

Accelerating Advanced Manufacturing with New Research Centers

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Summary

Manufacturing remains a critical sector for the economic health of the nation as a whole and for the states. The sector accounts for the bulk of U.S. exports, is key to innovation, and provides many high-wage jobs for less educated workers. So reversing or at least stemming manufacturing job losses is essential to an economic recovery that leads to a sustained period of export-oriented, innovation-fueled, opportunity-rich economic growth. For these and other reasons, manufacturing should be an important part of state job growth strategies. But state efforts are not focused on what would be most helpful for manufacturers: which is helping them, particularly small and medium-sized businesses in the manufacturing supply chain, develop or apply more advanced technologies. To remedy this problem, states should create advanced manufacturing centers that provide both research to develop new, relevant technologies and the education to help businesses throughout the supply chain apply these technologies to their work. These centers would take only a modest investment of \$9 million per year, which is a small share of what states typically spend on traditional business attraction efforts.

I. Introduction

The United States as a whole, and every state except Alaska, had fewer manufacturing jobs in 2009 than in 2000.¹ Between 2000 and 2009, the nation lost 31.2 percent of its manufacturing jobs, and manufacturing fell from 13.1 percent of total employment to 9.1 percent.² The nation's manufacturing output grew by only 11.0 percent during this period, while GDP grew by 15.7 percent. As a result, manufacturing's share of GDP fell from 14.2 percent to 11.0 percent.³

Yet even this comparatively diminished manufacturing sector accounts for the bulk of U.S. exports, is key to innovation, and provides many high-wage jobs for less educated workers. So reversing or at least stemming these losses is essential to an economic recovery that leads to a sustained period of export-oriented, innovation-fueled, opportunity-rich economic growth.

States have an especially high stake in manufacturing. The Great Recession and its aftermath produced especially high unemployment rates for workers with less than a bachelor's degree, who account for 70 percent of American adults.⁴ These losses have not only harmed those who have lost jobs, but have also put downward pressure on the wages of less educated workers and strained state unemployment insurance trust funds and other social safety nets that are funded largely by or through state governments.⁵ Because average weekly earnings in manufacturing are 19.3 percent higher than the national private sector average, even though manufacturing employs a greater than average share of workers without a college degree, manufacturing should be an important part of state job recovery strategies.⁶

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Manufacturing also matters to states because it can be part of a firm foundation for long-term economic growth. Innovation is the key to long-term growth for states and metropolitan areas as well as for the nation as a whole.⁷ Manufacturing firms are more likely to innovate than those in almost all other industries.⁸ Manufacturing employs 36.4 percent of the nation's engineers and accounts for 70 percent of industry-funded research and development (R&D).⁹ In addition, manufacturing contributes to the prosperity of states by bringing in income from other states and countries, thus supporting job creation in other parts of the economy that primarily serve state residents; only a few service industries (and only parts of those industries) accomplish this.¹⁰

Manufacturing is especially important to some states and metropolitan areas. For example, 11.9 percent of all jobs in Michigan and 11.8 percent of all jobs in Tennessee are manufacturing jobs, well above the national average of 9.1 percent. Even states that do not depend as heavily on manufacturing have regions where it is very important. For example, the New York metropolitan areas of Buffalo (where 9.4 percent of jobs are in manufacturing) and Rochester (12.5 percent) are heavily manufacturing-based, as are the Colorado metropolitan areas of Boulder (9.6 percent) and Greeley (13.6 percent).¹¹ Manufacturing is still critical to these state and metropolitan economies even though manufacturing employment fell by a greater percentage in Michigan, Tennessee and the metropolitan areas of Buffalo and Rochester, NY, and Boulder, CO, than nationwide between 2000 and 2009.¹²

The loss of manufacturing jobs should not be treated as an inevitability. The manufacturing sector may not ever regain the shares of GDP and employment that it commanded in the 1980s, but policy-makers should not acquiesce in its disappearance. Other economically advanced countries, except for Great Britain, have not suffered the degree of manufacturing job loss that has occurred in the United States. Germany, for example, lost only about one-eighth the share of manufacturing employment that the United States lost during the past decade, while Australia and France had less than half the U.S. percentage loss.¹³

To strengthen their manufacturing bases, states must go beyond simply attracting large manufacturers from other states and even beyond assisting manufacturers with training and early-stage financing. They need to support the development and diffusion of improved manufacturing technologies, ways of organizing work, and relationships between final goods producers (typically, assemblers) and their suppliers. To accomplish these goals states should establish advanced manufacturing centers, based in their metropolitan areas, to help manufacturers solve generic technical and management problems in one or more industries.

II. Challenges

Strengthening the manufacturing base is critical for states as well as the nation as a whole. Yet, even in the face of huge manufacturing job losses during the last decade, state-level manufacturing policy has been aimed more at attracting manufacturing from other states than at strengthening the existing manufacturing base. Even in states that have policies to strengthen manufacturing, those policies have important gaps, as do federal efforts to assist manufacturing. There are only a few state and privately supported programs that perform the kind of highly applied technological research that manufacturers need and that also investigate and educate manufacturers about the changes in production, work organization, and business organization that they would need to make to implement the technologies they develop.

State policies toward manufacturing emphasize financial incentives for business attraction and retention over the improvement of existing manufacturing or the support of new manufacturing. The most common state manufacturing policies are financial incentives designed to attract new firms from other states, prevent existing firms from moving elsewhere, or help existing firms expand within the state. Policies typically take the form of tax incentives or low-interest loans for new investment in plant and equipment, job creation, and training, as well as more general policies designed to create a "good business climate" (e.g., right-to-work laws or low corporate or individual tax rates). They may be directed specifically at manufacturers or offered to businesses regardless of industry (but primarily intended to target manufacturers). In most Southern states, including Tennessee, these policies are the only manufacturing policies that exist (other than state support for the joint federal-state

Manufacturing Extension Partnership program).¹⁴ Northern industrial states, such as New York and Michigan, have similar attraction and retention policies but with less generous financial incentives or more restrictions on eligibility; they also lack the “business climate” policies of Southern states. Northern industrial states are more likely than Southern states to have manufacturing-specific subsidy programs. Western states, such as Colorado, provide smaller subsidies to firms than those in other regions.¹⁶ Some Northern and Western states do have industry-neutral financial assistance programs that have the potential to strengthen manufacturing. For example, New York and Colorado offer assistance with exporting (which disproportionately benefits manufacturers) and Colorado subsidizes access to early stage capital.

States do not focus on helping small and medium-sized businesses in the manufacturing supply chain adopt new technologies. Many manufacturing industries, including aircraft, autos, and agricultural equipment, are characterized by long supply chains, where layers of specialized firms provide components for a finished product. Over the last few decades, suppliers, often small or medium-sized, have become responsible for designing and making much of the content of manufactured goods. Consequently, innovation in U.S. manufacturing depends increasingly on the capabilities of these firms. Yet most of them do little or no formal R&D and cannot easily take advantage of university-based R&D. Unlike many European countries, the United States has few institutions that help coordinate upgrading of suppliers, and few state efforts fill this gap.

State-supported programs very rarely combine highly applied engineering research with research and education on the problems manufacturers, especially suppliers, face in implementing technological changes. Technological advances are important to improving the performance of U.S. manufacturers but there is little research on the kinds of highly applied problems that are of great importance to a wide range of manufacturers, including suppliers (e.g., joining two kinds of materials together, a key capability in product weight-reduction efforts that reduce energy use). Moreover, the implementation of new technologies often requires changes in management processes, work organization, and relationships between suppliers and assemblers. Manufacturers need to learn about both the technologies and the management/organizational changes they need to make to adopt those technologies. There are a few organizations that combine the technical and organizational research and education that manufacturers need (see text box), but they typically focus on the needs of one manufacturing industry (rather than conducting research and education that are useful for a range of manufacturing applications), depend heavily on federal grants (and so are vulnerable to changes in federal agency funding and priorities), and do not explicitly work on supply chain problems.

States cannot count on the federal government to provide manufacturing support in their stead. Federal programs to strengthen manufacturing have important gaps. The federal Manufacturing Extension Partnership program (MEP), funded jointly by federal and state governments and fees from manufacturers that use its services, provides technical assistance to small and medium-sized manufacturers to help them become more productive and competitive. However, it is underfunded (in part because states have had difficulty meeting their funding obligations during and after the Great Recession), offers services that vary greatly in quality among and within states, is not set up to work with groups of assemblers and suppliers, and does not coordinate its work with that of the federal laboratories and programs that conduct or fund engineering research on manufacturing methods. Those laboratories and programs, in turn, focus solely on specialized areas of scientific and engineering research. For example, the Manufacturing Engineering Laboratory develops measurement methods and technical standards for manufacturing. The Department of Energy funds R&D programs on renewable energy manufacturing and automotive fuel efficiency and also operates national laboratories, which conduct research on manufacturing technologies. These efforts operate for the most part independently of one another, without consideration of the organizational and shop-floor changes that manufacturers would need to make to adopt the technologies they develop, and their research is not sufficiently applied to help a wide range of manufacturers improve their performance.

Combining research and education so manufacturers can apply technological advances

Technology is not (usually) self-implementing, and changing technologies can mean changing ingrained work habits and structures. While it is easy in hindsight to see how new technologies have changed workplaces, it is difficult to understand in advance how to reorganize a business to take advantage of them. A small number of organizations in the U.S., mostly funded by federal and industry grants, have taken on the task of helping manufacturers adapt to breakthroughs in tools and methods.

- ▶ Connecticut Center for Advanced Technology, a nonprofit organization funded largely by federal grants, works with Connecticut aerospace/defense suppliers to improve both their technological capacity and their organizational efficiency.
- ▶ Center for Integrated Manufacturing Studies is operated by the Rochester Institute of Technology and funded by federal, industry, and, to a lesser extent, state grants, gifts, and contracts. It assists suppliers in a variety of manufacturing industries in making changes to their technologies, business strategies, and methods of work organization that will help them become more productive, and performs applied research in those areas.
- ▶ Florida Center for Advanced Aero-Propulsion, started by the state government, funded in part by aerospace firms, and operated by Florida universities to help train and sustain the skilled aerospace workforce, design and develop new technologies and products required to help sustain the aerospace industry, and help firms adopt new technologies quickly and efficiently.
- ▶ Advanced Materials in Transport Aircraft Structures, begun and funded by the Federal Aviation Administration and housed at the University of Washington and Wichita State University for the research and development of advanced composite materials for use in commercial and defense aircraft. The center is run by research scientists at the University of Washington who work with executives and engineers from large aerospace companies in the development of new aircraft structures and manufacturing methods.
- ▶ Laboratory for Surface Science and Technology, operated by the University of Maine's engineering program and funded by federal and industry grants, performs basic and applied research on high-performance paint and coatings, participates in joint university-industry research projects, and assists manufacturers with commercialization.

But the best example of an organization that combines research and education in this way comes from abroad. The Fraunhofer Institutes in Germany combine these efforts on a much larger scale than anything that currently exists in the United States. Their efforts contribute to Germany's ability to retain high-wage manufacturing jobs. The 59 Fraunhofer Institutes perform applied research on the problems of service firms and governments as well as those of manufacturers. Two-thirds on their funding comes from contract research for firms and from government-funded projects; the remaining third is general support that comes from the German federal and state governments. The Institutes began as a nonprofit organization devoted to rebuilding Germany's research infrastructure after World War II. Although they have always been a national organization, they initially focused on Bavaria and later expanded their geographic scope. See www.fraunhofer.de/en/about-fraunhofer.

III. A New State Approach

States should create advanced manufacturing centers that provide both research to develop new, relevant technologies and the education to help businesses throughout the supply chain apply these technologies to their work. States should set up one or more centers that focus on one or more areas within advanced manufacturing. These centers could be established with a comparatively tiny investment of state funds, approximately \$9 million a year per center at the outset, with the state contribution possibly dropping over time. States could redirect a fraction the funds they now spend (either directly or as tax expenditures) on subsidies to attract new businesses. In fiscal 2009, for example, Michigan spent an estimated \$127.9 million on its investment tax credit, \$94.6 million on Michigan Economic Growth Authority tax credits for new or expanding firms, and \$116.6 million on motion picture tax credits. In fiscal 2009-2010, Tennessee spent an estimated \$24.4 million on its jobs tax credit and \$32.3 million on its industrial machinery tax credit, in addition to \$55.6 million on direct expenditures to recruit specific firms to the state.¹⁷ In states like these, \$9 million is a very small cut to existing programs. Smaller states that spend much less on these kinds of programs (e.g., Maine and Vermont) may want to consider pooling their resources to form multi-state consortia to operate centers.

These centers should balance research and extension activities (i.e., direct assistance to manufacturers and ongoing training of state manufacturing assistance agents) such that each activity strengthens the other. Centers will gain knowledge of real problems affecting firms in their states from the extension work, while the research focus will allow a deepening of extension, by involving both firms and extension agents as customers for research.

Activities. The centers would do research that both advances knowledge and is of practical use in the near term. An example of such research, in addition to those mentioned above, is improved knowledge about the chemical and structural properties of new, lightweight materials that could aid in reducing energy use.¹⁸ Centers would perform both self-initiated research of broad usefulness to manufacturers in the state and contract research and extension work for client firms. The precise areas of the centers' research focus will vary from state to state, but they should contribute to economic development by building on the existing economic development strengths of each state or of regional industry clusters within the state.

To overcome the challenges that suppliers face, centers could include a Supply Chain Office, which could help align incentives and capabilities where many firms within the same supply chain, acting in coordinated fashion, could produce big efficiency gains. One example of such coordinated action is development and adoption of standardized information technology tools for planning and scheduling production. Another is sophisticated costing tools that can help quantify the benefits of hard-to-measure actions that raise piece prices but may create long-term savings, such as investments in more-reliable (but more expensive) systems, relocation of offshored production to the United States, reduced lead times, etc. Currently, many purchasing firms do not know how to measure the benefits of these actions, meaning that supplier firms that invest in worker training and other measures that increase their responsiveness can be undercut by competitors that offer their customers lower upfront costs, even though these firms' long-term costs are higher.

Organization and Governance. States have a number of options for organizing the centers. They should choose among these options based on their own economic development priorities, the needs of particular industries and regions within the state, their desired level of financial commitment, and their desired relationship between the centers and the executive branch of state government.

- ▶ **State-operated or contracted out.** Some states may choose to establish their centers as free-standing, state-operated organizations similar to the federal government's national laboratories. Others may situate them within state universities or community colleges. Still others may contract with existing nonprofit organizations (such as those described in the text box or those that operate Manufacturing Extension Partnership centers in the state) to operate their centers and/or open up the contracting process to newly established organizations or consortia.
- ▶ **Location within state government.** In many states, the state agency responsible for economic development or commerce would be the appropriate agency to operate the center(s) or contract with external organizations to operate them.¹⁹ States where the governor's office plays a major role in setting economic development policy directly may choose to locate this responsibility in the governor's office. At the opposite extreme, states that wish to afford the centers a maximum of independence from the executive branch may decide to establish an independent board or commission to oversee their centers.
- ▶ **Single center or multiple centers.** Some states may choose to operate a single center whose activities are relevant to a wide variety of industries in many regions of the state. This option may be especially appealing to smaller states whose manufacturing needs are relatively homogeneous throughout the state and whose funding capacity is relatively limited. Other states may decide to operate separate centers that address the needs of particular industries or regions.
- ▶ **Governing or advisory board.** Regardless of other options chosen, each center should have a governing board or advisory board that includes representatives of its state's manufacturers (suppliers as well as assemblers), Manufacturing Extension Partnership centers, universities, community colleges, labor unions, professional engineering associations, and others with expertise in manufacturing applications, as well as consumers. Such a board would help keep the manufacturing centers' activities relevant to the technological and management needs of manufacturing in the state.

Funding. Each center would require approximately \$10 million per year in total. For newly established centers as much as \$9 million of that amount would have to come initially from state funds. Over time, as the centers received more support from manufacturers and federal and foundation grants, state funding could decline to \$7 million or less, depending on how much contract research the centers perform for manufacturers and how much grant support they receive. Because our state funding estimate applies to each center, a state would have to be willing to invest multiples of these amounts of it decided to establish more than one center.

Each state would establish a target for the share of total center funding that would come from contract research and fee-for-serve extension work for manufacturers. This target should be between 10 percent and 30 percent of the center's total budget—an amount large enough to ensure that the centers remained in touch with the expressed needs of manufacturers but small enough not to compromise the center-directed research that benefits a large number of manufacturers within the state. Each contract research or fee-for-service extension activity would require a 50 percent match from the firm served if the project was for the benefit of a single firm and a 30 percent match from firms if the project was for the benefit of a group of two or more firms. Alternatively, firms could participate for a minimal match if they committed to providing one job paying above the state median compensation for at least five years for each \$100,000 in services received.

Location. Because most of the people who would benefit from the centers work in metropolitan areas and most of the resources that the centers would need are located in metropolitan areas, the centers should also be located in metropolitan areas. Nearly 80 percent of U.S. manufacturing jobs are in metropolitan areas.²⁰ So are most of the universities and nonprofit organizations that some states may choose to operate their centers. Likewise, people with expertise in engineering, business, and work organization, who would staff the centers, also live primarily in metropolitan areas.

IV. Conclusion

Strengthening manufacturing is critical for states, especially those that depend strongly on manufacturing or that have regions that depend strongly on it. Manufacturing centers are not a complete solution to the problems of retaining, growing, and improving manufacturing in states. States also need to pursue complementary workforce development and R&D policies that would benefit manufacturing and to use a combination of incentives and penalties to keep more high-wage manufacturing jobs within their borders or within the borders of nearby states and metropolitan areas that would yield spillover benefits to them.²¹

Complementary expenditures by the federal government are also needed. Specifically, the federal government should provide additional funding for a restructured Manufacturing Extension Partnership program, grants to consortia to help solve supply chain and other multi-firm problems that cross state lines, and additional manufacturing lab capacity to the extent that states do not fund all the labs required to meet the nation's critical manufacturing needs. Also needed are changes in federal trade policy. In addition, state as well as federal assistance to manufacturers should go only to those that have reasonably high productivity, wages, and employee benefits relative to their industries and locations or produce and make progress on credible plans to reach such productivity, wage, and benefit levels.²²

But state-supported manufacturing centers are superior to states' typical business attraction incentives as a way of strengthening a state's manufacturing base. Their job-creating and wage-boosting potential is longer-term but more solid because it builds on states' existing technological, management, and workforce capacities in manufacturing instead of chasing footloose plants.²³

Endnotes

1. Authors' analysis of Bureau of Labor Statistics Current Employment Statistics data.
2. Authors' analysis of Bureau of Labor Statistics' Current Employment Statistics data.
3. Authors' analysis of Bureau of Economic Analysis' Industry Accounts data. Output data are adjusted for inflation. The official data may overstate the growth of manufacturing output because they may not properly account for manufacturers' use of temporary help services and offshored services. See Susan Houseman and others, "Offshoring and the State of American Manufacturing," Upjohn Institute Working Paper 10-166 (Kalamazoo, MI: Upjohn Institute for Employment Research, 2010); and Susan Houseman, "Outsourcing, Offshoring, and Productivity Measurement in U.S. Manufacturing," Upjohn Institute Working Paper 06-130 (Kalamazoo, MI: Upjohn Institute for Employment Research, 2006).
4. Authors' analysis of 2009 Current Population Survey data for the population aged 25 and up. For those with less than a high school diploma the unemployment rate was 14.6 percent in 2009 and for those with a high school diploma it was 9.7 percent, while for those with a bachelor's degree it was 4.6 percent.
5. Between 2006 and 2007, median usual weekly earnings grew by 4.8 percent (not adjusting for inflation) for workers aged 25 and up with less than a high school diploma and by 1.0 percent for those with a high school diploma but no further formal education. Between 2009 and 2010, earnings fell by 5.4 percent for those with less than a high school diploma and by 0.2 percent for those with a high school diploma. Workers with more education saw reduced earnings growth rates. See Lawrence Mishel and Heidi Shierholz, "Recession Hits Workers' Paychecks," EPI Briefing Paper 277 (Washington: Economic Policy Institute, 2010). As of October 29, 2010, 28 states had negative balances in their unemployment insurance trust funds and had to borrow from the federal government to pay benefits. See National Employment Law Project, "Unemployment Insurance Solvency—Key Measures, November 2010," available at www.nelp.org/page/-/UI/2010/uisolvencykeymeasures.pdf?nocdn=1.
6. Authors' analysis of Bureau of Labor Statistics' Current Employment Statistics data for 2009; Robert E. Scott, "The Importance of Manufacturing: Key to Economic Recovery in the States and the Nation," Briefing Paper 211 (Washington: Economic Policy Institute, 2008).
7. Robert Atkinson and Howard Wial, "Boosting Productivity, Innovation, and Growth through a National Innovation Foundation" (Washington: Brookings Institution and Information Technology and Innovation Foundation, 2008).
8. A recent National Science Foundation survey found that 22 percent of manufacturers, but only 8 percent of non-manufacturing firms, introduced a new or significantly improved product between 2006 and 2008. The figures were identical for new or significantly improved production processes. The only non-manufacturing industries that exceeded the manufacturing average on either product or process innovation were software, telecommunications, computer systems design and related services, and scientific R&D services. In contrast, all manufacturing industries exceeded the non-manufacturing average on both product and process innovation. Mark Boroush, "NSF Releases New Statistics on Business Innovation," NSF 11-300 (Arlington, VA: National Science Foundation, 2010).
9. Authors' analysis of Bureau of Labor Statistics' Occupational Employment Statistics survey data for May 2009; Gregory Tassej, "Rationales and Mechanisms for Revitalizing U.S. Manufacturing R&D Strategies," December 2009.
10. Howard Wial and Alec Friedhoff, "Bearing the Brunt: Manufacturing Job Loss in the Great Lakes Region, 1995-2005" (Washington: Brookings Institution, 2006).
11. Authors' analysis of Bureau of Labor Statistics' Current Employment Statistics data.
12. While the entire United States lost 31.2 percent of its manufacturing jobs between 2000 and 2009, Michigan lost 48.5 percent, Tennessee 37.2 percent, Buffalo 39.4 percent, Rochester 38.9 percent, and Boulder 37.9 percent. Authors' analysis of Labor Statistics' Current Employment Statistics data.

13. The Bureau of Labor Statistics tracks the number of people employed in manufacturing (which differs from the number of manufacturing jobs) in the United States and nine other advanced countries. Between 2000 and 2009, U.S. manufacturing employment fell by 27.7 percent, a loss exceeded only by the United Kingdom's 33.6 percent loss. Germany lost 3.6 percent of its manufacturing employment during this period, while Australia lost 7.2 percent. Data for 2009 were not available for France, but France's 2000-2008 loss was 10.3 percent. Statistics are from the authors' analysis of Bureau of Labor Statistics, "International Comparisons of Annual Labor Force Statistics, Adjusted to U.S. Concepts, 10 Countries, 1970-2009," table 2-4, available at www.bls.gov/fls/flscomparelf/employment.htm#table2_4.
14. Tennessee has job creation tax credits (with minimum job creation and investment requirements), an industrial machinery tax credit, and integrated supplier and customer tax credits (to encourage the relocation of both assemblers and their suppliers). It also has a right-to-work law.
15. New York offers grants and loans to manufacturers for capital improvements and grants to manufacturers that create at least 300 jobs, and subsidizes projects that improve manufacturers' interstate competitiveness. It also subsidizes export initiatives undertaken by New York firms in any industry. Michigan subsidizes manufacturers' training costs. It also has tax credits for companies that expand or relocate to small counties and for companies that are in danger of closing or laying off workers; these are not restricted to manufacturers.
16. Colorado offers grants to small and medium-sized firms for export promotion activities and has a selective program to assist in-state firms in exporting clean technologies to China and Mexico. The state also offers customized job training subsidies, income tax credits for aircraft manufacturers located in aviation development zones, subsidies for infrastructure improvements to attract or retain firms, selective sales and use tax exemptions for manufacturers, and tax credits to subsidize investments in small startup companies.
17. See State of Michigan, *Executive Budget Appendix on Tax Credits, Deductions, and Exemptions, Fiscal Year 2009*, available at http://www.michigan.gov/documents/treasury/Budget_Report_09_257559_7.pdf, and State of Tennessee, *The Budget, Fiscal Year 2009-2010*, available at www.state.tn.us/finance/bud/bud0910/0910Document.pdf.
18. For other historical examples of such research, see Donald E. Stokes, *Pasteur's Quadrant* (Washington: Brookings Institution Press, 1997).
19. For example, this would be the Office of Economic Development and International Trade in Colorado; Department of Energy, Labor and Economic Growth in Michigan; Empire State Development in New York; and Department of Economic and Community Development in Tennessee.
20. This figure varies among states. For example, 93 percent of manufacturing jobs in Colorado, 85 percent in New York, 82 percent in Michigan, and 66 percent in Tennessee are located in metropolitan areas. These statistics are from the authors' analysis of Bureau of Labor Statistics Quarterly Census of Employment and Wages data for 2009.
21. On spillover benefits to the Great Lakes states from the location of suppliers in other Great Lakes states, see Dan Luria, Matt Vidal, and Howard Wial, "Full-Utilization Learning Lean' in Component Manufacturing: A New Industrial Model for Mature Regions, and Labor's Stake in Its Success," Sloan Industry Studies Working Paper WP-2006-3 (New York: Alfred P. Sloan Foundation, 2006).
22. See Susan Helper and Howard Wial, "Strengthening American Manufacturing: A New Federal Approach" (Washington: Brookings Institution, 2010), available at www.brookings.edu/~media/Files/rc/papers/2010/0927_great_lakes/0927_great_lakes_papers/0927_great_lakes_manufacturing.pdf.
23. For example, tax abatements have been shown to have little impact on the long-term location of firms. See Robert G. Lynch, *Rethinking Growth Strategies* (Washington: Economic Policy Institute, 2004), and updated evidence in Robert G. Lynch, "The Impact of State Tax Policy on Economic Growth," Presentation made before the Maryland Business Tax Reform Commission, Business Incentives in the Tax Code Subcommittee, May 4, 2010, available at http://btrc.maryland.gov/articles/documents/Impact_of_State_Tax_Policy.pdf.

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