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Structure of Indiana's Manufacturing Sector during and after the Great Recession: A Spatial Perspective[*]

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ABSTRACT

The trend in manufacturing employment is on a downward trajectory nationally, further exacerbated by short-term fluctuations. Indiana mirrors this trend, and as such, we explore the structure of the manufacturing sector using a spatial and snapshot approach during and after the Great Recession of 2007–2009. Using two measures—average firm size and gap in percentage of local manufacturing employment—we explain the dynamics at specific periods, namely, 2007 (the beginning of the recession), 2009 (the trough of the Great Recession), 2014 (a point in recovery from the Great Recession), and 2016 (the endpoint for our analysis). Our results show counties are spatially dependent for the average firm size and percentage employed in the manufacturing sector but spatially independent for the change (gap) in the same variables both during and after the Great Recession. Between 2007 and 2009, the decline in average firm size was greatest for rural (R), followed by nonmetro but adjacent to metro (NMA), and then metro (M) counties. By 2016, however, the average firm size in metro counties was higher than the 2007 level, whereas in NMA and rural counties, size had failed to rebound to 2007 levels. The relative ranking by degree of urbanization remains consistent with respect to local employment in manufacturing, although all groups experienced a decline during the Great Recession and even in recovery. These results suggest location is an important determinant, and they reinforce the importance of economic

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policies that can affect a group of counties or economic growth regions rather than individual counties.

KEY WORDS Firm Size; Manufacturing Sector; Great Recession; Spatial Analysis; Indiana

The manufacturing sector has a large footprint in the U.S. economy, employing close to 12.4 million workers in 2021, or about 7.8% of U.S. total employment; however, two striking trends over the past half century, as noted by Baily and Bosworth (2014), have emerged. First, the manufacturing sector's growth has equaled or exceeded that of the total GDP, keeping the manufacturing share of the total economy constant. Second, the trend in the share of manufacturing in total employment has seen a steady decline. Since 2000, there has been, on average, a 0.1% long-term monthly decline in U.S. manufacturing employment.[1] Indiana mirrors the nation's long-term decline in manufacturing employment, albeit at a slower pace, averaging about 0.06% monthly decline since 2000.[2] In 2021, Indiana employed about 525,000 workers in manufacturing, 17.51% of its workforce and accounting for 26.56% of total output in the state. Although there is a downward long-term trend in manufacturing employment, short-run fluctuations exist, with recessions and booms being an integral part of market economies as they move through the business cycle.

The Great Recession of 2007–2009 had a notable impact on the economies of the U.S. and Indiana in many aspects. This economic disruption resulted in a steeper decline in manufacturing employment across the nation. Nationally, the manufacturing sector experienced an average monthly decline in manufacturing employment of 0.09%, while Indiana experienced a much higher average monthly decline rate of 1.4% in manufacturing employment.[3] In Indiana, this adverse shock on the manufacturing sector that resulted in layoffs, downsizing of firms, and/or firm exits was not uniform across all 92 counties. In addition, a short-run fluctuation brought about by an adverse economic shock (i.e., the Great Recession) can have impacts on these local economies, distinct from the impact of a long-term decline (e.g., temporary layoffs vs. firm exits). This paper therefore takes a spatial perspective and a snapshot approach to examine the manufacturing sector in Indiana. In particular, we investigate manufacturing across all counties in Indiana by classifying the counties by degree of urbanization—metro, nonmetro but adjacent to metro (NMA), and rural—and in four separate periods: (1) 2007, to capture the beginning of the Great Recession; (2) 2009, to capture the trough of the Great Recession; (3) 2014, to examine a point in expansion; and (4) 2016, to examine if conditions were back to their prerecession levels. We use average firm size (FS), measured as the ratio of employment in the manufacturing sector to the number of manufacturing establishments, and the gap in the percentage of manufacturing employment (PMFTGAP) in the county, measured as the difference in the percentage of the labor force employed in the manufacturing sector between 2016 and 2007 and between 2016 and 2009, to examine the spatial dependence of counties during and after the Great Recession.

Researchers have studied the effects of the Great Recession and recovery on important aspects such as exit rates of small establishments (Eubanks and Wiczer 2017), U.S. employment and output performance relative to other advanced economies (Barth et al. 2017), relative employment effects on large versus small firms (Sahin et al. 2011), and varied state-by-state performances relative to the U.S. national performance (Connaughton and Madsen 2012). A closer examination of the manufacturing sector, particularly during the Great Recession, is important given its already long-term downward trend in employment. Hicks (2013) reports that between 2004 and 2022, the sector shed jobs, although the output per worker has risen dramatically, fueled by technological improvements. Total factor productivity (TFP), the part of growth that takes advantage of innovative technology and improved human capital in production, effectively organizing production, had been negative before the Great Recession but rebounded during the recession as businesses let go of less productive plants and workers. TFP has since grown dramatically, accounting for almost half of production growth. This implies an increasingly advanced production process, which, according to Hicks (2013), is cause for optimism in the manufacturing sector. With respect to location, Low (2017) reports that manufacturing, both in terms of share of jobs and earnings is more important to the rural economy compared to the urban economy. Moreover, employment in the largest rural subsectors declined less, rebounding after the recession.

Our study contributes to the literature by examining the spatial aspect of firm size and employment gap in the manufacturing sector by metro, NMA, and rural counties of Indiana at specific points in time before, during, and after the Great Recession. The spatial approach allows us to determine the importance of location when local economies go through an adverse economic shock. We find that counties are spatially dependent for both the average firm size and percentage employed in the manufacturing sector but are spatially independent for the change (gap) in the same variables both during and after the Great Recession. The location of the counties is an important determinant, with metro counties noticing an improvement in firm size relative to NMA and rural counties during recovery. The rural counties of Indiana were net losers of both firm size and manufacturing employment during and after the adverse economic shock. Overall, our spatial and snapshot approaches to investigate the dynamics of the manufacturing sector in Indiana are the main contributions of this paper to the existing literature.

DATA AND METHODS

The Great Recession (2007–2009)

We examine the structure of manufacturing in Indiana by developing a measure of firm size at the county level, FS, by dividing the total manufacturing employment by the number of manufacturing establishments for each county. This provides an approximation of average firm size, a single succinct measure, that captures two variables that are relevant in describing the makeup of the industry at the county level. We utilize establishment data collected from the U.S. Bureau of Labor Statistics' (n.d.) Quarterly Census of Employment and Wages (QCEW) and employment data. Further, we classify the counties by relative

geographic location as metro, NMA, and rural counties[4] and then map the average firm size in 2007, at the beginning of the recession, and in 2009, at the trough of the Great Recession, and the change in average firm size (ΔFS) between 2009 and 2007 to visually explore the spatial patterns.

To determine whether a significant spatial relationship emerges from these maps, we utilize Moran's *I*, which measures spatial autocorrelation to determine whether the patterns noticed are clustered, dispersed, or random. The z-scores and *p* values are used to evaluate the significance of Moran's *I* index values. A significant Moran's *I* index implies clustering.

The Moran's *I* statistic for spatial autocorrelation is given as

$$I = \frac{n}{S_0} \frac{\sum_{i-1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2}$$

where $z_i$is the deviation of an attribute for feature i from its mean $(x_i - \bar{X})$, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of counties, and S_o is the aggregate of all spatial weights. The z-scores for the statistic are computed as

$$Z_i = \frac{I - E[I]}{\sqrt{V[I]}}$$

where $E[I] = -1/[n-1]$ and $V[I] = E[I^2] - E[I]^2$.

Moran's *I* identifies the presence of global spatial autocorrelation (i.e., clustering) but does not provide information on the specific locations of spatial patterns (i.e., clusters). We utilize local indicators of spatial association (LISA; Anselin 1999) to identify local clusters of counties that are positively and negatively spatially correlated. LISA has two important characteristics: It provides a statistic for each location with an assessment of significance, and it establishes a proportional relationship between the sum of the local statistics and a corresponding global statistic. LISA allows us to find areas of interest that contribute particularly strongly to the overall spatial trend and produces (1) a cluster map, identifying counties as high-high (having high values and having neighbors that also have high values), low-low, low-high, and high-low and (2) a significance map, showing how each county can be regarded as contributing meaningfully (statistically significantly) to the global spatial autocorrelation using Monte Carlo randomization procedure.[5]

Beyond the Great Recession (2014–2016)

As an economy starts to expand from the trough of a recession, firms and businesses must adapt to the new economic environment and policies that were instituted in response to the recession. Procyclical sectors in the economy would rebound seamlessly, while a few other sectors may recover slowly because of economic conditions that could be beyond their control. First, to investigate the industry during recovery, we examine the ΔFS at two specific periods after the trough (2009): 2014 and 2016. We chose 2016 as the endpoint of our analysis to be consistent with Pratt's (2021) finding that nationally, the average

recovery time of employment loss during the Great Recession was seven years, and because of the change of administration in the White House after the 2016 presidential election. As a robustness check, we look at 2014 to explore the level of the rebound prior to 2016. Our data reveal that for Indiana by 2014, the average firm size, measured as the ratio of manufacturing employment to manufacturing establishment, was comparable to the beginning-of-recession level. Similarly, Hertz et al. (2014) report that by May 2014, nonfarm employment reached its prerecession peak level. In addition, we examine ΔFS between 2007 and 2016, to observe if, by 2016, the average firm size had rebounded comparable to the beginning of the recession.

Second, since firms exit during a downturn, workers lose jobs because of layoffs, reflected in the percentage employed in the manufacturing sector. When the economy starts to recover, however, workers are rehired or find jobs that could lead to an increase in the percentage employed in the manufacturing sector. We utilize PMFTGAP, which is the difference in the percentage of manufacturing employment to the overall county employment between 2007 and 2016, to determine whether employment in the manufacturing sector had returned to the 2007 level by 2016. As previously indicated, the average recovery time in employment for the nation was seven years, from the trough in 2009 (Pratt 2021). The gap could be positive, negative, or zero. A zero implies that by 2016, the percent employed in the manufacturing sector relative to the total employed in the county was back to the 2007 level. If the gap is positive, the county has gained manufacturing employment during the recovery relative to the 2007 level, and if the gap is negative, the county has not gained or reached employment in the manufacturing sector relative to the 2007 level. As a robustness check, we also calculate the PMFTGAP between 2009 and 2014 and between 2009 and 2016. For both the ΔFS and PMFTGAP outcome measures, we designed maps by relative location—metro, NMA, and rural—to conduct spatial autocorrelation analysis and identify local clusters (LISA).[6]

RESULTS

The Great Recession (2007–2009)

At the beginning of the Great Recession in 2007, average FS in manufacturing across all Indiana counties was about 58 workers per establishment, and by the end of 2009, it was down by 11, to 47 workers per establishment. The variation in average FS across these two years is not statistically significant, however. As Table 1 shows, in 2007, the metro counties' firm size averaged 58.42 employees per establishment while rural and NMA counties averaged 59.04 and 56.93 workers per establishment, respectively. While the manufacturing sector accounted for 27.85% of the labor force in the rural counties, the NMA and metro counties accounted for 20.81% and 15.99%, respectively, in the same period and are statistically significant. In addition, to provide context to the relative cost of labor across these locations, Table 1 also includes the weekly average wage rate. In 2007, the average weekly real wage in metro counties was $455.71, which was higher than in NMA ($394.90) and rural counties ($376.87). In 2009, at the trough of the Great Recession, rural counties on average lost more workers per establishment (13.90) relative to NMA

(12.72) and metro (10.39) counties. The pattern remains consistent with respect to job loss in the manufacturing sector in the rural counties, which experienced a much higher (4.78%) job loss relative to NMA (3.09%) and metro (2.12%) counties. Interestingly, the weekly real wage rate declined across the board, with metro counties noticing a $7.62 drop on average and rural counties noticing a sizable $22.90 drop.

Table 1. Average Firm Size and Employment by Relative Location during the Great Recession

	2007				2009				Change			
Variables	**Overall**	**Metro**	**NMA**	**Rural**	**Overall**	**Metro**	**NMA**	**Rural**	**Overall**	**Metro**	**NMA**	**Rural**
Average FS	57.50 (29.78)	58.42 (31.23)	59.04 (23.48)	56.93 (26.54)	47.16 (22.95)	48.03 (25.56)	46.76 (19.61)	43.04 (24.90)	–11.61 (9.71)	–10.39 (10.27)	–12.72 (8.80)	–13.90 (11.35)
Percentage employed in manufacturing	18.93 (16.78)	15.99 (11.45)	20.81 (10.99)	27.85 (14.77)	16.26 (10.50)	13.89 (9.86)	18.06 (10.05)	23.07 (14.40)	–2.71 (2.73)	–2.12 (2.67)	–3.09 (2.57)	–4.78 (3.22)
Weekly wage rate	424.25 (113.06)	$455.71 (135.07)	$394.90 (70.23)	$376.87 (99.42)	$416.64 (102.66)	$488.10 (123.28)	$388.46 (61.52)	$353.97 (54.59)	–$9.74 (35.02)	–$8.04 (40.58)	–$9.68 (23.87)	–$22.90 (51.39)
Number of counties	92	46	40	6	92	46	39	6	92	46	40	6

Notes: FS=firm size; NMA=nonmetro but adjacent to metro.

Values in parenthesis are standard deviations.

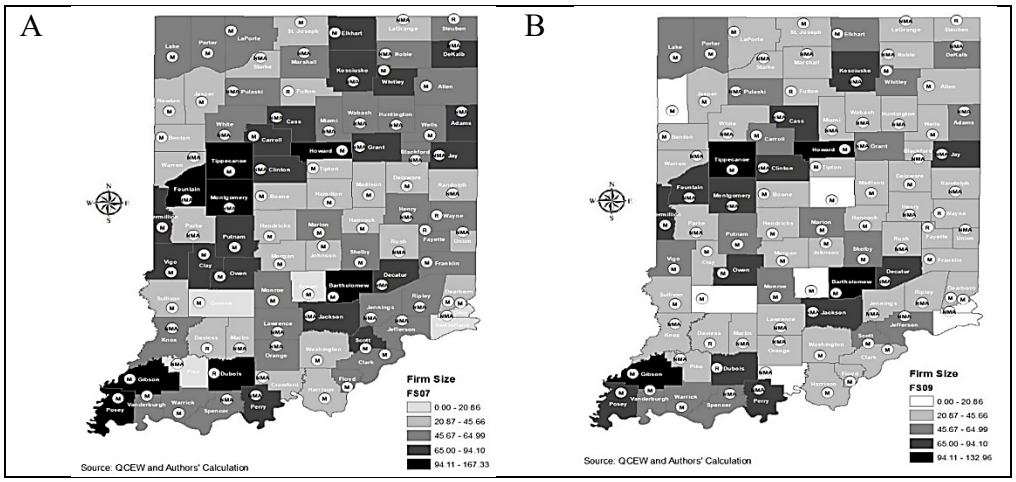
Figures 1*A* and 1*B* illustrate the geography of the distribution of the average firm size in 2007 and 2009 by relative location—metro (M), nonmetro but adjacent to metro (NMA), and rural (R) counties. As the intensity of the color increases, so does the average firm size. As shown in Table 1, on average, metro counties have a larger manufacturing firm size relative to other groups of counties. In 2007, Howard County led the pack, followed by Fountain, Gibson, Posey, and Tippecanoe Counties (Figure 1*A*). These counties with the largest manufacturing firm size remained consistent between the beginning (2007) and the trough (2009) of the recession, except Fountain County, which dropped to eighth.

The three metro counties mentioned above—Howard, Fountain, and Tippecanoe—are part of Economic Growth Region (EGR) 4, which is considered a highly specialized center for automotive and heavy vehicle manufacturing. Firms in Howard County manufacture machines, engine block castings, and transmission components (in aluminum or steel) for major auto manufacturers. In addition, the county has several firms that specialize in nickel- and cobalt-based alloys used in corrosion and high-temperature applications, and others that make customized automotive components for major automobile manufacturers across the United States.

Fountain County is a hub for manufacturing automotive parts such as bumpers, quality plastics, metals, lighting, mechanical products, and systems. They also have a global leader in manufacturing and supporting innovative systems for the conversion and storage of electrical power. Tippecanoe County hosts more than manufacturers in the automotive industry; it has North America’s leading manufacturer of semitrailers, the

world's leading supplier of surface technologies, and the global leader in manufacturing engines for heavy equipment.

Figure 1. Average manufacturing firm size by relative location. (*A*) 2007. (*B*) 2009.



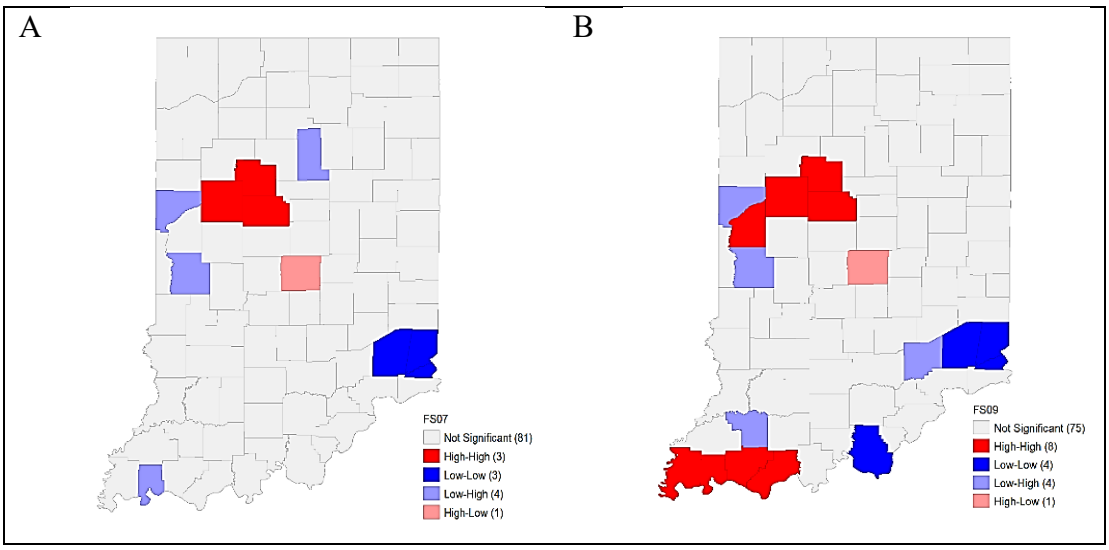
Gibson and Posey Counties are in EGR 11, a region known for having a strong history of manufacturing and that currently has a stronghold for plastics and aluminum product manufacturing. The City of Princeton, in Gibson County, prides itself on having major manufacturers and employers in automobile manufacturing, namely AC/DC synchronous and stepper motor producers, automotive interior systems producers, and filter manufacturers. In comparison, Posey County manufacturers specialize in innovative plastics and a wide range of commercial and engineering-grade polymers. Moreover, the county is also home to a major drug manufacturer and supplier of nuclear components to the U.S. government.

The Moran's *I* for average firm size is 0.128 ($p = .023$) in 2007 and 0.107 ($p = .06$) in 2009. These results confirm the clustering of counties observed in Figures 1*A* and 1*B*, indicating global positive spatial autocorrelation (i.e., overall clustering of counties with firms of similar size). Broadly, this is consistent with the premise of agglomeration economies, in which firms cluster from positive external economies of scale. This phenomenon is prominent in the manufacturing sector as firms cluster to gain from the benefits brought about by sharing intermediate inputs and labor pooling. To support our assertion, we identified 11 local clusters in 2007 and 17 local clusters in 2009 (Figures 2*A* and 2*B*). In 2007, six counties exhibited positive spatial correlation with three high-high clusters, which include Tippecanoe, Clinton, and Carroll Counties, all metro and NMA counties located in Indiana's EGR 4, and three low-low clusters, which include Ohio, Dearborn, and Ripley Counties, all in the southeastern corner of the state, which borders Ohio, again all metro and NMA counties located in EGR 9.

In the high-high county cluster, Tippecanoe County, a major manufacturing hub, is a consistent leader in employing Hoosiers in that region and attracting major supply chain

firms related to the auto industry such as a power train manufacturer for cars, trucks, and commercial vehicles, as well as a supplier of car seats for automakers in North America. In addition, Clinton County, adjacent to Tippecanoe, is the host of manufacturers of precision axles and industrial and automotive filtration systems. The manufacturing sector in EGR 9 is like that in EGR 4 in consistently being a leader in job creation for well over 10 years; however, the other sectoral employers within and across regions vary because of individual counties' unique core competencies and characteristics. For example, tourism and entertainment industries are the primary sectors in Dearborn and Ohio Counties within EGR 9, with numerous parks, lakes, forests, slopes, wildlife refuges, and casinos. In contrast, Ripley County, also in EGR 9, relies on job creation by firms that specialize in custom and digital printing, residential/commercial and industrial propane services, and appliance maintenance in the southeastern region of the state.

Figure 2. Local clusters by average firm size. (*A*) 2007. (*B*) 2009.



Sources: Authors' calculations; U.S. Bureau of Labor Statistics (n.d.).

There are five local clusters with negative spatial autocorrelation (i.e., clustering of counties with dissimilar firm sizes): one high-low cluster—Marion County, which is in the Indianapolis Metro area and technically an economic growth region on its own—and four low-high clusters that include Warren County (western Indiana, bordering Illinois), Parke County, and Miami County, all adjacent to metro counties in EGR 4, and Vanderburg County (Southwestern Indiana), a metro county in EGR 11. Indianapolis, the most populous city in Marion County and the state, hosts leading pharmaceutical companies, advanced medical research, and medical device manufacturing firms. In addition, numerous healthcare service providers, hospitals, and educational institutions employ a significant number of Hoosiers and complement Marion County's sizeable manufacturing sector workforce. Vandenburg County, besides being in EGR 11, is also part of the larger

Illinois–Indiana–Kentucky tristate area, which is dominated by manufacturing, healthcare service, utility, and financial service sectors. In the manufacturing sector, it has a firm that leads in manufacturing and marketing plastic packaging and a firm that supplies paints, coatings, optical, specialty, and fiberglass products for the entire world. Besides the manufacturing sector, the region's economy is equally supported by the healthcare sector.

In 2009, at the trough of the Great Recession, a majority of the local clusters from 2007 remained, with the addition of Posey, Warrick, Spencer, and Vanderburg Counties that are positively spatially correlated (high-high) metro counties in Southwestern Indiana's EGR 11; Harrison County (low-low), a metro county in Southern Indiana's EGR 10; and a negative spatially correlated cluster in Jennings County (low-high), an NMA county in EGR 9.

Overall, the local manufacturing clusters in 2007 and 2009, in terms of average firm size, were found in urbanized areas (metro and NMA) and EGR 4 in North Central Indiana, EGR 9 in southeast-central Indiana, EGR 10 in Southern Indiana, and EGR 11 in Southwestern Indiana.

Figure 3. Spatial Distribution of the Change in Average Manufacturing Firm Size between 2007 and 2009 by Relative Location

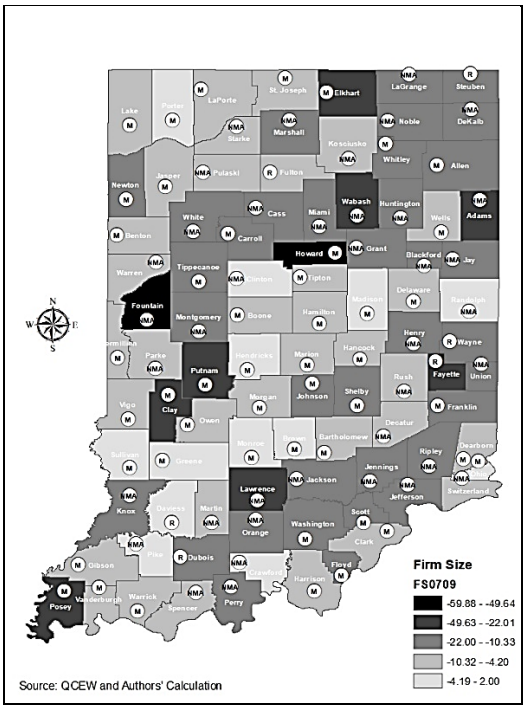


Figure 3 further explores the dynamics of the average firm size across Indiana counties during the Great Recession. The map illustrates the change in the average firm size (gain, loss, or no change) across the metro, NMA, and rural counties between 2007 and 2009. During the Great Recession, all but two counties[7] experienced a drop in the

number of employees per firm, with the extent of the drop displayed with darker shades on the map. Rural counties experienced the largest drop (13.90 employees per establishment), followed by NMA counties (12.72) and metro counties (10.39). Table 2 further shows that the top two counties with the largest firm size at the beginning of the recession in 2007, a metro county and an NMA county, likewise experienced the steepest drop during the recession (2007–2009). Howard County, with the largest average firm size in 2007 and the heavy presence of auto and specialized auto-related supply chain manufacturing firms, showed greater volatility and reduction in employment per firm due to the cyclical nature of vehicle production and sales, consistent with the recessionary economic cycle leading to a sizable drop of 60 employees per firm, while Fountain County, which has similar automotive sector presence and dominance, experienced a drop of 50 employees per firm.

Table 2. Change in Average Firm Size during the Great Recession for Top Five Counties by Average Firm Size in 2007

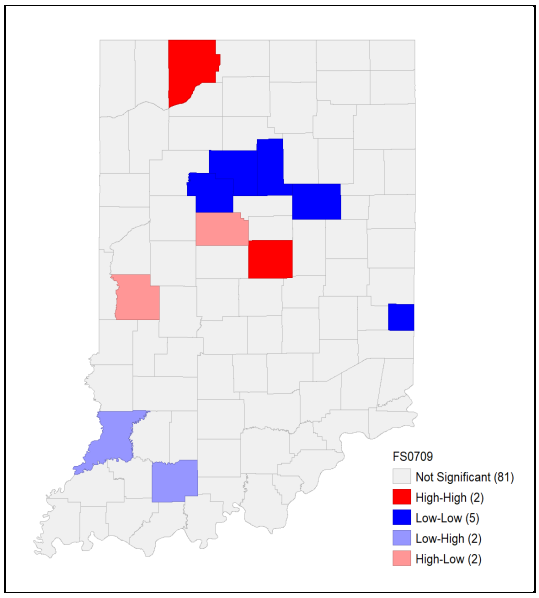
County	2007 Average Firm Size	2009 Average Firm Size	Change in Firm Size
Howard	167	107	–60
Fountain	140	90	–50
Gibson	138	133	–5
Posey	115	92	–23
Tippecanoe	115	97	–18

The Moran's *I* for the spatial pattern displayed in Figure 3, the change in average firm size during the Great Recession, is 0.024 (p = .55), signifying no significant global spatial clustering, indicating that the spatial pattern for the change in firm size due to the economic shock is random; however, Figure 4 shows there are 11 local clusters—2 counties (La Porte and Hamilton) in the high-high cluster, 5 (Union, Carroll, Cass, Miami, and Grant)in the low-low cluster, 2 (Clinton and Fountain) in the high-low cluster, and 2 (Knox and Dubois) in the low-high cluster. Clinton and Fountain Counties are in EGR 4 and, as reported earlier, have a high concentration (worker concentration is nine times greater than the U.S. average) of automotive manufacturing industries with high growth and wage rates.

Beyond the Great Recession (2014–2016)

Table 3 summarizes the structure of the manufacturing sector in Indiana during (2014) and after (2016) the recovery from the Great Recession. Both measures, average firm size and percentage employed in the manufacturing sector, increased, along with the weekly wage rates, showing signs of recovery from the economic shock across metro, NMA, and rural counties. In 2014, the firm size was higher by 10.44 workers relative to 2009 in metro counties, 11.57 workers per firm in NMA counties, and 8.63 workers per firm in rural counties. Further, by 2016, real wage rates had gradually started to increase across the board.

Figure 4. Local Clusters of Change in Average Firm Size, 2007–2009



Sources: Authors' calculations; U.S. BLS (n.d.).

Table 3. Average Firm Size and Employment by Relative Location during the Recovery (2014–2016)

	2014				2016			
Variables	Overall	Metro	NMA	Rural	Overall	Metro	NMA	Rural
Average FS	57.74 (27.88)	58.11 (32.72)	58.26 (21.27)	51.67 (29.42)	60.03 (31.20)	61.48 (37.30	59.24 (22.55)	54.14 (32.70)
ΔFS vs 2009	10.77 (10.13)	10.44 (12.13)	11.51 (7.71)	8.63 (7.75)	13.06 (15.04)	13.81 (18.40)	12.48 (10.80)	11.10 (11.17)
Weekly wage rate	$420.25 (99.02)	$450.07 (119.28)	$393.06 (61.52)	$368.78 (50.55)	$435.97 (97.75)	$466.56 (116.37)	$409.75 (62.63)	$372.67 (38.78)
Percent employed in manufacturing	18.02 (11.52)	15.98 (11.27)	20.29 (10.67)	24.52 (14.72)	17.94 (11.57)	15.24 (11.63)	20.00 (10.53)	24.46 (14.24)
PMFTGAP vs 2009	1.81 (2.45)	1.50 (2.52)	2.22 (2.42)	1.45 (1.94)	1.73 (3.09)	1.61 (3.45)	1.93 (2.65)	1.39 (3.26)
Number of Counties with PMFTGAP >0	70***	34** of 46	32* of 40	4 of 6	67***	34** of 46	29* of 40	4 of 6

Notes: ΔFS=change in average firm size; FS=average firm size; NMA=nonmetro but adjacent to metro; PMFTGAP=percentage of manufacturing employment gap.

Number of asterisks (*) indicates number of missing observations. Values in parenthesis are standard deviations.

Table 4 presents disaggregated information by comparing the values of our outcome variables, average firm size and percentage employed in the manufacturing sector, at the beginning of the recession (2007) and the endpoint of our analysis (2016). By 2016, the overall average firm size across all Indiana counties was higher than at the beginning of the recession in 2007 (60.03 vs. 57.50). In metro counties, the average manufacturing firm size was larger by about 3.57 workers per firm. Meanwhile, in rural counties, average firm size was about 2.79 lower in 2016, while in NMA counties, it was minutely lower, by 0.24 employees per firm. The variation in average firm size across the locations is not significant, however. In contrast, the gap in percentage employed in manufacturing is negative and significant between 2016 and 2007 for metro, NMA, and rural counties, indicating that by 2016, local manufacturing employment had not rebounded to its 2007 level.

Table 4. Average Firm Size and Employment by Relative Location at the Start of the Great Recession (2007) vs. Recovery (2016)

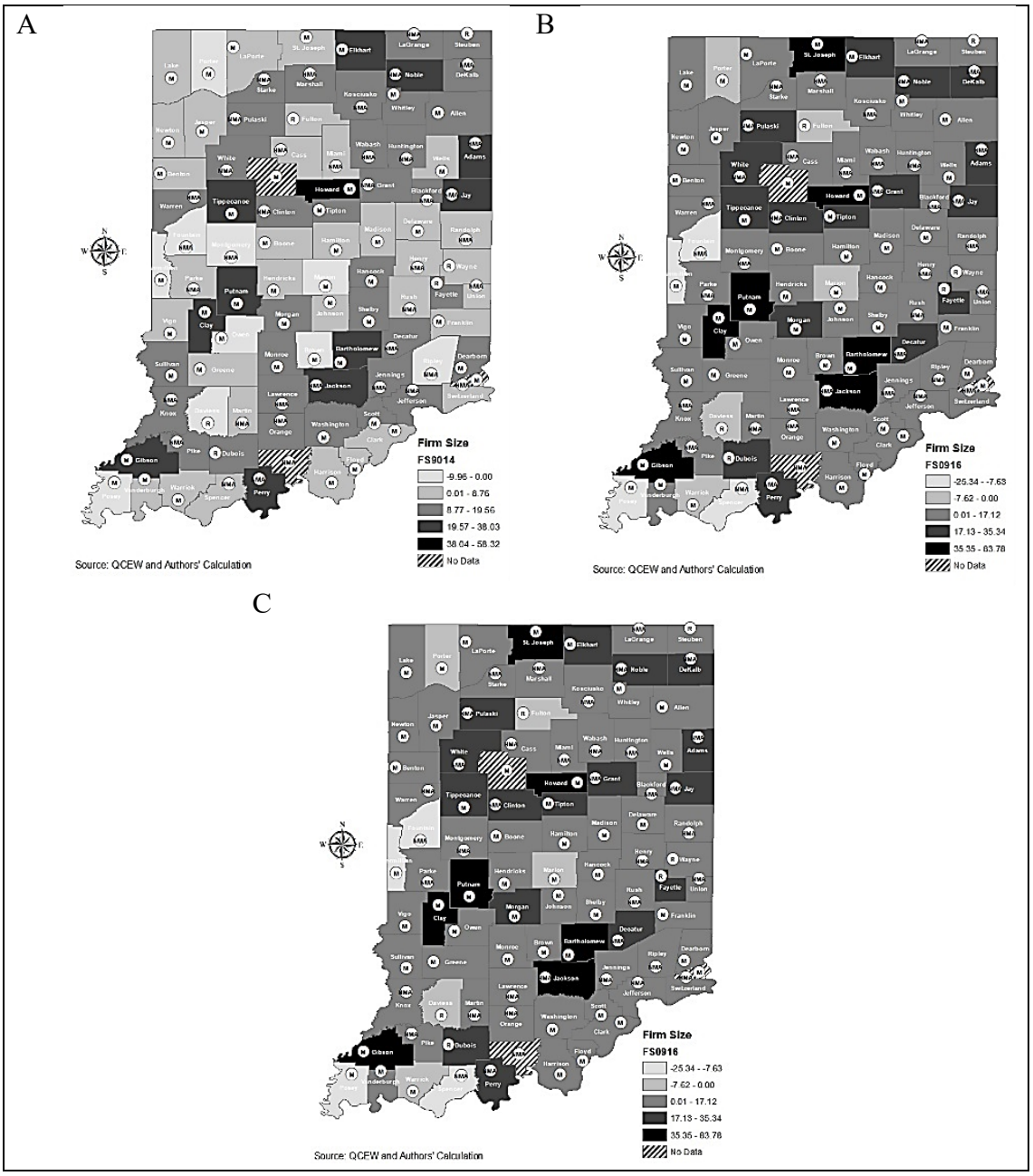
	2007				2016				Change			
Variables	Overall	Metro	NMA	Rural	Overall	Metro	NMA	Rural	Overall	Metro	NMA	Rural
Average FS	57.50 (29.78)	58.42 (31.23)	59.04 (23.48)	56.93 (26.54)	60.03 (31.20)	61.48 (37.30)	59.24 (22.55)	54.14 (32.70)	1.51 (14.61)	3.57 (14.13)	–0.24 (15.68)	–2.79 (9.75)
Percent employed in manufacturing	18.93 (16.78)	15.99 (11.45)	20.81 (10.99)	27.85 (14.77)	17.94 (11.57)	15.24 (11.63)	20.00 (10.53)	24.46 (14.24)	–0.98 (3.14)	–0.51 (3.33)	–1.56 (2.81)	–3.40 (2.30)

Notes: FS=firm size; NMA=nonmetro but adjacent to metro.

Values in parenthesis are standard deviations.

Figure 5*A* and 5*B* provide snapshots of manufacturing firm size in 2014 and 2016 relative to 2009, and Figure 5*C* illustrates manufacturing firm size in 2016 relative to 2007. On the maps, as the intensity of color increases, so does the average firm size. As shown in Figure 5*A*, between 2014 and 2009, Howard County experienced the largest increase in firm size (58 workers per firm) and reached its 2007 level of 167. Further, the county's average firm size increased to 191 by 2016. The other notable counties that experienced a sizable (significant) increase in firm size—upward of 30 workers between 2014 and 2009—were Putnam, Clay, Bartholomew, and Elkhart, which are also metro counties. Elkhart County, the "RV (recreational vehicle) capital of the world," employs skilled workers, assemblers, and workers in a manufacturing sector that is highly sensitive to the business cycle. Columbus, in Bartholomew County, known for its world-class architecture and manufacturing industrial base, is home to the world's largest manufacturer of diesel and alternative-fuel engines and generators. Columbus is also home to firms that manufacture and distribute forklifts, scissor lifts, tow tractors, and automated guided vehicles (AGVs). Putnam and Clay Counties are neighboring counties in West Central Indiana and EGR 7, while Bartholomew County is in southeast-central Indiana and EGR 9 and Elkhart County is in Northeast Indiana and EGR 2.

Figure 5. Spatial distribution of gap in firm size by relative location. (*A*) 2014 vs. 2009. (*B*) 2016 vs. 2009. (*C*) 2016 vs. 2007.



Howard County remained on the top-five list in average firm size increase between 2009 and 2016, gaining about 84 workers per firm. Mostly the same counties were the top gainers between 2009 and 2016 and between 2009 and 2014, with the addition of St. Joseph County, which neighbors Elkhart County in Northeast Indiana, both counties bordering Michigan. Between 2007 and 2016, the top five increases in firm size were upward of 24

workers per firm and were all metro and NMA counties: St. Joseph, Gibson (in Southwestern Indiana and EGR 11), Bartholomew, Howard, and Jackson Counties.

Fountain County, which had the second largest average manufacturing firm size in 2007, experienced the steepest decline in firm size by 2016, a significant drop of about 75 workers per firm. This decline in firm size could be due to downsizing, exits, and a notable shift in the establishments from rural to metro and NMA counties in Indiana.

The Moran's *I* values for the change in average firm size in 2014 and 2016 relative to 2009 (–0.01, $p = .97$ and 0.01, $p = .69$) and in 2016 relative to 2007 (0.001, $p = .84$) indicate no significant global spatial autocorrelation. This implies no spatial clustering or mutual dependence of counties in the change in average firm size as the manufacturing sector recovered from the Great Recession. Counties behaved independently during the recovery and did not depend on neighboring counties for positive spillover benefits.

Although the average manufacturing firm size is larger for metro relative to NMA and rural counties, the reverse is true in terms of the percentage of local employment in manufacturing. In 2014, five years after the trough of the Great Recession, rural counties employed close to 25% in the manufacturing sector, compared to 20% in NMA and 16% in metro counties (Table 3).

The overall gap in manufacturing employment between 2014 and 2009 was 1.81 percentage points and dropped slightly, to 1.73 percentage points, between 2016 and 2009 (Table 3). These imply a marginal gain in manufacturing employment from the levels relative to the trough of the Great Recession. In 2016, three quarters (34 of 46) of metro and NMA (29 of 40) counties had gained employment relative to the 2009 level, while two thirds of rural counties (4 of 6) gained the same. Further, by 2016, overall employment in the manufacturing sector was still 0.98 percentage points below the 2007 level (Table 4). The rural counties of Indiana lost 3.4% of employment in the manufacturing sector between 2016 and 2007, followed by 1.56% in NMA counties, and metro counties saw a minimal drop of 0.51 percentage points.[8]

The maps in Figure 6 show the spatial pattern of the PMFTGAP across all Indiana counties between 2014 and 2009 (*A*), between 2016 and 2009 (*B*), and between 2016 and 2007 (*C*). By 2014, about 76% of the counties had gained manufacturing employment relative to 2009, but this dropped to 73% (3 fewer counties) by 2016 (darker shades on the maps). The top gainers were all in metro and NMA counties, including Clay County (which is in the Terre Haute metro area, in West Central Indiana), Elkhart and LaGrange Counties (bordering Michigan in North Central Indiana), and Perry County (Southwestern Indiana). Interestingly, Marion County experienced one of the larger drops in the percentage of local employment in manufacturing—close to a 3 percentage-point drop between 2009 and 2016. For 34% of the counties, percentage of employment in the manufacturing sector was higher by 2016 than in 2007 (darker shades on the maps).[9]

Figures 6*A*, 6*B*, and 6*C* exhibit no significant overall spatial pattern, as indicated by the Moran's *I* values (0.018, $p = .65$; 0.084, $p = .13$; and –0.03, $p = .71$, respectively); hence, there is insufficient evidence of global clustering of the change in local manufacturing employment during the recovery from the Great Recession. The LISA analysis identified significant local clusters, however, as shown in Figures 7*A*, 7*B*, and 7*C*. During the recovery, between 2009 and 2016, there were nine local clusters of similar

values. Four local clusters of high-high in the northeast region (EGR 3), bordering Michigan and Ohio, are metro and NMA counties. This region's industry base is centered on manufacturing. Marion County, along with Boone County, its neighbor to the northwest, and Hancock County, its neighbor to the east, was in the low-low cluster; all are in EGR 5. Nine local clusters were identified between 2007 and 2016, mostly located in the southwestern region of the state and mostly metro and NMA counties.

Figure 6. Spatial distribution of gap in the percentage of manufacturing employment by relative location. (*A*) 2014 vs. 2009. (*B*) 2016 vs. 2009. (*C*) 2016 vs. 2007.

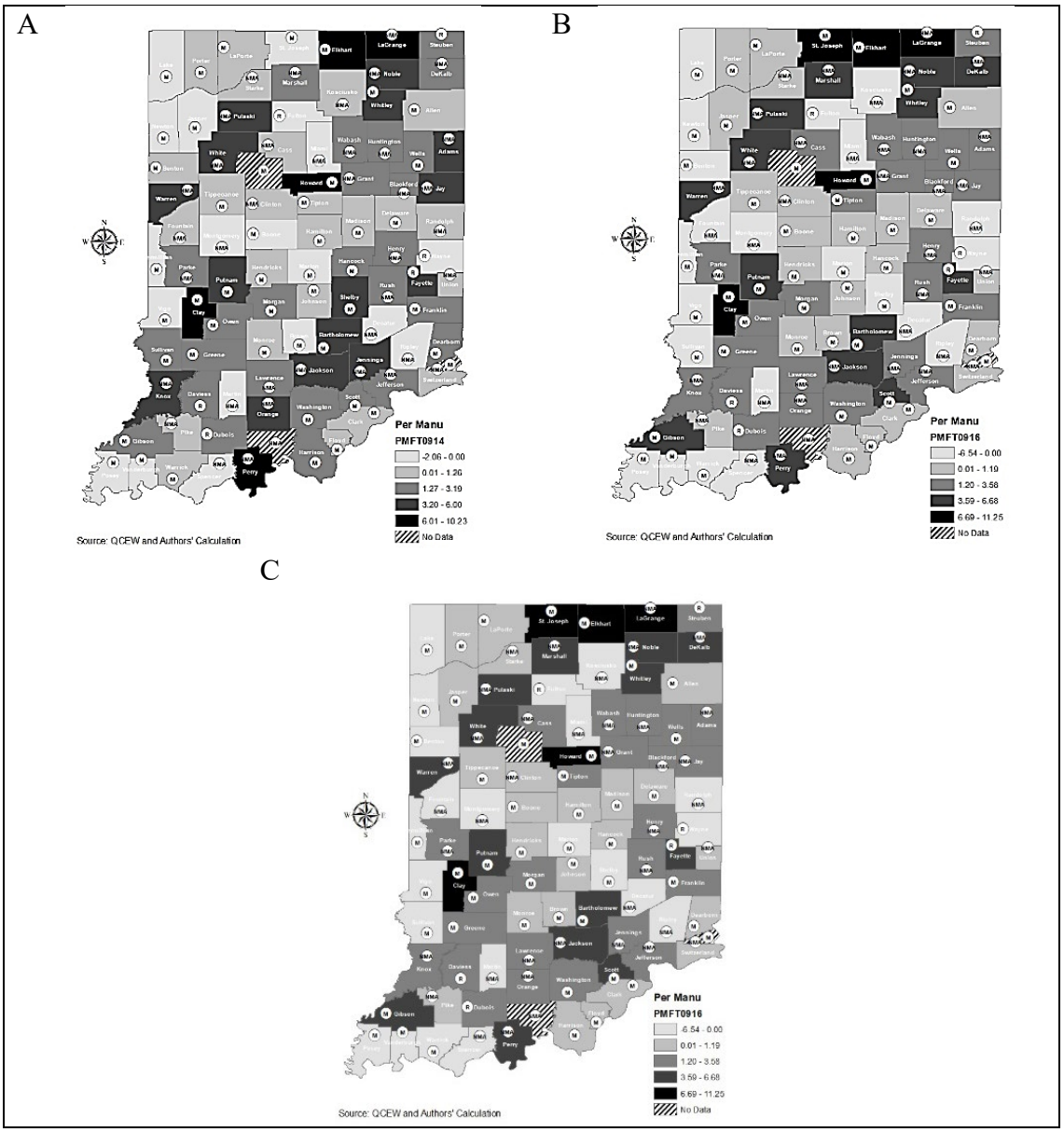
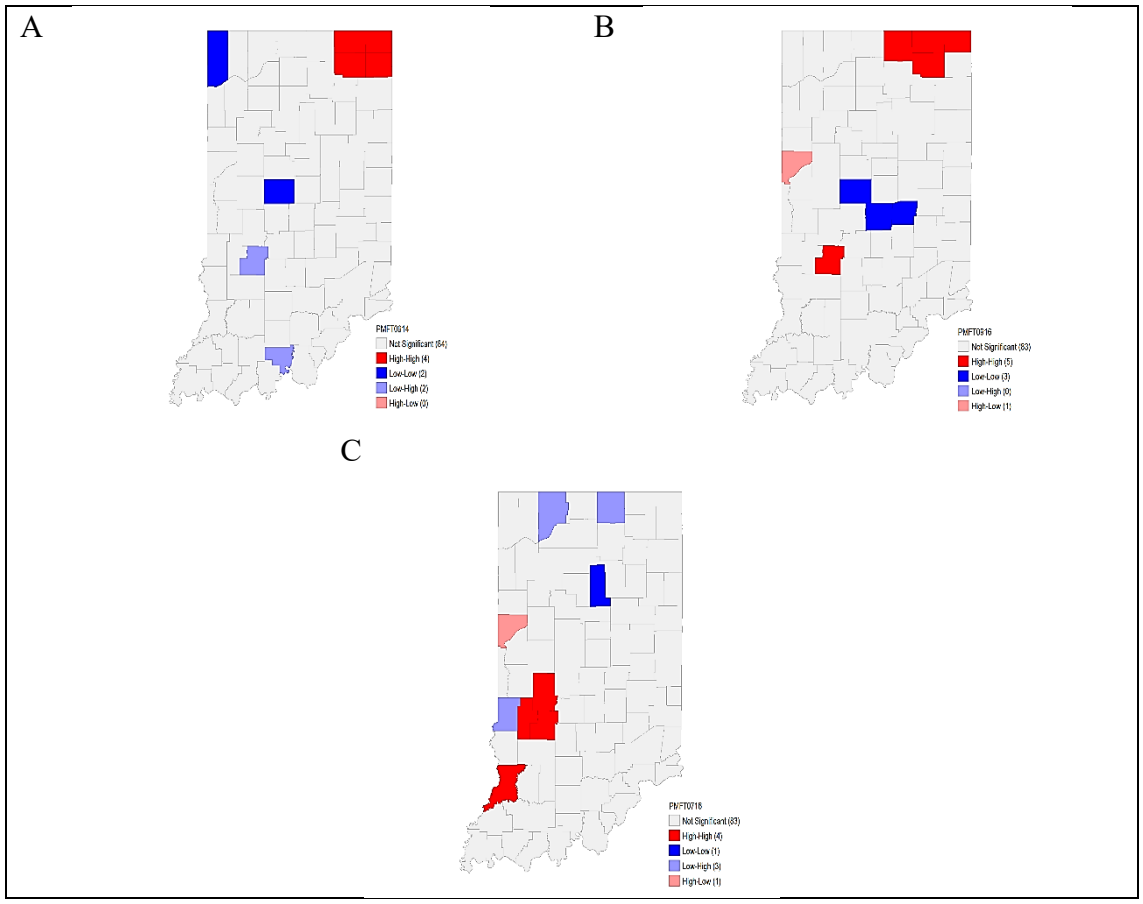


Figure 7. Local clusters of manufacturing employment gap. (*A*) 2014 vs. 2009. (*B*) 2016 vs. 2009. (*C*) 2016 vs. 2007.



Discussion

The observed patterns from the spatial analysis revealed a few common and interesting findings. First, the average manufacturing firm size was slightly larger by 2016 relative to the beginning of the Great Recession (1.51 more workers per firm), but comparison across locations indicates disparities.[10] By 2016, the average manufacturing firm size was smaller in rural counties but larger in metro counties. In terms of the percentage of local employment in manufacturing, it was still slightly lower overall by 2016, a result that is consistent with the overall long-term decline in manufacturing employment in the state that predates the Great Recession. Even here, we see disparities by location: Rural and NMA counties experienced greater declines while metro counties experienced only a marginal drop. These results imply that the tradeoff between benefits of agglomeration economies that lead to clusters (vs. the higher costs associated with clustering) is more valuable in metro counties compared to rural counties. This disproportionate impact is consistent with the findings of Bennett, Yuen, and Blanco-Silva (2018) that rural areas did not recover as quickly as urban areas after the Great Recession. Similarly, Shearer, Vey, and Kim (2019)

report that less-dense suburban and exurban areas lost jobs faster than did urban areas during the Great Recession but that as the economy recovered, job growth was higher for the densest and metro areas.

Second, although the average manufacturing firm size in 2007 and 2016 was larger for metro counties than rural counties, the opposite is true for the percentage of local employment in manufacturing. This implies that the manufacturing sector in the local rural economies of Indiana is a relatively more significant source of employment than in the state's local urban economies. The combination of higher average firm size and slightly lower local manufacturing employment in metro counties maybe be an indication of a larger market for the specific types of manufacturing located in metro counties and an increase in total factor productivity for these firms. This highlights the role of advanced manufacturing (sectors) that is critical for the future of manufacturing in the state. In comparison, the decline in average firm size and local employment in manufacturing in rural counties implies the weakening importance of rural-based manufacturing to the overall manufacturing output in the state. The larger decline in rural local manufacturing employment in Indiana is different from the national trend as reported by Low (2017), where employment declined less in the largest rural subsectors and even rebounded after the Great Recession.

Third, the spatial patterns show significant spatial dependence for both average firm size and manufacturing employment[11] but not for the change (gap) during and after the Great Recession. This indicates that spatial proximity and spillover effects matter in determining manufacturing firm size and employment because of agglomeration economies, but during and after an economic shock (e.g., the Great Recession), the response of manufacturing firms and local economies is spatially independent. The overall impact of the Great Recession was felt across all counties, but the response was not as coordinated and was more county-specific. It is important to note that the spatial analysis and the subsequent identification of local clusters is an exploratory analysis suggesting spatial dependence and interesting locations to examine further; it does not explain the sources of the spatial patterns. Our analysis suggests that the characteristics of counties, such as access to resources, quality of human capital, local policies, tax structures, and incentives, are potential explanatory variables in the variation in local manufacturing firm size and employment across Indiana counties. This could be explored further by developing a spatial econometric model to estimate the impact of county characteristics on these outcome variables during the shock and the recovery.

CONCLUSIONS

This paper explored the dynamics in the structure of the manufacturing sector in Indiana, focusing on the geography (relative location) and spatial patterns of manufacturing firm size and employment across all counties during and after the Great Recession. We employed a spatial perspective and a snapshot approach—an exploratory analysis to identify spatial patterns and local clusters. The local manufacturing clusters we identified, based on firm size and employment, are all in metro and NMA counties and are mostly located in EGR 4, in North Central Indiana, which is a highly specialized region for

automotive and heavy vehicle manufacturing. Other notable regions where local clusters were found include EGRs 9, 10, and 11, all in Southern Indiana. We also found evidence that manufacturing in local rural economies was disproportionately affected by the Great Recession and even in recovery. During the Great Recession, the decline in average firm size was greatest for rural, followed by NMA and then metro counties. In comparison, by 2016, the average firm size in metro counties was higher than in 2007, whereas for NMA and rural counties, the average firm size had not rebounded to 2007 levels. The relative ranking by the degree of urbanization remained consistent with respect to local employment in manufacturing—although all groups experienced a decline during the Great Recession and even in recovery.

The spatial approach and subsequent identification of local manufacturing clusters in Indiana during the Great Recession and recovery uncovered disparities by geography and degree of urbanization. The county clusters, which indicate productive advantage from spatial proximity and spillover, help identify a region's economic strengths as well as its challenges (Cortright 2006).

Our analysis reinforces the importance of cluster analysis to help orient economic-development policies and practices toward a group of counties in contrast to individual counties and provides insights into the types of policies that could be instituted to combat economic shocks. The fact that Indiana is divided into 12 economic growth regions shows the state government's commitment to a regional approach to economic development; however, our results show that during the Great Recession and recovery, the manufacturing sector's response was more localized and was independent of spatial proximity or dependency. Coordination of policies that are specific to counties that can also affect adjacent/neighboring counties should therefore be encouraged during economic shocks—for example, providing tax incentives, subsidies, and worker (re)training to retain and attract new manufacturing firms to locate across counties within their respective economic regions. Moreover, policies addressing differences between rural and urban areas should be emphasized, as supported by our empirical analysis.

Finally, the fact that the average manufacturing firm size is slightly larger and local employment in manufacturing lower after the recession is consistent with the idea of increased total factor productivity from technological advancements and shows the evolution of the type of manufacturing in the state and its implications for the future. This points to the rising importance of advanced manufacturing in the state moving forward. In fact, the Indiana Economic Development Corporation has indicated that the state's combination of a strong legacy in automotive manufacturing, an extensive network of the supply chain, and attractive economic policies for employees makes it ripe for the future of advanced manufacturing.

ENDNOTES

1. Authors' calculations from U.S. Bureau of Labor Statistics (BLS) Current Employment Statistics (CES) seasonally adjusted data.
2. Authors' calculations from BLS CES seasonally adjusted data.
3. Authors' calculations from BLS CES seasonally adjusted data.

4. Based on the 2003 Rural-Urban Continuum Codes from the U.S. Department of Agriculture Economic Research Service. The classification codes distinguish metropolitan counties by population size of their metro area, and nonmetropolitan counties by degree of urbanization and adjacency to a metro area. There are nine categories: three metro and six nonmetro. For parsimony in modeling, we created three categories: (1) metro, combining categories 1–3, including all metro counties with population lower than 250,000, (2) nonmetro but adjacent to metro (NMA), combining categories 4, 6, and 8, including all nonmetro counties with populations lower than 2,500 but adjacent to metro areas, and (3) rural, combining categories 5, 7, and 9, including all nonmetro counties with populations less than 2,500 and not adjacent to metro areas.
5. For full details of the methodology, refer to Anselin (2020).
6. To further explore the recovery period after the 2009 trough, we also devised a crude measure of time to recovery, *YearsRecov.* This captures the number of years that each county's unemployment rate took to recover to its 2007 level after 2009. A county is considered to have recovered when its unemployment rate has reached the 2007 level for the first time, starting in 2009. This measure, however, is not specific to the manufacturing sector. The map is presented in the appendix (Figure A1).
7. Two observations are missing.
8. We also found that, overall, 39 of the 92 counties in Indiana (about 42%) had unemployment rates that reached the 2007 level by 2016 (i.e., years to recovery from the trough was about seven years). Figure A1 illustrates the spatial distribution.
9. Refer to Figure A3 for a gain/loss map configuration.
10. Of the 89 counties in Indiana (2 missing data), 46 experienced an increase in average firm size between 2007 and 2016. The spatial distribution of gain/loss is included in Figure A2. The Moran's I of 0.001 (p = .84) indicates no global spatial dependence.
11. The spatial dependence of average firm size dissipates in 2014 and 2016. This is not surprising given the spatial independence during the Great Recession (i.e., independence of counties' response to the adverse economic shock).

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APPENDIX

Figure A1. Years to Recovery from the Great Recession by Relative Location

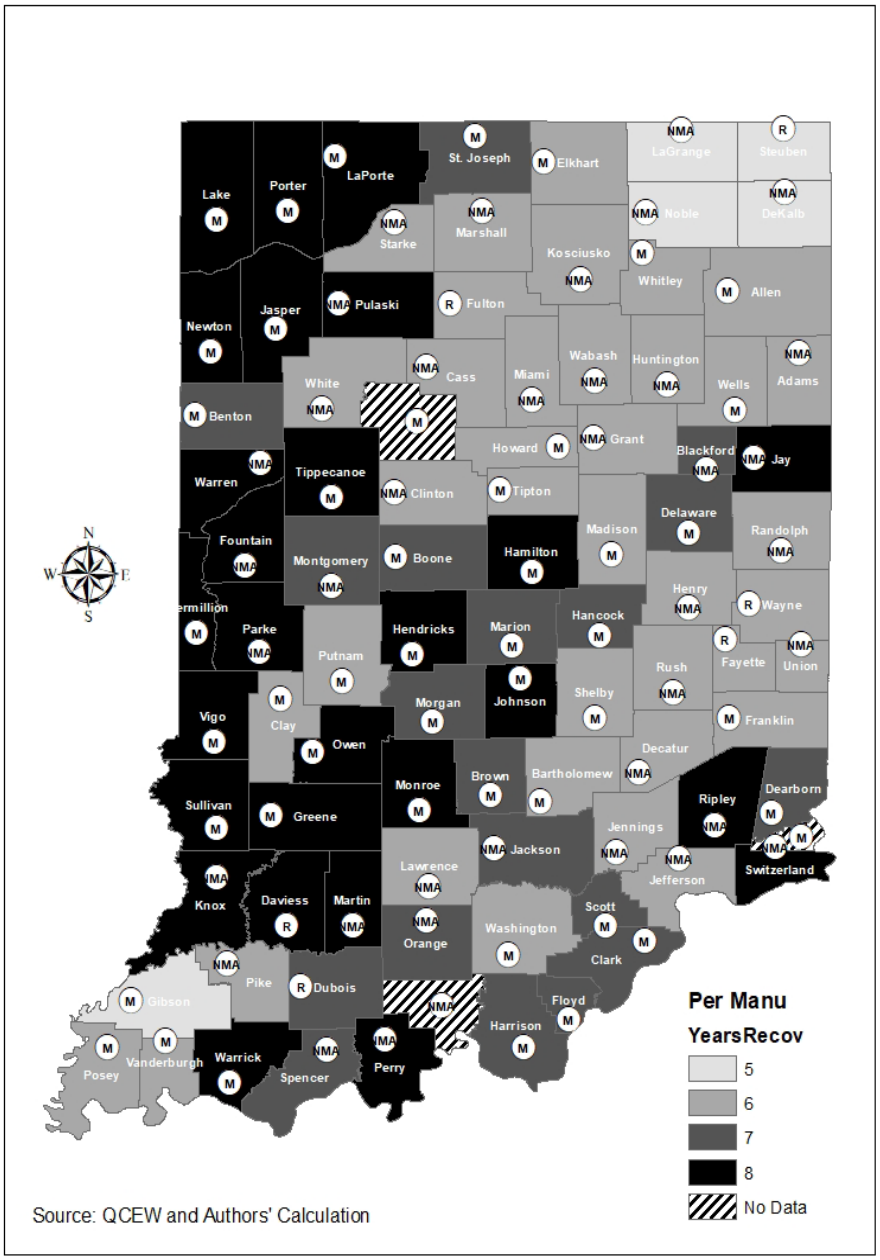

Figure A2. Gain and Loss in Firm Size by Counties before and after the Great Recession

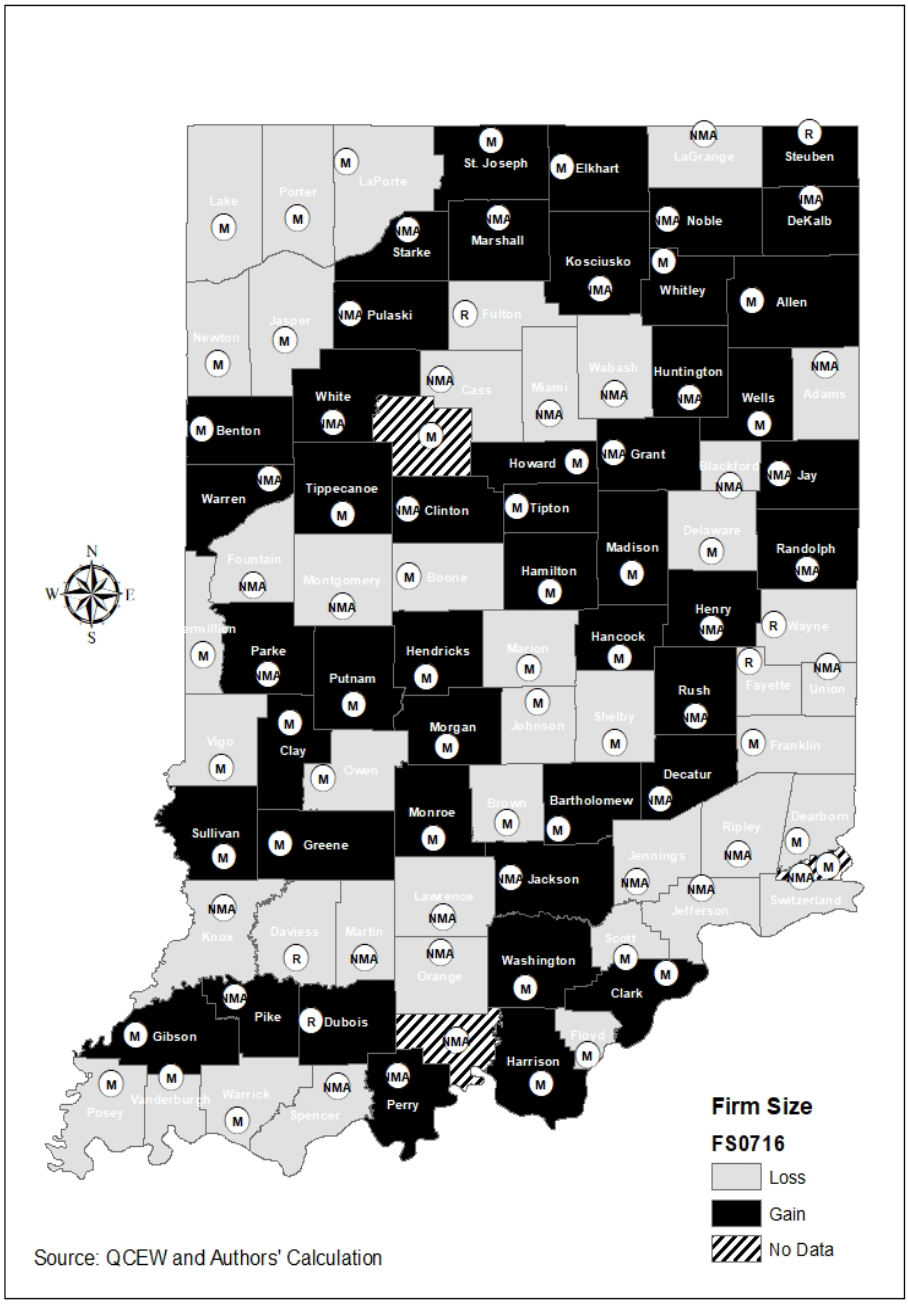

Figure A3. Gain and Loss in Percent Manufacturing Employment by Counties before and after the Great Recession