I. A., Sun, C., and Grado, S. C. (2008). Economic impacts of woody biomass utilization for bioenergy in Mississippi. Forest Products Journal, 58(11):75–83.

Quddus, M., Williams, M., Quazi, R., Ojumu, O., and Osho, G. (2022). Economic impact of Prairie View A&M University on the local, regional and state economies in Texas. Research in Higher Education Journal, 42:1–22.

Reynolds, C. J., Piantadosi, J., and Boland, J. (2015). Rescuing food from the organics waste stream to feed the food insecure: An economic and environmental assessment of Australian food rescue operations using environmentally extended waste input-output analysis. Sustain- ability, 7(4):4707–4726.

Smith, C., Driver, D., and Michaud, G. (2018). The solar and wind economy in Ohio. Con- silience, 20(20):43–61.

Sohngen, B. and Alig, R. (2000). Mitigation, adaptation, and climate change: results from recent research on US timber markets. Environmental Science & Policy, 3(5):235–248.

Steinback, S. R. (1999). Regional economic impact assessments of recreational fisheries: An application of the IMPLAN modeling system to marine party and charter boat fishing in Maine. North American Journal of Fisheries Management, 19(3):724–736.

Sun, Y.-Y., Cadarso, M. A., and Driml, S. (2020). Tourism carbon footprint inventories: A review of the environmentally extended input-output approach. Annals of Tourism Research, 82:102928.

Tsao, S. (2023). Eia projects coal capacity will decrease in our Annual Energy Outlook 2023.

U.S. Energy Information Administration, 11 May.

United States Department of Agriculture (2023). Economic, Social, and Ecosystem Service Analysis: Applications for Forest Planning. USDA Forest Service.

U.S. Energy Information Administration (2022). Preliminary Monthly Electric Generator Inven- tory (based on Form EIA-860M as a supplement to Form EIA-860). U.S. Energy Information Administration, Washington, DC.

Van Kooten, G. C., Eagle, A. J., Manley, J., and Smolak, T. (2004). How costly are carbon offsets? A meta-analysis of carbon forest sinks. Environmental Science & Policy, 7(4):239– 251.

Wang, J. and Yu, L. (2024). Environmental regulation and fiscal revenue growth: Is it win–win or win–lose?—evidence of a multi-tasking performance evaluation system in China. Sustain- ability, 16(5).

Zendehdel, K., Sloboda, B. W., and Horner, E. C. (2021). Economic impact analysis of farm- ers' markets in the Washington, DC metropolitan area: Evidence of a circular economy. Sustainability, 13(13):7333.