Models for Building Regional Manufacturing Economies

From 'Home Alone' to 'Regional Ecosystems'

MIT Initiative for Knowledge and Innovation in Manufacturing
October 2021

OVERVIEW

At the national level, U.S. manufacturing has suffered from slow productivity, wage, and job growth for decades. At the regional level, industrial decline has hollowed out once-thriving industrial cities. Places with a legacy of manufacturing have often faced population losses, infrastructure decay, and even declines in public health. At the firm level, U.S. manufacturers that have survived these challenges are often – as MIT's Production in the Innovation Economy study put it – "home alone."[i]

When there is an opportunity for U.S. manufacturers to acquire new business and grow, they often must do so on their own. This is in sharp contrast to thriving industrial ecosystems in places like Germany and Japan, where firms pursue growth opportunities with support from long-term suppliers, training institutions, and government agencies.[ii] For "home alone" manufacturers, growth and innovation are more challenging and higher risk than they would be if these firms could draw on a network of local firms and organizations for resources and knowledge. Supporting the growth of regional manufacturing hubs in the United States can decrease the risk for U.S. manufacturers to invest in growth and innovation opportunities.

How can the federal government's investments in revitalizing U.S. manufacturing support the growth of high-performing manufacturing regions? Research and policy have typically focused on three models of industrial regions: *legacy* industrial regions like post-war Detroit; *innovative* regions like Silicon Valley; and *coordinated* regions like Baden-Wurttemberg, Germany.[iii] Places in the U.S. aspiring to promote similar levels of growth and innovation have established local public and non-profit organizations focused on various aspects of economic development: attracting new businesses, serving the needs of existing industries, training workers, and improving local amenities. The "home alone" problem does not appear to result from a shortage of regional institutions. However, our research casts doubt on whether these organizations have achieved their intended aims – or if the models on which they are based are the right ones.

After all, most U.S. regions lack the industry concentration of post-war Detroit, the research assets of Silicon Valley, or the longstanding institutional alliances of Southwest Germany.

In this study, MIT's Initiative for Knowledge and Innovation in Manufacturing examines U.S. regions that have experienced high levels of manufacturing growth since 2000. Firms in these high-performing manufacturing regions continued to grow even during a period of national industrial decline. Data across more than 20 variables measuring the regional manufacturing economy suggest that the high-performing regions do not follow a single pattern. They come from nearly every part of the country. Some stand out for regional innovation; others have high levels of unionization and few college graduates; still others appear to rely on exports or defense contracts. But there are common lessons from these diverse places.

Case studies of three regions – Ames, IA, Columbus, IN, and Tulsa, OK – illustrate the positive role local "ecosystem" organizations can play. Wage and productivity growth in Ames, Iowa is associated with high levels of technology adoption and automation. The presence of Iowa State University's College of Engineering, as well as the university's focus on commercial applications of its research, has supported technology adoption and development at local firms.

In Columbus, IN, more than one-third of the local workforce is employed in manufacturing. The region is home to Cummins Engine, a Fortune 500 company, and its legacy is as a "company town." Today, it is the one of the largest regions for foreign direct investment in the country. Its path to wage, earnings, and productivity growth is associated with the growth of foreign manufacturers – particularly from Japan – alongside Cummins. A statewide training system offering customized training and apprenticeship programs to local companies appears to have supported local wage and job growth.

Tulsa, OK has diversified from a hub for oil and gas production to a center for aerospace manufacturing, as well as related industries. Diversification in Tulsa depended on the concentration of welding and machining talent in the region, a regional strategy to move away from oil and gas, and a training

system that could support the growth of new manufacturers in the region. Each of these three regions has thrived without fitting any of the standard models noted above. Rather, the three regions have succeeded with support from ecosystem institutions that adopt strategies supporting diversification and tolerating risk.

Policymakers can draw three main lessons from these cases as they adopt policies and make investments in regional manufacturing ecosystems:

1. Manufacturing firms and regions benefit from having diverse capabilities, and regional organizations should support diversification. By supporting infrastructure, technology adoption, and workforce development in sectors adjacent to a region's existing specialties, regional ecosystem organizations can encourage diversification and unlock opportunities for growth.
2. Regional organizations are typically divided between "firm-focused" and "people-focused" groups. Activities that bridge the priorities of manufacturing firms and manufacturing communities are important to generate productivity and employment benefits.
3. Diversification and growth require firms and regions to take risks by investing in new infrastructure and capabilities that go beyond their existing specialties. Regional organizations should be prepared to share firms' risks when they set out to adopt a new technology or enter a new product area.

The long-term goal of adopting these policies is to support U.S. manufacturing regions where a positive feedback loop of innovation, job growth, and expanding capabilities can continue.

About IKIM

The Initiative for Knowledge and Innovation in Manufacturing (IKIM) aims to foster a thriving domestic manufacturing ecosystem by educating an agile workforce, creating resilient innovation in manufacturing processes, developing nimble organizations, and proposing transformative policies.

Acknowledgements

This study was made possible by sponsorship from the Defense-Wide Manufacturing Science and Technology Program and generous support from MIT IKIM and the Industrial Performance Center, including the time and excellent advice of colleagues including Lionel Kimerling, Randolph Kirchain, and John Liu. Julie Diop managed the project from its inception, contributing valuable advice and excellent editing throughout the research. We are also grateful to the many generous individuals and organizations from Ames, IA; Tulsa, OK; Columbus, IN; Kankakee, IL; Bellingham, WA; and Savannah, GA who shared their expertise in interviews.

Methodological Note

This study draws on the research team's 50+ interviews with U.S. manufacturing firms, as well as interviews with government officials, community colleges, and related organizations. The study also cites a variety of domestic and international data sources that measure the performance of the manufacturing economy over the past 70 years. This project builds on research and interviews from previous MIT initiatives on related subjects, including the 2020 Work of the Future Task Force, the 2014 Production in the Innovation Economy (PIE) initiative, and the 1989 Made in America study, each of which conducted interviews with an array of firms and other organizations to generate new knowledge and new policy recommendations about the future of U.S. manufacturing.

MIT Research Team

Corresponding Author:

Ben Armstrong | armst@mit.edu

Research Scientist

MIT Initiative for Knowledge and Innovation in Manufacturing

Dan Traficonte

Postdoctoral Research Associate

MIT Initiative for Knowledge and Innovation in Manufacturing

Table of Contents

I. A Regional Lens on Rebuilding Manufacturing

The federal government's first efforts to grow a U.S. manufacturing base focused on building a thriving industrial region. In the early 1790s, Treasury Secretary Alexander Hamilton sought to transform a small agricultural community along the Passaic River into a manufacturing city – the first of its kind in the young United States.[iv] Hamilton initially approached the U.S. Congress with a request for $1 Million. Congress refused, but Hamilton eventually convinced the Governor of New Jersey – William Paterson – to embrace the idea. They convened a group of private investors to form what they called the Society for Establishing Useful Manufactures.[v] The New Jersey state legislature granted the Society a charter with "vast financial and government privileges" to develop an industrial center that they called Paterson, NJ. The Society had tax-exempt status for a decade; the authority to raise revenue; rights to the local water supply; and the power to condemn property that interfered with its aims.[vi] Shaped by these government interventions – what we would now consider industrial policies[vii] – Paterson went on to become a hub for textile manufacturing and one of the fastest-growing American cities of the 19th Century.[viii] The rise of U.S. manufacturing during the 19th and early 20th Centuries is a story of concentrated growth in industrial regions like Paterson.

More than two centuries later, the Biden Administration has made rebuilding domestic manufacturing a key pillar of its "Build Back Better" agenda. The U.S. manufacturing economy faces substantial challenges, including long-term job losses and wage stagnation for production workers, as well as a decade of flat productivity growth for American manufacturers.[ix] Many industrial communities that thrived during the growth of American manufacturing have now lost jobs and people in a downward spiral. Economic turmoil has led to social and public health crises in these communities.[x] These persistent challenges manifested as acute problems when American factories faced pressure to mobilize production in response to the COVID-19 pandemic. The pandemic helped reveal a longstanding reality: when the United States depends on the rest of the world for critical goods like masks, pharmaceuticals, and

semiconductors, the country is vulnerable to market shocks and misses opportunities for innovation.

There have been three main approaches to revitalizing U.S. manufacturing that emerge from public policy and academic debates.

1. The first approach has focused on stimulating manufacturing innovation. The creation of the network of Manufacturing Innovation Institutes (MIIs) – collectively, the "Manufacturing USA" program – emphasizes the development and diffusion of new manufacturing technologies as the United States has fallen behind international competitors like China and Japan in manufacturing-related patents. Recognizing the importance of "advanced manufacturing" technologies like robotics, 3-D printing, and photonics, the institutes support technology development as well as training related to their designated technology areas. U.S. investment in the Institutes parallels similar industrial policy programs in countries like Germany and China, which have their own versions of manufacturing innovation hubs that bring together industry, university, and government actors with a focus on technology development.

2. A second approach has focused on workforce development. In addition to MII programs on education and workforce development, community colleges and non-profit organizations have dedicated programs and studies to training more workers in skills related to "advanced manufacturing." These efforts complement federal investments in manufacturing innovation. As manufacturing technologies become more advanced, the concern is that companies will have increasingly sophisticated tools to produce new products, but they might not have workers with the skills to work with advanced manufacturing technologies. Workforce development efforts target "the skills gap," or the degree to which manufacturers' technological capabilities exceed the capabilities of their workers.[xi] The way to bridge the skills gap, programs and policies often suggest, is to develop new curricula that incorporates the latest manufacturing technologies and responds to the needs of manufacturing firms for advanced skills.

3. A third approach focuses on technology adoption. It begins with the observation that – despite great advances in advanced manufacturing technologies – the adoption of manufacturing innovations at small and medium enterprise (SME) manufacturers remains quite low. National data show that the gap in capital expenditures between SME factories and large

> factories has grown substantially over the past several decades. Interviews confirm that technology adoption at many SME manufacturers is slow. This affects the workforce challenges that SMEs face. If SMEs have not invested in advanced manufacturing equipment, they are not aiming to recruit workers with advanced manufacturing skills. Among many manufacturing firms, a skills gap is not the problem; a technology gap is. Thus, this approach to America's manufacturing challenges aims to stimulate technology acquisition at firms that have not yet embraced advanced equipment and production techniques.[xii]

These three approaches can be complementary. If firms adopt new manufacturing technologies as they are developed – and a flexible higher education system trains the workforce to operate those technologies – it is a recipe for growth in manufacturing wages and productivity. The challenge is *how* to integrate these approaches. This study takes a regional approach. It argues that "regional manufacturing ecosystems," or constellations of market and non-market organizations that collaborate to support manufacturing competitiveness, have the potential to stimulate innovation, skill development, and technology adoption. It sets out to examine what makes an effective regional manufacturing ecosystem by studying high-performing manufacturing regions that have followed different paths to growth. Our main finding emphasizes the importance of diversification for regional economies. While many regional ecosystem organizations are pressured to deepen a region's specialization in an industry or technology, this research finds that regional institutions that promote diversification by balancing the interests of firms and the public have been important for high-performing manufacturing regions.

The study is organized in four sections. The first reviews the "home alone" problem, as well as the current policy models for addressing regional economic development challenges. It finds that these models are insufficient for addressing current manufacturing challenges. One reason is that these models fail to address the "ecosystem dilemma" whereby regions are pressured to specialize but need to diversify. Second, the paper examines data on wages and earnings, productivity (measured as GDP per worker), and job creation in manufacturing regions since 2000. It identifies fifteen "high-performing" regions where wage and earnings growth have been high, and job growth has been stable, even as national manufacturing performance has suffered. Summary data suggest that these regions

followed multiple paths to manufacturing growth. The third section offers short case studies of three manufacturing regions to illustrate their diverse paths to growth, as well as common threads between them. The fourth and final section draws policy lessons from the data and case studies.

II. Deindustrialization and the 'Home Alone' Problem

The map of U.S. industrial activity at its peak in the early 20th Century was pockmarked with manufacturing hubs specialized in product and industry areas. The emergence of manufacturing cities was rarely engineered in the way that Hamilton helped found Paterson. Instead, a combination of ingredients interacted to fuel the growth of places like Detroit, MI; Cleveland, OH; Pittsburgh, PA; Rochester, NY; and Springfield, MA. Locational advantages like access to waterways and natural resources certainly played a role. So, too, did local entrepreneurs whose ingenuity helped spark a new cluster of local businesses. And finally, government interventions – such as the construction of canals, railroads, and armories – enabled some regions to access new markets and win contracts to provide new technology to the military.[xiii] The concentration of industrial activity in regional hubs is not unique to the United States. For more than a century, economic geography research has found that industrial activity naturally concentrates in local areas. This phenomenon has been characterized as agglomeration economies, and the hubs have been referred to as industrial districts or regional clusters.

Why does manufacturing activity cluster in certain regions and not spread evenly across a country? In the late 1800s, in his studies of manufacturing in the United Kingdom, Alfred Marshall recognized three primary forces that appeared to shape industrial communities: a common pool of talent, shared infrastructure, and knowledge spillovers between firms and workers.[xiv] When regions have a large workforce with skills or experience in particular fields – or water, power, or technical infrastructure that enables more efficient production – manufacturers flock to recruit and build locally. Concentrations of talent and infrastructure fuel a positive feedback loop. The more companies that arrive and invest in a region, the more talent and investment that region can attract. At a certain level of local concentration, the interactions between firms and workers – and the movement of workers between firms – enables local manufacturers to gain new knowledge that they could not have gained if they had located outside the hub. Marshall attributed comparative advantage in trade to these knowledge spillovers: "so great are the advantages which people following the same skilled trade

get from near neighbourhood to one another. The mysteries of trade become no mysteries; but are as it were in the air."[xv] Research following Marshall's observations has confirmed empirically that firms concentrating near other firms in related industries are more productive than firms locating outside a related industry cluster.

During the rise of U.S. manufacturing for much of the 19th and 20th centuries, the clustering of economic activity worked to the advantage of many industrial regions and firms. Manufacturing firms moving to thriving regions had access to local talent, investment, buyers and suppliers, and government support. Manufacturing regions benefiting from new firms enjoyed more job opportunities for their residents, as well as new tax revenue from the influx of people and businesses. New tax revenue enabled these regions to provide more public goods like infrastructure, parks, and cultural amenities, which in turn attracted more people and businesses. The places where manufacturing concentrated during this period experienced high levels of population growth and became hubs for American innovation (Figure 1).[xvi]

When U.S. manufacturing began to decline under pressure from foreign competition – first from Japan in the 1970s and 1980s, then from China beginning in the 2000s – industrial regions faced acute challenges. For communities that had specialized in steel or automotive manufacturing, turmoil in these industries translated into local job losses in factories, as well as service industries that depended on factories. Fewer people moved to these regions, and populations stagnated.[xvii] Governments lost local tax revenues and could not afford to reinvest in local infrastructure.

Scholars have associated the decline of manufacturing with negative outcomes for industrial communities. Manufacturing losses have been linked to public health struggles including "deaths of despair," as well as social alienation.[xviii] The loss of well-paying manufacturing jobs have also been linked to challenges facing inner-city African-American communities.[xix]

FIGURE 1. MAPS OF INDUSTRIAL AND INNOVATIVE ACTIVITY

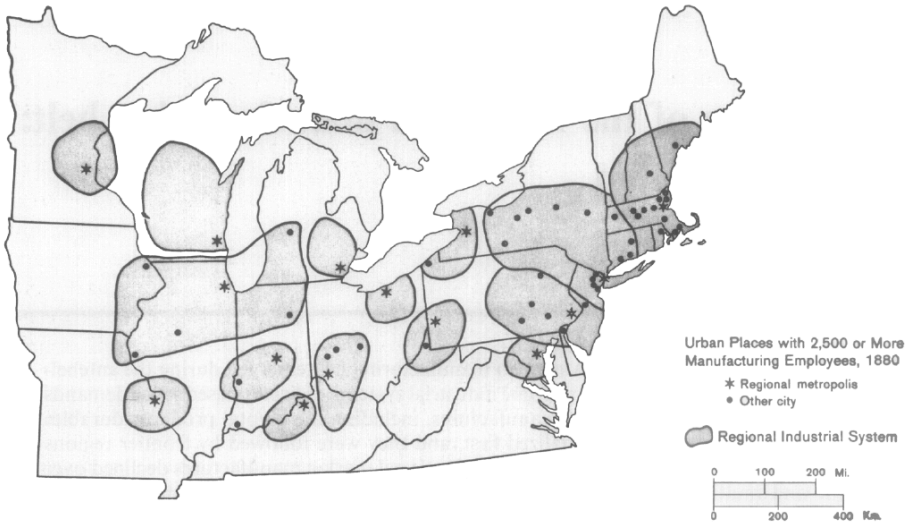


Figure 1. Regional industrial systems in the American manufacturing belt c. 1880.

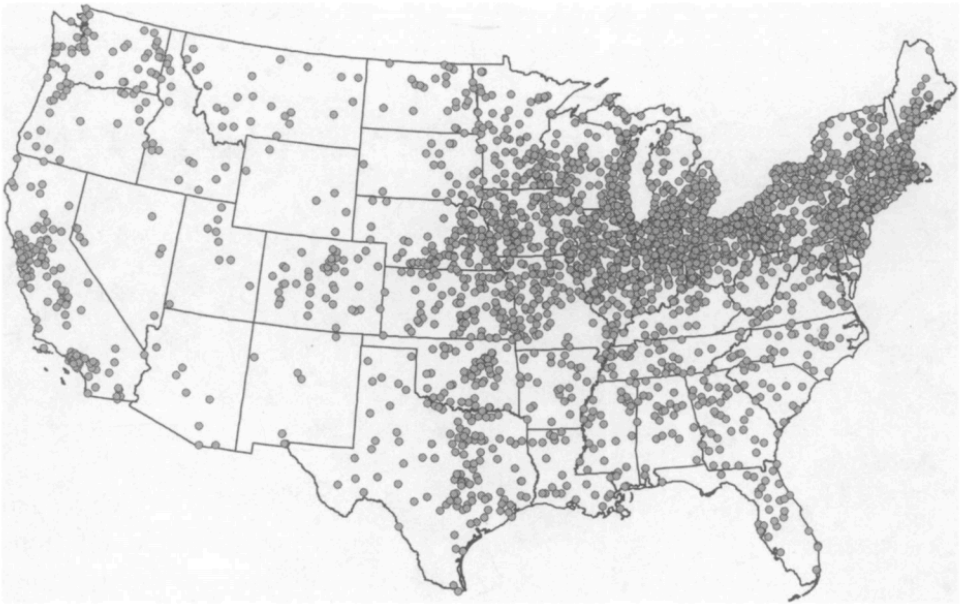


FIGURE 2
THE GEOGRAPHIC LOCATION OF INDEPENDENT INVENTORS, 1880–1930

Notes: Geocoding is based on the residential address of the first named patentee.

Sources: These figures from economic history papers highlight the correspondence of American industrialization in the mid-19th Century with innovation in later decades.[xx]

Just as agglomeration economies fed a positive feedback cycle that led to jobs and innovation, deindustrialization and the loss of core industries contributed to a downward spiral for many regions with a legacy of manufacturing. Regions with a concentration of industries that faced import competition from Chinese manufacturers have performed much worse economically following the rise of trade with China beginning around 2000.[xxi] The so-called "China Shock" meant that regions that had once benefited from the concentration of productive and innovative economic activity now had to contend with the challenges of decline.[xxii]

The manufacturers that survived the "China Shock" and continued to operate did so without many of the benefits of being located amidst a manufacturing region. Researchers from MIT's Production in the Innovation Economy (PIE) project interviewed more than 150 manufacturers and ecosystem organizations in the United States – as well as more than 100 abroad – as part of a systematic look at the challenges facing American manufacturing firms as they looked to deploy new technologies and grow. The project concluded that one of the key challenges facing U.S. manufacturers was that they were "home alone" – without the supportive institutions and surrounding firms that characterize thriving regional manufacturing hubs.[xxiii]

When a U.S. manufacturing firm looks to develop a new product, hire a new type of worker, attract investment, adopt a new technology, or enter a new market, the firm is often left to find a solution on its own, all while it continues to keep its business afloat. "Even start-up companies with great novel technologies and generous venture backing cannot do it all in-house: they need to find suppliers, qualified production workers and engineers, expertise beyond their own," the PIE study concludes. "Established Main Street manufacturers in the regions we visited find little beyond their own internal resources to draw on when they seek to develop new projects. They're 'home alone.'"[xxiv] The PIE study contrasts "home alone" firms in the United States with their competitors in Germany, which find "dense networks of trade associations, suppliers, technical schools, and applied research centers all within easy reach."[xxv]

What is puzzling about the home alone problem facing U.S. firms is that nearly every American metro area has organizations dedicated to

promoting regional economic development. These organizations include Chambers of Commerce, industry and trade associations, economic development organizations dedicated to business attraction, vocational schools and community colleges, startup incubators, and Manufacturing Extension Partnership organizations. At an initial glance, at least, there would seem to be ample supportive institutions available to manufacturing firms in many industrial regions. However, these firms are often not embedded in the regional institutional network, and they rarely turn to these institutions for help in solving their problems. There are two explanations for how U.S. manufacturers can still be home alone despite the presence of these organizations in their region.

The first factor is that firms looking to innovate and gain new business are likely to benefit from the diversification of the local economy, whereas regional ecosystem organizations typically focus on specialization. These organizations face pressure to specialize in sectors and technology areas where the region already excels. These are the lowest-risk areas for investing their resources. Moreover, the economic development organizations can claim success if pre-existing sectors continue to grow. Consider a trade association and an economic development organization targeting new investment to the region. A trade association in a U.S. region is focused on serving its members' needs, which are specific to the association's industry of focus. The association is interested in growing its dues-paying members, which would bias it toward building up the region's capabilities in its industry – not diversifying into new areas. For economic development professionals bidding for business from elsewhere, the most-likely candidates to invest are firms that recognize the region as excelling in their product or technology area.

Although specialization in pre-existing strengths is the lowest-risk economic development strategy, economic development officials often recognize the benefits of diversification. Relying too much on a small group of sectors exposes a region to downturns in those industries or layoffs at individual anchor firms. Jane Jacobs argued that innovation in urban economies emerges from interactions between firms with *related* capabilities, not the same ones.[xxvi] Studies of industry clustering provide empirical support to Jacobs's approach. Ed Glaeser and his colleagues found that regions with more diverse industries experienced more substantial

growth – what they referred to as Jacobs externalities – than regions with more concentrated ones.[xxvii] The ecosystem dilemma is that organizations focused on economic development are pressured to specialize, but would benefit from investing in diversification.

Another challenge facing regional economic development efforts is that they strive to emulate unrealistic model regions. Consider three popular regional economic development strategies: business attraction policies chase after the industry concentration of post-war Detroit. Innovation policies supporting R&D and entrepreneurial startup companies aim to create the next Silicon Valley. And more recently, efforts to promote apprenticeships or more industry-focused training programs are modeled after German regions like Baden-Wurttemberg that include close coordination between industry associations, trade unions, and government agencies. For many regions, these models are unachievable – and might not even be desirable.

The concentration of automakers in Detroit arose in part due to the vertical integration of Ford, and the co-location of different parts of the automotive supply chain. Decades of globalization and shareholder-value capitalism have meant that vertical integration of this type has largely disappeared. If business attraction efforts successfully win a large anchor firm or factory, it is unlikely to generate the same level of industry concentration and positive spillovers that large firms like Ford achieved.[xxviii] Moreover, it is unclear how any region could become an innovation hub like Silicon Valley without leading universities and a highly-educated workforce. Given these limitations, scholars have questioned whether innovation policy can make much of a contribution at the regional level.[xxix]

And finally, policymakers marvel at the German coordinated market economy model; however, it relies on a level of long-term, institutionalized cooperation between government, labor, and industry that U.S. regions cannot import piecemeal. The coordination that supports industry involvement in workforce training, for example, is linked to the organization of the German financial sector ("patient capital") as well as the longer-term, more durable relationship between German OEMs and their suppliers.[xxx] Mirroring the coordination of German regions would require a significant overhaul of American capitalism. Given the limitations of

existing economic development organizations and approaches to regional economic development, there is reason to search for new models for informing policy approaches to supporting U.S. manufacturing firms.

III. In Search of a New Regional Manufacturing Model

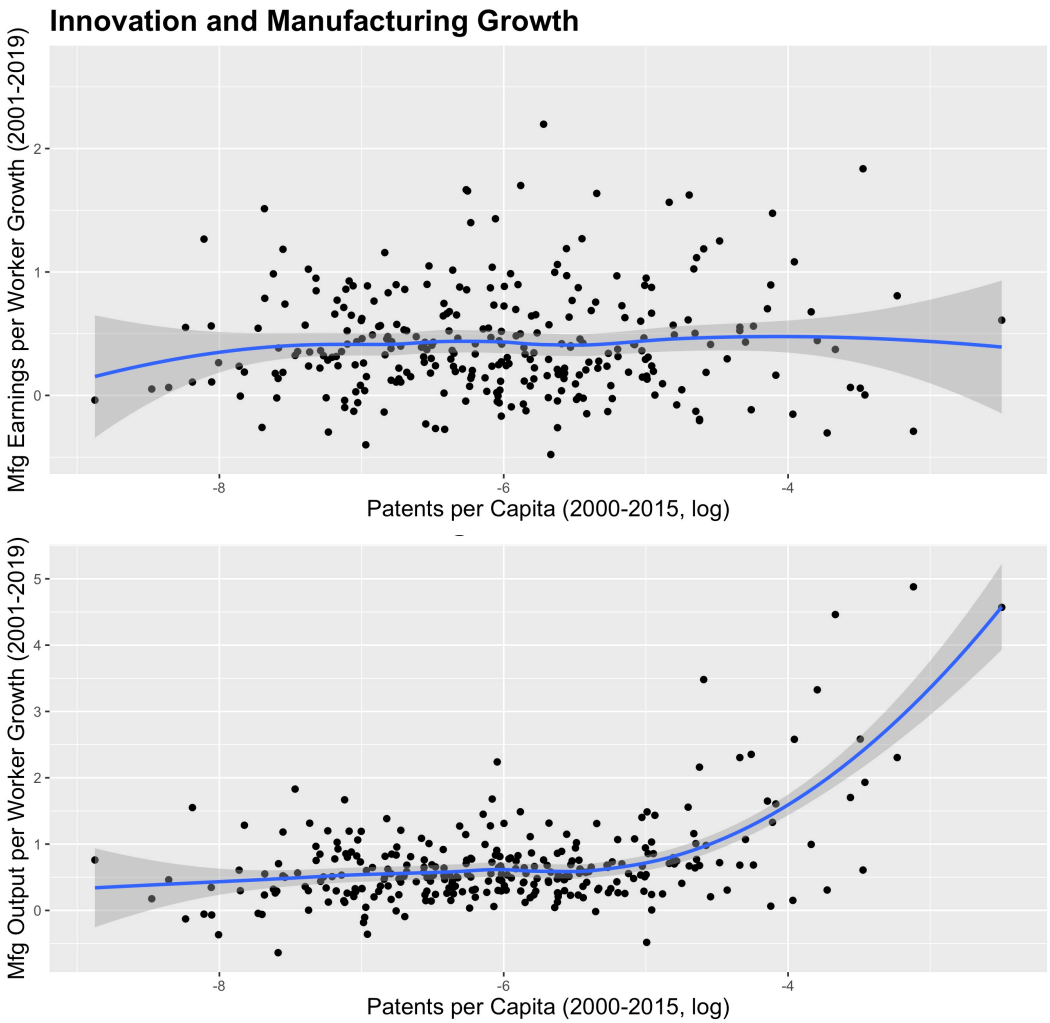
Even as U.S. manufacturing performance has suffered overall in terms of jobs, wages, and productivity since 2000, a small group of regions have experienced growth in manufacturing wages, earnings, and output per worker, all while sustaining manufacturing job opportunities. Understanding the characteristics that differentiate these regions from those that struggled with decline is useful for informing a national policy approach for building regional manufacturing hubs. Current policy approaches that emphasize innovation and workforce development would suggest two hypotheses: first, the highest-performing manufacturing regions are more likely to be innovative places than manufacturing regions that did not perform as well. And second, the highest-performing manufacturing regions are more likely to have a concentration of skilled workers than regions that did not perform as well.

Data on the manufacturing performance of more than 300 U.S. metro areas call these hypotheses into question. The analysis aggregated data on manufacturing wage, earnings, output, and jobs data from more than 300 metro areas between 2001 and 2019. Wage data captures salaries given to manufacturing workers. Earnings data includes wages to workers, as well as income to owners of manufacturing businesses (sole proprietorships and partnerships). What we call "output" data is measured as Gross Domestic Product (GDP) for manufacturing firms at the county level, or "the value of goods and services produced by the county's [manufacturing] economy less the value of goods and services used up in their production." The county data is aggregated to the metro area level for the purposes of this analysis.

Although wage, earnings, and output data are related, they have important differences. Average wage growth, or growth in wages per worker, reflects

benefits that flow to workers. Earnings growth captures benefits that flow to workers as well as to some business owners. Output growth is the broadest measure. It includes all gross operating surplus (e.g. corporate profits, capital investments), as well as wages and earnings.

FIGURE 2. MANUFACTURING GROWTH AND REGIONAL INNOVATION



Note: The individual points are U.S. metro areas. The blue line marks the loess curve fitting the trend in the points. The first panel shows – and regression models confirm – that there is no association between regional patenting (a proxy for innovation) and manufacturing earnings growth per worker. Similarly flat curves indicate a lack of association between manufacturing earnings growth per worker and other variables, such as the share of a region's college-educated adults, the share of adults in a region with Associate's Degrees, or a region's share of workers employed by foreign-owned companies. The second panel shows (and the regression results confirm) that there is a relationship between patents per capita and growth in output per worker. The relationship appears to be driven by the metros with the highest concentration of patents, which are much more likely to have experienced high levels of growth in output per worker.

We merged these manufacturing performance data with earnings, wage, and job data for the regional economies overall, as well as data on patents (our proxy for innovation), foreign direct investment, exports, education levels, union membership, intergenerational mobility, and the density of startup firms. The purpose of aggregating these data was to compare high-performing and low-performing manufacturing regions to understand the factors affecting earnings and GDP growth per worker. The goal was also to identify individual cases of high-performing regions to understand how those regions excelled, which will be covered in the next section.

TABLE 1. FACTORS AFFECTING MANUFACTURING GROWTH IN U.S. METRO AREAS

	Dependent variable:			
	Growth in Earnings / Worker (2001-2019)		Growth in Output / Worker (2001-2019)	
	(1)	(2)	(3)	(4)
Population (2019)	−0.00 (0.0000)	−0.00 (0.0000)	0.0000 (0.0000)	−0.0000 (0.0000)
Manufacturing Jobs (2019)	0.0000 (0.0000)	0.0000 (0.0000)	−0.0000 (0.0000)	0.0000 (0.0000)
Manufacturing Job Growth (2001-2019)	0.17*** (0.05)	0.15* (0.08)	−0.27 (0.16)	−0.03 (0.27)
Young Firm Jobs	−0.23 (0.21)	−0.37 (0.27)	0.43 (0.62)	0.68 (0.88)
Patents p.c. (2000-2015,log)	0.01 (0.01)	−0.01 (0.02)	0.27*** (0.04)	0.19*** (0.07)
BAs (2013-2017)		−0.001 (0.01)		−0.0003 (0.02)
Employed by Foreign Corporations		0.05 (0.79)		−3.58 (2.57)
Exports to Mfg Earnings (2019, log)		0.0003 (0.02)		0.03 (0.05)
Intergenerational Mobility (Chetty et al.)		0.01 (0.005)		−0.004 (0.01)
Union Members		−0.37* (0.20)		−1.07* (0.64)
Constant	0.68*** (0.08)	0.37 (0.29)	2.26*** (0.24)	2.14** (0.93)
Observations	294	152	294	152
R^2	0.04	0.09	0.20	0.16
Adjusted R^2	0.02	0.03	0.19	0.10
Residual Std. Error	0.20 (df = 288)	0.17 (df = 141)	0.60 (df = 288)	0.56 (df = 141)
F Statistic	2.22* (df = 5; 288)	1.41 (df = 10; 141)	14.60*** (df = 5; 288)	2.77*** (df = 10; 141)
Note:				*p<0.1; **p<0.05; ***p<0.01

Three primary findings emerge from the data.

1. The places with higher growth in earnings per worker were also more likely to experience higher job growth. Although it is expected for earnings per worker to parallel wages per worker, it is not guaranteed that places with higher wage growth will also experience higher job growth on average. Indeed, in a manufacturing environment where firms compete on costs, one might expect the opposite to be true: regions with slower wage growth might be more attractive to new jobs. Instead, the correlation between earnings, wage, and job growth suggests that some regions are more competitive than others, enabling them to excel along multiple outcomes. The same relationship does not hold for output growth, or

GDP growth, per worker. There is no statistically significant association between a region's GDP growth per worker and its job growth. As a caveat, it is important to note that since U.S. manufacturing declined so dramatically overall during this period, regions with comparatively high job growth might not have added net jobs overall – they might have merely maintained the same level of manufacturing employment that they had before the sharp decline in U.S. manufacturing employment.

2. Improvements in manufacturing earnings per worker during this period are not associated with measures of innovation, education, or access to foreign markets. Growth in a region's overall output per worker is associated with its patents per capita – a proxy for innovation – but not its human capital or exports. In discussions of advanced manufacturing, the knowledge economy, and globalization, these forces are often assumed to contribute to positive regional performance outcomes. However, there only appears to be a limited association between high-performing manufacturing regions and their concentration of patents, advanced degree holders, or exports. This finding does not suggest that technology, skills or competitiveness in foreign markets are unimportant. Instead, other measures – such as proxies for technology adoption or more specific manufacturing skills – might be more equipped to capture the relationship between these factors and manufacturing performance. Even still, there are individual regions that excel in these categories and have also performed well in manufacturing.

3. Although unions have historically been linked to helping workers in manufacturing and other industries obtain higher wage levels, there is not any strong association between the density of union membership in a region and its earnings growth. To the contrary, there is a weak negative association between a region's earnings growth per worker and its union density. The same negative relationship is present for growth in GDP per worker and union density. We approach these associations with caution because data on union membership is not available for all metros. Moreover, there

are high-performing manufacturing metros such as Columbus, IN – studied below – with a strong legacy of union membership.

The highest-performing manufacturing regions appeared to follow multiple different paths to growth. We defined performance by the metro area's levels of manufacturing job growth 2001-2019, manufacturing wages (2019), wage growth (2001-2019), earnings growth (2001-2019), earnings growth per worker (2001-2019), and output growth per worker (2001-2019). We identified the highest-performing regions as places above the median in each category, as well as in the upper quartile for manufacturing job growth. The resulting set includes 11 metro areas (Table 2). Seven of these metro areas were also above the median in output per worker growth.

The metros are remarkable for their variety. They cover nearly every region of the United States (except the Northeast) and range in their manufacturing legacies, education levels, levels of exports and foreign investment, as well as their dominant industries. Several metros specialize in natural resource processing, including oil hubs like Lake Charles, LA. However, other metros are concentrated in aerospace (Palm Bay, FL) or diversified without a clearly dominant industry (Ames, IA and Kankakee, IL).

The variety of characteristics that these metro areas exhibit suggests that there are multiple paths to productivity, wage, and job growth in manufacturing. Recognizing multiple paths to growth among manufacturing regions contrasts with frequent discussions of "innovation hubs" like Silicon Valley or Boston. These places are commonly associated with a path to growth including research-intensive industries, highly-educated workforces, and an active startup community. The multiple paths inherent in the data could be interpreted in several ways. An optimistic interpretation is that multiple paths suggest that growth could be available to a variety of regions, even those without the assets (skilled workforce, research universities) often associated with the knowledge economy. An alternative interpretation is that the variety of paths suggest that each of these places grew for specific reasons and there are not generalizable lessons or models that other regions might follow. Determining what lessons to draw from these manufacturing regions will require a closer look at the trajectories that individual regions took to growth.

TABLE 2. SUMMARY OF HIGH-PERFORMING MANUFACTURING REGIONS

Metro Area	Population (2019)	Mfg Jobs (%, '19)	Average Mfg Pay ($, '19)	Mfg Pay Growth (%, '01-'19)	Mfg Jobs (%, '70)	Adults with BAs only (%, '13-17)	Patents per 1,000 residents ('00-15)	Jobs at foreign-owned firms (%, '12)
Ames, IA	123351	10.76%	74,166	70.79%	13.48%	27.6%	9.6	6.25%
Bellingham, WA	229247	10.43%	81,432	65.36%	22.66%	22.3%	3.6	2.78%
Columbus, IN	83779	36.84%	96,654	79.38%	57.37%	18.5%	11.3	15.53%
Dubuque, IA	97311	15.10%	76,727	62.05%	36.91%	19.6%	4.6	2.04%
Kankakee, IL	109862	14.87%	94,171	63.26%	36.83%	12.4%	1.8	8.09%
Lake Charles, LA	210409	8.80%	143,377	83.84%	21.27%	14.4%	.9	4.87%
Mt. Vernon, WA	129205	11.19%	88,525	82.81%	25.03%	16.3%	1.7	3.47%
Palm Bay-Melbourne-Titusville, FL	601942	10.22%	109,318	84.90%	19.29%	17.5%	10.1	2.41%
Savannah, GA	393353	8.96%	107,896	81.78%	22.99%	19.3%	1.1	2.82%
Tulsa, OK	998626	10.54%	80,313	71.48%	21.31%	18.5%	2.5	3.90%
Waco, TX	273920	11.75%	75,547	73.75%	22.65%	14.4%	.8	3.18%
Median	248,257	8.47%	72,179	57.6%	24.2%	17.1%	2.4	4%

IV. Lessons from High-Performing Manufacturing Regions

With the goal of drawing specific lessons from high-performing manufacturing regions, our research team focused on three regions that appeared based on preliminary data to represent different paths to growth: Ames, IA; Columbus, IN; and Tulsa, OK.

Based on the summary statistics in Table 2, Ames, IA is a comparatively innovative place with a highly-educated workforce. These factors could help explain the region's high growth in output per worker. Columbus, IN stands out for its manufacturing legacy (nearly 40% of the workforce employed in manufacturing in 1970), as well as its high share of workers employed by foreign-owned companies, which is top among metro areas in the United States. The path to growth for Tulsa, OK is not readily apparent from summary statistics. Instead, Tulsa, OK appears to be near the median for most measures of innovation, education, and access to foreign markets. It is unclear what other factors might be affecting its manufacturing outcomes.

Our case studies of these three cities drew on publicly available data of the sector and occupational breakdown within each metro area, as well as more than 25 interviews with government, business, and non-profit leaders in the three regions. Our interviews and case studies focus on the intentional steps that each region took to promote manufacturing growth. They aim to examine whether there are policy lessons in the paths that each region has followed.

i. Ames, IA

In the early 2000s, Ames would not have made a list of prominent manufacturing or high-wage regions. The shares of manufacturing employment in the metro area – as well as local manufacturing wages – were above the median for U.S. metro areas overall. The region's population growth had long been flat, and the primary legacy industry in Iowa – agriculture – had been struggling for decades. And yet, over the past two decades, Ames experienced exceptional growth in manufacturing wages and earnings – all while maintaining the number of manufacturing jobs. Our

research suggests that the primary force behind this growth is technology adoption at large and small manufacturing firms in the region. Multiple interviews pointed toward a regional strategy to support automation in manufacturing, as well as firm-specific resources to support technology upgrading. These resources were the exception among the regions that we have studied. Moreover, summary statistics confirm that the Ames region has high levels of patents per capita and college graduates compared to other U.S. metro areas. Three factors appear to have contributed to technology adoption in Ames: a tight regional labor market, the university as a talent pool, and non-market organizations bridging private and public interests in manufacturing.

The Ames region has had persistently low unemployment since 2000. The Ames metro area unemployment rate has consistently been less than half of the national unemployment rate, often dropping in the range of 2-3%, which is widely considered full employment. Between 2000 and the beginning of the COVID-19 pandemic, the Ames unemployment rate only exceeded 5% for a total of three months at the height of the Great Recession. The Ames unemployment rate was still well below the national rate of 9%. One explanation for such low unemployment is low population growth. The annual population growth rate is less than 1% with the metro area growing only 16% between 2001 and 2019. The significance of the consistently low unemployment rate in Ames is that tight labor markets are associated with wage growth. When firms struggle to recruit, workers are in a better position to bargain for higher wages. In the early 2000s, Ames had manufacturing wages below the median of the average metro area. Manufacturing wages in the Ames region are now high compared to other metros. Nonetheless, low population growth and unemployment rates have been a source of frustration for Ames leaders. Tight labor markets make it challenging for employers to recruit, and a flat population suggests low growth in tax revenues. So, while tight labor markets are a positive for workers' wages, they could also deter manufacturing firms from investing in a region. Additional factors help explain why this was not the case in Ames.

A second force driving technology adoption in Ames is that local economic development strategy has focused on targeting higher-wage jobs at higher-wage firms in manufacturing. Although automation has been more often associated with job displacement rather than job creation, the economic

development strategy in Ames appears to embrace automation. A leading economic development official in the region noted that low population growth and a tight labor market affected the types of companies that they sought to attract and retain in the region. Their economic development strategy has accepted low population growth and low unemployment. This has translated into a strategy where Ames does not aim to attract companies offering $13 / hour production jobs because firms offering these wages will be unable to retain workers when unemployment is 2%. Instead, Ames focuses on companies willing to invest in training and offer $20 / hour in production jobs. The only way that these firms will be able to afford higher wages and training is for them to be engaged in higher-technology, advanced manufacturing practices. In contrast to those who view technological upgrading as job-replacing, key institutions in Ames view automation as job-stabilizing, particularly given the conditions of the Ames labor market.

The third factor associated with technology adoption and manufacturing growth in the region is Iowa State University. The university is by far the largest employer in the metro area, employing more than 10% of the regional population (more than 16,000 people) and enrolling more than 30,000 students at a time. Local leaders recognize benefits of being a university town. The presence of the university helps explain why a higher share of Ames adults have college degrees than most regions. In one interview, an economic development official in Ames said that the presence of ISU helped the region through recessions. When the national economy suffered during the Great Recession of 2007-2008, for example, the Ames economy added jobs. When jobs were scarce elsewhere, people in Iowa sought out education.

Interviews with local economic development leaders – including one affiliated with ISU – suggested two mechanisms by which the presence of ISU contributed to higher technology adoption at local manufacturing firms. The first is that the university's college of engineering has a large student body that is a source of technical talent to local firms. The college graduates more than 1,500 undergraduate engineers each year, many of which complete a co-op or internship during their undergraduate education, building practical engineering skills and professional connections with firms, many of which are in Iowa.

ISU has also invested in multiple programs to support local industry. In the early 1960s, the College of Engineering launched the Center for Industrial Research and Service (CIRAS), a group within the university focused on "[enhancing] the performance of Iowa industry." CIRAS works directly with manufacturing firms in Iowa, connecting them to related technology and talent at Iowa State. In contrast to other MEPs that perform consulting arrangements with small and medium manufacturers focused on operational techniques like LEAN and six sigma, many of CIRAS's engagements emphasize new technologies. An interviewee reported that CIRAS draws on the technological expertise of the university to inform its work, estimating that 50% of CIRAS projects are technology-focused and 20-25% of their work draws on ISU faculty, staff, and student time. CIRAS is also a founding partner with the local utility, Alliant Energy, in establishing a "Digital Manufacturing Lab" to serve as a resource for Iowa manufacturers pursuing automation. After the national network of Manufacturing Extension Partnerships (MEPs) was created in the 1980s, CIRAS took on the role of Iowa's MEP.

CIRAS is located within the ISU Research Park, which was founded in 1987 – around the same time that many industrial parks were established near universities in an attempt to replicate the success of Research Triangle Park in Raleigh-Durham, as well as Stanford's Industrial Park – both of which had attracted economic activity near campus. More than three decades later, the ISU Research Park boasts 90+ tenants including branches of John Deere and Siemens with more than 2,500 employees across more than 800,000 square feet of office space. University offices and buildings are in the park alongside privately held ones. Multiple interviewees pointed to the success of the park as a vehicle for the university's contribution to local industry. What explains the park's apparent success in attracting and retaining tenants? One factor appears to be that the Park was the focal point of ISU President's strategy for contributing to the local economy. Another is that the university partnered with local organizations focused on the success of the local economy, including the local utility, to provide services in the research park that appeared to prove attractive to firms.

ii. Columbus, IN

The small region of Columbus, Indiana stands out among metro areas for its legacy of manufacturing. In 1970, nearly more than half of the local workforce was employed in manufacturing industries, making the concentration of manufacturing jobs in Columbus more than double that of the median metro area. The city's manufacturing economy was long centered on Cummins, a multinational engine manufacturer which had been founded in Columbus in 1919 and shaped the growth of the region as the company grew to employ more than 25,000 people globally by 2000. In 2019, Cummins still employed approximately 8,000 people in the Columbus region, which equaled approximately 40% of the local manufacturing workforce – and manufacturing jobs still amounted to more than a third (36%) of the Columbus workforce overall (compared to 8% for the median metro area).

Narratives of U.S. manufacturing decline have frequently associated "company towns" like Columbus with decline. Janesville, WI suffered when it lost the General Motors plant on which it had long depended for local employment. In Rochester, NY, the bankruptcy of Eastman Kodak translated into acute hardship for the region. In Detroit, MI, downturns in the American auto industry contributed to long-term population and employment decline for the region. But in Columbus, the region's manufacturing employment and wages have continued to grow – all while employment growth at Cummins has occurred primarily outside Indiana. A primary factor affecting growth in Columbus is the extraordinary share of local workers employed by foreign firms – 11% of the workforce overall – making the small Indiana region a national leader in Foreign Direct Investment. Unlike other company towns, the Columbus manufacturing economy has diversified in recent decades. The region has attracted eight foreign manufacturers, including five from Japan, together employing more than 7,200 people in the region – nearly as many local employees as Cummins. How did Columbus become a hub for foreign company employment and support the growth of manufacturing wages and earnings?

One potential explanation is that foreign companies in industries adjacent to Cummins were attracted to the region because Cummins had attracted a common pool of talent related to engine design and manufacturing. The firm was a global technology leader, so it could reasonably attract other

firms to grow locally and benefit from proximity to an innovative corporate headquarters. But, the presence of a large innovative company does not always attract related firms. Large companies alone do not necessarily spur clusters of economic activity, particularly when those companies have a variety of locations. In 2000, Cummins had technical centers all over the world, including sites in Tennessee, Minnesota, Wisconsin, Japan, and England. They had factories in New York, North Carolina, Texas, Japan, and South Korea, among many other countries. Why were all the other prominent manufacturers that located in Columbus foreign-owned companies?

Evidence from public reporting suggests that Columbus leadership, along with the leadership of Cummins, made a concerted effort in the 1980s to diversify away from their status as a company town. Cummins was influential – along with another large local manufacturer at the time, Arvin – in establishing the Columbus Economic Development Board with a mission to find other sources of economic activity in the region. Part of the team to recruit new companies included a former Cummins executive, who – along with others – made trips abroad to attract new companies to the region. The investment, mostly from Japan, started small in the 1980s, followed by expanded investments that ultimately rivaled the size of Cummins's local workforce. Columbus, IN was not the only community at the time to support this kind of global business recruitment. As large Japanese automakers Toyota and Nissan in particular sought to expand in the United States, midwestern and southern regions traveled to Japan in droves to build relationships and attract investment.

Cummins's global expansion efforts help explain why foreign companies – particularly from Japan – choose to invest and expand in Columbus and not elsewhere. While economic development officials from Columbus were searching for foreign investment, Cummins built its own partnerships abroad to diversify its business, particularly with the Japanese automotive company Komatsu. Cummins's entry into the Japanese market began in the 1960s associated with post-war construction in Japan. In 1993, Cummins and Komatsu agreed to jointly produce diesel engines at a Cummins factory in Indiana as well as a Komatsu factory in Japan. The partnership deepened cooperation between Cummins and the Japanese automotive industry. The company was open to foreign partnerships as well as foreign talent. A now-

senior Cummins technical leader reported in an interview that Cummins sponsored an H1-B visa for him to work in the United States at a time when it was rare for companies to take that risk and recruit talent from abroad. He said that this had been Cummins policy since the 1960s.

Another factor that could have helped stimulate foreign investment and wage growth is the transformation of the regional training system. In the mid-2000s, the State of Indiana's vocational training system, which had been divided into regions throughout the state, became a statewide community college system called Ivy Tech. The Ivy Tech system has six sites in the Columbus community along with an active construction project that they are developing in partnership with a local Columbus non-profit, the Community Education Coalition (CEC). The value of Ivy Tech to the manufacturing community is that they conduct customized training and apprenticeship programs for local companies, including Cummins as well as Toyota's local manufacturer and Faurecia, a French manufacturer located in the area. Ivy Tech maintains a close relationship with local business in Columbus. Interviews with Ivy Tech administrators and business leaders suggest an ongoing dialogue between educators and industry to ensure that the school stays on top of what local business most needs. Ivy Tech has also maintained a forward-thinking approach to technology and training, aiming to anticipate what skills will be most needed in the near future. For example, the Columbus campus of Ivy Tech is planning to launch a new program focused on electric vehicle engine technology, which may soon become a dominant part of Cummins's business.

The CEC often acts as the bridge institution between Cummins, other leading firms in the area, and training centers like Ivy Tech. In an interview, CEC representatives described their organization as the "backbone" that allows business and education providers to exchange information and form a shared long-term strategy. This involves convening representatives from firms and schools into facilitated group meetings where these different stakeholders can chart out what their needs are and how to arrange mutually beneficial strategies. By doing so, CEC can help realize the "bigger picture of what the business community needs," as one CEC representative described, in contrast to a more siloed approach. Taken together, these education and training institutions likely contribute to a higher-wage and more competitive local manufacturing economy. Training centers like Ivy

Tech are highly responsive to the skills that businesses need, and their forward-thinking posture ensures that the skills of their graduates remain cutting-edge. Acting as a bridge between business and the local community, the CEC ensures that the region is flexible and can respond to changing market demands. Collectively, these institutions have helped keep Columbus manufacturing diversified and robust.

iii. Tulsa, OK

In a summary review of regional economic indicators, it is unlikely that Tulsa, OK would stand out. Unlike Ames and Columbus, its levels of innovation, education, foreign business interests, and other variables are all near the median for metro areas in the United States. It is not apparent from the data what forces have driven Tulsa to experience exceptional manufacturing wage and earnings growth. For some leaders in the city, those seeking to attract innovation and new economic activity to Tulsa, the news of its high manufacturing performance came as something of a surprise. But those embedded in the training institutions and infrastructure supporting the local manufacturing sector offered several explanations.

First, the Tulsa manufacturing economy has undergone several waves of diversification from its roots as a hub for the oil and gas industry. The discovery of the Glenn Pool oilfield in Tulsa County in the beginning of the 20th Century attracted a cluster of energy industry interests to set up businesses in and around Tulsa. Estimates suggest that as much as 10% of Tulsa's workforce was once employed in oil and gas extraction. The oil booms helped make the region a hub for workers with skills in the oil and gas industry, which included welding, as well as the production to support the construction of pipelines and related equipment.

In the 1980s and 1990s, the region began diversifying away from the oil and gas sectors. Interviewees described the shift as intentional and welcome. Volatile energy prices contributed to extreme boom-and-bust cycles in the oil sector, which led to local economic instability. Current employment in oil and gas extraction is less than 1,000 workers in a regional manufacturing economy more than 50,000 strong.

The most prominent sectors in the Tulsa regional economy circa 2019 are aerospace, HVAC systems, and metal fabrication, along with related industrial equipment. The Tulsa aerospace industry employs nearly 10,000 people, approximately half of whom are in manufacturing. There are more than 6,000 manufacturing employees in sectors related to HVAC and heat exchange. And there are more than 9,000 employees in business related to metal fabrication. All told, these three sectors account for approximately 40% of the local manufacturing sector.

Second, the institutions for training and workforce development in Tulsa are structured differently than programs elsewhere in the country, which has helped the region support the workforce needs of companies in new sectors as they grow. The aerospace, HVAC, and metal fabrication industries in Tulsa require skills related to the legacy oil and gas sector. Welding and metalwork are important for all sectors; however, the type of welding and the firm-specific skills vary across contexts.

Tulsa Tech – the regional technical training center – partners with manufacturing companies in Tulsa to provide tailored training programs for the workers that they recruit. Approximately 10,000 workers per year go through a Tulsa Tech company training program. The programs begin with Tulsa Tech matching a student with a company for several weeks to see if there is a fit. If the company and the student agree, then the student will come back to Tulsa Tech for a specific series of trainings related to the work of the firm. And after the student – now employee – begins work, they might return to Tulsa Tech for training on new equipment or regulations as the need arises.

Tulsa Tech does not offer degree programs. It is distinct from Oklahoma's community colleges. Instead, it was founded to provide vocational education to support the Oklahoma business community. The state helps fund Tulsa Tech and other technical centers throughout the state with property tax dollars. One interviewee said that this funding arrangement helped align the incentives of Tulsa Tech with the growth of the communities where they are based. Several manufacturing leaders praised Tulsa Tech for providing industry-relevant training. When we asked about the metrics for success, one interviewee said that employers keep returning to Tulsa Tech for recruiting and training. However, the skeptics of the

training program suggested that there were tradeoffs with Tulsa Tech's vocational focus. According to data on college mobility, Tulsa Tech does not perform as well as community colleges or four-year institutions in supporting graduates' upward mobility. One possible explanation for this datapoint is that while manufacturing wages in Tulsa have grown since 2000, there is still a comparatively low ceiling.

Third, the growth of new industries in Tulsa build on legacy infrastructure in the region. The rise of the Tulsa aerospace industry relied on military infrastructure at Tulsa International Airport dating back to the late 1930s. During World War II, the federal government established a factory to produce bombers in Tulsa. Rather than let the critical infrastructure established during the war go to waste, American Airlines took over some of the facilities in the 1940s to establish a center for maintenance and repair operations (MRO), while private military contractors took over some of the production facilities. In the decades since, American Airlines has consolidated its MRO activities in Tulsa, and the aerospace manufacturing sector in Tulsa has grown to support the need for relevant components. The infrastructure for aerospace maintenance and production in Tulsa is flexible in that it supports commercial as well as military production.

These factors help illustrate a path to continued manufacturing growth in Tulsa by which the skills and technologies relevant to the oil and gas industries became the foundation for growth in related sectors. Welding expertise and training infrastructure could also be a basis for aerospace companies to expand in the region, drawn by the ample talent base. The technologies around heat exchange that were developed and improved for the oil industry also proved relevant for the HVAC industry, which was also attracted to a similar set of production skills. The Tulsa path highlights how diversification can build from infrastructure and skills that at first appear specialized.

In retrospect, it is unclear the extent to which diversification in Tulsa was "strategic" and benefited from government or the local ecosystem. Multiple interviewees noted that the region was focused on diversification after downturns in the oil and gas sector in the 1980s, as well as the migration of large corporate energy headquarters to Houston, TX. Interviewees cite tax benefits for high-wage jobs and vocational training at the state level, as well

as the Tulsa Tech system in supporting new manufacturing activity. They also note targeted business recruiting efforts. However, the evidence of diversification – the rise of aerospace and HVAC as complements to the local oil and gas industries – appears to grow almost naturally from the region's legacy in the energy sector. The role of the local government and economic development organizations in diversification was to welcome new categories of businesses rather than focusing exclusively on retaining the region's legacy sectors.

TABLE 3. CASE SUMMARIES

PLACE	GROWTH FACTORS	KEY COMPONENTS
AMES, IA	Local companies increase their technology adoption and invest in automation, expanding their demand for skilled workers.	• Iowa State University is a source for local engineering talent and technology expertise. • CIRAS (Iowa's MEP) and Alliant Energy (the regional utility) connect local manufacturers with ISU technology opportunities.
COLUMBUS, IN	Concentration of foreign investment, particularly from Japan, helped transition away from "company town" legacy with employment centered on Cummins.	• Cummins supported regional strategy to attract foreign investment and diversify the regional economy. • Community education coalition and statewide community college network support training for companies to grow in the region.
TULSA, OK	Growth of local aerospace and HVAC industries, coupled with diversification away from local oil and gas legacy.	• Technical training system has company training programs that support customized training and employee / employer matching. • Aerospace production infrastructure dates back to World War II, attracts cluster of related firms.

V. Policy Directions

Regional ecosystem organizations matter because they can help manufacturing firms identify opportunities for innovation and growth that they would not have found in the market. Although the market might not support the risk of investing in new infrastructure or investments in capital equipment, regional ecosystem organizations have the potential to defray that risk and support opportunities for growth in manufacturing. Nonetheless, policy investments in regional ecosystem organizations have primarily supported risk-averse, incremental efforts: investments in regions' pre-existing specialties rather than the development of more diverse capabilities.

Policymakers can draw three lessons from the case studies above to inform their investments in regional manufacturing:

1. High-performing regions have diversified away from their legacy industries and institutions as part of their efforts to improve manufacturing employment and productivity. This pattern of diversification among high-performing regions is consistent with regional economics research that shows regions with diversified industries can achieve more productivity benefits than regions with a few extremely concentrated sectors. The implication for policymakers is to support regions in exploring economic activities that are adjacent to – but not duplicative of – their historical strengths. For Columbus, IN, this meant the local economic development board and Community Education Coalition helping facilitate the growth of new manufacturers that were independent of Cummins Engine, the region's largest employer.

   For the Department of Defense, supporting diversification is important in manufacturing regions specialized in producing military equipment. When federal funding for military procurement drops, it is important that these manufacturing communities continue to grow so they can pick up supplying advanced equipment when procurement picks back up. To facilitate diversification in specialized manufacturing regions in the defense industrial base, the federal government can support organizations like Columbus's economic development board that target investment from

firms in adjacent industries that complement the region's existing strengths and insulate the region against potential downturns.

2. Each region had key "bridge" organizations that managed the diverse interests of firms, workers, non-profits, and the public. In Ames, the local Manufacturing Extension Partnership and the local utility bridged Iowa State University and local industry. And in Tulsa, the technical training institution bridged workers' career interests with industry's interest in retaining skilled workers. The lesson from these examples is that regions can work to empower categories of actors that accommodate multiple interests, rather than target a limited set of industries or technologies.

   Manufacturing Innovation Institutes (MIIs) can serve as bridge organizations when they link the priorities of their member organizations (e.g. firms and universities) with the broader priorities of the regions in which they are situated. For example, following the example of CIRAS in Ames, a MII could partner with a local utility or other organization with an interest in expanding technology adoption, to provide shared infrastructure and recruit local businesses to make use of the MII's technological advancements.

3. Effective regional organizations take risks. Part of the home alone problem is that individual firms are left to take on the risks of investing in new technologies and areas of business. The role of a regional "ecosystem" of supporting organizations is to offload some of that risk from individual firms. However, our research finds that many organizations are risk-averse; they target expanding economic activity in a region's existing strengths. Risk-taking organizations support investment in new areas of economic activity that would not have otherwise emerged. Policymakers at the federal level can incentivize regional organization to take risks and build in monitoring processes so that – on the occasions when these risks do not pay off – the regional organizations can change course.

   For example, Tulsa Tech is organized to share risk with manufacturers that rely on it for technical training. When manufacturers look to external training providers, they bear the risk that the trainee they hire will have the skills they need and fit within their organization. Tulsa Tech works to defray the risk by matching trainees with firms – and getting buy-in from

each – *before* they undergo a training program tailored to that firm. A similar approach to sharing risk could apply to capital equipment. MIIs and other regional organizations focused on driving technology adoption could work with technology vendors to encourage experimentation with equipment – proving its value – before firms commit to purchase it.

Taken together, these observations suggest that regional manufacturing economies are not locked in to preordained paths of industrial decline. Rather, ecosystem institutions can take active steps toward achieving more diversified, interconnected, and robust regional industrial sectors. While the exact development paths of Ames, Columbus, and Tulsa cannot – and need not – be replicated, other regions can and should take inspiration from their ecosystem strategies.

[i] Suzanne Berger and MIT Task Force on Production and the Innovation Economy, *Making in America* (Cambridge: MIT Press, 2014).
[ii] For more information on institutions for skill development in Germany and Japan, see: Kathleen Ann Thelen, *How Institutions Evolve: The Political Economy of Skills in Germany, Britain, the United States, and Japan*, Cambridge Studies in Comparative Politics (Cambridge ; New York: Cambridge University Press, 2004).
[iii] Peter A. Hall and David Soskice, *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage* (OUP Oxford, 2001), https://books.google.com/books?hl=en&lr=&id=EU02HzYJeFsC&oi=fnd&pg=PP12&dq=varieties+of+capitalism+hall+soskice&ots=-gBT5I0-W6&sig=zcnQHKb_X4SvMVucA8aUk99lPZM; Timothy Bresnahan, Alfonso Gambardella, and Annalee Saxenian, "'Old Economy' Inputs for 'New Economy' Outcomes: Cluster Formation in the New Silicon Valleys," *Industrial and Corporate Change* 10, no. 4 (December 1, 2001): 835–60, https://doi.org/10.1093/icc/10.4.835; AnnaLee Saxenian, *Regional Advantage* (Harvard University Press, 1996).
[iv] Christopher Norwood, *About Paterson; the Making and Unmaking of an American City* (New York, Saturday Review Press, 1974).
[v] Ron Chernow, *Alexander Hamilton* (New York: Penguin, 2004).
[vi] Norwood, *About Paterson; the Making and Unmaking of an American City*, 37.
[vii] Industrial policies are a subset of the government interventions in the economy that I discuss in this paper. I adopt Rodrik's general definition of industrial policy as government efforts to "stimulate specific economic activities and promote structural change." See Dani Rodrik, "Normalizing Industrial Policy" (Commission on Growth and Development, 2008), 2, https://siteresources.worldbank.org/EXTPREMNET/Resources/489960-1338997241035/Growth_Commission_Working_Paper_3_Normalizing_Industrial_Policy.pdf.
[viii] Norwood, *About Paterson; the Making and Unmaking of an American City*, 42.
[ix] For more background, see Benjamin Armstrong, Suzanne Berger, and Bill Bonvillian, "Advanced Technology, Advanced Training: A New Policy Agenda for U.S. Manufacturing" (Cambridge, MA: Initiative for Knowledge and Innovation in Manufacturing, February 2021).
[x] Matthew Lang, T. Clay McManus, and Georg Schaur, "The Effects of Import Competition on Health in the Local Economy," *Health Economics* 28, no. 1 (2019): 44–56, https://doi.org/10.1002/hec.3826; David Autor, David Dorn, and Gordon Hanson, "When Work Disappears: Manufacturing Decline and the Falling Marriage Market Value of Young Men," *American Economic Review: Insights* 1, no. 2 (September 2019): 161–78, https://doi.org/10.1257/aeri.20180010.
[xi] Deloitte Insights and Manufacturing Institute, "2018 Deloitte and The Manufacturing Institute Skills Gap and Future of Work Study," 2018, https://documents.deloitte.com/insights/2018DeloitteSkillsGapFoWManufacturing.
[xii] Armstrong, Berger, and Bonvillian, "Advanced Technology, Advanced Training: A New Policy Agenda for U.S. Manufacturing"; Ben Armstrong, "A Firm-Level Study of Workforce Challenges at U.S. Manufacturers," in *Working Paper Series*

(MIT Work of the Future, 2021), https://workofthefuture.mit.edu/wp-content/uploads/2021/02/2021-Working-Paper-Armstrong.pdf.

[xiii] David Meyer, "Emergence of the American Manufacturing Belt: An Interpretation," *Journal of Historical Geography* 9, no. 2 (1983); David R. Meyer, "Midwestern Industrialization and the American Manufacturing Belt in the Nineteenth Century," *The Journal of Economic History* 49, no. 4 (1989): 921–37; John A. James, "Structural Change in American Manufacturing, 1850-1890," *The Journal of Economic History* 43, no. 2 (1983): 433–59.

[xiv] Alfred Marshall, *Principles of Economics*, 9th (variorum) ed (London, New York: Macmillan for the Royal Economic Society, 1961).

[xv] Marshall.

[xvi] Meyer, "Emergence of the American Manufacturing Belt: An Interpretation"; Tom Nicholas, "The Role of Independent Invention in U.S. Technological Development, 1880–1930," *The Journal of Economic History* 70, no. 1 (2010): 57–82.

[xvii] Barry Bluestone and Bennett Harrison, *The Deindustrialization of America: Plant Closings, Community Abandonment, and the Dismantling of Basic Industry* (New York: Basic Books, 1982).

[xviii] Anne Case and Angus Deaton, *Deaths of Despair and the Future of Capitalism*, *Deaths of Despair and the Future of Capitalism* (Princeton University Press, 2020), https://doi.org/10.1515/9780691199955.

[xix] Autor, Dorn, and Hanson, "When Work Disappears"; William J. Wilson, *The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy* (Chicago: University of Chicago Press, 1987); William Julius Wilson, *When Work Disappears : The World of the New Urban Poor*, vol. 1st ed (New York: Vintage, 1996), https://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=732605&site=ehost-live&scope=site&authtype=shib&custid=s8978330.

[xx] Meyer, "Emergence of the American Manufacturing Belt: An Interpretation"; Nicholas, "The Role of Independent Invention in U.S. Technological Development, 1880–1930."

[xxi] Susan Houseman, "Understanding the Decline of U.S. Manufacturing Employment" (Kalamazoo, MI: Upjohn Institute for Employment Research, 2018); Teresa C. Fort, Justin R. Pierce, and Peter K. Schott, "New Perspectives on the Decline of US Manufacturing Employment," *Journal of Economic Perspectives* 32, no. 2 (May 2018): 47–72, https://doi.org/10.1257/jep.32.2.47.

[xxii] David Autor, David Dorn, and Gordon Hanson, "The China Shock: Learning from Labor-Market Adjustment to Large Changes in Trade," *Annual Review of Economics* 8 (2016): 205–40.

[xxiii] Berger and MIT Task Force on Production and the Innovation Economy, *Making in America*.

[xxiv] Berger and MIT Task Force on Production and the Innovation Economy, 20.

[xxv] Berger and MIT Task Force on Production and the Innovation Economy, 20.

[xxvi] Jane Jacobs, *The Economy of Cities* (New York: Vintage Books, 1970).

[xxvii] Edward Glaeser et al., "Growth in Cities," *Journal of Political Economy* 100, no. 6 (1992): 1126–52.

[xxviii] Michael Greenstone, Richard Hornbeck, and Enrico Moretti, "Identifying Agglomeration Spillovers: Evidence from Million Dollar Plants" (National Bureau of Economic Research, 2008), http://www.nber.org/papers/w13833; Robert W. Wassmer and John E. Anderson, "Bidding for Business: New Evidence on the Effect of Locally Offered Economic Development Incentives in a Metropolitan Area,"

Economic Development Quarterly 15, no. 2 (May 1, 2001): 132–48, https://doi.org/10.1177/089124240101500203; Timothy Bartik, "Making Sense of Incentives: Taming Business Incentives to Promote Prosperity," *Upjohn Press*, October 8, 2019, https://doi.org/10.17848/9780880996693.

[xxix] Aaron Chatterji, Edward Glaeser, and William Kerr, "Clusters of Entrepreneurship and Innovation," *Innovation Policy and the Economy* 14, no. 1 (January 1, 2014): 129–66, https://doi.org/10.1086/674023.

[xxx] Hall and Soskice, *Varieties of Capitalism*; Thelen, *How Institutions Evolve*.