

Maryland Supply Chain Analysis

Prepared for
Maryland Department of Commerce

Daraius Irani, Ph.D., Chief Economist
Shelby Francis, Economist
Catherine Menking, Technical Advisor
Ruisha Prasai, Research Associate
Amber Taylor, Research Associate

April 2, 2024



Towson, Maryland 21204 | www.towson.edu/resi

Table of Contents

Table of Contents.....	2
Table of Figures.....	4
1.0 Executive Summary.....	6
2.0 Introduction	13
3.0 Background on Supply Chain Challenges.....	13
4.0 Manufacturing and Transportation and Warehousing Analysis.....	19
4.1 National and Regional Labor Force Trends in the Manufacturing Industry	19
4.2 National and Regional Labor Force Trends in the Transportation and Warehousing Industry	25
4.3 Diversity in Maryland’s Manufacturing and Transportation and Warehousing Industries	30
5.0 Industry Profiles.....	33
5.1 Other Food Manufacturing Industry (NAICS 3119).....	36
5.2 Pharmaceutical and Medicine Manufacturing (NAICS 3254)	38
5.3 Communication Equipment Manufacturing (NAICS 3342)	40
5.4 Navigational, Measuring, Electromedical, and Control Instruments Manufacturing (NAICS 3345).....	42
5.5 Manufacturing and Reproducing Magnetic and Optical Media (NAICS 3346)	44
5.6 Aerospace Product and Parts Manufacturing (NAICS 3364).....	45
5.7 Railroad Rolling Stock Manufacturing (NAICS 3365).....	47
5.8 Other Furniture Related Product Manufacturing (3379).....	49
5.9 Support Activities for Water Transportation (NAICS 4883)	51
5.10 Warehousing and Storage (NAICS 4931).....	54
5.11 Other Financial Investment Activities (NAICS 5239).....	55
5.12 Architectural, Engineering, and Related Services (NAICS 5413)	57
5.13 Computer Systems Design and Related Services (NAICS 5415).....	59
5.14 Management, Scientific, and Technical Consulting Services (NAICS 5416).....	61
5.15 Scientific Research and Development Services (NAICS 5417)	63
6.0 Industry Commodity Analysis	64
7.0 Interview Findings.....	75
8.0 Initiatives to Strengthen Supply Chains.....	81
8.1 Federal Direct Investment and Onshoring.....	82
8.2 Maryland Programs.....	86
8.3 CONNEX™ Marketplace	90
8.4 Other U.S. State Programs	91
9.0 Strengths, Weaknesses, Opportunities and Threats	96
9.1 SWOT Items.....	96
9.2 SWOT Cross Analysis	97
10.0 Conclusion.....	102
References	105
Appendix A – Detailed Industry and Subsector Data.....	134
Appendix B – Detailed Project Descriptions	138

Maryland Supply Chain Analysis
RESI of Towson University

Appendix C – Key Industry Subsectors.....	140
Appendix D – Interview Questions	143
Appendix E – NAICS to IMPLAN Industries	145
Appendix F – Technical Methodology.....	146
Manufacturing and Transportation and Warehousing Analysis.....	146
Commodity Analysis.....	147
Appendix G – Detailed Commodity Regional Purchasing Coefficients.....	150

Table of Figures

Figure 1: Top Five Regional Commodity Gaps	9
Figure 2: U.S. Manufacturing Job Openings, Hires, and Total Separations, 2018 to 2023.....	20
Figure 3: Maryland Manufacturing Annual Pay Comparison, 2018 to 2022 (2022 Dollars)	22
Figure 4: Maryland Manufacturing Industry Shift-Share Analysis, 2018-2022	23
Figure 5: Manufacturing Industry Employment Growth, 2018 to 2022.....	24
Figure 6: Top Employment Gains in Maryland Manufacturing Subsectors, 2018-2022	24
Figure 7: Maryland Manufacturing Location Quotients, 2018 to 2022.....	25
Figure 8: U.S. Transportation, Warehousing, and Utilities Job Openings, Hires, and Total Separations, 2018-2023	26
Figure 9: Maryland Transportation and Warehousing Annual Pay Comparison, 2018 to 2022 ..	27
Figure 10: Maryland Transportation and Warehousing Industry Shift-Share Analysis, 2018-2022	28
Figure 11: Transportation and Warehousing Industry Employment Growth, 2018 to 2022	29
Figure 12: Top Employment Gains in Maryland Transportation and Warehousing Subsectors, 2018-2022	29
Figure 13: Maryland Transportation and Warehousing Location Quotients, 2018 to 2022	30
Figure 14: Industry Employment by Gender, 2022.....	30
Figure 15: Industry Employment by Age Group, 2022	31
Figure 16: Industry Employment by Race and Ethnicity, 2022.....	32
Figure 17: Key Maryland Industries with Select Employment Data, 2022	34
Figure 18: Buyers and Suppliers Flow Chart	35
Figure 19: NAICS to IMPLAN Crosswalk	65
Figure 20: Top Commodities in Pharmaceutical and Medicine Manufacturing.....	67
Figure 21: Top Commodities in Communications Equipment Manufacturing.....	68
Figure 22: Top Commodities in Navigational, Measuring, Electromedical, and Control Instruments Manufacturing.....	69
Figure 23: Top Commodities in Manufacturing and Reproducing Magnetic and Optical Media.	70
Figure 24: Top Commodities in Other Furniture Related Product Manufacturing	71
Figure 25: Top Commodities in Computer Systems Design and Related Services	72
Figure 26: Top Commodities in Management, Scientific, and Technical Consulting Services	73
Figure 27: Top Five Regional Commodity Gaps	74
Figure 28: SWOT Items for Maryland Supply Chain	97
Figure 29: 2X2 SWOT Analysis Matrix of Maryland and Key Supply Chain Industries	99
Figure 30: Key Industries and Maryland Data, 2022.....	134
Figure 31: Detailed Project Descriptions	138
Figure 32: Key Maryland Industry Subsectors	140
Figure 33: Full NAICS to IMPLAN Crosswalk for Industries of Interest.....	145
Figure 34: Top Commodity RPCs in Pharmaceutical and Medicine Manufacturing.....	150
Figure 35: Top Commodity RPCs in Communications Equipment Manufacturing.....	150
Figure 36: Top Commodity RPCs in Navigational, Measuring, Electromedical, and Control Instruments Manufacturing.....	151

Figure 37: Top Commodity RPCs in Manufacturing and Reproducing Magnetic and Optical Media	151
Figure 38: Top Commodity RPCs in Other Furniture Related Product Manufacturing	151
Figure 39: Top Commodity RPCs in Computer Systems Design and Related Services	152
Figure 40: Top Commodity RPCs in Management, Scientific, and Technical Consulting Services	152

1.0 Executive Summary

The Maryland Department of Commerce (Commerce) commissioned the Regional Economic Studies Institute (RESI) of Towson University to undertake a statewide supply chain and logistics assessment. This analysis is comprised of a review of supply chain data for the *Manufacturing* and *Transportation and Warehousing* industries, an overview of 15 key industries in the state, a focused commodity analysis, interviews with companies engaged in the state's supply chain, and a strengths, opportunities, weaknesses, and threats (SWOT) analysis. Over the past several years, supply chain operations have been strained by the COVID-19 pandemic, changes in labor force trends, inventory management disruptions, geopolitical tensions, shipping container overcrowding and shortages, and rising prices due to high inflation. The aim of the current analysis is to serve as a tool for decisionmakers as they develop policies to address challenges and inefficiencies within the state's supply chain.

Major findings from each section of the report are outlined below.

Supply Chain Challenges

- *Labor shortages* – The COVID-19 pandemic created initial fluctuations in labor market with employers closing and absences due to illness, followed by early retirements and difficulties filling positions with skilled and experienced workers.¹
- *Transportation challenges* – Significant disruptions were experienced in container shipping and port delays with steep increases in shipping costs.² Impacts on trucking varied, with more demand for light-duty and local trucking needs while there were initial layoffs for heavy trucking. Since then, heavy trucking labor shortages have been further exacerbated due to retirements, high turnover, and poor retention rates.³
- *Inventory management* – Flaws with the commonly used just-in-time inventory model were exposed with the COVID-19 pandemic as shortages of goods and materials were experienced across many industries.⁴ Because of this, many organizations have switched to more flexible fulfillment strategies and use tools (such as warehouse management software) to optimize inventory levels and efficiency.⁵
- *Geopolitics* – Factors including sanctions, tariffs, and conflicts can disrupt transportation routes, increase costs, and cause major supply chain inefficiencies due to uncertain

¹ Maury Gittleman, "The "Great Resignation" in Perspective," U.S. Bureau of Labor Statistics, July 2022, accessed July 7, 2023, <https://www.bls.gov/opub/mlr/2022/article/the-great-resignation-in-perspective.htm>.

² Su-Lin Tan, "The Global Shipping Industry is Facing a New Problem – Too Many Containers," *CNBC*, November 10, 2022, accessed July 6, 2023, <https://www.cnbc.com/2022/11/11/global-shipping-industry-faces-a-new-problem-too-many-containers.html>.

³ Peter S. Goodman, "The Real Reason America Doesn't Have Enough Truck Drivers," *The New York Times*, February 9, 2022, accessed December 18, 2023, <https://www.nytimes.com/2022/02/09/business/truck-driver-shortage.html>.

⁴ Peter Goodman and Niraj Chokshi, "Global Shortages During Coronavirus Reveal Failings of Just in Time Manufacturing," *The New York Times*, October 22, 2021, accessed January 20, 2023, <https://www.nytimes.com/2021/06/01/business/coronavirus-global-shortages.html>.

⁵ "How the Pandemic Changed Inventory Management," *Sikich*, May 16, 2023, accessed December 19, 2023, <https://www.sikich.com/insight/how-the-pandemic-changed-inventory-management/>.

operating environments.⁶ For example, the U.S. has had to adapt supply chains for several metals used for batteries and electronics following the start of the Russia-Ukraine conflict.⁷

- *Inflation* – With inflation reaching a 40-year high in 2022, costs have climbed for labor, materials, energy, shipping, and storing goods, and has had rippling effects throughout supply chain operations.⁸ However, there has been a significant decline in supply chain pressures since peaking in late 2021, as measured by the Federal Reserve Bank of New York's Global Supply Chain Pressure Index.⁹

Manufacturing Data Analysis

- Job openings consistently exceeded hires in the *Manufacturing* industry, with a 9 percent surplus between January 2018 and May 2023.¹⁰
- Factors hindering hiring have included a lack of qualified applicants, negative industry perceptions, and limited work flexibility.
- Maryland's *Manufacturing* employment growth outpaced the national average, rising by 2.0 percent compared to 0.8 percent nationally between 2018 and 2022.
- Despite an 8 percent decline in total Maryland private employment, the state's *Manufacturing* industry only experienced a 3 percent decline from 2019 to 2020.¹¹
- While Maryland has a slightly higher proportion of female workers than the national *Manufacturing* average, there is still a large disparity between males and females in the industry. Efforts to increase gender and racial diversity in *Manufacturing* are ongoing.¹²

Transportation and Warehousing Data Analysis

- Job openings have consistently exceeded hires in the national *Transportation, Warehousing, and Utilities* sector.¹³
- Maryland's *Transportation and Warehousing* industry saw significant employment growth of approximately 29 percent between 2018 and 2022.

⁶ Matthew Comte, "How to Manage Supply Chain Risk During Geopolitical Unrest," PwC, March 18, 2022, accessed July 8, 2023, <https://www.pwc.com/us/en/services/consulting/business-transformation/library/supply-chain-geopolitical-unrest.html>.

⁷ Eric Hamilton, "The Global Supply Chain Consequences of the Russia-Ukraine War," University of Florida News, February 21, 2023, accessed December 19, 2023, <https://news.ufl.edu/2023/02/russia-ukraine-global-supply-chain/>.

⁸ David Vallejo, "3 Major Impacts of Inflation on Global Supply Chains," *Forbes*, October 28, 2022, accessed July 19, 2023, <https://www.forbes.com/sites/sap/2022/10/28/3-major-impacts-of-inflation-on-global-supply-chains/?sh=43f508f31614>.

⁹ "Global Supply Chain Pressure Index (GSCPI)," Federal Reserve Bank of New York, accessed November 13, 2023, <https://www.newyorkfed.org/research/policy/gscpi#/interactive>.

¹⁰ "Job Openings and Labor Turnover Survey," U.S. Bureau of Labor Statistics, accessed July 18, 2023, <https://www.bls.gov/jlt/>.

¹¹ "QCEW Data Files, Quarterly Census of Employment and Wages," U.S. Bureau of Labor Statistics, last modified July 2023, accessed July 20, 2023, <https://www.bls.gov/cew/downloadable-data-files.htm>.

¹² "LED Extraction Tool Quarterly Workforce Indicators," U.S. Census Bureau, accessed August 3, 2023, <https://ledextract.ces.census.gov/qwi/all>.

¹³ "Job Openings and Labor Turnover Survey," U.S. Bureau of Labor Statistics.

- Average annual pay in Maryland's *Transportation and Warehousing* sector has remained significantly lower than the state's average, with a widening pay gap over time.¹⁴
- Despite low wages in the sector, employment surged—particularly in *General Warehousing* and *Couriers and Express Delivery Services*—likely driven by a 92 percent increase in worldwide e-commerce sales.¹⁵

Industry Profiles

To gain a greater understanding of different *Manufacturing* needs and challenges, Commerce identified 15 industries for further evaluation. The COVID-19 pandemic presented numerous challenges across several key industries, but also increased demand for some sectors. While there were variations between focus industries, common themes also emerged. Many of the issues that emerged in research on these industries are outlined in the supply chain challenges, such as shortages of semiconductor chips, labor shortages, transportation disruptions, and geopolitical concerns.

- Shortages and increased competition for semiconductor chips impacted a number of focus industries including *Communication Equipment Manufacturing; Navigational, Measuring, Electromedical, and Control Instruments Manufacturing; and Aerospace Product and Parts Manufacturing*.
- In addition to scarcity due to production limitations, increased demand for electric vehicles, electronics, and other lithium-battery-reliant products has raised competition and costs for semiconductor chips and other raw materials needed for battery production. More recently, supplies have been exacerbated by geopolitical concerns related to Russia and China, including the availability of metals used for batteries and electronics.¹⁶
- Some sectors saw increased demand for both entertainment and work-from-home products driven by the COVID-19 pandemic, including *Communication Equipment Manufacturing* and *Reproducing Magnetic and Optical Media Manufacturing*.^{17,18} Other key industries—such as *Pharmaceutical and Medicine Manufacturing* and *Scientific Research and Development*—have seen increased demand related to vaccine production and research and development in biotechnologies.¹⁹

¹⁴ "QCEW Data Files, Quarterly Census of Employment and Wages," U.S. Bureau of Labor Statistics.

¹⁵ Stephanie Chevalier, "Retail E-Commerce Sales Worldwide from 2014 to 2026," Statista, September 21, 2022, accessed December 20, 2023, <https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/>.

¹⁶ Eric Hamilton, "The Global Supply Chain Consequences of the Russia-Ukraine War," University of Florida News, February 21, 2023, accessed December 19, 2023, <https://news.ufl.edu/2023/02/russia-ukraine-global-supply-chain/>.

¹⁷ "Industry at a Glance, Communication Equipment Manufacturing in the US," IBISWorld.

¹⁸ Adam Epstein, "Game On: How COVID-19 Became the Perfect Match for Gamers," World Economic Forum, September 28, 2020, accessed July 31, 2023, <https://www.weforum.org/agenda/2020/09/covid19-coronavirus-pandemic-video-games-entertainment-media/>.

¹⁹ "Products & Markets, Scientific Research & Development in the US," IBISWorld, last modified May 17, 2023, <https://my.ibisworld.com/us/en/industry/54171/products-and-markets>.

- Sustainability has an expanding role in consumer behavior, impacting a large range of industries. For example, the *Other Furniture Related Product Manufacturing* industry has faced increased demand for eco-friendly and organic products. Growing awareness of the environmental impacts from harmful materials and chemicals used in mattress production has increased consumers' scrutiny, driving purchases of organic mattresses.²⁰ Similarly, consumers are willing to pay a premium of approximately 30 to 40 percent for sustainable food products, impacting sectors such as *Other Food Manufacturing*.²¹

Industry Commodity Analysis

- Among the industries of interest, *Manufacturing* sectors tended to have more commodities with Regional Purchase Coefficient (RPC) values lower than 50 percent, meaning that firms must obtain most of these commodities from outside of the region. Conversely, the service-based industries evaluated were able to source a greater proportion of commodities from local suppliers.
- RESI identified several commodities with significant gaps between gross absorption and regional absorption, meaning that the industry relies on purchases made outside of the region to meet commodity needs. These individual commodities represent areas for further evaluation to assess specific barriers to local production or sourcing issues, as they may represent opportunities to strengthen supply chains for critical industry components. The top five commodities with the greatest gaps are shown in Figure 1 below.

Figure 1: Top Five Regional Commodity Gaps

Commodity Description	Industry	Percent Obtained Out-of-Region
Biological Products (Except Diagnostic)	Pharmaceutical and Medicine Manufacturing	99.3%
Urethane and Other Foam Products (Except Polystyrene)	Other Furniture Related Product Manufacturing	93.0%
Coated Fabric Coating	Other Furniture Related Product Manufacturing	98.8%
Broadcast and Wireless Communications Equipment	Communications Equipment Manufacturing	100.0%
Broadwoven Fabrics and Felts	Other Furniture Related Product Manufacturing	100.0%

Sources: Commerce, IMPLAN, RESI

²⁰ Mariana Zapata and Mili Godio, "Top-rated Organic, Natural and Eco-friendly Mattresses," *NBC News*, August 22, 2022, accessed July 21, 2023, <https://www.nbcnews.com/select/shopping/best-eco-friendly-mattress-ncna1193591>.

²¹ Peter Walker, "Consumers Are Willing to Pay More for Sustainable Food Products," *LEK*, July 20, 2022, accessed January 15, 2024, <https://www.lek.com/insights/ar/consumers-are-willing-pay-more-sustainable-food-products>.

Company Interviews

- Several interviewees noted strengths of operating in Maryland including tax advantages, proximity to a number of transportation options, and access to an educated workforce. Conversely, interviewees also cited a number of business challenges related to labor supply and costs, inefficient intrastate transportation, environmental regulations, and effects from the COVID-19 pandemic.
- Multiple interviewees discussed labor challenges, reporting that it was difficult to find workers with the necessary skills for their organizations. With a reduced pipeline of workers and fewer younger employees entering the *Manufacturing* industry, there have also been challenges overcoming skill gaps to fill supervisory roles.
- One expert stated that they have to outsource labor and that they need to train their *Manufacturing* employees from “ground zero” due to a lack of local training programs. Another interviewee said that their business had formed a partnership with a local educational institution to facilitate a direct workforce pipeline, and had also developed an internship program to ensure graduates with the required skillsets and knowledge.
- The COVID-19 pandemic impacted those interviewed in a number of ways. Some organizations struggled with shutdowns, while others experienced substantial growth in demand. Increased lead times and volatile prices were another common theme, which many interview participants anticipated would be persistent.

Supply Chain Initiatives

- Disruptions created by the COVID-19 pandemic drove a push by both federal and state governments to increase supply chain resiliency, bolster local and domestic production of critical components, and reduce vulnerabilities within the distribution ecosystem. Federal efforts include the passing of the Creating Helpful Incentives to Produce Semiconductors for America Act—also known as the CHIPS Act—which incentivizes domestic semiconductor chip manufacturing plants.²²
- The CONNEX™ Marketplace, which is an online platform designed to connect manufacturers with local suppliers, has expanded to 40 states and includes CONNEX™ Maryland/DC as of June 2023.^{23,24} State governments have also taken actions to improve food supply chains and strengthen industry supply chains that are critical to state economies, such as *Manufacturing*.

²² “Fact Sheet: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China,” The White House, August 9, 2022, accessed September 11, 2023, <https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/>.

²³ “Our Partners,” CONNEX Marketplace, accessed October 30, 2023, <https://connexmarketplace.com/partners/>.

²⁴ “CONNEX Maryland Launches to Help Connect Regional Supply Chain,” CONNEX Marketplace, June 6, 2023, accessed October 30, 2023, <https://connexmarketplace.com/press/connex-maryland-launch/>.

- In Maryland, supply chains and the *Manufacturing* industry are being bolstered by programs and initiatives that include the Maryland Manufacturing Extension Partnership (Maryland MEP); the Maryland Manufacturing 4.0 grant program; the Employment Advancement Right Now (EARN) Maryland competitive workforce development initiative; and the Maryland Apprenticeship and Training Program (MATP).²⁵

SWOT Analysis

Based on the findings throughout this analysis, a number of factors were characterized within a Strengths, Weaknesses, Opportunities, and Threats (SWOT) matrix. Recommended strategies for further consideration are outlined below.

- **Facilitate Training and Education Programs:** To address hiring challenges and capitalize on Maryland's educated workforce, facilitators such as Commerce, industry organizations, and stakeholders can collaborate to increase awareness and utilization of existing training opportunities. Creating pipeline programs with local educators can also help connect qualified workers with employers, particularly in roles with limited training options.
- **Leverage Federal Funding Opportunities:** Maryland can harness federal funding available through initiatives such as the CHIPS Act to bolster its semiconductor industry and support regional technological hubs. Collaborative efforts with county organizations and state universities can strengthen these endeavors.
- **Explore Sustainable Production:** With growing consumer demand for sustainably produced goods, Commerce can investigate industries like *Other Food Manufacturing* and *Other Furniture Related Product Manufacturing* to identify barriers to production. Assistance in increasing supply chain transparency and diversification can further strengthen the state's *Manufacturing* base.
- **Rebranding and Technology Adoption:** Maryland has the opportunity to rebrand its *Manufacturing* industry to attract skilled labor by highlighting advanced technologies and evolving career opportunities. Outreach efforts to colleges and universities can showcase these career paths and combat negative industry perceptions.
- **Develop Contingency Plans:** Given Maryland's strategic geographical positioning, the state can attract new businesses and remain competitive by developing contingency plans to address transportation disruptions. Collaboration with firms to develop and implement these plans will be crucial.
- **Promote Awareness of Support Programs:** Programs including the Maryland MEP, Maryland Manufacturing 4.0, and CONNEX™ Maryland/DC Marketplace play vital roles

²⁵ References for each program can be found within Section 8 under the "Maryland Programs" and "Other U.S. State Programs" subsections.

in strengthening supply chain operations. Promoting awareness and adoption of these resources among manufacturers will be essential.

- **Identify Barriers to Local Production:** Maryland can work with industry firms to identify barriers to local production and evaluate regional conditions to enable local production. Leveraging the CONNEX™ Marketplace can facilitate inquiries on production feasibility by in-state firms.
- **Centralize Information Resources:** To help firms navigate changing regulations and access support programs, Commerce could expand its website to include a centralized directory of resources, updates on regulations, and information on industry programs.

By implementing these strategies, Maryland can effectively capitalize on its strengths, address weaknesses, navigate potential threats, and explore emerging opportunities. With these efforts, the state can better position itself for sustained growth while also improving resiliency in Maryland's supply chains.

2.0 Introduction

The Maryland Department of Commerce (Commerce) commissioned the Regional Economic Studies Institute (RESI) of Towson University to undertake a statewide supply chain and logistics assessment. This analysis is comprised of a review of supply chain data for the *Manufacturing* and *Transportation and Warehousing* industries, a focused commodity analysis, an overview of 15 key industries in the state, interviews with companies engaged in the state's supply chain, and a strengths, opportunities, weaknesses, and threats (SWOT) analysis. Ultimately the report aims to serve as a tool for decisionmakers as they develop policies to address challenges and inefficiencies within the state's supply chain.

This report will continue as follows:

- Section 3 provides an overview of supply chain challenges faced by the *Manufacturing* and *Transportation and Warehousing* industries;
- Section 4 contains the primary data analysis of the *Manufacturing* and *Transportation and Warehousing* industries;
- Section 5 outlines 15 key industries within the state, providing more specific information on industry size, challenges, opportunities, and supply chain constraints;
- Section 6 contains a commodity analysis of seven key industries;
- Section 7 reviews major findings from the interviews conducted;
- Section 8 highlights measures aimed at strengthening supply chains in Maryland and the U.S.;
- Section 9 includes a strengths, weaknesses, opportunities, and threats (SWOT) analysis for the state; and
- Section 10 concludes the report.

The report also contains seven appendices with information including detailed data tables, interview questions, a technical methodology, and detailed commodity information.

3.0 Background on Supply Chain Challenges

A number of challenges have occurred over the past several years—some primarily driven by the COVID-19 pandemic—that have impacted many industries, and the *Manufacturing* and *Transportation and Warehousing* sectors in particular. These issues include changes in labor force trends, inventory management disruptions, geopolitical tensions, transportation and shipping bottlenecks, and rising prices due to high inflation. This section will provide an overview of several key challenges that have impacted the efficiency of the *Manufacturing* and *Transportation and Warehousing* industries.

Labor Shortages

In 2021, demand for labor exceeded the available supply as the rate of resignations outpaced the number typically expected from labor market tightening alone.^{26,27} Employment disruptions

²⁶ Fowler, "Five Reasons Labor Shortages Are Impacting Supply Chains."

²⁷ Gittleman, "The "Great Resignation" in Perspective," U.S. Bureau of Labor Statistics.

caused by COVID-19 outbreaks and variants persisted through 2022, with the rise in Omicron variant cases starting in late 2021 causing high levels of absences. At the peak of Omicron cases in January 2022, it was reported that 3.6 million people were unable to work because of illness. Within the same month, six million individuals were unemployed due to employers closing or losing business due to COVID-19.²⁸ The growth of e-commerce also placed pressure on the supply chain and increased demand for labor, exacerbating workforce strains as pandemic-related disruptions persisted.²⁹

The *Manufacturing* industry is facing labor issues due to its aging workforce and difficulty hiring qualified employees. As older workers have exited the field, there has been difficulty attracting young, qualified candidates to fill vacant roles in *Manufacturing*. The evolving demographic in the industry also poses a problem in fulfilling managerial roles due to the lack of supervisory experience possessed by many younger workers. Advances in automation have also shifted workforce needs as manufacturers adopt new technologies that require a more advanced skillset—even for entry-level workers. Additionally, public perception of the *Manufacturing* sector has also limited hiring in the industry. A Deloitte survey found that while more than 80 percent of Americans believed that *Manufacturing* is a “vital” industry to the country, less than half of those surveyed believed that industry jobs are “interesting and rewarding, clean and safe, and stable and secure.”³⁰ While these perceptions shift as the industry becomes more technologically advanced and requires a higher base skillset, *Manufacturing* firms are currently competing for talented and skilled employees with other high-tech industries possessing a more positive public image.³¹

Transportation Challenges

The COVID-19 pandemic caused issues throughout the global shipping industry, from container shortages to the overcrowding of ports.³² Demand for transportation services increased due to the pandemic, affecting nearly all modes of freight and cargo transport. In 2021, truck spot rates, ocean freight rates, and in-land transport rates increased to all-time highs, driving up the cost of business for many companies.³³ These increased operational costs have subsequently

²⁸ Congressional Research Service, “Supply Disruptions and the U.S. Economy,” 1, accessed October 11, 2022, <https://crsreports.congress.gov/product/pdf/IN/IN11926>.

²⁹ Heider Al Mashalah, et al., “The Impact of Digital Transformation on Supply Chains Through E-Commerce: Literature Review and a Conceptual Framework.” *Research Part E: Logistics and Transportation Review* 165 (September 2022): 2, accessed January 20, 2023, <https://doi.org/10.1016/j.tre.2022.102837>.

³⁰ Deloitte, “A Look Ahead – How Modern Manufacturers Can Create Positive Perceptions with the US Public,” 6, accessed November 14, 2023, <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-public-perception-manufacturing-study.pdf>.

³¹ Ibid, 5.

³² Su-Lin Tan, “The Global Shipping Industry is Facing a New Problem – Too Many Containers,” *CNBC*, November 10, 2022, accessed July 6, 2023, <https://www.cnbc.com/2022/11/11/global-shipping-industry-faces-a-new-problem-too-many-containers.html>.

³³ U.S. Department of Transportation, Bureau of Transportation Statistics, “Transportation Statistics Annual Report 2022,” 3-2, 3-3, accessed November 28, 2023, <https://doi.org/10.21949/1528354>.

been transferred, at least in part, to households when businesses are faced with higher prices for transportation services.^{34,35}

Pandemic impacts on the trucking industry were uneven between heavy and light-duty operations, with the former experiencing furloughs during the early pandemic and the latter having an increase in demand (and wages) due to higher online shopping volume and other delivery services.³⁶ Despite the increased need for light-duty drivers and recovery of heavy trucking demand, the pandemic further exacerbated the driver shortage resulting from factors including retirements, high turnover, and poor retention rates.³⁷ The need for air freight also increased compared to pre-pandemic demand, partially due to the decline of passenger travel and the corresponding “belly cargo capacity” typically utilized during passenger flights.³⁸ Waterway freight and intermodal transport experienced high demand for container and port services, which exceeded the capacity of U.S. ports and container supply.³⁹ Consequently, ports across the U.S. experienced substantial congestion and bottlenecks as vessels waited to dock at terminals and containers awaited service or transport.⁴⁰

Since the pandemic, vessel calls and volumes have increased at East Coast ports, while West Coast Ports have seen a decline in vessel calls. The East Coast has become a major containerized gateway for Asian import trades, surpassing the West Coast in cargo volume by nearly three million tons in 2021.⁴¹ Reports suggest that the shift is likely the result of enhancements and modifications at the Panama and Suez Canals.⁴² However, the sudden shifts have put pressure on East Coast supply chain operations to expand their capacity. Specifically, the Port of Baltimore noted the benefits of increased services and added rail business during

³⁴ U.S. Department of Transportation, Bureau of Transportation Statistics, “Transportation Statistics Annual Report 2022,” 4-1, 4-2.

³⁵ MSC, “Panama Canal Surcharge,” MSC Newsroom, Customer Advisories, November 23, 2023, accessed November 27, 2023, <https://www.msc.com/en/newsroom/customer-advisories/2023/november/panama-canal-surcharge>.

³⁶ “How Trucking Changed During the COVID-19 Pandemic,” Truck Info.net, April 1, 2023, accessed December 11, 2023, <https://www.truckinfo.net/research/how-trucking-changed-during-the-pandemic>.

³⁷ Peter S. Goodman, “The Real Reason America Doesn’t Have Enough Truck Drivers,” *The New York Times*, February 9, 2022, accessed December 18, 2023, <https://www.nytimes.com/2022/02/09/business/truck-driver-shortage.html>.

³⁸ “The Impact of the COVID-19 Pandemic on Freight Transportation Services and U.S. Merchandise Imports,” U.S. International Trade Commission, accessed December 18, 2023, [https://www.usitc.gov/research_and_analysis/tradeshifts/2020/special_topic.html#:~:text=In%202020%2C%20air%20freight%20experienced,%E2%80%9D\)%20due%20to%20cancelled%20flights](https://www.usitc.gov/research_and_analysis/tradeshifts/2020/special_topic.html#:~:text=In%202020%2C%20air%20freight%20experienced,%E2%80%9D)%20due%20to%20cancelled%20flights).

³⁹ U.S. Department of Transportation, Bureau of Transportation Statistics, “2023 Port Performance Freight Statistics Program: Annual Report to Congress,” 16, accessed November 27, 2023, <https://doi.org/10.21949/1528357>.

⁴⁰ “Container Vessel Dwell Times,” U.S. Department of Transportation, Bureau of Transportation Statistics, accessed November 30, 2023, <https://data.bts.gov/stories/s/Container-Vessel-Dwell-Times/pbag-pyes>.

⁴¹ U.S. Department of Transportation, Bureau of Transportation Statistics, “Transportation Statistics Annual Report 2022,” 3-20.

⁴² Ibid, 3-19.

this shift.⁴³ With recent port improvements and infrastructure advancements on the East Coast, some ports now have the capacity to service larger vessels, manage increased port activity, and attract container shipping lines that were previously routed to the West Coast.⁴⁴ The shift in Asian container trade on the East Coast has also increased trucking freight from intermodal rail transport because of the shorter distance traveled to deliver goods to Midwest.⁴⁵ Research suggests that additional containerized freight shifts are anticipated as nearshoring efforts and foreign direct investments increase in the U.S., impacting transportation modal choices and cross-border trade flows.^{46,47}

Inventory Management Changes

Disruptions caused by the pandemic also led many organizations to rethink the way they manage their inventory. Prior to COVID-19, many organizations relied on just-in-time inventory management, which refers to a system where inventory is replaced in small shipments as it is needed.⁴⁸ With this system, manufacturers were able to effectively meet consumer demand while also significantly reducing warehousing costs.⁴⁹ Due to its efficiency, this process had been adopted across many industries over the last 50 years.⁵⁰ Drawbacks of this inventory management system were exposed during the global pandemic, however, due to halted factory operations and issues with global shipping.⁵¹ Heavy reliance on just-in-time inventory systems coupled with pandemic disruptions resulted in a vast shortage of goods and production materials across many industries.⁵²

To address the shortfalls of just-in-time inventory management, distributors have several strategies available that cushion stock availability. One option is to aim for lean stock, but also include some additional inventory and work with multiple suppliers to reduce the risk of product unavailability.⁵³ Software can also assist through automated reordering with set minimums that trigger a restock, or by using historical data to forecast inventory needs. Additionally, warehouse management systems can help optimize layouts of distribution centers, make picking and packing processes more efficient, and improve inventory

⁴³ William P. Doyle, "Improvements Are Coming to Shorten Turnaround Times," *The Port of Baltimore*, 2022 No. 3, 6, accessed November 30, 2023, <https://mpa.maryland.gov/Port%20of%20Baltimore%20Magazines/poblssue3in2022.pdf>.

⁴⁴ U.S. Department of Transportation, Bureau of Transportation Statistics, "Transportation Statistics Annual Report 2022," 3-19, 3-20.

⁴⁵ Ibid, 3-26.

⁴⁶ Ibid, 3-22.

⁴⁷ Ibid, 3-2.

⁴⁸ Anna Baluch and Cassie Bottorff, "What Is Just in Time Inventory (JIT)?" *Forbes*, October 12, 2022, accessed February 3, 2023, <https://www.forbes.com/advisor/business/just-in-time-inventory/>.

⁴⁹ Peter Goodman and Niraj Chokshi, "Global Shortages During Coronavirus Reveal Failings of Just in Time Manufacturing," *The New York Times*, October 22, 2021, accessed January 20, 2023, <https://www.nytimes.com/2021/06/01/business/coronavirus-global-shortages.html>.

⁵⁰ Ibid.

⁵¹ Baluch and Bottorff, "What Is Just in Time Inventory (JIT)?"

⁵² Goodman and Chokshi, "Global Shortages During Coronavirus Reveal Failings of Just in Time Manufacturing."

⁵³ "How the Pandemic Changed Inventory Management," Sikich, May 16, 2023, accessed December 19, 2023, <https://www.sikich.com/insight/how-the-pandemic-changed-inventory-management/>.

communications with suppliers.⁵⁴ Exploring contingency plans through “what-if” scenarios is another step that businesses can take to build resiliency to unforeseen circumstances.⁵⁵

The pandemic also caused many retailers to shift from multichannel fulfillment—which is more siloed and restricts orders to assigned channels—to a more flexible omnichannel fulfillment strategy. For example, with multichannel fulfillment, an order placed and assigned to a warehouse for fulfillment will only be processed and shipped through that resource. Conversely, omnichannel fulfillment is not limited to the channel through which a customer first places an order. With omnichannel systems, an online order would prompt a check of inventory levels at stores or fulfillment centers closest to the consumer, minimizing time to delivery or offering the option of picking up at a store.⁵⁶ These shifts have collectively given businesses and distributors greater flexibility and resilience against temporary shocks to inventory or demand levels.

Geopolitics

Geopolitical tensions have also been impacting supply chain operations across the nation. Even prior to recent conflicts such as the trade war with China or the Russia-Ukraine conflict, supply chain experts have followed geopolitical issues closely due to their impact on transporting goods internationally.⁵⁷ Factors including sanctions, tariffs, and conflicts can disrupt transportation routes, increase costs, and cause major inefficiencies due to uncertain operating environments.⁵⁸ In a recent survey of CEOs conducted by PwC, 32 percent of respondents indicated that geopolitical conflict was a top threat to company growth, while 71 percent believed it could negatively impact sales of products or services.⁵⁹ These impacts may be global or have concentrated effects for certain regions or countries.

For example, after the Russia-Ukraine war began, top exports from Russia, such as fuel, metals, wheat, and nitrogen fertilizers became more difficult to obtain. Some countries have a limited ability to pivot to alternative suppliers, subsequently creating shortages. Many African countries have historically relied on grain exports from Russia and Ukraine to provide more than half of domestic consumption levels and have few options for alternative suppliers.⁶⁰ In the U.S., supply chains have had to adapt after losing Russia as a source of several metals used

⁵⁴ “How the Pandemic Changed Inventory Management,” Sikich.

⁵⁵ Nate Rosier, “Inventory Management in the Pandemic Era,” Multichannel Merchant, September 8, 2022, accessed December 19, 2023, <https://multichannelmerchant.com/operations/inventory-management-in-the-pandemic-era/>.

⁵⁶ Beth Owens, “Omnichannel Fulfillment,” RyderECommerce, February 18, 2021, accessed December 19, 2023, <https://whiplash.com/blog/why-omnichannel-fulfillment-21/>.

⁵⁷ Matthew Comte, “How to Manage Supply Chain Risk During Geopolitical Unrest,” PwC, March 18, 2022, accessed July 8, 2023, <https://www.pwc.com/us/en/services/consulting/business-transformation/library/supply-chain-geopolitical-unrest.html>.

⁵⁸ Ibid.

⁵⁹ Ibid.

⁶⁰ Eric Hamilton, “The Global Supply Chain Consequences of the Russia-Ukraine War,” University of Florida News, February 21, 2023, accessed December 19, 2023, <https://news.ufl.edu/2023/02/russia-ukraine-global-supply-chain/>.

for batteries and electronics, such as nickel and titanium.⁶¹ Tariffs imposed by the U.S. on certain Chinese products have also affected supply chains.⁶² Since the trade war that began in 2018, U.S. imports of Chinese goods have fallen from 22 percent to 18 percent of all imports.⁶³ While there has been diversification of global suppliers, near-term costs to the supply chain have included shortages and additional expenses to locate new suppliers.

Inflation

Inflation has risen substantially in the U.S. since the onset of the COVID-19 pandemic.⁶⁴ Between December 2020 and December 2021, the consumer price index (CPI) increased by 7.0 percent.⁶⁵ In comparison, prior to COVID-19, the consumer price index increased by approximately 2 percent annually between 2015 and 2019.^{66,67} In January 2022, inflation reached a 40-year high, and continued to rise following the announcement that the global pandemic health emergency was over in May 2023.⁶⁸ Some subsectors experienced drastic cost increases during the pandemic; for example, the price of ocean freight rose nearly 600 percent between January 2020 and July 2021.⁶⁹ As costs have climbed for labor, materials, and energy, shipping and storing goods has become more expensive and had rippling effects throughout supply chain operations.⁷⁰

In summary, various issues have impacted supply chains in recent years, making their viability a top priority for organizations across the country. Though the impact of many of these challenges caused major disruptions to supply chain operations, some experts believe that

⁶¹ Hamilton, "The Global Supply Chain Consequences of the Russia-Ukraine War," University of Florida News.

⁶² Chad P. Brown, "Four Years Into the Trade War, Are the US and China Decoupling?" Peterson Institute for International Economics, October 20, 2022, accessed December 19, 2023, <https://www.piie.com/blogs/realtime-economics/four-years-trade-war-are-us-and-china-decoupling>.

⁶³ Ibid.

⁶⁴ Jongrim Ha, M. Ayhan Kose, and Franziska Ohnsorge, "Inflation During the Pandemic: What Happened? What is Next?" World Bank Group (July 2021): 3, accessed July 19, 2023, <https://thedocs.worldbank.org/en/doc/1ad246272dbbc437c74323719506aa0c-0350012021/related/WP-inflation.pdf>.

⁶⁵ Drew Desilver, "As Inflation Soars, A Look at What's Inside the Consumer Price Index," Pew Research Center, January 24, 2022, accessed July 19, 2023, <https://www.pewresearch.org/short-reads/2022/01/24/as-inflation-soars-a-look-at-whats-inside-the-consumer-price-index/>.

⁶⁶ "Consumer Price Index: 2019 in Review," U.S. Bureau of Labor Statistics, January 16, 2020, accessed November 13, 2023, <https://www.bls.gov/opub/ted/2020/consumer-price-index-2019-in-review.htm>.

⁶⁷ CPI annual increases ranged from 1.9 percent to 2.3 percent across the four years evaluated.

⁶⁸ "Inflation Continues to Climb in US After Hitting 40-year High," World Economic Forum, last modified March 16, 2022, accessed July 19, 2023, <https://www.weforum.org/agenda/2022/03/inflation-pandemic-COVID-united-states/>.

⁶⁹ Hannah Rubinton and Maggie Isaacson, "Inflation and Shipping Costs," Federal Reserve Bank of St. Louis (March 2022): 1, accessed July 19, 2023, <https://files.stlouisfed.org/files/htdocs/publications/economic-synopses/2022/03/18/inflation-and-shipping-costs.pdf>.

⁷⁰ David Vallejo, "3 Major Impacts of Inflation on Global Supply Chains," *Forbes*, October 28, 2022, accessed July 19, 2023, <https://www.forbes.com/sites/sap/2022/10/28/3-major-impacts-of-inflation-on-global-supply-chains/?sh=43f508f31614>.

conditions are improving.⁷¹ According to the Federal Reserve Bank of New York's Global Supply Chain Pressure Index, there has been a steep decline in the index since peaking in late 2021. The index, which uses data from sources including transportation and purchasing indices to estimate supply chain strains, showed a drop from 4.3 in December 2021 to -1.7 in October 2023.⁷² While some immediate concerns have been alleviated with the end of the pandemic, many industry and company leaders are aiming to insulate themselves from similar situations in the future by evaluating, diversifying, and strengthening supply chain operations.

4.0 Manufacturing and Transportation and Warehousing Analysis

The effectiveness of an organization's supply chain is heavily influenced by the ability to source demanded goods or materials from manufacturers, as well as the capacity to store and transport them as needed. Additionally, surpluses of consumer demand exacerbate labor issues in *Manufacturing* and *Transportation and Warehousing* industries as they grapple with difficulty attracting and retaining employees. RESI used data from the U.S. BLS Job Openings and Labor Turnover Survey (JOLTS), employment data from the U.S. BLS Quarterly Census of Employment and Wages (QCEW), and demographic data by industry from the North American Industry Classification System (NAICS) to assess the current labor force trends in the *Manufacturing* and *Transportation and Warehousing* industries. Please note that while RESI used region-specific data where possible, some of the relevant data used in this section were only available nationally.⁷³ RESI also supplemented the data analysis with qualitative information drawn from relevant literature and publications.

4.1 National and Regional Labor Force Trends in the Manufacturing Industry

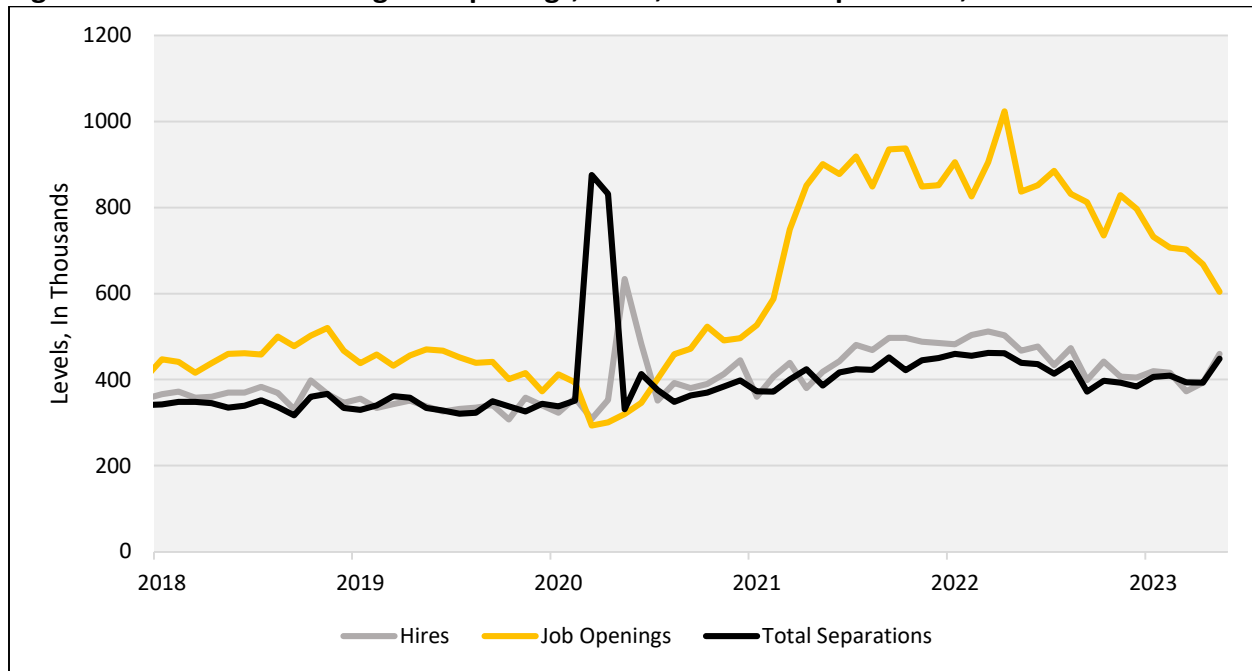
Nationally, demand for labor in the *Manufacturing* industry currently exceeds the number of workers being hired. An overview of nationwide job openings, hires, and total separations in the *Manufacturing* industry can be seen below in Figure 2. Between January 2018 and May 2023, job openings in the *Manufacturing* industry increased by 35 percent, while hires only increased by 26 percent over the same period. Job openings in this industry peaked in April 2022 and have been on a general downward trend since that time. Although the number of unfilled positions in U.S. *Manufacturing* is falling, the most recent data available show that job openings within this sector still outnumber hires by 144,000.

⁷¹ Garth Friesen, "The End of the Supply Chain Crisis: A Relief from Inflationary Pressures," *Forbes*, July 9, 2023, accessed July 19, 2023, <https://www.forbes.com/sites/garthfriesen/2023/07/09/the-end-of-the-supply-chain-crisis-a-relief-from-inflationary-pressures/?sh=1852b8a64422>.

⁷² "Global Supply Chain Pressure Index (GSCPI)," Federal Reserve Bank of New York, accessed November 13, 2023, <https://www.newyorkfed.org/research/policy/gscpi#/interactive>.

⁷³ Because JOLTS data is only available nationally, RESI was not able to assess industry specific job openings data for the state compared to national trends.

Figure 2: U.S. Manufacturing Job Openings, Hires, and Total Separations, 2018 to 2023



Sources: RESI, U.S. Bureau of Labor Statistics

The labor force in this industry has also seen minimal growth due to the increased number of total separations. Between January 2018 and May 2023, total separations in *Manufacturing* increased by approximately 31 percent. During the onset of the pandemic, total separations increased due to a spike in layoffs. However, these layoffs were temporary, and since late 2020, total separations have been driven primarily by quits.

There are several factors influencing the shortage of labor in American *Manufacturing*. In a 2023 survey of manufacturers conducted by Deloitte, 89.4 percent of respondents reported having unfilled positions within their firms due to difficulty finding qualified applicants.⁷⁴ Further, more than 74 percent of National Association of Manufacturers' (NAM) Outlook Survey respondents reported that the inability to attract and retain qualified talent was their greatest obstacle in the second quarter of 2023.⁷⁵ While workforce challenges in the *Manufacturing* industry are not new, shutdowns from the pandemic along with increased consumer demand exacerbated the issue.^{76,77}

⁷⁴ Deloitte, "2023 Manufacturing Industry Outlook," accessed August 2, 2023, <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/us-2023-outlook-manufacturing.pdf>.

⁷⁵ National Association of Manufacturers', "NAM Manufacturers' Outlook Survey, Second Quarter 2023," 2, accessed August 8, 2023, https://www.nam.org/wp-content/uploads/2023/03/Manufacturers_Outlook_Survey-Q2_June_2023.pdf.

⁷⁶ Parija Kavilanz, "Desperately Seeking Americans for Factory Jobs," CNN Money, July 23, 2012, accessed August 7, 2023. https://money.cnn.com/2012/02/16/smallbusiness/manufacturing_jobs/index.htm.

⁷⁷ Matt Egan, "American Factories are Desperate for Workers. It's a \$1 Trillion Problem," CNN, May 4, 2021, accessed August 8, 2023, <https://www.cnn.com/2021/05/04/economy/manufacturing-jobs-economy/index.html>.

It was also reported that young applicants were turning away from *Manufacturing* jobs in favor of more attractive career options in fields such as health care and technology.⁷⁸ Conditions for *Manufacturing* jobs may be unfavorable at times, as some production workers may work in hot or noisy conditions and must sit or stand for long periods of time. There is also a heightened risk of workplace injury and illness associated with many *Manufacturing* jobs.⁷⁹ Blue-collar occupations have also become less desirable because many jobs offer work-from-home options prompted by the pandemic. In a 2023 survey conducted by Forbes, it was reported that approximately 13 percent of full-time workers worked from home only, and approximately 28 percent of full-time workers worked a hybrid model. The same article also reported that 57 percent of the survey sample would look for work elsewhere if their company did not allow remote work.⁸⁰ This level of work flexibility was a key reason why many blue-collar workers transitioned into jobs in other industries.⁸¹

Along with obstacles in attracting labor due to unfavorable conditions, the *Manufacturing* industry faces diversity challenges, as labor force participation is lower than average amongst women and other demographic groups.⁸² Efforts to increase diversity within the *Manufacturing* labor force have been on the rise, as experts believe that an inclusive labor force will play a key role in revitalizing American *Manufacturing*.^{83,84} Along with ramping up efforts to increase diversity in the *Manufacturing* workforce, organizations are raising wages, using smart technology, and increasing benefits and flexibility where possible. Flexible work options that manufacturers are exploring include split work weeks, compressed schedules, and adjusted shift times.⁸⁵ Sign-on bonuses have also been offered to attract new talent.⁸⁶ Though efforts to increase flexibility in *Manufacturing* work options are underway, it is reported that the inflexibility of the production process is a barrier to shifting work arrangements.⁸⁷ Occupations geared toward more clerical duties can often be done from home, while remote work options for assembly employees are limited due to the nature of their tasks.⁸⁸ Manufacturers are

⁷⁸ Fowler, "Five Reasons Labor Shortages Are Impacting Supply Chains."

⁷⁹ "Got Skills? Think Manufacturing, Career Outlook" U.S. Bureau of Labor Statistics, June 2014, accessed August 7, 2023, <https://www.bls.gov/careeroutlook/2014/article/manufacturing.htm>.

⁸⁰ Katherine Haan and Kelly Main, "Remote Work Statistics and Trends In 2023," *Forbes Advisor*, June 12, 2023, accessed December 10, 2023, <https://www.forbes.com/advisor/business/remote-work-statistics/>.

⁸¹ Alex Tanzi, "Work-From-Home Spurs Blue-Collar Americans to Seek Career Shifts," *Bloomberg*, July 31, 2022, accessed August 7, 2023, <https://www.bloomberg.com/news/articles/2022-01-31/work-from-home-spurs-blue-collar-americans-to-seek-career-shifts>.

⁸² Deloitte, "2023 Manufacturing Industry Outlook," 5.

⁸³ "U.S. Commerce Secretary Gina Raimondo Calls on Students from Every Level of Education to Consider Careers in the Semiconductor Industry," U.S. Department of Commerce.

⁸⁴ "2.1 Million Manufacturing Jobs Could Go Unfilled by 2030," National Association of Manufacturers.

⁸⁵ National Association of Manufacturers', "NAM Manufacturers' Outlook Survey, Second Quarter 2023," 3.

⁸⁶ National Association of Manufacturers', "NAM Manufacturers' Outlook Survey, First Quarter 2022," 3, accessed August 2, 2023, https://www.nam.org/wp-content/uploads/2022/03/Manufacturers_Outlook_Survey_Write_Up_Mar2022.pdf.

⁸⁷ National Association of Manufacturers', "NAM Manufacturers' Outlook Survey, Second Quarter 2023," 3.

⁸⁸ Camila Domonoske, "A Remote Work Revolution is Underway – But Not for Everyone," *NPR*, May 6, 2021, accessed August 7, 2023, <https://www.npr.org/2021/05/06/994274793/a-remote-work-revolution-is-underway-but-not-for-everyone>.

concerned about the differences in employment arrangements for different segments of their workforce, as some employees find remote work policies unfair due to the lack of work-from-home opportunities for everyone.^{89,90}

RESI also assessed whether changes in pay for *Manufacturing* employees may play a role in the difficulty attracting workers. RESI found that the average annual pay in Maryland's *Manufacturing* industry and across *All Industries* has fluctuated in recent years. Between 2018 and 2019, average annual pay in *Manufacturing* decreased by approximately 2 percent, while average annual pay across *All industries* had increased by less than 1 percent. However, between 2019 and 2020, average annual pay in the *Manufacturing* industry and across *All Industries* increased significantly. Specifically, the average annual pay in the *Manufacturing* industry increased to \$97,386 in 2020, representing a 7 percent increase from the prior year, while the average annual pay across *All Industries* increased by 8 percent. Since 2020, average annual pay has decreased in both *Manufacturing* and *All Industries*. Despite the downward trend, Maryland's *Manufacturing* industry has maintained above-average annual pay over these five years.

Figure 3: Maryland Manufacturing Annual Pay Comparison, 2018 to 2022 (2022 Dollars)

Year	Average Annual Pay, Manufacturing	Average Annual Pay, All Industries	Percent Difference
2018	\$92,453	\$72,158	28%
2019	\$90,868	\$72,422	25%
2020	\$97,386	\$78,522	24%
2021	\$93,230	\$75,989	23%
2022	\$91,496	\$73,609	24%

Sources: RESI, U.S. Bureau of Labor Statistics

While higher-than-average pay may attract more workers, they could also cause firms to perform operations outside of Maryland in locations where labor costs are lower. The need to outsource for cheaper labor may be intensified by the increase in prices for material inputs offered to *Manufacturing* firms. This trend can be seen through the Producer Price Index (PPI), an index produced by the U.S. BLS that shows prices received by domestic producers for goods and services.⁹¹ The PPI for *Manufacturing* reached its peak in June 2022 before beginning to decline, which may alleviate some of the price pressures manufacturers are facing.⁹²

RESI used the shift-share model to better understand factors driving changes within Maryland's *Manufacturing* labor force. A shift-share analysis shows how changes in industry employment are impacted by different factors, including how well the national economy is doing, regional

⁸⁹ National Association of Manufacturers', "NAM Manufacturers' Outlook Survey, Second Quarter 2023," 3.

⁹⁰ Domonoske, "A Remote Work Revolution is Underway – But Not for Everyone."

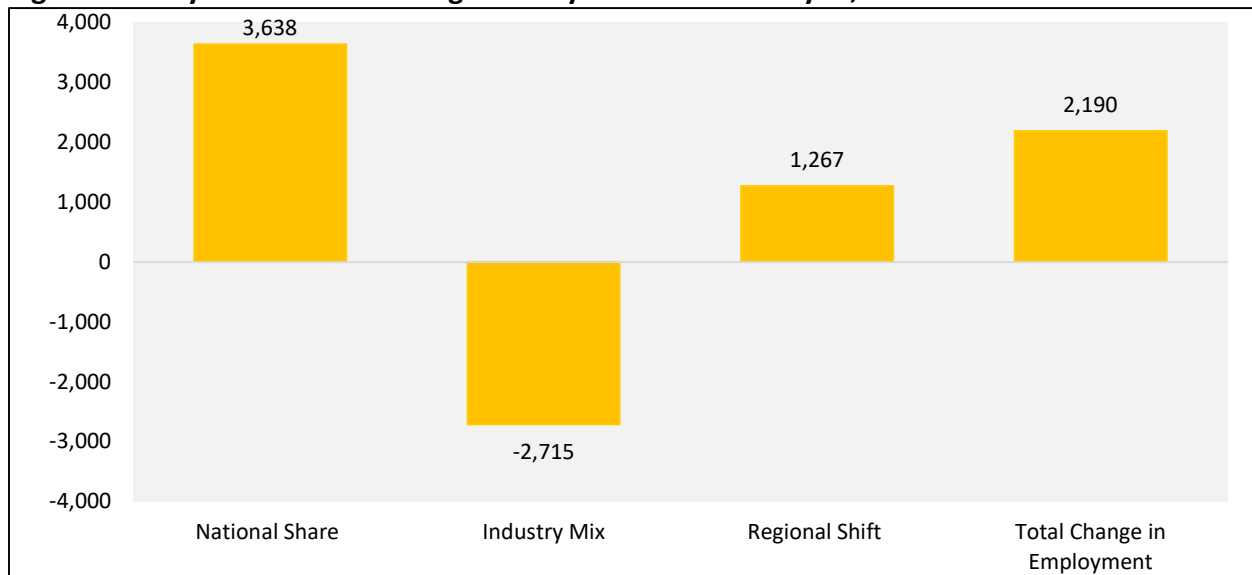
⁹¹ "Producer Price Indexes," U.S. Bureau of Labor Statistics, accessed January 8, 2024, <https://www.bls.gov/ppi/>.

⁹² "Producer Price Index by Industry: Total Manufacturing Industries," Federal Reserve Bank of St. Louis, accessed August 8, 2023, <https://fred.stlouisfed.org/series/PCUOMFGOMFG>.

conditions that are impacting growth, and patterns of change within the industry itself. The national share is the proportion of regional growth that can be attributed to national employment trends. The industrial mix indicates the amount of regional growth that can be attributed to employment trends within a specific industry after accounting for national growth trends across all industries. The regional shift is an indicator of whether an area possesses a unique competitive advantage (or disadvantage) within a specific industry and provides the amount of job growth that cannot be explained by national or industry employment trends.

Figure 4 below shows the shift-share analysis of employment changes in Maryland *Manufacturing* from 2018 to 2022.

Figure 4: Maryland Manufacturing Industry Shift-Share Analysis, 2018-2022



Sources: RESI, U.S. Bureau of Labor Statistics

As seen above, Maryland employment in the *Manufacturing* industry grew by 2,190 jobs from 2018 to 2022. Notably, the industry mix for *Manufacturing* was negative, indicating that national employment across *All Industries* grew at a faster pace than national employment in the *Manufacturing* industry. The national share had the largest positive impact, with U.S. employment trends credited for the bulk of positive employment shifts. Figure 5 below provides an overview of the year-to-year changes in employment that took place in the *Manufacturing* industry, as well as the total change over the four-year period.

Figure 5: Manufacturing Industry Employment Growth, 2018 to 2022

Region	2018-19	2019-20	2020-21	2021-22	Total Change, 2018-2022	
Maryland, <i>Manufacturing</i>	2,590	-3,773	2,136	1,237	2,190	2.0%
United States, <i>Manufacturing</i>	128,257	-692,678	219,178	451,645	106,402	0.8%

Sources: RESI, U.S. Bureau of Labor Statistics

Although Maryland's *Manufacturing* employment growth outpaced the national *Manufacturing* industry, it did not outpace overall employment growth of 3.3 percent across *All Industries* in the U.S.⁹³ In Maryland, however, employment in *Manufacturing* rose by 2.0 percent between 2018 and 2022, while employment in *All Industries* fell by 1.3 percent.⁹⁴ Notably, job losses in Maryland *Manufacturing* were not as drastic as in the national economy from 2019 to 2020. As national employment in *Manufacturing* declined by 5.4 percent, Maryland *Manufacturing* only experienced a 3.4 percent decline. Figure 6 below shows a breakdown of the top employment gains by subsector in Maryland *Manufacturing* between 2018 and 2022.

Figure 6: Top Employment Gains in Maryland Manufacturing Subsectors, 2018-2022

NAICS Industry	Total
NAICS 33451 Electronic Instrument Manufacturing	1,984
NAICS 32541 Pharmaceutical and Medicine Manufacturing	1,864
NAICS 33641 Aerospace Product and Parts Manufacturing	1,007
NAICS 31199 All Other Food Manufacturing	835
NAICS 32619 Other Plastics Product Manufacturing	672
NAICS 31141 Frozen Food Manufacturing	503
NAICS 31194 Seasoning and Dressing Manufacturing	477
NAICS 31181 Bread and Bakery Product Manufacturing	368
NAICS 33392 Material Handling Equipment Manufacturing	307
NAICS 33999 All Other Miscellaneous Manufacturing	287

Sources: RESI, U.S. Bureau of Labor Statistics

RESI also used location quotients from the U.S. BLS' QCEW to analyze the changes in Maryland *Manufacturing* employment relative to the national average from 2018 to 2022. Location quotients (LQs) are defined as a measurement of "an industry's regional concentration of value added, employment, or compensation relative to the U.S. industry's share."⁹⁵ LQs are based on a numeric system where a score of 1 indicates that regional concentration within the industry is equal to the national average. A LQ above 1 indicates that the industry is more concentrated in the area compared to the national average, while an LQ value below 1 indicates that the

⁹³ "QCEW Data Files, Quarterly Census of Employment and Wages," U.S. Bureau of Labor Statistics.

⁹⁴ Ibid.

⁹⁵ "Definitions," U.S. Bureau of Economic Analysis, accessed May 26, 2022, <https://apps.bea.gov/regional/pdf/acpsa/-definitions.pdf>.

industry is less concentrated than the national average. Figure 7 below shows the LQs for Manufacturing in Maryland.

Figure 7: Maryland Manufacturing Location Quotients, 2018 to 2022

Year	Location Quotient
2018	0.47
2019	0.48
2020	0.50
2021	0.50
2022	0.50

Source: U.S. Bureau of Labor Statistics

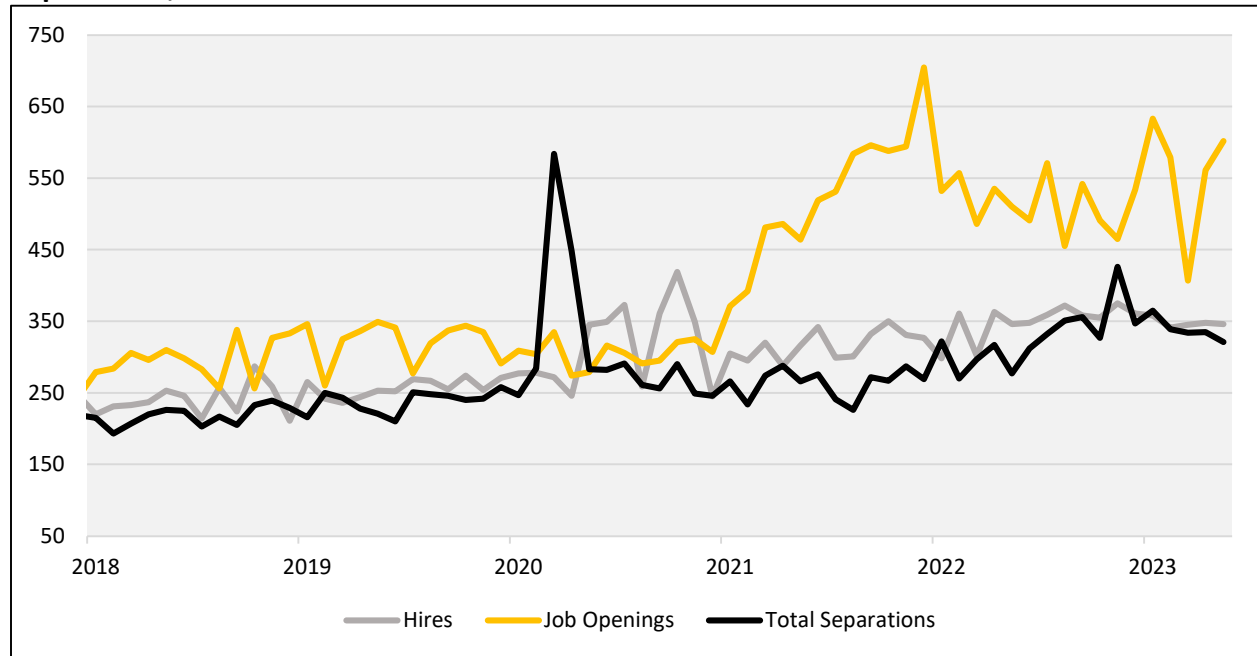
As shown above, Maryland's *Manufacturing* industry had an employment LQ of 0.50 in 2022, which indicates that the state's employment share in the industry is 50 percent below the industry's national employment share. From 2018 to 2022, Maryland's *Manufacturing* workforce employment has become more concentrated, but only by a small margin. Further, the concentration of employment in Maryland relative to the national average has remained unchanged since 2020.

4.2 National and Regional Labor Force Trends in the Transportation and Warehousing Industry

To continue the analysis of relevant industries to supply chain operations, RESI also assessed labor force trends in the *Transportation and Warehousing* sector. Figure 8 provides an overview of labor turnover trends in the *Transportation, Warehousing, and Utilities* sector.⁹⁶ Notably, this data on hires, openings, and total separations were available on the national supersector level for *Transportation, Warehousing, and Utilities*. For this data set, that means impacts between the *Transportation and Warehousing* industry and the *Utilities* industry cannot be isolated.

⁹⁶ Because JOLTS data were only available at the supersector level, Figure 8 presents labor turnover data for the *Transportation, Warehousing, and Utilities* sector, rather than just *Transportation and Warehousing*.

Figure 8: U.S. Transportation, Warehousing, and Utilities Job Openings, Hires, and Total Separations, 2018-2023



Sources: RESI, U.S. Bureau of Labor Statistics

In the last five years, job openings have typically exceeded the level of hires taking place in the national *Transportation, Warehousing, and Utilities* sector. In March 2020, there was a spike in total separations driven by layoffs and discharges, which were more than two times higher than the prior month. The spike in 2020 separations was followed by an increase in job openings throughout 2021, signifying a growing need for labor within this sector during this timeframe. According to the most recent JOLTS data, quits in this industry are currently on a slight decline after hitting 303,000 in November 2022.⁹⁷ In more recent months, this industry has seen a slight expansion as hires outnumber separations.

There are several factors impacting labor force trends in the *Transportation and Warehousing* industry. In 2021, separations outnumbered hires, while a surge in demand for online goods caused an increased need for workers in distribution and fulfillment centers.^{98,99} Further, warehouses are known to experience large seasonal spikes in demand that are driven by

⁹⁷ Please note that Total Separations is comprised of quits, layoffs and discharges, and other separations (e.g., retirements).

⁹⁸ Steve Banker, "Warehouse Woes are Worse than Ever," *Forbes*, October 12, 2021, accessed August 11, 2023, <https://www.forbes.com/sites/stevebanker/2021/10/12/warehouse-labor-woes-are-worse-than-ever/?sh=6e40b7778aaf>.

⁹⁹ Aki Ito, "How the Warehouse Boom Devoured America's Workforce," *Business Insider*, October 19, 2022, accessed August 14, 2023, <https://www.businessinsider.com/warehouse-jobs-economy-impact-blue-collar-pay-employment-hiring-boom-2022-10>.

holiday shopping, which also create a need for additional labor.^{100,101} Typically, many warehouses operate for 24 hours a day and hire temporary labor to meet demand. Inability to attract new applicants because of unattractive overnight shifts often causes many managers to resort to asking existing employees to work long overtime hours.¹⁰²

Another labor force challenge in the industry is the lengthy training times needed to get warehouse workers sufficiently trained after being hired. It was reported that only 29 percent of warehousing firms are capable of training their workers to work at the average speed of all warehouse employees at a given site within one month of hiring.¹⁰³ Warehousing work can also be very physically demanding, with some workers reportedly standing for ten hours a day or walking nine miles in a single shift.¹⁰⁴ Similar to *Manufacturing* jobs, warehouse workers have a heightened risk of injury. It is reported that the *Warehousing* industry has more than double the average number of injuries rate of all other occupations.¹⁰⁵

Low wages were cited as a major reason for the increase in separations within the *Transportation and Warehousing* industry.¹⁰⁶ Using QCEW data, RESI found that average annual pay in *All Industries* was significantly higher than in the *Transportation and Warehousing* industry. This information can be seen below in Figure 9.

Figure 9: Maryland Transportation and Warehousing Annual Pay Comparison, 2018 to 2022

Year	Average Annual Pay, Transportation and Warehousing	Average Annual Pay, All Industries	Percent Difference
2018	\$60,850	\$72,158	-16%
2019	\$57,271	\$72,422	-21%
2020	\$57,529	\$78,522	-27%
2021	\$53,306	\$75,989	-30%
2022	\$52,645	\$73,609	-28%

Sources: RESI, U.S. Bureau of Labor Statistics

Reports show that companies have offered higher starting wages and even raffle prizes to attract new warehousing talent.¹⁰⁷ Data from the U.S. BLS show that while average annual pay in Maryland's *Transportation and Warehousing* sector increased slightly from 2019 to 2020, it has otherwise declined since 2018. The largest decline in annual average pay took place

¹⁰⁰ Mary Hanbury, "Retailers Struggle to Hire Warehouse Workers Ahead of the Holidays," Business Insider, October 13, 2021, accessed August 11, 2021, <https://www.businessinsider.com/labor-shortage-warehouse-jobs-workers-put-off-hours-conditions-2021-10>.

¹⁰¹ Banker, "Warehouse Woes are Worse than Ever."

¹⁰² Ibid.

¹⁰³ Ibid.

¹⁰⁴ Ibid.

¹⁰⁵ Ito, "How the Warehouse Boom Devoured America's Workforce."

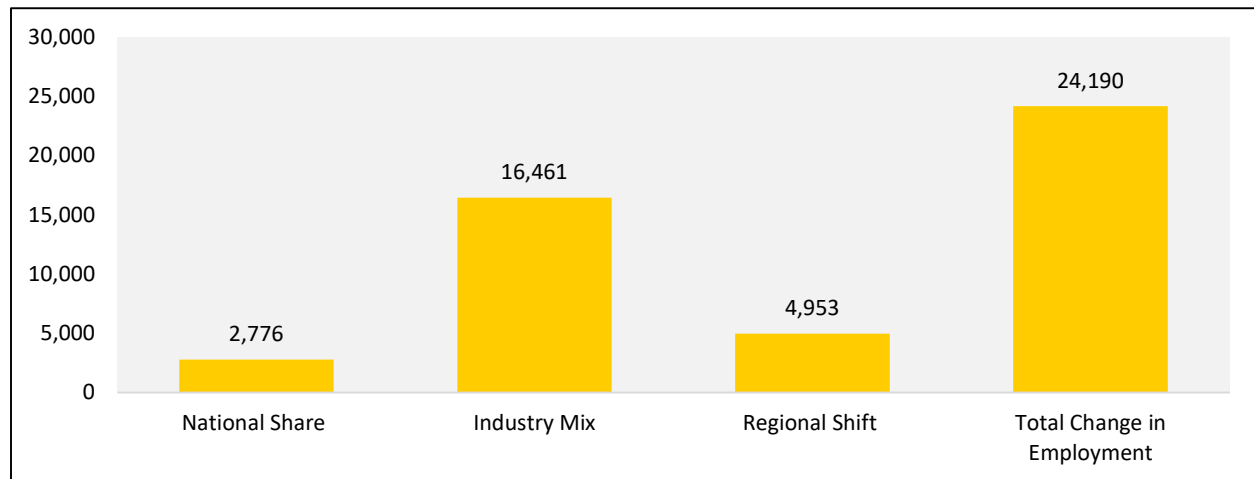
¹⁰⁶ Banker, "Warehouse Woes are Worse than Ever."

¹⁰⁷ Ibid.

between 2020 and 2021, where it fell by approximately 7 percent. Further, the pay gap between the *Transportation and Warehousing* industry and *All industries* has increased over time. As of 2022, *Transportation and Warehousing* wages were approximately 28 percent lower than annual pay across *All industries*. Due to lower-than-average wages being a persistent problem in the *Transportation and Warehousing* industry, it would be beneficial to analyze wages across other low-wage industries (such as retail or food service) to see how they compare, as applicants may opt for an occupation that is less physically taxing if wages are similar.¹⁰⁸

To better understand industry, regional, and national economic impacts on employment, RESI also performed a shift-share analysis for Maryland's *Transportation and Warehousing* industry. This information can be seen in Figure 10 below.

Figure 10: Maryland Transportation and Warehousing Industry Shift-Share Analysis, 2018-2022



Sources: RESI, U.S. Bureau of Labor Statistics

The large influx in demand for workers in the *Transportation and Warehousing* industry led to a staggering increase in employment between 2018 and 2022. During this time, Maryland's *Transportation and Warehousing* industry saw a net change of 24,190 employees, representing an increase of approximately 29 percent. As shown in the graph above, the national share, industry mix, and regional shift were all positive during this time. Notably, the industry mix of the shift share was the dominant component of the employment change between 2018 and 2022, meaning that growth of the *Transportation and Warehousing* industry grew significantly faster than employment across *All Industries*. A breakdown of the employment changes in *Transportation and Warehousing* in both the U.S. and Maryland is shown in Figure 11 below.

¹⁰⁸ Ito, "How the Warehouse Boom Devoured America's Workforce."

Figure 11: Transportation and Warehousing Industry Employment Growth, 2018 to 2022

Region	2018-19	2019-20	2020-21	2021-22	Total Change, 2018-2022	
Maryland, <i>Transportation and Warehousing</i>	5,321	6,806	8,836	3,227	24,190	28.9%
United States, <i>Transportation and Warehousing</i>	283,614	55,828	415,827	441,905	4,131,390	23.0%

Sources: RESI, U.S. Bureau of Labor Statistics

As shown above, Maryland's employment growth of 28.9 percent in the *Transportation and Warehousing* industry outpaced national industry gains of 23.0 percent. This industry growth was in stark contrast to employment changes in *All Industries*, which fell by 1.3 percent in Maryland and increased by 3.3 percent across the U.S. over the time period evaluated.¹⁰⁹ Because the employment changes in the *Transportation and Warehousing* industry were so large between 2018 and 2022, RESI analyzed industry subsectors to assess which were responsible for the largest changes in employment.

Figure 12 below shows that *General Warehousing and Storage* had the greatest employment increase by far, with an increase of 17,435 employees, followed by *Couriers and Express Delivery Services* with 6,065 new workers.

Figure 12: Top Employment Gains in Maryland Transportation and Warehousing Subsectors, 2018-2022

NAICS Industry	Total
NAICS 49311 General Warehousing and Storage	17,435
NAICS 49211 Couriers and Express Delivery Services	6,065
NAICS 48832 Marine Cargo Handling	1,918
NAICS 48411 General Freight Trucking, Local	1,500
NAICS 49221 Local Messengers and Local Delivery	1,451
NAICS 48899 Other Support Activities for Transportation	865
NAICS 48412 General Freight Trucking, Long-distance	699
NAICS 48422 Other Specialized Trucking, Local	614
NAICS 48541 School and Employee Bus Transportation	492
NAICS 48599 Other Transit and Ground Passenger Transportation	433

Sources: RESI, U.S. Bureau of Labor Statistics

The *General Warehousing and Storage* industry is primarily engaged in the operation of warehousing and storage facilities for general merchandise.¹¹⁰ The increase in employment in

¹⁰⁹ "QCEW Data Files, Quarterly Census of Employment and Wages," U.S. Bureau of Labor Statistics.

¹¹⁰ Statista, "Warehousing & Storage in the U.S. – Industry Insights & Data Analysis," 6, accessed January 8, 2023, <https://www.statista.com/study/30173/warehousing-and-storage-in-the-us/>.

this sector happened alongside a substantial increase in e-commerce sales, which had a strong influence on the increase in demand for general warehousing. Between 2018 and 2022, worldwide sales grew by approximately 92 percent.¹¹¹

RESI also assessed employment LQs in Maryland's *Transportation and Warehousing* industry, shown below in Figure 13.

Figure 13: Maryland Transportation and Warehousing Location Quotients, 2018 to 2022

Year	Location Quotient
2018	0.88
2019	0.89
2020	0.96
2021	0.98
2022	0.96

Source: U.S. Bureau of Labor Statistics

Between 2018 and 2022, this industry became 8 percent more concentrated relative to the national average. In 2022, the concentration of employment in Maryland's *Transportation and Warehousing* industry was 4 percent below the national average. While employment concentration in this industry has increased over time in Maryland, it remains slightly below the national average concentration of employment.

4.3 Diversity in Maryland's Manufacturing and Transportation and Warehousing Industries

To assess diversity within Maryland's *Manufacturing* labor force, RESI used NAICS data to obtain information on the labor force by gender, age, and race. RESI also assessed the same diversity statistics in the *Transportation and Warehousing* industry to analyze whether the industry is facing similar challenges. Figure 14 below provides an industry overview by gender.

Figure 14: Industry Employment by Gender, 2022

Region	Male	Female
Manufacturing		
Maryland	68.0%	32.0%
United States	69.9%	30.1%
Difference	1.9%	
Transportation and Warehousing		
Maryland	70.2%	29.8%
United States	67.9%	32.1%
Difference	-2.3%	

Sources: NAICS LED Extraction Tool, RESI

¹¹¹ Chevalier, "Retail E-Commerce Sales Worldwide from 2014 to 2026."

While the percentage of females working in Maryland *Manufacturing* is slightly greater than nationally, the differences are minimal. In 2022, the percentage of females working in *Manufacturing* was approximately 1.9 percent higher compared to national levels. Conversely, the percentage of females working in Maryland's *Transportation and Warehousing* industry was approximately 2.3 percent lower than the national level. Most notably, women represented less than one-third of employees in both *Manufacturing* and *Transportation and Warehousing*, highlighting the gender disparity within these industries.

Maryland's labor force participation by age group is also very close to national statistics, which are shown below in Figure 15.

Figure 15: Industry Employment by Age Group, 2022

Age Group	Maryland	United States	Difference
<i>Manufacturing</i>			
24 or younger	7.1%	7.8%	-0.7%
25-54	62.8%	64.4%	-1.6%
55-64	22.7%	21.7%	1.0%
65 or older	7.4%	6.1%	1.3%
<i>Transportation and Warehousing</i>			
24 or younger	9.2%	12.6%	-3.4%
25-54	63.4%	63.1%	0.3%
55-64	19.6%	17.7%	1.9%
65 or older	7.8%	6.6%	1.2%

Sources: NAICS LED Extraction Tool, RESI

In 2022, the majority of employees within the *Manufacturing* and *Transportation and Warehousing* industries were between the age of 25 and 54. Differences in the national workforce and state-level workforce by age group in these industries were also modest, with the largest gap existing for individuals 24 or younger in the *Transportation and Warehousing* industry. In Maryland, there were approximately 3.4 percent fewer individuals under the age of 24 working in the state's *Transportation and Warehousing* industry compared to national proportions.

Below in Figure 16, a breakdown of the *Manufacturing* and *Transportation and Warehousing* industries by race can be found.

Figure 16: Industry Employment by Race and Ethnicity, 2022

Race/Ethnicity	Maryland	United States	Difference
<i>Manufacturing</i>			
White Alone	68.0%	78.6%	-10.6%
Black or African American Alone	21.3%	11.0%	10.3%
Asian Alone	8.3%	7.2%	1.1%
Two or More Race Groups	1.8%	1.9%	-0.1%
American Indian or Alaska Native Alone	0.5%	1.0%	-0.5%
Native Hawaiian or Other Pacific Islander Alone	0.1%	0.3%	-0.2%
<i>Transportation and Warehousing</i>			
White Alone	52.1%	69.6%	-17.5%
Black or African American Alone	42.0%	21.2%	20.8%
Asian Alone	3.1%	5.0%	-1.9%
Two or More Race Groups	2.1%	2.5%	-0.4%
American Indian or Alaska Native Alone	0.5%	1.2%	-0.7%
Native Hawaiian or Other Pacific Islander Alone	0.1%	0.5%	-0.4%

Sources: NAICS LED Extraction Tool, RESI

In 2022, the *Manufacturing* and *Transportation and Warehousing* industries in Maryland were predominantly composed of Black and White individuals. However, the percentage of White workers in Maryland's *Manufacturing* industry was approximately 10.6 percent lower than the national average, while Black individuals accounted for approximately 10.3 percent more of Maryland's *Manufacturing* workforce. The differences were larger in Maryland's *Transportation and Warehousing* industry, which had approximately 17.5 percent fewer White workers and approximately 20.8 percent more Black workers than the national average in 2022. While these findings could suggest that Maryland's *Manufacturing* and *Transportation and Warehousing* industry workforces are more diverse than the national average, there are notable demographic differences between Maryland and the total U.S. population. In 2023 Maryland's White population was 18.2 percentage points lower than the U.S., while Maryland's Black population was 18.1 percentage points higher than the U.S. overall.¹¹² Based on these differences, the demographic findings specifically within these two industries is largely explained by variation in populations.

National and state-level differences in racial and ethnic groups such as Asian, American Indian, Alaska Native, Native Hawaiian, Other Pacific Islanders or those who belonged to two or more races were more modest. Cumulatively, these groups comprised approximately 10.7 percent of Maryland's *Manufacturing* workforce and approximately 10.4 percent of the national *Manufacturing* workforce. The gap was more pronounced in Maryland's *Transportation and Warehousing* industry, as these groups represented approximately 5.8 percent of the state's

¹¹² "QuickFacts: United States, Maryland," U.S. Census Bureau, accessed March 25, 2024, <https://www.census.gov/quickfacts/fact/table/US,MD/PST045223>.

workforce and 9.2 percent nationally.

5.0 Industry Profiles

To gain a greater understanding of different needs and challenges, Commerce identified 15 *Manufacturing* industries for further evaluation. The industry profiles in this section will provide information on the functions of each key industry, their role in the supply chain, top-tier suppliers and buyers, as well as how each industry is impacted by various supply chain issues. To complete these profiles, data were obtained from the U.S. BLS' QCEW to highlight the industry size within the state of Maryland. Due to data and privacy limitations, some industries may vary in the amount of information provided within the industry profiles. Various industry websites, news sources, and reports were used to provide additional information on each sector and the challenges and opportunities they have faced.

The industries covered in this section, as well as 2022 Maryland employment and wage statistics and employment location quotients (LQs), are shown in Figure 17 below.

Figure 17: Key Maryland Industries with Select Employment Data, 2022

NAICS Code	Industry Title	Maryland Employment	Average Annual Wage	Employment Location Quotient
3119	Other Food Manufacturing	5,552	\$67,680	1.3
3254	Pharmaceutical and Medicine Manufacturing	10,698	\$163,333	1.8
3342	Communications Equipment Manufacturing	3,113	\$127,196	2.1
3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	16,037	\$136,286	2.2
3346	Manufacturing and Reproducing Magnetic and Optical Media	815	\$208,796	3.9
3364	Aerospace Product and Parts Manufacturing	2,555	\$102,268	0.3
3365	Railroad Rolling Stock Manufacturing ¹¹³	N/D	N/D	N/D
3379	Other Furniture Related Product Manufacturing	1,122	\$47,182	1.8
4883	Support Activities for Water Transportation	4,756	\$55,370	2.8
4931	Warehousing and Storage	39,115	\$40,495	1.2
5239	Other Financial Investment Activities	11,144	\$217,397	1.1
5413	Architectural, Engineering, and Related Services	39,906	\$106,183	1.4
5415	Computer Systems Design and Related Services	85,448	\$131,838	2.0
5416	Management, Scientific, and Technical Consulting Services	49,485	\$112,815	1.6
5417	Scientific Research and Development Services	39,301	\$131,788	2.5
Maryland, All Private Employment		2,160,905	\$71,104	N/A

Sources: RESI, U.S. Bureau of Labor Statistics

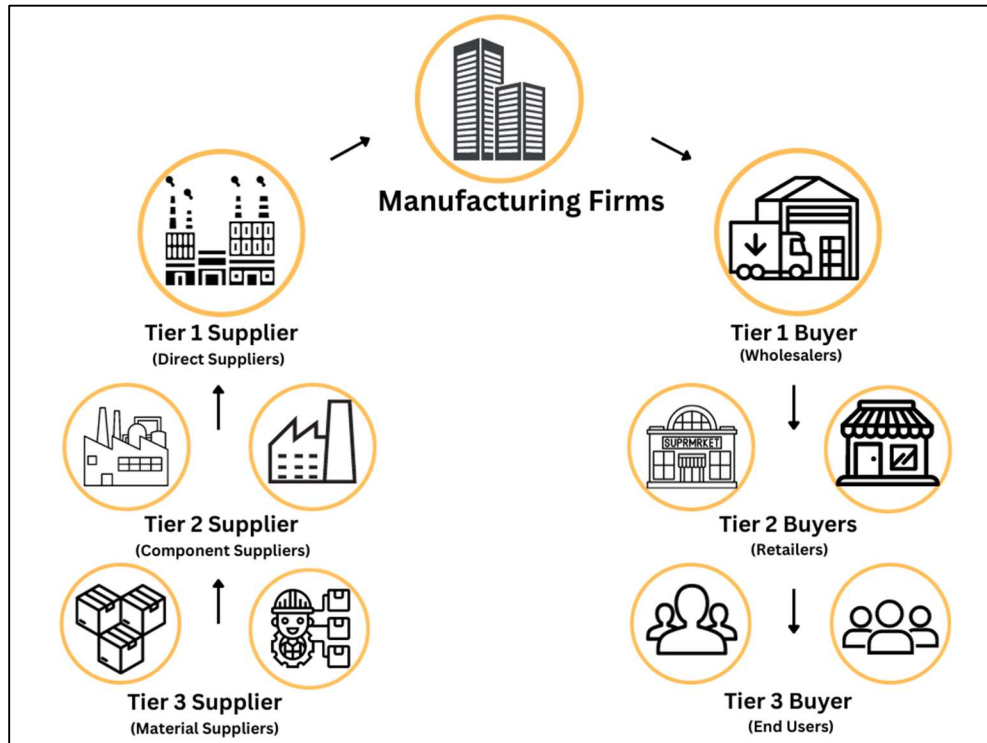
As detailed above, there was significant variation in the size of each industry, ranging from 815 employees in *Manufacturing and Reproducing Magnetic and Optical Media* to 85,448 employees in *Computer Systems Design and Related Services*. For the majority of industries shown, the average wage exceeded the 2022 Maryland average of \$71,104. Four industries had a lower-than-average wage, while two industries had roughly three times the average Maryland earnings. All but one industry—*Aerospace Product and Parts Manufacturing*—had a greater concentration of employment in Maryland compared to the U.S. as a whole (shown by location

¹¹³ Please note that QCEW data for NAICS 3365, *Railroad Rolling Stock Manufacturing*, are suppressed by the U.S. BLS for privacy reasons. This often occurs when disclosing data on a small industry or industry with only a few employers would enable identification of individual employers.

quotient). The highest industry concentration was seen for *Manufacturing and Reproducing Magnetic and Optical Media*, with a concentration approximately 3.9 times higher than the national average.

For each of the industries profiled, common first-tier suppliers and buyers are also noted in profile summaries. Figure 18 below shows an example of the flow between suppliers for a *Manufacturing* firm, and subsequent buyers of the output produced.

Figure 18: Buyers and Suppliers Flow Chart



Sources: Canva, RESI

As illustrated above, third-tier suppliers typically provide raw materials to second-tier suppliers, who produce components or intermediate products. First-tier suppliers are those from which manufacturers directly buy materials and products. Issues with any tiered supplier can create complications further up the supply chain. For example, a scarce raw material that is difficult to obtain by third-tier suppliers subsequently causes delays on providing shipments to second- and first-tier suppliers. On the buyer side of the supply chain, first-tier buyers are firms that purchase directly from the manufacturer. From there, second-tier buyers purchase products from first-tier buyers and ultimately end with third-tier buyers at the consumer level.

The following subsections will provide additional details on common products, manufacturing processes, and industry challenges and opportunities for each key industry identified. A full list of detailed subsectors within each key industry can be found in Appendix C.

5.1 Other Food Manufacturing Industry (NAICS 3119)

The *Other Food Manufacturing* industry consists of establishments that primarily manufacture food products such as snack foods, coffee, and tea, concentrates, condiments, and spices.¹¹⁴ Firms in the food manufacturing subsector are responsible for transforming raw agricultural products and livestock into intermediate goods or goods for final consumption.¹¹⁵ To do this, industry providers use diverse food manufacturing processes.¹¹⁶ The supply chain in food manufacturing industries is particularly important due to its impact on food access. A strong supply chain in food manufacturing allows for greater traceability and transparency and also allows for quicker identification of issues such as shortages or contamination.¹¹⁷ Industry groups are classified based on the raw material inputs that are processed for intermediate or final consumption.¹¹⁸

The *Other Food Manufacturing* supply chain begins with sourcing raw materials (such as crop seeds) from farmers.¹¹⁹ Common first-tier suppliers for the industry include sugar processors; flour millers; margarine and cooking oil processors; plastic film, sheet, and bag manufacturers; dairy, tea, coffee, and chocolate producers; agriculturists; and seasoning, sauce, and condiment producers.¹²⁰ After raw materials are obtained, they are farmed, harvested, and processed by manufacturers. Once raw materials are fully processed, manufacturers transport their products to distributors who deliver products to first-tier buyers. First-tier buyers for the *Other Food Manufacturing* industry include supermarkets and grocery stores; soft drink, baked goods and grocery wholesalers; distilleries; and soda, juice, candy, snack food, and frozen food producers.¹²¹ The food manufacturing supply chain ultimately ends with household consumers who buy these products.

Firms within the *Other Food Manufacturing* industry had to manage negative impacts from the COVID-19 pandemic while also facing more typical industry supply chain challenges. During the pandemic, operations were further disrupted by stay-at-home orders that resulted in labor shortages at farms, manufacturing plants, and grocery stores—ultimately impacting supply chain operations and access to food products.¹²² Aside from issues raised by the pandemic, food manufacturers contended with additional threats to food production, processing, and distribution. These include outbreaks of agricultural diseases and/or contaminants, extreme weather conditions, and energy or water constraints.

¹¹⁴ “3119 – Other Food Manufacturing,” NAICS Association, accessed August 8, 2023, <https://www.naics.com/naics-code-description/?code=3119>.

¹¹⁵ “Industries at a Glance – Food Manufacturing: NAICS 311,” U.S. Bureau of Labor Statistics, accessed January 29, 2023, <https://www.bls.gov/iag/tgs/iag311.htm>.

¹¹⁶ “North American Industry Classification System: Search Results 3119,” U.S. Census Bureau, last modified August 7, 2023, accessed August 7, 2023, <https://www.census.gov/naics/?input=3119&year=2022&details=3119>.

¹¹⁷ Leon Altomonte, “Food Chain Supply,” Safety Culture, June 16, 2023, accessed July 19, 2023, <https://safetyculture.com/topics/food-supply-chain/>.

¹¹⁸ Ibid.

¹¹⁹ Ibid.

¹²⁰ “Search Results – 3119,” IBISWorld, accessed October 23, 2023, <https://my.ibisworld.com/search/?q=3119>.

¹²¹ Ibid.

¹²² Altomonte, “Food Chain Supply.”

Outbreaks of foodborne illnesses resulting from contaminated products (e.g., those with *Salmonella*, *E. coli*, or *Listeria*) can cause significant issues and require the ability to trace products along the supply chain to implement warnings or recalls.^{123,124} To mitigate these risks, firms can manage potential sources of contamination—such as polluted water, manure, and unsanitary conditions in packing facilities—by following best practices to help prevent the spread of foodborne illness.¹²⁵ Extreme weather conditions and natural disasters also impact the food manufacturing supply chain and can have dire impacts on farms, factories, and delivery routes. Lastly, many farms rely heavily on energy and water to provide the food that is demanded by consumers, sometimes straining available resources.¹²⁶

Consumers are also increasingly demanding products that are sustainably produced and utilize ethically sourced labor.¹²⁷ According to a survey completed by McKinsey and Company, 66 percent of all respondents and 75 percent of Millennial respondents reported that they consider sustainability when making a purchase.¹²⁸ Consumers also show a willingness to pay a premium for sustainably produced products; for food this premium is estimated to be roughly 30 to 40 percent.¹²⁹ As younger generations (i.e., Millennials and Generation Z) gain more purchasing power, consumers' trust in companies to be transparent about sustainable practices is expected to have a greater impact on business operations.¹³⁰ As with other food-production industries, firms within the *Other Food Manufacturing* industry must also begin or increase the adoption of sustainable practices to meet the demands of discerning consumers for transparent and guilt-free supply chains.

Issues caused by the COVID-19 pandemic and other environmental factors have led to an increased focus on the viability of agriculture and food systems to ensure food security among

¹²³ "Current and Past Multistate Foodborne Outbreaks," Centers for Disease Control and Prevention, accessed November 14, 2023, <https://www.cdc.gov/foodsafety/outbreaks/lists/index.html>.

¹²⁴ Rutgers University, Rutgers NJAES Cooperative Extension, "2022/2023 Mid-Atlantic Commercial Vegetable Production Recommendations," 35, last modified March 3, 2022, accessed July 19, 2023, <https://extension.psu.edu/mid-atlantic-commercial-vegetable-production-recommendations-sections>.

¹²⁵ Mike Munnely, "Where are the Risks for Contamination in a Food Processing Plant?" ThermoFisher Scientific, January 25, 2022, accessed November 14, 2023, <https://www.thermofisher.com/blog/food/where-are-the-risks-for-contamination-in-a-food-processing-plant/>.

¹²⁶ "Water, Food and Energy," United Nations – Water, accessed July 19, 2023, <https://www.unwater.org/water-facts/water-food-and-energy>.

¹²⁷ Öykü Ilgar, "The Sustainability Problems Percolating in The Coffee Supply Chain," *Forbes*, September 29, 2022, accessed August 7, 2023, <https://www.forbes.com/sites/sap/2022/09/29/the-sustainability-problems-percolating-in-the-coffee-supply-chain/?sh=260cf504c673>.

¹²⁸ Andrew Martins, "Most Consumers Want Sustainable Products and Packaging," *Business News Daily*, November 13, 2023, accessed January 15, 2024, <https://www.businessnewsdaily.com/15087-consumers-want-sustainable-products.html>.

¹²⁹ Peter Walker, "Consumers Are Willing to Pay More for Sustainable Food Products," *LEK*, July 20, 2022, accessed January 15, 2024, <https://www.lek.com/insights/ar/consumers-are-willing-pay-more-sustainable-food-products>.

¹³⁰ Ashley Reichheld, John Peto, and Cory Ritthaler, "Research: Consumers' Sustainability Demands Are Rising," *Harvard Business Review*, September 18, 2023, accessed January 15, 2024, <https://hbr.org/2023/09/research-consumers-sustainability-demands-are-rising>.

millions of people.¹³¹ Aiming to diversify production, output markets, import sources, and supply chains has become a central goal for both farmers and governments.¹³² Diversity in the primary production stage of the food manufacturing supply chain creates greater resilience for farms in the event of a crop failure by spreading the risk over several types of crops or other means of agricultural income (e.g., livestock, providing agricultural services such as storage).¹³³ Experts also suggest diversifying supply chain processes by using a mixture of traditional, modern, and local supply chains in food manufacturing to avoid supply chain bottlenecks.¹³⁴ Addressing these challenges will be critical to ensuring stability and growth in the *Other Food Manufacturing* industry.¹³⁵

5.2 Pharmaceutical and Medicine Manufacturing (NAICS 3254)

Industries within the *Pharmaceutical and Medicine Manufacturing* sector are responsible for manufacturing and processing biological, pharmaceutical, and medicinal products.¹³⁶ The drug manufacturing process typically begins with research to formulate new products or improve existing medications. On average, the overall time to research, develop, and manufacture a new drug is 10 to 15 years and costs over \$800 million.¹³⁷ Pharmaceutical development has substantial risk involved, with only 13.8 percent of all drugs advancing from the initial research phase into phase two trials.¹³⁸ Firms within the *Pharmaceutical and Medicine Manufacturing* industry must also adhere to strict FDA regulations that satisfy trade, public health, product safety, and industry standards, including requirements (such as temperature or humidity stability) during periods of storage or shipment.¹³⁹

There are two primary approaches to pharmaceutical manufacturing: batch processing and continuous manufacturing. In batch manufacturing, each product batch completes multiple individual production steps before a new lot begins.¹⁴⁰ In continuous manufacturing, a drug is brought from its raw ingredients to a finished product through a single uninterrupted

¹³¹ "Is Our Food Supply at Risk?" Food and Agriculture Organization of the United Nations, last modified 2021, accessed July 19, 2023, <https://www.fao.org/state-of-food-agriculture/en/>.

¹³² "Is Our Food Supply at Risk?" Food and Agriculture Organization of the United Nations.

¹³³ Lynn Kime, "Diversification of Your Operation, Why," The Pennsylvania State University, January 3, 2023, accessed July 19, 2023, <https://extension.psu.edu/diversification-of-your-operation-why>.

¹³⁴ "Is Our Food Supply at Risk?" Food and Agriculture Organization of the United Nations.

¹³⁵ Ilgar, "The Sustainability Problems Percolating in The Coffee Supply Chain."

¹³⁶ "North American Industry Classification System: Search Results 3254," United States Census Bureau, accessed May 4, 2023, <https://www.census.gov/naics/?input=3254&year=2022&details=3254>.

¹³⁷ "Global Regulatory Perspectives on Quality by Design in Pharma Manufacturing," ScienceDirect, last modified March 29, 2019, accessed May 4, 2023, <https://www.sciencedirect.com/science/article/pii/B9780128157992000022>.

¹³⁸ Chi Heem Wong, Kien Wei Siah, and Andrew W Lo, "Estimation of Clinical Trial Success Rates and Related Parameters," *Biostatistics* 20, no. 2 (2018): 285, <https://doi.org/10.1093/biostatistics/kxx069>.

¹³⁹ "Five Critical Challenges Facing Pharma Supply Chains," SupplyChainBrain, accessed May 4, 2023, <https://www.supplychainbrain.com/articles/34798-five-critical-challenges-facing-pharma-supply-chains>.

¹⁴⁰ "Accelerating Data Acquisition Process in the Pharmaceutical Industry Using Internet of Things," ScienceDirect, accessed May 4, 2023, <https://www.sciencedirect.com/science/article/pii/B978012821326100005X>.

process.¹⁴¹ This type of manufacturing requires raw materials and energy to be fed into the system at a constant rate.¹⁴² For both processes, it is crucial to maintain reliable equipment and a consistent workforce to ensure efficient pharmaceutical production that meets demand.

At each phase of the drug manufacturing process, from the assembly of equipment to the distribution of the final products, having a stable supply chain is crucial. First-tier suppliers of *Pharmaceutical and Medicine Manufacturing* include medical supply wholesalers, organic chemical manufacturers, and industrial machinery and equipment wholesalers.¹⁴³ First-tier buyers of pharmaceuticals are primarily drug, cosmetic, and toiletry wholesalers. Second-tier buyers who then purchase from these wholesalers include hospitals, pharmacies, and nursing care facilities.¹⁴⁴ Failures at any stage along the supply chain ultimately impact doctors' and other medical professionals' ability to provide needed pharmaceuticals to patients. Supply chain issues could mean lost revenue, a damaged reputation, or even lives at risk.¹⁴⁵

In this tightly regulated industry, real-time visibility is vital for accurate orders, reliable schedules, effective inventory management, and compliance with regulations. "On-time in-full" (OTIF) delivery has become the gold standard in the pharmaceutical industry, making partial fulfillment as detrimental as non-delivery, whether the product is a raw material for manufacturers or a drug order for consumers.¹⁴⁶ The *Pharmaceutical and Medicine Manufacturing* industry also has to rely on the just-in-time inventory model as perishable drugs have limited storage viability, making it difficult to plan manufacturing output and stocking levels during periods of uncertainty such as the COVID-19 pandemic.

The pandemic exacerbated pre-existing challenges in the *Pharmaceutical and Medicine Manufacturing* supply chain, particularly those related to supplier transparency and drug transportation. A 2020 survey of pharmaceutical manufacturers found that 90 percent of respondents did not have full visibility of their supply chains, while a quarter of respondents had lost inventory due to transport issues such as damage or spoilage.¹⁴⁷ It is estimated that pharmaceutical firms lose an average of \$34 billion annually due to temperature deviations alone.¹⁴⁸ The mass production of COVID-19 vaccines—with some requiring precise cryogenic temperature ranges—highlighted the delicate nature of transporting and storing products that

¹⁴¹ "Batch vs. Continuous Pharmaceutical Manufacturing," General Kinematics, accessed August 7, 2023, <https://www.generalkinematics.com/blog/batch-vs-continuous-pharmaceutical-manufacturing/>.

¹⁴² "The Pharmaceutical Manufacturing Process – Steps, Tools and Considerations," Thomasnet, accessed May 4, 2023, <https://www.thomasnet.com/articles/chemicals/the-pharmaceutical-manufacturing-process-steps-tools-and-considerations/>.

¹⁴³ IBISWorld, "Generic Pharmaceutical Manufacturing in the US," 41, accessed May 4, 2023, <https://my.ibisworld.com/us/en/industry/32541b/about>.

¹⁴⁴ Ibid.

¹⁴⁵ "Five Critical Challenges Facing Pharma Supply Chains," SupplyChainBrain.

¹⁴⁶ Ibid.

¹⁴⁷ Ibid.

¹⁴⁸ Ibid.

may spoil if temperatures vary by just one or two degrees.¹⁴⁹ In 2021, cold chain issues resulted in a 20 percent loss of COVID-19 vaccines. The pandemic also spurred overstocking, leading producers at every part of the supply chain to overestimate actual product demand.¹⁵⁰ Striking the right balance between these constraints to optimize inventory will remain a persistent challenge for firms as demand levels stabilize.

5.3 Communication Equipment Manufacturing (NAICS 3342)

The *Communications Equipment Manufacturing* industry is responsible for producing equipment related to wire telephones, data communications, radio and television broadcast, and all other communications equipment.¹⁵¹ These include antennas, set-top boxes, GPS systems, cell phones, satellite uplink technologies and radios, and TV broadcasting equipment.¹⁵² The supply chain dynamics governing the manufacturing and distribution of these products can be segmented into two main categories:

- First-tier suppliers that include computer manufacturers, telecommunication networking equipment manufacturers, computer peripheral manufactures, and communication equipment manufactures; and
- First-tier buyers such as internet publishing and broadcasters, computer and packaged software wholesalers, wireless telecommunications carriers, television broadcasters, radio broadcasters, and cable networks.¹⁵³

The *Communications Equipment Manufacturing* industry is expanding due to the rapid development of 4G/LTE and 5G networks. This advancement has accelerated the use of internet-enabled communication devices and has offered mobile consumers extensive coverage with increased speeds that also support high-definition (HD) streaming.¹⁵⁴ Because of this, consumer demand has increased for the latest smartphones and communication equipment, promoting market expansion in this industry segment. In 2022, the *Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing* subsector—responsible for producing cellular phones and GPS equipment—comprised the majority of employment for the *Communications Equipment Manufacturing* industry, representing 60.3 percent of total U.S. employment and 75.9 percent of total industry employment in Maryland.¹⁵⁵

¹⁴⁹ “Pharmaceutical Transport Best Practices for Shippers to Know,” Tive, accessed November 20, 2023, <https://www.tive.com/blog/pharmaceutical-transport-best-practices-for-shippers-to-know>.

¹⁵⁰ “Five Critical Challenges Facing Pharma Supply Chains,” SupplyChainBrain.

¹⁵¹ “North American Industry Classification System: Search Results 3342,” U.S. Census Bureau, accessed March 8, 2023, <https://www.census.gov/naics/?input=3342&year=2022&details=3342>.

¹⁵² “Communication Equipment Manufacturing in the US – Industry Market Research Report,” Market Research.com, accessed July 18, 2023, <https://www.marketresearch.com/IBISWorld-v2487/Communication-Equipment-Manufacturing-Research-33442999/>.

¹⁵³ “Industry at a Glance, Communication Equipment Manufacturing in the US,” IBISWorld, last modified January 2023, accessed July 6, 2023, <https://my.ibisworld.com/us/en/industry/33422/industry-at-a-glance>.

¹⁵⁴ “U.S. Communication Equipment Market Size, Share & Trends Analysis Report by Product (Mobile, Fixed-line), Competitive Landscape, and Segment Forecasts, 2018-2025,” Research and Markets, accessed July 18, 2023, <https://www.researchandmarkets.com/reports/4613450/u-s-communication-equipment-market-size-share>.

¹⁵⁵ “QCEW Data Files, Quarterly Census of Employment and Wages,” U.S. Bureau of Labor Statistics.

The *Communication Equipment Manufacturing* industry benefitted from the COVID-19 pandemic, as businesses were forced to invest more in equipment to enable work-from-home options.¹⁵⁶ These investments likely drove the industry's 11 percent increase in revenue between 2020 and 2021.¹⁵⁷ However, numerous ongoing challenges within the industry have slowed revenue in some sectors. For example, the widespread use of wireless communication devices has decreased demand for conventional fixed-line tools and equipment.¹⁵⁸ Additionally, many systems are moving from primarily hardware-only to software-defined networking and cloud-enabled solutions.¹⁵⁹

While increased connectivity has many advantages, sending sensitive data through networks raises the possibility of potential security issues. Because of this, *Communication Equipment Manufacturing* manufacturers are increasingly expected to produce products that reduce vulnerabilities and prevent cyberattacks. The industry is also facing stiff domestic and international competition, with innovations driving consumer demand for new products.¹⁶⁰ Despite domestic companies often leading in product innovation, cost considerations have led to the outsourcing of less profitable manufacturing to Asian countries, contributing to 75 percent of industry imports.¹⁶¹ However, restrictions placed on imports from China for reasons including national security and labor concerns might encourage mid-size manufacturers to switch back to domestic production.¹⁶²

The availability of critical industry components—particularly semiconducting silicon—was significantly reduced after the pandemic began, leading to production delays and increased semiconductor costs.¹⁶³ The *Communication Equipment Manufacturing* industry, marked by high competition, experienced cost and price pressures as customers demanded cost-effective solutions without compromising quality, performance, and compliance amid heightened international scrutiny.¹⁶⁴ Domestic producers might also be forced to completely switch to high-end or specialized goods to differentiate themselves from cheaper import options.

In general, the *Communication Equipment Manufacturing* industry is competitive and highly valued. Demand for 5G technologies is rising and is evident by the market size of the industry in

¹⁵⁶ "Industry at a Glance, Communication Equipment Manufacturing in the US," IBISWorld.

¹⁵⁷ "Industry Performance, Communication Equipment Manufacturing in the US," IBISWorld, last modified January 2023, accessed July 6, 2023, <https://my.ibisworld.com/us/en/industry/33422/industry-performance>.

¹⁵⁸ "U.S. Communication Equipment Market," Grand View Research, accessed July 6, 2023, <https://www.grandviewresearch.com/industry-analysis/us-communication-equipment-market>.

¹⁵⁹ S&P Global, "The Sustainability Yearbook 2022," 93, accessed July 6, 2023, https://www.spglobal.com/esg/csa/yearbook/files/Communications_Equipment.pdf.

¹⁶⁰ "Communication Equipment Manufacturing in the US – Industry Market Research Report," Market Research.com.

¹⁶¹ "Industry at a Glance, Communication Equipment Manufacturing in the US," IBISWorld.

¹⁶² Ibid.

¹⁶³ "Prices for Import Semiconductors Up Over the Past 12 Months," U.S. Bureau of Labor Statistics, August 18, 2022, accessed July 18, 2023, <https://www.bls.gov/opub/ted/2022/prices-for-import-semiconductors-up-over-the-past-12-months.htm>.

¹⁶⁴ "Industry at a Glance, Communication Equipment Manufacturing in the US," IBISWorld.

the U.S., which increased faster than the *Manufacturing* sector overall.¹⁶⁵ However, due to competition and the numerous challenges described here, revenues are starting to fall, including a 3.7 percent decrease in 2023 alone.¹⁶⁶ To remain viable, manufacturers must aim for increased innovation while simultaneously overcoming competition and supply chain challenges.

5.4 Navigational, Measuring, Electromedical, and Control Instruments Manufacturing (NAICS 3345)

The *Navigational, Measuring, Electromedical, and Control Instruments Manufacturing* industry produces instruments mainly for the purpose of search, detection, and navigation, along with industrial process variable instruments (used to measure and control parameters like pressure, temperature, pH, speed, and force in processes, including manufacturing and production).^{167,168} Within the industry's supply chain, first-tier suppliers include plastic pipe and parts manufacturers, hose and belt manufacturers, glass producers, plastic and resin manufacturers, and manufacturers of rubber and plastic products. Notably, second-tier suppliers for the industry include semiconductor and circuit manufacturers, which have been a major source of supply chain delays due to shortages.^{169,170} First-tier buyers include automobile manufacturers, laboratory supply wholesalers, electronic part and equipment wholesalers, hospitals, and medical supply wholesalers.^{171,172}

Supply chain challenges and disruptions faced within the industry have varied by subsector. During the early COVID-19 pandemic, there was a decline of some elective surgeries such as dental, orthopedic, and ophthalmic procedures.¹⁷³ This caused a subsequent decrease in demand and revenue for manufacturing firms that regularly supply this equipment.¹⁷⁴ Geopolitical issues and import restrictions have caused volatility in raw material prices and

¹⁶⁵ "Communication Equipment Manufacturing in the US – Market Size 2005-2029," IBISWorld, January 26, 2023, accessed July 18, 2023, <https://www.ibisworld.com/industry-statistics/market-size/communication-equipment-manufacturing-united-states/#:~:text=The%20market%20size%2C%20measured%20by,industry%20increased%200.9%25%20in%202022.>

¹⁶⁶ "Communication Equipment Manufacturing in the US – Market Size 2005-2029," IBISWorld.

¹⁶⁷ Vineet K. Vaishnavi, "Navigational, Measuring, Electro Medical and Control Instruments Market Overview 2032," Allied Market Research, June 2023, accessed July 22, 2023, <https://www.alliedmarketresearch.com/navigational-measuring-electro-medical-and-control-instruments-market-A74849>.

¹⁶⁸ "Navigational, Measuring, Electromedical, and Control Instruments," Maryland Workforce Exchange, last modified July 1, 2019, accessed May 10, 2023, <https://mwejobs.maryland.gov/vosnet/lmi/profiles/profileSummary.aspx?session=inddetail&valueName=industry>.

¹⁶⁹ "Medical Device Manufacturing – 33451A, Competitive Forces," IBIS World, accessed October 30, 2023, <https://my.ibisworld.com/us/en/industry/33451a/competitive-forces>.

¹⁷⁰ "Medical Device Manufacturing – 33451B, Competitive Forces," IBIS World, accessed October 30, 2023, <https://my.ibisworld.com/us/en/industry/33451b/competitive-forces>.

¹⁷¹ "Medical Device Manufacturing – 33451A, Competitive Forces," IBIS World.

¹⁷² "Medical Device Manufacturing – 33451B, Competitive Forces," IBIS World.

¹⁷³ "U.S. Medical Devices Market Size, Share & Covid-19 Impact Analysis," Fortune Business Insights, May 2023, accessed August 1, 2023, <https://www.fortunebusinessinsights.com/u-s-medical-devices-market-107009>.

¹⁷⁴ Ibid.

impacted the availability of some resources—such as alloy—that are needed for device manufacturing across several subsectors.¹⁷⁵ Multiple sectors have been affected by the shortage of semiconductor chips, which are required to produce a significant number of instruments and devices.¹⁷⁶ Labor supply has also been an issue, with a substantial number of programmers and skilled machinists approaching retirement age and a current lack of replacement workers available. For skilled technicians in particular, the shift towards college degrees rather than skilled trade schools over the past 20 years has contributed to the challenge of attracting and obtaining new entrants to the field.¹⁷⁷

Some sectors experienced positive impacts during the pandemic, such as increased sales of in-vitro diagnostic (IVD) devices due to the need for COVID-19 tests.¹⁷⁸ More recently, demand has increased for diabetic tests and cancer screenings, along with newly available COVID-19 tests.¹⁷⁹ To help provide routine care and treatment plans among an aging population, there is a growing emphasis on devices with advanced capabilities, such as wearable heart rate trackers or other technologies utilizing AI intelligence. Because of this, medical device manufacturers are prioritizing research and development of these products and concentrating investments in new technologies for wearable devices.¹⁸⁰

As innovations occur within multiple industries, there is likely to be steady demand for products made by *Navigational, Measuring, Electromedical, and Control Instruments Manufacturing* firms. New technologies are being incorporated into many devices, such as smart building environmental controls, appliances, and security systems.¹⁸¹ For manufacturers producing navigational systems, there are opportunities for growth as equipment with augmented reality (AR) has become the preferred technology for marine operations.¹⁸² Additionally, while the Russia-Ukraine war has negatively impacted supply chain operations, the conflict has also spurred increased demand for defense aircraft manufacturing. Due to this increase, there is expected growth for the navigation, search, and detection instruments required for these crafts.¹⁸³

To meet these demands, industry producers will need to strengthen and diversify their supply chains to minimize disruptions. A study by Deloitte in 2022 found that more than half of

¹⁷⁵ “Looking Ahead: Risk Outlook for the Medical Device Supply Chain,” FTI Consulting, January 12, 2023, accessed Aug 1, 2023, <https://www.fticonsulting.com/insights/white-papers/looking-ahead-risk-outlook-medical-supply-chain#:~:text=Geopolitical%20volatility%2C%20energy%20crises%2C%20health,disruptions%20and%20long%20lead%20times>.

¹⁷⁶ “Looking Ahead: Risk Outlook for the Medical Device Supply Chain,” FTI Consulting.

¹⁷⁷ Ibid.

¹⁷⁸ “U.S. Medical Devices Market Size, Share & Covid-19 Impact Analysis,” Fortune Business Insights.

¹⁷⁹ Ibid.

¹⁸⁰ Ibid.

¹⁸¹ Vaishnavi, “Navigational, Measuring, Electro Medical and Control Instruments Market Overview 2032.”

¹⁸² “Search, Detection, and Navigation Instruments Global Market Report 2023 – By Type,” The Business Research Company, January 2023, accessed July 27, 2023, <https://www.thebusinessresearchcompany.com/report/search-detection-and-navigation-instruments-global-market-report>.

¹⁸³ Ibid.

medical device manufacturers did not have diversified semiconductor supply chains and a third of manufacturers were utilizing brokers to acquire semiconductors. Competition for chips will likely increase as demand grows from auto, electronic, and aerospace equipment production and will present additional challenges for manufacturers to source these crucial components. Many medical device manufacturers plan to increase their supply, which ultimately could encourage hoarding and place further constraints on smaller companies and critical medical devices.¹⁸⁴ Increased domestic chip production, spurred by the CHIPS Act, will be a key factor in industry firms' ability to reinforce their supply chain operations.¹⁸⁵

5.5 Manufacturing and Reproducing Magnetic and Optical Media (NAICS 3346)

Entities within the *Manufacturing and Reproducing Magnetic and Optical Media* industry are primarily engaged in manufacturing optical and magnetic media (such as blank audio tape, blank video tape, and blank diskettes) and/or mass duplication of audio, video, software, and similar media.¹⁸⁶ Related industries that utilize products from the industry include *Software Publishing, Designing and Developing Software, Motion and Sound Recording Production, and Doll, Toy, and Game Manufacturing*.¹⁸⁷ The *Manufacturing and Reproducing Magnetic and Optical Media* industry is driven by consumer needs for data storage, with formats often changing as new technologies emerge.¹⁸⁸ Examples of common industry products include audiotapes, videotapes, CDs, DVDs, game cartridges, hard drive media, computer software, and laser disks.¹⁸⁹

Manufacturing media—such as CDs—requires sourcing both raw materials and processed components such as glass, polycarbonates, plastic, aluminum, and acrylics.¹⁹⁰ Extracting information from readable products such as CDs, DVDs, and software/game discs requires the use of disk readers, which contain semiconductor lasers to read the embedded data.¹⁹¹ Within the industry's supply chain, first-tier suppliers include plastic and resin manufacturers, cardboard box and container manufacturers, and miscellaneous plastic product manufacturers. First-tier buyers consist of consumer electronics stores, movie and video producers, major label music producers, and software publishers.¹⁹²

¹⁸⁴ "Looking Ahead: Risk Outlook for the Medical Device Supply Chain," FTI Consulting.

¹⁸⁵ Frédérique Carrier, "The Chip Industry's Reshoring Revolution," RBC, November 14, 2023, accessed November 21, 2023, <https://www.rbcwealthmanagement.com/en-us/insights/the-chip-industrys-reshoring-revolution>.

¹⁸⁶ "Manufacturing and Reproducing Magnetic and Optical Media," Maryland Workforce Exchange, last modified July 1, 2019, accessed July 27, 2023, <https://mwejobs.maryland.gov/vosnet/lmi/profiles/profileSummary.aspx?Session=inddetail&valueName=industry>.

¹⁸⁷ "North American Industry Classification System: Search Results 3346," U.S. Census Bureau, last modified July 23, 2023, accessed July 23, 2023, <https://www.census.gov/naics/?input=3346&year=2022&details=334610>.

¹⁸⁸ "Magnetic and Optical Media Manufacturing Market Size, Share, Analysis Report," Market Research Engine, January 2, 2022, accessed August 1, 2023, <https://www.marketresearchengine.com/magnetic-and-optical-media-manufacturing-market>.

¹⁸⁹ "North American Industry Classification System: Search Results 3346," U.S. Census Bureau.

¹⁹⁰ "Methods and Materials: CDs and DVDs," Yale University, Ismail-Beigi Research Group, accessed July 26, 2023, <https://volga.eng.yale.edu/teaching-resources/cds-and-dvds/methods-and-materials>.

¹⁹¹ Ibid.

¹⁹² "Recordable Media Manufacturing – 33461, Competitive Forces," IBISWorld, accessed November 1, 2023, <https://my.ibisworld.com/us/en/industry/33461/competitive-forces>.

The video game industry saw rapid growth during the COVID-19 pandemic, providing an avenue of entertainment during isolation periods as game popularity surged. Video game sales increased substantially, reaching 29.4 billion dollars in the U.S. by September 2020. This represented a 23 percent increase from 2019, with digital downloads and physical discs comprising the majority of purchases.¹⁹³ Notably, video game console inventories dwindled in 2020 and 2021 as popularity increased, yet console manufacturers faced a shortage of semiconductor chips that nearly halted production.¹⁹⁴ Although console production is not directly included within the *Manufacturing and Reproducing Magnetic and Optical Media* industry, the ability to purchase consoles is related to demand for games and other media and can be affected by chip shortages and other production delays. Similarly, as companies aim to reduce their environmental impacts and cloud gaming increases, there is potential for spillover impacts on gaming software and console components.¹⁹⁵

The *Manufacturing and Reproducing Magnetic and Optical Media* industry has faced other challenges as technology and access to entertainment has evolved. Throughout these periods of change, many products and their supporting playing devices (e.g., audiocassettes and tape players) have become almost obsolete, though at times they have made nostalgia-driven returns to the market.¹⁹⁶ In 2021, for example, vinyl record and CD revenues grew for the first time in over two decades. Vinyl records were particularly popular, with sales increasing by more than 50 percent.¹⁹⁷ Similar shifts can be seen through the television and film industry, as consumers have moved from physical media (DVDs, VHS) to online streaming platforms. Overall, the U.S. home video market has declined by 86 percent over the last 13 years.¹⁹⁸ As digital media continues to grow, the *Manufacturing and Reproducing Magnetic and Optical Media* Industry will need to adapt to these evolving consumer preferences and their supportive technologies.

5.6 Aerospace Product and Parts Manufacturing (NAICS 3364)

The *Aerospace Product and Parts Manufacturing* industry is primarily engaged in the manufacturing of equipment, including aircraft, helicopters, missiles, spacecraft, target drones,

¹⁹³ Adam Epstein, "Game On: How COVID-19 Became the Perfect Match for Gamers," World Economic Forum, September 28, 2020, accessed July 31, 2023, <https://www.weforum.org/agenda/2020/09/covid19-coronavirus-pandemic-video-games-entertainment-media/>.

¹⁹⁴ Jonathan Lee, "PlayStation 5 Shortage Over, Announces Sony Exec Jim Ryan," *The Washington Post*, January 6, 2023, accessed July 31, 2023, <https://www.washingtonpost.com/video-games/2023/01/06/sony-playstation-5-shortage-over/>.

¹⁹⁵ Dave McCarthy, "An Update on Xbox Sustainability Efforts," Xbox Wire, March 10, 2022, accessed July 27, 2023, <https://news.xbox.com/en-us/2022/03/10/an-update-on-xbox-sustainability-efforts/>.

¹⁹⁶ Douglas Broom, "Global Music Sales Hit a New Record In 2021 Thanks to the Rapid Growth of Streaming," World Economic Forum, April 20, 2022, accessed July 31, 2023, <https://www.weforum.org/agenda/2022/04/music-sales-record-streaming-surge/>.

¹⁹⁷ Ibid.

¹⁹⁸ Sarah Whitten, "The Death of the DVD: Why Sales Dropped More Than 86% In 13 Years," *CNBC*, August 4, 2019, accessed July 31, 2023, <https://www.cnbc.com/2019/11/08/the-death-of-the-dvd-why-sales-dropped-more-than-86percent-in-13-years.html>.

aerospace engines and propulsion units, and aerospace prototypes.¹⁹⁹ The industry's supply chain engages multiple tiers of suppliers and buyers with varying roles and responsibilities. First-tier suppliers are often responsible for design builds, large systems work packages, and structure assemblies.²⁰⁰ Second-tier suppliers often have engineering responsibilities and will provide individual parts and components of sub-assemblies, while third-tier firms produce structural components and parts.²⁰¹ Major first-tier buyers within *Aerospace Product and Parts Manufacturing* include domestic and international airlines, military and defense agencies, and business aviation.^{202,203}

The COVID-19 pandemic shifted the aviation industry's operations and affected demand for aircraft and equipment. Although passenger travel rates have since recovered to pre-pandemic levels, the sharp decrease in demand resulted in a 44 percent reduction in new commercial aircraft production in 2021 compared to 2018 levels.^{204,205} The pandemic also prompted an increase in passenger aircraft being converted to cargo aircraft, starting as alternate transport methods were utilized to alleviate or avoid ocean freight bottlenecks during the pandemic.²⁰⁶ With demand for new aircraft now rising, firms in the *Aerospace Product and Parts Manufacturing* industry have struggled to meet orders. Issues have largely been blamed on faulty or difficult-to-acquire parts, which are also having a negative impact on the time to complete aircraft repairs.²⁰⁷ One firm specializing in aircraft conversions reported that a diode needed for smoke detectors has become a substantial obstacle to production.²⁰⁸ Additionally, some manufacturing firms are attempting to stockpile parts to lessen the impact of shortages,

¹⁹⁹ "33641 – Aerospace Product and Parts Manufacturing," NAICS Association, accessed August 7, 2023, <https://www.naics.com/naics-code-description/?code=33641>.

²⁰⁰ National Aeronautics Research Institute, "AeroDynamic Advisory, AAM Supply Chain-Considerations," 4, accessed May 12, 2023, <https://nari.arc.nasa.gov/sites/default/files/attachments/2021-09-09%20AeroDynamic%20Advisory%20AAM%20Supply%20Chain%20Working%20Group%20Presentation.pdf>.

²⁰¹ Ibid, 3-4.

²⁰² IBISWorld, "Aircraft, Engine & Parts Manufacturing in the US," 56, accessed November 21, 2023, <https://www.ibisworld.com/united-states/market-research-reports/aircraft-engine-parts-manufacturing-industry/#CompetitiveForces>.

²⁰³ IBISWorld, "Space Vehicle & Missile Manufacturing in the US," 53, accessed November 21, 2023, <https://www.ibisworld.com/united-states/market-research-reports/space-vehicle-missile-manufacturing-industry/>.

²⁰⁴ Jinshan Hong and Anthony Palazzo, "Air Travel Is Back to Pre-pandemic Levels with New Turbulence Ahead," *Bloomberg*, October 8, 2023, accessed November 21, 2023, <https://www.bloomberg.com/news/articles/2023-10-08/air-travel-finally-reaches-pre-covid-l-evels-but-profits-suffer?embedded-checkout=true>.

²⁰⁵ "Industry Outlook: Commercial Aviation Post Pandemic," Aviation Pros, March 11, 2021, accessed November 21, 2023, <https://www.aviationpros.com/aircraft/article/21210525/industry-outlook-post-pandemic>.

²⁰⁶ PwC, "Global Aerospace and Defense: Annual Performance and Outlook – 2022 Edition," 14, accessed May 12, 2023, <https://www.pwc.com/us/en/industrial-products/publications/assets/pwc-aerospace-defense-annual-industry-performance-outlook-2022.pdf>.

²⁰⁷ Ian Putzger, "Threat to Freighters as Parts Shortages Hobble Airlines, Manufacturers, and MRO," *The Loadstar*, April 28, 2023, accessed November 21, 2023, <https://theloadstar.com/threat-to-freighters-as-parts-shortages-hobble-airlines-manufacturers-and-mro/#>.

²⁰⁸ Ibid.

yet this has further strained suppliers who were already struggling to meet post-pandemic demand.²⁰⁹

With rising demand for electrical vehicles, the aerospace supply chain is also likely to face increased competition to secure materials used to produce batteries and other electronics.²¹⁰ Between 2018 and 2030, demand for raw materials (such as cobalt, lithium, and nickel) is expected to grow 20 times due to the rise in electric vehicle production.²¹¹ The availability and development of aviation batteries will likely depend upon advancements in manufacturing processes that utilize fewer of these raw materials.²¹² In March 2022, President Biden invoked the Defense Production Act to increase domestic production and mining of metals and minerals that are currently critical to electric vehicles and other products.²¹³ The ability to expand domestic production will help to reduce reliance on foreign suppliers, along with alternative-fuel technologies that are currently under development.²¹⁴

Opportunities within the industry are emerging as services for satellites expand, with growth expected to triple in the commercial space sector. These changes will be driven by an increase in small satellite launches, which are forecast to occur weekly or even daily over the next decade.²¹⁵ Aspirations for a permanent Moon space base, increased space exploration, and potential tourism may also spur demand for aerospace products and parts. The possibility of public-private collaborative missions could also be on the horizon.²¹⁶ The *Aerospace Product and Parts Manufacturing* industry is currently experiencing growth related to the expansion of the U.S. Space Force and the U.S. Department of Defense's strategic software modernization program.²¹⁷ Capitalizing on these industry growth opportunities will be dependent upon procurement system adjustments and new technology developments to overcome current supply chain limitations.²¹⁸

5.7 Railroad Rolling Stock Manufacturing (NAICS 3365)

Industries within the *Railroad Rolling Stock Manufacturing* sector are responsible for producing locomotives, locomotive frames, railroads, street and rapid transit cars, manufacturing rail

²⁰⁹ Putzger, "Threat to Freighters as Parts Shortages Hobble Airlines, Manufacturers, and MRO."

²¹⁰ National Aeronautics Research Institute, "AeroDynamic Advisory, AAM Supply Chain-Considerations," 20.

²¹¹ Ibid.

²¹² Ibid, 19.

²¹³ The White House, Briefing Room, "Fact Sheet: President Biden Takes Bold Executive Action to Spur Domestic Clean Energy Manufacturing," The Whitehouse, June 6, 2022, accessed May 25, 2023, <https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/06/fact-sheet-president-biden-takes-bold-executive-action-to-spur-domestic-clean-energy-manufacturing/>.

²¹⁴ The White House, Briefing Room, "Fact Sheet: President Biden Takes Bold Executive Action to Spur Domestic Clean Energy Manufacturing."

²¹⁵ PwC, "Global Aerospace and Defense: Annual Performance and Outlook – 2022 Edition," 17.

²¹⁶ Ibid.

²¹⁷ Ibid, 20.

²¹⁸ Ibid.

layers, and other railway track maintenance equipment.²¹⁹ Within the industry's supply chain, first-tier suppliers include screw, nut, and bolt manufacturers; metalworking machinery manufacturers; and metal pipe and tube manufacturers.²²⁰ The manufacturing process consists of a series of stages: contract execution, design completion, material and part ordering, manufacturing and assembly, and delivery.²²¹ Numerous testing and inspection procedures are also completed on finished products to guarantee their adherence to quality and safety standards.²²² First-tier buyers of these finished products include rail transportation, public transportation, and rail maintenance services.²²³ Overall, manufacturing railroads and related products is an expensive, time-consuming, and risky process.²²⁴ Challenges can include both technical difficulties and political complications, increasing the cost and time necessary to complete projects.

Demand for the *Railroad Rolling Stock Manufacturing* industry is heavily influenced by the financial position and profitability of railroad companies, capital investment by manufacturers, and government investments in mass transit systems.²²⁵ Other factors, such as manufacturing production, automotive production, agricultural production, and demand for chemicals and resources also drive the industry's revenue. Sustainability is another consideration that influences this industry. As natural resources become scarcer and the climate changes, businesses and consumers are becoming more environmentally conscious and may develop travel preferences for rail as a more climate-friendly option. In fact, rail industry experts and environmentalists are looking to rail as a significant vehicle to reduce carbon emissions.²²⁶

The outbreak of COVID-19 negatively impacted both sides of the rail supply chain. The pandemic shut down nearly all aspects of the economy, including travel and freight transportation.^{227, 228} As the need for railcars declined, the demand for new production decreased substantially. Additionally, because existing railcars had minimal use, there was less need for repair and replacement, even once the economy began to recover. The Infrastructure

²¹⁹ "North American Industry Classification System: Search Results 336510," U.S. Census Bureau, accessed March 8, 2023, <https://www.census.gov/naics/?input=3365&year=2022&details=336510>.

²²⁰ "Competitive Forces, Train, Subway & Transit Car Manufacturing in the US," IBISWorld, last modified September 2023, accessed October 27, 2023, <https://my.ibisworld.com/us/en/industry/33651/competitive-forces>.

²²¹ "Rolling Stock Manufacture," The Railway Technical Website, accessed July 27, 2023, <http://www.railway-technical.com/trains/rolling-stock-manufacture.html>.

²²² "Railroad Rolling Stock Manufacturing, SOP Manual SOP-590," Fhysics, December 18, 2020, <https://blog.fhysics.net/sop/railroad-rolling-stock-manufacturing-sop-manual>.

²²³ "Competitive Forces, Train, Subway & Transit Car Manufacturing in the US," IBISWorld.

²²⁴ "Rolling Stock Manufacture," The Railway Technical Website.

²²⁵ "Products & Markets, Train, Subway & Transit Car Manufacturing in the US," IBISWorld, last modified April 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/33651/products-and-markets>.

²²⁶ Rachel Frazin, "Passenger Train Could Help Combat Climate Change – If Rail Can Actually Get Built," The Hill, December 15, 2023, accessed February 6, 2024, <https://thehill.com/policy/energy-environment/4361262-passenger-trains-climate-change-building-hurdles/>.

²²⁷ "Industry Performance, Train, Subway & Transit Car Manufacturing in the US," IBISWorld, last modified April 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/33651/industry-performance>.

²²⁸ "The Impact of the COVID-19 Pandemic on Freight Transportation Services and U.S. Merchandise Imports," U.S. International Trade Commission.

Investment and Jobs Act (IIJA) of 2021 was a driving factor in the industry's recovery from the pandemic, as it provided the most significant federal investment in public transportation and the largest federal investment in passenger rail since the founding of Amtrak in 1971.²²⁹

The *Railroad Rolling Stock Manufacturing* industry is facing additional challenges in the post-pandemic era. Global supply chain disruptions and technical issues have surged—such as electrical shorts, loose brake bolts, and inadequate quality tracking—leading to instances where newly manufactured trains are withdrawn from service.²³⁰ Moreover, deficiencies in quality tracking have resulted in some products initiating the assembly process with missing parts or undergoing incorrect assembly, furthering manufacturing delays. In the past, components required for assembly often came from countries including China and Russia. However, the limitations imposed by COVID-19 and geopolitical tensions, including wars and trade conflicts, have introduced supply chain complexities for manufacturers reliant on products and components from these regions.²³¹ While offshoring component supplies to other “less risky” countries is one alternative, it comes at a cost of decreased oversight with potential quality issues. Sourcing a strong, robust domestic supply chain and possibly onshoring factories could help mitigate supply risks for this industry.

5.8 Other Furniture Related Product Manufacturing (3379)

Entities within the *Other Furniture Related Product Manufacturing* industry are responsible for manufacturing furniture-related products such as mattresses, blinds, and shades.²³² These products furnish a variety of establishments including private residences, healthcare facilities, and hospitality businesses.²³³ The *Blind and Shade Manufacturing* subsector manufactures products that help to offer privacy and control light from outside entering an indoor space.²³⁴ Manufacturers have also incorporated modern technologies and engineering into these products to meet the unique needs of the consumer.

Manufacturing and production begin with sourcing components. First-tier industry suppliers include textile mills; apparel contractors; hardware component manufacturers; wire and spring, plastic and resin, and leather goods manufacturers; and plastic film, sheet, and bag

²²⁹ “Industry Performance, Train, Subway & Transit Car Manufacturing in the US,” IBISWorld.

²³⁰ Robert H. Cantwell, “North American Rail Supply and the Global Supply Risk: Why We Should Be Concerned,” *Railway Age*, June 16, 2023, <https://www.railwayage.com/mechanical/freight-cars/north-american-rail-supply-and-the-global-supply-risk-why-we-should-be-concerned/>.

²³¹ Ibid.

²³² “Other Furniture Related Product Manufacturing,” Maryland Workforce Exchange, last modified July 1, 2019, accessed May 10, 2023, <https://mwejobs.maryland.gov/vosnet/lmi/profiles/profileSummary.aspx?session=inddetail&valueName=industry>.

²³³ Ranwat Lokendra, “7 Ways the Furniture Supply Chain is Different from Other Industries,” *Architect and Interiors India*, August 7, 2021, accessed July 10, 2023, <https://www.architectandinteriorsindia.com/insights/22934-7-ways-the-furniture-supply-chain-is-different-from-other-industries>.

²³⁴ “Blinds & Shades Market Size, Share & COVID-19 Impact Analysis,” *Fortune Business Insights*, accessed May 10, 2023, <https://www.fortunebusinessinsights.com/blinds-and-shades-market-104636>.

manufacturers.^{235,236} The blind and shade manufacturing process involves creating design concepts and sourcing raw materials such as wood, metals, textiles, and components, including batteries and motors.²³⁷ Mattress manufacturing requires raw materials including metals for springs, oils to produce foams, and cotton to produce fabrics.²³⁸ After these materials are sourced, factories manufacture and assemble products and then sell the finished product to wholesalers, third-party distributors, brick-and-mortar stores, and/or directly to consumers through ecommerce. First-tier buyers include furniture and department stores, apartment and condominium construction, home builders, public schools, and warehouse clubs or supercenters.^{239,240} Some blind and shade products are custom manufactured to order to meet home or commercial project specifications.²⁴¹

The *Mattress Manufacturing* industry has expanded over the last several years, with online mattress shopping in particular experiencing a surge in 2021.²⁴² One driving cause of the rise of online shopping was the increasing popularity of boxed foam-style mattresses, especially during the pandemic.²⁴³ During this period the industry was also contending with shipping bottlenecks, which caused delays, backlogs of orders, and deferred delivery times.²⁴⁴ These delays were mainly due to the limited availability of shipment containers and the overall increase in consumer demand.²⁴⁵ As pandemic online shopping steadily slowed, so did online mattress shopping trends, hitting the industry hard with a slowdown.²⁴⁶ The *Blind and Shade Manufacturing* industry also saw severe disruptions in the number of residential and commercial projects, which ultimately impacted sales.^{247,248}

In addition to production and availability challenges, the *Other Furniture Related Product Manufacturing* industry has faced increased demand for eco-friendly and organic mattresses

²³⁵ "Blind & Shade Manufacturing-33792, Competitive Forces," IBISWorld, accessed October 31, 2023, <https://my.ibisworld.com/us/en/industry/33792/competitive-forces>.

²³⁶ "Mattress Manufacturing-339791, Competitive Forces," IBISWorld, accessed October 31, 2023, <https://my.ibisworld.com/us/en/industry/339791/competitive-forces>.

²³⁷ Panchal Jitesh, "Manufacturing Cost Analysis," U.S.A. Consumer Product Safety Commission (February 22, 2016): 8, accessed May 11, 2023, <https://www.cpsc.gov/s3fs-public/ManufacturingCostAnalysis.pdf>.

²³⁸ Tempur Sealy International, Inc. "Tempur Sealy International, Inc. SWOT Analysis," 1–7, accessed May 24, 2023, <https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=164562960&site=eds-live&scope=site>.

²³⁹ "Blind & Shade Manufacturing-33792, Competitive Forces," IBISWorld.

²⁴⁰ "Mattress Manufacturing-339791, Competitive Forces," IBISWorld.

²⁴¹ Tempur Sealy International, Inc. "Tempur Sealy International, Inc. SWOT Analysis," 32.

²⁴² Ashley Zlatopolsky, "The Mattress Industry is Evolving for the Future: Statistics and Trends," Mattress Clarity, June 22, 2023, accessed July 12, 2023, <https://www.mattressclarity.com/news/mattress-industry-statistics/>.

²⁴³ Ibid.

²⁴⁴ Abha Bhattarai, "Booming Furniture Sales Mean 'Unprecedented' Delays for Sofas and Desks," *The Washington Post*, March 8, 2021, accessed July 13, 2023, <https://www.washingtonpost.com/business/2021/03/08/furniture-sales-pandemic/>.

²⁴⁵ Ibid.

²⁴⁶ Zlatopolsky, "The Mattress Industry is Evolving for the Future: Statistics and Trends."

²⁴⁷ "Blinds & Shades Market Size, Share & COVID-19 Impact Analysis," Fortune Business Insights.

²⁴⁸ "Industrial Production: Manufacturing: Durable Goods: Furniture and Related Product (NAICS = 337)," Federal Reserve Bank of St. Louis, last modified June 15, 2023, accessed July 13, 2023, <https://fred.stlouisfed.org/series/IPG337S#>.

and window coverings. Growing awareness of the environmental impacts of harmful materials and chemicals used in mattress production has increased consumers' scrutiny, driving purchases of organic mattresses.²⁴⁹ Eco-conscious trends are also being seen within the Blind and Shade industry as consumers demand environmentally friendly window coverings to enhance energy efficiency and reduce energy consumption.²⁵⁰ This industry has also seen increases in requests for durable, harder blind materials and smart window coverings.²⁵¹ These popular demands are likely due to expanding smart home features incorporated in sustainable designs and technologies.²⁵² Availability and cost of these products will be a limiting factor on industry growth as consumers balance the costs and benefits of installations. As sustainable buildings and smart home designs continue to be adopted, demand for environmentally responsible products and materials is expected to grow.²⁵³

5.9 Support Activities for Water Transportation (NAICS 4883)

Firms within the *Support Activities for Water Transportation* industry are responsible for providing services to water transportation firms.²⁵⁴ While four subsector industries comprise the *Support Activities for the Water Transportation* industry, RESI will primarily focus on the services provided by the *Port and Harbor Operations* industry due to its crucial role in supply chain functions for Maryland's businesses and consumers.²⁵⁵ The *Marine Cargo Handling* industry, which also falls within *Support Activities for Water Transportation*, will also be briefly discussed due to the relevance of Longshoremen and other marine cargo handling activity. Cargo loading and unloading from ships, running lighthouses, setting up documentation for incoming shipments, operating computer systems to link cargo with receivers, and providing lodging for docked vessels are some of the critical tasks performed in these sectors. Three downstream markets—including importers, exporters, and domestic transportation—drive demand for industry services.²⁵⁶

The supply chain for the *Port and Harbor Operations* industry can be categorized as follows:

- First-tier suppliers include marine cargo handlers; dry docks and cargo inspection services; heavy engineering construction, tugboat, and shipping navigational services; public administration; and transportation and warehousing firms.

²⁴⁹ Mariana Zapata and Mili Godio, "Top-rated Organic, Natural and Eco-friendly Mattresses," *NBC News*, August 22, 2022, accessed July 21, 2023, <https://www.nbcnews.com/select/shopping/best-eco-friendly-mattress-ncna1193591>.

²⁵⁰ "Blinds & Shades Market Size, Share & COVID-19 Impact Analysis," Fortune Business Insights.

²⁵¹ Ibid.

²⁵² Kristina Miladinovic, "Mattress Industry Trends and Statistics (Market Overview)," *Sleepline*, June 30, 2022, accessed July 21, 2023, <https://www.sleepline.com/mattress-industry-trends/>.

²⁵³ "Blinds & Shades Market Size, Share & COVID-19 Impact Analysis," Fortune Business Insights.

²⁵⁴ "North American Industry Classification System: Search Results 488390," U.S. Census Bureau, accessed March 8, 2023, <https://www.census.gov/naics/?input=4883&year=2022&details=488390>.

²⁵⁵ "Industry at a Glance, Port & Harbor Operations in the US," IBISWorld, last modified March 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/48831/industry-at-a-glance>.

²⁵⁶ Jonathan Burns, "Industry Report 48831, Port & Harbor Operations in the US," IBIS World (March 2023): 8, accessed July 28, 2023, <https://my.ibisworld.com/us/en/industry/48831/at-a-glance>.

- First-tier buyers include sectors such as rail transportation, transportation and warehousing, freight forwarding brokerages and agencies, local freight trucking, ocean and coastal transportation, and marine cargo handling.²⁵⁷

Since the U.S. is a significant net importer of products, import levels largely dictate demand for port operators in international trade.²⁵⁸ Domestic demand and the price differentials between locally produced items and imports, in turn, determine the level of imports. In the domestic market, demand for port and harbor services is determined by the freight volumes accessible to both interior and coastal freight transporters. The selection of one port over another is based on traffic congestion and adequate land-based transit, as trucks and trains require open access into and out of ports to transport incoming freight to harbors and inland locations.²⁵⁹ Additionally, other factors such as disposable income, consumption levels, price, port security, trade activity, cruise ship volume, fuel costs, and demand for bulk commodities also impact the demand for this industry.²⁶⁰

Each year, U.S. ports handle an immense volume of shipments totaling billions of tons. In 2019, the value of trade volume through these ports reached nearly \$2.6 billion.²⁶¹ However, the outbreak of COVID-19 had a profound impact on shipping ports and harbor operations, causing substantial delays in freight movement due to significant backlogs. As a result, revenues declined substantially in 2020.²⁶² Additionally, as the value of the U.S. dollar appreciated rapidly, exports from the U.S. diminished while imports from foreign manufacturers continued to arrive. The shift in these trends led to a significant trade value decline of 10.8 percent in 2020, a stark contrast to the year-over-year increase of 0.9 percent recorded in 2019.²⁶³

Despite these obstacles, the industry is slowly recovering. The value of the U.S. dollar is anticipated to stabilize, which will likely increase exports as domestic goods become more affordable to overseas consumers.²⁶⁴ Although the dollar strengthened in early 2024, meaning that U.S. exports are more expensive for foreign consumers, this is expected to decline with

²⁵⁷ "Competitive Forces, Port & Harbor Operations in the US," IBISWorld, last modified September 2023, accessed October 27, 2023, <https://my.ibisworld.com/us/en/industry/48831/competitive-forces>.

²⁵⁸ "Products & Markets, Port & Harbor Operations in the US," IBISWorld, last modified March 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/48831/products-and-markets>.

²⁵⁹ Burns, "Industry Report 48831, Port & Harbor Operations in the US," 15.

²⁶⁰ Ibid.

²⁶¹ "U.S. 2022 Ports Update: Industrial Insights: United States," Cushman & Wakefield, accessed July 27, 2023, <https://www.cushmanwakefield.com/en/united-states/insights/north-american-ports-report>.

²⁶² "Industry Performance, Port & Harbor Operations in the US," IBISWorld, last modified March 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/48831/industry-performance>.

²⁶³ Burns, "Industry Report 48831, Port & Harbor Operations in the US," 41.

²⁶⁴ "Industry Outlook, Port & Harbor Operations in the US," IBISWorld, last modified March 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/48831/industry-outlook>.

anticipated interest rate cuts by the Federal Reserve in 2024.^{265,266} It is also believed that the expected recovery of other international economies will simultaneously increase imports into the U.S. Furthermore, port operations are expected to see increased profits as oil prices are predicted to decrease and as ports are becoming more efficient through automation and technological advancements.²⁶⁷

Even though the industry is recovering, supply chain challenges remain. During the pandemic, demand for ocean shipping and port services exceeded the supply capacity. This heightened demand, coupled with limited shipping containers and chassis, caused disruptions throughout the supply chain. While the pandemic increased the supply chain imbalance, the *Port and Harbor Operations* industry already struggled with port delays prior to COVID-19.²⁶⁸ According to the United Nations Conference on Trade and Development (UNCTAD), U.S. ports exceeded the average global time (21.7 hours) that container ships spent in port in 2019 by three hours.^{269,270} Forcing ships to wait offshore for a berthing space—often holding thousands of full containers—translates to fewer available containers, higher prices, and more stress on the system.

Port backlogs are a long-term issue that has been complicated by a number of factors, including labor agreements. U.S. ports are open fewer hours per week than many other ports worldwide. This is dictated by union labor contracts, which specifically limit the overall and per-shift number of hours that employees may work, and require overtime pay for all unauthorized work and any work done on weekends and holidays.²⁷¹ Unions have also opposed efforts to automate ports on both the west and east coasts. For example, the International Longshoremen's Association (ILA) made an agreement for ports on the Gulf and East Coast in 2018 that includes "generous pay increases" for union longshoremen as well as "landmark protections against job-killing fully automated ports," prohibiting complete automation for covered ports through 2024. Trade policy is also a contributing factor to the current shipping crisis, especially after imposing significant trade remedy duties on imports of truck chassis.²⁷²

²⁶⁵ Kathy Jones, "Where the U.S. Dollar May Be Headed in 2024," Charles Schwab, January 10, 2024, accessed April 1, 2024, <https://www.schwab.com/learn/story/where-us-dollar-may-be-headed-2024>.

²⁶⁶ Saqib Iqbal Ahmed, "King Dollar Seen Vulnerable in 2024 If Fed Pivots," *Reuters*, December 29, 2023, accessed April 1, 2024, <https://www.reuters.com/markets/currencies/king-dollar-seen-vulnerable-2024-if-fed-pivots-2023-12-20/>.

²⁶⁷ Burns, "Industry Report 48831, Port & Harbor Operations in the US," 12.

²⁶⁸ Scott Lincicome, "America's Ports Problem Is Decades in the Making," Cato Institute, September 22, 2021, accessed July 27, 2023, <https://www.cato.org/commentary/americas-ports-problem-decades-making>.

²⁶⁹ United Nations Conference on Trade and Development, "Review of Maritime Transport 2020, Performance Indicators," 18-19, accessed July 28, 2023, https://unctad.org/system/files/official-document/rmt2020ch3_en.pdf.

²⁷⁰ Averages are based on port times for the top 25 global economies.

²⁷¹ Lincicome, "America's Ports Problem Is Decades in the Making."

²⁷² Scott Lincicome and Alfredo Carrillo Obregon, "New U.S. Tariffs Are Contributing to the Shipping Crisis, and There's Little We Can Do About It," CATO Institute, August 26, 2021, accessed March 27, 2023, <https://www.cato.org/blog/new-us-tariffs-are-contributing-shipping-crisis-theres-little-we-can-do-about-it>.

While the pandemic exacerbated issues with port shipping operations, there was not a single cause of the current shipping situation. Rather, the current port crisis in the U.S. has been decades-long in the making and has been influenced by systemic trade and labor policies that reduced the effectiveness and flexibility of U.S. ports. While these laws undoubtedly have some benefits for American workers and businesses, the ongoing port challenges have highlighted some of these policies' more adverse effects and the need for potential reforms.

5.10 Warehousing and Storage (NAICS 4931)

Firms in the *Warehousing and Storage* industry group are responsible for warehouse and storage facility operations for general merchandise, refrigerated goods, and other warehoused products.²⁷³ Firms within the industry can also offer a variety of logistics-related services that are connected to commodity distribution operations, such as labeling, inventory control and management, order entry and fulfillment, packaging, and transportation planning.²⁷⁴ First-tier suppliers within the *Warehousing and Storage* supply chain include commercial leasing, industrial building construction, local specialized freight trucking, metal tank manufacturers, and heating and air conditioning wholesalers. First-tier buyers from the industry include wholesale traders, retail traders, gasoline and petroleum wholesalers, and tank and refrigeration trucking.^{275, 276, 277, 278}

The *Warehousing and Storage* industry encompasses four subsectors, with the *General Warehousing and Storage* subsector representing 96 percent of all private employees working in the industry in Maryland.²⁷⁹ This subsector has also experienced the most substantial increase in demand—particularly during the COVID-19 pandemic—due to a surge in product shipments and a higher demand for warehouse space.²⁸⁰ This growth was primarily driven by the expansion of e-commerce, as many online sellers lack their own warehouse facilities. In 2020 alone, e-commerce sales saw a sharp increase of 39.1 percent, resulting in a 3.2 percent rise in revenue for the *General Warehousing and Storage* industry.²⁸¹ However, the surge in e-commerce has also presented challenges for the sector. Products that are sold directly to online

²⁷³ "Industries at a Glance – Warehousing and Storage: NAICS 493," U.S. Bureau of Labor Statistics, accessed March 8, 2023, <https://www.bls.gov/iag/tgs/iag493.htm>.

²⁷⁴ "Warehousing and Storage – 2022 U.S. Market Research Report with Updated COVID-19 Forecasts," Market Research, June 16, 2022, accessed July 27, 2023, <https://www.marketresearch.com/Kentley-Insights-v4035/Warehousing-Storage-Research-Updated-COVID-31717667/>.

²⁷⁵ "Competitive Forces, Refrigerated Storage in the US," IBISWorld, last modified September 2023, accessed October 27, 2023, <https://my.ibisworld.com/us/en/industry/49312/competitive-forces>.

²⁷⁶ "Competitive Forces, Farm Product Storage & Warehousing in the US," IBISWorld, last modified September 2023, accessed October 27, 2023, <https://my.ibisworld.com/us/en/industry/49313/competitive-forces>.

²⁷⁷ "Competitive Forces, Specialized Storage & Warehousing in the US," IBISWorld, last modified September 2023, accessed October 27, 2023, <https://my.ibisworld.com/us/en/industry/49319/competitive-forces>.

²⁷⁸ "Competitive Forces, Public Storage & Warehousing in the US," IBISWorld, last modified September 2023, accessed October 27, 2023, <https://my.ibisworld.com/us/en/industry/49311/competitive-forces>.

²⁷⁹ "QCEW Data Files, Quarterly Census of Employment and Wages," U.S. Bureau of Labor Statistics.

²⁸⁰ "Industry at a Glance, Public Storage & Warehousing in the US," IBISWorld, last modified March 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/49311/industry-at-a-glance>.

²⁸¹ "Performance, Refrigerated Storage in the US," IBISWorld, last modified September 2023, accessed October 27, 2023, <https://my.ibisworld.com/us/en/industry/49311/performance>.

consumers, rather than palletized for bulk shipments to retailers, take up more storage space and demand more processing time. This shift has increased salary and rent prices for any businesses that use third-party warehousing and storage space, limiting these businesses' earnings in recent years.²⁸²

Subsectors within the *Warehousing and Storage* industry are constantly evolving, and keeping up with new trends while trying to regain momentum post-pandemic can be difficult. Additionally, obstacles with the supply chain might keep the industry from running at peak performance. For example, pandemic-induced disruptions to the supply chain caused a shift from lean inventory to having additional supply on hand.²⁸³ As a result, businesses within the *Warehousing and Storage* industry need flexible and customizable fulfillment solutions that allow varied picking techniques and meet their consumers' needs. The current labor shortage is another challenge slowing the industry. While e-commerce has automated some of its operations with robot assistants, some procedures still require considerable manual labor from workers.²⁸⁴ A 2022 survey disclosed that about 73 percent of warehouse operators do not have sufficient labor available—an increase from 26 percent in 2021.²⁸⁵ While warehouse operators have tried to increase wages to improve retention amid the tight labor market, thin operating margins have made any substantial wage increases difficult.

5.11 Other Financial Investment Activities (NAICS 5239)

The *Other Financial Investment Activities* industry provides financial services and management for portfolios, financial investments, and other miscellaneous financial investment activities within a complex variety of marketplaces.²⁸⁶ This industry also provides certified financial and investment planning, advice, and consulting; counseling and management services; and management of mutual funds, trust funds, and private equity funds.²⁸⁷ Firms can act as agents and brokers for escrow agencies, exchange clearinghouses, deposit brokers, virtual currency trading, business start-up fundraising, and crowdfunding platforms.²⁸⁸ First-tier suppliers for the *Other Financial Investment Activities* industry include venture capital firms; stock and commodity exchanges; commodity markets; portfolio management firms; and accounting and tax preparation services.²⁸⁹ First-tier buyers include business start-ups; retirement and pension

²⁸² "Competitive Forces, Public Storage & Warehousing in the US," IBISWorld.

²⁸³ Fergal Glynn, "Eight Warehousing Trends Continuing in 2022: What You Need to Know," 6 River Systems, January 18, 2023, <https://6river.com/eight-warehousing-trends-continuing-in-2022-what-you-need-to-know/>.

²⁸⁴ Matt Leonard, "Warehouse Employment Is at an All-Time High," Supply Chain Dive, October 6, 2020, <https://www.supplychaindive.com/news/warehouse-employment-ecommerce-peak-season/586465/>.

²⁸⁵ Brian Straight, "Survey: 73% of Warehouse Operators Can't Find Enough Labor," FreightWaves, February 18, 2022, <https://www.freightwaves.com/news/survey-73-of-warehouse-operators-cant-find-enough-labor>.

²⁸⁶ "Search Results: 5239," U.S. Census Bureau, accessed July 21, 2023, <https://www.census.gov/naics/?input=5239&year=2022>.

²⁸⁷ Ibid.

²⁸⁸ Ibid.

²⁸⁹ "Search Results-5239, Competitive Forces," IBISWorld, accessed October 30, 2023, <https://my.ibisworld.com/search/?q=5239>.

plans; property, casualty, and direct insurance providers; and private equity, hedge funds, and other investment vehicles.²⁹⁰

Factors impacting the *Other Financial Investment Activities* industry include inflationary challenges amidst the geopolitical landscape impacting the U.S. market.²⁹¹ Because of high interest rates, liquidity has been drained from the market and could lead to future volatility for venture capital firms.²⁹² A prolonged market downturn could also have substantial impacts on these firms, with some investment firms already experiencing impacts.²⁹³ Industry firms are also facing challenges with capital expenses for technology upgrades and expansions. As costs associated with this spending increase, gaps between smaller firms and more dominant investment management firms could widen further.²⁹⁴

Digital transformations are increasingly being adopted within the industry to help improve client experiences, contribute to operational efficiency, and achieve a competitive advantage for firms.²⁹⁵ Advanced technologies, such as blockchains, help to execute smart contracts automatically and are ‘cutting out middlemen’ such as brokers, lawyers, and/or mediators while also increasing transparency.²⁹⁶ However, blockchains have the disadvantages of being energy intensive and requiring large amounts of computing resources. Additionally, changing regulations have become more of a risk for investors, as cryptocurrencies and the relatively new blockchain platform are still in their infancies in terms of government regulations.²⁹⁷

As there has been an intensifying focus on environmental, social, and governance (ESG) metrics within investment products, these portfolios have become more prominent and are expanding.²⁹⁸ Firms have called the current investment environment “policy tightening,” as regulations are becoming more strict—especially around ESG investments.^{299,300} Hiring an ESG compliance specialist to help firms maintain transparency and monitor regulations is becoming

²⁹⁰ “Search Results-5239, Competitive Forces,” IBISWorld.

²⁹¹ Franklin Templeton Institute, “Allocation Views, Storm Clouds on the Horizon,” 2, accessed July 28, 2022, <https://franklintempletonprod.widen.net/content/hxujizbwto/pdf/allocation-views-storm-clouds-on-the-horizon-1222-u.pdf>.

²⁹² Cesar Maldonado, “Venture Capital & Principal Trading in the US,” IBISWorld, accessed July 31, 2023, <https://my.ibisworld.com/us/en/industry/52391/about>.

²⁹³ Krissy Davis et al., “2023 Investment Management Outlook,” Deloitte Center for Financial Services (2022): 6, accessed July 23, 2023, https://www2.deloitte.com/content/dam/insights/articles/us175546_cfs_fsi-outlook-investment-mgmt/DI_US175546_CFS_FSI-Outlook-Investment-mgmt.pdf.

²⁹⁴ Ibid, 6.

²⁹⁵ Ibid, 3.

²⁹⁶ “What is Blockchain? Here’s What You Need to Know About the Technology Powering Cryptocurrencies,” Fidelity, June 23, 2022, accessed July 31, 2023, <https://www.fidelity.com/learning-center/trading-investing/what-is-blockchain>.

²⁹⁷ Ibid.

²⁹⁸ Ibid.

²⁹⁹ Franklin Templeton Institute, “Allocation Views,” 3.

³⁰⁰ Davis et al., “2023 Investment Management Outlook,” 22.

crucial to adhering to regulations as more investments incorporate ESG risk disclosures.^{301,302} Additionally, a recent report by Deloitte stated that the current talent pool is lacking investment professionals who maintain ESG skills.³⁰³ In addition to offering client portfolios that focus on ESGs, firms are also incorporating ESG principles within their organizational values.³⁰⁴

Since 2015 when more digital banks and brokerages emerged, competition between industry firms has increased significantly.³⁰⁵ Effectively managing talent has become very important to help retain workers, especially as employers have managed returns to physical workplaces and balance work/life culture.³⁰⁶ In 2021, data reported by the U.S. BLS showed that the *Financial Services Industry* was experiencing high voluntary turnover at a level not seen since 2008.³⁰⁷ Organizational culture and success are often formed through strengthened connections, and since the pandemic, employees have struggled with adaptation.³⁰⁸ As these organizational and cultural shifts evolve, establishing company leadership with a strong vision—and the ability to implement new practices—will be critical to ensuring the success of these financial firms.³⁰⁹

5.12 Architectural, Engineering, and Related Services (NAICS 5413)

Entities within the *Architectural, Engineering, and Related Services* industry are primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings or structures by applying knowledge of design, construction procedures, zoning regulations, building codes, and building materials.³¹⁰ Industry workers are directly responsible for infrastructure systems that impact and improve quality of life such as planning and designing houses, engineering aerospace equipment, developing solutions to environmental concerns, and solving manufacturing or production issues.³¹¹ Many of these industry applications are utilized in the manufacturing and production of materials.

³⁰¹ Tania Lynn Taylor and Sean Collins, “Ingraining Sustainability in the Next Era of ESG Investing,” Deloitte Financial Services, April 5, 2022, accessed July 24, 2023, <https://www2.deloitte.com/us/en/insights/industry/financial-services/esg-investing-and-sustainability.html>.

³⁰² Ibid.

³⁰³ Taylor and Collins, “Ingraining Sustainability in the Next Era of ESG Investing.”

³⁰⁴ PwC, “Current Developments for the Mutual Fund Industry,” 9, accessed July 24, 2023, <https://www.pwc.com/us/en/industries/financial-services/library/pdf/pwc-current-developments-for-mutual-funds-summer-2023.pdf>.

³⁰⁵ Balazs Czimer, et al., “The Future of Banks, A \$20 Trillion Breakup Opportunity,” McKinsey & Company, December 20, 2022, accessed July 24, 2022, https://www.mckinsey.com/industries/financial-services/our-insights/the-future-of-banks-a-20-trillion-dollar-breakup-opportunity#.

³⁰⁶ Davis et al., “2023 Investment Management Outlook,” 9.

³⁰⁷ Taylor and Collins, “Ingraining Sustainability in the Next Era of ESG Investing.”

³⁰⁸ Davis et al., “2023 Investment Management Outlook,” 10.

³⁰⁹ Ibid, 6.

³⁰⁹ “North American Industry Classification System: Search Results: 5413,” U.S. Census Bureau, last modified May 8, 2023, accessed May 8, 2023, <https://www.census.gov/naics/?input=5413&year=2022&details=541310>.

³¹⁰ “QCEW Data Files Quarterly Census of Employment and Wages,” U.S. Bureau of Labor Statistics.

³¹¹ Michelle Meisels, Paul Wellener, and Kate Hardin, “2023 Engineering and Construction Industry Outlook,” Deloitte (August 2022): 5, accessed May 8, 2023, <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/us-eri-outlook-engineering-and-construction-2023.pdf>.

The supply chain within the *Architectural, Engineering, and Related Services* industry often involves subsector industries providing services to one another. Services that provide support to industry projects include drafting, surveying and mapping, geophysical surveying, building inspections, and testing.³¹² First-tier suppliers within the industry include landscapers, engineers, mappers, surveyors, office supply stores, law firms, and companies that provide materials and services to complete projects. Outputs from the *Architectural, Engineering, and Related Services* industry—such as plans, designs, engineering processes, equipment, buildings, and facilities—contribute to the framework of multiple supply chain ecosystems. First-tier buyers of industry output include colleges; hospitals; entertainment/recreational facilities; residential, business, and government entities; construction companies; excavation contractors; and architects.³¹³

One of the greatest challenges currently impacting the *Architectural, Engineering, and Related Services* supply chain is the volatility of material prices.³¹⁴ According to the U.S. Census Bureau, annual construction spending more than doubled between 2013 and 2023, rising by 118 percent.³¹⁵ The cost of materials has intensified over the last several years since the pandemic began, causing disruptions and bottlenecks in the transportation of materials.³¹⁶ These challenges were further exacerbated by inflationary pressures and geopolitical issues from the Russia-Ukraine war.³¹⁷ Additionally, imposed tariffs and sanctions for nations with trade barriers (e.g., China) further deteriorated an already weakened supply chain.³¹⁸

As with many employers, firms in the *Architectural, Engineering, and Related Services* industry have faced a tight labor market and difficulty attracting and retaining workers. In particular, the engineering industry is facing more acute labor shortage constraints as more experienced senior-level engineers are retiring, leaving firms with inadequate replacements of junior

³¹² “5413 - Architectural, Engineering, and Related Services,” NAICS Association, accessed March 25, 2024, <https://www.naics.com/naics-code-description/?code=5413>.

³¹³ “Search Results – 5413, Competitive Forces,” IBISWorld, accessed October 30, 2023, <https://my.ibisworld.com/search/?q=5413>.

³¹⁴ “Monthly Construction Spending, July 2023,” U.S. Census Bureau, last modified July 3, 2023, accessed July 10, 2023, [https://www.census.gov/econ/currentdata/?programCode=VIP&startYear=2013&endYear=2023&categories\[\]=AXXXX&dataType=T&geoLevel=US&adjusted=1¬Adjusted=0&errorData=0#table-results](https://www.census.gov/econ/currentdata/?programCode=VIP&startYear=2013&endYear=2023&categories[]=AXXXX&dataType=T&geoLevel=US&adjusted=1¬Adjusted=0&errorData=0#table-results).

³¹⁵ “Construction Materials, Installation, and Composite Construction Cost Index in the United States in 2021, by City,” Statista, last modified February 17, 2023, accessed July 10, 2023, <https://www.statista.com/statistics/916435/us-construction-market-cost-index-by-city/>.

³¹⁶ “Global Growth Prospects Have Weakened Significantly Amid the War in Ukraine,” United Nations Department of Economic and Social Affairs, last modified June 1, 2022, accessed July 10, 2023, <https://www.un.org/development/desa/dpad/publication/world-economic-situation-and-prospects-june-2022-briefing-no-161/>.

³¹⁷ “Import Tariffs, China – Country Commercial Guide,” International Trade Administration, last modified April 7, 2023, accessed July 10, 2023, <https://www.trade.gov/country-commercial-guides/china-import-tariffs>.

³¹⁸ Jay Landers, “2022: The First Year of Several Solid Years for the AEC Industry,” American Society of Civil Engineers, January 3, 2022, accessed July 11, 2023, <https://www.asce.org/publications-and-news/civil-engineering-source/civil-engineering-magazine/issues/magazine-issue/article/2022/01/2022-the-first-of-several-solid-years-for-the-aec-industry>.

engineers and/or new graduates.³¹⁹ Additionally, employers are facing significant wage increase requirements to retain existing engineering employees. Prior to the pandemic, annual wages rose by approximately 1.3 percent annually but have since increased to 4.5 percent per year.³²⁰ To stay competitive with other job offers, employers are offsetting these labor costs with price increases and reducing spending on nonlabor costs such as office space and business travel.³²¹

Another challenge that has arisen within the industry is sourcing and procurement of green construction materials, as sustainable buildings have become more prominent in designs. Engineering and construction firms have stated that a lack of visibility for both materials and labor significantly limits their ability to ensure that their products are ethically sourced.³²² Factors driving the change for sustainable designs include increasing government regulations to reduce emissions and enhance sustainability efforts, greater social responsibility, and expanding environmental concerns.³²³ Recent enactment of the U.S. Infrastructure Investment and Jobs Act (IIJA), calls for more sustainable construction and engineering solutions.³²⁴ In particular, demand for *Architectural, Engineering, and Related Services* will be expected to rise substantially due to the IIJA.³²⁵

5.13 Computer Systems Design and Related Services (NAICS 5415)

Many organizations rely on computers and information technology (IT) to conduct business and operate efficiently. To do so, they need internal resources for designing, implementing, or managing the products and systems, for which they turn to the *Computer Systems Design and Related Services* industry.³²⁶ Companies in this industry create custom software programs, manage computer facilities, and build computer and information systems. They might also carry out additional tasks, such as software setup and disaster recovery services. Firms typically work either under contract helping an organization with a specific project or issue, such as setting up a secure website or creating an online marketplace, or for ongoing services, such as running a help desk or an on-site data center.³²⁷

³¹⁹ Landers, “2022: The First Year of Several Solid Years for the AEC Industry.”

³²⁰ Ibid.

³²¹ Ibid.

³²² Catherine Lynch, “The Construction Industry Is Getting Greener: Why, How, And What’s Changing?” *Forbes*, August 25, 2021, accessed May 9, 2023, <https://www.forbes.com/sites/sap/2021/08/25/the-construction-industry-is-getting-greener-why-how-and-whats-changing/?sh=326dc91e52bc>.

³²³ Ibid.

³²⁴ “Updated Fact Sheet: Bipartisan Infrastructure Investment and Jobs Act,” The White House, last modified August 2, 2021, accessed May 13, 2023, <https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/02/updated-fact-sheet-bipartisan-infrastructure-investment-and-jobs-act/>.

³²⁵ Jay Landers, “2022 Economic Outlook Strong for AEC Sector, Despite Challenges,” American Society of Civil Engineers, June 14, 2022, accessed July 11, 2023, <https://www.asce.org/publications-and-news/civil-engineering-source/civil-engineering-magazine/article/2022/06/2022-economic-outlook-strong-for-aec-sector-despite-challenges>.

³²⁶ “Computer Systems Design and Related Services Industries,” CollegeGrad, accessed July 27, 2023, <https://collegegrad.com/industries/computer-systems-design>.

³²⁷ “Industry at a Glance, IT Consulting in the US,” IBISWorld, last modified January 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/54151/industry-at-a-glance>.

The *Computer Systems Design and Related Services* industry is very labor intensive and service oriented, although some operators within the sector may manufacture and offer enterprise systems that utilize expensive technology. As a result, a high percentage of revenue for most firms is allocated to labor expenditures.³²⁸ In addition to labor needs, the supply chain for the industry relies on first-tier suppliers that include software publishers, computer and packaged software wholesalers, and internet service providers.³²⁹ Application programs produced by the *Computer Systems Design and Related Services* industry often need to be updated every one to five years. This means software typically has a shorter useful lifespan than many other products, requiring continuous industry innovations to stay competitive. First-tier buyers from the industry include retail trade firms, hospitals, finance and insurance providers, healthcare and social assistance providers, and other manufacturers.³³⁰

Over the past several years, the *Computer Systems Design and Related Services* industry experienced an increase in demand that was largely driven by corporate profits and a rise in computer and software investments.³³¹ Consequently, technological changes that shifted towards cloud computing and data analytics also increased demand for new services, prompting companies to replace older technology.³³² Moreover, the rise in cloud computing and data analytics has increased security concerns, further driving demand for this industry. As businesses continue to invest in mobile platforms to serve a younger, more technologically sophisticated generation that has already integrated smartphone use into everyday life, the industry should see a greater demand for application and system designs.

The COVID-19 pandemic furthered growth in the *Computer Systems Design and Related Services* industry. As more businesses had to rely on computer and IT infrastructure for employees to operate remotely, the demand for services grew substantially and drove a revenue increase of 35.6 percent between 2019 and 2023.³³³ However, it has also heightened competition amongst businesses within the industry and encouraged businesses to spend more on research and new product development to keep up with market changes. As a result, larger companies have sought to acquire smaller specialized firms and capitalize on these new and emerging technologies.³³⁴

³²⁸ "Operating Conditions, IT Consulting in the US," IBISWorld, last modified January 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/54151/operating-conditions>.

³²⁹ "Competitive Forces-5415," IBISWorld, last modified January 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/54151/competitive-forces>.

³³⁰ Ibid.

³³¹ "Industry Performance, IT Consulting in the US," IBISWorld, last modified January 2023, accessed July 27, 2023, <https://my.ibisworld.com/us/en/industry/54151/industry-performance>.

³³² Ibid.

³³³ Ibid.

³³⁴ Ibid.

The recent technology boom has exposed new risks that leave the *Computer Systems Design and Related Services* supply chain vulnerable.³³⁵ For example, the potential for malicious attacks is a constant threat to the supply chain and, subsequently, product consumers. When system updates or patches go untested, the possibility that an attacker could introduce malware into the system increases. Devices can also become vulnerable to malware and counterfeit software and hardware when equipment is acquired from new suppliers without sufficient security measures in place. This can become an even bigger issue when industry firms need to meet tight deadlines, and for reasons such as availability or price, they acquire products from alternative sources. These suppliers can include independent distributors, brokers, and the gray market, which increases the likelihood of running into inferior, compromised, or counterfeit goods.³³⁶

Products can also be threatened while in transit to the purchaser, even when equipment is acquired from a qualified and reliable service provider. Outsourcing manufacturing to other countries comes with its own risks, such as threats to national security. For example, China has several vague and broad rules that allow government authorities to request private information from companies doing business there. Similarly, Russia's lawful intercept system enables their federal services to monitor, retain, and analyze all data traveling over Russian communication networks.³³⁷

Mitigating supply chain risks within the *Computer Systems Design and Related Services* industry requires actions at multiple levels. Proposed efforts include expanding the domestic production of equipment (such as circuit boards and semiconductors) and increasing supply chain transparency through verified supplier programs. Additionally, strengthening public-private partnerships that emphasize risk-mitigation techniques would help to strengthen the U.S. supply chain for this industry.³³⁸

5.14 Management, Scientific, and Technical Consulting Services (NAICS 5416)

Industries in the *Management, Scientific, and Technical Consulting Services* industry provide advice and assistance to businesses and other organizations on management, environmental, scientific, and technical issues.³³⁹ Consulting services are demanded by a variety of sectors, including *Financial Services, Health and Life Science, Manufacturing, and Energy*.³⁴⁰ The services provided by workers in this industry influence how businesses, governments, and institutions

³³⁵ "Information and Communications Technology and the Supply Chain Risk," Office of the Director of National Intelligence, 5-7, accessed July 27, 2023, <https://www.dni.gov/files/NCSC/documents/supplychain/ict-supply-chain-risk-2022-5BE169B1-.pdf>.

³³⁶ "Information and Communications Technology and the Supply Chain Risk," Office of the Director of National Intelligence, 5-7.

³³⁷ Ibid.

³³⁸ Ibid, 8-9.

³³⁹ "North American Industry Classification System: Search Results 5416," U.S. Census Bureau, accessed May 4, 2023, <https://www.census.gov/naics/?input=5416&year=2022&details=5416>.

³⁴⁰ Helene Laffitte, "Global Management Consulting Industry: A Comprehensive Guide (2022)," Consulting Quest, last modified May 2, 2022, accessed May 4, 2023, <https://consultingquest.com/insights/comprehensive-guide-global-management-consulting-industry/>.

make decisions by providing technical expertise, information, contacts, and tools that aid clients in identifying key issues and problem-solving strategies.³⁴¹

First-tier suppliers within the *Management, Scientific, and Technical Consulting Services* industry include computer suppliers, office supply stores, and commercial leasing firms.³⁴² First-tier buyers from the industry include firms in a wide range of sectors including *Manufacturing, Wholesale Trade, Retail Trade, Transportation and Warehousing, and Healthcare and Social Assistance*. Though there are several subsectors that comprise the *Management, Scientific, and Technical Consulting Services* industry, the *Process, Physical Distribution, and Logistics Consulting Services* sector is of particular interest due to its role in supply chain functions.

The *Process, Physical Distribution, and Logistics Consulting Services* sector offers products and services such as manufacturing operations improvement, productivity improvement, quality assurance and control, distribution networks, warehouse use and operations, and materials management and handling.³⁴³ Despite the disruptions caused by the pandemic, several technological tools emerged that have helped the industry to become more resilient and responsive. For example, cloud platforms are frequently being used by consulting firms to analyze operational and security risks and quickly mitigate potential issues.³⁴⁴ This, coupled with the rise of e-commerce, globalization, and complex regulatory environments, has driven the growth of consulting services and the need for skilled workers.³⁴⁵ While there has been an increased need for logistics services, some businesses have shifted and begun to hire in-house experts, rather than hiring outside consultants.³⁴⁶

Supply chain issues have had both positive and negative impacts on the *Process, Physical Distribution, and Logistics Consulting Services* industry's growth. Manufacturers rely on inputs from different locations to complete their products, and also need warehouses to store their inventory.³⁴⁷ While many firms already relied on the industry for distribution operations, challenges during the pandemic caused manufacturers to seek out inventory and logistic consultants to safeguard their supply chains against future disruptions. Firms within the

³⁴¹ "Management, Scientific, and Technical Consulting Services Industries," CollegeGrad, accessed May 4, 2023, <https://collegegrad.com/industries/management-scientific-and-technical-consulting-services>.

³⁴² "NAICS Code 541614 – Process, Physical Distribution, and Logistics Consulting Services," IBISWorld, accessed May 10, 2023, <https://www.ibisworld.com/classifications/naics/541614/process-physical-distribution-and-logistics-consulting-services/>.

³⁴³ "NAICS Code 541614 – Process, Physical Distribution, and Logistics Consulting Services," IBISWorld.

³⁴⁴ David Groombridge, "Gartner Top 10 Strategic Technology Trends for 2023," Gartner, last modified October 17, 2022, accessed May 10, 2023, <https://www.gartner.com/en/articles/gartner-top-10-strategic-technology-trends-for-2023>.

³⁴⁵ "Global Management Consulting Services Market Share Is Projected to Reach USD 477.3 Billion by 2033, At a CAGR Of 4.8%: Fact.MR Analysis," GlobeNewswire, last modified February 21, 2023, accessed May 10, 2023, <https://www.globenewswire.com/en/news-release/2023/02/21/2612637/0/en/Global-Management-Consulting-Services-Market-Share-Is-Projected-To-Reach-USD-477-3-Billion-by-2033-At-a-CAGR-Of-4-8-Fact-MR-Analysis.html>.

³⁴⁶ "Industry Performance, Distribution and Logistics Consulting Services in the US," IBISWorld, accessed May 10, 2023, <https://my.ibisworld.com/us/en/industry-specialized/od6144/industry-performance>.

³⁴⁷ Ibid.

Process, Physical Distribution, and Logistics Consulting Services industry play a crucial role in helping their clients to strengthen their supply chains and quickly mitigate issues during unpredictable events such as the pandemic. Diversifying supply chains and creating cost-effective solutions that insulate businesses from external shocks help to protect clients from events that can delay distribution processes and increase overall transportation and logistics costs.³⁴⁸

5.15 Scientific Research and Development Services (NAICS 5417)

The *Scientific Research and Development Services* industry consists of a range of firms engaged in research and experimental development across various fields.³⁴⁹ Generally, these establishments are involved in systematic, original investigations aimed at acquiring new knowledge (research). They also apply research findings and scientific knowledge to create new or substantially improved products or processes (experimental development).³⁵⁰

Three general types of activity fall under research and development (R&D): basic research, applied research, and development.³⁵¹ Basic research involves conducting further scientific knowledge. Because most basic research involves a high level of theory and risk, funding by government, universities, or nonprofit organizations is often required. Although this research type occasionally produces results, many projects fail to yield beneficial or novel research. Applied research bridges science and business and is often used to guide problem-solving needs or for specific industry issues. Development, a significant portion of R&D, exercises the applied research into immediately usable products. Most development is done by private industry and is generally oriented toward manufacturing. Nearly everything consumers use, from antibiotics to zoom lenses, is a product of basic research, applied research, and development.

The *Scientific Research and Development Service* industry is highly dependent on its first-tier suppliers. These include colleges and universities that produce labor talent and chemical manufacturers and wholesalers who supply raw materials.³⁵² Labor shortages and challenges in sourcing raw materials can hinder industry operations. For example, the substantial surge in semiconductor demand in recent years has posed difficulties in the biotechnology sector as

³⁴⁸ "Market Research Report, Distribution and Logistics Consulting Services Industry in the US," IBISWorld, last modified March 30, 2023, accessed May 10, 2023, <https://www.ibisworld.com/united-states/market-research-reports/distribution-logistics-consulting-services-industry/>.

³⁴⁹ "North American Industry Classification System: Search Results 5417," United States Census Bureau, accessed May 4, 2023, <https://www.census.gov/naics/?input=5417&year=2022&details=5417>.

³⁵⁰ "NAICS Code 5417 – Scientific Research and Development Services," U.S. Census Bureau, accessed October 27, 2023, [https://www.naics.com/naics-code-description/?code=5417#:~:text=This%20industry%20group%20comprises%20establishments,improved%20products%20or%20processes%20\(experimental\)](https://www.naics.com/naics-code-description/?code=5417#:~:text=This%20industry%20group%20comprises%20establishments,improved%20products%20or%20processes%20(experimental).).

³⁵¹ "Scientific Research and Development Services Industries," CollegeGrad, accessed May 4, 2023, <https://collegegrad.com/industries/scientific-research-and-development-services>.

³⁵² "Scientific Research and Development Service in the US," IBISWorld, accessed May 4, 2023, <https://my.ibisworld.com/us/en/industry/54171/about>.

companies struggle to acquire the materials necessary for hardware production.³⁵³ On the other side of the supply chain, first-tier industry buyers include public administration entities, pharmaceutical manufacturers, and semiconductor machinery manufacturers.³⁵⁴

The demand for services within the *Scientific Research and Development Services* industry is largely influenced by the cost of research, making companies hesitant to invest heavily when costs grow. However, the emergence of new technologies and product innovations has increased the overall demand for R&D. This is particularly true for microelectronics, biochips, genomics, and biomaterials, which have been significantly improved through the development of new products and high-quality research. Similarly, the COVID-19 pandemic fueled funding for R&D in biotechnology as government-initiated operations aimed to roll out vaccines as quickly and effectively as possible.³⁵⁵ Prior to the pandemic, the average life cycle of a new product was approximately 6.9 years.³⁵⁶ However, the urgency of developing a COVID-19 vaccine accelerated the research cycle and established a new benchmark. More rapid research and treatment availability translate to increased revenue and profit, but this trend also raises concerns among many scientists and scholars regarding potential financial interests that could compromise the industry's commitment to methodological and ethical standards.³⁵⁷

6.0 Industry Commodity Analysis

Commerce selected several industries for further evaluation through a commodity analysis. To complete this task, RESI used commodity data from IMPLAN's input-output model to determine their relative importance to each NAICS industry outlined by Commerce. Because IMPLAN and NAICS use different industry schemes, RESI used the NAICS-to-IMPLAN crosswalk tool to determine which industries corresponded to those chosen by Commerce. All of the NAICS industries evaluated were associated with several IMPLAN industry codes, although not all of the cross-walked IMPLAN industries were selected by Commerce for inclusion in this analysis.³⁵⁸

Figure 19 details each NAICS industry evaluated, as well as their corresponding IMPLAN industries.

³⁵³ Darci Edwards, "Life Sciences: The Challenges of Research & Development," Lockton, September 26, 2022, accessed May 4, 2023, <https://global.lockton.com/gb/en/news-insights/life-sciences-the-challenges-of-research-and-development>.

³⁵⁴ "Products & Markets, Scientific Research & Development in the US," IBISWorld, last modified May 17, 2023, <https://my.ibisworld.com/us/en/industry/54171/products-and-markets>.

³⁵⁵ "Products & Markets, Scientific Research & Development in the US," IBISWorld.

³⁵⁶ Edwards, "Life Sciences: The Challenges of Research & Development."

³⁵⁷ David B. Resnik, "Science and Money: Problems and Solutions," *Journal of Microbiology & Biology Education* 15, no. 2 (December 2014): 159, accessed May 4, 2023, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4278468/>.

³⁵⁸ RESI, with input from Commerce, performed this analysis on a subset of the IMPLAN industries that correspond with the focused NAICS industries shown in Figure 19. For a full list of all IMPLAN industries that correspond with these NAICS industries, please refer to Appendix E.

Figure 19: NAICS to IMPLAN Crosswalk

NAICS Industry	Corresponding IMPLAN Industries
NAICS 3254 Pharmaceutical and Medicine Manufacturing	IMPLAN 171 Medicinal and Botanical Manufacturing IMPLAN 172 Pharmaceutical Preparation Manufacturing IMPLAN 173 In-vitro Diagnostic Substance Manufacturing IMPLAN 174 Biological Product (Except Diagnostic) Manufacturing
NAICS 3342 Communications Equipment Manufacturing	IMPLAN 302 Broadcast and Wireless Communications Equipment Manufacturing IMPLAN 303 Other Communications Equipment Manufacturing
NAICS 3345 Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	IMPLAN 311 Electromedical and Electrotherapeutic Apparatus Manufacturing IMPLAN 312 Search, Detection, and Navigation Instruments Manufacturing IMPLAN 313 Automatic Environmental Control Manufacturing IMPLAN 314 Industrial Process Variable Instruments Manufacturing IMPLAN 315 Totalizing Fluid Meter and Counting Device Manufacturing IMPLAN 316 Electricity and Signal Testing Instruments Manufacturing IMPLAN 317 Analytical Laboratory Instrument Manufacturing
NAICS 3346 Manufacturing and Reproducing Magnetic and Optical Media	IMPLAN 320 Blank Magnetic and Optical Recording Media Manufacturing
NAICS 3379 Other Furniture Related Product Manufacturing	IMPLAN 374 Mattress Manufacturing IMPLAN 375 Blind and Shade Manufacturing
NAICS 5415 Computer Systems Design and Related Services	IMPLAN 459 Custom Computer Programming Services IMPLAN 460 Computer Systems Design Services
NAICS 5416 Management, Scientific, and Technical Consulting Services	IMPLAN 462 Management Consulting Services

Sources: Commerce, IMPLAN, NAICS

RESI used data from IMPLAN's 2022 Industry Balance Sheets for this section of the report, which provide information on industries and commodities within the region.³⁵⁹ The Balance Sheets offer an overview of commodities that are important to an industry's supply chain

³⁵⁹ Candi Clouse, "Social Accounts," IMPLAN, accessed January 10, 2023, <https://support.implan.com/hc/en-us/articles/360036665954-Social-Accounts>.

through metrics such as gross absorption, gross inputs, regional absorption, regional inputs, and regional purchase coefficients (RPCs). Definitions for each of these key metrics are outlined below.

Gross Absorption is the percentage of an industry's total output that is allocated to the purchase of a specific commodity in an industry's Leontief Production Function.³⁶⁰ RESI used this metric to rank commodities to assess which were the most important to each respective industry. Sorting commodities in this way helped RESI parse out which commodities were of utmost importance to an industry but may not be easily obtained by firms within the region.

Gross Inputs are the dollar amount that an industry spends for the purchase of a given commodity.³⁶¹

Regional Inputs are the dollar amount that an industry spends within a specific region for the purchase of a given commodity.³⁶²

Regional Absorption is the percentage of an industry's total output that is allocated to the local purchase of a specific commodity.³⁶³ RESI used the difference, or 'gap', between gross and regional absorption to assess how much an industry's output is being allocated toward the purchase of specific commodities outside of the region.

Regional Purchase Coefficient (RPC) represents the proportion of all local demands (industrial and institutional) for a specific commodity that is supplied by the region.³⁶⁴ For example, an RPC of 40 percent for a given commodity indicates that 40 percent of local demand is met by local supplies of that commodity, while 60 percent is imported.³⁶⁵

This section will detail the results from RESI's evaluation of the top ten commodities for each industry outlined in Figure 19. Top commodities for each focus industry were sorted based on their gross absorption percentage, or the proportion of the industry's total output that is allocated towards purchasing a certain commodity. As a note, commodities marked with an asterisk (*) were not found in every IMPLAN industry that fell within the collective NAICS industry, but were a top commodity by gross absorption levels in at least one IMPLAN industry

³⁶⁰ "Gross Absorption," IMPLAN, accessed October 24, 2023, <https://support.implan.com/hc/en-us/articles/360033534314-Gross-Absorption>.

³⁶¹ "Gross Inputs," IMPLAN, accessed October 24, 2023, <https://support.implan.com/hc/en-us/articles/360043781314-Gross-Inputs>.

³⁶² "Regional Inputs," IMPLAN, accessed January 22, 2024, <https://support.implan.com/hc/en-us/articles/360043781434-Regional-Inputs>.

³⁶³ "Regional Absorption," IMPLAN, accessed October 24, 2023, <https://support.implan.com/hc/en-us/articles/360044284833-Regional-Absorption>.

³⁶⁴ IMPLAN Data Team, "Regional Purchase Coefficients," IMPLAN, updated July 12, 2022, accessed October 24, 2023, <https://support.implan.com/hc/en-us/articles/115009674588-Regional-Purchase-Coefficients>.

³⁶⁵ Please see Appendix G for Regional Purchase Coefficients (RPCs) of each top commodity by industry. Note that commodity RPCs are for all industries purchasing the commodity and are not isolated to the RPC for the specific industry being evaluated.

within the sector. For a more detailed methodology, please refer to Appendix F. Additionally, please see Appendix G for Regional Purchase Coefficients (RPCs) of each top commodity by industry.³⁶⁶

Figure 20 below shows the top ten commodities for the *Pharmaceutical and Medicine Manufacturing* industry.

Figure 20: Top Commodities in Pharmaceutical and Medicine Manufacturing

Commodity Description	Gross Absorption	Gross Inputs (Millions)	Regional Absorption	Percent Obtained Out-of-Region
Biological Products (Except Diagnostic)	13.9%	\$1,310.0	0.1%	99.3%
Wholesale Services - Drugs and Druggists' Sundries	9.4%	\$884.0	5.3%	43.6%
Medicines and Botanicals	3.8%	\$360.0	0.2%	94.7%
Management of Companies and Enterprises	2.8%	\$267.0	1.9%	32.1%
Other Basic Organic Chemicals	2.1%	\$196.0	0.0%	100.0%
Advertising, Public Relations, and Related Services	1.7%	\$162.0	1.2%	35.3%
Pharmaceuticals*	1.0%	\$77.2	0.0%	100.0%
Wholesale Services - Other Nondurable Goods Merchant Wholesalers	0.6%	\$59.0	0.50%	16.7%
Other Plastics Products	0.6%	\$54.4	0.00%	83.3%
Truck Transportation Services	0.5%	\$51.0	0.40%	40.0%

Sources: Commerce, IMPLAN, RESI

As shown above, the largest percentages of total output for the combined IMPLAN industries were allocated toward the purchase of *Biological Products (Except Diagnostic)*; *Wholesale Services – Drugs and Druggists' Sundries*; and *Medicines and Botanicals*. *Biological Products (Except Diagnostic)* was the top commodity purchased in this industry based on its gross absorption. The low regional absorption for this commodity suggests that virtually none of the industry's purchases are local, with approximately 99.3 percent of the local demand for *Biological Products (Except Diagnostic)* met by out-of-region (OOR) suppliers. In second was *Wholesale Services – Drugs and Druggists' Sundries*, which had approximately 43.6 percent of commodity demand from out-of-region suppliers, meaning that the majority of this industry's local demand for this commodity is met by regional suppliers. Lastly, *Medicines and Botanicals* represented approximately 3.8 percent of the combined IMPLAN industry's total output, with approximately 94.7 percent of this commodity was purchased from OOR suppliers. Of the top

³⁶⁶ Note that commodity RPCs are for all industries purchasing the commodity and are not isolated to the RPC for the specific industry being evaluated.

Maryland Supply Chain Analysis
RESI of Towson University

ten commodities listed in the figure above, five had more than 80.0 percent of purchases from OOR, indicating that local suppliers can meet only a modest fraction of demand.

Figure 21: Top Commodities in Communications Equipment Manufacturing

Commodity Description	Gross Absorption	Gross Inputs (Millions)	Regional Absorption	Percent Obtained Out-of-Region
Wholesale Services – Household Appliances and Electrical and Electronic Goods	12.8%	\$165.0	9.1%	28.9%
Management of Companies and Enterprises	7.1%	\$91.3	4.8%	31.0%
Broadcast and Wireless Communications Equipment	6.8%	\$87.7	0.0%	100.0%
Printed Circuit Assemblies (Electronic Assemblies)	2.5%	\$32.9	0.0%	100.0%
Custom Computer Programming Services	2.4%	\$31.6	1.9%	25.0%
Semiconductors and Related Devices	2.2%	\$28.0	0.0%	100.0%
Other Electronic Components	1.7%	\$22.5	0.0%	100.0%
Wholesale Services – Machinery, Equipment, and Supplies	1.3%	\$17.1	0.8%	38.5%
Advertising, Public Relations, and Related Services	1.2%	\$15.4	0.8%	33.3%
Wholesale Services – Professional and Commercial Equipment and Supplies	0.8%	\$10.0	0.7%	12.5%

Sources: Commerce, IMPLAN, RESI

The combined IMPLAN industries for NAICS 3342 spent the largest percentage of their total output on *Wholesale Services – Household Appliances and Electrical and Electronic Goods*; *Management of Companies and Enterprises*; and *Broadcast and Wireless Communications Equipment*. The top two commodities in this industry had relatively high proportions of the demand met regionally, suggesting that there is a moderate supply of these commodities in Maryland. Approximately 28.9 percent of the local demand for *Wholesale Services – Household Appliances and Electrical and Electronic Goods* was obtained from OOR suppliers, and approximately 31.0 percent of *Management of Companies and Enterprises* was not sourced locally. Conversely, no substantial purchasing for *Broadcast and Wireless Communications Equipment* was local, meaning that demand for this commodity was met by OOR suppliers. Of the top commodities in this industry, there were four that had virtually no demand met by local suppliers.

Figure 22: Top Commodities in Navigational, Measuring, Electromedical, and Control Instruments Manufacturing

Commodity Description	Gross Absorption	Gross Inputs (Millions)	Regional Absorption	Percent Obtained Out-of-Region
Management of Companies and Enterprises	10.6%	\$791.0	7.2%	31.1%
Wholesale Services – Household Appliances and Electrical and Electronic Goods	3.2%	\$238.0	2.3%	28.1%
Custom Computer Programming Services*	2.5%	\$186.2	1.9%	24.0%
Printed Circuit Assemblies (Electronic Assemblies)	2.4%	\$180.0	0.0%	100.0%
Advertising, Public Relations, and Related Services	1.8%	\$138.0	1.2%	33.3%
Other Electronic Components	1.8%	\$136.0	0.0%	100.0%
Semiconductors and Related Devices	1.7%	\$126.0	0.0%	100.0%
Automatic Environmental Controls*	1.6%	\$0.2	0.0%	100.0%
Electricity and Signal Testing Instruments*	1.5%	\$107.0	0.1%	93.3%
Warehousing and Storage Services	1.3%	\$101.0	1.2%	15.4%

Sources: Commerce, IMPLAN, RESI

The top commodities in this industry were *Management of Companies and Enterprises*; *Wholesale Services – Household Appliances and Electrical and Electronic Goods*; and *Custom Computer Programming Services*. The top commodity by gross absorption, *Management of Companies and Enterprises*, accounted for approximately 10.6 percent of the total output of the combined industries. The majority of local demand for this commodity can be supplied locally, with only 31.1 percent supplied from OOR. The majority of the *Wholesale Services – Household Appliances and Electrical and Electronic Goods* purchased by this industry are sourced locally as well, with 28.1 percent of commodity supplied from OOR. Similarly, *Custom Computer Programming Services* showed an OOR purchase rate of 24.0 percent, indicating that the majority of this commodity can be fulfilled with local resources. Of the top ten commodities within this industry, five had more than 90.0 percent of demand met by OOR suppliers.

Figure 23: Top Commodities in Manufacturing and Reproducing Magnetic and Optical Media

Commodity Description	Gross Absorption	Gross Inputs (Millions)	Regional Absorption	Percent Obtained Out-of-Region
Management of Companies and Enterprises	14.3%	\$46.7	9.8%	31.5%
Other Plastics Products	5.5%	\$17.9	0.4%	92.7%
Warehousing and Storage Services	3.8%	\$12.3	3.2%	13.2%
Advertising, Public Relations, and Related Services	3.6%	\$11.6	2.4%	33.3%
Blank Magnetic and Optical Recording Media	3.5%	\$11.6	0.1%	100.0%
Noncomparable Imports	2.0%	\$6.7	0.0%	100.0%
Plastics Packaging Materials and Unlaminated Films and Sheets	1.7%	\$5.6	0.1%	100.0%
Truck Transportation Services	1.3%	\$4.4	0.9%	30.8%
Wholesale Services - Other Nondurable Goods Merchant Wholesalers	0.9%	\$3.0	0.7%	22.2%
Employment Services	0.9%	\$3.0	0.8%	11.1%

Sources: Commerce, IMPLAN, RESI

Management of Companies and Enterprises, *Other Plastics Products*, and *Warehousing and Storage Services* were the top three commodities purchased by the combined IMPLAN industries for NAICS 3346 (*Manufacturing and Reproducing Magnetic and Optical Media*). These industries spent 14.3 percent of their total output on the *Management of Companies and Enterprises*, 5.5 percent on *Other Plastics Products*, and 3.8 percent on *Warehousing and Storage Services*. *Other Plastic Products*, along with three other commodities, had OOR purchasing rates of 90.0 percent or higher. Conversely, there were six commodities that had more than half of demand met within the region, all of which were service and labor-oriented commodities. Specifically, *Employment Services* had the lowest OOR purchasing rate of all of the commodities listed in this figure, with nearly all of the local demand for this commodity being met regionally.

Figure 24: Top Commodities in Other Furniture Related Product Manufacturing

Commodity Description	Gross Absorption	Gross Inputs (Millions)	Regional Absorption	Percent Obtained Out-of-Region
Urethane and Other Foam Products (Except Polystyrene)*	14.2%	\$38.1	1.0%	93.0%
Coated Fabric Coating*	8.4%	\$11.8	0.1%	98.8%
Spring and Wire Products	6.7%	\$27.6	1.1%	83.6%
Broadwoven Fabrics and Felts*	5.7%	\$15.2	0.0%	100.0%
Scenic and Sightseeing Transportation Services and Support Activities for Transportation*	4.8%	\$12.7	3.7%	22.9%
Wholesale Services - Other Nondurable Goods Merchant Wholesalers	4.6%	\$19.0	3.7%	21.7%
Advertising, Public Relations, and Related Services	3.2%	\$13.1	2.1%	34.4%
Wholesale Services - Professional and Commercial Equipment and Supplies	3.0%	\$12.1	2.6%	13.3%
Wholesale Services - Other Durable Goods Merchant Wholesalers	2.9%	\$11.9	2.5%	13.8%
Fiber Filaments, Yarn, and Thread*	2.5%	\$6.6	0.0%	100.0%

Sources: Commerce, IMPLAN, RESI

According to IMPLAN data, *Urethane and Other Foam Products*, *Coated Fabric Coating*, and *Spring and Wire Products* were the top commodities in the *Other Furniture Related Product Manufacturing* industry. *Urethane and Other Foam Products* accounted for approximately 14.2 percent of the industry's total output, while *Coated Fabric Coating* represented approximately 8.5 percent, followed by *Spring and Wire Products* with 6.7 percent. Notably, the top commodity purchased by this industry was also one of the commodities that had the highest OOR purchasing rate. Approximately 7.0 percent of industry demand for *Urethane and Other Foam Products* can be sourced from local suppliers, with 93.0 percent being purchased OOR. Further, less than 2 percent of industry demand for *Coated Fabric Coating* can be obtained from local suppliers.

Figure 25: Top Commodities in Computer Systems Design and Related Services

Commodity Description	Gross Absorption	Gross Inputs (Millions)	Regional Absorption	Percent Obtained Out-of-Region
Employment Services	4.0%	\$645.0	3.7%	8.9%
Management Consulting Services	0.7%	\$112.0	0.6%	20.4%
Advertising, Public Relations, and Related Services	0.6%	\$94.1	0.4%	33.2%
Legal Services	0.6%	\$92.8	0.4%	23.4%
Management of Companies and Enterprises	0.6%	\$91.2	0.4%	31.5%
Other Real Estate Services	0.5%	\$86.8	0.5%	4.7%
Architectural, Engineering, and Related Services	0.5%	\$78.7	0.4%	19.3%
Office Administrative Services	0.5%	\$75.9	0.4%	10.4%
Accounting, Tax Preparation, Bookkeeping, and Payroll Services	0.5%	\$73.8	0.4%	20.1%
Data Processing, Hosting, and Related Services	0.4%	\$61.2	0.2%	43.7%

Sources: Commerce, IMPLAN, RESI

As shown above, *Employment Services*; *Management Consulting Services*; and *Advertising, Public Relations, and Related Services* were the top three commodities for the combined IMPLAN industries. Notably, there were no commodities in the top ten for this industry that had more than 50 percent purchased OOR, meaning that most of the industry's demand for the top ten commodities can be met with local supplies. The gross absorption levels for all but the top commodity were lower than 1.0 percent. This means that none of the individual commodities shown commanded a significant proportion of the industry's output, with the exception of *Employment Services*, which had a gross absorption of 4.0 percent.

Figure 26: Top Commodities in Management, Scientific, and Technical Consulting Services

Commodity Description	Gross Absorption	Gross Inputs (Millions)	Regional Absorption	Percent Obtained Out-of-Region
Employment Services	3.2%	\$256.8	2.9%	8.9%
Monetary Authorities and Depository Credit Intermediation	3.0%	\$240.6	1.4%	52.6%
Other Real Estate Services	2.1%	\$172.0	2.0%	4.7%
Internet Publishing and Broadcasting and Web Search Portals	2.0%	\$159.5	0.6%	72.3%
Management of Companies and Enterprises	1.8%	\$145.6	1.2%	31.5%
Management Consulting Services	1.8%	\$144.6	1.4%	20.3%
Accounting, Tax Preparation, Bookkeeping, and Payroll Services	1.6%	\$130.6	1.3%	20.1%
Data Processing, Hosting, and Related Services	1.0%	\$81.8	0.6%	43.7%
All Other Food and Drinking Place Services	0.9%	\$72.9	0.8%	7.7%
Advertising, Public Relations, and Related Services	0.9%	\$72.5	0.6%	33.3%

Sources: Commerce, IMPLAN, RESI

Employment Services, Monetary Authorities and Depository Credit Intermediation, and Other Real Estate Services were the top three commodities by gross absorption for the for *Management, Scientific, and Technical Consulting Services* industry. Notably, all but two commodities in this list had the majority of demand fulfilled from local suppliers. *Internet Publishing and Broadcasting and Web Search Portals* had the lowest rates of local purchasing, with 72.3 percent being obtained from OOR suppliers. *Monetary Authorities and Depository Credit Intermediation* had an OOR purchase rate of 52.6 percent, meaning that more than half of this commodity must be sourced from outside of the region. Similar to other industries in this analysis, all of the commodities with OOR purchasing rates under 50 percent were service or labor-oriented commodities. The small gaps between gross and regional absorption signify that there is a small percentage of these commodities being purchased from outside the region.

Key Takeaways

Amongst the industries of interest, *Manufacturing* sectors tended to have more commodities with RPC values lower than 50 percent, meaning that the majority of industry demand for these commodities must be obtained outside of the region. The *Computer Systems Design and Related Services* industry had no RPC values below 50 percent for the IMPLAN industries assessed, while only two of the top commodities for the *Management, Scientific, and Technical Consulting Services* industry had an RPC below 50 percent. Please see Appendix G for RPCs of each top commodity by industry.³⁶⁷

RESI identified several commodities with significant gaps between gross absorption and regional absorption, meaning that the industry is relying on purchases made outside of the region to meet commodity needs. The top five gaps from the analysis can be seen in Figure 27.

Figure 27: Top Five Regional Commodity Gaps

Commodity Description	Industry	Gross Absorption	Regional Absorption	Percent Obtained Out-of-Region	RPC
Biological Products (Except Diagnostic)	Pharmaceutical and Medicine Manufacturing	13.9%	0.1%	99.3%	0.4%
Urethane and Other Foam Products (Except Polystyrene)	Other Furniture Related Product Manufacturing	14.2%	1.0%	93.0%	6.7%
Coated Fabric Coating	Other Furniture Related Product Manufacturing	8.4%	0.1%	98.8%	1.3%
Broadcast and Wireless Communications Equipment	Communications Equipment Manufacturing	6.8%	0.0%	100.0%	0.6%
Broadwoven Fabrics and Felts	Other Furniture Related Product Manufacturing	5.7%	0.0%	100.0%	0.2%

Sources: Commerce, IMPLAN, RESI

As shown above, three of the top five commodity gaps were found within the *Other Furniture Related Product Manufacturing* industry. The top gaps were also accompanied by low RPCs, with the highest RPC in *Urethane and Other Foam Products* at 6.7 percent. These individual commodities represent areas for further evaluation to assess specific barriers to local production or sourcing issues, as they may represent opportunities to strengthen supply chains

³⁶⁷ Note that commodity RPCs are for all industries purchasing the commodity and are not isolated to the RPC for the specific industry being evaluated.

for critical industry components. Further research could help determine, for example, whether a commodity is being produced in the region but does not meet the exact specifications needed for industry use. There could also be potential connection issues between suppliers and producers, indicating that the commodity could be obtained from within the region but there is a lack of awareness. Identification of the specific issues with local production or purchasing could help to bolster the RPC of these important commodities and strengthen local supply chains.

7.0 Interview Findings

RESI interviewed a number of supply chain experts to get a more detailed understanding of the issues impacting operations in Maryland. To establish interview contacts, a Qualtrics survey was constructed that included a study overview and opportunity to gather contact details of consenting participants. This survey was distributed to a vast list of contacts curated by the RESI team with the help of the Department of Commerce. The initial outreach phase occurred between April and May 2023, resulting in the successful completion of six interviews. All participants received an email containing informed consent details and potential questions prior to the interviews, which each lasted between 60 and 90 minutes. Interview efforts were relaunched in September and October, encompassing a revamp of outreach materials, re-engagement with previous contacts, and the addition of new contacts. As a result, RESI was able to secure three additional interviews for a total of nine completed sessions. The following section summarizes interview findings, organized by general topics covered. For a full list of interview questions asked, please refer to Appendix D.

Maryland Geography and Regulations

Maryland possesses several regional advantages due to the state's strategic positioning along the East Coast. The district of Baltimore, Maryland, includes five ports: the cities of Annapolis, Baltimore, Cambridge, and Crisfield, and the Baltimore-Washington International Airport.³⁶⁸ The Port of Baltimore is the closest East Coast sea-based port to the Midwest and links several major interstate highways. Accessible through the Chesapeake Bay and Chesapeake and Delaware Canal, the Port of Baltimore allows overnight transportation to one-third of the American population.³⁶⁹ The Port is also ranked the best in the country at handling cars, light trucks, farm, and construction equipment, as well as imported gypsum.³⁷⁰ Within the past 10 to 15 years, there has been more focus on improving East Coast ports, especially with the expansion of the Panama Canal. One expert interviewed said that these improvements position Maryland at the forefront of business portal management and offer itself as a port alternative to New York, New Jersey, and Virginia. Additionally, Maryland is home to four federally mandated Foreign Trade Zones, as well as 36 Enterprise Zones that offer economic or tax

³⁶⁸ "USA Trade Online-Help Section," U.S. Census Bureau, accessed February 2, 2023, <https://www.census.gov/foreign-trade/statistics/dataproducts/uto-help/uto-help.html#district>.

³⁶⁹ "Maryland at a Glance," Port of Baltimore, Maryland, accessed August 10, 2023, <https://msa.maryland.gov/msa/mdmanual/01glance/html/port.html>.

³⁷⁰ Ibid.

incentives for businesses.³⁷¹ In terms of rail transportation, the state is serviced by two Class I Rail Carriers—CSX Transportation and Norfolk Southern—which support commerce and trade.

Several experts pointed out financial advantages of operating in Maryland, particularly for smaller businesses in the *Manufacturing* sector. These included the ability to deduct the total cost of capital equipment purchases within the same calendar year, presenting unique growth opportunities. For example, if a business generates \$0.5 million in profit for the year, it could either pay taxes on this profit or invest \$0.5 million in equipment and claim a tax deduction within the same calendar year. As a result, they acquire state-of-the-art machinery and equipment, increasing their production capacity and product quality. This tax structure essentially encourages *Manufacturing* businesses to expand. Maryland also offers a limited number of HUBZones that provide industrial manufacturing space, facilitating business growth. These HUBZones offer favorable property taxation conditions for businesses that meet the requirements and are located in urban areas, such as Baltimore City, making them more conducive to building networks.

While experts provided input on regional features that make Maryland an attractive location, they also mentioned some factors that make operating in the state challenging. One expert noted that *Manufacturing* operations often require centralized locations, and finding affordable buildings can be difficult. Another interviewee mentioned that the expansion of their operations was possible only because they are located in a rural area of the state with affordable warehouse prices. Infrastructure was discussed, with one interviewee sharing how many of the tunnels in Maryland were dug out during the 1800s with no intention of being used for the volume of trade that exists today. Many of these tunnels need improvements and repairs. However, many are located beneath the city and cannot be easily accessed due to buildings above ground. The Howard Street Tunnel Project was referenced as a positive infrastructure initiative in Maryland, with the venture aiming to modernize the tunnel and accommodate double-stacked containers.³⁷²

It was also reported that importing products through the Port of Baltimore takes a day longer than some other ports due to open-ocean proximity and the time needed to travel up the Chesapeake Bay. One expert said that some clients would ship to ports other than the Port of Baltimore because they did not want to wait for the extra day of transit. Another interviewee discussed an instance where there were Maryland suppliers that they tried to work with, but shipping times were longer compared to out-of-state suppliers. Interviewees did note that the plans to address the double-stack container issues within the Northeast Corridor will help to transport goods and materials more efficiently by rail.

³⁷¹ "Maryland at a Glance: Economy," Maryland State Archives, accessed January 27, 2023, <https://msa.maryland.gov/msa/mdmanual/01glance/economy/html/economy.html#trade>.

³⁷² "Skanska-Fay Joint Venture Selected for Howard Street Tunnel Project, Elevating I-95 Freight Rail Infrastructure," Skanska, December 22, 2023, accessed January 9, 2024, <https://www.usa.skanska.com/who-we-are/media/press-releases/277333/SkanskaFay-Joint-Venture-selected-for-Howard-Street-Tunnel-Project%2C-elevating-I95-freight-rail-infrastructure>.

Some interviewees also emphasized that Maryland could adopt a more “business-friendly” stance, particularly to the *Manufacturing* sector where they noted that many apprenticeship programs have been phased out the past two decades. Though interviewees did not believe the state is hostile toward manufacturers, they believe *Manufacturing* has been neglected and that there is a preference toward other industries like *Biotechnology* and *Cybersecurity*. It was also stated that environmental regulations in Maryland are more challenging to navigate than in neighboring states. On the other hand, some experts found themselves growing due to community support through vendor visits and outreach programs, including workforce training initiatives. One industry expert mentioned that while government contracting can be daunting due to its complexity, support such as the University of Maryland's Procurement Technical Assistance Center (PTAC) helps local manufacturers prepare government contract proposals and understand deliverables, all at no cost. This service acts as a valuable incentive for small businesses looking to expand.

Labor Force

Maryland has access to a pool of highly skilled individuals, as it is surrounded by colleges and universities such as the University of Maryland, Johns Hopkins University, Morgan State University, Loyola University of Maryland, and more. One interviewee reported that the access to a large number of engineering graduates is a benefit to their firm. However, many experts pointed out labor issues that must be addressed. First, interviewees reported a general mindset that artificial intelligence is replacing jobs. While technologies may replace certain workers when appropriately integrated, businesses will still need to train workers in other skill sets to improve productivity. For this reason, one interviewee believes the public notion that machines will replace workers must be revised.

Some experts interviewed felt that Maryland currently has less vocational education opportunities than ten years ago, which has resulted in a limited supply of labor in blue-collar work.

One interviewee reported that they outsource labor valued at approximately \$1 million dollars per year, representing one third of their organization's operating costs. The same interviewee reported having to train machinists from “ground zero” due to lack of local educational programs. The existing *Manufacturing* workforce is also aging out, and those who remain in the workforce charge higher prices due to their years of experience. Despite the higher labor costs for these older and knowledgeable workers, it is reported that many of their skills are becoming outdated as the *Manufacturing* industry shifts away from more traditional technologies and practices. Trouble finding skilled labor is also coupled with high turnover rates, as workers have left for more competitive or appealing jobs.

“We’re forced to hire unskilled and train in house and that’s becoming a nightmare.”

Another specialist mentioned a strategy they adopted to meet the organizations need of machinists. To enhance their pool of skilled labor, they have forged a partnership with a local educational institution where they share close connections to both faculty and curriculum. In return, the educational institution possesses an understanding of the specific workforce requirements that the company seeks. Consequently, they have established an internship

program, through which the company accommodates interns and provides them with structured training based on a predefined curriculum.

Expansion Opportunities

For some interviewees, expansion meant growing their supply network, while for others it meant adding a new facility or increasing their labor force. One interviewee reported that the research needed to assess and compare quotes across different vendors—as well as finding out if a vendor is dependable and trustworthy—can require a significant amount of time and manpower. One interviewee stated that it takes their firm approximately two years from the first contact to finalize their network, with only ten percent of vendors from initial contacts reaching the final network. Further, one individual reported not being able to form close relationships with suppliers as they diversify, causing a shift in supplier attitudes around serving consumers due to ample demand. The pandemic also impacted relationship-building efforts, with one expert noting that there were many in-person opportunities for relationship building prior to COVID-19.

One interviewee's organization had to pause its expansion in 2022 because it outgrew the physical capacity of their building due to unprecedented demand and needed to build inventory as quickly as possible. Adding shelving to maximize storage, renting trailers, and purchasing capital such as forklifts to manage larger amounts of inventory were mentioned as ways to increase capacity. It was also reported that when finding a new warehouse location that affordability is the most important component. For some smaller manufacturers there are additional limitations when expanding. As an example, one expert noted how large manufacturers have constructed their own rail access to facilitate expansion, while that option is out of reach for smaller firms.

"I don't have a lot of room to expand here, so. If I were going to expand, I'd have to do it somewhere else."

Almost all experts who were interviewed said that if they could find more Maryland-based suppliers, they would work with them. However, only a limited number have the opportunity to make use of suppliers based in the state. Several factors contribute to this situation, such as the scarcity of local suppliers, concerns about their reliability, and the availability of necessary materials. According to one expert, when seeking domestic suppliers, Maryland faces competition from neighboring states like Pennsylvania, known for their rich industrial history. The proximity of states such as New York, New Jersey, and North Carolina further complicate the efforts to expand the supply chain within Maryland. Experts also indicated that they give new suppliers a chance and if they fail, they will not work with them again, nor recommend them to other companies. It was also reported that in the event that a major supplier stops supplying one of their materials or goods, it is best practice to recommend a new, reliable supplier of that good or material.

Notably, none of the experts interviewed mentioned the CONNEX™ Marketplace which is discussed in Section 8 of the current report. This is likely due to the recent launch of CONNEX™

Maryland/DC in June 2023, but aims to address these local supply chain building challenges described by interviewees.³⁷³

Risk Mitigation

Multiple viewpoints were shared on how organizations have adopted new risk mitigation strategies following the pandemic. One expert explained the three main strategies they have implemented, starting with the need to monitor their supply chains and adapt consistently. Second, more reactive decisions must be made as quickly as possible. Lastly, technology should be utilized appropriately to share information and communicate effectively. Another expert said they emphasize the reduction of single-point failures so that there is more flexibility in their operations if things go wrong. For example, they will have several people who have the skillset and knowledge to work on a single project to avoid disruptions if one member of the team falls ill or cannot make it to work. Another expert's organization has adopted many new internal processes to allow his team to be more efficient. This has included onboarding and training new workers to be productive with less manpower. To combat long lead times, one interviewee's organization has begun substituting materials and is working with more vendors to get the materials they need. This diversification in an organization's supplier base helps optimize operations in terms of the cost of materials, and also minimizes time needed to reach the consumer. Furthermore, an expert suggested when engaged in international trade, it is essential to monitor currency fluctuations, as this can be advantageous for businesses, particularly when the U.S. dollar exhibits strength.

Another expert underscored the significance of adhering to ISO 9001 standards in risk mitigation. The ISO 9001 standards are considered a global quality management benchmark and are the most widely used quality standards.³⁷⁴ This expert acknowledged that although achieving ISO 9001 certification entails additional effort and expenses, it is instrumental in requiring companies to maintain a comprehensive risk register. ISO 9001 certification encompasses various aspects, from supplier management to site visits, ensuring redundancy in specific supply chains, and addressing questions such as staffing levels, employee training, resource availability, financial readiness, on-time delivery risk, and inspection capabilities. All of these elements are integrated into the company's operational structure through adherence to ISO 9001, which not only facilitates risk analysis but also establishes operational standards. As a result, the expert has strongly advocated for the adoption of ISO 9001, especially for small businesses.

³⁷³ "CONNEX Maryland Launches to Help Connect Regional Supply Chain," CONNEX Marketplace.

³⁷⁴ "ISO 9001 Quality Management Systems," ISO, accessed December 22, 2023, <https://www.iso.org/standard/62085.html>.

Transportation and Distribution

Some experts told RESI that transportation is relatively straightforward in their business. They rely on standard shippers such as UPS, FedEx, air cargo, and trucking for facilities. One expert said they also rely on less-than-truckload (LTL) freight shipping and have direct software links between their system and the LTL system to share all shipment transactions electronically.

Another expert shared difficulty in shipping their products due to the several layers of separation between the person they first contact for a quote and the person who performs the delivery. This is due to what the individual called the “Uber-ification” of the trucking industry. The interviewee used this term to describe the change in shipping practices

“I think, really right now our biggest issue is transportation. And just the I’ll say excessive cost due to what I would call inefficiencies at the port and rail.”

where trucking companies rely on the use of apps to hire contractors that deliver goods and materials. If something goes wrong with a shipment, having to go through several parties creates a lack of visibility and increases the time needed to identify issues. Additionally, many experts agreed that there is a shortage of drivers, which is increasing shipping prices for businesses.

According to several of those interviewed, struggles with the container chassis shortage have also created transportation issues.³⁷⁵ Chassis are typically provided by steamship companies, and most truck drivers do not have their own. When the containers arrive at the port, they must be put on a chassis. Even if the goods are ready to be picked up, the unavailability of chassis can result in goods sitting at the ports for extended amounts of time. The chassis shortage has impacted the ability to quickly receive goods and quickly ship them out. Further, if the container sits at the port for too long, demerging fees are charged as a penalty, which can be very expensive for clients.

In the context of enhancing product distribution, it was noted by one expert that maintaining a sales team actively engaged in direct interactions with end-users to understand their preferences and requirements—and subsequently relaying this valuable feedback to distributors—has proven instrumental. Another industry authority highlighted the significance of their collaboration with Xometry, a prominent online brokerage firm known for its extensive network of buyers. For small businesses, leveraging these types of services is recommended not only for efficient product delivery, but also for expanding their professional network.

COVID-19 Related Challenges

Several interviewees reported losing many clients due to the uncertainty of the pandemic. Labor shortages, which were covered earlier in this section, were also an issue that was brought up several times in the interviews. While some organizations struggled with shutdowns, one interviewee reported having experienced approximately 20 percent growth in demand during the pandemic, which was very difficult to meet because of the labor shortage.

³⁷⁵ Natalie Kienzle, “Container Chassis Shortage: The Latest Logistics Struggle,” Truckload Shipping, August 28, 2023, accessed December 11, 2023, <https://usatruckloadshipping.com/container-chassis-shortage/>.

For those interviewed, issues with the availability of materials and long lead times reportedly began with COVID-19. One expert said it costs them five times more to get materials than it did

"I mean, basically from COVID on is where we're seeing these major inefficiencies. We never had problems like this in the past."

prior to the pandemic. Another interviewee shared that before the pandemic, materials used to arrive within six weeks of the order date, but these times now range from 26 to 40 weeks. Experts are also spending large amounts to alleviate these issues. One individual reported paying expedited fees and asking for favors to get their organizational needs met. Even though it was reported that long lead times have begun to improve slightly, several of those interviewed believe this issue will be ongoing.

Geopolitical Issues

Experts that were interviewed had varied responses on how geopolitical issues have impacted their organizations. Some interviewees said they did not have any disruptions from foreign conflicts and international trade factors, as they typically work primarily with domestic suppliers and customers. Their interaction with international suppliers is based on needs and preferences. One interviewee reported that communication across avenues is more accessible when done domestically, compared to internationally.

Conversely, other interviewees felt the effects of global geopolitics. One expert said that tensions with China could disrupt their supply chain, as they rely heavily on Chinese goods. They reported attempts toward sourcing from other countries such as India or Indonesia, though they do not believe these countries will be realistic alternatives for the next five to ten years. This expert also noted that their business operations in Taiwan and mainland China have been adversely affected by the 301 tariffs imposed five to six years ago, leading to increased import costs for the company. Due to efforts to bring back some production due to the 301 and 232 tariffs, the industry is undergoing changes and there is a growing tendency to reduce reliance on Asian suppliers, the expert observed. Another interviewee noted that while they never sourced from Russia, the conflict with Ukraine could affect the cost of shipping steel and aluminum.

8.0 Initiatives to Strengthen Supply Chains

Among the myriad disruptions driven by the COVID-19 pandemic were issues related to supply chains operations, both domestically and globally. Difficultly obtaining some products—such as semiconductor chips—highlighted how a shortage of a single component could create much larger ripple effects throughout multiple industries. Furthermore, these issues showed that diversified supply chains are important not only for businesses and consumers, but for national security as well. These disruptions drove a push by both federal and state governments to increase supply chain resiliency, bolster local and domestic production of critical components, and reduce vulnerabilities within the distribution ecosystem.

This section will provide an overview of existing programs and initiatives designed to strengthen supply chains—particularly within the *Manufacturing* industry—both in Maryland and across the U.S. The following subsections will detail the following topics:

- Federal CHIPS Act aimed at increasing U.S. semiconductor production;
- Maryland programs designed to strengthen the state’s workforce and *Manufacturing* industry;
- CONNEX™ Marketplace and its role in strengthening supply chains; and
- Examples of other State programs focused on supply chain resiliency and/or the *Manufacturing* industry.

8.1 Federal Direct Investment and Onshoring

Due to the substantial impact of the global semiconductor chip shortage, there has been a greater focus on prioritizing domestic manufacturing and investment. The chip shortage has impacted numerous industries including producers of computer systems, electronics, and automobiles, which has in turn limited availability for consumers. While the U.S. is the second-largest market for these chips, they are only the fifth-largest producer with approximately 12 percent of total manufacturing capacity.^{376,377} This is a marked decrease from 1990, when U.S. production represented 37 percent of global supply.³⁷⁸ Because semiconductor chips are crucial components of many applications and products, having a steady supply is necessary to ensure national economic and technological security. Geographic diversification of the semiconductor chip supply chain also provides insulation from geopolitical issues and localized factors (e.g., natural disasters, power outages, labor shortages), which have the potential to further disrupt chip availability.³⁷⁹

For advanced semiconductor chip manufacturing, typically defined as chips with nodes of 14 nanometers (nm) or smaller, there is currently a limited number of companies with the necessary design and manufacturing capabilities.³⁸⁰ Five- and seven-nm microchips, which are used for complex applications such as AI systems, are produced solely in Taiwan and South Korea and represent the “most significant choke point” in the global supply chain of semiconductors.³⁸¹ The limited geographic production of these chips is a particular concern for the U.S. Department of Defense, with all of the advanced semiconductor chips used by the U.S. military currently being imported.³⁸²

³⁷⁶ Lara Williams, “Can FDI Fix the Semiconductor Supply Chain?” *Investment Monitor*, July 29, 2022, accessed September 5, 2023, <https://www.investmentmonitor.ai/features/can-fdi-fix-the-semiconductor-supply-chain/?cf-view>.

³⁷⁷ Vishwam Sankaran, “Samsung to Build \$17bn Chip Factory in Texas’s Biggest Ever Foreign Investment,” *Independent*, November 24, 2021, accessed September 5, 2023, <https://www.independent.co.uk/tech/samsung-chip-shortage-texas-factory-b1963295.html>.

³⁷⁸ *Ibid.*

³⁷⁹ Williams, “Can FDI Fix the Semiconductor Supply Chain?”

³⁸⁰ “Semiconductor Design and Manufacturing: Achieving Leading-edge Capabilities,” McKinsey and Company, August 20, 2020, accessed September 11, 2023, <https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities>.

³⁸¹ Williams, “Can FDI Fix the Semiconductor Supply Chain?”

³⁸² *Ibid.*

While the U.S. has a dominant share of semiconductor design capacity, representing approximately 85 percent of the global market, a number of challenges have hindered domestic manufacturing.³⁸³ New semiconductor manufacturing plants—also known as semiconductor foundries or fabs—typically cost between \$10-\$20 billion dollars and take three to five years to construct.³⁸⁴ The cost of building semiconductor manufacturing facilities in the U.S. is also significantly higher compared to many other countries. For example, it is estimated that constructing a facility in the U.S. is five times greater than the cost to build in Taiwan.³⁸⁵ This type of manufacturing also requires substantial expertise, with complex processing often taking several weeks and multiple steps to make the numerous chip layers.³⁸⁶

In August of 2022, the Creating Helpful Incentives to Produce Semiconductors for America Act—also known as the CHIPS Act or CHIPS and Science Act—was signed into law. This legislation included \$52.7 billion in incentives to onshore semiconductor manufacturing facilities, incentivize foreign direct investment (FDI), and alleviate supply chain challenges.³⁸⁷ Notably, however, inflation, material costs, and labor costs have risen substantially since the CHIPS Act was initially proposed in 2020. This means that the federal grants that are expected to fund up to 15 percent of new plant construction may not reach as far now as when the legislation was initially written.³⁸⁸

There are a number of goals that the federal government outlined with the passing of the CHIPS Act. Collectively, the objective is to increase the resiliency of the semiconductor chip supply chain and bolster the U.S. as a leader and innovator in semiconductor research, development, and manufacturing.³⁸⁹ These aims include:

- Creating a minimum of two clusters of cutting-edge logic semiconductor manufacturing facilities, comprised of multiple commercial fabs with suppliers, research and development facilities, and other supporting infrastructure in the area;
- Increasing manufacturing capacity of semiconductors that use “mature technologies” but are still currently used heavily for applications such as auto manufacturing;

³⁸³ Sujai Shivakumar and Charles Wessner, “Semiconductors and National Defense: What Are the Stakes?” Center for Strategic and International Studies, June 8, 2022, accessed September 11, 2023, <https://www.csis.org/analysis/semiconductors-and-national-defense-what-are-stakes>.

³⁸⁴ Joel Hruska, “Why We Can’t Build Our Way Out of the Semiconductor Shortage,” Extreme Tech, May 11, 2021, accessed September 11, 2023, <https://www.extremetech.com/computing/322695-why-we-cant-build-our-way-out-of-the-semiconductor-shortage>.

³⁸⁵ Williams, “Can FDI Fix the Semiconductor Supply Chain?”

³⁸⁶ “Foundry,” PCMag, accessed September 5, 2023, <https://www.pcmag.com/encyclopedia/term/foundry>.

³⁸⁷ “Fact Sheet: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China,” The White House, August 9, 2022, accessed September 11, 2023, <https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/>.

³⁸⁸ Alexandra Alper, Stephen Nellis, and Heekyong Yang, “Samsung’s New Texas Chip Plant Cost Rises Above \$25 Billion,” *Reuters*, March 15, 2023, accessed September 5, 2023, <https://www.reuters.com/technology/samsungs-new-texas-chip-plant-cost-rises-above-25-billion-sources-2023-03-15/>.

³⁸⁹ “Fact Sheet: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China,” The White House.

- Producing memory and DRAM chips (currently the most bit-dense memory chips available); and
- Establishing advanced, high-capacity packing capabilities for both logic and memory chips.³⁹⁰

Since its passing, the CHIPS Act has spurred the announcements of 60 new semiconductor ecosystem projects, more than \$210 billion in private investments, and an estimated 44,000 new jobs.³⁹¹

The U.S. government began accepting applications for the CHIPS Act in March 2023 with full applications accepted in October 2023.^{392,393} In June 2023, the scope of funding was expanded to include companies planning capital investments of \$300 million or more to construct, expand, or modernize commercial facilities.³⁹⁴ Several types of funding will be available through the CHIPS Act: direct funding, loans, and guarantees. Approximately \$38.2 billion will be allocated to direct funding, including a minimum of \$2 billion for “mature-node” facilities, while a combined \$75 billion will be earmarked for loans and loan guarantees.³⁹⁵ Additionally, the U.S. Treasury Department will provide Investment Tax Credits in addition to the funding outlined above.³⁹⁶ There are a number of conditions that must be adhered to by those receiving funds, including no expansions outside of the U.S., no stock buy backs, and no relocations of existing facilities.³⁹⁷ Companies that receive more than \$150 million in funding have additional conditions, including “upside sharing” with the government for CHIPS Act funding if their profits exceed projections by a certain margin.³⁹⁸

Several dominant companies have broken ground or have plans underway to onshore or expand U.S. production capabilities. In Phoenix, Arizona, Taiwan’s leading chip manufacturing company, Taiwan Semiconductor Manufacturing Company (TSMC), has begun construction on their new semiconductor fab complex. The \$40 billion commitment for U.S. semiconductor

³⁹⁰ Samuel K. Moore, “United States Kicks Off CHIPS Act Funding,” IEEE Spectrum, March 1, 2023, accessed September 5, 2023, <https://spectrum.ieee.org/us-chips-act-funding>.

³⁹¹ Robert Casanova, “The CHIPS Act Has Already Sparked \$200 Billion in Private Investments for U.S. Semiconductor Production,” Semiconductor Industry Association, last updated August 15, 2023, <https://www.semiconductors.org/the-chips-act-has-already-sparked-200-billion-in-private-investments-for-u-s-semiconductor-production/>.

³⁹² Moore, “United States Kicks Off CHIPS Act Funding.”

³⁹³ “Notice of Funding Opportunity: Commercial Fabrication Facilities,” National Institute of Standards and Technology, CHIPS for America, last modified August 25, 2023, accessed September 12, 2023, <https://www.nist.gov/chips/notice-funding-opportunity-commercial-fabrication-facilities>.

³⁹⁴ Ibid.

³⁹⁵ Moore, “United States Kicks Off CHIPS Act Funding.”

³⁹⁶ CHIPS Incentives Program, “CHIPS Incentives Program – Commercial Fabrication Facilities,” 9, accessed September 12, 2023, <https://www.nist.gov/system/files/documents/2023/06/23/CHIPS-Commercial%20Fabrication%20Facilities%20NOFO%20Amendment%201.pdf>.

³⁹⁷ Ibid.

³⁹⁸ Ibid.

production represents one of the largest FDIs in national history.³⁹⁹ Additional major investments include Intel's \$20 billion funding in Ohio for two leading-edge semiconductor chip factories with the potential for further expansion. The company has also committed an additional \$100 million to boost the talent pipeline and support research programs in the region.⁴⁰⁰ In Taylor, Texas, Samsung is investing \$25 billion in an advanced chip factory that represents the largest FDI in Texas to date.⁴⁰¹ The company is now aiming to complete construction by the end of 2024, with expected chip production beginning in 2025 rather than 2024, as originally anticipated.⁴⁰² Micron Technology, an Idaho-based firm, announced plans to build four semiconductor fabs in Syracuse, New York with a \$100 billion investment over the next two decades.⁴⁰³ Over time, the company aims to increase domestic production to 40 percent of its global DRAM output.⁴⁰⁴

There have been no announcements of new projects in Maryland seeking funding as of August 2023, based on information from the Semiconductor Industry Association.⁴⁰⁵ In 2021, there were 18 semiconductor establishments in the state with a total of 216 semiconductor manufacturing jobs.⁴⁰⁶ In Prince George's County, however, the Prince George's County Chip Act was introduced to the County Council in July 2023. The bill aims to create an investment incentive for companies to move to the county and both develop and manufacture semiconductor chips.⁴⁰⁷ In particular, the Prince George's County Economic Development Corporation is hoping to procure a portion of the \$11 billion allocated for research and development through the CHIPS Act.⁴⁰⁸ There is an abundant supply of industrial space in the county, though it has attracted more warehouses than other types of commercial infrastructure.⁴⁰⁹ The proposed legislation would provide tax reimbursements to companies that conduct semiconductor chip research, development, and manufacturing for a ten-year

³⁹⁹ Michael Sainato, "They Would Not Listen to Us: Inside Arizona's Troubled Chip Plant," *The Guardian*, August 28, 2023, accessed September 12, 2023, <https://www.theguardian.com/business/2023/aug/28/phoenix-microchip-plant-biden-union-tsmc>.

⁴⁰⁰ "Intel Invests in Ohio," Intel, August 8, 2023, accessed September 18, 2023, <https://www.intel.com/content/www/us/en/newsroom/resources/intel-invests-ohio.html#gs.5vmuiw>.

⁴⁰¹ Sankaran, "Samsung to Build \$17bn Chip Factory in Texas's Biggest Ever Foreign Investment."

⁴⁰² Alper, Nellis, and Yang, "Samsung's New Texas Chip Plant Cost Rises Above \$25 Billion."

⁴⁰³ "Micron Announces Historic Investment of Up to \$100 Billion to Build Megafab in Central New York," Micron, October 4, 2022, accessed September 18, 2023, <https://investors.micron.com/news-releases/news-release-details/micron-announces-historic-investment-100-billion-build-megafab>.

⁴⁰⁴ Ibid.

⁴⁰⁵ Casanova, "The CHIPS Act Has Already Sparked \$200 Billion in Private Investments for U.S. Semiconductor Production."

⁴⁰⁶ Semiconductor Industry Association, "Semiconductors in Maryland," 1, accessed September 12, 2023, <https://www.semiconductors.org/wp-content/uploads/2022/05/Maryland-2022.pdf>.

⁴⁰⁷ Tom Fitzgerald, "Proposed Chip Act Aims to Boost High-tech Manufacturing in Prince George's County," *FOX 5*, July 11, 2023, accessed September 12, 2023, <https://www.fox5dc.com/news/proposed-chip-act-aims-to-boost-high-tech-manufacturing-in-prince-georges-county>.

⁴⁰⁸ John Domen, "The Effort to Bring More 'Chips' into Prince George's Co.-Microchips," *WTOP News*, July 12, 2023, accessed September 12, 2023, <https://wtop.com/prince-georges-county/2023/07/the-effort-to-bring-more-chips-into-prince-georges-co-microchips-overnighter-too-btw/>.

⁴⁰⁹ Fitzgerald, "Proposed Chip Act Aims to Boost High-tech Manufacturing in Prince George's County."

period.⁴¹⁰ Through this new bill, the county would aim to become a regional technological hub and capitalize on existing infrastructure and the concentration of Engineers and Computer Scientists in the area.⁴¹¹

8.2 Maryland Programs

Maryland has a number of programs designed to bolster the *Manufacturing* industry and strengthen the state's workforce. While most of these programs existed prior to COVID-19, the disruptions created by the pandemic have emphasized the need for robust supply chains in the state and the importance of a skilled and available workforce. The following subsection will briefly highlight some of these key initiatives and programs.

Maryland MEP

The Maryland Manufacturing Extension Partnership (Maryland MEP) is a nonprofit organization dedicated to the growth and enhancement of Maryland's *Manufacturing* sector.⁴¹² Maryland MEP collaborates with the Regional Manufacturing Institute (RMI) of Maryland to collectively represent the interests of manufacturers across all industries and regions in the state. Each year, the Maryland MEP team engages with over 500 manufacturers statewide, resulting in nearly \$500 million in economic impacts and the creation or preservation of more than 2,500 jobs.⁴¹³

MEP provides support to Maryland-based manufacturers through six key avenues:

- Offering guidance to develop strategies, identify new opportunities, and foster organizational growth by acquiring new customers and commercializing novel products and processes.
- Assisting manufacturers with formulating a comprehensive strategy for identifying, recruiting, training, and retaining their future workforce.
- Helping organizations to recognize and implement advanced manufacturing technologies to enhance efficiency.
- Providing guidance to local manufacturing companies on refining their operations and processes through various continuous improvement initiatives.
- Collaborating with businesses to assess their supply chains, identify and validate new suppliers, and reduce overall business risk.
- Committing to reducing the *Manufacturing* industry's environmental footprint by delivering programs and services that decrease environmental waste, boost energy efficiency, and enhance sustainability.⁴¹⁴

MEP's primary role in supply chain management is to assist manufacturers in evaluating supply chain risks and opportunities. This includes identifying Maryland and domestic suppliers,

⁴¹⁰ Domen, "The Effort to Bring More 'Chips' into Prince George's Co.-Microchips."

⁴¹¹ Ibid.

⁴¹² "Maryland MEP & RMI of Maryland," Maryland MEP, accessed November 28, 2023, <https://mdmep.org/>.

⁴¹³ Ibid.

⁴¹⁴ "Maryland MEP & RMI of Maryland," Maryland MEP.

conducting supply chain assessments, qualifying suppliers, fostering business-to-business connections, and conducting market research.⁴¹⁵ A notable example of MEP's support in supply chain management is the Maryland Supply Chain Resiliency Program, aimed at helping manufacturers build, expand, and fortify their supply chains.⁴¹⁶ This program facilitates connections and communication between manufacturers and local suppliers, customers, and partners. Additionally, grants were made available to provide technical assistance to manufacturers adversely impacted by the COVID-19 pandemic, as well as those facing disruptions in their workforce or supply chain operations.⁴¹⁷

Maryland Manufacturing 4.0

The Maryland Manufacturing 4.0 grant program was launched in 2022 and extends financial support to small- and mid-sized *Manufacturing* companies in Maryland.⁴¹⁸ This aid is directed towards these businesses to make investments in Industry 4.0 technologies—such as new machinery, robotics, and digital business systems—with the goals of enhancing their competitiveness and fostering growth. Much like the concept of smart manufacturing, which underscores the significance of modern technology in production, “Industry 4.0 represents the fourth industrial revolution,” with a primary focus on digitizing and automating manufacturing processes to assist companies in staying competitive and promoting business expansion.⁴¹⁹ Organizations that invest in these technological advancements can enjoy a range of benefits, including heightened productivity, increased sales, lower costs, and increased employee retention.⁴²⁰

In early 2023, the first round of funding for the Maryland Manufacturing 4.0 program was allocated to 23 local businesses.⁴²¹ Grant recipients had a range of investments that included purchases of automation equipment, robotics systems, and 3D scanners and printers.⁴²² Applications for the second round of grant funding—totaling \$1 million—were accepted between August and October 2023. Grant amounts range from \$25,000 to \$0.5 million and are

⁴¹⁵ “Supply Chain & Defense,” Maryland MEP, accessed November 28, 2023, <https://mdmep.org/supply-chain-solutions/>.

⁴¹⁶ “MD MEP With Maryland Department of Commerce to Deliver New Maryland Supply Chain Resiliency Initiative,” Maryland MEP, accessed November 28, 2023, <https://mdmep.org/md-mep-with-maryland-department-of-commerce-to-deliver-new-maryland-supply-chain-resiliency-initiative/>.

⁴¹⁷ Ibid.

⁴¹⁸ “Maryland Manufacturing 4.0,” Department of Commerce, accessed November 28, 2023, <https://commerce.maryland.gov/fund/maryland-manufacturing-4-0>.

⁴¹⁹ “Governor Hogan Announces Maryland Manufacturing 4.0 Grant Program,” Maryland Department of Commerce, August 22, 2022, accessed December 4, 2023, <https://commerce.maryland.gov/media/governor-hogan-announces-maryland-manufacturing-40-grant-program#:~:text=Similar%20to%20smart%20manufacturing,competitive%20and%20drive%20business%20growth>.

⁴²⁰ “Maryland Manufacturing 4.0,” Department of Commerce.

⁴²¹ “Governor Moore Announces Second Round of Funding for Maryland Manufacturing 4.0 Program,” Maryland Economic Development Association, August 7, 2023, accessed November 28, 2023, <https://www.medamd.com/program-development/governor-moore-announces-second-round-of-funding-for-maryland-manufacturing-4-0-program/>.

⁴²² Maryland Department of Commerce, “Maryland Manufacturing 4.0 Grant Recipients,” 1-2, accessed December 4, 2023, https://commerce.maryland.gov/Documents/FinanceDocument/M4Grants_Recipients.pdf.

expected to cover 75 percent of project expenses for small manufacturers (those with less than 50 employees) and 50 percent of project costs for mid-sized manufacturers (employing 51-250 workers).⁴²³

EARN Maryland

The Employment Advancement Right Now (EARN) Maryland program is a competitive workforce development initiative funded by the State, with the aim of increasing employee readiness and skill development.⁴²⁴ The program is designed to address specific industry workforce requirements while concurrently addressing the needs of workers by establishing structured career pathways to secure employment, removing obstacles to job access, and supporting the stability or growth of middle-class employment opportunities.⁴²⁵ These objectives are achieved by making focused investments in key industry partnerships across all state regions.⁴²⁶ The program is industry-led, emphasizes regional involvement, and has had success with helping businesses to maintain a competitive edge through workforce development strategies.⁴²⁷

These partnerships blend collaborative efforts among education, workforce development, and economic initiatives to meet the diverse demands of companies, beginning with the training of skilled workers.⁴²⁸ Once established, these partnerships create actionable plans for employee training and education, followed by job placement efforts. Currently, EARN Maryland has 65 established industry partnerships, spanning ten distinct sectors: *Biotechnology, Healthcare, Hospitality, Construction, Green, Cyber and Information Technology, Automotive, Childcare, Manufacturing, and Transportation and Logistics*.⁴²⁹ Among them, the *Cyber and Information Technology* sector has the highest number of strategic partnerships at 18, followed by the *Healthcare* industry with 13 partnerships.⁴³⁰ Within the *Manufacturing* sector, there are six partnerships and two dedicated training programs to prepare workers for positions in the industry, such as Welder and Product Technician.⁴³¹

⁴²³ "Maryland Manufacturing 4.0," Department of Commerce.

⁴²⁴ "Governor Moore Announces More Than \$2 Million in Grants to Expand Nationally-Recognized EARN Maryland Program," Maryland Department of Labor, accessed November 28, 2023, <https://www.dllr.state.md.us/whatsnews/gov32earn.shtml>.

⁴²⁵ "What is EARN Maryland?" Maryland Department of Labor, accessed November 28, 2023, <https://www.dllr.state.md.us/earn/earnwhatisearn.shtml>.

⁴²⁶ "Current EARN Maryland Partnerships," Maryland Department of Labor, accessed November 28, 2023, <https://www.dllr.state.md.us/earn/earngrantpartners.shtml>.

⁴²⁷ "What is EARN Maryland?" Maryland Department of Labor.

⁴²⁸ Ibid.

⁴²⁹ Maryland Department of Labor, "EARN Maryland Strategic Industry Partnerships," 1-6, accessed November 6, 2023, <https://www.dllr.state.md.us/earn/earnmdsummaries.pdf>.

⁴³⁰ Ibid.

⁴³¹ "Manufacturing," Maryland Department of Labor, accessed December 4, 2023, <https://www.labor.maryland.gov/earn/earnmanufacturing.shtml>.

Maryland Apprenticeship and Training Program (MATP)

There are numerous benefits to completing an apprenticeship, such as earning while training, gaining hands-on work experience, and learning directly from experienced professionals.⁴³² The Maryland Apprenticeship and Training Program (MATP) coordinates the matching of apprenticeship candidates with participating employers across a variety of occupations. These positions span a number of industries and include titles such as Additive Manufacturing Technician, Carpenter, Computer Programmer, Electrician, Machinist, and Welder.⁴³³ The MATP consists of two components—apprenticeship candidates and apprenticeship sponsors.

The first component focuses on offering opportunities to Maryland residents who wish to become registered apprentices.⁴³⁴ These apprenticeships are paid employment positions where individuals receive comprehensive one-on-one training from experienced craftspeople, alongside relevant classroom instruction.⁴³⁵ Apprentices are sponsored by an employer or association and receive compensation based on a progressive pay scale. Hundreds of registered apprenticeships are currently available with opportunities in every Maryland county.⁴³⁶ Furthermore, these opportunities are extended to high school students in specific counties through a program known as Youth Apprenticeships. Although similar to registered apprenticeships, these programs predominantly focus on occupations related to *Manufacturing* and other science, technology, engineering, and mathematics (STEM) industries.

The second component of MATP focuses on the business side, where organizations can become registered apprenticeship sponsors.⁴³⁷ An apprenticeship sponsor is an enterprise or association that oversees a registered apprenticeship program that has been approved by the Maryland Apprenticeship and Training Council.⁴³⁸ Businesses participating in MATP may be eligible for the Maryland Business Works program, which can cover up to 50 percent of their eligible training costs, up to a maximum of \$4,500 per apprentice and \$40,000 per company during each program year, provided they meet the eligibility criteria.⁴³⁹ Depending on availability, the Apprenticeship Innovation Fund offers grants to businesses, offering up to \$50,000 to support innovative apprenticeship solutions. Additionally, eligible registered apprenticeship sponsors or

⁴³² “What Are the Benefits of a Manufacturing Apprenticeship?” Northeast Advanced Manufacturing Consortium, February 15, 2022, accessed December 4, 2023, <https://namcnetwork.com/what-are-the-benefits-of-a-manufacturing-apprenticeship/>.

⁴³³ “Explore Registered Occupations - Maryland Apprenticeship and Training Program (MATP),” Maryland Department of Labor, accessed November 1, 2023, <https://www.dllr.state.md.us/employment/approcc/approcc.shtml#w>.

⁴³⁴ “Be an Apprentice – Maryland Apprenticeship and Training Program (MATP),” Maryland Department of Labor, accessed November 6, 2023, <https://www.dllr.state.md.us/employment/appr/apprbecomeappr.shtml>.

⁴³⁵ Ibid.

⁴³⁶ Ibid.

⁴³⁷ “Hire an Apprentice - Maryland Apprenticeship and Training Program (MATP),” Maryland Department of Labor, accessed November 1, 2023, <https://www.dllr.state.md.us/employment/appr/apprbecomesponsor.shtml>.

⁴³⁸ Ibid.

⁴³⁹ Ibid.

participating employers may qualify for tax credits—up to a maximum of \$15,000 per year—for each eligible registered apprentice and/or youth apprentice employed.⁴⁴⁰

8.3 CONNEX™ Marketplace

The CONNEX™ Marketplace was created in 2014 for an economic development project in Utah that sought to keep manufacturing operations local and increase jobs and revenue.⁴⁴¹ During the research phase of the project, the developers interviewed manufacturers throughout the state and found that one of the major barriers to local sourcing was connecting with other manufacturing firms. A searchable state database was then built, which identified manufacturers along with their capabilities and products. In one of the initial searches that was conducted, a new local connection was established that resulted in a \$70 million manufacturing contract.⁴⁴²

After its initial successes, the database was expanded nationally through partnerships with the National Association of Manufacturers (NAM) and state manufacturing associations.⁴⁴³ Additional state-level marketplaces were developed with support from the National Institute of Standards and Technology (NIST) and state Manufacturing Extension Partnerships (MEPs), with the national- and state-level platforms now combined as the CONNEX™ Marketplace. In Maryland, CONNEX™ Maryland/DC was launched in June 2023 and is facilitated through an MEP partnership.⁴⁴⁴ Maryland MEP provides a sponsorship that allows local manufacturers to access a free version of the platform, while a national access upgrade can also be purchased.⁴⁴⁵

There are currently 40 states that are included in the CONNEX™ Marketplace, with participation varying between state installations with MEP Partners, NAM state partners, or other state industry partners.⁴⁴⁶ The platform currently contains data for approximately 140,000 U.S. manufacturers and suppliers, such as company processes, equipment, certifications, Small Business Administration designations, and manufacturing capabilities. The platform allows small- and medium-sized manufacturers to find more opportunities with larger buyers, such as government purchasers. Large prime manufacturers and original equipment manufacturers (OEMs) can post their manufacturing needs to find qualified local suppliers.⁴⁴⁷ Additionally, the platform can be used identify vulnerabilities within the supply chain and evaluate regional manufacturing activity.⁴⁴⁸ Collectively, the aim of the platform is to increase

⁴⁴⁰ “Maryland Tax Credit for Eligible Apprentices - Maryland Apprenticeship and Training Program (MATP),” Maryland Department of Labor, accessed December 4, 2023, <https://www.dllr.state.md.us/employment/appr/apprtaxcreditinfo.shtml>.

⁴⁴¹ “About Us,” CONNEX Marketplace, accessed October 23, 2023, <https://connexmarketplace.com/about/>.

⁴⁴² “About Us,” CONNEX Marketplace, accessed October 23, 2023, <https://connexmarketplace.com/about/>.

⁴⁴³ Ibid.

⁴⁴⁴ “CONNEX Maryland Launches to Help Connect Regional Supply Chain,” CONNEX Marketplace.

⁴⁴⁵ Ibid.

⁴⁴⁶ “Our Partners,” CONNEX Marketplace, accessed October 30, 2023, <https://connexmarketplace.com/partners/>.

⁴⁴⁷ “Introduction to CONNEX Marketplace,” CONNEX Marketplace, accessed October 30, 2023, <https://youtu.be/3IhEtTjs5CU>.

⁴⁴⁸ “Introduction to CONNEX Marketplace,” CONNEX Marketplace.

supply chain strength and resiliency through an accessible and diverse collection of suppliers and transparent data.⁴⁴⁹

8.4 Other U.S. State Programs

In response to the strains experienced during the COVID-19 pandemic, several states have done evaluations of the strengths and weaknesses within their state's supply chains. Many of these efforts have focused on food supply resilience, while some states have concentrated on certain industry needs, such as *Manufacturing*. This subsection will highlight programs or initiatives that are funded, at least in part, by state governments.

Alaska

In Alaska, the vast majority (95 percent) of food purchased is imported from outside of the state.⁴⁵⁰ When the COVID-19 pandemic strained the state's supply chains, it became difficult for many households to find food and other essentials products. The Port of Seattle, on which Alaska relies heavily for many imported products, nearly closed during the pandemic and would have severely impacted residents' ability to obtain adequate food. Due to these supply chain strains, as well as lost revenue opportunities for the state, the Alaskan Governor established the Alaska Food Security and Independence Task Force in 2022.⁴⁵¹ This task force was responsible for evaluating the state's food security, including identifying barriers to increased production. According to the administrative order, the overarching goals of the order were to "increase food security, strengthen local economies, and lessen Alaska's dependence on external foods and supply chains."⁴⁵² Based on their findings, the task force was asked to provide recommendations to increase production, harvesting, processing, and storage of food products in the state.⁴⁵³

The *Alaska Food Security and Independence Task Force 2023 Report* was released in March 2023.⁴⁵⁴ The task force evaluated a number of food system sectors, such as wild foods, production, processing, and access, and completed a strengths, weaknesses, opportunities, and threats (SWOT) analysis for each sector. Although wild food sources are abundant in the state, the task force found that both meat and seafood processors were difficult to find within the state's borders.⁴⁵⁵ One of the recommended actions from the task force was to bolster the

⁴⁴⁹ "A Match Made in America," CONNEX Marketplace, accessed October 30, 2023, <https://connexmarketplace.com/>.

⁴⁵⁰ "Administrative Order No. 334," Office of Governor Mike Dunleavy, accessed October 10, 2023, <https://gov.alaska.gov/admin-orders/administrative-order-no-334/>.

⁴⁵¹ University of Alaska Fairbanks, Alaska Food Policy Council, and 2022 Governor's Task Force on Food Security and Independence, "Alaska Food Security and Independence Task Force 2023 Report," 5, accessed October 10, 2023, https://static1.squarespace.com/static/584221c6725e25d0d2a19363/t/640fb433f524b6421008ad3e/1678750824303/2023+Food+Security+Task+Force+Report+DIGITAL+2023.03.03+final_Parts1-3.pdf.

⁴⁵² "Administrative Order No. 334," Office of Governor Mike Dunleavy.

⁴⁵³ Ibid.

⁴⁵⁴ University of Alaska Fairbanks, Alaska Food Policy Council, and 2022 Governor's Task Force on Food Security and Independence, "Alaska Food Security and Independence Task Force 2023 Report."

⁴⁵⁵ Ibid, 106.

infrastructure required to expand local food production, including cold-chain transport and storage, and utilizing wholesalers to help sell and distribute products out of state. Additionally, expanding and enforcing the Local Purchase Preference program, as well as the Farm-to-School and Fish-to-School programs, would help the state become more diversified in their food supply chain while increasing economic benefits to local producers.⁴⁵⁶

Delaware

Delaware began the First State Food System Program in 2022, aiming to increase resilience of the food supply chain and increase access for residents.⁴⁵⁷ During the pandemic, food was being produced by small- and mid-sized farmers in the state, but there were significant obstacles to getting food to Delaware residents due to local supply chain issues.⁴⁵⁸ Because of this, the Delaware Council on Farm and Food Policy used federal funds to start the First State Food System Program to strengthen production, processing and distribution, and retail and consumer market outlets.⁴⁵⁹

Applicants can seek funding for single-use projects and/or multiuse projects. Single-use projects are short-term projects (one year or less) for which businesses need a one-time purchase of equipment or other expenses.⁴⁶⁰ Multiuse projects are for more than one year and can cover a wider range of funding needs.⁴⁶¹ In the first round of funding, nearly \$0.7 million was distributed by the State, with the plurality of funding (43 percent) going to food production and processing projects.⁴⁶² In the second year of grants, 50 percent of funds were awarded to Delaware farms, followed by 34 percent for community organizations that concentrate on food access, nutritional education, and community development.⁴⁶³ The program focuses support on small- and mid-sized farms, with funding eligibility limited to farms with \$20,000 to \$300,000 in sales and no more than 300 acres of crops.⁴⁶⁴

⁴⁵⁶ "Alaska Food Security and Independence Task Force 2023 Report," 109-110.

⁴⁵⁷ "First State Food System Program Opens Second Grant Application Cycle," State of Delaware, April 18, 2023, accessed October 10, 2023, <https://news.delaware.gov/2023/04/18/first-state-food-system-program-opens-second-grant-application-cycle/>.

⁴⁵⁸ Joe Irizarry, "Delaware is Using Federal Funds to Make Sure Food Grown in First State Gets to Communities," Delaware Public Media, November 29, 2021, accessed October 16, 2023, <https://www.delawarepublic.org/politics-government/2021-11-29/delaware-is-using-federal-funds-to-make-sure-food-grown-in-first-state-gets-to-communities>.

⁴⁵⁹ Ibid.

⁴⁶⁰ "Program Accepting Grant Applications from Delaware Food Producers," Daily State News, April 28, 2022, accessed October 16, 2023, <https://baytobaynews.com/stories/program-accepting-grant-applications-from-delaware-food-producers,77436>.

⁴⁶¹ "Program Accepting Grant Applications from Delaware Food Producers," Daily State News.

⁴⁶² "First State Food System Program Opens Second Grant Application Cycle," State of Delaware.

⁴⁶³ "Delaware Department of Agriculture Awards Over \$665,000 for Innovative Projects to Improve Food Supply Chain," State of Delaware, July 24, 2023, accessed October 10, 2023, <https://news.delaware.gov/2023/07/24/delaware-department-of-agriculture-awards-over-665000-for-innovative-projects-to-improve-food-supply-chain/>.

⁴⁶⁴ "Program Accepting Grant Applications from Delaware Food Producers," Daily State News.

California

When the COVID-19 pandemic began, California experienced significant disruptions with maritime supply chains and logistical operations. The increased demand for goods, combined with existing port delays and other challenges, caused record wait times for container ships.⁴⁶⁵ The state has several of the largest ports in the U.S. by size and cargo volume, including the Port of Los Angeles and Port of Long Beach.⁴⁶⁶ These ports have a wide-reaching impact on not only California, but also on other states, industries (such as rail and truck transportation), and economies across the country and world.

To alleviate congestion and delays at these ports, Governor Gavin Newsom issued an executive order creating the California Supply Chain SUCCESS Initiative (SUCCESS Initiative) which directed State agencies to identify ways to reduce congestion at California's ports.⁴⁶⁷ The SUCCESS Initiative is led through a collaborative effort between a number of entities including the Governor's Office of Business and Economic Development, the California State Transportation Agency, the Port of Long Beach, and the Port of Oakland.⁴⁶⁸ Through several meetings in 2021 that included a stakeholder workshop and summit, several areas for modification were identified that focused on port and related operations. These included improving capacity and utilization of equipment and system management (such as truck appointments); increasing hours of operation for terminal operations, warehousing, and rail; expanding cargo storage areas; and increasing data access and transparency to improve real-time communication and optimize shipping routes.⁴⁶⁹

Based on the insight and recommendations produced by the SUCCESS Initiative from these meetings and evaluations, several actions were initiated by various agencies. For example, the Port of Long Beach launched a data-sharing portal and made plans to expand hours to 24/7 operations.⁴⁷⁰ The California Office of Freight was established by the California Association of Port Authorities and the Port of Oakland, and a plan was developed to reduce congestion that includes measures such as allowing off-port container staging areas. Additionally, the U.S. Department of Transportation, which participated in the SUCCESS Initiative summit, has

⁴⁶⁵ Greg Miller, "California Port Pileup Shatters Record and Imports Still Haven't Peaked," August 30, 2021, accessed October 17, 2023, <https://www.freightwaves.com/news/california-port-pileup-breaks-record-and-imports-still-havent-peaked>.

⁴⁶⁶ Zahra Ahmed, "Top 10 Largest and Busiest Container Ports in the United States," May 4, 2023, accessed October 16, 2023, <https://www.marineinsight.com/know-more/top-10-largest-and-busiest-container-ports-in-the-united-states/>.

⁴⁶⁷ "Governor Newsom Signs Executive Order to Help Tackle Supply Chain Issues," Office of Governor Gavin Newsom, October 20, 2021, accessed October 17, 2023, <https://www.gov.ca.gov/2021/10/20/governor-newsom-signs-executive-order-to-help-tackle-supply-chain-issues/>.

⁴⁶⁸ California Governor's Office of Business and Economic Development, "California Supply Chain Success Initiative – A Summary Report – 2022," 2, accessed October 16, 2023, https://business.ca.gov/wp-content/uploads/2022/11/Supply-Chain-Initiative-Report-2022_GOBiz.pdf.

⁴⁶⁹ California Governor's Office of Business and Economic Development, "California Supply Chain Success Initiative – A Summary Report – 2022," 11.

⁴⁷⁰ Ibid, 15.

partnered with the State to modernize supply chain operations.⁴⁷¹ Collectively, the State is aiming for these actions to reduce the delays and congestion of California's ports and increase the resiliency of supply chain operations.

Connecticut

Connecticut is the only U.S. state that has a Chief Manufacturing Officer, part of the State's executive government, who is responsible for strategic initiatives to growth the industry.⁴⁷² Connecticut is known as a hub for innovation and advanced manufacturing activities.

Manufacturing is a significant driver of the state's economy and is responsible for approximately 13 percent of gross domestic product (GDP) and 90 percent of state exports, with concentrations in aerospace, chemical, and fabricated metal product manufacturing.⁴⁷³ Operations within the state have been negatively impacted by a number of factors including pandemic-driven issues (e.g., port delays and bottlenecks), production delays, and adverse weather events.⁴⁷⁴ In their 2023 Strategic Plan, supply chain resiliency serves as the second of three objective pillars, with the goals of reducing operating costs and strengthening and shortening supply chains.⁴⁷⁵ To meet this goal, the state has adopted two strategic initiatives: "Drive Operational Efficiency and Innovation," and "Drive Industry 4.0 Adoption."⁴⁷⁶

The first of these two strategies, focused on operational efficiency and innovation, includes three initiatives that aim to "support small to medium manufacturers by strengthening their operations to facilitate growth opportunities."⁴⁷⁷ The Manufacturing Voucher Program provides matching grants for equipment purchases and other expenses that increase supply chain resiliency, while the Manufacturing Concierge Program would help manufacturers access resources to grow and strengthen their businesses' supply chains. The third initiative presented in this strategy was the CONNEXTM CT Supply Chain Initiative, which launched in February 2023 and ties into the larger national CONNEXTM Marketplace. Notably, the State will provide technical and other support to manufacturers through Connecticut Manufacturing Consulting Services (CONNSTEP) personnel to increase utilization and effectiveness of the platform.^{478,479}

The second strategy within the Supply Chain Resiliency Pillar involves Connecticut's Industry 4.0, which focuses on the digital and physical technological transformation of the

⁴⁷¹ California Governor's Office of Business and Economic Development, "California Supply Chain Success Initiative – A Summary Report – 2022," 15.

⁴⁷² State of Connecticut, "Connecticut's Manufacturing Strategic Plan 2023," 1, accessed October 17, 2023, <https://portal.ct.gov/-/media/Manufacturing/PDF/2023-CT-Mfg-Strategic-Plan---final---HR.pdf>.

⁴⁷³ Ibid, 4.

⁴⁷⁴ Sean Teehan, "After Year of Disruptions, CT Manufacturers Rethink Supply Chain Strategies," Hartford Business Journal, April 19, 2021, accessed October 31, 2023, <https://www.hartfordbusiness.com/article/after-year-of-disruptions-ct-manufacturers-rethink-supply-chain-strategies>.

⁴⁷⁵ State of Connecticut, "Connecticut's Manufacturing Strategic Plan 2023," 11-13

⁴⁷⁶ Ibid, 12.

⁴⁷⁷ Ibid.

⁴⁷⁸ State of Connecticut, "Connecticut's Manufacturing Strategic Plan 2023," 12.

⁴⁷⁹ "CONNEX Connecticut," CBIA, February 3, 2023, accessed October 30, 2023, <https://www.cbia.com/resources/manufacturing/connex-connecticut/>.

Manufacturing sector. For many small- and mid-sized businesses, it can be difficult to transition to automation and adopt new technologies, both financially and logistically.⁴⁸⁰ To help these manufacturers acquire this technology and remain competitive among an expanding market, several programs and tools are outlined in the strategic plan.⁴⁸¹ These include funding the Digital Transformation Program at Connecticut Center for Advanced Technology; providing Smart Industry Readiness Index (SIRI) and cybersecurity assessments to small- and mid-sized manufacturers; and developing an Office of Manufacturing website to disseminate information on available funding and initiatives. Collectively, the strategies outlined aim to solidify and strengthen Connecticut's role in manufacturing, while increasing the resiliency and diversity of the state's supply chain.

Kentucky

Manufacturing is integral to Kentucky's economy, representing the state's third-largest industry by employment levels in 2022.⁴⁸² In addition to the manufacturing base, Kentucky also has a strong logistics and distribution industry and is the second-largest air cargo state with shipping hubs from Amazon Air, UPS, and DHL.⁴⁸³ In March 2023, "Supply Kentucky" was launched in an effort to increase job growth, strengthen supply chains, and reduce costs associated with manufacturing.⁴⁸⁴ Through a partnership between the State and the Kentucky Association of Manufacturers (KAM), Kentucky joined the CONNEX™ Marketplace, which was developed to join manufacturers and suppliers within states, regions, and across the country.⁴⁸⁵

On CONNEX™ Kentucky, manufacturers can register and find local suppliers to meet their current needs, search for other domestic suppliers, or find suppliers that can meet the demands of new or evolving industries.⁴⁸⁶ Kentucky is also seeking to expand the state's role as a leader in manufacturing and capitalize on their skilled workforce and logistical infrastructure.⁴⁸⁷ In addition to its existing manufacturing base, the state is trying to bolster its presence in the growing agritech industry. Several projects are currently underway, including

⁴⁸⁰ Erica Phillips, "Tech Is Changing Connecticut Manufacturing. Can Business Keep Up?" CT Mirror, February 19, 2023, accessed October 30, 2023, <https://ctmirror.org/2023/02/19/ct-manufacturing-industry-4-0-business-tech-ai-robotics-colleges-universities/>.

⁴⁸¹ State of Connecticut, "Connecticut's Manufacturing Strategic Plan 2023," 12-13.

⁴⁸² "Employment and Wages by Industry," Kentucky Center for Statistics, accessed October 9, 2023, <https://kystats.ky.gov/KYLM/I/QCEWCoveredEmployment>.

⁴⁸³ "Kentucky Uniquely Positioned to Prosper Post-Pandemic," Kentucky Cabinet for Economic Development, accessed October 10, 2023, https://ced.ky.gov/Newsroom/Article/20200901_post_pandemic.

⁴⁸⁴ Bruce Schreiner, "Governor Launches Supply Chain Initiative for Kentucky," *Associated Press*, March 6, 2023, accessed October 9, 2023, <https://apnews.com/article/kentucky-economy-supply-chain-andy-beshear-0e8bf37f0e3709a9cdb7f19eb438dbc4>.

⁴⁸⁵ "New 'Supply Kentucky' Initiative Ensures the Commonwealth's Supply Chain Will Continue to Thrive," Building Kentucky, March 24, 2023, accessed October 9, 2023, <https://buildingkentucky.com/news/new-supply-kentucky-initiative-ensures-the-commonwealths-supply-chain-will-continue-to-thrive/>.

⁴⁸⁶ "New 'Supply Kentucky' Initiative Ensures the Commonwealth's Supply Chain Will Continue to Thrive," Building Kentucky.

⁴⁸⁷ "Kentucky Uniquely Positioned to Prosper Post-Pandemic," Kentucky Cabinet for Economic Development.

the construction of a \$97 million high-tech greenhouse that is expected to create 285 new jobs.⁴⁸⁸

As shown throughout this section, numerous initiatives and programs have been created to address the challenges many states and firms have faced. While some of these were created in response to COVID-19, others predate the pandemic and have shifted to address evolving needs. Collectively, these programs show that efforts to bolster supply chain operations have become a top priority by both industry groups and governing bodies.

9.0 Strengths, Weaknesses, Opportunities and Threats

This section integrates the previous research and findings to present a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, which forms the basis of the key points and actionable items for the Maryland Department of Commerce's consideration. The SWOT analysis considers four different items, outlined below.

- *Strengths*: Internal assets or advantages that the entity being evaluated possesses or can access.
- *Weaknesses*: Internal shortcomings or faults that the entity being evaluated struggles with.
- *Opportunities*: External factors or situations that could benefit the entity being evaluated.
- *Threats*: External factors or situations that could harm the entity being evaluated.

The SWOT analysis is divided into two subsections. The first provides factors from the analysis and interviews that align with each component of the SWOT. These factors are then evaluated in the context of a cross analysis that highlights strategies for building resiliency and strengthening Maryland's supply chain.

9.1 SWOT Items

In order to conduct a SWOT analysis, RESI first identified various strengths, weaknesses, opportunities, and threats to supply chain operations in Maryland based on the information in this report. These factors are outlined in Figure 28 below.

⁴⁸⁸ "How Industry Strength, Location Prime Kentucky for Post-pandemic Growth," Kentucky Cabinet for Economic Development, accessed October 30, 2023, https://ced.ky.gov/Newsroom/Article/20200701_ky_prime.

Figure 28: SWOT Items for Maryland Supply Chain

Factor	Examples Relating to Maryland Supply Chain
Strengths	<ul style="list-style-type: none"> • High-tech job opportunities in <i>Manufacturing/Transportation and Warehousing</i> industries • Proximity to major transportation routes (airports, ports, rail, interstate) • Existing labor force and industry development programs • Local sourcing advantage for service-oriented industries • Above-average wages in Maryland's <i>Manufacturing</i> workforce
Weaknesses	<ul style="list-style-type: none"> • Limited physical space and high expansion costs • Relatively high labor costs in Maryland • Transition to responsive inventory systems still in progress • Aging infrastructure impacting transportation efficiency • Limited awareness of CONNEX™ Maryland/DC Marketplace • Changing state regulations, particularly environmental • Inflexible industry positions regarding work environment • Size limitations of current Manufacturing base (LQ) • Reliance on external sources for Manufacturing commodities
Opportunities	<ul style="list-style-type: none"> • Growth potential with the new CONNEX™ Maryland/DC Marketplace • Opportunities for commodity production expansion in regional gaps • Federal funding opportunities (CHIPS Act, Inflation Reduction Act, Infrastructure Investment and Jobs Act) • Ongoing infrastructure projects such as the Howard Street Tunnel expansion • Adoption of technological/automated systems for warehouse management and logistics • Capitalizing on demand for sustainable goods and services • Collaboration with colleges/universities for workforce training • Diversity and inclusion initiatives for workforce expansion
Threats	<ul style="list-style-type: none"> • Tight labor market and competition with tech sector • Increasing flexibility and remote work options from many employers • Geopolitical tensions impacting supply chains • Costly transportation delays (e.g., port truck driver wait times, chassis shortage increasing wait times) • High inflation and price volatility in the market

Sources: Interview participants, RESI

9.2 SWOT Cross Analysis

Once SWOT items are identified, they can be used to gain additional insight on an organization's standing in its environment. The SWOT analysis allows for a well-rounded assessment by considering organizational characteristics within the context of external realities. The insight gained from a SWOT analysis can help organizations make realistic changes and/or

facilitate the planning process. Each Strength and Weakness is paired with an Opportunity or Threat to create innovative and efficient solutions. The pairings are defined as follows:

- Strengths with Opportunities: Using strengths to take advantage of new opportunities and using external opportunities to further boost strengths;
- Weaknesses with Opportunities: Using external opportunities to combat internal challenges;
- Strengths with Threats: Identifying internal strengths could be used to insulate against external challenges;
- Weaknesses with Threats: Considering how external conditions could exacerbate internal weaknesses and creating strategies to avoid them.

Using the information in the earlier sections of this report as a basis for this analysis, RESI paired complementary SWOT attributes to identify potential avenues of success for improving supply chain operations in Maryland. These findings are detailed in Figure 29 below.

Figure 29: 2X2 SWOT Analysis Matrix of Maryland and Key Supply Chain Industries

	Strengths	Weaknesses
Opportunities	<ul style="list-style-type: none"> • Increase availability of pipeline programs for <i>Manufacturing</i> workforce, including more advanced and high-tech roles. • Evaluate potential for regional specialization in semiconductor chip manufacturing or related research and development with federal funding support. • Capitalize on consumer willingness to pay a premium for sustainably and responsibly produced goods and services. 	<ul style="list-style-type: none"> • Ensure all Maryland manufacturers are familiar with available resources—CONNEX™ Maryland/DC is relatively new and may not be known to a significant number of firms. • Help companies to shift to more technological/automated systems that assist with efficient management of warehouses, inventory, ordering, etc. • Evaluate potential for expansion of commodity production where large regional gaps exist.
Threats	<ul style="list-style-type: none"> • Emphasize the advanced needs of the <i>Manufacturing</i> industry to potential employees and work to rebrand the industry in the state. • Use the state’s geographic location to develop alternative transportation routes to protect against shocks. 	<ul style="list-style-type: none"> • Create an up-to-date system that tracks and reports changing State regulations, particularly those with respect to environmental factors that impact <i>Manufacturing</i> firms. • Increase awareness of programs and initiatives available within the state. If necessary, knowledge can be increased through marketing, outreach campaigns, or other support to increase utilization.

Source: RESI

Strengths/Opportunities: Strategies to Explore

Maryland has a diverse and educated workforce, which presents an opportunity to expand key industries such as *Manufacturing* and *Transportation and Warehousing*. The state's colleges and universities produce a wide range of qualified workers each year, which can help fill the demand for technical backgrounds needed in these industries. However, competition with other industries for educated graduates along with a low number of training opportunities for some roles (e.g., Machinists) has contributed to hiring challenges. To address these issues and capitalize on the available talent pool, facilitators could help to increase utilization of existing training opportunities and work with local educators to create pipeline programs to connect qualified workers with employers. Facilitators could include Commerce, manufacturers, industry organizations, or other stakeholders.

Federal funding available through the CHIPS Act presents an opportunity for the state to increase its role in the domestic supply chain of semiconductor chips. Funds are not isolated to manufacturing and can also be used for research and development purposes. Prince George's County is currently seeking federal funding to support a regional technological hub that would utilize the existing infrastructure and the concentration of Engineers and Computer Scientists in the area. Commerce could potentially work with county organizations and state universities to collaborate and strengthen these efforts.

Another potential opportunity lies in consumers' willingness to pay a premium for sustainably produced products. Specifically, Commerce may choose to investigate industries such as *Other Food Manufacturing* and *Other Furniture Related Product Manufacturing* to determine what barriers exist to production of these specialty products. This may also involve assisting firms with increasing supply chain transparency and diversification. With changing consumer preferences, strengthening the sustainable aspects of production may be an avenue to cost-effectively grow the *Manufacturing* base in the state.

Strengths/Threats: Strategies to Avoid Threats

With the shift in technologies being used in the *Manufacturing* sector, there is an opportunity to help rebrand the industry and attract from the pool of highly skilled labor in Maryland. Factors including negative industry perceptions and limited remote work abilities for some roles have hindered hiring and retainment efforts. This is particularly challenging amid a tight labor market, with multiple employers competing for the same skilled workers. However, Maryland's higher-than-average wages can be used as a selling point to attract employees in light of inflexible work options. Further, an industry rebranding campaign that highlights the advanced technologies being used, the need for skilled workers, and reframing *Manufacturing's* image could bolster interest. This may involve outreach efforts to colleges and universities showcasing career paths and evolving opportunities within the industry,

Maryland benefits from its strategic positioning along the East Coast. With access to five ports, BWI Airport, rail, and links to several interstate highways, one-third of the American population

is accessible by overnight transport.⁴⁸⁹ This geographical strength allows Maryland the opportunity to attract new business to the state and remain a competitive location for current organizations to operate within. To protect against transportation disruptions, contingency plans can be developed for firms to use in the event that preferred transport modes or routes are unavailable or experience price volatility.

Weaknesses/Opportunities: Strategies to Exploit

Maryland has several initiatives meant to aid in easing supply chain challenges, though these resources may not be known by all firms in the state. Programs such as the Maryland MEP, Maryland Manufacturing 4.0, EARN Maryland, and CONNEX™ Maryland/DC Marketplace all serve to strengthen key industries in supply chain operations. Ensuring that all manufacturers are aware of these resources will play an integral role in their adoption and widen the impacts that these programs can potentially have. Similarly, Maryland also has tax incentives that are offered to manufacturers that operate within HUBZones, providing manufacturers an opportunity to benefit from locating their operations within these areas.

According to the commodity analysis, Maryland is less likely to have the material inputs needed for *Manufacturing* industries within the region compared to service-based sectors. Because Maryland is an import-heavy region, it is important that strengths in logistics and service industries be capitalized on in developing risk mitigation strategies. Several interviewees reported ways they mitigate risk in their operations, such as regular monitoring, reducing the instances of single point failures, investing in training opportunities to increase worker efficiency, and material substitution and diversifying suppliers. Utilizing new technologies and automated systems can further increase the efficiency of operations and allow firms to quickly adapt to changing conditions. Adoption of quality standards such as the ISO 9001 also serves as a way for organizations to identify and reduce risks associated with their operations.

The commodity analysis also revealed several industries with a significant gap between gross and regional absorption levels, indicating that industry firms are relying on suppliers outside the region for production. This is an opportunity for Commerce to work with industry firms to identify what the barriers are to local purchasing and evaluate whether regional conditions would enable local production. Further, this is also an opportunity to leverage the power of the CONNEX™ Marketplace to make inquiries on production feasibility by in-state firms that may not be aware of these commodity needs.

Weaknesses/Threats: Strategies to Confront

The commodity analysis highlighted that for the Manufacturing firms evaluated, many of the top commodities are sourced from outside of the region. Coupled with uncertainty surrounding price volatility, geopolitics, and transportation-related delays, this leaves firms vulnerable to shortages and other disruptions that impact operations. To mitigate associated risks, supply chain diversity and system flexibility are crucial factors. Although some firms have moved to

⁴⁸⁹ "Maryland at a Glance," Port of Baltimore, Maryland, accessed August 10, 2023, <https://msa.maryland.gov/msa/mdmanual/01glance/html/port.html>.

more technologically advanced and automated systems, there is still a transition taking place for many companies. With Maryland Manufacturing 4.0 there are funding opportunities available to aid with these upgrades, but companies need to be aware of these to apply.

Further, the CONNEX™ Maryland/DC Marketplace is relatively new and may not be known to a significant number of manufacturers. One potential threat to local sourcing efforts is if the marketplace experiences limited adoption due to lack of awareness amongst manufacturers. It would be useful to assess the level of awareness of the CONNEX™ marketplace and similar programs. If necessary, awareness can be increased through marketing and outreach campaigns, incentives for early adopters, or training and support for marketplace utilization.

Several experts who were interviewed noted that they had difficulty keeping up with changing regulations, particularly with respect to Maryland's environmental directives. While there is a wealth of information to be found on regulations, tax incentives, and industry programs, this information is dispersed through a number of websites including Commerce, Maryland MEP, and other State agencies. To help firms find information in a central location, Commerce could expand upon their current website to include an up-to-date directory of resources, information, and links. Having a single website that highlights new programs, changing regulations, and resources for *Manufacturing* firms in one location would reduce the time needed to stay up to date and increase awareness of resources and programs available to them. Additionally, changing environmental regulations could present an opportunity for manufacturers to invest in sustainable practices to preempt regulatory pressures.

10.0 Conclusion

Based on the comprehensive analysis conducted, several key challenges have emerged within Maryland's relevant supply chain sectors. Labor shortages, exacerbated by pandemic impacts and retirements, have posed significant hurdles for both skilled and unskilled labor markets. Transportation challenges, characterized by disruptions in container shipping and port delays, have led to increased costs and logistical complications. The pandemic also revealed flaws in inventory management practices, prompting organizations to adopt more adaptable strategies. Furthermore, geopolitical factors such as sanctions and conflicts have disrupted transportation routes and raised costs, while a 40-year high for inflation has compounded challenges with the supply of materials and shipping costs.

Within *Manufacturing*, job openings have outpaced hires due to a lack of qualified applicants and negative industry perceptions. Despite this, Maryland's *Manufacturing* employment growth has exceeded the national average, with ongoing efforts to enhance gender and racial diversity within the industry. Similar trends are observed in the *Transportation and Warehousing* sector, where job openings have surpassed hires amidst increased demand, compounded by lower-than-average annual pay. The industry profiles show that the pandemic has had varied impacts across industries, with some sectors experiencing increased demand, while others grappled with challenges such as semiconductor shortages. Sustainability concerns have also influenced consumer behavior, underscoring the importance of environmentally responsible practices.

The IMPLAN commodity analysis revealed a heavy reliance on external sources for *Manufacturing* industries, highlighting the need to strengthen local supply chains. Company interviews identified Maryland's strengths, including tax advantages, robust transportation infrastructure, and an educated workforce, alongside challenges such as labor supply constraints and transportation inefficiencies.

To address these challenges, experts are implementing diverse strategies tailored to their specific circumstances. Both federal and state initiatives aim to enhance supply chain resilience and support manufacturing and workforce development.

Based on the information outlined in this report, several key strategies can be explored to capitalize on strengths and opportunities, mitigate threats, and address weaknesses.

- **Facilitate Training and Education Programs:** To address hiring challenges and capitalize on Maryland's educated workforce, facilitators such as Commerce, industry organizations, and stakeholders can collaborate to increase awareness and utilization of existing training opportunities. Creating pipeline programs with local educators can also help connect qualified workers with employers, particularly in roles with limited training options.
- **Leverage Federal Funding Opportunities:** Maryland can harness federal funding available through initiatives such as the CHIPS Act to bolster its semiconductor industry and support regional technological hubs. Collaborative efforts with county organizations and state universities can strengthen these endeavors.
- **Explore Sustainable Production:** With growing consumer demand for sustainably produced goods, Commerce can investigate industries like *Other Food Manufacturing* and *Other Furniture Related Product Manufacturing* to identify barriers to production. Assistance in increasing supply chain transparency and diversification can further strengthen the state's *Manufacturing* base.
- **Rebranding and Technology Adoption:** Maryland has the opportunity to rebrand its *Manufacturing* industry to attract skilled labor by highlighting advanced technologies and evolving career opportunities. Outreach efforts to colleges and universities can showcase these career paths and combat negative industry perceptions.
- **Develop Contingency Plans:** Given Maryland's strategic geographical positioning, the state can attract new businesses and remain competitive by developing contingency plans to address transportation disruptions. Collaboration with firms to develop and implement these plans will be crucial.
- **Promote Awareness of Support Programs:** Programs including the Maryland MEP, Maryland Manufacturing 4.0, and CONNEX™ Maryland/DC Marketplace play vital roles

in strengthening supply chain operations. Promoting awareness and adoption of these resources among manufacturers will be essential.

- **Identify Barriers to Local Production:** Maryland can work with industry firms to identify barriers to local production and evaluate regional conditions to enable local production. Leveraging the CONNEX™ Marketplace can facilitate inquiries on production feasibility by in-state firms.
- **Centralize Information Resources:** To help firms navigate changing regulations and access support programs, Commerce can expand its website to include a centralized directory of resources, updates on regulations, and information on industry programs.

Within these recommendations, there are areas that warrant further research stemming from the findings in the current analysis. Evaluation of the top commodities with the greatest reliance on out-of-region suppliers, as shown in Section 6, would help to assess specific barriers to local production or sourcing issues. Further research could help determine, for example, whether a commodity is being produced in the region but does not meet the exact specifications needed for industry production. There could also be potential connection issues between suppliers and producers, indicating that the commodity could be obtained from within the region but there is a lack of awareness. Identifying the specific issues with local production or purchasing could help to bolster regional availability of these critical commodities and strengthen industry supply chains. Further, information gained from more research could help to determine whether beginning or expanding local production could be an economic opportunity for the state.

Related to the above point, more research could help to assess awareness and utilization levels of the CONNEX™ Maryland/DC Marketplace. Because the CONNEX™ Maryland/DC Marketplace was launched less than one year ago, Maryland manufacturers may not be fully aware of the platform and its capabilities. Based on the findings gained from this additional research, more conclusions could be drawn on whether local purchasing is more limited by commodity availability or a lack of knowledge that there are underutilized local suppliers.

By implementing these strategies and conducting follow-up research, Maryland can effectively capitalize on its strengths, address weaknesses, navigate potential threats, and explore emerging opportunities. With these efforts, the state can better position itself for sustained growth while also improving resiliency in Maryland's supply chains.

References

- Ahmed, Saqib Iqbal. "King Dollar Seen Vulnerable in 2024 If Fed Pivots." *Reuters*, December 29, 2023. Accessed April 1, 2024. <https://www.reuters.com/markets/currencies/king-dollar-seen-vulnerable-2024-if-fed-pivots-2023-12-20/>.
- Ahmed, Zahra. "Top 10 Largest and Busiest Container Ports in the United States." May 4, 2023. Accessed October 16, 2023. <https://www.marineinsight.com/know-more/top-10-largest-and-busiest-container-ports-in-the-united-states/>.
- Alper, Alexandra, Stephen Nellis, and Heekyong Yang. "Samsung's New Texas Chip Plant Cost Rises Above \$25 Billion." *Reuters*, March 15, 2023. Accessed September 5, 2023. <https://www.reuters.com/technology/samsungs-new-texas-chip-plant-cost-rises-above-25-billion-sources-2023-03-15/>.
- Altomonte, Leon. "Food Chain Supply." *Safety Culture*. June 16, 2023. Accessed July 19, 2023. <https://safetyculture.com/topics/food-supply-chain/>.
- Aviation Pros. "Industry Outlook: Commercial Aviation Post Pandemic." March 11, 2021. Accessed November 21, 2023. <https://www.aviationpros.com/aircraft/article/21210525/industry-outlook-post-pandemic>.
- Baluch, Anna, and Cassie Bottorff. "What Is Just in Time Inventory (JIT)?" *Forbes*, October 12, 2022. Accessed February 3, 2023. <https://www.forbes.com/advisor/business/just-in-time-inventory/>.
- Banker, Steve. "Warehouse Woes are Worse than Ever." *Forbes*, October 12, 2021. Accessed August 11, 2023. <https://www.forbes.com/sites/stevebanker/2021/10/12/warehouse-labor-woes-are-worse-than-ever/?sh=6e40b7778aaf>.
- Bhattarai, Abha. "Booming Furniture Sales Mean 'Unprecedented' Delays for Sofas and Desks." *The Washington Post*, March 8, 2021. Accessed July 13, 2023. <https://www.washingtonpost.com/business/2021/03/08/furniture-sales-pandemic/>.
- Broom, Douglas. "Global Music Sales Hit a New Record In 2021 Thanks to the Rapid Growth of Streaming." *World Economic Forum*. April 20, 2022. Accessed July 31, 2023. <https://www.weforum.org/agenda/2022/04/music-sales-record-streaming-surge/>.
- Brown, Chad P. "Four Years Into the Trade War, Are the US and China Decoupling?" *Peterson Institute for international Economics*. October 20, 2022. Accessed December 19, 2023. <https://www.piie.com/blogs/realtime-economics/four-years-trade-war-are-us-and-china-decoupling>.

- Building Kentucky. "New 'Supply Kentucky' Initiative Ensures the Commonwealth's Supply Chain Will Continue to Thrive." March 24, 2023. Accessed October 9, 2023.
<https://buildingkentucky.com/news/new-supply-kentucky-initiative-ensures-the-commonwealths-supply-chain-will-continue-to-thrive/>.
- Burns, Jonathan. "Industry Report 48831, Port & Harbor Operations in the US." IBIS World (March 2023). Accessed July 28, 2023.
<https://my.ibisworld.com/us/en/industry/48831/at-a-glance>.
- The Business Research Company. "Search, Detection, and Navigation Instruments Global Market Report 2023 – By Type." January 2023. Accessed July 27, 2023.
<https://www.thebusinessresearchcompany.com/report/search-detection-and-navigation-instruments-global-market-report>.
- California Governor's Office of Business and Economic Development. "California Supply Chain Success Initiative – A Summary Report – 2022." Accessed October 16, 2023.
https://business.ca.gov/wp-content/uploads/2022/11/Supply-Chain-Initiative-Report-2022_GOBiz.pdf.
- Cantwell, Robert H. "North American Rail Supply and the Global Supply Risk: Why We Should Be Concerned." Railway Age. June 16, 2023.
<https://www.railwayage.com/mechanical/freight-cars/north-american-rail-supply-and-the-global-supply-risk-why-we-should-be-concerned/>.
- Carrier, Frédérique. "The Chip Industry's Reshoring Revolution." RBC. November 14, 2023. Accessed November 21, 2023. <https://www.rbcwealthmanagement.com/en-us/insights/the-chip-industrys-reshoring-revolution>.
- Casanova, Robert. "The CHIPS Act Has Already Sparked \$200 Billion in Private Investments for U.S. Semiconductor Production." Semiconductor Industry Association. Last updated August 15, 2023. <https://www.semiconductors.org/the-chips-act-has-already-sparked-200-billion-in-private-investments-for-u-s-semiconductor-production/>.
- CBIA. "CONNEX Connecticut." February 3, 2023. Accessed October 30, 2023.
<https://www.cbia.com/resources/manufacturing/connex-connecticut/>.
- Centers for Disease Control and Prevention. "Current and Past Multistate Foodborne Outbreaks." Accessed November 14, 2023.
<https://www.cdc.gov/foodsafety/outbreaks/lists/index.html>.
- Centers for Disease Control and Prevention. "Isolation and Precautions for People with COVID-19, COVID-19." Last modified May 11, 2023. Accessed August 8, 2023.
<https://www.cdc.gov/coronavirus/2019-ncov/your-health/isolation.html>.

- Chevalier, Stephanie. "Retail E-Commerce Sales Worldwide from 2014 to 2026." Statista. September 21, 2022. Accessed December 20, 2023.
<https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/>.
- CHIPS Incentives Program. "CHIPS Incentives Program – Commercial Fabrication Facilities." June 22, 2023. Accessed September 12, 2023.
<https://www.nist.gov/system/files/documents/2023/06/23/CHIPS-Commercial%20Fabrication%20Facilities%20NOFO%20Amendment%201.pdf>.
- Clouse, Candi. "Social Accounts." IMPLAN. Accessed January 10, 2023.
<https://support.implan.com/hc/en-us/articles/360036665954-Social-Accounts>.
- CollegeGrad. "Computer Systems Design and Related Services Industries." Accessed July 27, 2023. <https://collegegrad.com/industries/computer-systems-design>.
- CollegeGrad. "Management, Scientific, and Technical Consulting Services Industries." Accessed May 4, 2023. <https://collegegrad.com/industries/management-scientific-and-technical-consulting-services>.
- CollegeGrad. "Scientific Research and Development Services Industries." Accessed May 4, 2023. <https://collegegrad.com/industries/scientific-research-and-development-services>.
- Comte, Matthew. "How to Manage Supply Chain Risk During Geopolitical Unrest." PwC. March 18, 2022. Accessed July 8, 2023.
<https://www.pwc.com/us/en/services/consulting/business-transformation/library/supply-chain-geopolitical-unrest.html>.
- Congressional Research Service. "Supply Disruptions and the U.S. Economy." May 13, 2022. Accessed October 11, 2022. <https://crsreports.congress.gov/product/pdf/IN/IN11926>.
- CONNEX Marketplace. "About Us." Accessed October 23, 2023.
<https://connexmarketplace.com/about/>.
- CONNEX Marketplace. "A Match Made in America." Accessed October 30, 2023.
<https://connexmarketplace.com/>.
- CONNEX Marketplace. "CONNEX Maryland Launches to Help Connect Regional Supply Chain." June 6, 2023. Accessed October 30, 2023.
<https://connexmarketplace.com/press/connex-maryland-launch/>.
- CONNEX Marketplace. "Introduction to CONNEX Marketplace." Accessed October 30, 2023.
<https://youtu.be/3IhEtTjs5CU>.

CONNEX Marketplace. “Our Partners.” Accessed October 30, 2023.
<https://connexmarketplace.com/partners/>.

Cushman & Wakefield. “U.S. 2022 Ports Update: Industrial Insights: United States.” Accessed July 27, 2023. <https://www.cushmanwakefield.com/en/united-states/insights/north-american-ports-report>.

Czímer, Balázs, Miklós Dietz, Valéria László, and Joydeep Sengupta. The Future of Banks, A \$20 Trillion Breakup Opportunity.” McKinsey & Company. December 20, 2022. Accessed July 24, 2022. https://www.mckinsey.com/industries/financial-services/our-insights/the-future-of-banks-a-20-trillion-dollar-breakup-opportunity#/.

Daily State News. “Program Accepting Grant Applications from Delaware Food Producers.” April 28, 2022. Accessed October 16, 2023. <https://baytobaynews.com/stories/program-accepting-grant-applications-from-delaware-food-producers,77436>.

Davis, Krissy, Julia Cloud, Tony Gaughan, and Doug Dannemiller. “2023 Investment Management Outlook.” Deloitte Center for Financial Services (2022). Accessed July 23, 2023. https://www2.deloitte.com/content/dam/insights/articles/us175546_cfs_fsi-outlook-investment-mgmt/DI_US175546_CFS_FSI-Outlook-Investment-mgmt.pdf.

Deloitte. “2023 Manufacturing Industry Outlook.” November 2022. Accessed August 2, 2023. <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/us-2023-outlook-manufacturing.pdf>.

Deloitte. “A Look Ahead – How Modern Manufacturers Can Create Positive Perceptions with the US Public.” Accessed November 14, 2023. <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-public-perception-manufacturing-study.pdf>.

Desilver, Drew. “As Inflation Soars, A Look at What’s Inside the Consumer Price Index.” Pew Research Center. January 24, 2022. Accessed July 19, 2023. <https://www.pewresearch.org/short-reads/2022/01/24/as-inflation-soars-a-look-at-whats-inside-the-consumer-price-index/>.

Domen, John. “The Effort to Bring More ‘Chips’ into Prince George’s Co.-Microchips.” *WTOP News*, July 12, 2023. Accessed September 12, 2023. <https://wtop.com/prince-georges-county/2023/07/the-effort-to-bring-more-chips-into-prince-georges-co-microchips-overnighter-too-btw/>.

Domonoske, Camila. “A Remote Work Revolution is Underway – But Not for Everyone.” *NPR*, May 6, 2021. Accessed August 7, 2023. <https://www.npr.org/2021/05/06/994274793/a-remote-work-revolution-is-underway-but-not-for-everyone>.

- Doyle, William P. "Improvements Are Coming to Shorten Turnaround Times." *The Port of Baltimore*, 2022 No. 3. Accessed November 30, 2023.
<https://mpa.maryland.gov/Port%20of%20Baltimore%20Magazines/pobIssue3in2022.pdf>.
- Edwards, Darci. "Life Sciences: The Challenges of Research & Development." Lockton. September 26, 2022. Accessed May 4, 2023. <https://global.lockton.com/gb/en/news-insights/life-sciences-the-challenges-of-research-and-development>.
- Egan, Matt. "American Factories are Desperate for Workers. It's a \$1 Trillion Problem." *CNN*, May 4, 2021. Accessed August 8, 2023.
<https://www.cnn.com/2021/05/04/economy/manufacturing-jobs-economy/index.html>."
- Epstein, Adam. "Game On: How COVID-19 Became the Perfect Match for Gamers." World Economic Forum, September 28, 2020, accessed July 31, 2023.
<https://www.weforum.org/agenda/2020/09/COVID19-coronavirus-pandemic-video-games-entertainment-media/>.
- Federal Reserve Bank of New York. "Global Supply Chain Pressure Index (GSCPI)." Accessed November 13, 2023. <https://www.newyorkfed.org/research/policy/gscpi#/interactive>.
- Federal Reserve Bank of St. Louis. "Industrial Production: Manufacturing: Durable Goods: Furniture and Related Product (NAICS = 337)." Last modified June 15, 2023. Accessed July 13, 2023. <https://fred.stlouisfed.org/series/IPG337S#>.
- Federal Reserve Bank of St. Louis. "Producer Price Index by Industry: Total Manufacturing Industries." Accessed August 8, 2023.
<https://fred.stlouisfed.org/series/PCUOMFGOMFG>.
- Fidelity. "What is Blockchain? Here's What You Need to Know About the Technology Powering Cryptocurrencies." June 23, 2022. Accessed July 31, 2023.
<https://www.fidelity.com/learning-center/trading-investing/what-is-blockchain>.
- Fitzgerald, Tom. "Proposed Chip Act Aims to Boost High-tech Manufacturing in Prince George's County." *FOX 5*, July 11, 2023. Accessed September 12, 2023.
<https://www.fox5dc.com/news/proposed-chip-act-aims-to-boost-high-tech-manufacturing-in-prince-georges-county>.
- Food and Agriculture Organization of the United Nations. "Is Our Food Supply at Risk?" Last modified 2021. Accessed July 19, 2023.
<https://www.fao.org/state-of-food-agriculture/en/>.

Fhyzics. "Railroad Rolling Stock Manufacturing, SOP Manual SOP-590." December 18, 2020.
<https://blog.fhyzics.net/sop/railroad-rolling-stock-manufacturing-sop-manual>.

Fortune Business Insights. "Blinds & Shades Market Size, Share & COVID-19 Impact Analysis." Accessed May 10, 2023. <https://www.fortunebusinessinsights.com/blinds-and-shades-market-104636>.

Fortune Business Insights. "U.S. Medical Devices Market Size, Share & COVID-19 Impact Analysis." May 2023. Accessed August 1, 2023.
<https://www.fortunebusinessinsights.com/u-s-medical-devices-market-107009>.

Fowler, Kristen. "Five Reasons Labor Shortages Are Impacting Supply Chains." *Forbes*, October 19, 2021. Accessed January 20, 2023.
<https://www.forbes.com/sites/forbeshumanresourcescouncil/2021/10/19/five-reasons-labor-shortages-are-impacting-supply-chains/?sh=22b154375b94>.

Franklin Templeton Institute. "Allocation Views, Storm Clouds on the Horizon." December 2022. Accessed July 28, 2022. <https://franklintempletonprod.widen.net/content/hxujzbwto/pdf/allocation-views-storm-clouds-on-the-horizon-1222-u.pdf>.

Frazin, Rachel. "Passenger Train Could Help Combat Climate Change – If Rail Can Actually Get Built." *The Hill*. December 15, 2023. Accessed February 6, 2024.
<https://thehill.com/policy/energy-environment/4361262-passenger-trains-climate-change-building-hurdles/>.

Friesen, Garth. "The End of the Supply Chain Crisis: A Relief from Inflationary Pressures." *Forbes*, July 9, 2023. Accessed July 19, 2023.
<https://www.forbes.com/sites/garthfriesen/2023/07/09/the-end-of-the-supply-chain-crisis-a-relief-from-inflationary-pressures/?sh=1852b8a64422>.

FTI Consulting. "Looking Ahead: Risk Outlook for the Medical Device Supply Chain." January 12, 2023. Accessed Aug 1, 2023. <https://www.fticonsulting.com/insights/white-papers/looking-ahead-risk-outlook-medical-supply-chain#:~:text=Geopolitical%20volatility%2C%20energy%20crises%2C%20health,disruptions%20and%20long%20lead%20times>.

General Kinematics. "Batch vs. Continuous Pharmaceutical Manufacturing." Accessed August 7, 2023. <https://www.generalkinematics.com/blog/batch-vs-continuous-pharmaceutical-manufacturing/>.

Gittleman, Maury. "The "Great Resignation" in Perspective." U.S. Bureau of Labor Statistics. July 2022. Accessed July 19, 2023. <https://www.bls.gov/opub/mlr/2022/article/the-great-resignation-in-perspective.htm>.

- Glynn, Fergal. "Eight Warehousing Trends Continuing in 2022: What You Need to Know." 6 River Systems. January 18, 2023. <https://6river.com/eight-warehousing-trends-continuing-in-2022-what-you-need-to-know/>.
- GlobeNewswire. "Global Management Consulting Services Market Share Is Projected to Reach USD 477.3 Billion by 2033, At a CAGR Of 4.8%: Fact.MR Analysis." Last modified February 21, 2023. Accessed May 10, 2023. <https://www.globenewswire.com/en/news-release/2023/02/21/2612637/0/en/Global-Management-Consulting-Services-Market-Share-Is-Projected-To-Reach-USD-477-3-Billion-by-2033-At-a-CAGR-Of-4-8-Fact-MR-Analysis.html>.
- Goodman, Peter, and Niraj Chokshi. "Global Shortages During Coronavirus Reveal Failings of Just in Time Manufacturing." *The New York Times*, October 22, 2021. Accessed January 20, 2023. <https://www.nytimes.com/2021/06/01/business/coronavirus-global-shortages.html>.
- Goodman, Peter S. "The Real Reason America Doesn't Have Enough Truck Drivers." *The New York Times*, February 9, 2022. Accessed December 18, 2023. <https://www.nytimes.com/2022/02/09/business/truck-driver-shortage.html>.
- Grand View Research. "U.S. Communication Equipment Market." Accessed July 6, 2023. <https://www.grandviewresearch.com/industry-analysis/us-communication-equipment-market>.
- Groombridge, David. "Gartner Top 10 Strategic Technology Trends for 2023." Gartner. Last modified October 17, 2022. Accessed May 10, 2023. <https://www.gartner.com/en/articles/gartner-top-10-strategic-technology-trends-for-2023>.
- Ha, Jongrim, M. Ayhan Kose, and Franziska Ohnsorge. "Inflation During the Pandemic: What Happened? What is Next?" World Bank Group (July 2021). Accessed July 19, 2023. <https://thedocs.worldbank.org/en/doc/1ad246272dbbc437c74323719506aa0c-0350012021/related/WP-inflation.pdf>.
- Hamilton, Eric. "The Global Supply Chain Consequences of the Russia-Ukraine War." University of Florida News. February 21, 2023. Accessed December 19, 2023. <https://news.ufl.edu/2023/02/russia-ukraine-global-supply-chain/>.
- Haan, Katherine and Kelly Main. "Remote Work Statistics and Trends In 2023." Forbes Advisor. June 12, 2023. Accessed December 10, 2023. <https://www.forbes.com/advisor/business/remote-work-statistics/>.

- Hanbury, Mary. "Retailers Struggle to Hire Warehouse Workers Ahead of the Holidays." *Business Insider*. October 13, 2021. Accessed August 11, 2021.
<https://www.businessinsider.com/labor-shortage-warehouse-jobs-workers-put-off-hours-conditions-2021-10>.
- Hong, Jinshan and Anthony Palazzo. "Air Travel Is Back to Pre-pandemic Levels with New Turbulence Ahead." *Bloomberg*, October 8, 2023. Accessed November 21, 2023.
<https://www.bloomberg.com/news/articles/2023-10-08/air-travel-finally-reaches-pre-covid-l-evels-but-profits-suffer?embedded-checkout=true>.
- Hruska, Joel. "Why We Can't Build Our Way Out of the Semiconductor Shortage." *Extreme Tech*. May 11, 2021. Accessed September 11, 2023.
<https://www.extremetech.com/computing/322695-why-we-cant-build-our-way-out-of-the-semiconductor-shortage>.
- IBISWorld. "Aircraft, Engine & Parts Manufacturing in the US." November 2023. Accessed November 21, 2023. <https://www.ibisworld.com/united-states/market-research-reports/aircraft-engine-parts-manufacturing-industry/#CompetitiveForces>.
- IBISWorld. "Blind & Shade Manufacturing-33792, Competitive Forces." Accessed October 31, 2023. <https://my.ibisworld.com/us/en/industry/33792/competitive-forces>.
- IBISWorld. "Communication Equipment Manufacturing in the US – Market Size 2005-2029." January 26, 2023. Accessed July 18, 2023. <https://www.ibisworld.com/industry-statistics/market-size/communication-equipment-manufacturing-united-states/#:~:text=The%20market%20size%2C%20measured%20by,industry%20increased%200.9%25%20in%202022>.
- IBISWorld. "Competitive Forces-5415." Last modified January 2023. Accessed July 27, 2023. <https://my.ibisworld.com/us/en/industry/54151/competitive-forces>.
- IBISWorld. "Competitive Forces, Farm Product Storage & Warehousing in the US." Last modified September 2023. Accessed October 27, 2023. <https://my.ibisworld.com/us/en/industry/49313/competitive-forces>.
- IBISWorld. "Competitive Forces, Port & Harbor Operations in the US." Last modified September 2023. Accessed October 27, 2023. <https://my.ibisworld.com/us/en/industry/48831/competitive-forces>.
- IBISWorld. "Competitive Forces, Public Storage & Warehousing in the US." Last modified September 2023. Accessed October 27, 2023. <https://my.ibisworld.com/us/en/industry/49311/competitive-forces>.

- IBISWorld. "Competitive Forces, Refrigerated Storage in the US." Last modified September 2023. Accessed October 27, 2023.
<https://my.ibisworld.com/us/en/industry/49312/competitive-forces>.
- IBISWorld. "Competitive Forces, Specialized Storage & Warehousing in the US." Last modified September 2023. Accessed October 27, 2023.
<https://my.ibisworld.com/us/en/industry/49319/competitive-forces>.
- IBISWorld. "Competitive Forces, Train, Subway & Transit Car Manufacturing in the US." Last modified September 2023. Accessed October 27, 2023.
<https://my.ibisworld.com/us/en/industry/33651/competitive-forces>.
- IBISWorld. "Generic Pharmaceutical Manufacturing in the US." September 2023. Accessed May 4, 2023. <https://my.ibisworld.com/us/en/industry/32541b/about>.
- IBISWorld. "Industry at a Glance, Communication Equipment Manufacturing in the US." Last modified January 2023. Accessed July 6, 2023.
<https://my.ibisworld.com/us/en/industry/33422/industry-at-a-glance>.
- IBISWorld. "Industry at a Glance, Farm Product Storage & Warehousing in the US." Last modified June 2022. Accessed July 27, 2023.
<https://my.ibisworld.com/us/en/industry/49313/industry-at-a-glance>.
- IBISWorld. "Industry at a Glance, IT Consulting in the US." Last modified January 2023. Accessed July 27, 2023. <https://my.ibisworld.com/us/en/industry/54151/industry-at-a-glance>.
- IBISWorld. "Industry at a Glance, Port & Harbor Operations in the US." Last modified March 2023. Accessed July 27, 2023. <https://my.ibisworld.com/us/en/industry/48831/industry-at-a-glance>.
- IBISWorld. "Industry at a Glance, Public Storage & Warehousing in the US." Last modified March 2023. Accessed July 27, 2023.
<https://my.ibisworld.com/us/en/industry/49311/industry-at-a-glance>.
- IBISWorld. "Industry at a Glance, Refrigerated Storage in the US." Last modified January 2023. Accessed July 27, 2023. <https://my.ibisworld.com/us/en/industry/49312/industry-at-a-glance>.
- IBISWorld. "Industry Outlook, Port & Harbor Operations in the US." Last modified March 2023. Accessed July 27, 2023. <https://my.ibisworld.com/us/en/industry/48831/industry-outlook>.

- IBISWorld. "Industry at a Glance, Specialized Storage & Warehousing in the US." Last modified April 2023. Accessed July 27. <https://my.ibisworld.com/us/en/industry/49319/industry-at-a-glance>.
- IBISWorld. "Industry Performance, Communication Equipment Manufacturing in the US." Last modified January 2023. Accessed July 6, 2023. <https://my.ibisworld.com/us/en/industry/33422/industry-performance>.
- IBISWorld. "Industry Performance, Distribution and Logistics Consulting Services in the US." Accessed May 10, 2023. <https://my.ibisworld.com/us/en/industry-specialized/od6144/industry-performance>.
- IBISWorld. "Industry Performance, IT Consulting in the US." Last modified January 2023. Accessed July 27, 2023. <https://my.ibisworld.com/us/en/industry/54151/industry-performance>.
- IBISWorld. "Industry Performance, Port & Harbor Operations in the US." Last modified March 2023. Accessed July 27, 2023. <https://my.ibisworld.com/us/en/industry/48831/industry-performance>.
- IBISWorld. "Industry Performance, Train, Subway & Transit Car Manufacturing in the US." Last modified April 2023. Accessed July 27, 2023. <https://my.ibisworld.com/us/en/industry/33651/industry-performance>.
- IBISWorld. "Market Research Report, Distribution and Logistics Consulting Services Industry in the US." Last modified March 30, 2023. Accessed May 10, 2023. <https://www.ibisworld.com/united-states/market-research-reports/distribution-logistics-consulting-services-industry/>.
- IBISWorld. "Mattress Manufacturing-339791, Competitive Forces." Accessed October 31, 2023. <https://my.ibisworld.com/us/en/industry/33791/competitive-forces>.
- IBIS World. "Medical Device Manufacturing - 33451A, Competitive Forces." Accessed October 30, 2023. <https://my.ibisworld.com/us/en/industry/33451a/competitive-forces>.
- IBIS World. "Medical Device Manufacturing - 33451B, Competitive Forces." Accessed October 30, 2023. <https://my.ibisworld.com/us/en/industry/33451b/competitive-forces>.

- IBISWorld. "NAICS Code 541614 - Process, Physical Distribution, and Logistics Consulting Services." Accessed May 10, 2023.
<https://www.ibisworld.com/classifications/naics/541614/process-physical-distribution-and-logistics-consulting-services/>.
- IBISWorld. "Operating Conditions, IT Consulting in the US." Last modified January 2023. Accessed July 27, 2023. <https://my.ibisworld.com/us/en/industry/54151/operating-conditions>.
- IBISWorld. "Performance, Refrigerated Storage in the US." Last modified September 2023. Accessed October 27, 2023.
<https://my.ibisworld.com/us/en/industry/49311/performance>.
- IBISWorld. "Products & Markets, Port & Harbor Operations in the US." Last modified March 2023. Accessed July 27, 2023.
<https://my.ibisworld.com/us/en/industry/48831/products-and-markets>.
- IBISWorld. "Products & Markets, Train, Subway & Transit Car Manufacturing in the US." Last modified April 2023. Accessed July 27, 2023.
<https://my.ibisworld.com/us/en/industry/33651/products-and-markets>.
- IBISWorld. "Products & Markets, Scientific Research & Development in the US." Last modified May 17, 2023. <https://my.ibisworld.com/us/en/industry/54171/products-and-markets>.
- IBISWorld. "Recordable Media Manufacturing - 33461, Competitive Forces." Accessed November 1, 2023. <https://my.ibisworld.com/us/en/industry/33461/competitive-forces>.
- IBISWorld. "Scientific Research and Development Service in the US." Accessed May 4, 2023.
<https://my.ibisworld.com/us/en/industry/54171/about>.
- IBISWorld. "Search Results – 3119." Accessed October 23, 2023.
<https://my.ibisworld.com/search/?q=3119>.
- IBISWorld. "Search Results – 5239, Competitive Forces." Accessed October 30, 2023.
<https://my.ibisworld.com/search/?q=5239>.
- IBISWorld. "Search Results – 5413, Competitive Forces." Accessed October 30, 2023.
<https://my.ibisworld.com/search/?q=5413>.
- IBISWorld. "Space Vehicle & Missile Manufacturing in the US." September 2023. Accessed November 21, 2023. <https://www.ibisworld.com/united-states/market-research-reports/space-vehicle-missile-manufacturing-industry/>.

IBM. "What is Industry 4.0?." Accessed August 9, 2023.
<https://www.ibm.com/topics/industry-4-0>.

Ilgar, Öykü. "The Sustainability Problems Percolating in The Coffee Supply Chain." *Forbes*, September 29, 2022. Accessed August 7, 2023.
<https://www.forbes.com/sites/sap/2022/09/29/the-sustainability-problems-percolating-in-the-coffee-supply-chain/?sh=260cf504c673>.

IMPLAN Data Team. "Regional Purchase Coefficients." IMPLAN. Updated July 12, 2022. Accessed October 24, 2023. <https://support.implan.com/hc/en-us/articles/115009674588-Regional-Purchase-Coefficients>.

IMPLAN. "Gross Absorption." Accessed October 24, 2023. <https://support.implan.com/hc/en-us/articles/360033534314-Gross-Absorption>.

IMPLAN. "Gross Inputs." Accessed October 24, 2023. <https://support.implan.com/hc/en-us/articles/360043781314-Gross-Inputs>.

IMPLAN. "IMPLAN Data Sources." June 27, 2017. Accessed December 4, 2023.
<https://support.implan.com/hc/en-us/articles/115009674448-IMPLAN-Data-Sources>.

IMPLAN. "Regional Absorption." Accessed October 24, 2023.
<https://support.implan.com/hc/en-us/articles/360044284833-Regional-Absorption>.

IMPLAN. "Regional Inputs." Last modified February 28, 2020. Accessed January 22, 2024.
<https://support.implan.com/hc/en-us/articles/360043781434-Regional-Inputs>.

Intel. "Intel Invests in Ohio." August 8, 2023. Accessed September 18, 2023.
<https://www.intel.com/content/www/us/en/newsroom/resources/intel-invests-ohio.html#gs.5vmuiw>.

International Trade Administration. "Import Tariffs, China – Country Commercial Guide." Last modified April 7, 2023. Accessed July 10, 2023. <https://www.trade.gov/country-commercial-guides/china-import-tariffs>.

Irizarry, Joe. "Delaware is Using Federal Funds to Make Sure Food Grown in First State Gets to Communities." Delaware Public Media. November 29, 2021. Accessed October 16, 2023.
<https://www.delawarepublic.org/politics-government/2021-11-29/delaware-is-using-federal-funds-to-make-sure-food-grown-in-first-state-gets-to-communities>.

ISO. "ISO 9001 Quality Management Systems." Accessed December 22, 2023.
<https://www.iso.org/standard/62085.html>.

- Ito, Aki. "How the Warehouse Boom Devoured America's Workforce." Business Insider. October 19, 2022. Accessed August 14, 2023. <https://www.businessinsider.com/warehouse-jobs-economy-impact-blue-collar-pay-employment-hiring-boom-2022-10>.
- Jitesh, Panchal. "Manufacturing Cost Analysis." U.S.A. Consumer Product Safety Commission (February 22, 2016). Accessed May 11, 2023. <https://www.cpsc.gov/s3fs-public/ManufacturingCostAnalysis.pdf>.
- Jones, Kathy. "Where the U.S. Dollar May Be Headed in 2024." Charles Schwab. January 10, 2024. Accessed April 1, 2024. <https://www.schwab.com/learn/story/where-us-dollar-may-be-headed-2024>.
- Kavilanz, Parija. "Desperately Seeking Americans for Factory Jobs." CNN Money. July 23, 2012. Accessed August 7, 2023. https://money.cnn.com/2012/02/16/smallbusiness/manufacturing_jobs/index.htm.
- Kentucky Cabinet for Economic Development. "Kentucky Uniquely Positioned to Prosper Post-Pandemic." Accessed October 10, 2023. https://ced.ky.gov/Newsroom/Article/20200901_post_pandemic.
- Kentucky Cabinet for Economic Development. "How Industry Strength, Location Prime Kentucky for Post-pandemic Growth." Accessed October 30, 2023. https://ced.ky.gov/Newsroom/Article/20200701_ky_prime.
- Kentucky Center for Statistics. "Employment and Wages by Industry." Accessed October 9, 2023. <https://kystats.ky.gov/KYLM/QCEW/CoveredEmployment>.
- Kienzle, Natalie. "Container Chassis Shortage: The Latest Logistics Struggle." Truckload Shipping. August 28, 2023. Accessed December 11, 2023. <https://usatruckloadshipping.com/container-chassis-shortage/>.
- Kime, Lynn. "Diversification of Your Operation, Why." The Pennsylvania State University. January 3, 2023. Accessed July 19, 2023. <https://extension.psu.edu/diversification-of-your-operation-why>.
- Laffitte, Helene. "Global Management Consulting Industry: A Comprehensive Guide (2022)." Consulting Quest. Last modified May 2, 2022. Accessed May 4, 2023. <https://consultingquest.com/insights/comprehensive-guide-global-management-consulting-industry/>.

- Landers, Jay. "2022 Economic Outlook Strong for AEC Sector, Despite Challenges." American Society of Civil Engineers. June 14, 2022. Accessed July 11, 2023. <https://www.asce.org/publications-and-news/civil-engineering-source/civil-engineering-magazine/article/2022/06/2022-economic-outlook-strong-for-aec-sector-despite-challenges>.
- Landers, Jay. "2022: The First Year of Several Solid Years for the AEC Industry." American Society of Civil Engineers. January 3, 2022. Accessed July 11, 2023. <https://www.asce.org/publications-and-news/civil-engineering-source/civil-engineering-magazine/issues/magazine-issue/article/2022/01/2022-the-first-of-several-solid-years-for-the-aec-industry>.
- Lee, Jonathan. "PlayStation 5 Shortage Over, Announces Sony Exec Jim Ryan." *The Washington Post*, January 6, 2023. Accessed July 31, 2023. <https://www.washingtonpost.com/video-games/2023/01/06/sony-playstation-5-shortage-over/>.
- Leonard, Matt. "Warehouse Employment Is at an All-Time High." Supply Chain Dive, October 6, 2020. <https://www.supplychaindive.com/news/warehouse-employment-ecommerce-peak-season/586465/>.
- Lincicome, Scott. "America's Ports Problem Is Decades in the Making." Cato Institute. September 22, 2021. Accessed July 27, 2023. <https://www.cato.org/commentary/americas-ports-problem-decades-making>.
- Lincicome, Scott, and Alfredo Carrillo Obregon. "New U.S. Tariffs Are Contributing to the Shipping Crisis, and There's Little We Can Do About It." CATO Institute. August 26, 2021. Accessed March 27, 2023. <https://www.cato.org/blog/new-us-tariffs-are-contributing-shipping-crisis-theres-little-we-can-do-about-it>.
- Lokendra, Ranwat. "7 Ways the Furniture Supply Chain is Different from Other Industries." Architect and Interiors India. August 7, 2021. Accessed July 10, 2023. <https://www.architectandinteriorsindia.com/insights/22934-7-ways-the-furniture-supply-chain-is-different-from-other-industries>.
- Lucas, Maria. "Industry Leontief Production Functions in IMPLAN." IMPLAN. September 26, 2019. Accessed December 4, 2023. <https://support.implan.com/hc/en-us/articles/360035967274-Industry-Leontief-Production-Functions-in-IMPLAN>.
- Lynch, Catherine. "The Construction Industry Is Getting Greener: Why, How, And What's Changing?" *Forbes*, August 25, 2021. Accessed May 9, 2023. <https://www.forbes.com/sites/sap/2021/08/25/the-construction-industry-is-getting-greener-why-how-and-whats-changing/?sh=326dc91e52bc>.

- Maldonado, Cesar. "Venture Capital & Principal Trading in the US." IBISWorld. Accessed July 31, 2023. <https://my.ibisworld.com/us/en/industry/52391/about>.
- Market Research.com. "Communication Equipment Manufacturing in the US – Industry Market Research Report." Accessed July 18, 2023. <https://www.marketresearch.com/IBISWorld-v2487/Communication-Equipment-Manufacturing-Research-33442999/>.
- Market Research Engine. "Magnetic and Optical Media Manufacturing Market Size, Share, Analysis Report." January 2, 2022. Accessed August 1, 2023. <https://www.marketresearchengine.com/magnetic-and-optical-media-manufacturing-market>.
- Market Research. "Warehousing and Storage - 2022 U.S. Market Research Report with Updated COVID-19 Forecasts." June 16, 2022. Accessed July 27, 2023. <https://www.marketresearch.com/Kentley-Insights-v4035/Warehousing-Storage-Research-Updated-COVID-31717667/>.
- Martins, Andrew. "Most Consumers Want Sustainable Products and Packaging." Business News Daily. November 13, 2023. Accessed January 15, 2024. <https://www.businessnewsdaily.com/15087-consumers-want-sustainable-products.html>.
- Maryland Department of Commerce. "Governor Hogan Announces Maryland Manufacturing 4.0 Grant Program." August 22, 2022. Accessed December 4, 2023. <https://commerce.maryland.gov/media/governor-hogan-announces-maryland-manufacturing-40-grant-program#:~:text=Similar%20to%20smart%20manufacturing,competitive%20and%20drive%20business%20growth>.
- Maryland Department of Commerce. "Maryland Manufacturing 4.0, Funding & Incentives." Accessed August 9, 2023. <https://commerce.maryland.gov/fund/maryland-manufacturing-4-0>.
- Maryland Department of Commerce. "Maryland Manufacturing 4.0 Grant Recipients." March 2023. Accessed December 4, 2023. https://commerce.maryland.gov/Documents/FinanceDocument/M4Grants_Recipients.pdf.
- Maryland Department of Labor. "Be an Apprentice – Maryland Apprenticeship and Training Program (MATP)." Accessed November 6, 2023. <https://www.dllr.state.md.us/employment/appr/apprbecomeappr.shtml>.

Maryland Department of Labor. "Current EARN Maryland Partnerships." Accessed November 28, 2023. <https://www.dllr.state.md.us/earn/earngrantpartners.shtml>.

Maryland Department of Labor. "EARN Maryland Strategic Industry Partnerships." October 31, 2023. Accessed November 6, 2023. <https://www.dllr.state.md.us/earn/earnmdsummaries.pdf>.

Maryland Department of Labor. "Explore Registered Occupations - Maryland Apprenticeship and Training Program (MATP)." Accessed November 1, 2023. <https://www.dllr.state.md.us/employment/approcc/approcc.shtml#w>.

Maryland Department of Labor. "Governor Moore Announces More Than \$2 Million in Grants to Expand Nationally-Recognized EARN Maryland Program." Accessed November 28, 2023. <https://www.dllr.state.md.us/whatsnews/gov32earn.shtml>.

Maryland Department of Labor. "Hire an Apprentice - Maryland Apprenticeship and Training Program (MATP)." Accessed November 1, 2023. <https://www.dllr.state.md.us/employment/appr/apprbecomesponsor.shtml>.

Maryland Department of Labor. "Manufacturing." Accessed December 4, 2023. <https://www.labor.maryland.gov/earn/earnmanufacturing.shtml>.

Maryland Department of Labor. "Maryland Tax Credit for Eligible Apprentices - Maryland Apprenticeship and Training Program (MATP)." Accessed December 4, 2023. <https://www.dllr.state.md.us/employment/appr/apprtaxcreditinfo.shtml>.

Maryland Department of Labor. "What is EARN Maryland?" Accessed November 28, 2023. <https://www.dllr.state.md.us/earn/earnwhatisearn.shtml>.

Maryland Economic Development Association. "Governor Moore Announces Second Round of Funding for Maryland Manufacturing 4.0 Program." August 7, 2023. Accessed November 28, 2023. <https://www.medamd.com/program-development/governor-moore-announces-second-round-of-funding-for-maryland-manufacturing-4-0-program/>.

Maryland MEP. "Maryland MEP & RMI of Maryland." Accessed November 28, 2023. <https://mdmep.org/>.

Maryland MEP. "MD MEP With Maryland Department of Commerce to Deliver New Maryland Supply Chain Resiliency Initiative." Accessed November 28, 2023. <https://mdmep.org/md-mep-with-maryland-department-of-commerce-to-deliver-new-maryland-supply-chain-resiliency-initiative/>.

Maryland MEP. "Supply Chain & Defense." Accessed November 28, 2023. <https://mdmep.org/supply-chain-solutions/>.

- Maryland State Archives. "Maryland at a Glance: Economy." Accessed January 27, 2023.
<https://msa.maryland.gov/msa/mdmanual/01glance/economy/html/economy.html#trade>.
- Maryland Workforce Exchange. "Manufacturing and Reproducing Magnetic and Optical Media." Last modified July 1, 2019. Accessed July 27, 2023.
<https://mwejobs.maryland.gov/vosnet/lmi/profiles/profileSummary.aspx?session=inddetail&valueName=industry>.
- Maryland Workforce Exchange. "Navigational, Measuring, Electromedical, and Control Instruments." Last modified July 1, 2019. Accessed May 10, 2023.
<https://mwejobs.maryland.gov/vosnet/lmi/profiles/profileSummary.aspx?session=inddetail&valueName=industry>.
- Maryland Workforce Exchange. "Other Financial Investment Activities, 5239." Last modified July 1, 2019. Accessed July 21, 2023.
<https://mwejobs.maryland.gov/vosnet/lmi/profiles/profileSummary.aspx?session=inddetail&valueName=industry>.
- Maryland Workforce Exchange. "Other Furniture Related Product Manufacturing." Last modified July 1, 2019. Accessed May 10, 2023.
<https://mwejobs.maryland.gov/vosnet/lmi/profiles/profileSummary.aspx?session=inddetail&valueName=industry>.
- Mashalah, Heider Al, Hassini Elkafi, Angappa Gunasekaran, and Deepa Bhatt. "The Impact of Digital Transformation on Supply Chains Through E-Commerce: Literature Review and a Conceptual Framework." *Research Part E: Logistics and Transportation Review* 165 (September 2022). Accessed January 20, 2022.
<https://doi.org/10.1016/j.tre.2022.102837>.
- McCarthy, Dave. "An Update on Xbox Sustainability Efforts." Xbox Wire. March 10, 2022. Accessed July 27, 2023.
<https://news.xbox.com/en-us/2022/03/10/an-update-on-xbox-sustainability-efforts/>.
- McKinsey and Company. "Semiconductor Design and Manufacturing: Achieving Leading-edge Capabilities." August 20, 2020. Accessed September 11, 2023.
<https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities>.
- Meisels, Michelle, Paul Wellener, and Kate Hardin. "2023 Engineering and Construction Industry Outlook." Deloitte (August 2022). Accessed May 8, 2023.
<https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/us-eri-outlook-engineering-and-construction-2023.pdf>.

- Micron. "Micron Announces Historic Investment of Up to \$100 Billion to Build Megafab in Central New York." October 4, 2022. Accessed September 18, 2023. <https://investors.micron.com/news-releases/news-release-details/micron-announces-historic-investment-100-billion-build-megafab>.
- Miladinovic, Kristina. "Mattress Industry Trends and Statistics (Market Overview)." Sleepline. June 30, 2022. Accessed July 21, 2023. <https://www.sleepline.com/mattress-industry-trends/>.
- Miller, Greg. "California Port Pileup Shatters Record and Imports Still Haven't Peaked." August 30, 2021. Accessed October 17, 2023. <https://www.freightwaves.com/news/california-port-pileup-breaks-record-and-imports-still-havent-peaked>.
- Moore, Samuel K. "United States Kicks Off CHIPS Act Funding." IEEE Spectrum. March 1, 2023. Accessed September 5, 2023. <https://spectrum.ieee.org/us-chips-act-funding>.
- MSC. "Panama Canal Surcharge." MSC Newsroom. November 23, 2023. Accessed November 27, 2023. <https://www.msc.com/en/newsroom/customer-advisories/2023/november/panama-canal-surcharge>.
- Munnely, Mike. "Where are the Risks for Contamination in a Food Processing Plant?" ThermoFisher Scientific. January 25, 2022. Accessed November 14, 2023. <https://www.thermofisher.com/blog/food/where-are-the-risks-for-contamination-in-a-food-processing-plant/>.
- NAICS Association. "3319 – Other Food Manufacturing." Accessed August 8, 2023. <https://www.naics.com/naics-code-description/?code=3119>.
- NAICS Association. "33641 – Aerospace Product and Parts Manufacturing." Accessed August 7, 2023. <https://www.naics.com/naics-code-description/?code=33641>.
- NAICS Association. "5413 - Architectural, Engineering, and Related Services." Accessed March 25, 2024. <https://www.naics.com/naics-code-description/?code=5413>.
- National Aeronautics Research Institute. "AeroDynamic Advisory, AAM Supply Chain-Considerations." 2022. Accessed May 12, 2023. <https://nari.arc.nasa.gov/sites/default/files/attachments/2021-09-09%20AeroDynamic%20Advisory%20AAM%20Supply%20Chain%20Working%20Group%20Presentation.pdf>.
- National Association of Manufacturers. "2.1 Million Manufacturing Jobs Could Go Unfilled by 2030." May 4, 2021. Accessed August 2, 2023. <https://www.nam.org/2-1-million-manufacturing-jobs-could-go-unfilled-by-2030-13743/?stream=workforce>.

- National Association of Manufacturers. "Maryland Manufacturer to Increase Hiring, Invest." May 8, 2019. Accessed August 9, 2023. <https://www.nam.org/maryland-manufacturer-to-increase-hiring-20-percent-invests-in-new-technology-thanks-to-tax-reform-3174/>.
- National Association of Manufacturers'. "NAM Manufacturers' Outlook Survey, First Quarter-2022." Accessed August 2, 2023. https://www.nam.org/wp-content/uploads/2022/03/Manufacturers_Outlook_Survey_Write_Up_Mar2022.pdf.
- National Association of Manufacturers'. "NAM Manufacturers' Outlook Survey, Second Quarter 2023." Accessed August 8, 2023. https://www.nam.org/wp-content/uploads/2023/03/Manufacturers_Outlook_Survey_Q2_June_2023.pdf.
- National Institute of Standards and Technology, CHIPS for America. "Notice of Funding Opportunity: Commercial Fabrication Facilities." Last modified August 25, 2023. Accessed September 12, 2023. <https://www.nist.gov/chips/notice-funding-opportunity-commercial-fabrication-facilities>.
- National Institute of Standards and Technology. "MfgTech Roadmap Partners, Office of Advanced Manufacturing." Last modified October 24, 2022. Accessed August 9, 2023. https://www.nist.gov/oam/mfgtech-roadmap-partners#_Strengthen_US_Mfg.
- Ng, Greg, Jenny Fulginiti, and Tramon Lucas. "2021 Timeline: Coronavirus in Maryland." *WBAL-TV 11*, January 4, 2022. Accessed August 8, 2023. <https://www.wbaltv.com/article/COVID-19-in-maryland-2021-timeline/35169408>.
- Northeast Advanced Manufacturing Consortium. "What Are the Benefits of a Manufacturing Apprenticeship?" February 15, 2022. Accessed December 4, 2023. <https://namcnetwork.com/what-are-the-benefits-of-a-manufacturing-apprenticeship/>.
- Office of the Director of National Intelligence. "Information and Communications Technology and the Supply Chain Risk." April 2022. Accessed July 27, 2023. <https://www.dni.gov/files/NCSC/documents/supplychain/ict-supply-chain-risk-2022-5BE169B1-.pdf>.
- Office of Governor Gavin Newsom. "Governor Newsom Signs Executive Order to Help Tackle Supply Chain Issues." October 20, 2021. Accessed October 17, 2023. <https://www.gov.ca.gov/2021/10/20/governor-newsom-signs-executive-order-to-help-tackle-supply-chain-issues/>.
- Office of Governor Mike Dunleavy. "Administrative Order No. 334." Accessed October 10, 2023. <https://gov.alaska.gov/admin-orders/administrative-order-no-334/>.

- Owens, Beth. "Omnichannel Fulfillment." RyderECommerce. February 18, 2021. Accessed December 19, 2023. <https://whiplash.com/blog/why-omnichannel-fulfillment-21/>.
- PCMag. "Foundry." Accessed September 5, 2023. <https://www.pcmag.com/encyclopedia/term/foundry>.
- Phillips, Erica. "Tech Is Changing Connecticut Manufacturing. Can Business Keep Up?" CT Mirror. February 19, 2023. Accessed October 30, 2023. <https://ctmirror.org/2023/02/19/ct-manufacturing-industry-4-0-business-tech-ai-robotics-colleges-universities/>.
- Port of Baltimore, Maryland. "Maryland at a Glance." Accessed August 10, 2023. <https://msa.maryland.gov/msa/mdmanual/01glance/html/port.html>.
- Putzger, Ian. "Threat to Freighters as Parts Shortages Hobble Airlines, Manufacturers, and MRO." The Loadstar. April 28, 2023. Accessed November 21, 2023. <https://theloadstar.com/threat-to-freighters-as-parts-shortages-hobble-airlines-manufacturers-and-mro/#>.
- PwC. "Current Developments for the Mutual Fund Industry." Summer 2023. Accessed July 24, 2023. <https://www.pwc.com/us/en/industries/financial-services/library/pdf/pwc-current-developments-for-mutual-funds-summer-2023.pdf>.
- PwC. "Global Aerospace and Defense: Annual Performance and Outlook - 2022 Edition." June 2022. Accessed May 12, 2023. <https://www.pwc.com/us/en/industrial-products/publications/assets/pwc-aerospace-defense-annual-industry-performance-outlook-2022.pdf>.
- PwC. "Global Entertainment and Media Outlook 2023–2027." June 21, 2023. Accessed August 3, 2023. <https://www.pwc.com/gx/en/industries/tmt/media/outlook/insights-and-perspectives.html>.
- The Railway Technical Website. "Rolling Stock Manufacture." Accessed July 27, 2023. <http://www.railway-technical.com/trains/rolling-stock-manufacture.html>.
- Reichheld, Ashley, John Peto, and Cory Ritthaler. "Research: Consumers' Sustainability Demands Are Rising." Harvard Business Review. September 18, 2023. Accessed January 15, 2024. <https://hbr.org/2023/09/research-consumers-sustainability-demands-are-rising>.

- Research and Markets. "U.S. Communication Equipment Market Size, Share & Trends Analysis Report by Product (Mobile, Fixed-line), Competitive Landscape, and Segment Forecasts, 2018-2025." Accessed July 18, 2023.
<https://www.researchandmarkets.com/reports/4613450/u-s-communication-equipment-market-size-share>.
- Resnik, David B. "Science and Money: Problems and Solutions." *Journal of Microbiology & Biology Education* 15, no. 2 (December 2014): 159-161. Accessed May 4, 2023.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4278468/>.
- Rosier, Nate. "Inventory Management in the Pandemic Era." Multichannel Merchant. September 8, 2022. Accessed December 19, 2023.
<https://multichannelmerchant.com/operations/inventory-management-in-the-pandemic-era/>.
- Rubinton, Hannah, and Maggie Isaacson. "Inflation and Shipping Costs." Federal Reserve Bank of St. Louis (March 2022). Accessed July 19, 2023.
<https://files.stlouisfed.org/files/htdocs/publications/economic-synopses/2022/03/18/inflation-and-shipping-costs.pdf>.
- Rutgers University, Rutgers NJAES Cooperative Extension. "2022/2023 Mid-Atlantic Commercial Vegetable Production Recommendations." Last modified March 3, 2022. Accessed July 19, 2023. <https://extension.psu.edu/mid-atlantic-commercial-vegetable-production-recommendations-sections>
- Sainato, Michael. "'They Would Not Listen to Us': Inside Arizona's Troubled Chip Plant." *The Guardian*, August 28, 2023. Accessed September 12, 2023.
<https://www.theguardian.com/business/2023/aug/28/phoenix-microchip-plant-biden-union-tsmc>.
- S&P Global. "The Sustainability Yearbook 2022." February 2022. Accessed July 6, 2023.
https://www.spglobal.com/esg/csa/yearbook/files/Communications_Equipment.pdf.
- Sankaran, Vishwam. "Samsung to Build \$17bn Chip Factory in Texas's Biggest Ever Foreign Investment." *Independent*. November 24, 2021. Accessed September 5, 2023.
<https://www.independent.co.uk/tech/samsung-chip-shortage-texas-factory-b1963295.html>.
- ScienceDirect. "Accelerating Data Acquisition Process in the Pharmaceutical Industry Using Internet of Things." Accessed May 4, 2023.
<https://www.sciencedirect.com/science/article/pii/B978012821326100005X>.

- ScienceDirect. "Global Regulatory Perspectives on Quality by Design in Pharma Manufacturing." Last modified March 29, 2019. Accessed May 4, 2023. <https://www.sciencedirect.com/science/article/pii/B9780128157992000022>.
- Schreiner, Bruce. "Governor Launches Supply Chain Initiative for Kentucky." *Associated Press*, March 6, 2023. Accessed October 9, 2023. <https://apnews.com/article/kentucky-economy-supply-chain-andy-beshear-0e8bf37f0e3709a9cdb7f19eb438dbc4>.
- Semiconductor Industry Association. "Semiconductors in Maryland." May 31, 2022. Accessed September 12, 2023. <https://www.semiconductors.org/wp-content/uploads/2022/05/Maryland-2022.pdf>.
- Shivakumar, Sujai and Charles Wessner. "Semiconductors and National Defense: What Are the Stakes?" Center for Strategic and International Studies. June 8, 2022. Accessed September 11, 2023. <https://www.csis.org/analysis/semiconductors-and-national-defense-what-are-stakes>.
- Sikich. "How the Pandemic Changed Inventory Management." May 16, 2023. Accessed December 19, 2023. <https://www.sikich.com/insight/how-the-pandemic-changed-inventory-management/>.
- Skanska. "Skanska-Fay Joint Venture Selected for Howard Street Tunnel Project, Elevating I-95 Freight Rail Infrastructure." December 22, 2023. Accessed January 9, 2024. <https://www.usa.skanska.com/who-we-are/media/press-releases/277333/SkanskaFay-Joint-Venture-selected-for-Howard-Street-Tunnel-Project%2C-elevating-I95-freight-rail-infrastructure>.
- Smith, Jennifer, Paul Berger, and Lydia O'Neal. "Shipping and Logistics Costs Are Expected to Keep Rising in 2022." *The Wall Street Journal*, December 19, 2021. Accessed July 19, 2023. <https://www.wsj.com/articles/shipping-and-logistics-costs-are-expected-to-keep-rising-in-2022-11639918804>.
- State of Connecticut. "Connecticut's Manufacturing Strategic Plan 2023." Accessed October 17, 2023. <https://portal.ct.gov/-/media/Manufacturing/PDF/2023-CT-Mfg-Strategic-Plan---final---HR.pdf>.
- State of Delaware. "Delaware Department of Agriculture Awards Over \$665,000 for Innovative Projects to Improve Food Supply Chain." July 24, 2023. Accessed October 10, 2023. <https://news.delaware.gov/2023/07/24/delaware-department-of-agriculture-awards-over-665000-for-innovative-projects-to-improve-food-supply-chain/>.

- State of Delaware. "First State Food System Program Opens Second Grant Application Cycle." April 18, 2023. Accessed October 10, 2023. <https://news.delaware.gov/2023/04/18/first-state-food-system-program-opens-second-grant-application-cycle/>.
- Statista. "Construction Materials, Installation, and Composite Construction Cost Index in the United States in 2021, by City." Last modified February 17, 2023. Accessed July 10, 2023. <https://www.statista.com/statistics/916435/us-construction-market-cost-index-by-city/>.
- Statista. "Warehousing & Storage in the U.S. – Industry Insights & Data Analysis." November 2022. Accessed January 8, 2023. <https://www.statista.com/study/30173/warehousing-and-storage-in-the-us/>.
- Stimson, Robert J., Roger R. Stough, and Brian H. Roberts. *Regional Economic Development Analysis and Planning Strategy*. New York: Springer-Verlag, 2002. Accessed December 4, 2023. https://stellar.mit.edu/S/course/11/sp13/11.S952/courseMaterial/topics/topic1/readings/Stimson_2006_RegionalED_pp105-125/Stimson_2006_RegionalED_pp105-125.pdf.
- Straight, Brian. "Survey: 73% of Warehouse Operators Can't Find Enough Labor." FreightWaves. February 18, 2022. <https://www.freightwaves.com/news/survey-73-of-warehouse-operators-cant-find-enough-labor>.
- SupplyChainBrain. "Five Critical Challenges Facing Pharma Supply Chains." Accessed May 4, 2023. <https://www.supplychainbrain.com/articles/34798-five-critical-challenges-facing-pharma-supply-chains>.
- Tan, Su-Lin. "The Global Shipping Industry is Facing a New Problem – Too Many Containers." *CNBC*, November 10, 2022. Accessed July 6, 2023. <https://www.cnn.com/2022/11/11/global-shipping-industry-faces-a-new-problem-too-many-containers.html>.
- Tanzi, Alex. "Work-From-Home Spurs Blue-Collar Americans to Seek Career Shifts." *Bloomberg*, July 31, 2022. Accessed August 7, 2023. <https://www.bloomberg.com/news/articles/2022-01-31/work-from-home-spurs-blue-collar-americans-to-seek-career-shifts>.
- Taylor, Tania Lynn and Sean Collins. "Ingraining Sustainability in the Next Era of ESG Investing." Deloitte Financial Services. April 5, 2022. Accessed July 24, 2023. <https://www2.deloitte.com/us/en/insights/industry/financial-services/esg-investing-and-sustainability.html>.

- Teehan, Sean. "After Year of Disruptions, CT Manufacturers Rethink Supply Chain Strategies." Hartford Business Journal. April 19, 2021. Accessed October 31, 2023. <https://www.hartfordbusiness.com/article/after-year-of-disruptions-ct-manufacturers-rethink-supply-chain-strategies>.
- Tempur Sealy International, Inc. "Tempur Sealy International, Inc. SWOT Analysis." Accessed May 24, 2023. <https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=164562960&site=eds-live&scope=site>.
- Thomasnet. "The Pharmaceutical Manufacturing Process - Steps, Tools and Considerations." Accessed May 4, 2023. <https://www.thomasnet.com/articles/chemicals/the-pharmaceutical-manufacturing-process-steps-tools-and-considerations/>.
- Tive. "Pharmaceutical Transport Best Practices for Shippers to Know." Accessed November 20, 2023. <https://www.tive.com/blog/pharmaceutical-transport-best-practices-for-shippers-to-know>.
- Truck Info.net. "How Trucking Changed During the COVID-19 Pandemic." April 1, 2023. Accessed December 11, 2023. <https://www.truckinfo.net/research/how-trucking-changed-during-the-pandemic>.
- United Nations Department of Economic and Social Affairs. "Global Growth Prospects Have Weakened Significantly Amid the War in Ukraine." Last modified June 1, 2022. Accessed July 10, 2023. <https://www.un.org/development/desa/dpad/publication/world-economic-situation-and-prospects-june-2022-briefing-no-161/>.
- United Nations Conference on Trade and Development. "Review of Maritime Transport 2020, Performance Indicators." Accessed July 28, 2023. https://unctad.org/system/files/official-document/rmt2020ch3_en.pdf.
- United Nations - Water. "Water, Food and Energy." Accessed July 19, 2023. <https://www.unwater.org/water-facts/water-food-and-energy>.
- University of Alaska Fairbanks, Alaska Food Policy Council, and 2022 Governor's Task Force on Food Security and Independence. "Alaska Food Security and Independence Task Force 2023 Report." March 2023. Accessed October 10, 2023. https://static1.squarespace.com/static/584221c6725e25d0d2a19363/t/640fb433f524b6421008ad3e/1678750824303/2023+Food+Security+Task+Force+Report+DIGITAL+2023.03.03+final_Parts1-3.pdf.
- U.S. Bureau of Economic Analysis. "Definitions." Accessed May 26, 2022. <https://apps.bea.gov/regional/pdf/acpsa/-definitions.pdf>.

- U.S. Bureau of Labor Statistics. "Architecture and Engineering Occupations, Occupational Outlook Handbook." Last modified September 8, 2022. Accessed May 8, 2023. <https://www.bls.gov/ooh/Architecture-and-Engineering/>.
- U.S. Bureau of Labor Statistics. "Consumer Price Index: 2019 in Review." Accessed November 13, 2023. <https://www.bls.gov/opub/ted/2020/consumer-price-index-2019-in-review.htm>.
- U.S. Bureau of Labor Statistics. "Got Skills? Think Manufacturing, Career Outlook." June 2014. Accessed August 7, 2023. <https://www.bls.gov/careeroutlook/2014/article/manufacturing.htm>.
- U.S. Bureau of Labor Statistics. "Industries at a Glance – Food Manufacturing: NAICS 311." Accessed January 29, 2023. <https://www.bls.gov/iag/tgs/iag311.htm>.
- U.S. Bureau of Labor Statistics. "Industries at a Glance – Warehousing and Storage: NAICS 493." Accessed March 8, 2023. <https://www.bls.gov/iag/tgs/iag493.htm>.
- U.S. Bureau of Labor Statistics. "Job Openings and Labor Turnover Survey." Accessed July 18, 2023. <https://www.bls.gov/jlt/>.
- U.S. Bureau of Labor Statistics. "Prices for Import Semiconductors Up Over the Past 12 Months." August 18, 2022. Accessed July 18, 2023. <https://www.bls.gov/opub/ted/2022/prices-for-import-semiconductors-up-over-the-past-12-months.htm>.
- U.S. Bureau of Labor Statistics. "Producer Price Indexes." Accessed January 8, 2024. <https://www.bls.gov/ppi/>.
- U.S. Bureau of Labor Statistics. "QCEW Data Files, Quarterly Census of Employment and Wages." Last modified July 2023. Accessed July 20, 2023. <https://www.bls.gov/cew/downloadable-data-files.htm>.
- U.S. Census Bureau. "LED Extraction Tool Quarterly Workforce Indicators." Accessed August 3, 2023. <https://ledextract.ces.census.gov/qwi/all>.
- U.S. Census Bureau. "Monthly Construction Spending, July 2023." Last modified July 3, 2023. Accessed July 10, 2023. [https://www.census.gov/econ/currentdata/?programCode=VIP&startYear=2013&endYear=2023&categories\[\]=AXXXX&dataType=T&geoLevel=US&adjusted=1¬Adjusted=0&errorData=0#table-results](https://www.census.gov/econ/currentdata/?programCode=VIP&startYear=2013&endYear=2023&categories[]=AXXXX&dataType=T&geoLevel=US&adjusted=1¬Adjusted=0&errorData=0#table-results).

- U.S. Census Bureau. "NAICS Code 5417 - Scientific Research and Development Services."
Accessed October 27, 2023. [https://www.naics.com/naics-code-description/?code=5417#:~:text=This%20industry%20group%20comprises%20establishments,improved%20products%20or%20processes%20\(experimental\).](https://www.naics.com/naics-code-description/?code=5417#:~:text=This%20industry%20group%20comprises%20establishments,improved%20products%20or%20processes%20(experimental).)
- U.S. Census Bureau. "North American Industry Classification System: Search Results 3119."
Last modified August 7, 2023. Accessed August 7, 2023.
<https://www.census.gov/naics/?input=3119&year=2022&details=3119>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results 3254."
Accessed May 4, 2023.
<https://www.census.gov/naics/?input=3254&year=2022&details=3254>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results 3342."
Accessed March 8, 2023.
<https://www.census.gov/naics/?input=3342&year=2022&details=3342>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results 3345." Last
modified July 22, 2023. Accessed July 22, 2023.
<https://www.census.gov/naics/?input=3345&year=2022>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results 3346."
Last modified July 23, 2023. Accessed July 23, 2023.
<https://www.census.gov/naics/?input=3346&year=2022&details=334610>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results: 3364."
Accessed May 12, 2023.
<https://www.census.gov/naics/?input=3364&year=2022&details=3364>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results 336510."
Accessed March 8, 2023.
<https://www.census.gov/naics/?input=3365&year=2022&details=336510>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results 3379." Last
modified May 8, 2023. Accessed May 8, 2023.
<https://www.census.gov/naics/?input=3379&year=2022&details=3379>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results 488390."
Accessed March 8, 2023.
<https://www.census.gov/naics/?input=4883&year=2022&details=488390>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results: 5239."
Accessed July 21, 2023. <https://www.census.gov/naics/?input=5239&year=2022>.

- U.S. Census Bureau. "North American Industry Classification System: Search Results: 5413." Last modified May 8, 2023. Accessed May 8, 2023.
<https://www.census.gov/naics/?input=5413&year=2022&details=541310>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results 5415." Accessed March 8, 2023.
<https://www.census.gov/naics/?input=5415&year=2022&details=5415>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results 5416." Accessed May 4, 2023.
<https://www.census.gov/naics/?input=5416&year=2022&details=5416>.
- U.S. Census Bureau. "North American Industry Classification System: Search Results 5417." Accessed May 4, 2023.
<https://www.census.gov/naics/?input=5417&year=2022&details=5417>.
- U.S. Census Bureau. "USA Trade Online-Help Section." Accessed February 2, 2023.
<https://www.census.gov/foreign-trade/statistics/dataproducts/uto-help/uto-help.html#district>.
- U.S. Department of Commerce. "U.S. Commerce Secretary Gina Raimondo Calls on Students from Every Level of Education to Consider Careers in the Semiconductor Industry." U.S. Department of Commerce: Blog. July 27, 2023. Accessed August 2, 2023.
<https://www.commerce.gov/news/blog/2023/07/us-commerce-secretary-gina-raimondo-calls-students-every-level-education-consider>.
- U.S. Department of Transportation, Bureau of Transportation Statistics. "2023 Port Performance Freight Statistics Program: Annual Report to Congress." January 2023. Accessed November 27, 2023. <https://doi.org/10.21949/1528357>.
- U.S. Department of Transportation, Bureau of Transportation Statistics. "Container Vessel Dwell Times." Accessed November 30, 2023. <https://data.bts.gov/stories/s/Container-Vessel-Dwell-Times/pbag-pyes>.
- U.S. Energy Information Administration. "Use of Energy Explained: Energy Use for Transportation." April 2022. Accessed July 31, 2023.
<https://www.eia.gov/energyexplained/use-of-energy/transportation.php>.
- U.S. International Trade Commission. "The Impact of the COVID-19 Pandemic on Freight Transportation Services and U.S. Merchandise Imports." Accessed December 18, 2023.
[https://www.usitc.gov/research_and_analysis/tradeshifts/2020/special_topic.html#:~:text=In%202020%2C%20air%20freight%20experienced,%E2%80%9D\)%20due%20to%20cancelled%20flights](https://www.usitc.gov/research_and_analysis/tradeshifts/2020/special_topic.html#:~:text=In%202020%2C%20air%20freight%20experienced,%E2%80%9D)%20due%20to%20cancelled%20flights).

- Vaishnavi, Vineet K. "Navigational, Measuring, Electro Medical and Control Instruments Market Overview 2032." Allied Market Research. June 2023. Accessed July 22, 2023. <https://www.alliedmarketresearch.com/navigational-measuring-electro-medical-and-control-instruments-market-A74849>.
- Vallejo, David. "3 Major Impacts of Inflation on Global Supply Chains." *Forbes*, October 28, 2022. Accessed July 19, 2023. <https://www.forbes.com/sites/sap/2022/10/28/3-major-impacts-of-inflation-on-global-supply-chains/?sh=43f508f31614>.
- Walker, Peter. "Consumers Are Willing to Pay More for Sustainable Food Products." LEK. July 20, 2022. Accessed January 15, 2024. <https://www.lek.com/insights/ar/consumers-are-willing-pay-more-sustainable-food-products>.
- The White House. "Fact Sheet: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China." August 9, 2022. Accessed September 11, 2023. <https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/>.
- The White House. "Fact Sheet: President Biden Takes Bold Executive Action to Spur Domestic Clean Energy Manufacturing." June 6, 2022. Accessed May 25, 2023. <https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/06/fact-sheet-president-biden-takes-bold-executive-action-to-spur-domestic-clean-energy-manufacturing/>.
- The White House. "Updated Fact Sheet: Bipartisan Infrastructure Investment and Jobs Act." Last modified August 2, 2021. Accessed May 13, 2023. <https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/02/updated-fact-sheet-bipartisan-infrastructure-investment-and-jobs-act/>.
- Whitten, Sarah. "The Death of the DVD: Why Sales Dropped More Than 86% In 13 Years." *CNBC*, August 4, 2019. Accessed July 31, 2023. <https://www.cnn.com/2019/11/08/the-death-of-the-dvd-why-sales-dropped-more-than-86percent-in-13-years.html>.
- Williams, Lara. "Can FDI Fix the Semiconductor Supply Chain?" *Investment Monitor*. July 29, 2022. Accessed September 5, 2023. <https://www.investmentmonitor.ai/features/can-fdi-fix-the-semiconductor-supply-chain/?cf-view>.
- Wong, Chi Heem, Kien Wei Siah, and Andrew W Lo. "Estimation of Clinical Trial Success Rates and Related Parameters." *Biostatistics* 20, no. 2 (2018): 285. <https://doi.org/10.1093/biostatistics/kxx069>.

- World Economic Forum. "Inflation Continues to Climb in US After Hitting 40-year High." Last modified March 16, 2022. Accessed July 19, 2023.
<https://www.weforum.org/agenda/2022/03/inflation-pandemic-COVID-united-states/>.
- Yale University, Ismail-Beigi Research Group. "Methods and Materials: CDs and DVDs." Accessed July 26, 2023.
<https://volga.eng.yale.edu/teaching-resources/cds-and-dvds/methods-and-materials>.
- Zapata, Mariana and Mili Godio. "Top-rated Organic, Natural and Eco-friendly Mattresses." *NBC News*, August 22, 2022. Accessed July 21, 2023.
<https://www.nbcnews.com/select/shopping/best-eco-friendly-mattress-ncna1193591>.
- Zlatopolsky, Ashley. "The Mattress Industry is Evolving for the Future: Statistics and Trends." *Mattress Clarity*. June 22, 2023. Accessed July 12, 2023.
<https://www.mattressclarity.com/news/mattress-industry-statistics/>.

Appendix A – Detailed Industry and Subsector Data

Figure 30: Key Industries and Maryland Data, 2022

NAICS Code	Industry Name/Subsectors	Establishment Count	Employment	Average Annual Wage
3119	Other Food Manufacturing	171	5,552	\$67,680
31191	<i>Snack Food Manufacturing</i>	12	N/D	N/D
31192	<i>Coffee and Tea Manufacturing</i>	26	212	\$65,138
31193	<i>Flavoring Syrup and Concentrate Manufacturing</i>	11	N/D	N/D
31194	<i>Seasoning and Dressing Manufacturing</i>	28	2,734	\$70,149
31199	<i>All Other Food Manufacturing</i>	94	1,681	\$58,070
3254	Pharmaceutical and Medicine Manufacturing	156	10,698	\$163,333
325411	<i>Medicinal and Botanical Manufacturing</i>	17	N/D	N/D
325412	<i>Pharmaceutical Preparation Manufacturing</i>	106	2,162	\$132,044
325413	<i>In-Vitro Diagnostic Substance Manufacturing</i>	13	3,621	\$107,452
325414	<i>Biological Product (except Diagnostic) Manufacturing</i>	20	N/D	N/D
3342	Communications Equipment Manufacturing	66	3,113	\$127,196
334210	<i>Telephone Apparatus Manufacturing</i>	9	136	\$151,612
334220	<i>Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing</i>	39	2,421	\$129,574
334290	<i>Other Communications Equipment Manufacturing</i>	19	555	\$110,832
3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	198	16,037	\$136,286
334510	<i>Electromedical and Electrotherapeutic Apparatus Manufacturing</i>	54	416	\$94,492
334511	<i>Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing</i>	28	N/D	N/D
334512	<i>Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use</i>	6	12	\$84,030

Maryland Supply Chain Analysis
RESI of Towson University

334513	<i>Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables</i>	25	216	\$69,132
334514	<i>Totalizing Fluid Meter and Counting Device Manufacturing</i>	2	N/D	N/D
334515	<i>Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals</i>	24	814	\$151,561
334516	<i>Analytical Laboratory Instrument Manufacturing</i>	27	1,224	\$108,122
334517	<i>Irradiation Apparatus Manufacturing</i>	6	15	\$103,473
334519	<i>Other Measuring and Controlling Device Manufacturing</i>	28	285	\$75,586
3346	<i>Manufacturing and Reproducing Magnetic and Optical Media</i>	37	815	\$208,796
334610	<i>Manufacturing and Reproducing Magnetic and Optical Media</i>	37	815	\$208,796
3364	<i>Aerospace Product and Parts Manufacturing</i>	36	2,555	\$102,268
336411	<i>Aircraft Manufacturing</i>	10	N/D	N/D
336412	<i>Aircraft Engine and Engine Parts Manufacturing</i>	3	N/D	N/D
336413	<i>Other Aircraft Parts and Auxiliary Equipment Manufacturing</i>	18	296	\$101,478
336414	<i>Guided Missile and Space Vehicle Manufacturing</i>	4	7	\$229,476
336415	<i>Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing</i>	*	*	*
336419	<i>Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing</i>	1	N/D	N/D
3365	<i>Railroad Rolling Stock Manufacturing</i>	4	N/D	N/D
336510	<i>Railroad Rolling Stock Manufacturing</i>	4	N/D	N/D
3379	<i>Other Furniture Related Product Manufacturing</i>	10	1,122	\$47,182
337910	<i>Mattress Manufacturing</i>	5	N/D	N/D
337920	<i>Blind and Shade Manufacturing</i>	5	N/D	N/D
4883	<i>Support Activities for Water Transportation</i>	59	4,756	\$55,370
488310	<i>Port and Harbor Operations</i>	7	N/D	N/D
488320	<i>Marine Cargo Handling</i>	21	3,931	\$48,725
488330	<i>Navigational Services to Shipping</i>	14	N/D	N/D

Maryland Supply Chain Analysis
RESI of Towson University

488390	<i>Other Support Activities for Water Transportation</i>	17	236	\$190,684
4931	Warehousing and Storage	270	39,115	\$40,495
493110	<i>General Warehousing and Storage</i>	206	37,711	\$39,685
493120	<i>Refrigerated Warehousing and Storage</i>	14	848	\$65,811
493130	<i>Farm Product Warehousing and Storage</i>	18	250	\$45,816
493190	<i>Other Warehousing and Storage</i>	32	306	\$65,818
5239	Other Financial Investment Activities	1,606	11,144	\$217,397
523910	<i>Miscellaneous Intermediation</i>	73	289	\$292,988
523940	<i>Portfolio Management and Investment Advice</i>	1,314	10,157	\$219,501
523991	<i>Trust, Fiduciary, and Custody Activities</i>	39	78	\$143,460
523999	<i>Miscellaneous Financial Investment Activities</i>	182	620	\$156,947
5413	Architectural, Engineering, and Related Services	3,063	39,906	\$106,183
541310	<i>Architectural Services</i>	416	2,839	\$96,346
541320	<i>Landscape Architectural Services</i>	132	731	\$75,476
541330	<i>Engineering Services</i>	1,973	32,587	\$110,046
541340	<i>Drafting Services</i>	29	140	\$84,520
541350	<i>Building Inspection Services</i>	185	617	\$56,822
541360	<i>Geophysical Surveying and Mapping Services</i>	28	156	\$71,986
541370	<i>Surveying and Mapping (except Geophysical) Services</i>	125	824	\$75,897
541380	<i>Testing Laboratories and Services</i>	178	2,013	\$100,352
5415	Computer Systems Design and Related Services	11,104	85,448	\$131,838
541511	<i>Custom Computer Programming Services</i>	4,210	26,219	\$143,143
541512	<i>Computer Systems Design Services</i>	5,760	54,558	\$127,211
541513	<i>Computer Facilities Management Services</i>	132	835	\$109,441
541519	<i>Other Computer Related Services</i>	1,002	3,837	\$125,248
5416	Management, Scientific, and Technical Consulting Services	7,838	49,485	\$112,815
541611	<i>Administrative Management and General Management Consulting Services</i>	3,871	28,088	\$117,621
541612	<i>Human Resources Consulting Services</i>	309	2,300	\$157,009
541613	<i>Marketing Consulting Services</i>	1,016	4,094	\$92,996

Maryland Supply Chain Analysis
RESI of Towson University

541614	<i>Process, Physical Distribution, and Logistics Consulting Services</i>	287	2,630	\$77,763
541618	<i>Other Management Consulting Services</i>	674	2,193	\$114,061
541620	<i>Environmental Consulting Services</i>	278	3,478	\$91,665
541690	<i>Other Scientific and Technical Consulting Services</i>	1,403	6,702	\$113,939
5417	Scientific Research and Development Services	1,912	39,301	\$131,788
541713	<i>Research and Development in Nanotechnology</i>	112	405	\$140,866
541714	<i>Research and Development in Biotechnology (except Nanobiotechnology)</i>	789	12,814	\$133,404
541715	<i>Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)</i>	784	20,355	\$139,916
541720	<i>Research and Development in the Social Sciences and Humanities</i>	228	5,726	\$98,633
Maryland, All Private Employment		183,083	2,160,905	\$71,104

Sources: RESI, U.S. Bureau of Labor Statistics

Appendix B – Detailed Project Descriptions

Figure 31: Detailed Project Descriptions

Project Name	Description
Advanced Technologies for Digitalization of Construction Industry	This project intends to form a construction consortium using cutting-edge technology and develop the first comprehensive digital construction roadmap. The project also seeks to identify areas of overlap and common interests among the various stakeholders in the field of digital building to explore the best mechanisms and strategies for implementing the roadmap. The project's ability to increase efficiency across six application areas—smart infrastructures, mass housing, disaster response, pandemic preparedness, and construction in space—will have the most significant overall impact.
AI-Enhanced Multimodal Sensing of Materials and Processes for Complete Product Lifecycle	This project aims to provide a technology roadmap for merging traditional material science and process knowledge with artificial intelligence (AI) and machine learning (ML) capabilities throughout the product life cycle. Upon completion, this will improve the visibility and responsiveness of the national supply chain and significantly affect the productivity and competitiveness of American industry.
Developing a Roadmap to Strengthen the U.S. Manufacturing Supply Chain via the Digital Thread	The project intends to identify significant weaknesses and gaps in digital thread technology and develop a technology roadmap to enhance the resilience and capacity of the U.S. industrial supply chain through the use of the digital thread. This project will help American firms increase operational effectiveness and efficiency, produce goods of higher quality, quickly detect disruptions in the supply chain and quality problems, and expand revenue.
Freeze-Thaw and Aseptic Drying Technology Roadmap for Pharma/Biotech Manufacturing	The LyoHUB consortium, which receives funding from AMTech, can expand its current technology roadmap with the help of this initiative. By addressing new product modalities, such as freeze-thaw and alternative aseptic drying technologies, the project intends to strengthen the pharmaceutical cold chain. It also creates infrastructure for roadmap implementation projects and workforce training on current and emerging technologies.

Maryland Supply Chain Analysis
RESI of Towson University

Microelectronic and Advanced Packaging Technology (MAPT)	Finding new applications that will drive the need for microelectronics and packaging in the future is one of the key objectives of MAPT. Industry, academia, and the government will utilize this to help them make crucial strategic technological, manufacturing, and workforce development decisions. By developing a resilient, diverse, and highly skilled workforce in microelectronics and advanced packaging to support R&D, the project may also help to meet a critical national need.
Next Generation Electric Machines and Systems for Clean Emissions (Next Electric)	The project seeks to identify and address the significant technological barriers in platform technologies, where early-stage developments will enable net zero emissions for many economic sectors. Once finished, Next Electric will swiftly advance the next generation of electric devices and systems across many economic sectors, addressing the pressing need to reduce carbon-based fuel emissions drastically.
Roadmap for Accelerating Production of Large Structures and Systems	With an emphasis on Large Structure 4.0 technologies, next-generation fabrication and inspection processes, and training programs that boost American competitiveness, the project intends to build a comprehensive U.S. industry and technology roadmap for producing large structures and systems.

Sources: NIST Office of Advanced Manufacturing, RESI

Appendix C – Key Industry Subsectors

Figure 32: Key Maryland Industry Subsectors

NAICS Code	Industry Title	Subsectors
3119	Other Food Manufacturing	31191-Snack Food Manufacturing, 31192-Coffee and Tea Manufacturing, 31193-Flavoring Syrup and Concentrate Manufacturing, 31194-Seasoning and Dressing Manufacturing, and 31199-All Other Food Manufacturing.
3254	Pharmaceutical and Medicine Manufacturing	325411-Medicinal and Botanical Manufacturing, 32541-Pharmaceutical Preparation Manufacturing, 325413-In-Vitro Diagnostic Substance Manufacturing, and 325414-Biological Product (Except Diagnostic) Manufacturing
3342	Communications Equipment Manufacturing	334210-Telephone Apparatus Manufacturing, 334220-Radio and Television Broadcasting and Wireless 3342-Communications Equipment Manufacturing, and 33429-Other Communications Equipment Manufacturing.
3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	334510-Electromedical and Electrotherapeutic Apparatus Manufacturing, 334511-Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing, 334512-Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use, 334513-Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables, 334514-Totalizing Fluid Meter and Counting Device Manufacturing; and 334515-Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals.
3346	Manufacturing and Reproducing Magnetic and Optical Media	334610-Manufacturing and Reproducing Magnetic and Optical Media. ⁴⁹⁰
3364	Aerospace Product and Parts Manufacturing	336411-Aircraft Manufacturing, 336412-Aircraft Engine and Parts Manufacturing, 336413-Other Aircraft parts and Auxiliary Equipment Manufacturing,

⁴⁹⁰ Please note that with the 2022 release of NAICS definitions, the previously defined industry subgroups were consolidated into the single industry code of 334610.

Maryland Supply Chain Analysis

RESI of Towson University

		336414-Guided Missile and Space Vehicle Manufacturing, 336415-Guided Missile and Space Vehicle Propulsion Unit and Unit Parts Manufacturing, and 336419-Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing.
3365	Railroad Rolling Stock Manufacturing	336510-Brakes and Parts for Railroad Rolling Stock Manufacturing, 336510-Locomotives Manufacturing, and 336510-Railroad Cars and Car Equipment Manufacturing
3379	Other Furniture Related Product Manufacturing	33791-Mattress Manufacturing, and 33792-Blind and Shade Manufacturing.
4883	Support Activities for Water Transportation	488310-Port and Harbor Operations, 488320-Marine Cargo Handling, 488330-Navigational Services to Shipping, and 4883-Other Support Activities for Water Transportation
4931	Warehousing and Storage	493110-General Warehousing and Storage, 493120-Refrigerated Warehousing and Storage, 493130-Farm Product Warehousing and Storage, and 4931-Other Warehousing and Storage.
5239	Other Financial Investment Activities	52391-Miscellaneous Intermediation; 52394-Portfolio Management and Investment Advice; 52399-All Other Financial Investment Activities; 523991-Trust, Fiduciary, and Custody Activities; and 523999-Miscellaneous Financial Investment Activities.
5413	Architectural, Engineering, and Related Services	541310-Architectural Services, 541320-Landscape Architectural Services, 541330-Engineering Services, 541340-Drafting Services, 541350-Building Services, 541360-Geophysical Surveying and mapping Services, 541370-Surveying and Mapping (except Geophysical) Services, and 541380-Testing Laboratories and Services (except Medical and Veterinary).
5415	Computer Systems Design and Related Services	541511-Custom Computer Programing Services, 541512-Computer Systems Design Services, 541513-Computer Facilities Management Services, and 5415-Other Computer Related Services.
5416	Management, Scientific, and Technical Consulting Services	541614-Process, Physical Distribution, and Logistics Consulting Services, 54161-Management Consulting Service, 541611-Administrative Management and General Consulting Services

Maryland Supply Chain Analysis

RESI of Towson University

		541612-Human Resources Consulting Services, 541613-Marketing Consulting Services, 541620-Environmental Consulting Services, 541690-Other Scientific and Technical Consulting Services, and 541618-Other Management Consulting Services.
5417	Scientific Research and Development Services	54171-Research and Development in the Physical, Engineering, and Life Sciences, 541713-Research and Development in Nanotechnology, 541714-Research and Development in Biotechnology, 541715-Research and Development in the Physical, Engineering, and Life Sciences, and 541712-Research and Development in the Social Sciences and Humanities

Sources: RESI, U.S. Census Bureau

Appendix D – Interview Questions

Below are the questions and format used during each participant interview.

First Topic Issues — Describing Your Supply Chain

Probe 1: Please describe the strengths and weaknesses of your organizations supply chain.

- Why does your company operate in Maryland? What are the advantages to being here? Challenges?
- How much of your organization’s supply chain is based in Maryland?

Probe 2: What influences the capacity for expansion within your organization’s supply chain?

- What opportunities for expansion exist?
- Do you believe your organization’s supply chain has the capacity to expand? Why or why not?

Probe 3: Where in your industry/organization do the biggest threats to the supply chain exist?

- Tell us about what risk mitigation strategies your organization has in place in the event of a supply chain disruption.

Probe 4: How does your product get to the end customer?

- What technology and transportation are used?
- Do any bottlenecks exist within this process?

Probe 5: What factors impact your industry's supply chain?

- Would you describe that as a positive or negative factor?
- How do regional features impact the supply chain?

Second Topic Issues— COVID-19 and Current Events Related Impacts

Probe 1: How has the COVID-19 pandemic impacted your industry’s operations and supply chain?

- How have your company’s operations been affected by recent events (pandemic, global wars, etc.)? Any supply chain issues? Are these issues ongoing, or have they been resolved?

Probe 2: If applicable, what new processes have you adopted that assist you in anticipating and responding to supply chain challenges or delays?

- How do new processes differ from best practices in the past?

Probe 3: Please explain whether you believe these impacts seem to be temporary or mark a structural shift going forward.

Third Topic Issues— Supplier Networks and Support

Probe 1: How robust is your supply chain?

- If a current supplier were to shut down operations how difficult would it be to transition?
- What factors are most important when choosing a supplier? How would you weigh those factors?

Probe 2: How would you describe your organization's relationship with international and domestic suppliers?

- How have you benefited from these relationships?
- Are there any specific challenges with suppliers that your organization or industry is facing?
- Have you noticed any patterns in your industry regarding supply chain logistics, for example, reshoring in the U.S. states or transitions away from certain countries or suppliers?

Probe 3: How has your supplier network changed since the pandemic?

- Has your company taken any steps to mitigate any supply chain issues that you've experienced? If so, what are they? What support could help you mitigate issues now or in the future?
- Can you describe your organization's process for finding a new supplier?

Probe 4: What support have you found most valuable in strengthening your organization's supply chain?

Probe 5: What services or support do you feel your organization needs to be successful?

- Do you have concerns about your supply chain going forward? If so, what are those concerns? How might they be addressed?

Appendix E – NAICS to IMPLAN Industries

Below in Figure 33 is an overview of the full NAICS to IMPLAN industry crosswalk for the industries of interest. Industries with an asterisk were not included in the commodity analysis.

Figure 33: Full NAICS to IMPLAN Crosswalk for Industries of Interest

NAICS Industry	Corresponding IMPLAN Industries
NAICS 3254 Pharmaceutical and Medicine Manufacturing	IMPLAN 171 Medicinal and Botanical Manufacturing IMPLAN 172 Pharmaceutical Preparation Manufacturing IMPLAN 173 In-vitro Diagnostic Substance Manufacturing IMPLAN 174 Biological Product (Except Diagnostic) Manufacturing
NAICS 3342 Communications Equipment Manufacturing	IMPLAN 301 Telephone Apparatus Manufacturing* IMPLAN 302 Broadcast and Wireless Communications Equipment Manufacturing IMPLAN 303 Other Communications Equipment Manufacturing
NAICS 3345 Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	IMPLAN 311 Electromedical and Electrotherapeutic Apparatus Manufacturing IMPLAN 312 Search, Detection, and Navigation Instruments Manufacturing IMPLAN 313 Automatic Environmental Control Manufacturing IMPLAN 314 Industrial Process Variable Instruments Manufacturing IMPLAN 315 Totalizing Fluid Meter and Counting Device Manufacturing IMPLAN 316 Electricity and Signal Testing Instruments Manufacturing IMPLAN 317 Analytical Laboratory Instrument Manufacturing IMPLAN 318 Irradiation Apparatus Manufacturing* IMPLAN 319 Watch, Clock, and Other Measuring and Controlling Device Manufacturing*
NAICS 3346 Manufacturing and Reproducing Magnetic and Optical Media	IMPLAN 320 Blank Magnetic and Optical Recording Media Manufacturing IMPLAN 321 Software and Other Prerecorded and Record Reproducing*
NAICS 3379 Other Furniture Related Product Manufacturing	IMPLAN 374 Mattress Manufacturing IMPLAN 375 Blind and Shade Manufacturing
NAICS 5415 Computer Systems Design and Related Services	IMPLAN 459 Custom Computer Programming Services IMPLAN 460 Computer Systems Design Services IMPLAN 461 Other Computer Related Services, Including Facilities Management*
NAICS 5416 Management, Scientific, and Technical Consulting Services	IMPLAN 462 Management Consulting Services IMPLAN 463 Environmental and Other Technical Consulting Services*

Sources: IMPLAN, RESI

Appendix F – Technical Methodology

This section will outline the methodology used for the *Manufacturing and Transportation and Warehousing* Analysis and the Commodity Analysis. Brief methodologies for the industry profiles and the supply chain expert interviews can be found in Section 5 and Section 7, respectively.

Manufacturing and Transportation and Warehousing Analysis

To supplement RESI's analysis of Maryland's *Manufacturing* labor force, RESI used the shift-share model. A shift-share analysis shows how changes in industry employment are impacted by different factors, including how well the national economy is doing, regional conditions that are impacting growth, and patterns of change within the industry itself. The national share is the proportion of regional growth that can be attributed to national employment trends. The industrial mix indicates the amount of regional growth that can be attributed to employment trends within a specific industry, after accounting for national growth trends across all industries. The regional shift is an indicator of whether an area possesses a unique competitive advantage within a specific industry and shows the amount of job growth that cannot be explained by national or industry employment trends.

The formulas used for the shift share analysis are as follows:⁴⁹¹

Change in Employment in an Industry = National Share + Industry Mix + Regional Shift

National Share = Regional employment in industry of interest in the first year * (Change in national employment in all industries in first year)

Industrial Mix = Regional employment in industry of interest in the first year * [(Change in national employment in industry of interest) - (change in national employment in all industries)]

Regional Shift = Regional employment in industry of interest in the first year * [(Change in regional employment in industry of interest) - (change in national employment in industry of interest)]

The national share is the proportion of regional growth that can be attributed to national employment trends. The industrial mix indicates the amount of regional growth that can be attributed to employment trends within a specific industry, after accounting for national growth trends across all industries. The regional shift is an indicator of whether an area possesses a unique competitive advantage (or disadvantage) within a specific industry and provides the amount of job growth that cannot be explained by national or industry employment trends.

⁴⁹¹ Robert J. Stimson, Roger R. Stough, and Brian H. Roberts, *Regional Economic Development Analysis and Planning Strategy* (New York: Springer-Verlag, 2002), 105-125, accessed December 4, 2023, https://stellar.mit.edu/S/course/11/sp13/11.S952/courseMaterial/topics/topic1/readings/Stimson_2006_RegionalED_pp105-125/Stimson_2006_RegionalED_pp105-125.pdf.

RESI also used location quotients from the U.S. Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW) to analyze the changes in Maryland *Manufacturing* employment relative to the national average from 2018 to 2022. Location quotients (LQs) are defined as a measurement of “an industry’s regional concentration of value added, employment, or compensation relative to the U.S. industry’s share.”⁴⁹² LQs are based on a numeric system where a score of 1 indicates that regional concentration within the industry equals the national average. A LQ above 1 indicates that the industry is more concentrated in the area compared to the national average, while an LQ value below 1 indicates that the industry is less concentrated than the national average.

Commodity Analysis

Commerce selected seven industries for further evaluation through a commodity analysis:

- NAICS 3254 Pharmaceutical and Medicine Manufacturing;
- NAICS 3342 Communications Equipment Manufacturing;
- NAICS 3345 Navigational, Measuring, Electromedical, and Control Instruments Manufacturing;
- NAICS 3346 Manufacturing and Reproducing Magnetic and Optical Media;
- NAICS 3379 Other Furniture Related Product Manufacturing;
- NAICS 5415 Computer Systems Design and Related Services; and
- NAICS 5416 Management, Scientific, and Technical Consulting Services.

To complete this task, RESI used commodity data from IMPLAN’s input-output model to determine the relative importance to each NAICS industry outlined by Commerce. Because IMPLAN and NAICS use different industry schemes, RESI used the NAICS-to-IMPLAN crosswalk tool to determine which industries corresponded to those chosen by Commerce. With the exceptions of NAICS 3346 *Manufacturing and Reproducing Magnetic and Optical Media* and NAICS 5416 *Management, Scientific, and Technical Consulting Services*, each other NAICS industry listed above was associated with several IMPLAN industry codes.

RESI used data from IMPLAN’s 2022 Industry Balance Sheets for this analysis, which provide information on industries and commodities within the region.⁴⁹³ IMPLAN groups industries based on their economic activities. The industry models are based on information from the Bureau of Economic Analysis’ Benchmark Input Output Tables, which estimate industry output, value added, and final demand for a given industry.⁴⁹⁴ IMPLAN then uses a regional value-added coefficient to localize the national spending patterns to a geographic area of interest, in this case, Maryland.⁴⁹⁵ Balance Sheet information is accessed by first entering the regional

⁴⁹² “Definitions,” U.S. Bureau of Economic Analysis, accessed May 26, 2022, <https://apps.bea.gov/regional/pdf/acpsa/-definitions.pdf>.

⁴⁹³ Clouse, “Social Accounts.”

⁴⁹⁴ “IMPLAN Data Sources,” IMPLAN, June 27, 2017, accessed December 4, 2023, <https://support.implan.com/hc/en-us/articles/115009674448-IMPLAN-Data-Sources>.

⁴⁹⁵ Maria Lucas, “Industry Leontief Production Functions in IMPLAN,” IMPLAN, September 26, 2019, accessed December 4, 2023, <https://support.implan.com/hc/en-us/articles/360035967274-Industry-Leontief-Production-Functions-in-IMPLAN>.

IMPLAN model for Maryland. Within Maryland's IMPLAN model for 2022 (the most recent data year), the Social Accounts data houses the industry balance sheets that provide an overview of commodity demand for a given industry. The Balance Sheets offer an overview of commodities that are important to an industry's supply chain through metrics such as gross absorption, gross inputs, regional absorption, regional inputs, and regional purchase coefficients (RPCs). Definitions for each of these key metrics are outlined below.

Gross Absorption is the percentage of an industry's total output that is allocated to the purchase of a specific commodity in an industry's Leontief Production Function.⁴⁹⁶ RESI used this metric to rank commodities to assess which were the most important to each respective industry. Sorting commodities in this way helped RESI parse out which commodities were of utmost importance to an industry but may not be easily obtained by firms within the region.

Gross Inputs are the dollar amount that an industry spends for the purchase of a given commodity.⁴⁹⁷

Regional Inputs are the dollar amount that an industry spends within a specific geographic region (e.g., state, county, or metro area) for the purchase of a given commodity.⁴⁹⁸ In the current analysis, RESI evaluated the state of Maryland as outlined within the IMPLAN model.

Regional Absorption is the percentage of an industry's total output allocated to the local purchase of a specific commodity.⁴⁹⁹ RESI used the difference, or 'gap', between gross and regional absorption to assess how much an industry's output is being allocated toward the purchase of specific commodities outside of the region.

Regional Purchase Coefficient (RPC) represents the proportion of all local demands (industrial and institutional) for a specific commodity that is supplied by the region.⁵⁰⁰ For example, an RPC of 40 percent for a given commodity indicates that 40 percent of local demand is met by local supplies of that commodity, while 60 percent is imported.

After commodity data were obtained for each sector within the seven focused IMPLAN industries, these individual data sets were combined using Stata statistical software. For each combined IMPLAN industry dataset, new variables were generated for the *combined gross input* and *combined regional input* for each commodity. From these new variables and total industry output data, calculations were done to create additional variables for the *combined gross absorption*, *combined regional absorption*, and the *gap* between gross absorption and regional absorption levels. The percent obtained out-of-region (OOR) was calculated from the *gross absorption* levels and the *gap* to determine the proportion of commodities that is not available from regional suppliers. Data were then evaluated to determine if any subsectors

⁴⁹⁶ "Gross Absorption," IMPLAN.

⁴⁹⁷ "Gross Inputs," IMPLAN.

⁴⁹⁸ "Regional Inputs," IMPLAN.

⁴⁹⁹ "Regional Absorption," IMPLAN.

⁵⁰⁰ IMPLAN Data Team, "Regional Purchase Coefficients."

within each IMPLAN industry had a top commodity by gross absorption level that was not captured in the combined data. For these instances, additional commodities were added to the top commodity lists where applicable. Results for the full analysis are found in Section 6.

Appendix G – Detailed Commodity Regional Purchasing Coefficients

This appendix shows the Regional Purchase Coefficients (RPCs) for each top commodity by industry. Note that commodity RPCs are for all industries purchasing the commodity and are not isolated to the RPC for the specific industry (e.g., *Pharmaceutical and Medicine Manufacturing*) being evaluated. The RPC represents the proportion of all local demands (industrial and institutional) for a specific commodity that is supplied by the region.⁵⁰¹ For example, an RPC of 40 percent for a given commodity indicates that 40 percent of local demand is met by local supplies of that commodity, while 60 percent is imported from out-of-region (OOR) suppliers. As a note, commodities marked with an asterisk (*) were not found in every IMPLAN industry that fell within the collective NAICS industry, but were a top commodity by gross absorption levels in at least one IMPLAN industry within the sector.

Figure 34: Top Commodity RPCs in Pharmaceutical and Medicine Manufacturing

Commodity Description	RPC
Biological Products (Except Diagnostic)	0.4%
Wholesale Services - Drugs and Druggists' Sundries	56.7%
Medicines and Botanicals	4.7%
Management of Companies and Enterprises	68.5%
Other Basic Organic Chemicals	0.1%
Advertising, Public Relations, and Related Services	66.8%
Pharmaceuticals*	2.0%
Wholesale Services - Other Nondurable Goods Merchant Wholesalers	78.6%
Other Plastics Products	7.2%
Truck Transportation Services	69.9%

Sources: Commerce, IMPLAN, RESI

Figure 35: Top Commodity RPCs in Communications Equipment Manufacturing

Commodity Description	RPC
Wholesale Services - Household Appliances and Electrical and Electronic Goods	71.2%
Management of Companies and Enterprises	68.5%
Broadcast and Wireless Communications Equipment	0.6%
Printed Circuit Assemblies (Electronic Assemblies)	0.4%
Custom Computer Programming Services	76.5%
Semiconductors and Related Devices	0.1%
Other Electronic Components	0.8%
Wholesale Services - Machinery, Equipment, and Supplies	62.4%
Advertising, Public Relations, and Related Services	66.8%
Wholesale Services - Professional and Commercial Equipment and Supplies	88.1%

Sources: Commerce, IMPLAN, RESI

⁵⁰¹ IMPLAN Data Team, "Regional Purchase Coefficients."

Figure 36: Top Commodity RPCs in Navigational, Measuring, Electromedical, and Control Instruments Manufacturing

Commodity Description	RPC
Management of Companies and Enterprises	68.5%
Wholesale Services – Household Appliances and Electrical and Electronic Goods	71.2%
Custom Computer Programming Services*	76.5%
Printed Circuit Assemblies (Electronic Assemblies)	0.4%
Advertising, Public Relations, and Related Services	66.8%
Other Electronic Components	0.8%
Semiconductors and Related Devices	0.1%
Automatic Environmental Controls*	0.3%
Electricity and Signal Testing Instruments*	4.0%
Warehousing and Storage Services	85.8%

Sources: Commerce, IMPLAN, RESI

Figure 37: Top Commodity RPCs in Manufacturing and Reproducing Magnetic and Optical Media

Commodity Description	RPC
Management of Companies and Enterprises	68.5%
Other Plastics Products	7.2%
Warehousing and Storage Services	85.8%
Advertising, Public Relations, and Related Services	66.8%
Blank Magnetic and Optical Recording Media	1.5%
Noncomparable Imports	0.0%
Plastics Packaging Materials and Unlaminated Films and Sheets	3.9%
Truck Transportation Services	69.9%
Wholesale Services - Other Nondurable Goods Merchant Wholesalers	78.6%
Employment Services	91.1%

Sources: Commerce, IMPLAN, RESI

Figure 38: Top Commodity RPCs in Other Furniture Related Product Manufacturing

Commodity Description	RPC
Urethane and Other Foam Products (Except Polystyrene)*	6.7%
Coated Fabric Coating*	1.3%
Spring and Wire Products	16.8%
Broadwoven Fabrics and Felts*	0.2%
Scenic and Sightseeing Transportation Services and Support Activities for Transportation*	77.1%
Wholesale Services - Other Nondurable Goods Merchant Wholesalers	78.6%
Advertising, Public Relations, and Related Services	66.8%
Wholesale Services - Professional and Commercial Equipment and Supplies	88.1%
Wholesale Services - Other Durable Goods Merchant Wholesalers	85.7%
Fiber Filaments, Yarn, and Thread*	0.7%

Sources: Commerce, IMPLAN, RESI

Figure 39: Top Commodity RPCs in Computer Systems Design and Related Services

Commodity Description	RPC
Employment Services	91.1%
Management Consulting Services	79.7%
Advertising, Public Relations, and Related Services	66.8%
Legal Services	76.7%
Management of Companies and Enterprises	68.5%
Other Real Estate Services	95.3%
Architectural, Engineering, and Related Services	80.7%
Office Administrative Services	89.6%
Accounting, Tax Preparation, Bookkeeping, and Payroll Services	79.9%
Data Processing, Hosting, and Related Services	56.3%

Sources: Commerce, IMPLAN, RESI

Figure 40: Top Commodity RPCs in Management, Scientific, and Technical Consulting Services

Commodity Description	RPC
Employment Services	91.1%
Monetary Authorities and Depository Credit Intermediation	47.4%
Other Real Estate Services	95.3%
Internet Publishing and Broadcasting and Web Search Portals	27.7%
Management of Companies and Enterprises	68.5%
Management Consulting Services	79.7%
Accounting, Tax Preparation, Bookkeeping, and Payroll Services	79.9%
Data Processing, Hosting, and Related Services	56.3%
All Other Food and Drinking Place Services	92.3%
Advertising, Public Relations, and Related Services	66.8%

Sources: Commerce, IMPLAN, RESI

END OF DOCUMENT