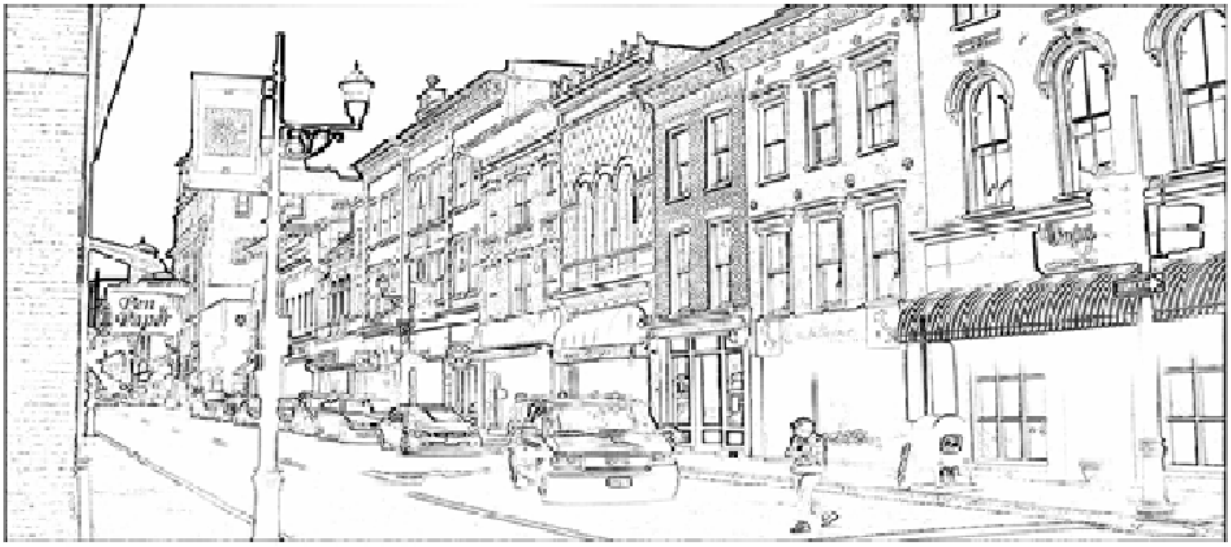

The State of Wisconsin Manufacturing

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Key Points

- Despite fluctuations, the recent number of manufacturing jobs in Wisconsin is close to the level in 1970 at 500,000. As a share of total employment, however, manufacturing employment has fallen from 28% in 1970 to 14% in 2015.

- Most manufacturing sectors in Wisconsin, including those that employ the most people, have declined in employment since 2000.

- Because manufacturing is declining more slowly in Wisconsin than in the rest of the country, Wisconsin now produces a larger share of national manufacturing product. This increasing spatial concentration of manufacturing in the state creates both potential opportunities and vulnerabilities due to future fluctuations in the industry.

- Over time, productivity and employment in manufacturing have diverged such that the sector is able to continue producing more and more but with fewer workers. Yet, in Wisconsin, the productivity gains have been modest compared to other states and the nation. While productivity and employment trends suggest that manufacturing is a critical component to sustaining the Wisconsin economy, its current contributions to economic growth are somewhat modest.

- The manufacturing industry has a large share and number of employees over the age of 55. Finding the means to replace these workers as they enter retirement or scale back capacity may be one of the biggest challenges facing the industry over the next decade.

- Based on one measure of susceptibility, Wisconsin's manufacturing sector has a large number of occupations with a high probability of automation and computerization. Automation within the sector could help solve some of the labor demand issues facing the industry but could also displace many workers and reshape the skills needed by manufacturing firms.

Introduction

Manufacturing and the long-run loss of production jobs have been the focus of recent local and national discussions, and rightly so. Manufacturing's role in providing employment and innovation remains significant (The Economist 2017). The recent attention to Wisconsin's success in attracting Foxconn, the world's largest contract electronics manufacturer specializing in display devices such as flat screen televisions and displays for smart phones, is a strong reminder of the historical and cultural role manufacturing plays in Wisconsin's economy and identity.

Yet, the type of jobs manufacturing has been known to provide, those that require mid-level skill and pay decent wages, are becoming scarcer. The sector was hit hard during the last recession and has yet to fully recover in Wisconsin. During the Great Recession (2007 to 2009) 65 thousand Wisconsin manufacturing jobs were lost, and just 33 thousand have been recovered. Though employment outcomes are troubling, the industry has become increasingly productive due to technological advancement. Consequently, determining the growth or decline of manufacturing depends on what you measure—employment, wages, productivity, or innovation.

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Manufacturers are more likely to export their products outside of the state which brings money into the Wisconsin economy. Given the competitive pressure of a broader market, exporters are, in turn, more productive than non-exporters. Exporters are also more capital intensive, as reaching larger markets drives down costs per unit sold (i.e., economics of size). Taken together, the sector as a whole has high productivity and high capital intensity positioning it to offer relatively high wages. For decades manufacturing did exactly that, offer competitive wages particularly for mid-skill men for the duration of their work life.

Over time such reliable and desirable manufacturing jobs have become harder to find. While it is true that manufacturing in Wisconsin offers nearly as many jobs today as it did almost 50 years ago, the small net change masks important shorter-term trends. Since 2000, manufacturing has lost 120 thousand jobs, offsetting the gains from the early rise of manufacturing in the 1970s and 80s. As manufacturing has been in a long-run decline which has leveled off in recent years, other parts of the economy have been growing. Much of the growth has occurred in service-related industries, led by the health care and social assistance sector, which alone created 93 thousand jobs. Several of these fast-growing sectors also pay higher wages than manufacturing. In 2016, the average wage in professional, scientific, and technical services was $31 per hour nationally, $28 per hour in health care, and $32 in financial activities, which are all higher than $26 per hour in manufacturing.

The persistent focus on reviving manufacturing, embodied by the recent Foxconn deal, when other sectors are growing faster and offer higher wages may be explained by other healthy aspects of the sector such as productivity and innovation. Briggs & Stratton chief executive Todd Teske, made the point in 2013 that "[t]o simply measure manufacturing health based on the number of jobs, that's not fair".

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Manufacturing employment in Wisconsin declined by a modest five percent between 1970 and today, yet Wisconsin manufacturing output increased by 44%, after adjusting for inflation, over the same time period. This apparent discrepancy is explained by growth in labor productivity, which is partly due to innovation that has led to technological advancement. Many manufacturers are adopting the technologies such as automation that reduced the need for lower and middle skilled workers. Thus, the shrinking share of employment in manufacturing, down from 28% in 1970 to 14%, has come alongside dramatic increases in productivity as shown by the growing average product per worker which has risen 55% in Wisconsin since 1970.

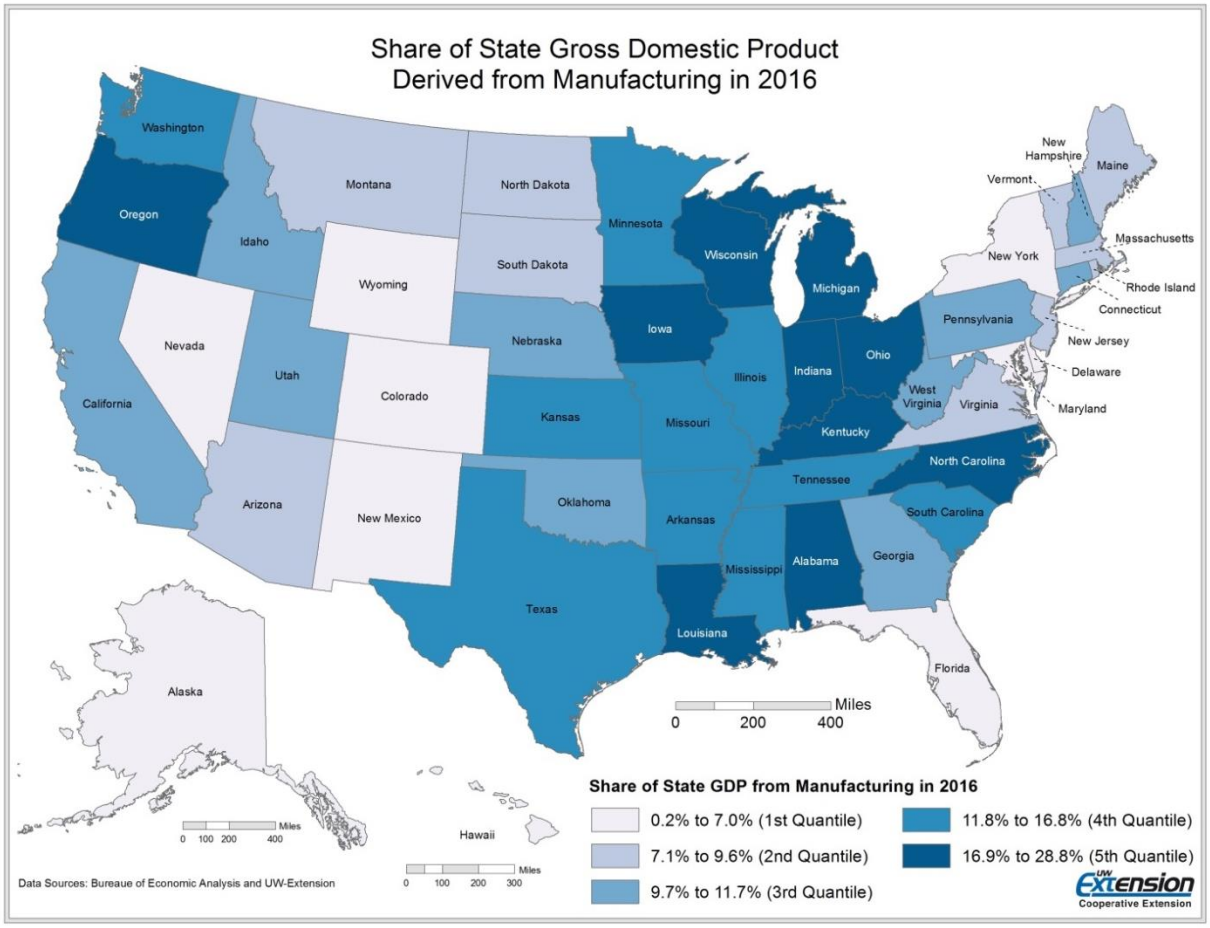
Despite the progress in technology and downward trend in employment, Wisconsin's elected officials, have made job growth the top economic priority with Governor Walker's campaign promise to generate 250,000 jobs. Today the Governor's Office oft points to Wisconsin's low unemployment rate as a sign of economic health and a perceived lack of qualified workers as the major hurdle to continued growth, both of which point to a primary focus on jobs as the key metric to economic growth and development.

The following analysis explores the status of manufacturing in Wisconsin by examining long term trends and benchmarking against comparable states in the Midwest region and the U.S. more generally. First, we review the role of manufacturing by looking at several basic aspects of the industry. Next, we focus on several aspects of how the sector is changing, followed by rural and urban comparison. Lastly, we consider the possible future of Wisconsin manufacturing.

Manufacturing in the Midwest

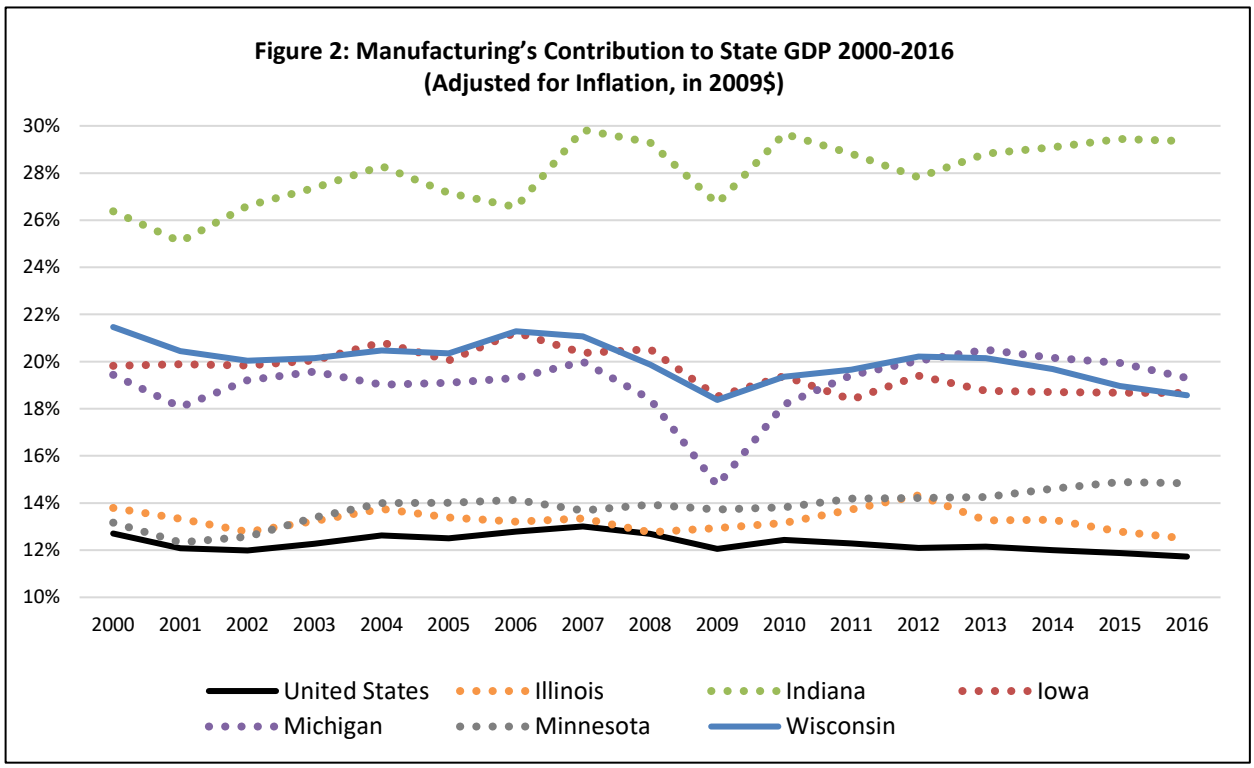
While manufacturing accounts for almost 12% of the nation's Gross Domestic Product (GDP), the state-by-state contributions of the manufacturing sector to state-level GDP vary dramatically. In 2016, Wisconsin derived 18.2% of its GDP from manufacturing, which was the eighth largest share in the nation. Notable shares are also found in other Great Lakes and Upper Midwest states including Indiana (28.8%, 1st), Michigan (19.2%, 5th), Iowa (18.3%, 7th) and Ohio (16.9%, 10th). Minnesota (14.4%, 16th) and Illinois (12.7%, 19th) derive somewhat smaller shares of GDP from manufacturing, but these contributions remain above the national average.

Figure 1 – Share of State Gross Domestic Product from Manufacturing (2016)



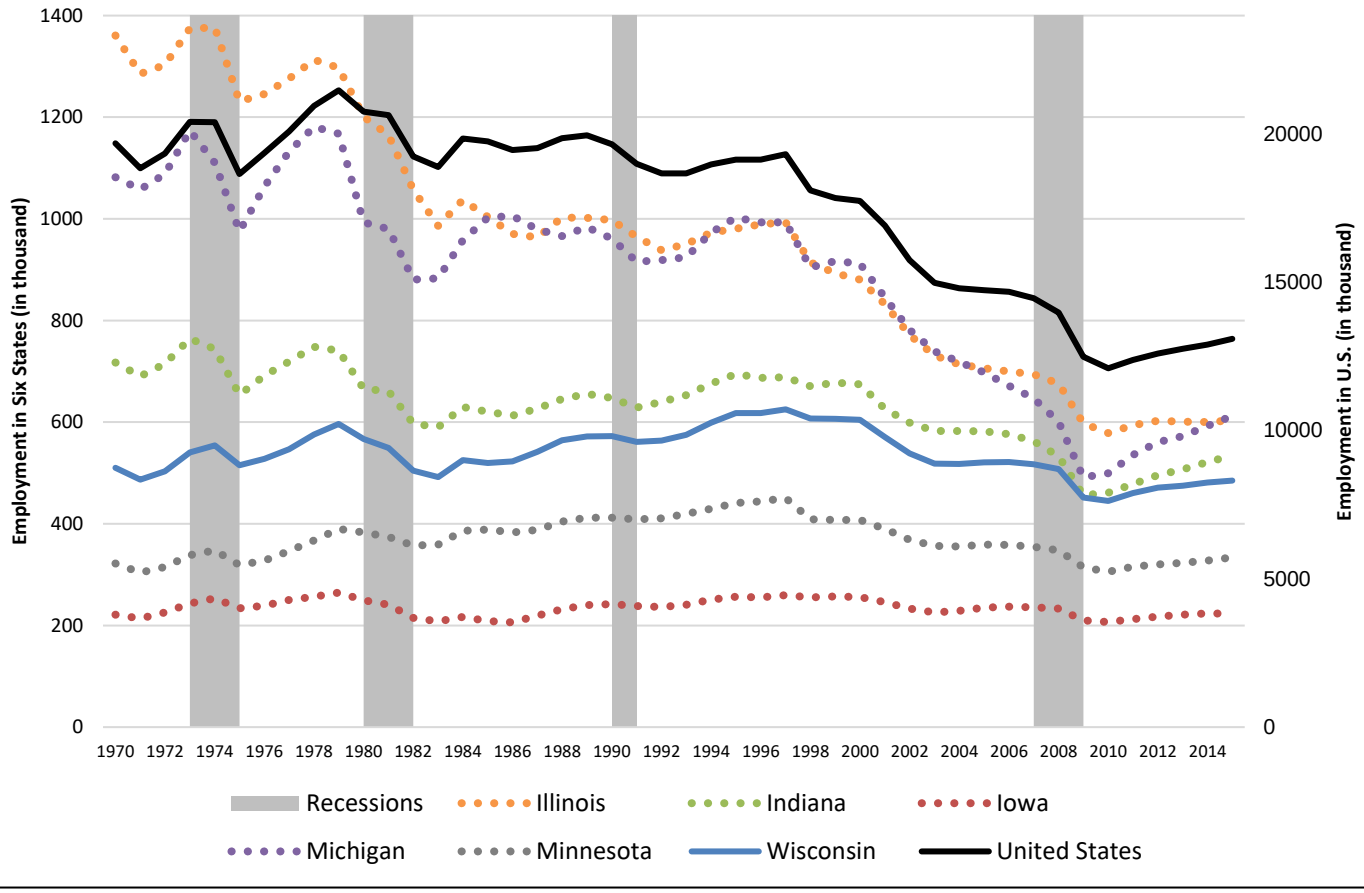
Nationally, manufacturing has provided a relatively stable contribution to total productivity, accounting for roughly 12% of GDP since 2000. This share, however, recently dropped to 11.7% in 2016, which was even lower than the 12.6% minimum during the Great Recession in 2009. As previously noted, approximately one-fifth of Wisconsin's state GDP comes from manufacturing, making it a key component of economic activity in the state. Despite this large contribution, it has been shrinking in recent years. As with the United States, Wisconsin's share of GDP from manufacturing in 2016 was near the lowest point during the Great Recession in 2009. Somewhat similar patterns in manufacturing GDP contributions are found in other neighboring states. However, both Indiana and Minnesota have seen their GDP contributions from manufacturing grow modestly in recent years.

As with contributions to state GDP, manufacturing employment levels in Wisconsin and its neighboring states are sizeable and among the highest in the nation (Figure 3). Note that high levels of employment in Illinois, Michigan, and Indiana compared to Wisconsin are mostly a reflection of the relative sizes of thei



r state economy. More interesting are the trends and fluctuations in employment. Each official recessionary period is highlighted in gray, to demonstrate how each economic contraction corresponds to a decline in manufacturing employment. Despite these contractions, the number of manufacturing jobs in Wisconsin has been relatively stable compared to Illinois, Michigan, and the U.S. where manufacturing employment has been both volatile and declining rapidly. The decline in Michigan, in particular, is reflective of the sensitivity of the automobile industry to consumer spending during economic contractions.

Figure 3: Total Full-Time and Part-Time Manufacturing Employment U.S. vs Illinois, Indiana, Iowa, Michigan, Minnesota, and Wisconsin, 1970-2015 (In Thousands)



In addition to total employment, fluctuations in manufacturing employment can be measured using a growth index where the number of jobs in 1970 are treated as benchmarks (1970 = 100, Figure 4). Again, recessionary periods are highlighted in gray and the negative impact of each recession on manufacturing employment is evident. Compared to other states, Wisconsin manufacturing employment has hovered comparatively close to its level in 1970 (index equal to 100). Thus, for nearly four decades, aside from swings associated with economic recessions, the level of employment in manufacturing has remained relatively unchanged compared to regional neighbors. In more recent years, however, the number of manufacturing jobs has dropped below the level in 1970 and is a reflection of both the lingering effects of the Great Recession as well as a longer-term down trend that began in the mid-1990s.

While Wisconsin has nearly the number of manufacturing jobs now as it did in 1970, the sector has experienced significant job losses since it peaked in the late 1990s. Between 2000 and 2015, durable manufacturing employment dropped by more than 85,000 jobs while non-durable manufacturing shed almost 35,000 jobs (Figure 5). In contrast, most non-manufacturing sectors in Wisconsin have demonstrated employment growth, with the health care sector thriving in particular.

Figure 4: Growth Index for Manufacturing Employment 1970-2015 (1970 = 100)

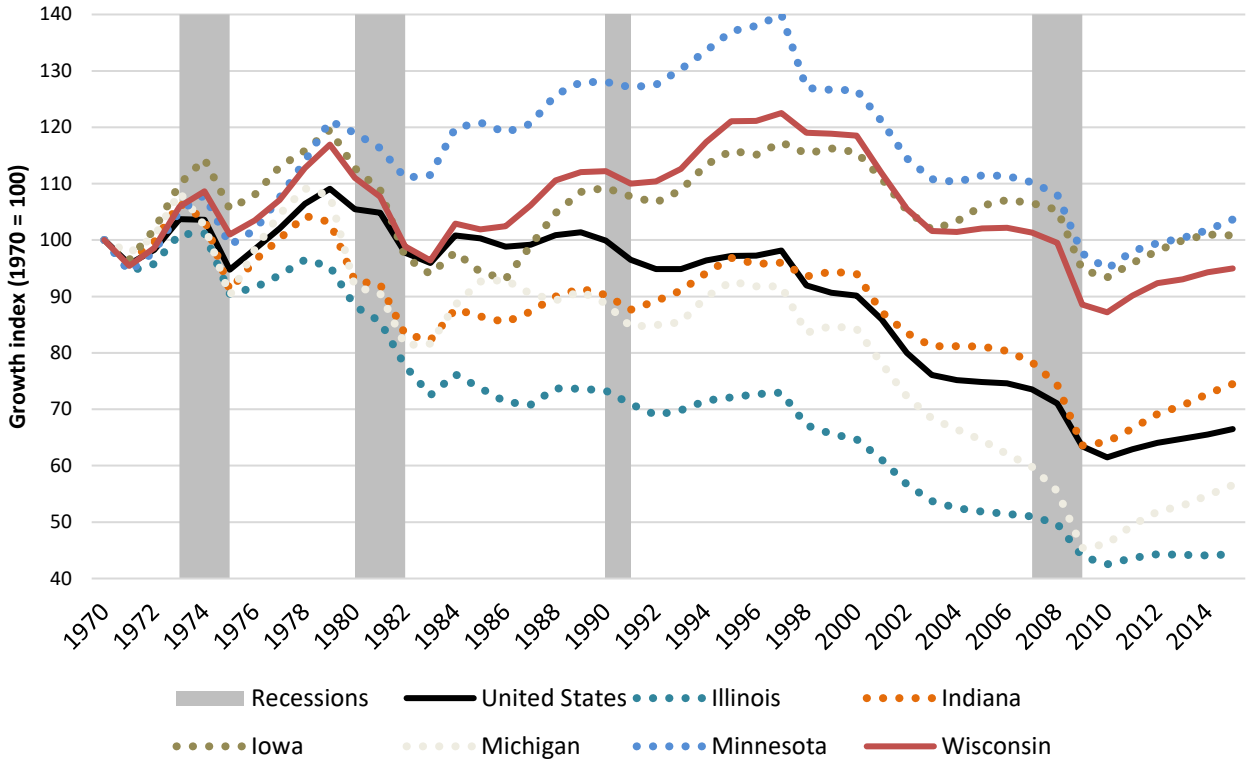
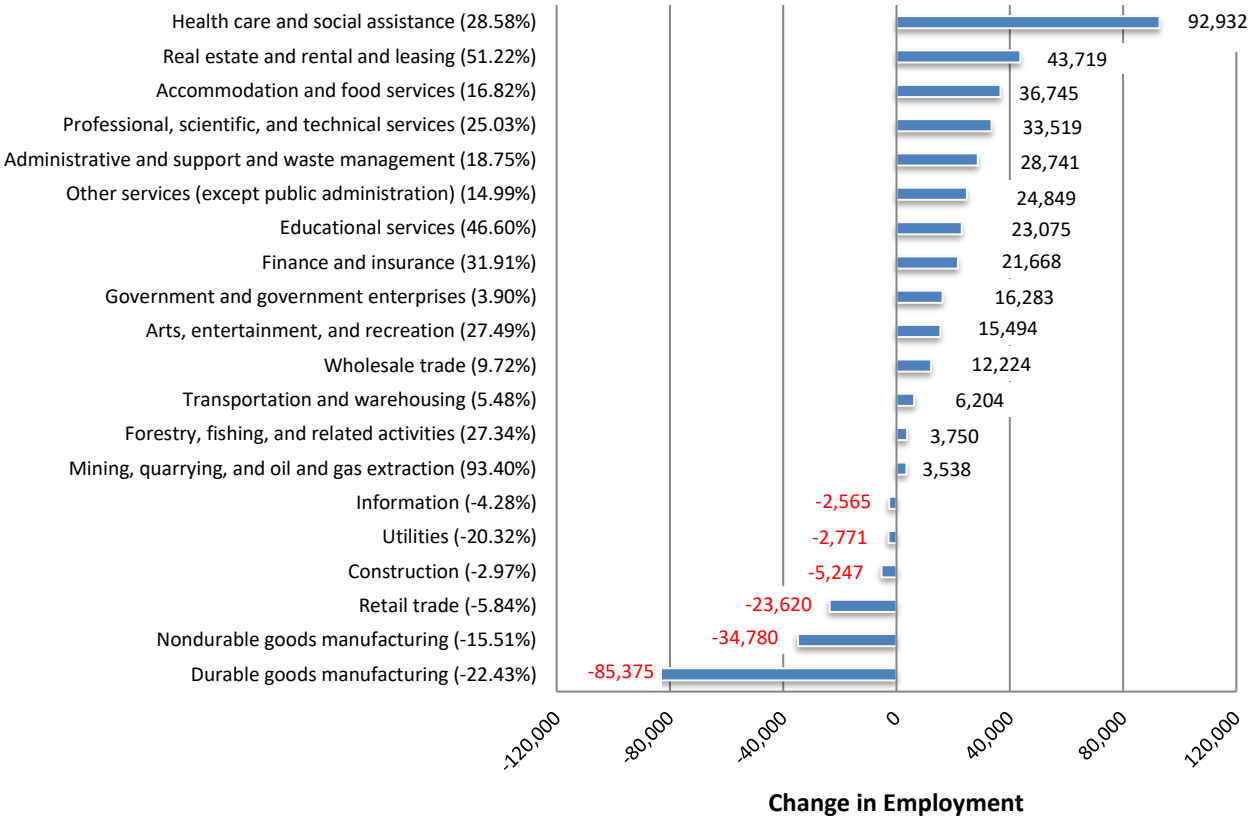
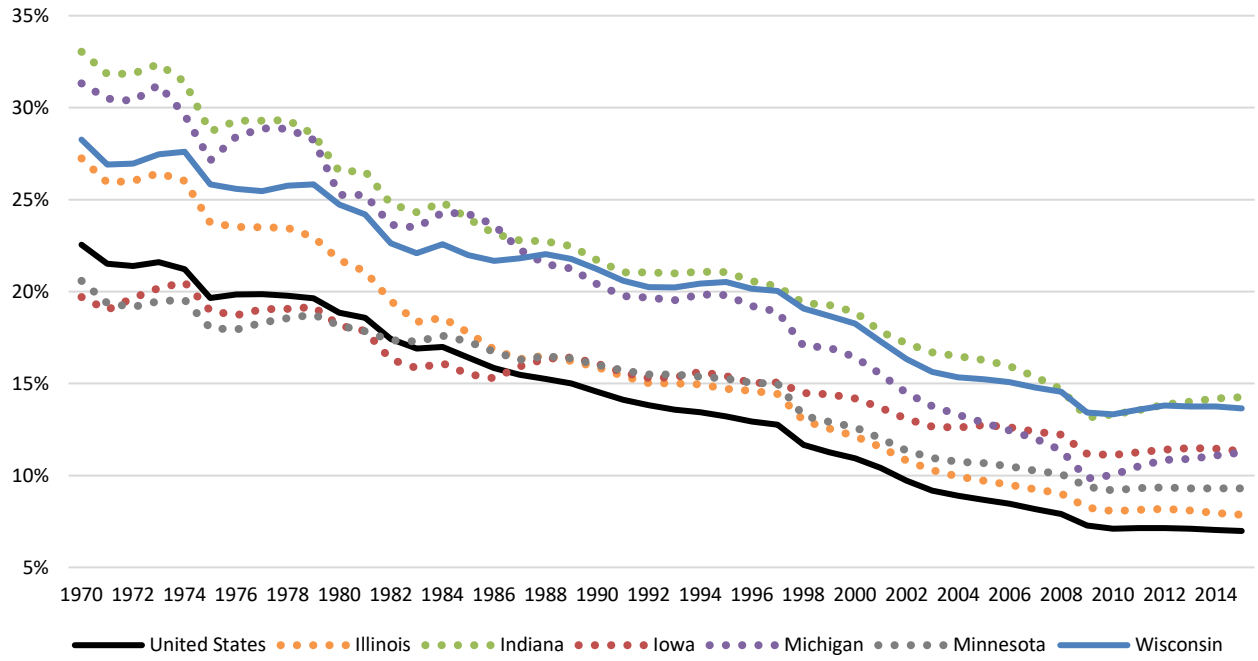


Figure 5: Change in Wisconsin Jobs 2000-2015 (% of total growth in parenthesis)



Although the level of employment in Wisconsin manufacturing appears relatively stable over the long term, the state's population and workforce have grown since 1970. Accordingly, manufacturing is employing an increasingly smaller share of overall workers, even though manufacturing still employs a large number of people (Figure 6). In Wisconsin, the share of all jobs attributed to the manufacturing sector was almost cut in half, declining from approximately 28% in 1970 to roughly 14% in 2015. Neighboring states and the U.S. experienced declines of similar magnitude over this period. However, the largest declines were found in Michigan and Illinois where the shares of total employment dropped from 31.3% to 11.2% and 27.2% to 8.0% respectively.

Figure 6: Manufacturing Employment as a Share of Total Nonfarm Employment by State, 1970-2015

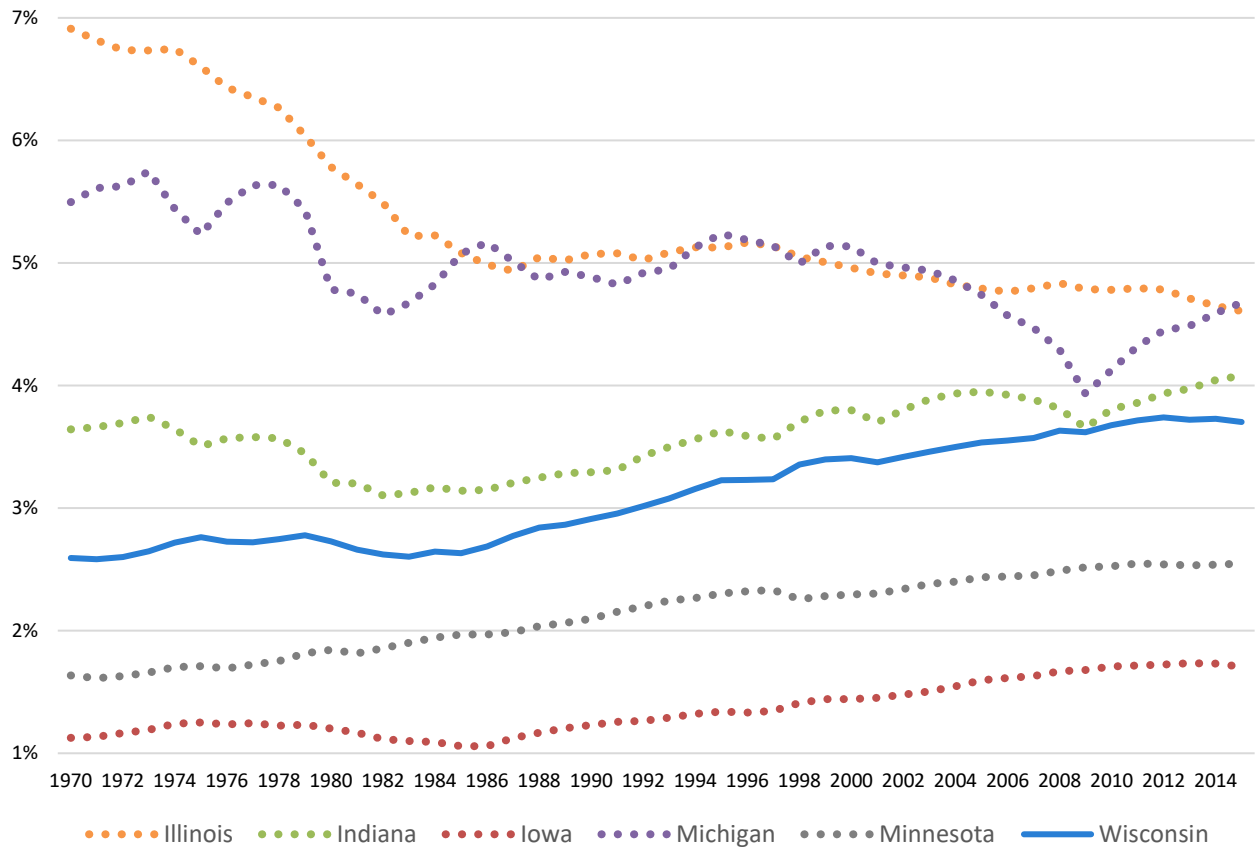


While manufacturing is responsible for a declining share of total Wisconsin employment, the manufacturing sector is becoming increasingly concentrated in the state. If all manufacturing jobs in the U.S. were distributed evenly across all 50 states, we would expect each state to have 2%. If instead, manufacturing employment were distributed across states based on their share of the national population, so that more populous states had more manufacturing, Wisconsin would have 1.8% of manufacturing employment. Instead, nearly 4% of all manufacturing jobs in the U.S. are located in Wisconsin (Figure 7). As this share has trended upwards since the early 1980s,

Although manufacturing employment in Wisconsin today is about the same level as it was 50 years ago, other sectors have grown significantly. As such manufacturing's share of total employment is growing smaller.

manufacturing employment is becoming increasingly concentrated in Wisconsin (and several other neighboring states). This trend could put the state in a beneficial position to grow or create vulnerability to decline with the expansion and contraction of the sector.

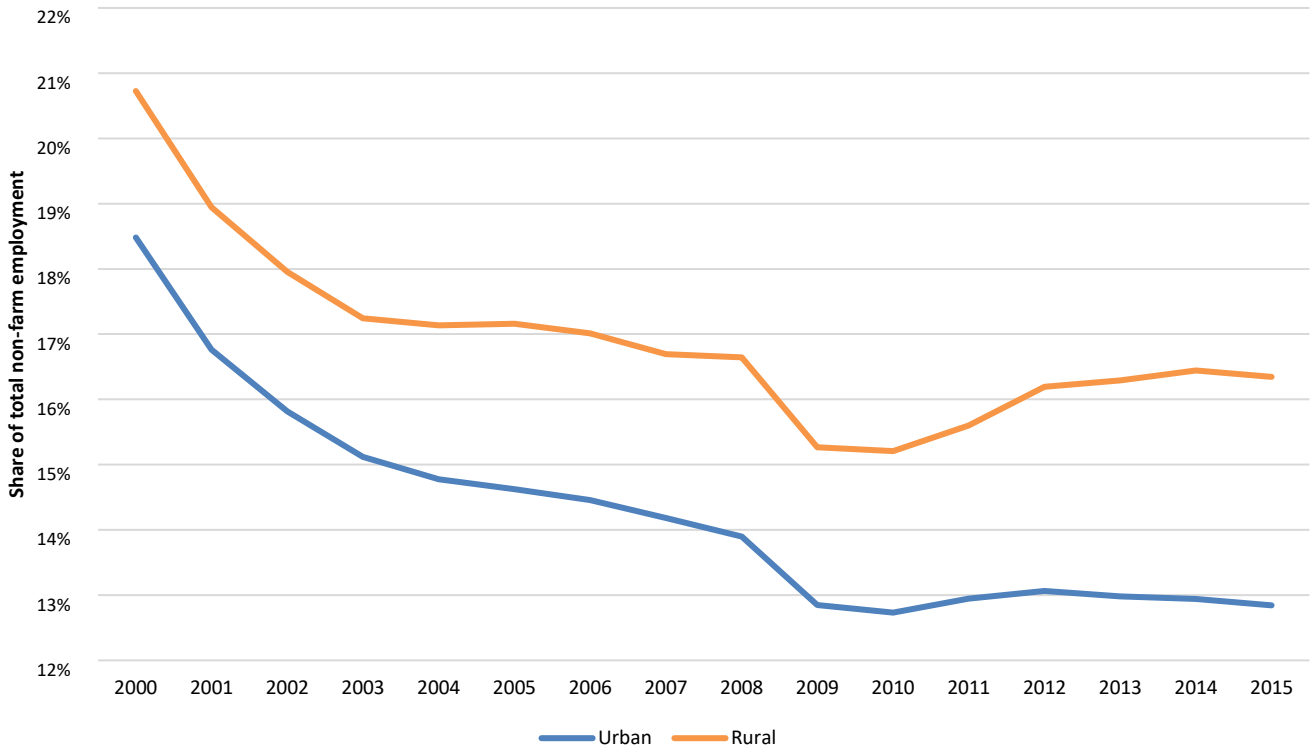
Figure 7: State Manufacturing Employment as a Share of National Manufacturing Employment, 1970-2015



Rural Manufacturing in Wisconsin

Given the concentration of Wisconsin's population, it is not surprising that most manufacturing jobs are in urban areas—in fact roughly, three times as many. Though there are many more manufacturing jobs in urban areas than there are in rural areas, as a share of total employment, rural Wisconsin relies more on manufacturing. In 2000, just over 20% of rural non-farm employment was in manufacturing compared to roughly 18% in urban counties. Both shares declined in the last two decades, but rural counties are still more dependent on manufacturing with approximately 16% of non-farm employment in manufacturing whereas manufacturing made up 13% of employment in urban counties as of 2015 (Figure 8). These dependencies are particularly high in rural counties such as Barron, Rusk, Price, Marinette, Waupaca, Trempealeau all have more than a quarter of their total employment in manufacturing (Figure 9).

Figure 8:The Share of Total Nonfarm Employment in Manufacturing in Rural and Urban Wisconsin Counties



Focusing just on rural Wisconsin, we show the growth of manufacturing employment compared to total employment in Figure 10. There is a clear divergence in the mid-1990s, where total employment continued to grow despite a steady decline in manufacturing employment. The split implies that even though rural Wisconsin was losing jobs, other sectors generated enough employment to more than offset those losses. While there has been a rebound in rural manufacturing since the Great Recession, employment is still far from reaching the level or growth trajectory of the late 1990s.

The differences between urban and rural Wisconsin in manufacturing employment reflects long-term growth. For example, urban manufacturing was relatively stable from 1970 to 2000, then began a sustained decline before rebounding after the end of the last recession (Figure 11). In rural Wisconsin, manufacturing employment grew more rapidly than in urban areas from 1970 to 2000, then declined and also rebounded after the end of the last recession.

> Given the disproportional concentration of manufacturing jobs and income in rural areas, these communities are more vulnerable to changes in the sector.

Figure 9: Manufacturing Employment as a Share of Total Employment (2016)

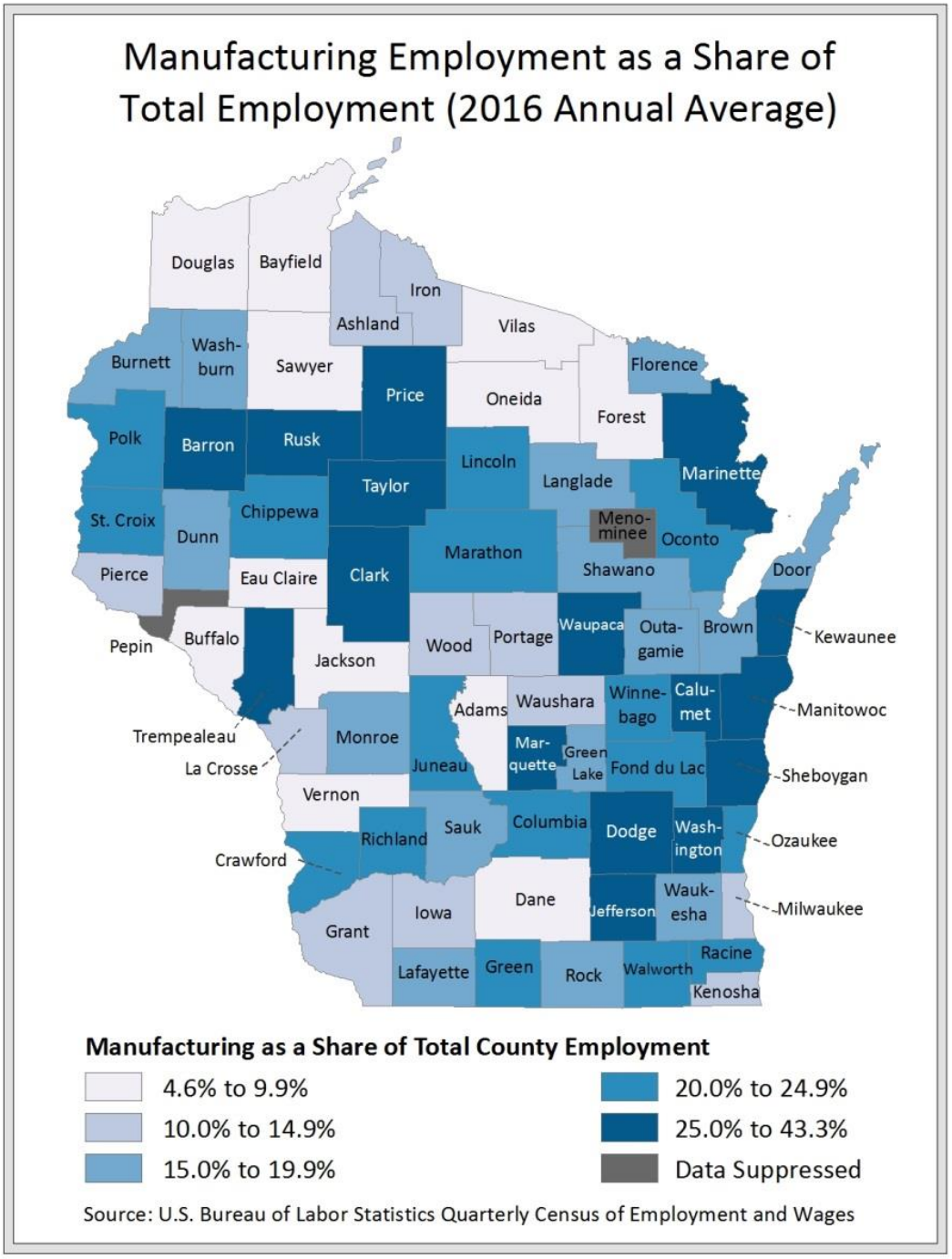


Figure 10: Wisconsin Non-Metropolitan Employment Growth Index

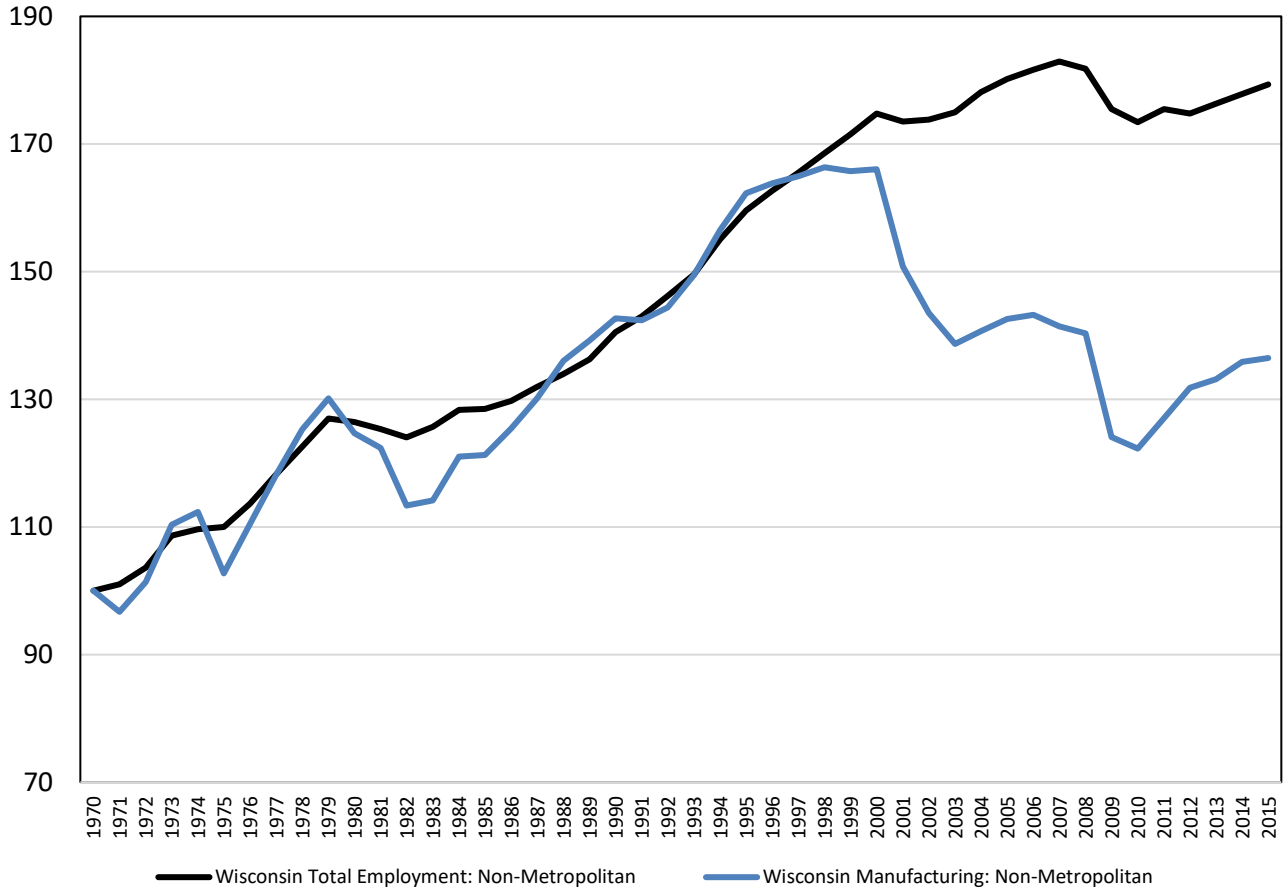


Figure 11: Wisconsin Manufacturing Employment Growth Index

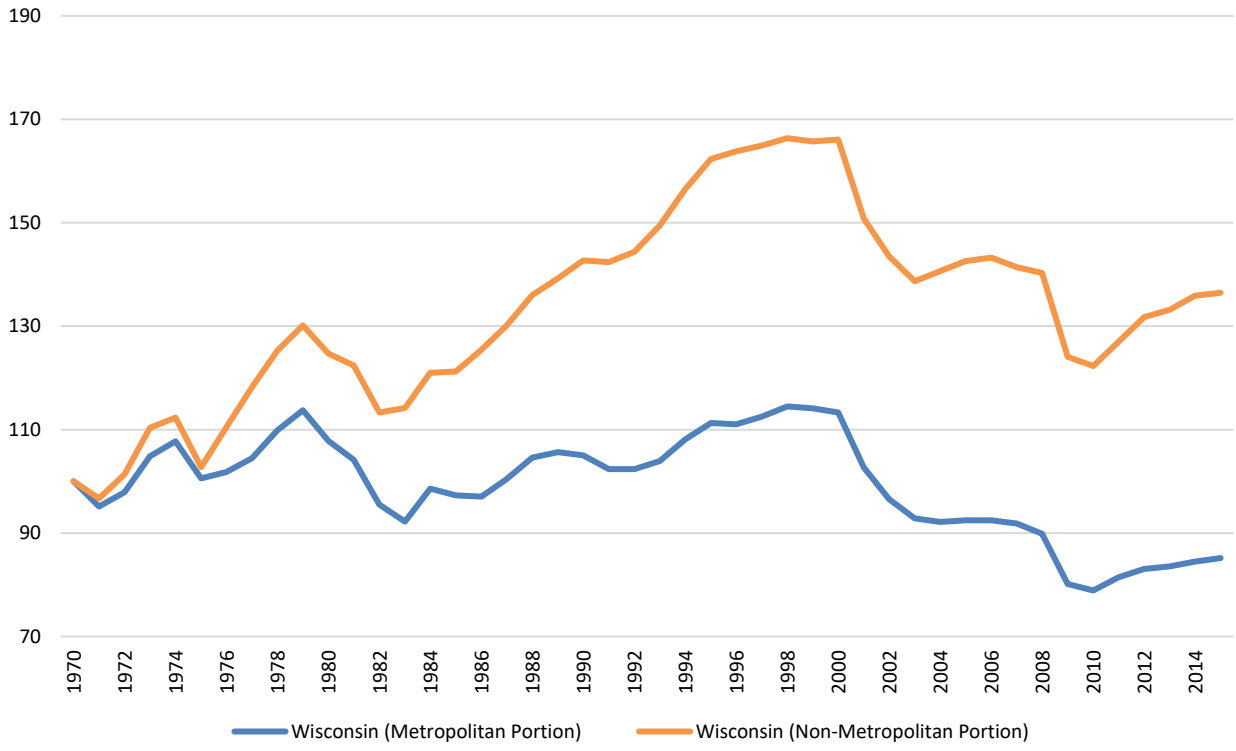
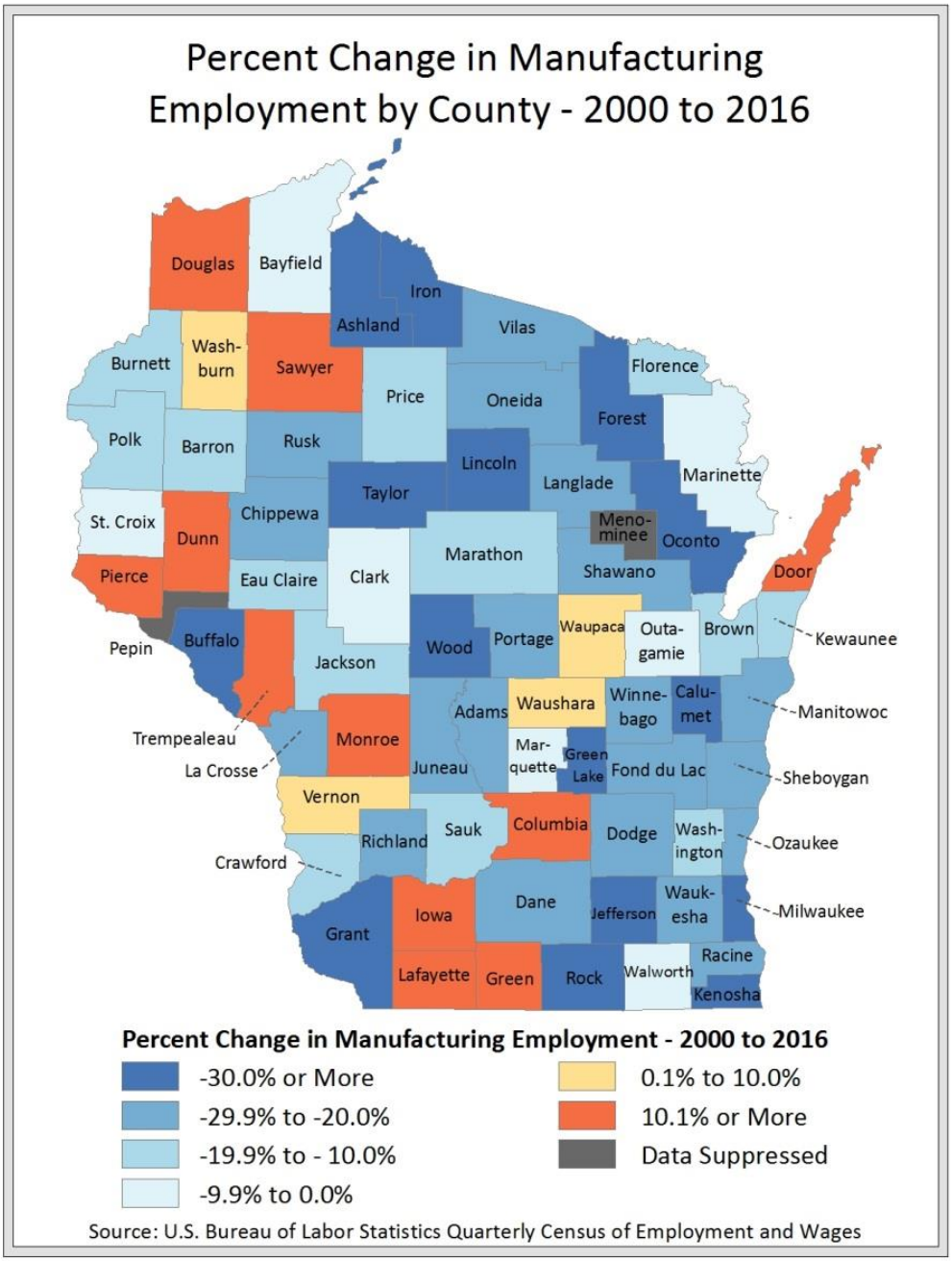


Figure 12: Percent Change in Manufacturing Employment by County (2000-2016)



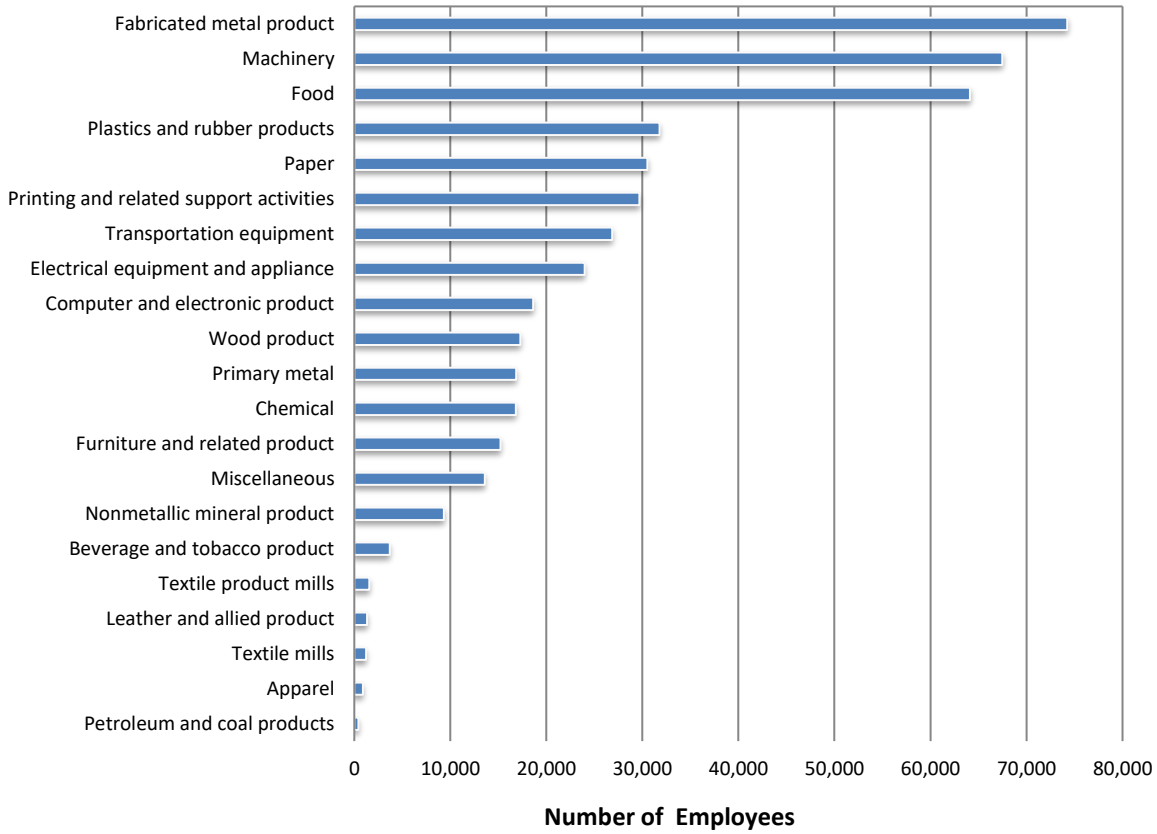
Given the disproportionate concentration of manufacturing jobs and income in rural areas, these communities are more vulnerable to changes in the sector. Indeed, the large share of rural employment in manufacturing makes rural employment more vulnerable to change in the industry. For example, the contraction of manufacturing since 2000 has been greater in many rural Wisconsin counties such as Lincoln, Wood, Grant and Green Lake (Figure 12). The decline in manufacturing is also an important piece to understanding the slow rural recovery from the Great Recession.

Further, within rural communities, the decline of manufacturing jobs primarily affected men. A recent research study links the declining employment prospects for men in manufacturing to higher unemployment, drug overdose rates, out-of-wedlock childbearing, and lower marriage rates (Autor, Dorn, Hansen 2017). Thus, in many ways, the decline of manufacturing has had ripple effects that affect families and their communities, especially in rural areas.

Manufacturing Diversity in Wisconsin

Manufacturing employment in Wisconsin is diverse, spanning many subsectors (Figure 13). Given this diversity, it may be informative to focus on these subsectors rather than solely focusing on manufacturing as a whole. The three subsectors with the most employees are fabricated metal products, machinery, and food processing. When combined, these three subsectors account for 44% of Wisconsin's manufacturing employment. The subsectors of plastics and rubber products, paper, and printing and related support activities are the next largest manufacturing categories and are responsible for another 20% of total manufacturing employment.

Figure 13: Manufacturing Sub-Sectors by Employment: 2015



The overall employment declines in the manufacturing sector are a reflection of nearly every manufacturing subsector which has shed employment between 2000 and 2015 (Table 1). Notable employment losses within several of the largest subsectors include declines of 23.08% in machinery manufacturing, 38.44% in paper manufacturing and 22.53% in printing and related support activities. In contrast, employment in the food manufacturing subsector grew slightly over this period. Furthermore, a somewhat related, but smaller subsector in beverage and tobacco product manufacturing has grown dramatically since 2000. This growth is likely the result of the state's growing beer, and to a lesser extent, wine industries. Even though the largest brewers are becoming more automated and offering fewer jobs, the state's small and medium sized breweries are growing

in both their number and scale. These smaller breweries also remain relatively labor intensive which further contributes to this subsector's employment growth.

Table 1: Growth Rate and Percentage in WI Manufacturing Sectors

Manufacturing Sub Sector	Location Quotient	% WI Non-Farm Emp. (2015)	% WI Mfg. Emp. (2015)	Growth rate (2000-2015)
Manufacturing	1.96	13.65%	N/A	-19.86%
Durable goods manufacturing	1.91	8.32%	60.92%	-22.43%
Wood product manufacturing	2.38	0.54%	3.97%	-35.16%
Nonmetallic mineral product manufacturing	1.23	0.28%	2.03%	-12.21%
Primary metal manufacturing	2.23	0.48%	3.53%	-27.00%
Fabricated metal product manufacturing	2.65	2.15%	15.75%	-6.96%
Machinery manufacturing	3.13	1.94%	14.22%	-23.08%
Computer and electronic product manufacturing	0.93	0.54%	3.93%	-34.44%
Electrical equipment, appliance, and component mfg.	3.21	0.69%	5.06%	-26.29%
Motor vehicles, bodies and trailers, and parts manufacturing	1.02	0.50%	3.66%	-43.10%
Other transportation equipment manufacturing	0.72	0.27%	1.99%	-18.07%
Furniture and related product manufacturing	2.06	0.46%	3.40%	-15.68%
Miscellaneous manufacturing	1.22	0.46%	3.37%	-17.43%
Nondurable goods manufacturing	2.04	5.34%	39.08%	-15.51%
Food manufacturing	2.19	1.88%	13.76%	1.30%
Beverage and tobacco product manufacturing	0.87	0.11%	0.84%	62.14%
Textile mills	0.58	0.04%	0.29%	-5.29%
Textile product mills	0.76	0.05%	0.40%	-35.72%
Apparel manufacturing	0.44	0.04%	0.31%	-50.68%
Leather and allied product manufacturing	2.24	0.04%	0.30%	-61.52%
Paper manufacturing	4.34	0.86%	6.33%	-38.44%
Printing and related support activities	3.17	0.88%	6.46%	-22.53%
Petroleum and coal products manufacturing	0.22	0.01%	0.10%	7.97%
Chemical manufacturing	1.09	0.49%	3.60%	14.87%
Plastics and rubber products manufacturing	2.42	0.91%	6.70%	-15.95%

While manufacturing is increasingly spatially concentrated in Wisconsin compared to the rest of the country, this trend is clearly not due to manufacturing growth. Rather, the state's growing concentration reflects a decline in Wisconsin manufacturing employment that has been slower than the national rate. The slow rates of employment decline, relative to the rest of the country, are found in the overall sector and also within several of the six largest subsectors (See Figure 1 in the Appendix). Five of the six largest sectors have contracted by 15 to 30 percent. Food processing, the third largest manufacturing subsector in Wisconsin, is clearly the best performing sector as its employment levels largely remained stable during most of the

A Location Quotient (LQ) is a relative measure of dependency on employment relative to a national average.

$$LQ \begin{cases} > 1 \text{ a "strength" or specialization} \\ < 1 \text{ a "weakness" or nonspecialized} \end{cases}$$

A "large" LQ suggests that Wisconsin employment is proportionately larger than the national average.

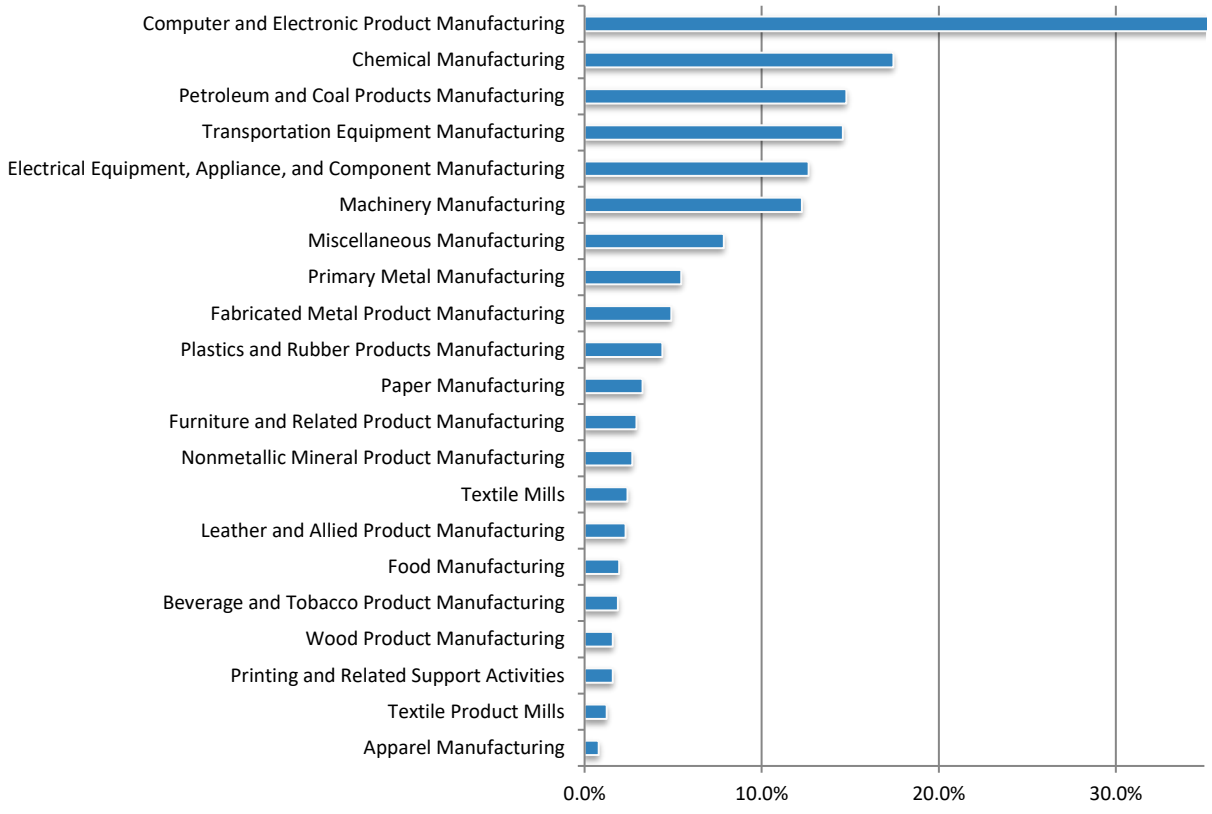
period considered. In most recent years the sector's employment has grown, perhaps making it a promising sector for investment and new business opportunities through entrepreneurship initiatives.

While Wisconsin's overall manufacturing sector is diverse, the state does not have a large concentration of industries in so-called "advanced industry" categories of manufacturing. The definitions of advanced industries vary but are generally recognized as those that have a STEM-intensive labor force and are highly active in research and development (Muro et al., 2015). Accordingly, these industries may have a higher probability of remaining competitive and may drive growth through innovation rather than relying on price sensitive commodities. Using the national share of manufacturing subsector employment found in STEM-related occupations as one measure, these industries include computer and electronic products; chemicals; petroleum and coal products; transportation equipment; electrical equipment, appliances and components; and machinery (Figure 14).

Overall, Wisconsin has a relatively small share of employment in these advanced industry categories of manufacturing, with the exception of machinery manufacturing and perhaps electrical equipment, appliance and component manufacturing. As with other subsectors of manufacturing, several of these advanced categories have also declined in employment since 2000. Computer and electronic product manufacturing employment dropped by nearly 35%. Similarly, motor vehicle and related parts manufacturing declined over 43%. However, there are some promising sectors. Though they employ a smaller share of workers, both chemical manufacturing and petroleum and coal product manufacturing have grown 8 and 15 percent respectively between 2000 and 2015.

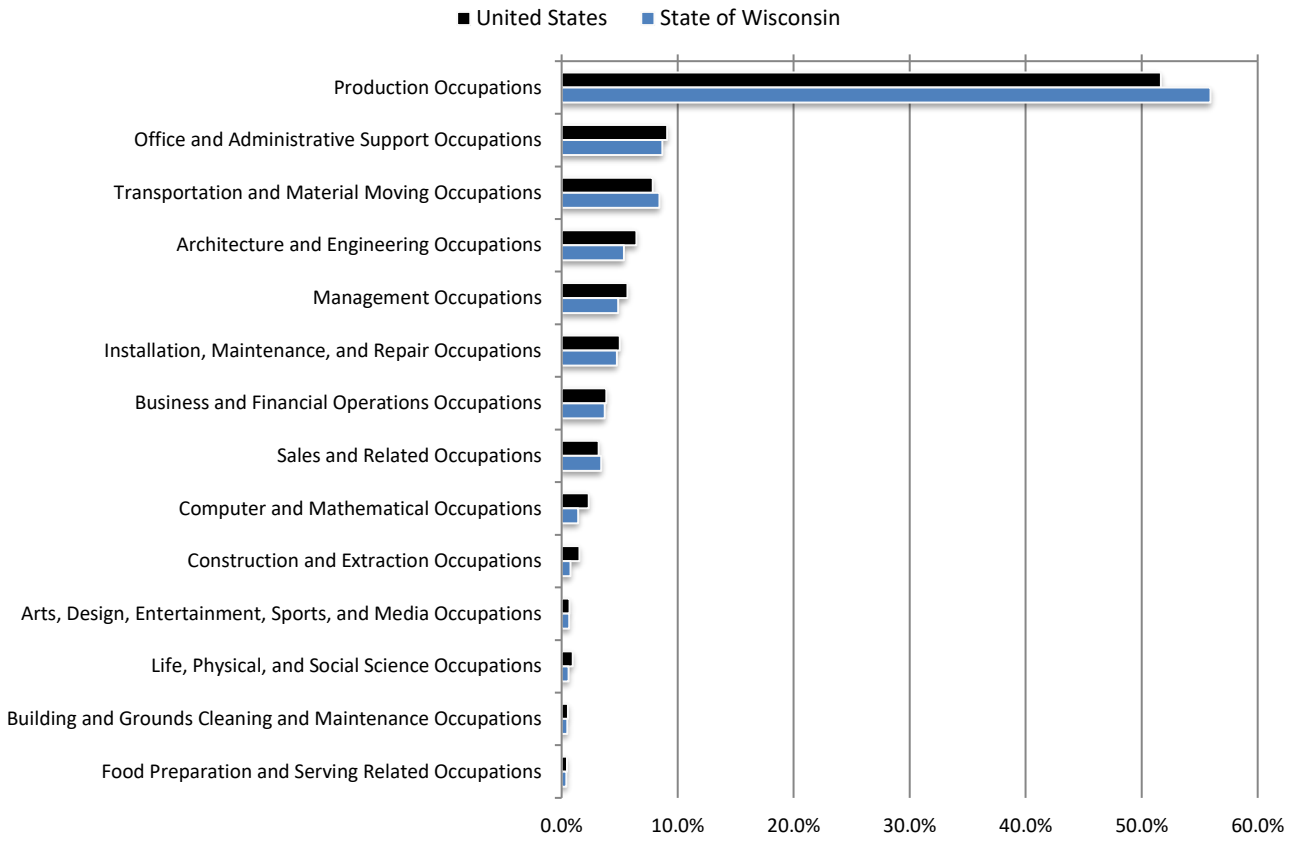
For a more in-depth discussion of the role of innovation and economic growth and development see Deller and Conroy (2017) in *The Wisconsin Economy* series entitled "Innovation and Economic Performance: R&D within Wisconsin." Patterns of Economic Growth and Development Study Series No.5.

Figure 14:Share of National Manufacturing Subsector Employment in STEM-Related Occupations (2016)



Wisconsin's distribution of manufacturing employment by subsector also influences its occupational structure. As previously suggested, Wisconsin's manufacturing sector has a smaller share of STEM-related occupations relative to the national distribution (Figure 15). Specifically, Wisconsin's manufacturing sector has a lower share of employment in architecture and engineering occupations; computer and mathematical occupations, and life, physical and social science occupations. In contrast, Wisconsin's manufacturing sector has a higher reliance on production occupations, transportation and material moving occupations and sales and related occupations. These differences in occupational structure are important as they could potentially influence the automation susceptibility of jobs in Wisconsin's manufacturing sector. Automation and computerization propensity is explored later in this study.

Figure 15: Share of Manufacturing Employment by Occupational Category
Wisconsin vs. United States (2016)

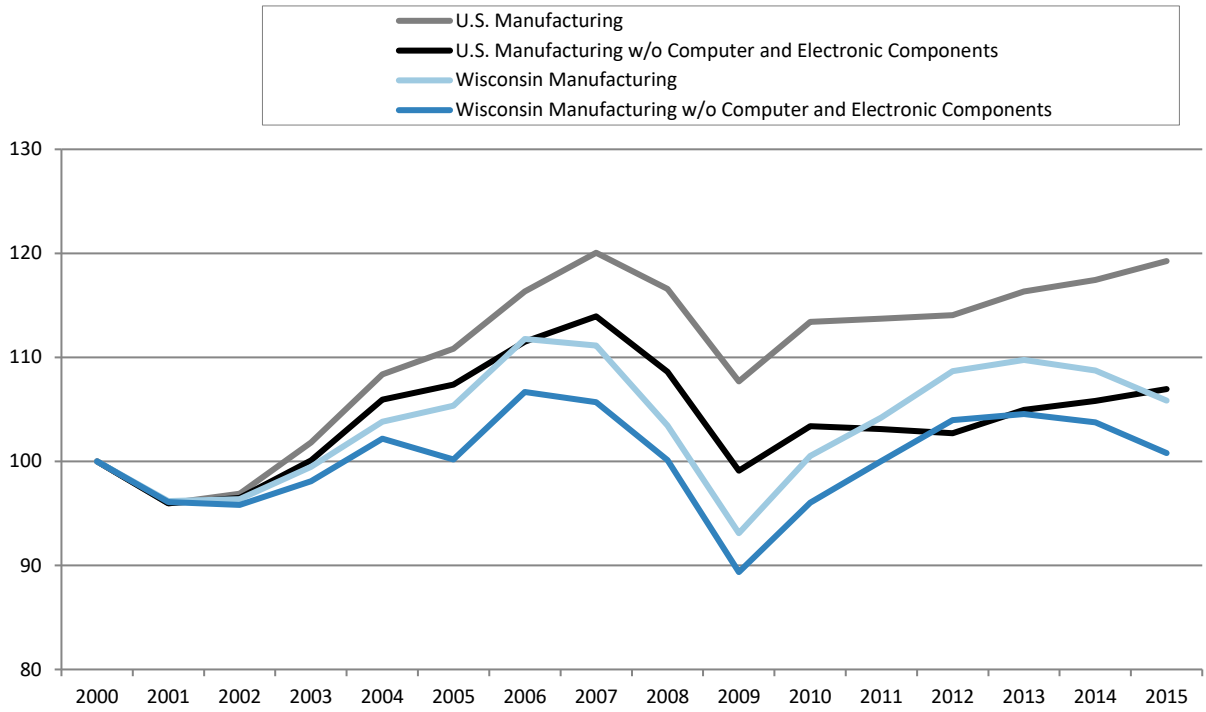


A Changing Industry

While manufacturing has persisted as a large component of Wisconsin's economy, the industry itself has continued to evolve. Perhaps the most striking aspect of manufacturing has been changes in productivity. As noted in the introduction, manufacturing employment is nearly at the same level today as in 1970, but when measured by output (adjusted for inflation) manufacturing grew by 44% over the same period. This growth in GSP alongside little change in employment is largely attributed to increases in productivity. Productivity gains, though, have slowed in recent years (Figure 17).

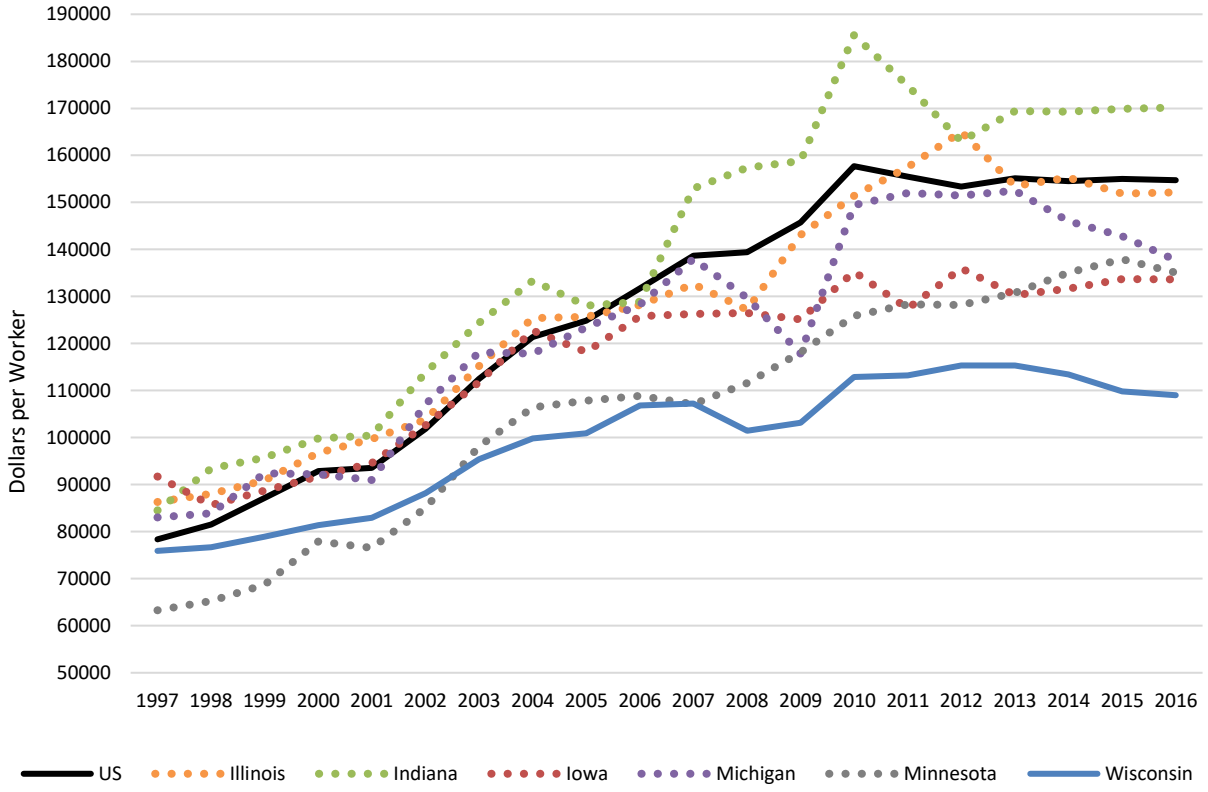
A more recent look at gross domestic product changes between 2000 and 2015 suggests that growth in the U.S. manufacturing sector outpaced that of Wisconsin's manufacturing industry. The national increase in GDP, however, is highly influenced by the computer and electronic components manufacturing industry (Baily and Bosworth, 2014; Houseman, Bartik and Sturgeon, 2014). If the influence of this subsector is removed, then overall growth in national manufacturing GDP is somewhat similar to that of Wisconsin's growth rate (Figure 16). Importantly, it also shows that national growth in manufacturing GDP has been has been somewhat sluggish since 2009.

Figure 16 - Wisconsin and U.S. Manufacturing GDP Indices of Growth (2000 = 100)



Across the U.S. and in each neighboring state individually, GDP per worker has increased dramatically, nearly doubling in most cases in just under 20 years (Figure 17). As previously noted, manufacturing employment also declined over this period and these changes in GDP per worker are a reflection of the industry's ability to produce the same amount or more with fewer workers. However, the productivity gains measured in GDP per worker have flattened since 2009 and even declined in some years. Furthermore, the productivity gain in Wisconsin has been the most modest among neighboring states, at roughly 30%. While the national GDP per worker figures may be influenced by the aforementioned gains in the computer and electronic component manufacturing subsector, the contributions from this sector are not enough to explain the differences in Wisconsin's GDP per worker and the national average.

Figure 17: Manufacturing Industry Gross State Product per Worker (Adjusted for Inflation, $2009)



Indeed, GDP per worker in five of Wisconsin's six largest manufacturing subsectors trails the national averages (Figure 18). Furthermore, GDP per worker in all of these subsectors has remained stagnant or declined in recent years. The GDP per worker performance within these large subsectors may help explain the overall trends in manufacturing productivity noted in Figure 17. Other measures of productivity, such as total factor productivity, may also help to explain these changes. While these alternative measures are unavailable for Wisconsin, exploring changes in national manufacturing total factor productivity may be a useful future exercise. Regardless of the reason behind these changes, these productivity trends are not encouraging for the manufacturing sectors in either Wisconsin or the United States. Further, the relatively modest productivity increase in recent years has been coupled with relatively low wage growth (Figure 19). Traditional economic theory suggests that workers are paid based on productivity; more productive workers are paid more than less productive workers. Thus, the modest growth of wages and productivity, particularly since 2009, is to be expected.

Figure 18 – GDP per Employee Indices of Change for Wisconsin's Six Largest Manufacturing Subsectors

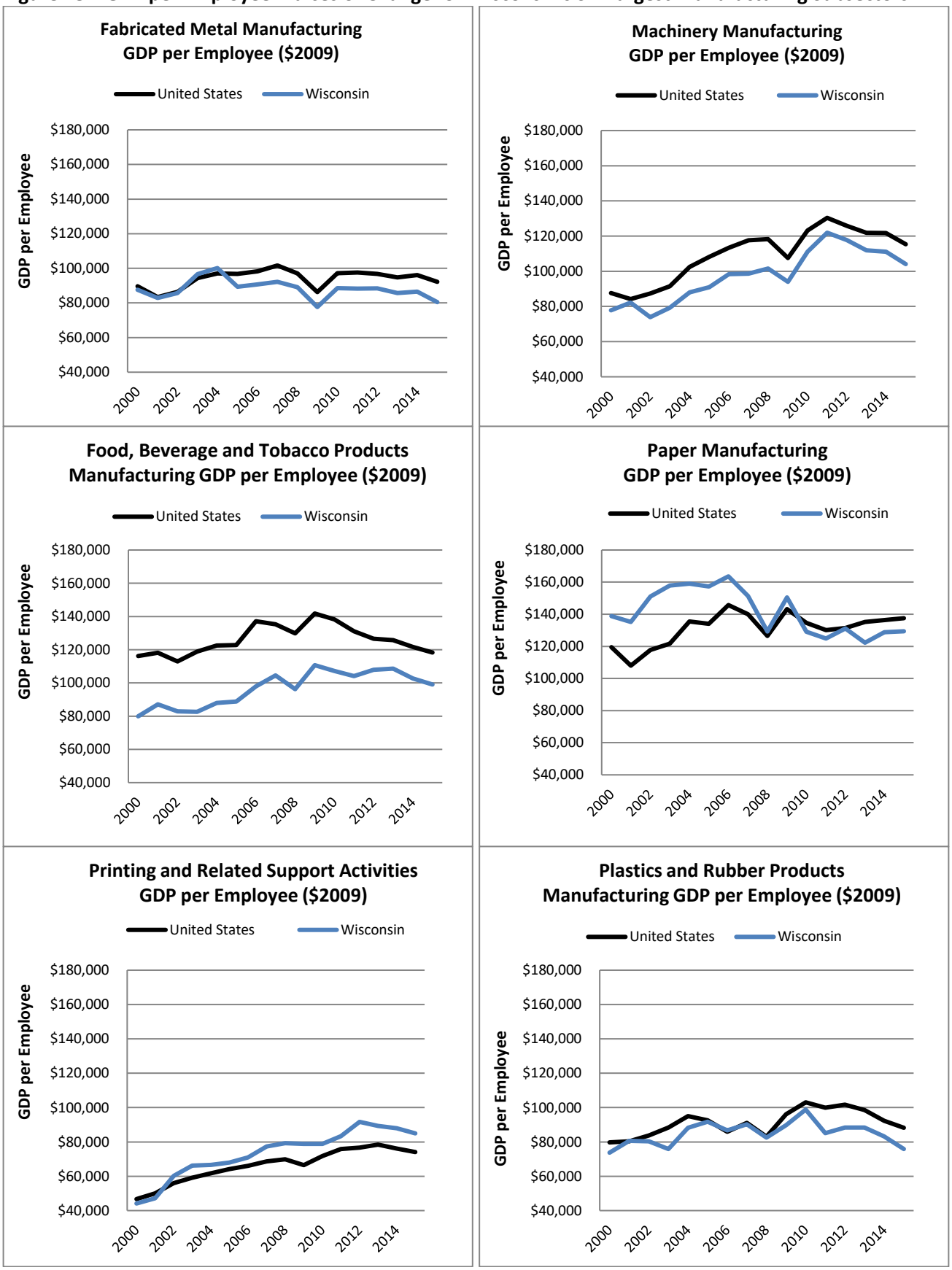


Figure 19: Average Annual Pay in Manufacturing, 2001-2015
(Adjusted for Inflation, in 2009$)

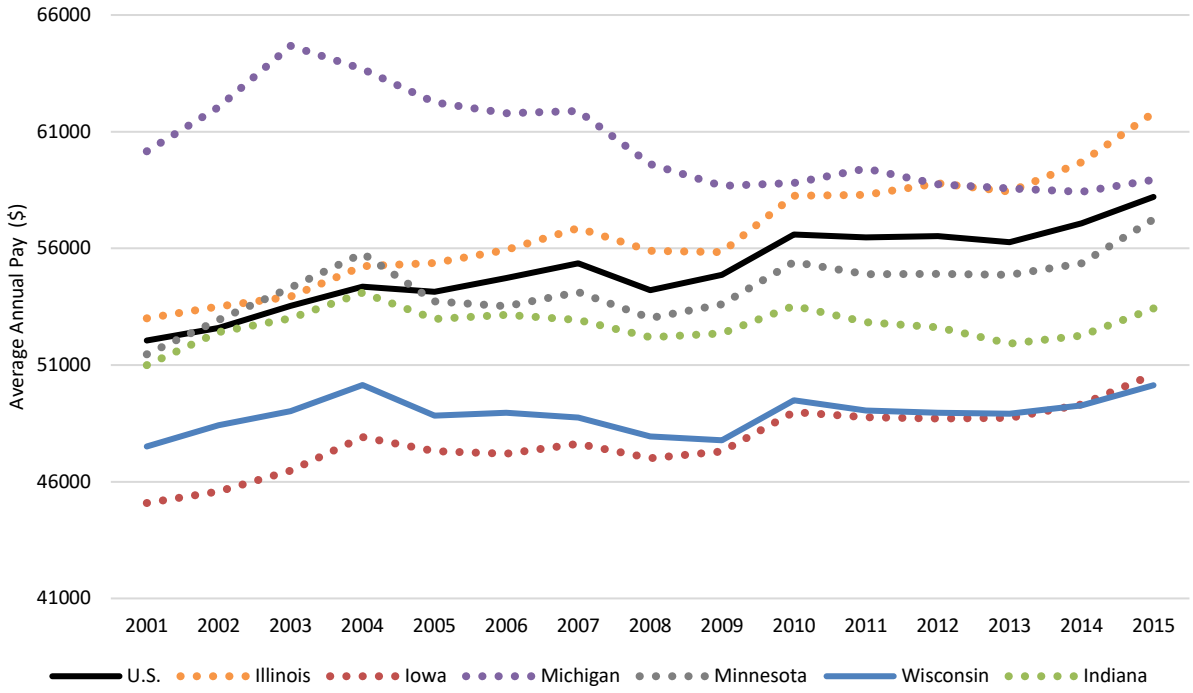
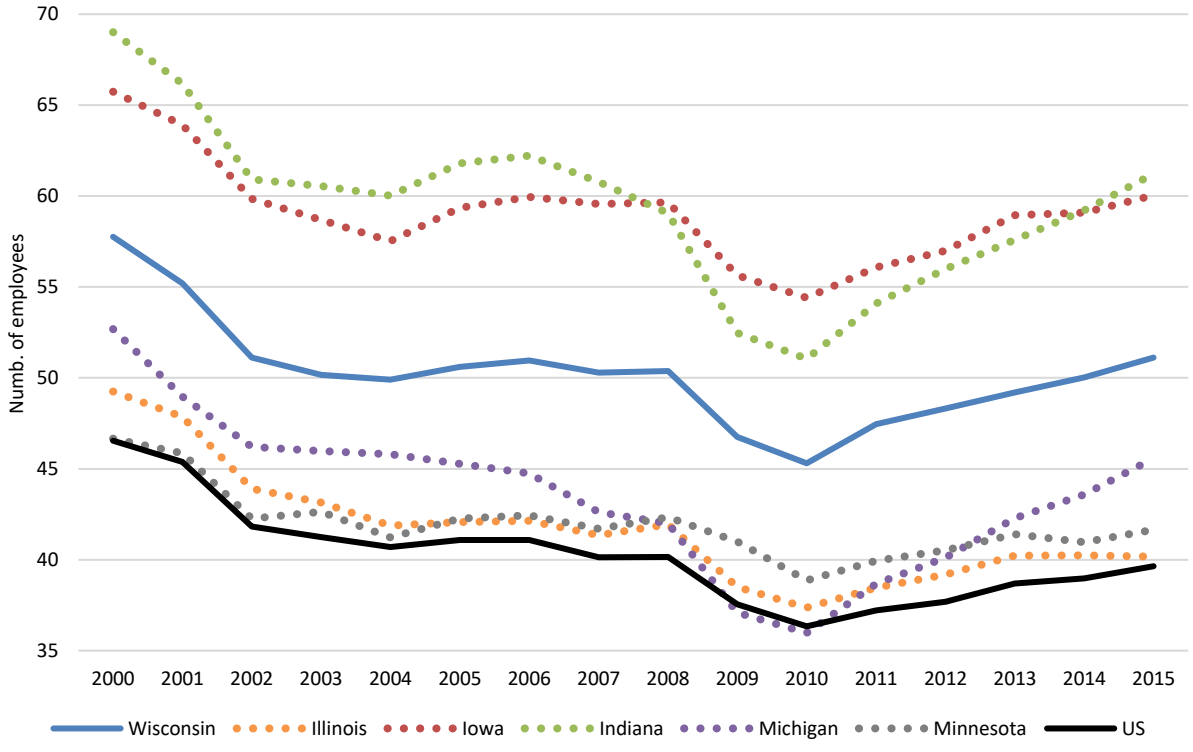
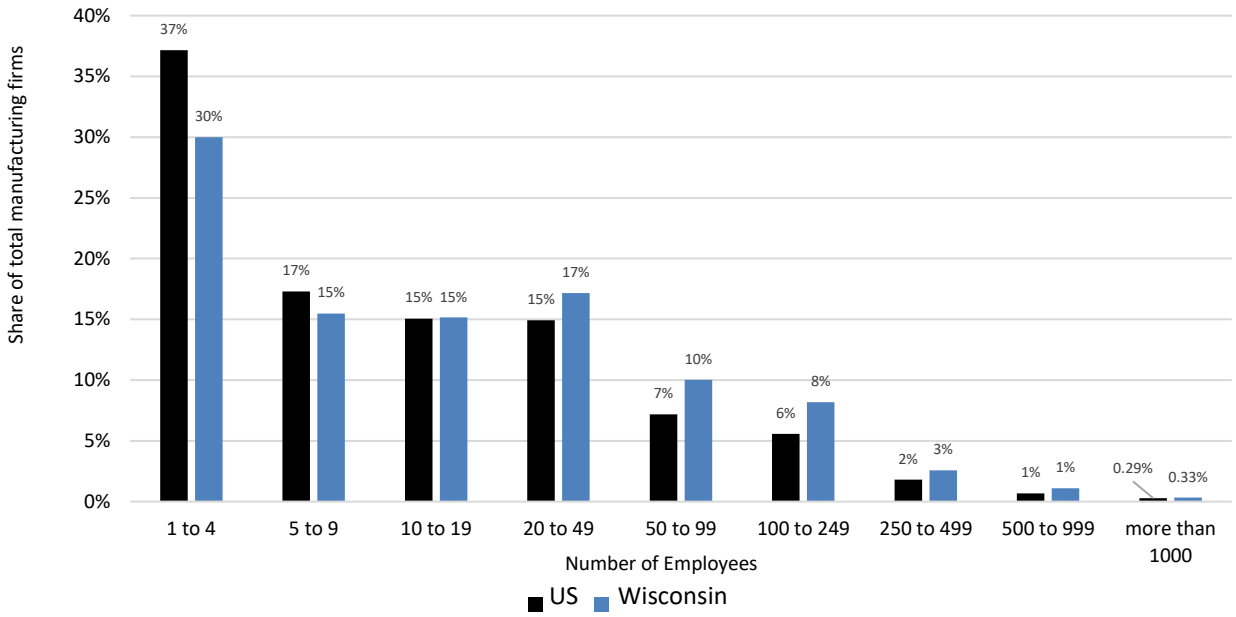


Figure 20: Average Manufacturing Establishment size, 2000-2015



The longer-term growth in productivity is also tied to the average number of employees per manufacturing establishment (Figure 20). Rapid declines in the size of manufacturing occurred with the severity of both the early 2000s recession and the later Great Recession. By 2014, average employment per establishment in nearly every neighboring state had almost recovered to 2007 levels. Still, manufacturing companies have generally become leaner in terms of the employment required to produce a given level of output. It is possible that the smaller size is due to a large number of young firms, but given that the birth rate of manufacturing establishments has fallen by 50% since 1977, it is unlikely that the decreasing size of manufacturing is attributable to new, small businesses entering the sector (U.S. Census Bureau, Business Dynamics Statistics (BDS)). More likely, this is due to an increase in small scale manufacturing and capital replacing labor in larger factories.

Figure 21: Manufacturing Firms by Size in the United States and Wisconsin as a Share of Total Manufacturing Firms

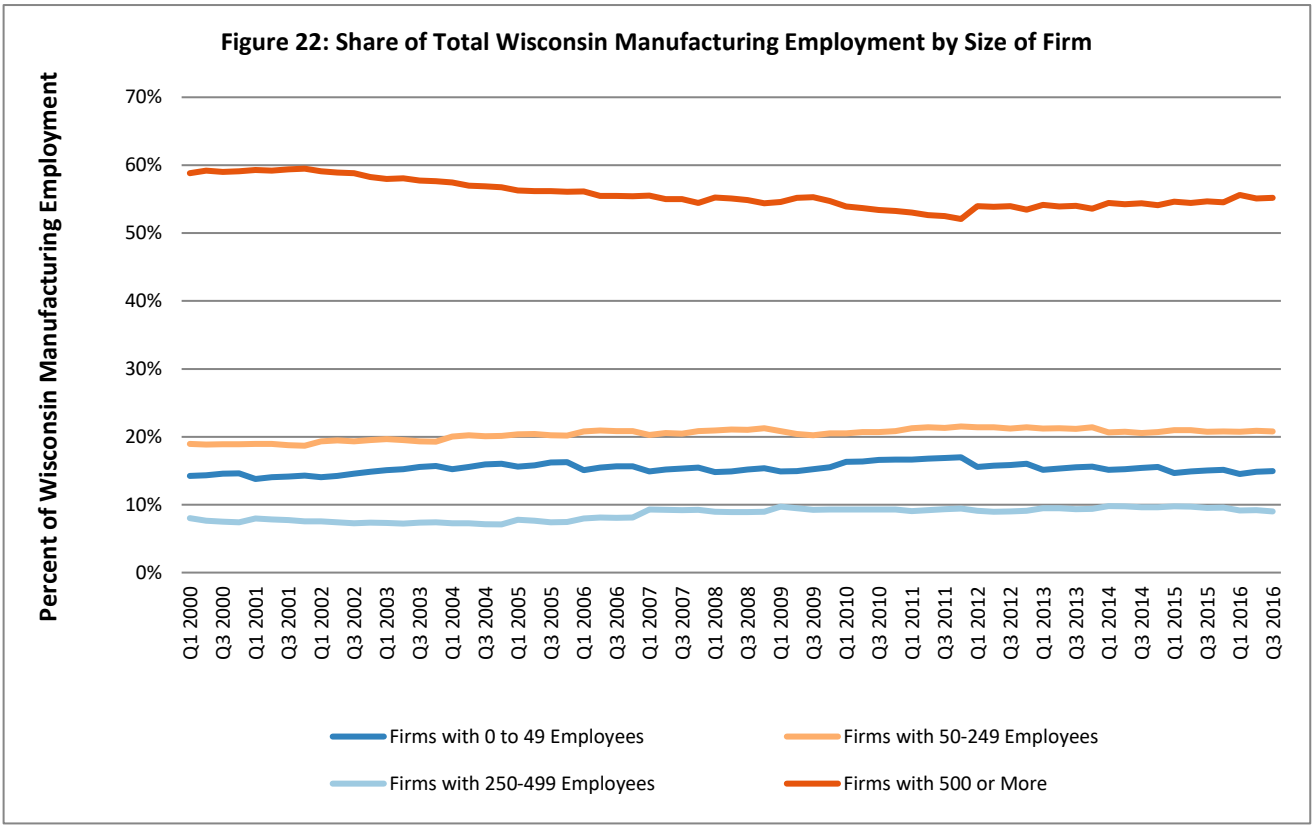


While large manufacturing establishments may comprise a small share of manufacturers in Wisconsin, these firms are responsible for a large percentage of total manufacturing employment.

Employment levels at manufacturing establishments can be viewed through several lenses. While much attention is paid to large manufacturers, most manufacturing establishments are actually quite small (Figure 21). The majority of establishments (77%) have fewer than 50 employees, and most (45%) of those have fewer than ten employees. Large, monolithic factory manufacturers that may come to mind when thinking of the industry are actually relatively rare both in Wisconsin and broader U.S. Indeed, less than 1.5% percent of manufacturers in either Wisconsin or the U.S. have more than 500 employees.

While large manufacturing establishments may comprise a small share of manufacturers in Wisconsin, these firms are responsible for a large percentage of total manufacturing employment. At the end of 2016, 55% of Wisconsin's manufacturing employees worked in firms with 500 or more employees (Figure 22). In comparison, firms with less than 50 employees accounted for 15% all

manufacturing employment. These different perspectives suggest that both large scale and small-scale firms have a significant presence in Wisconsin, depending on how they are measured. Accordingly, policies to support the state's manufacturing industry may not apply to all firms equally and may need to recognize the diversity of the industry.



Perhaps one of the most significant changes in Wisconsin's manufacturing labor force is the increase in workers age 55 and over. In 1990, only 11% of manufacturing employees were above age 55. Reflecting the aging of the Baby Boom generation, this share of manufacturing workers increased to almost 26 percent in 2015 (Figure 23). The share of manufacturing employees age 55 and over has also surpassed the average for all industries in Wisconsin. The growth in employees above age 55 is also notable given the size of Wisconsin's manufacturing sector. Only the health care and social assistance sector has a greater number of employees age 55 or older (Figure 24). Consequently, employers will be faced with the challenge of replacing these workers as they retire or reduce their work capacity.

Wisconsin manufactures' employees are disproportionately age 55 and over compared to other industries. Consequently, employers will be faced with the challenge of replacing these workers as they retire or reduce their work capacity.

Figure 23: Employees Age 55 and Over as a Share of Total Employment
United States
1990 to 2015

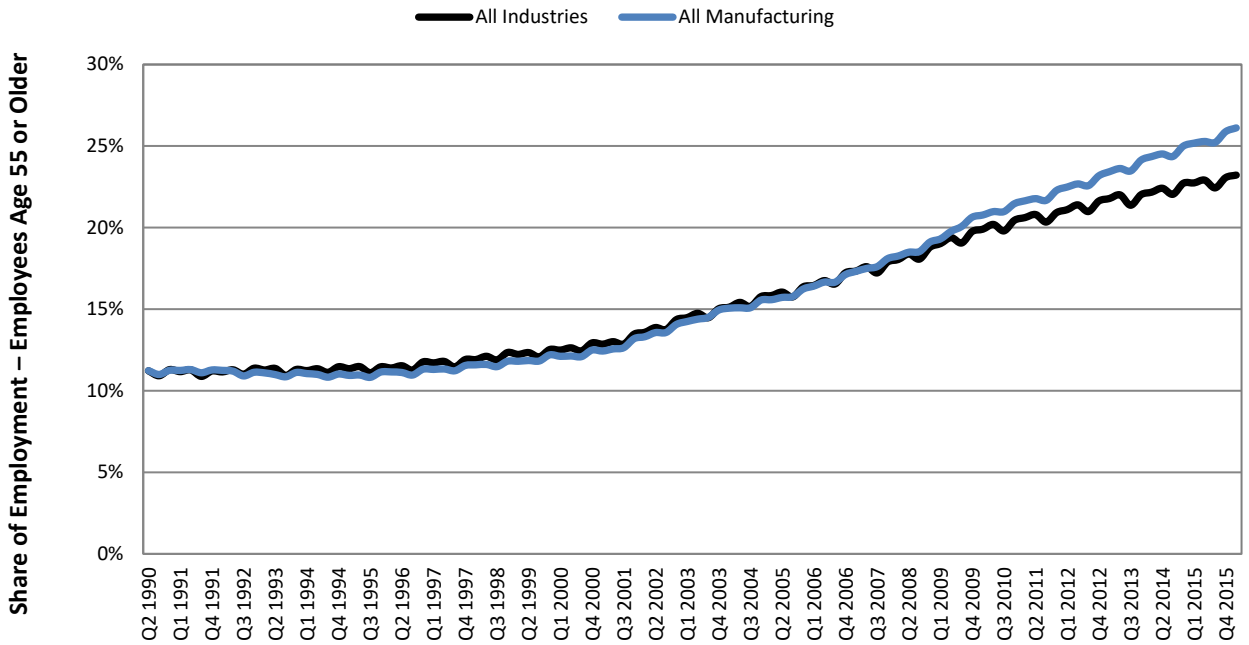
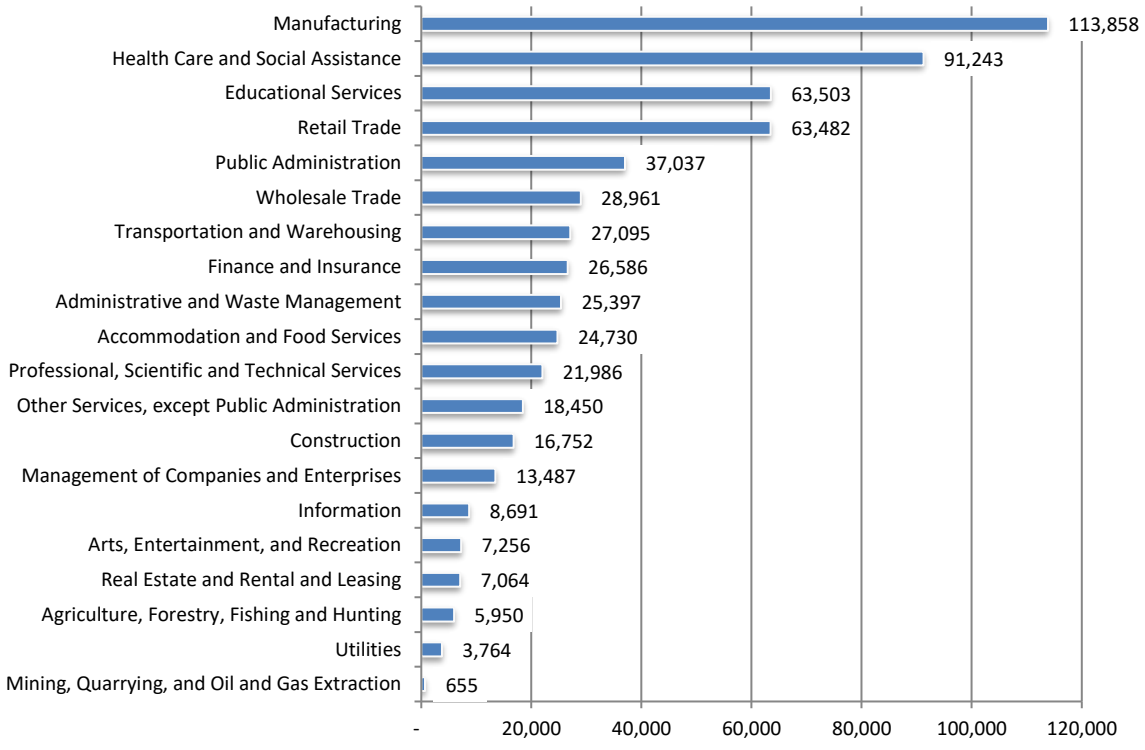


Figure 24: Number of Employees Age 55 and Over by Industry Sector
(State of Wisconsin Q2 2015)



A major trend in manufacturing is automation which in turn requires fewer workers. This is changing the nature of the occupations, and education/skills requirements. Occupations that have declined the most often do not require higher levels of education, while those that have remained more stable tend to require more education.

Nationally, much of the productivity growth in manufacturing is attributable to technological advances. As manufacturing has become more sophisticated, the labor needs of the industry have changed. Nationally, much of the employment declines have occurred in production occupations and transportation and material moving occupations (Table 2). In contrast, business and financial occupations, computer and mathematical occupations and architecture and engineering occupations have either increased or only experienced a minor decrease. The changes in these broad occupation categories partially reflect structural changes to educational and skill attainment in the industry. Specifically, the occupations that have declined the most often do not require higher levels of education, while those that have remained more stable tend to require more education.

Table 2: National Change in Manufacturing Occupations – 2003 to 2016

Occupation Category	2003	2016	Change
All Occupations	14,778,150	12,337,520	-2,440,630
Management	808,110	701,430	-106,680
Business and financial operations	413,220	475,870	62,650
Computer and mathematical	271,780	290,000	18,220
Architecture and engineering	833,520	796,750	-36,770
Life, physical, and social science	156,760	118,450	-38,310
Legal	4,900	6,480	1,580
Arts, design, entertainment, sports, and media	76,830	83,040	6,210
Healthcare practitioners and technical	15,880	24,710	8,830
Protective service	23,640	14,470	-9,170
Food preparation and serving related	39,750	56,510	16,760
Building and grounds cleaning and maintenance	107,320	65,880	-41,440
Sales and related	417,500	392,980	-24,520
Office and administrative support	1,458,080	1,123,680	-334,400
Farming, fishing, and forestry	39,050	32,250	-6,800
Construction and extraction	279,420	189,490	-89,930
Installation, maintenance, and repair	740,510	620,180	-120,330
Production	7,669,840	6,372,060	-1,297,780
Transportation and material moving	1,411,390	969,070	-442,320

The Future of Manufacturing

On the heels of a severe recession and a years-long economic recovery in Wisconsin, many policy discussions are geared toward generating job creation. Manufacturing has long been critical to the Wisconsin economy generating both jobs and income and will continue to important in the future. Before making blanket policies to bolster manufacturing and increase investment, however, it is worth considering the trajectory of manufacturing and placing it in the broader context of the whole economy by benchmarking against other sectors.

Perhaps one of the biggest questions surrounding the future of manufacturing is how automation or computerization might shape future employment and skills needs. The computerization or automation of occupations will depend on many factors, including labor availability, capital and labor costs, technological advances, regulatory issues, and the desires of ownership. Consequently, it is difficult to forecast which occupations may be susceptible to automation in either the near term or the more distant future. Nonetheless, a number of studies have attempted to either estimate how automation affects labor markets or produce broad estimates of the share of employment most susceptible to automation (Aaronson and Phelan, 2017; Acemoglu and Restrepo, 2017; Devaraj, Hicks, Wornell and Faulk, 2017; Autor, Dorn and Hanson, 2015; Autor, Levy and Murnane, 2003).

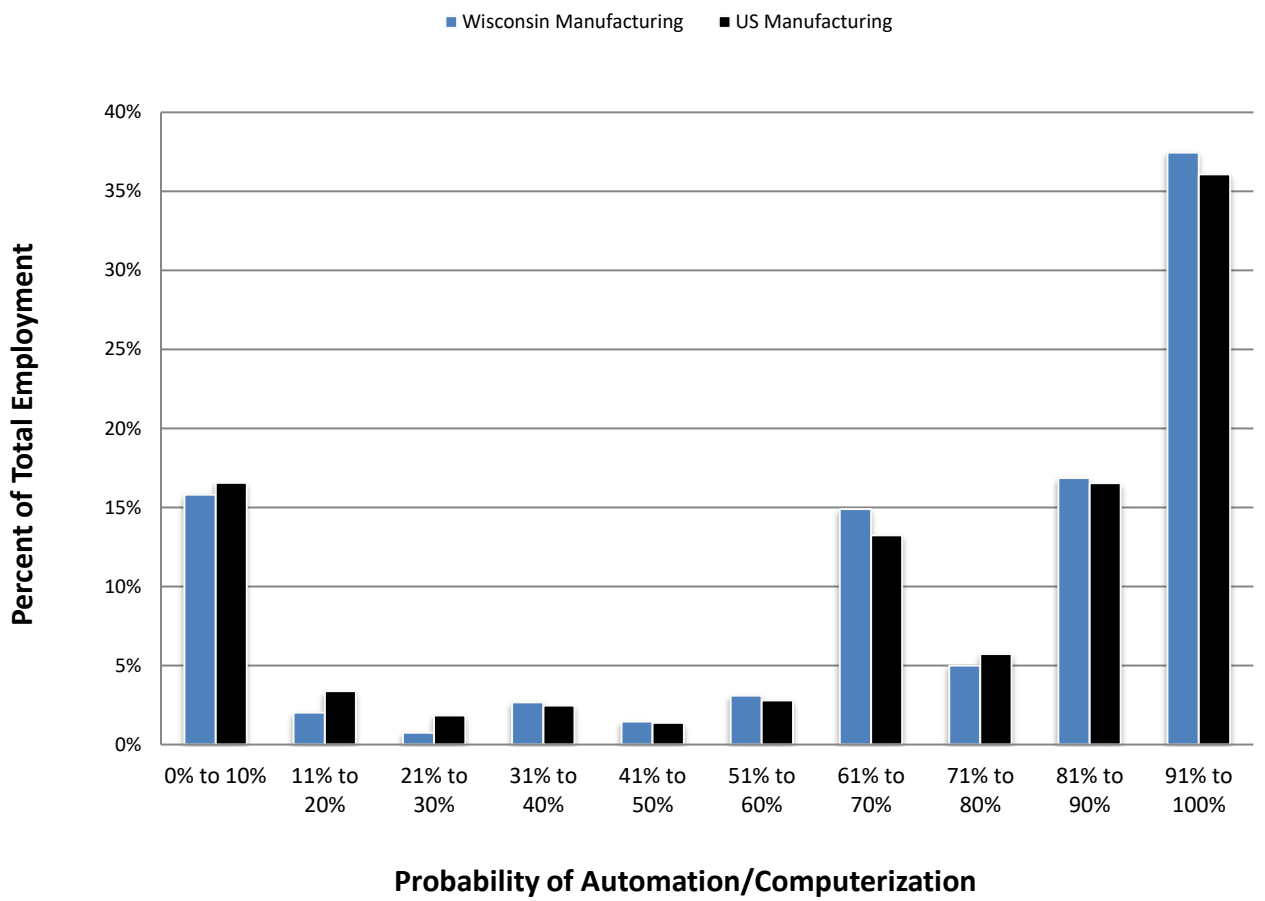
A detailed analysis by Frey and Osborne (2017) estimates the computerization or automation probabilities for more than 700 occupation categories. Their estimates are based on a model that considers information contained in the O*NET database; recent or anticipated advancements in machine learning, artificial intelligence, and mobile robotics; and current automation bottlenecks.[1]

Overall employment automation susceptibility distribution using the Frey and Osborne automation probabilities in combination with the types and numbers of occupations Wisconsin's manufacturing sector is depicted in Figure 25. This distribution is compared to automation probabilities for the types and numbers of occupations in the nation's overall manufacturing sector. Certainly, employees both locally and nationally face a risk for automation, but Wisconsin's overall manufacturing industry may have a somewhat greater susceptibility. Based on the Frey and Osborne probabilities, almost 70% of employment in the manufacturing sector has an automation probability of 60% or higher (Figure 25). Furthermore, over 37% of Wisconsin's manufacturing sector employment has an automation probability of 91% or higher. With the exception of paper manufacturing, a high probability of automation is also found among Wisconsin's six largest manufacturing subsectors (Figure 26).

> … almost 70% of employment in the Wisconsin manufacturing sector has an automation probability of 60% or higher…. over 37% of Wisconsin's manufacturing sector employment has an automation probability of 91% or higher…

[1] These bottlenecks are related to perception and manipulation tasks, creative intelligence tasks, and social intelligence tasks.

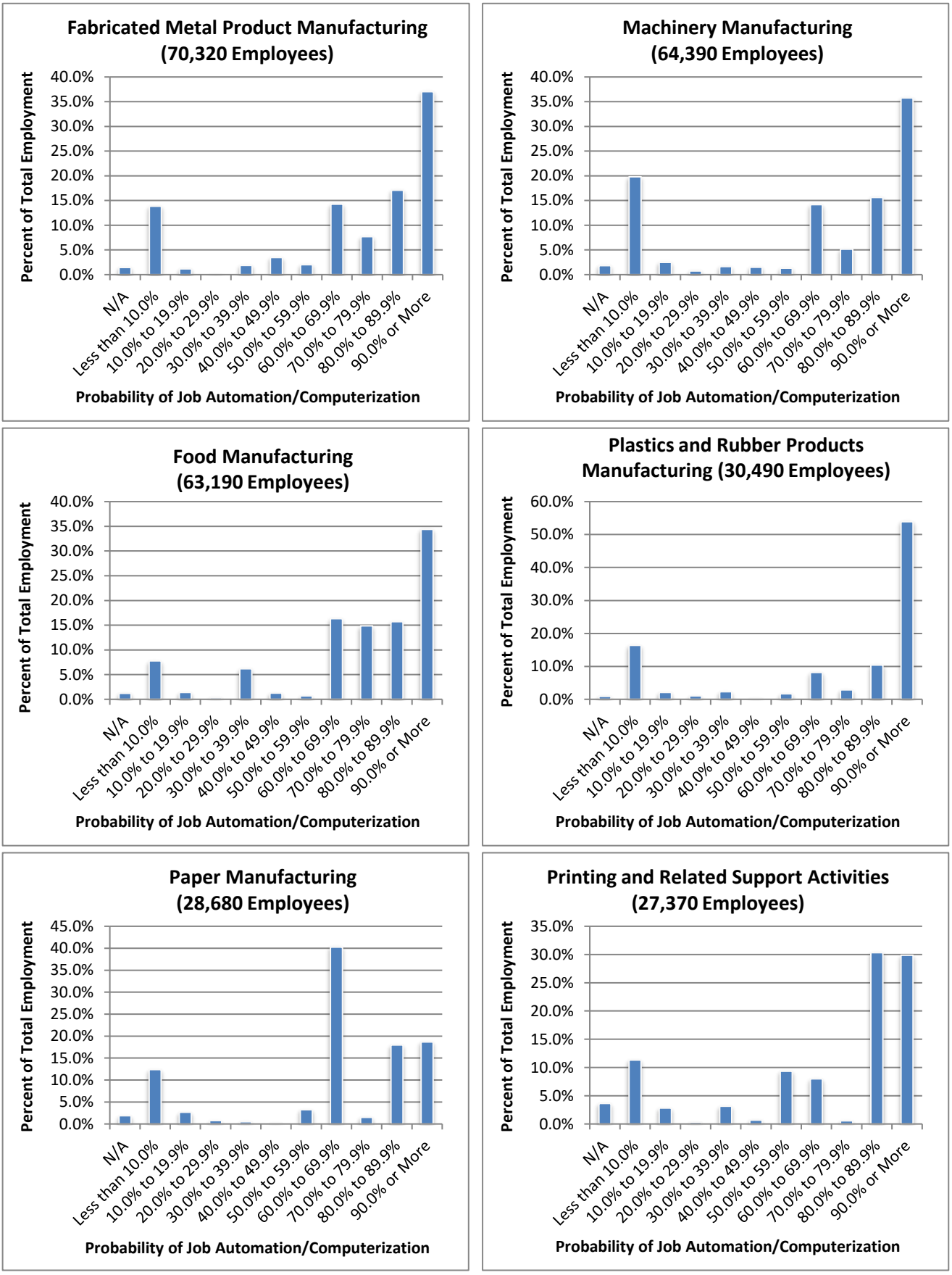
Figure 25 - Distribution of Employment by Probability of Automation/Computerization



While numerous occupations in manufacturing are at risk for automation at some point, there is no way of knowing how many jobs will actually become automated. Frey and Osborne also note that their methodology relies on anticipated advances in automation that will likely occur, but still face hurdles. Furthermore, it may be that many employees cannot be easily separated, or unbundled, from the equipment or technology that allows full automation to occur (Autor, 2015). Nonetheless, occupations with a high probability of computerization and automation are more likely to involve routine tasks and less likely to require creative or social intelligence functions. Many of these occupations are also less likely to require higher levels of education (Frey and Osborne, 2017). As a result, it is likely that the manufacturing sector will need higher levels of skill and education in the future.

While numerous occupations in manufacturing are at risk for automation at some point, there is no way of knowing how many jobs will actually become automated.

Figure 26 – Employment Indices of Change for Wisconsin's Six Largest Manufacturing Subsectors



When considering the probability of automation by individual occupations within the manufacturing sector, some of the industry's most numerous occupations have a high probability of automation (Table 3). The largest single manufacturing occupation in Wisconsin is "team assemblers" (SOC 51-2092) which accounts for just over 32,000 jobs. Based on the analysis of Frey and Osborne there is a 97% probability of these jobs being replaced by automation. Again, many of these occupations require lower levels of education or training compared to those that require a more advanced set of skills.

Table 3 - Top 25 Occupations in Wisconsin's Manufacturing Sector

SOC	Occupation Title	Total Employment	Probability of Automation	Annual Average Salary
51-2092	Team Assemblers	32,310	97.0%	$33,200
51-1011	First-Line Supervisors of Production and Operating Workers	19,760	1.6%	$58,420
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	14,770	85.0%	$32,580
51-4041	Machinists	13,080	65.0%	$42,280
51-4121	Welders, Cutters, Solderers, and Brazers	13,010	94.0%	$41,600
51-9111	Packaging and Filling Machine Operators and Tenders	11,860	98.0%	$33,700
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	11,340	98.0%	$39,660
51-4011	Computer-Controlled Machine Tool Operators, Metal & Plastic	10,220	86.0%	$42,210
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	10,180	85.0%	$70,200
49-9071	Maintenance and Repair Workers, General	8,920	64.0%	$44,600
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	8,790	78.0%	$36,710
51-9196	Paper Goods Machine Setters, Operators, and Tenders	8,580	67.0%	$40,790
51-2022	Electrical and Electronic Equipment Assemblers	8,360	95.0%	$32,750
51-3092	Food Batchmakers	8,240	70.0%	$36,010
43-9061	Office Clerks, General	7,810	96.0%	$35,370
51-9198	Helpers--Production Workers	7,750	66.0%	$30,790
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	7,500	91.0%	$36,150
17-2141	Mechanical Engineers	7,340	1.1%	$74,470
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	7,290	95.0%	$34,390
43-5071	Shipping, Receiving, and Traffic Clerks	6,970	98.0%	$36,180
43-4051	Customer Service Representatives	6,900	55.0%	$38,990
49-9041	Industrial Machinery Mechanics	6,790	67.0%	$49,860
53-7064	Packers and Packagers, Hand	6,750	38.0%	$28,700
51-5112	Printing Press Operators	6,750	83.0%	$39,020
17-2112	Industrial Engineers	6,720	2.9%	$74,670

If all the jobs in Wisconsin manufacturing that have a potential to be automated are indeed automated, this could result in a reduction of 187,000 jobs or 73% of total manufacturing employment. Of course, these are simple estimates and the actual level of future automation is very difficult to predict.

Employment Forecasts

To provide some basic insights into future employment trends in manufacturing we estimated a set of simple forecasts of manufacturing employment to the year 2026, a ten-

year forecast (see the Employment Forecasts text box for details). As with any economic forecast, care must be taken in drawing too strong of a conclusion. There are four broad areas of concern with long-term economic forecasts. First, any forecast must assume a specific structure and empirical methodology and subjective judgments must be made; each of those subjective judgments is a potential source of error. Second, as outlined more clearly in the text box the farther into the future any economic model forecasts, the larger the "confidence bands" or "confidence intervals". In other words, the statistical variance around the estimate will increase as the forecast horizon increases, resulting in a decline in the statistical confidence of the prediction. Third, and most likely, there are unexpected events, such as military conflicts, changes in international trade policies or radical technological changes, that can disrupt the larger economy and hence the forecasts. Finally, we do not consider the potential for automation discussed in the previous section of this study.

Consider first the ten-year forecast of manufacturing employment, both employment and share of total employment, for Wisconsin and several regional neighbors (Figures 27 and 28). In the best-case scenario, some states will continue a modest recovery perhaps reaching pre-recession levels, as in Michigan and Indiana, but never reaching the levels of the late 1990s and early 2000s. In the worst-case scenario, as in Illinois and Iowa, manufacturing employment is expected to continue to decline over the next several years. The forecast for Wisconsin is less extreme. Manufacturing employment is expected to be relatively stable, if modestly declining, over the next decade.

While these results may be seen as modest success, manufacturing has rebounded from the recession and appears to have stabilized. Yet, referring back to Figure 5, compared to the stability of other sectors, it is less impressive. Further, the projected performance of manufacturing in Wisconsin reflects the sum of performance across several subsectors. Many manufacturing sectors appear to be on the decline as shown in Table 1, but some do show promise. Food processing, for example appears to stable, if not growing. The variation in manufacturing suggests that strategically targeted policies may be more effective than blanket policies to boost manufacturing.

Figure 27: Manufacturing Employment Forecasting

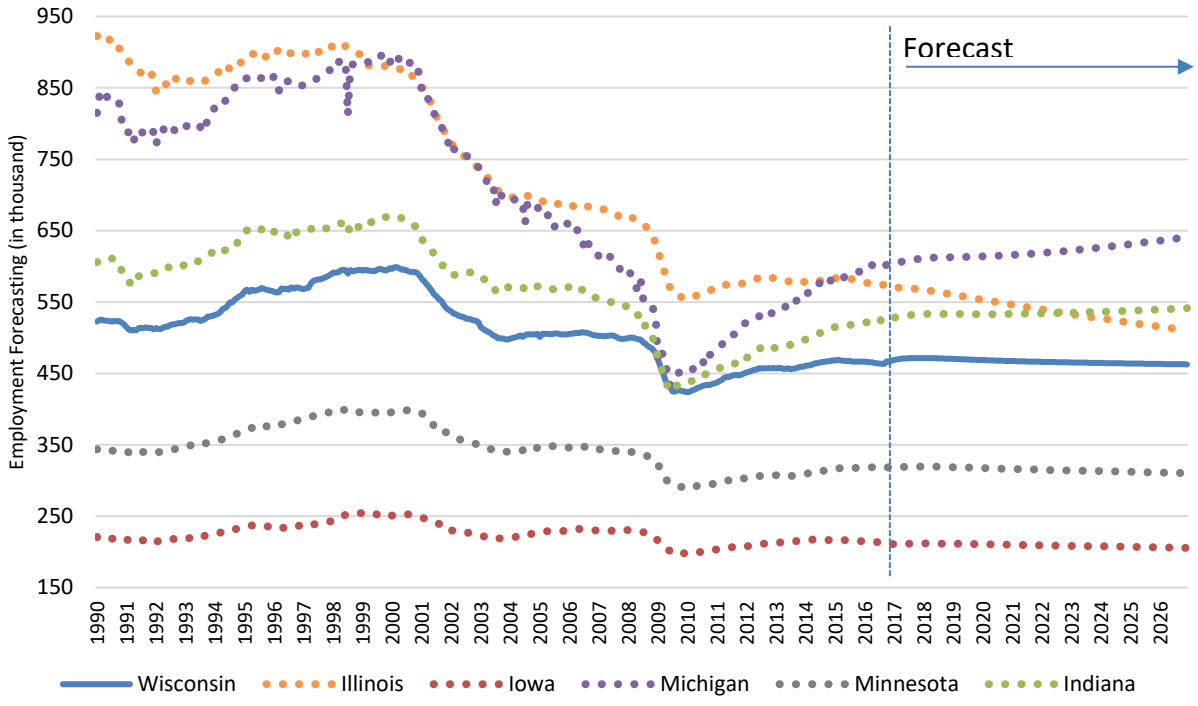
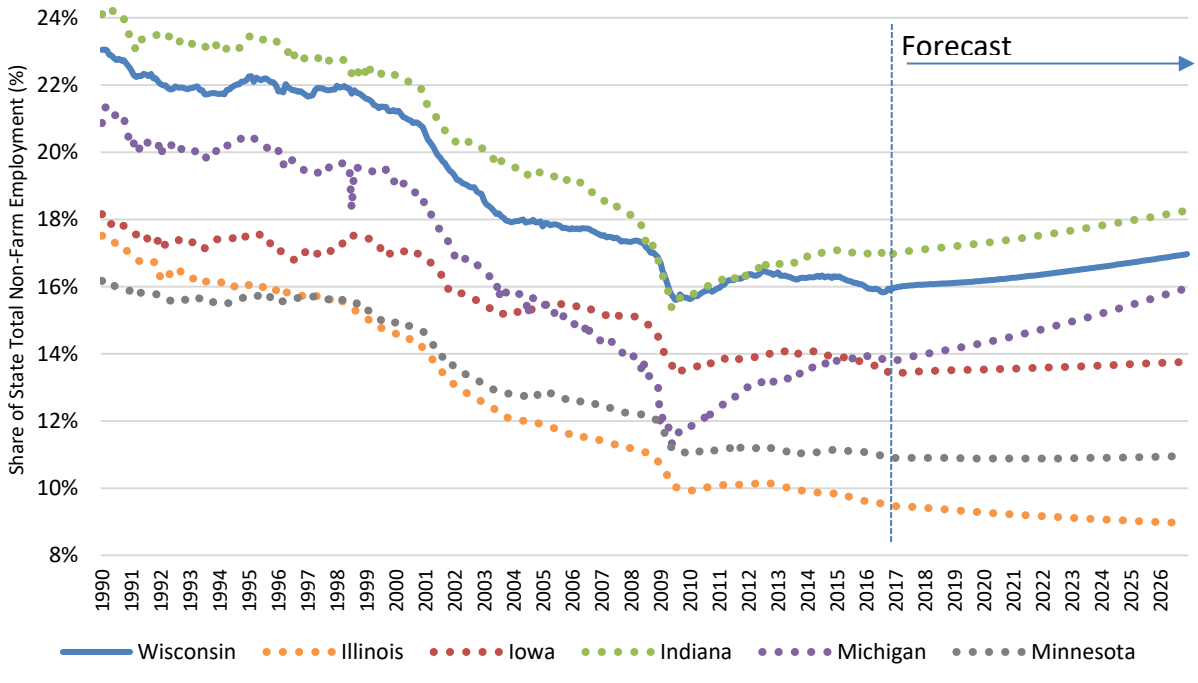


Figure 28: Manufacturing Employment as a Share of State Total Nonfarm Employment



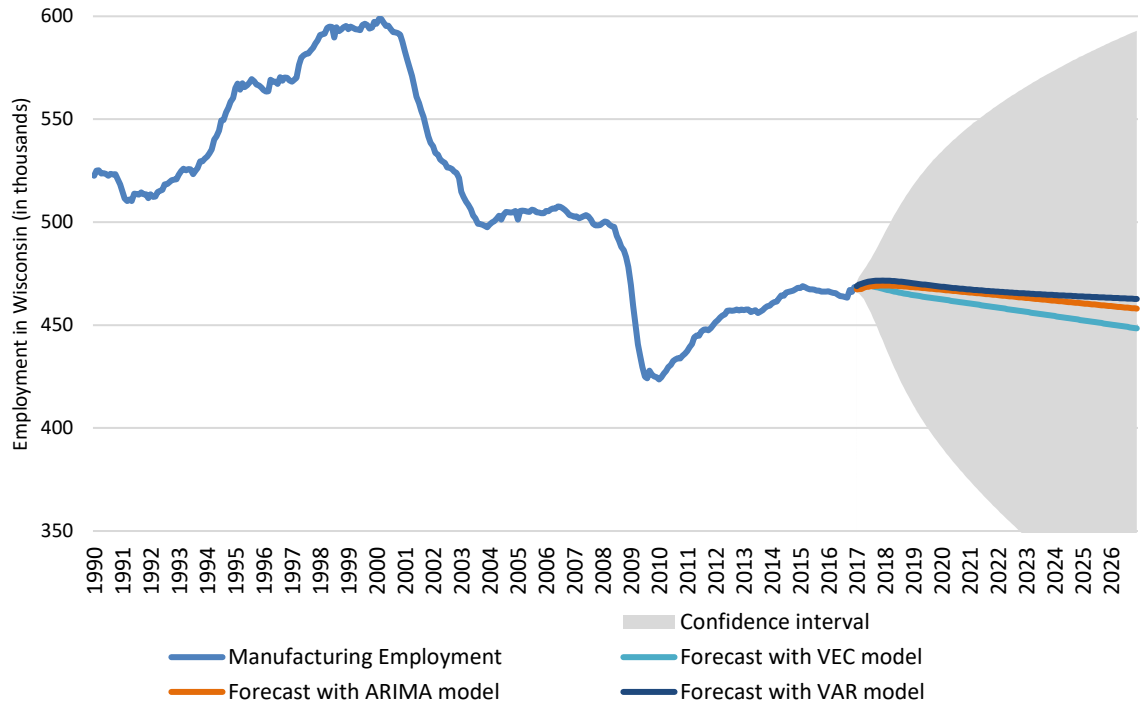
Employment Forecasts

The forecast method used for these employment projections is based on the growth rate of manufacturing employment and six economic indicators (lagged values of the growth rate, U.S. mfg./total employment, Chicago Fed National Activity Index, Interest rate spread, Midwest Housing Stats, Midwest Building Permits). These data are used in a Vector Autogressive Regressive model. This type of model is appropriate when the focal variable, in this case the growth rate of employment, shows no time trend. After forecasting the growth rate, we reconstruct the levels of employment in each year.

Alternatively, a vector error correction model could work well. We show these alternative forecasts in Figure 27. However, this type of model requires that variables are cointegrated which is very strong restriction. Since this assumption might not be true in our data, we rely primarily on VAR models for now.

When looking at forecasts, it is important to note that the quality of the forecasts deteriorate as they get further and further out. Generally, the forecasts are most reliable for the first two to three years. As we show in Figure 27, the confidence interval around expands over time, indicating that the forecasts are less and less precise during later years.

Figure 27: Manufacturing Employment Forecasting with Different Models



The Bigger Picture

A closer look at manufacturing can lend insight to Wisconsin's economy and perhaps the slow jobs recovery from the Great Recession. In a time of Apple and Google, many of Wisconsin's largest sectors are related to production industries such as paper manufacturing and commodity food products such as cheese for frozen pizzas, which are more than 100 years old. These old-growth industries, while still a large source of employment, have slowed to a tepid growth rate and face growing vulnerability. Just 10 years ago papermaking was a major economic driver in the state, but eventually shut down at the rate of more than one mill per year (Milwaukee Journal Sentinel). The recent announcement that Kimberly Clarke may close facilities in Wisconsin also reflects this trend. The large share of manufacturing in such production industries and relatively small presence in highly sophisticated sectors is coupled with below average innovation and technology (Deller and Conroy 2017), and relatively small share of highly educated workers in the state (Conroy, Kures, and Deller, 2016).

The potential skill shortage and lagging innovation are not unrelated to, perhaps, the more pressing issue of stalled productivity and wage growth. Wisconsin lags behind its peers in productivity and wages have been relatively flat across the sector for years. Because so many Wisconsin manufacturing industries are competing on price and the drive to enhance profits requires lowering the costs of operations, they may not be in the best position to make investments in productivity gaining technologies. In essence, the profit margins are too small to allow for these investments. Long-term shifts in manufacturing to those that compete on innovation could have many positive outcomes including incentivizing the work force to seek high-level training, increasing productivity, and raising wages.

> Many Wisconsin manufacturers compete on price and because of intense competition they have little influence on those prices. Profitability for these firms is driven by reducing costs which means reducing labor costs, perhaps through automation. These types of firms can also face labor shortages because they are not in position to offer higher wages and/or benefits.

Another significant challenge is automation which adds uncertainty to the future of manufacturing. While some occupations may become partly or entirely automated and reduce the demand for certain types of labor, there are possible gains from automation. For example, more efficient production processes may increase demand for labor in complementary tasks. Further, the sophistication of automation may increase the demand for workers with relevant skills. Last, with a looming labor shortage, particularly as baby boomers retire, automation may relieve some labor shortfalls. While the net effect on labor is uncertain, the potential for continual reshaping of labor needs in manufacturing is likely.

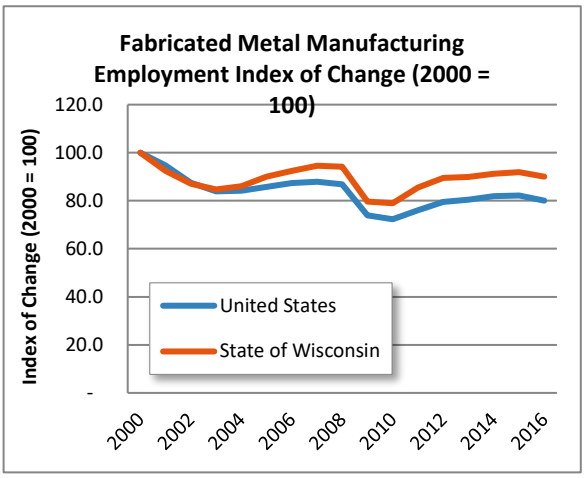
Many Wisconsin jobs are in manufacturing. Yet, the potential for gaining new jobs in manufacturing—job creation over and above the current levels—seems limited. This holds true despite the recent announcement by Foxconn. There are opportunities, however. Many of Wisconsin's manufacturers are relatively small. Manufacturing has gotten nimbler, and often uses sophisticated technologies. One can imagine how 3-D printing may reshape the size and structure of firms in some industries. To

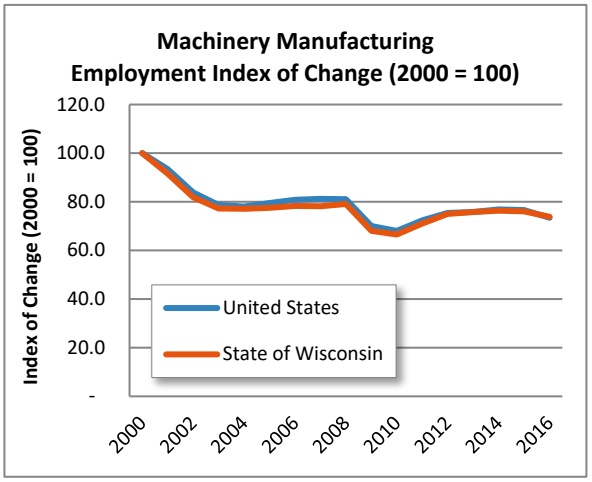
the extent that the capital requirements and labor needs become smaller, we can also expect fewer barriers to entry and more small manufacturers. Thus, these innovations and leaner production may lend themselves to an increasingly entrepreneurial manufacturing sector.

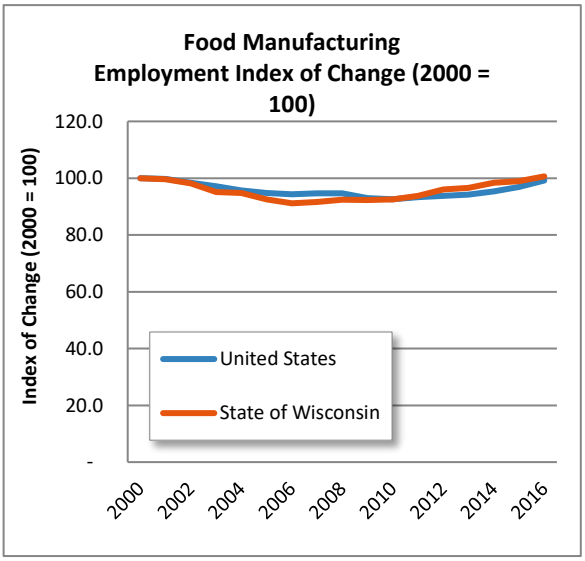
Given the magnitude of the sector in Wisconsin, the challenges in manufacturing are worth addressing and the opportunities worth pursuing. The employment, productivity, and automation trends in manufacturing suggest that it is changing rapidly and Wisconsin may have opportunities to take advantage of these changes. Shifting toward more advanced manufacturing, understanding the needs of automation, and embracing smaller, leaner and more entrepreneurial manufacturers may all have advantages going forward.

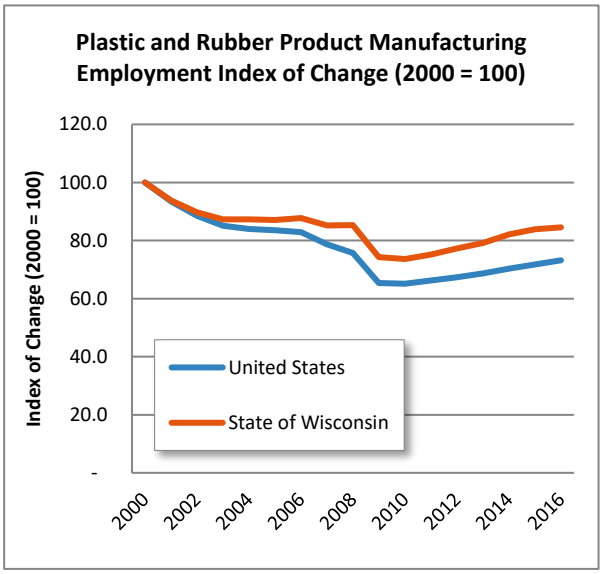
Appendix

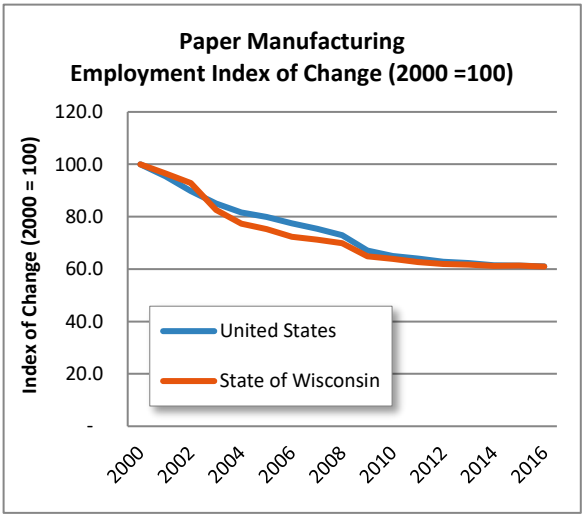
Figure 1 – Employment Indices of Change for Wisconsin's Six Largest Manufacturing Subsectors

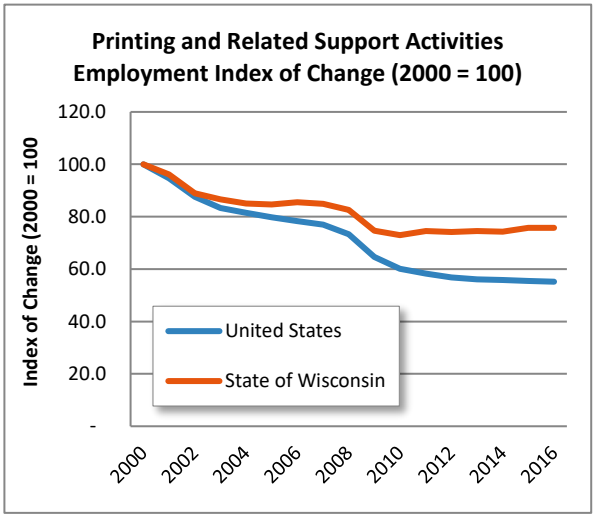












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Methods

Figure 1
Figure 1 is calculated from Bureau of Economic Analysis data. The denominator is equal to the real GDP in all industries by state. The manufacturing's contribution to State GDP is the ratio of real GDP in manufacturing to the state total real GDP (in $2016).

Figure 2
Figure 2 is calculated from Bureau of Economic Analysis data. The denominator is equal to the real GDP in all industries by state. The manufacturing's contribution to State GDP is the ratio of real GDP in manufacturing to the state total real GDP (adjusted for inflation, in 2009$).

Figures 3-4
For Figures 3-4 the total manufacturing employment is the sum of full-time and part-time employment by state from Bureau of Economic Analysis data. The growth index for manufacturing employment (Figure 4) is the ratio of job creation from base year to year *t* to the level in base year.

Figure 5
Figure 5 is calculated from Bureau of Economic Analysis data. The change in Wisconsin jobs is equal to the net job creation from 2000-2015 in different industries. The percentage of total growth is the ratio of total gross job creation to the total employment in base year by industry.

Figure 6
Figure 6 is calculated from Bureau of Economic Analysis data. The share of total nonfarm employment is the ratio of total manufacturing employment to total non-farm employment by states and U.S. total.

Figure 7
Figure 7 is calculated from Bureau of Economic Analysis data. The share of national manufacturing employment is the ratio of state manufacturing employment to U.S. total manufacturing employment.

Figure 8
Figure 8 is calculated from Bureau of Economic Analysis and Rural-Urban Continuum Codes. The share of counties' non-farm employment in urban (or rural) is the ratio of total manufacturing employment in urban (or rural) counties to the total non-farm employment in urban (or rural) counties.

Figure 9
Figure 9 is based the Quarterly Census of Employment Wages. Employment figures are based on each county's annual average manufacturing employment as a share of the county's total employment in all sectors (both public and private).

Figure 10

Figure 10 is calculated using data from the Bureau of Economic Analysis. Total employment change in Wisconsin's non-metropolitan counties is compared to manufacturing employment change in these same counties. Change is based on an index where the year 1970 is equal to 100.

Figure 11

Figure 11 is calculated using data from the Bureau of Economic Analysis. Manufacturing employment change in Wisconsin's non-metropolitan counties is compared to manufacturing employment change Wisconsin's metropolitan counties. Change is based on an index where the year 1970 is equal to 100.

Figure 12

Figure 12 is based the Quarterly Census of Employment Wages from the Bureau of Labor Statistics. Percent changes are based on each county's annual average manufacturing employment in 2000 and 2016.

Figure 13

Figure 13 is calculated from the Quarterly Census of Employment Wages from the Bureau of Labor Statistics. The employment by sector is the Wisconsin's statewide employees in all establishment sizes by three-digit NAICS codes for Manufacturing.

Table 1

Table 1 is calculated from Bureau of Economic Analysis data. The percentage of WI Non-Farm employment in 2015 is the ratio of employment in different sectors to Wisconsin total non-farm employment. Also, the percentage of WI manufacturing employment in 2015 is the ratio of employment in different sectors to Wisconsin total manufacturing employment. The growth rate is the ratio of total gross job creation between 2000 and 2015 to the level in base year.

Figure 14

Figure 14 is based on Occupational Employment Statistics from the Bureau of Labor Statistics. The data incorporate occupation by industry matrices to calculate each manufacturing subsector's share of total employment found in architecture and engineering occupations; computer and mathematical occupations; and life, physical and social science occupations.

Figure 15

Figure 15 is based on Occupational Employment Statistics from the Bureau of Labor Statistics. The data rely on occupation by industry matrices to calculate the distribution of major occupational categories found in the national manufacturing sector and the State of Wisconsin's manufacturing sector.

Figure 16

Figure 16 is calculated from Bureau of Economic Analysis GDP data adjusted for inflation. The manufacturing GDP change from 2000 to 2015 is represented as an index, with the year 2000 equaling 100. Figures are calculated for the total manufacturing sector and the manufacturing sector with the GDP contributions of the computer and electronics manufacturing subsector removed.

Figures 17

Figure 17 is calculated from Bureau of Economic Analysis data. The denominator is state total manufacturing employment. The gross state product per worker (or productivity) reflects the value of real manufacturing GDP divided by total manufacturing employment by state.

Figure 18

Figure 18 is calculated from Bureau of Economic Analysis GDP data. Subsector manufacturing GDP data (in constant $2009) is divided by the total number of employees in each subsector. Employment figures include both wage and salary employees and proprietors to properly represent the GDP contributions that both of these employment categories provide.

Figure 19

Data on manufacturing average annual pay in all establishment sizes by state and U.S. total are obtained from the Bureau of Labor Statistics. We focus on private ownerships because some states don't have the data on federal, state or local government ownerships.

Figures 20-21

Figures 20-21 are calculated from the United States Census Bureau. The average manufacturing establishment size is the number of paid employees per establishment. The denominator of average size is the total establishments in all establishment sizes. The share of total manufacturing firms (Figure 12) is the ratio of number of establishments in each size category to the total establishments.

Figure 22

Figure 22 is based on Quarterly Workforce Indicator data from the U.S. Census Bureau's Longitudinal-Employer Household Dynamics Program. Manufacturing employment within each firm size class is shown as a percent of all manufacturing employment. Figures are for the State of Wisconsin between Q1 2000 and Q3 2016.

Figure 23

Figure 23 is based on Quarterly Workforce Indicator data from the U.S. Census Bureau's Longitudinal-Employer Household Dynamics Program. Wisconsin manufacturing employees with an age 55 or greater are calculated as a share of all manufacturing employees regardless of age. Similar calculations are made for employees age 55 and over in all industry sectors combined. Figures are for the State of Wisconsin between Q1 1990 and Q4 2015.

Figure 24

Figure 24 is based on Quarterly Workforce Indicator data from the U.S. Census Bureau's Longitudinal-Employer Household Dynamics Program. Wisconsin employees with an age 55 or greater are totaled by industry sector for Q2 2015.

Table 2

Table 2 is based on Occupational Employment Statistics from the Bureau of Labor Statistics. The data rely on occupation by industry matrices to calculate the distribution of major occupational categories found in the national manufacturing sector. Occupational distributions in May 2003 are compared to those found in May 2016.

Figures 25 & 26

Figure 25 is based on 2016 Occupational Employment Statistics from the Bureau of Labor Statistics. The data rely on occupation by industry matrices which report the total number of occupations by standard occupation codes (SOC) within the state and national manufacturing sector. These occupational codes are combined with automation probability/susceptibility estimates by SOC as calculated by Frey and Osborne (2017). The share of total employment within each manufacturing sector is then summarized by different automation probability ranges. Similar calculations are made for the six Wisconsin manufacturing subsectors in Figure 26.

Table 3

Table 3 is based on 2016 Occupational Employment Statistics from the Bureau of Labor Statistics. The data rely on occupation by industry matrices which report the total number of occupations by standard occupation codes (SOC) within Wisconsin's manufacturing sector. These occupational codes are combined with automation probability/susceptibility estimates by SOC as calculated by Frey and Osborne (2017). Table 3 includes those occupational categories that account for the top 25 greatest numbers of employees within Wisconsin's manufacturing sector.

Figures 25-27

For Figures 25-27, the employment data in manufacturing and total non-farm industry by state and U.S. total are obtain from Bureau of Economic Analysis. Based on the data from 1990-2016, we forecast the manufacturing employment and the share of total nonfarm employment in the following 10 years. The share of total nonfarm employment is the ratio of state manufacturing employment to the state total nonfarm employment.