The US Auto Supply Chain at a Crossroads

Implications of an Industry in Transformation

Susan Helper
with Kyoung Won Park, Jennifer Kuan, Timothy Krueger,
Alex Warofka, Joy Zhu, William Eisenmenger, and Brian Peshek

This project is a part of Driving Change,
a research consortium of the Indiana, Michigan, and Ohio Labor Market Information offices and their strategic partners.

For more information on the Driving Change Project, visit drivingworkforcechange.org

For more information on this study, contact
susan.helper@case.edu

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executive summary

The automotive industry has played a critical role in the expansion of America's middle class for nearly a century. Yet the industry has suffered great losses in recent decades and was deeply affected by the recession of 2008-9, which saw auto sales fall by 40%, and two of the Detroit 3 automakers enter bankruptcy. To more effectively serve the large numbers of dislocated auto industry workers and to better understand and mitigate the negative repercussions of these trends, the Labor Market Information Offices of Indiana, Michigan and Ohio formed the Driving Change consortium.[1] This report details the findings of the National Survey of Automotive Suppliers, conducted by researchers at Case Western Reserve University as part of the Driving Change consortium.

Researchers at Case Western Reserve University investigated the automotive supply chain by reviewing past studies of the topic, interviewing suppliers and conducting a nationwide survey. We believe our study makes several contributions. First, existing studies of the auto industry focus on auto makers, or 'OEMs', and their direct suppliers, or 'tier 1 suppliers'. These firms are almost all very large, with tens of thousands of employees. In contrast, our study focused on smaller firms (those with fewer than 500 employees). These firms typically do not supply automakers directly; that is, they are usually "tier two" or "tier three" suppliers. These smaller firms account for 30% of employment in the auto supply chain, but are under-studied because they are difficult to identify as auto suppliers in existing data. In contrast, by combining multiple databases we have been able to construct a truer picture of the industry.

Second, our survey instrument is unusual in that it aims to capture a multi-faceted view of each firm. We chose this approach due to our belief that human resource policy both affects and is affected by the product and operations strategy of the firm; the causes and effects of workforce policies cannot be studied in isolation from other aspects of the firm. We believe the resulting survey data and insights from field interviews inform a more textured understanding of the situation facing supply chain firms. This information can be used by policy makers to understand specific challenges that firms face—such as regional shortages of skilled tradespeople—but in aggregate also reveals industry-wide norms and collective action dilemmas that illuminate why such challenges continue to exist.

Throughout our research, we find evidence of two possible futures for America's automotive industry. One future is characterized by collaborative relationships between firms at all tiers of the supply chain, wherein firms share cost savings from identifying and eradicating inefficiencies that they might not have been able to address on their own. In this scenario, firms will be more likely to collaborate when designing parts that will eventually end up in the same vehicle, resulting in products that can sell for better prices.

On the other path, fickle relationships and fear of investment will prevent progress at each tier. In this future, instead of developing better products, working with suppliers and customers to solve trans-tier problems and thinking critically about how to remove inefficiencies from processes that span multiple firms, each level of the supply chain generates profits by squeezing margins of the tier under them. This path is a recipe for industry-wide stagnation and declining relevance.

Our study finds that large segments of the automotive supply chain are characterized by each of these two scenarios, demonstrating certain elements of both. There is some evidence that relationships are becoming more collaborative, as many firms report that their main customers are more likely now to work with them to reduce costs than they were in 2007 before the recession. One large first tier supplier described how the recession made them realize the importance of

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1 The Consortium was led by the Labor Market Information Offices of Indiana, Michigan and Ohio (Indiana's Department of Workforce Development – Research & Analysis (Managing Partner); Michigan's Department of Technology, Management, and Budget – Bureau of Labor Market Information and Strategic Initiatives; and Ohio's Department of Jobs and Family Services – Labor Market Information Bureau). in collaboration with research institutions in each state: the Center for Automotive Research (Michigan), Case Western Reserve University (Ohio) and the Indiana Business Research Center at Indiana University's Kelley School of Business. The research was generously funded by an American Recovery and Reinvestment Act grant through the Department of Labor's Employment and Training Administration. For more information on the other studies undertaken by this project, please see http://drivingworkforcechange.org/.

keeping their own suppliers in better financial condition and reports that they now take more interest in the health of their suppliers and try to let many of them capture more profits. Yet other evidence suggests that some parts of the supply chain are focusing more on short-term cost-cutting, as recession-induced investment phobias run wild throughout large parts of the supply chain and many first tier firms continue to protect their profit margins by cutting the margins of their suppliers, rather than by trying to build positive-sum relationships. One representative of a first tier supplier, when asked about the relative importance of building long term relationships with lower tier suppliers, responded that "At [this company], everything is short term. Today is everything. That mentality drives the behavior: Get it now, and don't worry about the out years... Focus on today; worry about tomorrow tomorrow."

Inside the supplier firm, we find that certain practices are frequently adopted together. One such grouping is " high road" practices, which includes high wages, worker training and investment, and empowerment at all job levels. Among firms that engage in high-volume production (about 93 percent of the industry), firms that exhibit the above characteristics experienced 10.9 percent less sales loss during the crisis than the group of firms that least exhibits these "high road" characteristics. We identified two forms of such "high road" strategies: those that are "distinctive" and those that are "systematic." Distinctive firms develop novel products that are hard to imitate, whereas systematic production focuses on data collection to identify and eliminate sources of waste. Our cluster analysis finds that while combining these strategies is particularly effective, firms usually do not use both.

Despite evidence that these strategies (adopted separately or together) are correlated with improved performance, we find that many employers do not pursue such strategies. We find preliminary support for two main reasons why:

1) Customer purchasing strategies in many cases do not allow suppliers the financial or organizational resources they would need to implement such practices, and
2) Public policies do not do enough to "pave the high road" (which has benefits that spill over to workers and communities) and block the low road (which has costs that spill over to others).

We explored the possibility that these policies are not applicable to all firms; that they pay off only in certain industries or with certain managers and all firms who would profit from the policies have already adopted them. Clearly some policies work better in some cases than in others, but we doubt that this is the whole story. Our visits over several years to the same firms before and after their adoption of such policies showed real performance improvement with the same personnel. This view is consistent with a variety of other studies as well.

We also found that firms demonstrated different responses to the recent manufacturing crisis; we believe these different responses will continue to affect firm competitiveness for years to come. About two-thirds of firms surveyed chose to postpone investment in equipment, but those who continued to invest are faring better in the wake of the recession. Firms that demonstrate commitment to process improvement techniques like quality circles and preventative maintenance also fared better during the recession, posting modest sales growth on average while firms that did not engage in these two practices reported significant sales losses. Firms in Michigan, Indiana and Ohio are significantly more likely to have quality circles compared to firms in the other 47 states.

Michigan, Indiana and Ohio firms in our sample also differentiate themselves from the rest of the country by paying average wages in production facilities about 10% higher than firms in other states. This is likely attributable to an array of factors, but we specifically find that workers in these three states are more likely to belong to a union (unionization rates at sample firms in these three states are 3.5 times higher than rates among the rest of our sample) and about 6 percent more likely to have graduated from high school. In addition, Michigan (and to some extent Ohio) has far more R&D and technical center workers than do other states. We believe this bodes well for these three states, as firms that pay higher wages for better skills and more well-educated workforces will have the best chances of remaining competitive in the 21st century.

introduction

The automotive industry has played a critical role in the expansion of America's middle class for nearly a century. Automotive manufacturing firms have been drivers of innovation, bastions of engineering skill and places where workers could develop valuable skills over time. According to our analysis of data from the Quarterly Census of Employment and Wages (see Section II below), the automotive parts industry is currently comprised of over 13,000 establishments in at least 46 states, employing more than 750,000 workers. Yet the industry has suffered great losses in recent decades and was deeply affected by the onset of the recession in 2008. When large automakers such as Ford, General Motors and Chrysler cut production in late 2008, work shortages rippled through the network of manufacturing suppliers that accounts for about 70 percent of auto industry employment. The combined effects of the financial crisis and decades of auto-industry globalization have transformed the automotive industry in ways that are not yet fully understood by either policymakers or industry insiders.

Funded by an American Recovery and Reinvestment Act grant through the Department of Labor's Employment and Training Administration, researchers in Michigan, Indiana and Ohio conducted a detailed study of the automotive industry's transformation. Teams of researchers studied the greening of the automotive industry, career pathways for dislocated workers and the supply chain. Specific areas of focus included workforce skills, supply chain relations, firm health, technology, supplier diversification into other manufacturing industries and many other topics. This report details the findings of the National Survey of Automotive Suppliers, conducted by researchers at Case Western Reserve University.

Between July 2010 and June 2011, the CWRU Automotive Supply Research Group used a comprehensive three-phase process to study the US automotive supply chain. For this report, we focused our analysis on firms with fewer than 500 employees. These are the firms that researchers know the least about, but together they account for about 30% of all automotive employment, more than the automakers themselves. These firms are under-studied because they are difficult to identify as auto suppliers in existing data, such as the Census of Manufacturers.

This report is structured as follows. The rest of Section I outlines the main questions we have sought to answer. Section II draws on both publicly available data and our survey data to describe trends that have shaped the automotive parts industry in recent decades, including trends in employment and in industry structure. Section III reports the results of our cluster analysis and describes the nature of the four groups of practices commonly used in the automotive supply chain. Section IV describes our survey data on how firms responded to the recent manufacturing crisis with changes to production, investment, employment and finance and discusses preliminary observations about the continuing effects of these various responses. Section V catalogues findings about human resources practices and skills availability for different job categories. Section VI includes findings on innovation and investment, including investments in process improvement, energy efficiency and transition to manufacturing greener products. Section VII discusses customer relations, including differences in supply chain relationships between the upper and lower tiers of the automotive supply chain, as well as firms' efforts to diversify to non-automotive customers. Section VIII explores changes in the extent to which firms source their inputs locally. Section IX includes general analysis of our findings and their policy implications.

1.1. Purpose of the Study and Summary of Findings

Three major questions have driven this study. First, we seek to understand how the automotive supply chain has been transformed both by long-term economic forces and the recent manufacturing crisis. Next, we investigate the various paths to survival and profitability that different firms have pursued, and their implications for workers. Finally, we seek to understand how government, industry leaders, unions, workforce development professionals, trade associations and other relevant actors can most effectively strengthen the US manufacturing base.

The long-term economic forces that have driven the automotive industry's transformation include technology, decisions to globalize and off-shore many elements of production, the rise of competition from automakers based in Europe and Asia. While some individual firms have done well, overall these changes have gradually eroded America's base of good manufacturing jobs and the skilled workers who fill them. Collectively, many of these long-term changes can therefore be described as a slow, simmering crisis. Conversely, the financial crisis of 2008 bred immediate consequences for US manufacturing. A 40% decline in auto sales in late 2008 sent painful ripple effects through much of the automotive supply chain.

In order to answer the second question about survival strategies and implications for workers, we collected data on firms' approaches to their product markets and operations, as well as their human-resource policies. Our view is that HR policies and outcomes both constrain and and are constrained by the skills and incentives of workers. Our study finds that firms have charted out four basic paths to success. Based on our interviews and on cluster analysis of our survey data, we find that firms generally can be categorized into one of four groups:

1. "Engineering-intensive" firms that employ high percentages of engineers and profit from a focus on R&D work and/or non-repetitive processes such as machine-building;
2. "Craft skill" firms that pay competitive wages for highly-skilled workers, often participate in the tooling industry, and demonstrate below-average rates of formal process improvement initiatives;
3. "Clever cost-cutter" firms that pay lower wages for high percentages of low- or semi-skilled labor, are likely to avoid investment in workers and equipment, and often describe practical or creative solutions that help them avoid spending money; and finally
4. "Kaizen"[2] firms that pay moderate wages and are most likely to pursue Toyota-style management philosophies with the goals of flexible production, participation in various markets, inclusion of all workers in firm strategy, and institutionalization of continuous improvement practices.

This report describes these findings in greater detail in section III.

Finally, as noted above, this study aims to understand how individuals, companies and agencies can address the problems our study highlights in ways that produce good outcomes for firms, employees and the US manufacturing industry. This report discusses policy recommendations in the final section.

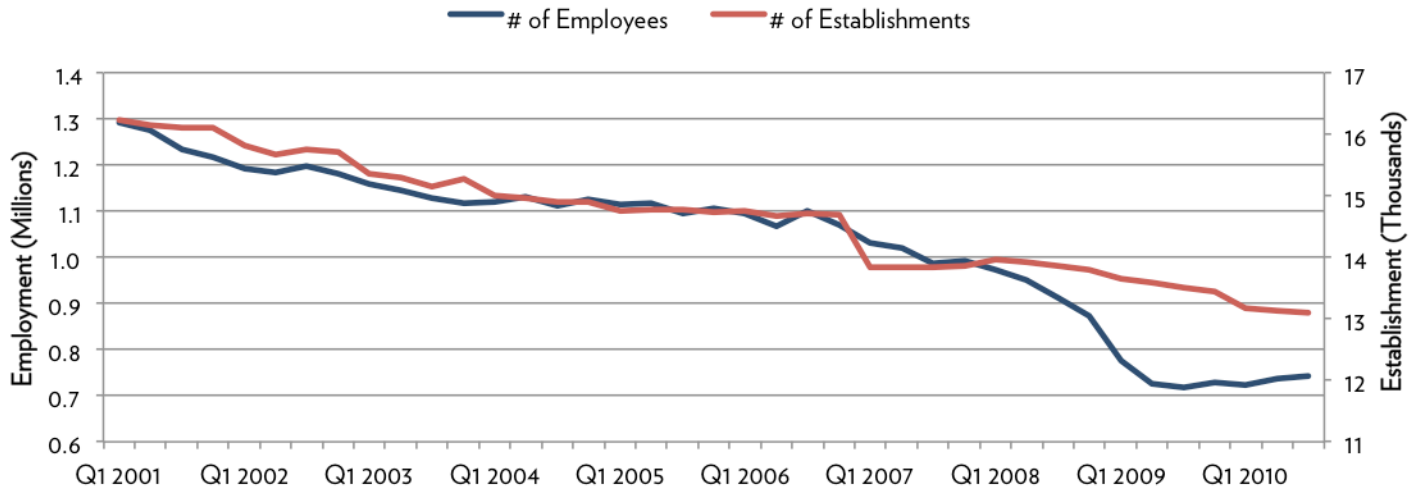
2 "Kaizen" is a Japanese word meaning "continuous improvement," a term commonly used in these firms.

industry snapshot

Before 1980, the Detroit Three automakers (Ford, GM, and Chrysler)—who at the time accounted for 90% of the nation's auto sales—produced and designed many of their own parts in-house. Since that time, they have shifted much of this work to supply chains of financially independent firms that now design and produce about 70% of the industry's parts. The major automakers share these supply chains, creating a "free-rider" situation in which automakers lack the incentives to invest adequately in their supply bases. That is, if an automaker helps its supplier develop a new technology, the supplier's other customers—typically the first automaker's rivals—will enjoy the same improvements without having contributed. As a result, automakers and large suppliers don't have an incentive to make such investments. Rather, they shift costs down the supply chain to weaker suppliers. These practices improve the larger firms' financial performance in the short run, but in the longer run rob the entire supply chain of incentives to invest. Automakers in other countries such as Japan and Germany have avoided this collective problem by developing institutions that govern supply chains. [3]

US auto suppliers have experienced a reduction in both the number of plants ("establishments") and in total employment. Figure 1 shows the overall trend from Q1 2001 through Q3 2010 for plants and employment in industry classifications commonly associated with automotive parts manufacturing.[4] The clear downward trend in establishments started at least a decade ago, and continued steadily through the financial crisis. At the same time, employment dropped sharply when the crisis hit and is only slowly beginning to recover near the end of the period for which data is available.

Figure 1: Employment and establishments in industries associated with automotive parts manufacturing



Source: Quarterly Census of Employment and Wages

To more closely examine the effects of the crisis on Michigan, Indiana and Ohio, we compare trends in employment and establishments between the tri-state region and other states. As illustrated in Figure 2, we observe a general shift away from concentration in the tri-state area; the region contained 41 percent of total US auto parts employment in 2001, but its share had fallen to just 34 percent in 2009. Between 2001 and 2009, employment fell by more than half in the tri-state region, but by just 34 percent in the other 47 states. This trend was reinforced by the crisis, with a 33.6 percent reduction in employment within Michigan, Indiana and Ohio but only a 22.9 percent decrease in other regions.

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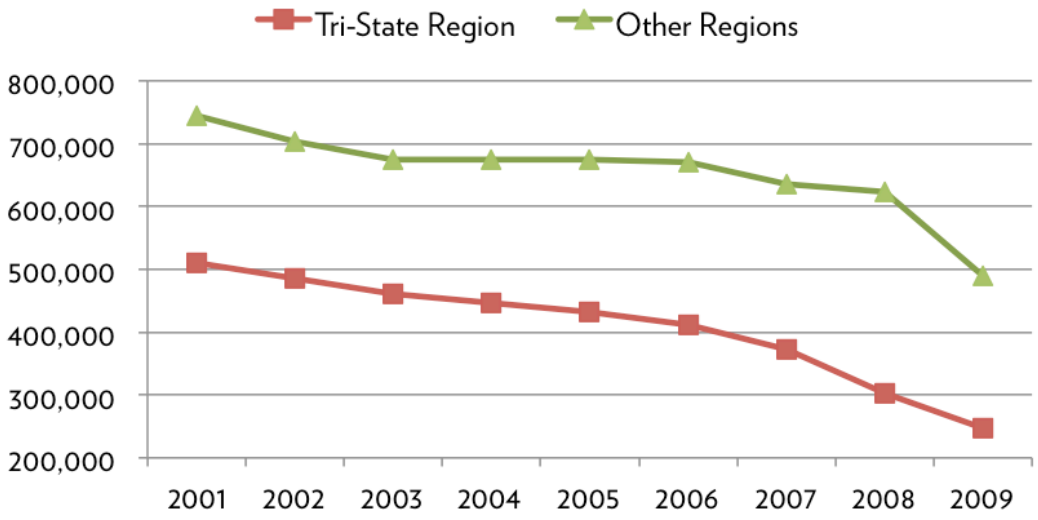
3 See Susan Helper, Challenge and opportunity in the US auto industry: the key role of suppliers. Journal of Industrial and Business Economics, 2, 2011, 51-68. For a more popular treatment, see http://www.thedailybeast.com/articles/2009/06/07/can-price-hikes-save-gm.html.

4 Data reported in Figure 1 is derived from the Quarterly Census of Employment and Wages and based upon the following NAICS classifications: 3363 (motor vehicle parts manufacturing), 336211 (motor vehicle body manufacturing), 326220 (rubber and plastics hose and belting manufacturing) and 326199 (all other plastics product manufacturing). A 2010 publication by the Center for Automotive Research, "Contribution of the Automotive Industry to the Economies of All Fifty States and the United States," helped us determine the NAICS codes most likely to contain establishments that supply the auto industry.

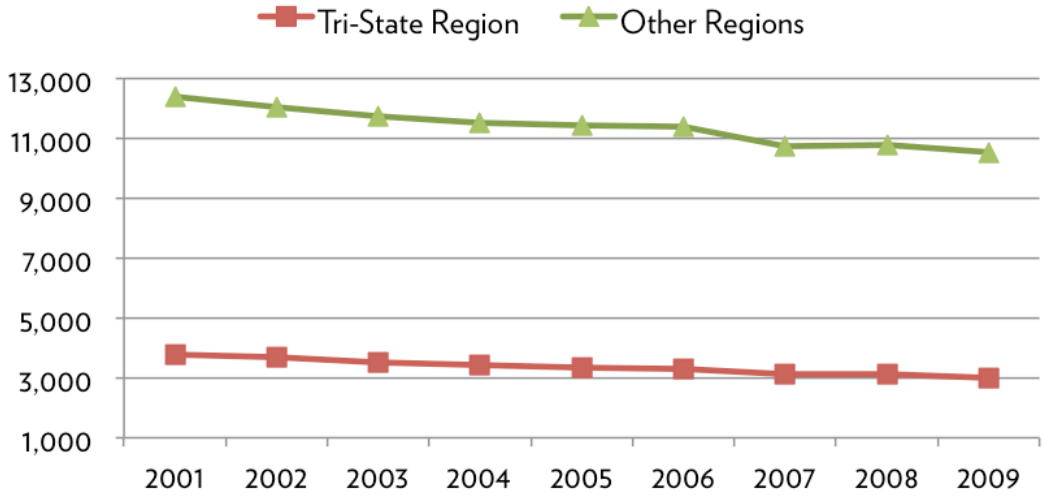
Figure 2: Automotive parts industry employment trends in the tri-state region versus other regions



Source: Quarterly Census of Employment and Wages

Between 2007 and 2009, the number of establishments in these three states fell 3.8 percent, compared with 1.7 percent in other regions. Furthermore, Michigan, Indiana and Ohio were home to only 23 percent of all establishments in 2001 and 22 percent in 2009, suggesting that establishments in these states were generally larger and thus better able to survive employment shocks through workforce reduction. Appendix B presents detailed descriptions of employment and establishments by NAICS classification.

Figure 3: Automotive parts industry establishment trends in the tri-state region versus other regions



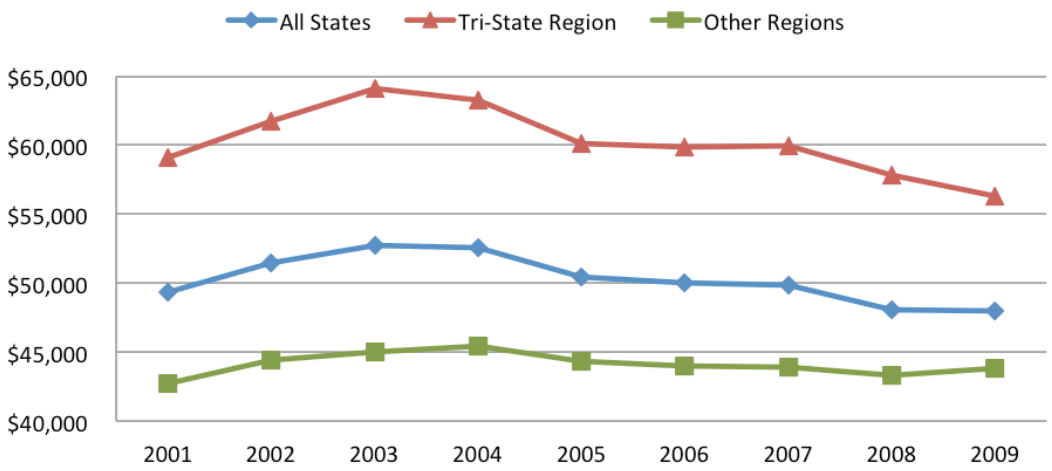
Source: Quarterly Census of Employment and Wages

In contrast to the continuous downward trend evident in both employment and establishments, mean annual pay per employee actually increased moderately at the beginning of the decade before beginning to fall from 2003 onward. Changes in wages were more pronounced in the tri-state region than in other states; during the crisis, for instance, wages in Michigan, Indiana and Ohio declined by an average of 6.1 percent but fell by just 0.4 percent in other states.

Firms in the tri-state region pay significantly higher wages than in other states. We believe that this is driven primarily by the comparatively high density of skilled workers participating in the motor vehicle parts manufacturing (NACIS 3363)

industry in Michigan; the greater prevalence of unionized establishments in the tri-state area is an additional factor. The extent of this wage differential by NAICS is explored in Appendix C. The reasons for the wage differential are explored in section 3.

Figure 4: Mean annual pay per employee in industries associated with automotive manufacturing



Source: Quarterly Census of Employment and Wages

Table 1 presents our employment projections for the four principal segments of the US auto supply chain in 2018. In aggregate, we project that nationwide auto supplier employment in 2018 will fall to 13.6 percent below 2008 levels; in Michigan, Indiana and Ohio, employment will decline by 13.5 percent, 14 percent and 25.3 percent, respectively.[5]

Table 1: Employment Projection 2008-2018

		Motor vehicle parts manufacturing (3363)	Motor vehicle body manufacturing (336211)	Rubber and plastics hose and belting manufacturing (326220)	All other plastics product manufacturing (326199)
National Employment	**2008 Employment**	541.1	61.5	26	298.8
	Change (%)	-18.6%	-7.8%	-15.5%	-5.7%
	Projected 2018	440.5	56.7	22	281.8
Michigan	**2008 Employment**	110.8	6.5	1.3	21
	Change (%)	-15.3%	-8%	-6.4%	-6.4%
	Projected 2018	93.8	6	1.2	19.7
Indiana	**2008 Employment**	59.4	4.4	0.6	19.4
	Change (%)	-18.6%	-7.8%	-15.5%	-5.7%
	Projected 2018	48.4	4.1	0.5	18.3
Ohio	**2008 Employment**	72.3	3.9	3.8	21.0

5 Table 1 projections are based upon Bureau of Labor Statistics 2008-2018 industry employment projections combined with state-level data. Because BLS data is available only at the level of four-digit NAICS codes, we extend these broader projections to six-digit NACIS classifications when applicable. 2008 QCEW employment data is used for base year figures. Available Michigan data did not include 2008-2018 projections for NAICS classifications 3363 and 336211, so 2006-2016 projections were used to compute an implied percentage change for 2018. Additionally, Michigan projections do not differentiate between NAICS 3261 and 3262, so the same percentage change was used in calculating projections for both industries. Finally, because 2008 Ohio employment figures for NAICS 326199 are unavailable in the QCEW, we use 2009 employment figures as a proxy. State level data for Michigan was retrieved from http://bit.ly/jMoj0C; for Indiana from http://bit.ly/knUaS2; and for Ohio from http://bit.ly/iZOCw9.

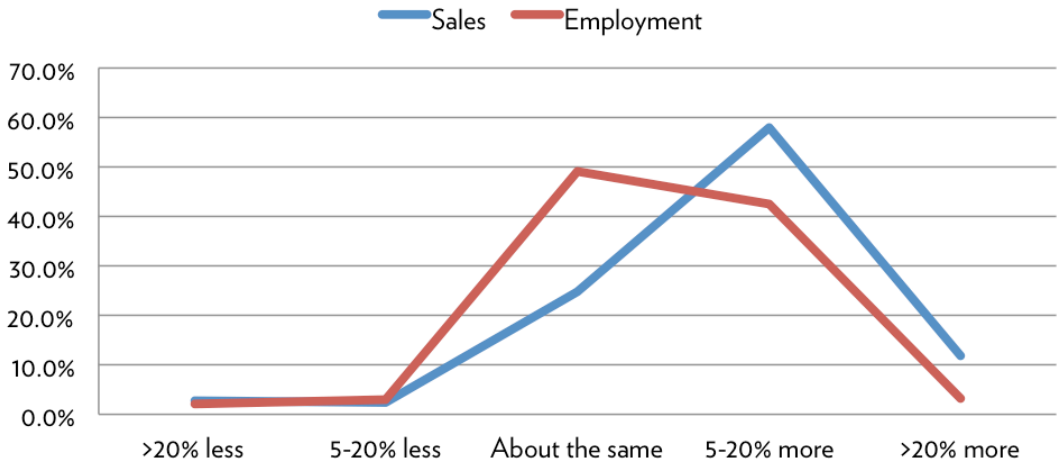
	Change (%)	-28.9%	-24.3%	-24.7%	-14%
	Projected 2018	51.4	3	2.9	18.1

Source: Quarterly Census of Employment and Wages

2.1. Employment trends among survey respondents[6]

The experience of our survey respondents reflects this overall trend, as re-hiring has been careful and conservative during the economic recovery. Although many firms saw sales begin to recover in 2010, employers appear to be concerned about the strength of the rebound and hesitate to re-hire for many recently eliminated positions. For example, our survey shows that about 70 percent of plant managers expect an increase in sales of more than 5 percent in the next 12 months, yet less than half (45.9 percent) expect an increase in employment of equivalent magnitude. Figure 5 shows graphically how hiring lags sales.

Figure 5: Expected sales growth and planned hiring over the next 12 months



2.2. About our Sampling Frame and Survey Respondents

A problem that has plagued research on the auto supply chain is that publicly available data does not provide a good picture of which establishments are currently in the auto supply chain. As we discuss below (and more thoroughly in Appendix A), many firms that supply the auto industry are not found in NAICS 3363 (auto parts) or the 3 related NAICS we looked at above. Conversely, many firms than are in NAICS 3363 no longer supply the auto industry. (Managers of establishments are responsible for classifying themselves into NAICS codes, and typically do not update these codes very often.)

Thus, in order to survey the automotive supply chain, we first had to do a great deal of work to determine which firms we should survey. As Appendix A describes, we first assembled a list of candidate firms and establishments from a variety of sources. We then called each of these, and asked if they currently supplied the auto industry. We defined the supply chain to include not just establishments producing parts (e.g. steering wheels or fuel injectors), but also establishments that produce equipment (production machines, tools, and dies). In addition, we had access to a directory of establishments performing automotive R&D in Michigan, so we included those firms as well. Both equipment producers and R&D establishments have higher skill and pay higher wages; we thought it particularly important to include these in a study of the future skill needs of the auto supply chain. Importantly, establishments performing R&D are classified in a separate NAICS code, even if the output is used primarily by the auto industry. A conservative count of establishments in the Michigan Automotive R&D directory yields are 25,000 employees of suppliers performing automotive R&D in this state

6 See section 2.2 for more information on the population of survey respondents.

alone.[7] Thus, traditional (NAICS-based) analyses of the auto supply chain significantly understate the employment, wages, and skill level of automotive production.

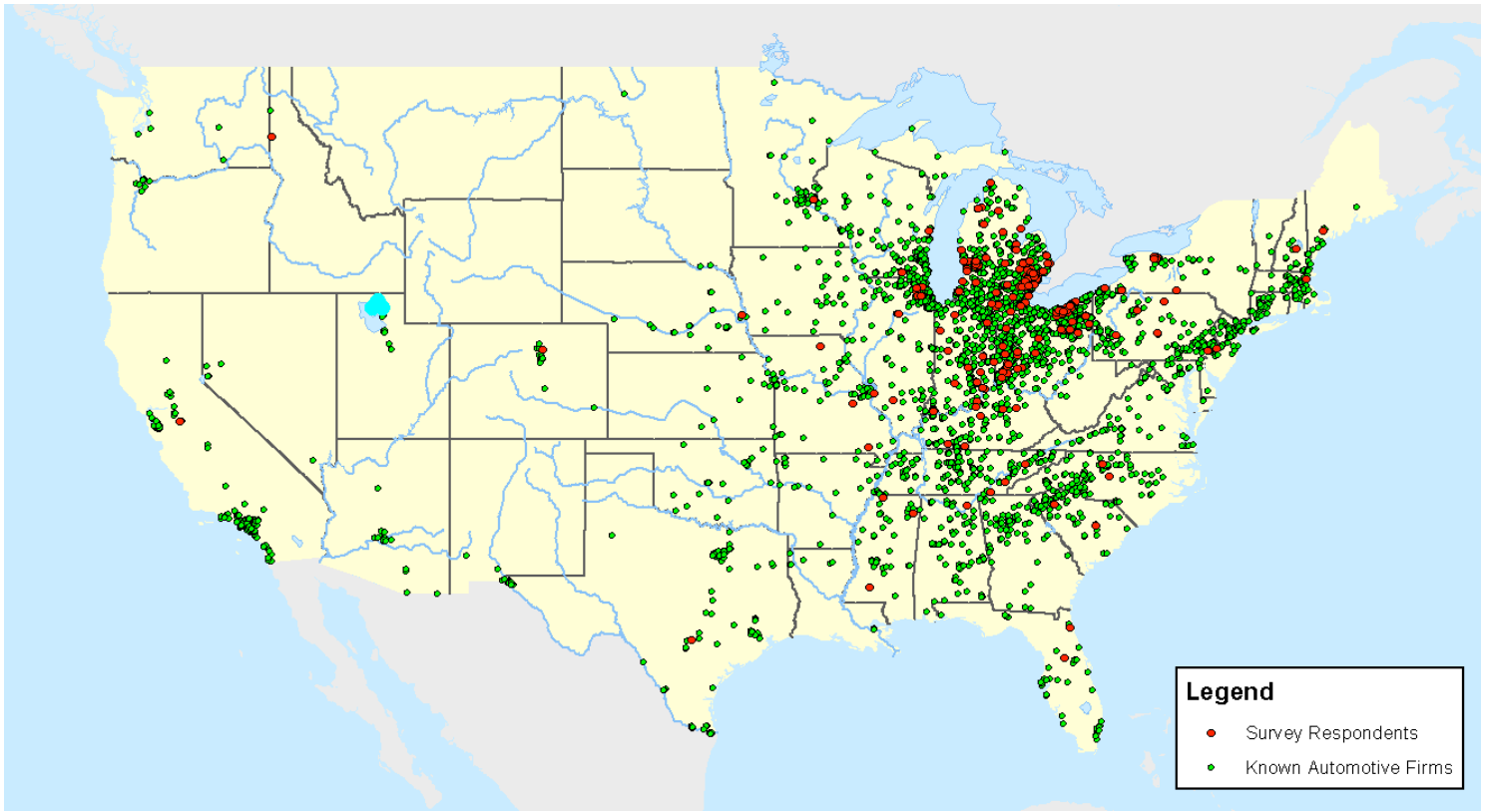
Table 2 gives the proportion of our sampling frame in each NAICS. Note that NAICS 3363 ("Motor vehicle parts manufacturing") accounts for only 37 % of the sample. In addition, a significant proportion (more than half) of establishments that listed themselves as being in NAICS 3363 said when called that they no longer supplied the auto industry.

Table 2: Proportion of sample frame by NAICS

NAICS	Percent
Motor vehicle parts manufacturing (3363)	37.1%
Special die and tool, die set, jig, and fixture manufacturing (333514)	14.3%
All other plastics product manufacturing (326199)	12.8%
Metal stamping (332116)	1.4%
Machine shops (332710)	1.1%
Rubber and plastics hose and belting manufacturing (326220)	0.9%
Motor vehicle body manufacturing (336211)	0.2%
Other industries	32.3%
Total	**100.0%**

To assess how our sample of respondents represents the universe of all plants in the auto supply chain, we map geographical locations of all plants (green) and respondent plants (red) on Map 1, below. The greatest concentration of auto supply chain firms is in Michigan, Ohio and Indiana; similarly, nearly two-thirds of our respondents are from this tri-state region.

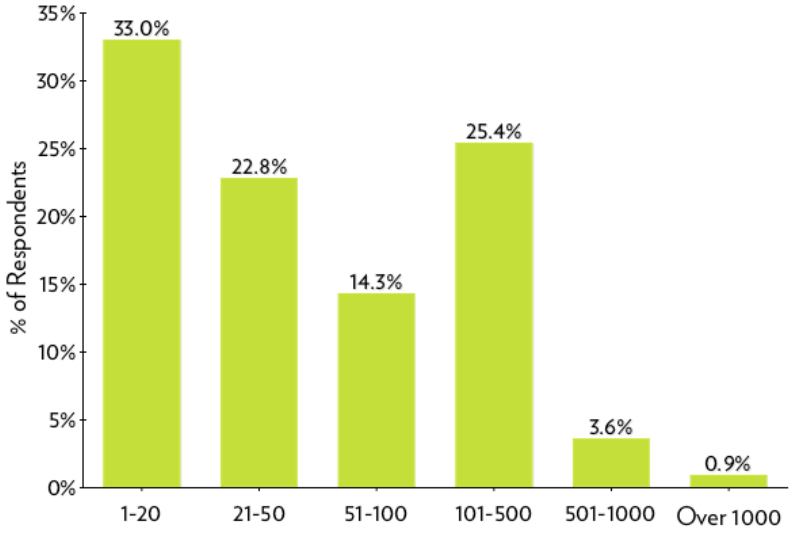
Map 1: Location of automotive suppliers and survey respondents



7 This figure does not include employees at technical centers owned by automakers.

While our survey was distributed to all the firms that we identified in the automotive supply chain, the rest of this report focuses in particular on small suppliers. Much attention has been paid to mega-suppliers such as Visteon, Delphi, Magna, Lear, and Johnson Controls. These firms have many many billions of dollars in annual sales. Almost all of these sales come from direct dealings with automakers. Thus, these firms are "first-tier" suppliers, who purchase from "second-tier" suppliers who in turn purchase from "third-tier" suppliers. We estimate (based on our sampling frame as described in Appendix A) that about 30 percent of the automotive supply chain consists of firms with fewer than 500 employees. Most of these smaller firms do not supply directly to automakers; Tier-1 suppliers (those who do directly supply automakers) comprise just under 25 percent of our sample. Because relatively little is known by researchers and policy makers about these smaller firms, we targeted small and medium sized firms for our interviews. In addition, we interviewed purchasing managers at 7 very large tier-1 suppliers, in conjunction with Bernard Swiecki of the Center for Automotive Research.

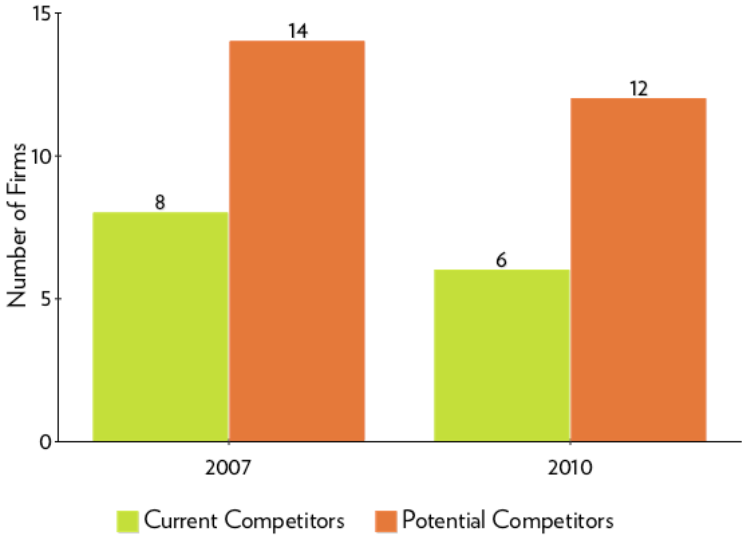
Figure 6: Survey respondents by number of employees



On average, firms surveyed were founded 32 years ago. Figure 6 shows the distribution of respondents' plant sizes; on average, these plants had about 100 regular and 12 temporary employees, though the range of workforce size was between 1 and 1,480. Only 7.8 percent of the sample is unionized.

During the 2008-2009 crisis, most of the firms in our sample cut their workforces; 41.6 percent reduced employment more than 20 percent and another 13.4 percent cut between 0 and 20 percent. For workers, the impact of such layoffs can be substantial depending on their ability to find new employment. Most workers at firms surveyed (90 percent) have at least a high school education and are middle-aged (average 40.4 years old).

Figure 7: Number of competitors and potential competitors in 2007 vs. 2011



Among firms providing information on the number of plants they operate, nearly two-thirds (65.7 percent) indicated that they had only a single facility. About half of the firms surveyed (51.6 percent) are family-owned and 20.8 percent are also family-run. Private equity groups control 14.6 percent of responding firms, while just 5.2 percent are publicly traded.

Most firms do not depend on the auto industry as their main source of business. Almost 30 percent of firms do less than 10 percent of their business in the automotive industry, while less than half rely on the auto industry for more than two-thirds of their sales.[8]

8 Because sales of autos fell so much more sharply than did sales in other industries, this degree of auto dependence is significantly less than it was in 2007.

2.2. Trends in industry structure

The decline in establishments over the past decade has also resulted in greater concentration within the auto supply chain. This trend was not entirely offset by a rise in global competition; our survey respondents reported a decline in the number of competitors between 2007 and 2011. We asked firms about the number of competitors also supplying their key product to the same customer as well as the number of firms potentially able to supply a similar product without major investment. Figure 7 shows a reduction over the period 2007 to 2011 from 8.2 current competitors to 6.3 and from 13.5 potential competitors to 11.8. Consolidation has benefited the remaining firms in the market, as we might expect, with many firms reporting better customer relations (discussed later in this report). Their customers, on the other hand, are mixed in their reaction to consolidation. In interviews with tier-1 suppliers, some express concern about higher prices set by the few firms left.[9] On the other hand, other firms feel that healthy suppliers are important to their own long-term health.[10]

9 Firms 24 and 25

10 Firms 23 and 26

long-term firm strategies

how product, operations, and human resource policies interact

To analyze the strategies of firms in our sample, we employed the technique of cluster analysis. Cluster analysis is a systematic approach to identifying groups of similar observations; the goal of the analysis is to construct groups with minimal variation in practices within the group and maximal variation between the groups.[11] Using information on firms' operational and human resource management strategies, we discern four groups of firms. Table 3 presents components used for and the final clusters from cluster analysis.

We characterize the first group of firms as "*engineering-intensive*." These firms employ a large number of engineers and a lower number of skilled trades workers. They are typically R&D facilities or machine builders, performing engineering-intensive non-repetitive tasks. These firms pay higher wages than firms in the other groups because of the level of skill employed. These firms are also more likely than average to implement quality circles[12], as well as have a greater degree of formal training in continuous improvement. Interestingly, the number of suggestions per employee is relatively small at these firms.

Engineering-intensive firms also engage in somewhat more thorough employee selection compared with other firms. That is, they report that they screen new employees a bit more than average to ensure that they have knowledge of specific equipment, fit with firm culture and overall aptitude. Conversely, these firms do not tend to develop a system of succession planning or career counselling that facilitates employees advancing internally, perhaps because engineers expect to advance by moving to a new company.

We characterize the second group of firms (about 30% of our respondents) as *"craft skill."* These firms have the largest proportion of skilled trades workers. Many of these firms make tooling; these are complex implements that form a product in a press. Many of these shops are quite versatile; they can make tools that allow automakers to produce both a door panel (a large part whose surface is seen by customers) and a bracket (a small part that customers may never see, making surface finish not so important). Despite their level of skill, these firms engage less than average in most formal improvement activities (such as quality circles and training in improvement methods). These firms do a bit more promoting from within than average.

To use the typology of Luria and Wiarda[13] these firms are "distinctive" in their capabilities --they can make products and use materials that are hard for others to imitate. However, they are not "systematic"; they typically don't have structures in place that allow them to methodically identify weaknesses and improve them.

One of our interviewees exemplifies the craft skill firm.[14] A tooling company with broad capability, it nonetheless faces intense competition from China (which provides large subsidies to the tooling industry). To compete with off-shore locations, this firm is focusing on enhancing its already-impressive expertise in computer-aided design and in producing tools that can yield high-quality parts from newer, lightweight materials whose properties remain something of a black art. The firm is also beginning to improve its scheduling capability to reduce lead times (currently it does not always deliver products more quickly than its Chinese rivals).

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11 Specifically, we used the k-means clustering technique, aiming to partition our survey respondents into k clusters, in which each respondent is assigned to the cluster with the nearest mean. The k-means clustering technique produced four clusters as the best solution (i.e, the value of k that produced the highest Calinski/Harabasz pseudo-F value (182.6). Therefore, our discussion is based on this four-cluster solution.

12 Quality circles are cross-functional groups of employees that meet regularly to discuss process improvement. These are discussed more fully in section 6.2, on process improvement.

13 Daniel Luria and Edith Wiarda, "Performance benchmarking and measuring program impacts on customers," Research Policy, 1996, 25, 233-46.

14 Firm 29

At the opposite end of the spectrum, the operations of low-road firms or "*clever cost cutters*," are primarily driven by low-wage, semi-skilled workers; the proportion of skilled workers and engineers is much lower than average. Though many employees of clever cost-cutting firms also received some formal continuous improvement training, they participated in quality circles and autonomous team meetings at a much lower rate and produced a much lower number of suggestions for improvement. Indeed, across all human resources indicators, cost cutter firms consistently performed the worst (see Table 3, below). About a quarter of our respondents fall into this category.

While clever cost-cutters make cuts to the workforce and forgo equipment investment, as cost cutting implies, they also apply practical knowledge to innovate in small yet lucrative ways. One of our interviewees[15] developed manufacturing processes using existing equipment to win new business that their customer had previously sourced in China. They produced higher quality than their Chinese competitor and offered better delivery terms as a result of their closer proximity to the customer. In a separate example, the firm's mechanics also cobbled together a new machine out of two old ones and won business in consumer products and health care markets.

Another firm[16] employs low-skill workers from a local high school and has a plant characterized by medieval-looking open boiling vats. However, it has the country's largest-capacity vessel for applying metal protectant, allowing it to serve geographically diverse customers. Other cost-efficient practices include a process for monitoring and maintaining chemical levels using custom real-time adjustments rather than pre-packaged mixes. This firm also makes custom fixtures to maximize throughput and manages subcontractors for its clients to reduce delivery times.

These cost cutter firms tended to survive the crisis by trimming costs rather than transforming their operations. Indeed, one interviewed firm[17] detailed a process they had themselves dubbed "clever cost-cutting"—reducing fixed costs, finding ways to substitute stamped parts for cast parts and capitalizing on low labor costs through decreased automation. While such models allowed firms to survive, the unintended consequences of these cost reduction strategies include increased vulnerability to low-wage overseas labor and limited future investment and growth.

Finally, 37 percent of our respondents fell into what we term a *"Kaizen"* model, named after the Japanese approach to management in which employees at all levels are involved in continuous improvement efforts. If the model is implemented fully, decisions are made for the long-term rather than immediate-term and firms enjoy such positive outcomes as agility to implement new products and processes quickly, and ability to influence the firm's future direction. Workers benefit through access to more robust skill sets, better wages and improved job security.

Kaizen firms' employees tend to be more actively engaged in quality circles than average, receive formal training in continuous improvement and greater number of suggestions for improvement. Thus this group acts in a way most consistent with a Toyota-style approach, though even this group's level of adoption of such policies remains shockingly low, as we discuss in section 6.2.

One of our interviewees[18] is a sheet-metal stamping firm whose main customer is a Japanese-owned firm that helped the firm implement Kaizen systems, invest in information technology and install sensors to help manage inventory and manufacturing processes. To survive the crisis, this firm made the deep cuts in personnel that many other firms made, but also had a healthy cash position going into the crisis, built up over the years of profitability. This firm is a model of systematic practice as defined above. It is not as distinctive as the "craft" firms; it does not design its own products or use exotic materials; many firms can make the products it makes, though not with the price or defect rates that the firm's systems allow it to provide.

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15 Firm 18

16 Firm 5

17 Firm 18

18 Firm 1

Table 3: Human resources cluster analysis[19]

Components	Engineering-intensive (7%)	Craft (31%)	Kaizen (37%)	Cost cutter (25.2%)	Total
% of skilled workers	6.5%	42.2%	19.9%	5.4%	22.1%
% of engineers	43.8%	9.6%	4.9%	2.5%	8.5%
Weighted wage ($)	32.5	20.6	15.3	11.0	17.0
Number of suggestions per employee	0.5	0.8	0.6	0.4	0.6
% of employees who attended quality circle/autonomous team meetings in the last six months	27.8%	18.7%	25.1%	13.3%	20.4%
% of employees who have received some formal training in continuous improvement	28.2%	25.0%	26.1%	25.1%	25.7%
Succession planning	2.8	3.4	3.0	2.4	3.0
Promotion-from-within	2.9	3.5	3.4	2.6	3.2
Employee selection	3.7	3.5	3.9	3.3	3.6

Our cluster analysis suggests that there are several successful operations and human resources strategies that firms can adopt to survive. We are also interested in the implications of these strategies for firms' financial and workforce performance. As indicators, we consider sales growth between 2007 and 2010 and absenteeism and turnover rates, respectively; figures 8 and 9, below, report these results.

We reliably find that clusters paying higher wages and having the most highly-trained workers fared the best. That is, engineering intensive firms do best, followed in order by craft, kaizen, and cost-cutter firms. This finding is consistent with the view that firms can prosper by adopting a high-road production recipe in which firms, their employees and suppliers work together to generate high productivity. The key to the success of a high-road recipe is to harness everyone's knowledge—from production workers to top executives—to produce high-quality innovative products. Even low-level workers, have much to contribute because they are close to the process: They interact with a particular machine all day, or they observe directly what frustrates consumers. Through coordination with highly skilled workers and suppliers, firms achieve high rates of innovation, quality, and fast response to unexpected situations. The resulting high productivity allows firms to pay fair wages to workers and fair prices to suppliers while still making fair profits.

A high-road recipe is consistent with systematic and/or distinctive operations. As mentioned above, Toyota's production system calls for workers to be engaged in problem-solving.[20] The high level of education and training found in the "engineering" and "craft" clusters helps workers be creative in a way that enhances both firm productivity and worker ability to bargain for a share of the pie they helped create. It is possible to combine both systematic operations and distinctiveness, though few firms did.[21]

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19 To measure succession planning, we asked firms to indicate their level of agreement with the statement: "We do succession planning to make sure we will have enough trained workers for each occupation over the next several years." Similarly, to measure internal promotion, we asked survey respondents to indicate their level of agreement with the statement: "We frequently provide advice to individual employees about how they could advance within our company." Both questions are coded on a 1-5 scale, with 1 indicating "Strongly Disagree" and 5 indicating "Strongly Agree." Employee selection is measured by the mean value of screening intensity indicated by respondents for "knowledge of specific equipment," "fit with our culture" and "overall aptitude," with 1 indicating a firm that "screens significantly less intensively than average" and 5 indicating a firm that "screens significantly more intensively than average."

20 Though as we discuss in section 6.2, some firms use some of the tools and much of the language (e.g. "lean production") in a way that does not empower workers.

21 Kristin Dziczek and Jay Baron outline a way that automakers and tool shops could work together to create repeatability and schedule stability that would allow tool shops to become systematic, but few shops have done this (http://www.cargroup.org/documents/WorldClassToolShopFINAL.pdf).

At right are our findings about the relationship between high-road firms and performance. We find that these firms enjoyed on average the lowest decline in sales between 2007 and 2010, while low-road firms were faced with the highest decline. A similar pattern is seen in absenteeism and turnover rates, with high-road suppliers reporting the lowest rates. In both sales growth and workforce performance, engineering-intensive firms were superior to high-volume suppliers.

Figure 8: Absenteeism and turnover by cluster

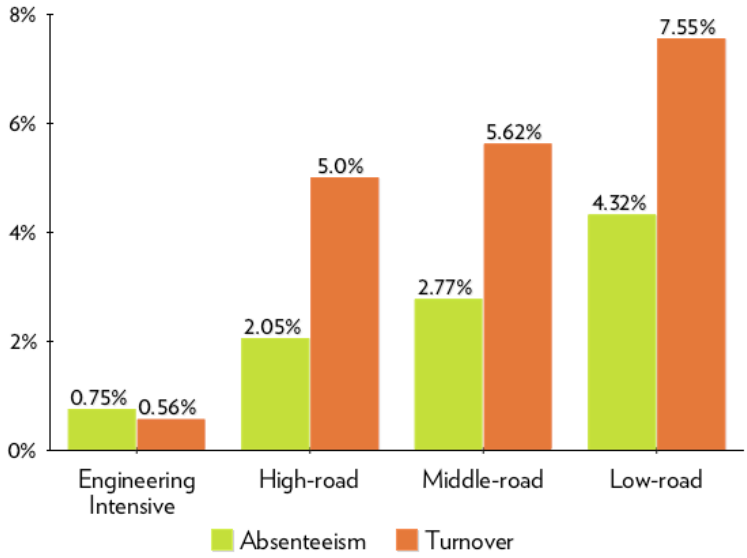
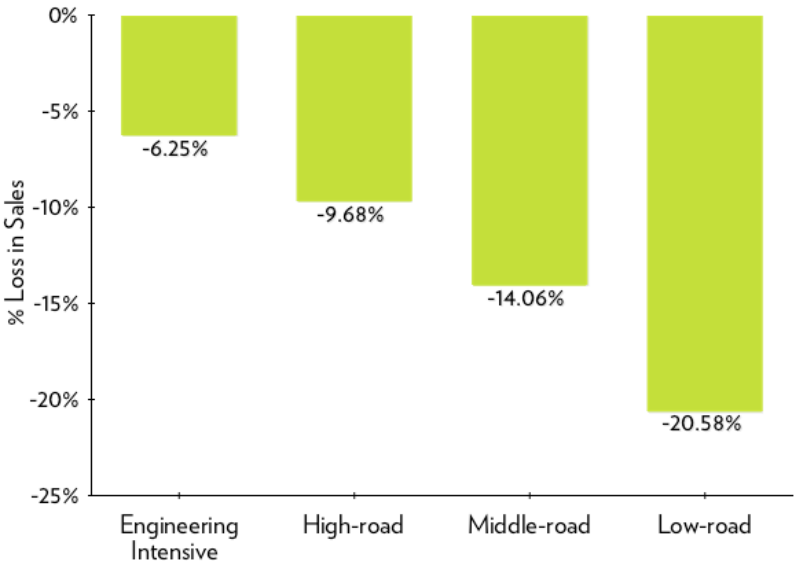


Figure 9: Sales growth between 2007 and 2010 by cluster



Our results regarding the performance of different practices are only suggestive; in future research we will perform more rigorous tests. However, these results are consistent with a large body of careful research. For example, a study of steel-finishing lines by Casey Ichniowski, Kathryn Shaw, and Giovanna Prennushi found that firms with high-road practices had 6.7 percent more uptime (generating $2 million annually in net profits for a small plant) than did lines without them. The increase in uptime is due to communication and knowledge overlap. In a firm that does not use high-road practices, all communication may go through one person. In contrast, in high-road facilities, such as plant 30, workers solve problems more quickly because they communicate with each other directly in a structured way[22].

A key point to note is that firms in even the same narrowly-defined industry may compete very differently, as Luria and Wiarda (op. cit) also find. For example, there are automotive stampers who compete against each other for the same work in three of the four clusters (i.e., all but the "engineering-intensive" cluster). The more high-road firms are able to offset their higher wage costs by such means as greater uptime and by suggesting how they could add performance-improving features to the product. Wages of direct labor are less than 10% of total cost for almost all stampers (steel is 60-70% of total cost). For this reason, even if a firm paid its production workers twice what another firm paid, the higher wages would be more than offset by a 10% increase in revenues, a not implausible increase from having more motivated, longer-tenure workers.

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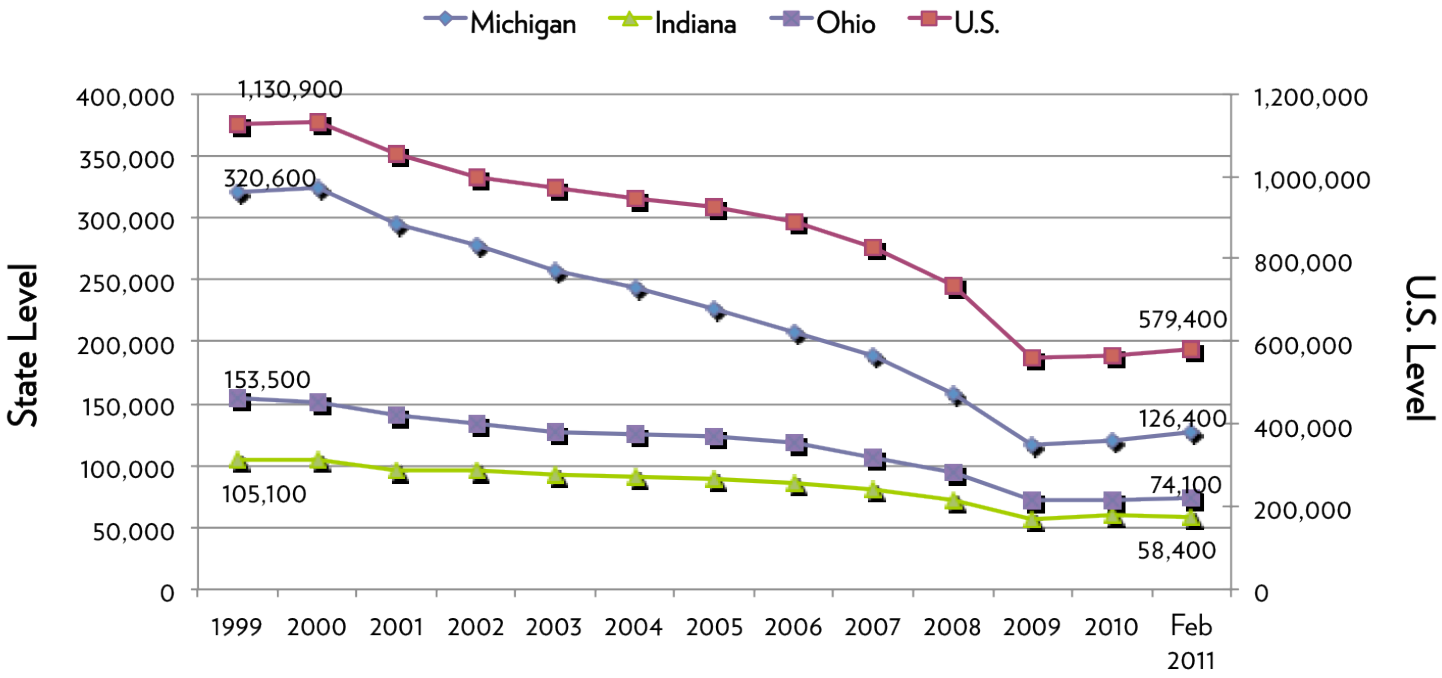
22 For a review of this literature, see Appelbaum, Eileen, Jody Gittell, and Carrie Leana. "High-Performance Work Practices and Sustainable Economic Growth." Employment Policy Research Network Brief. April 2011. http://bit.ly/qlkXmv.

Figure 10: Motor vehicle and parts manufacturing employment by state



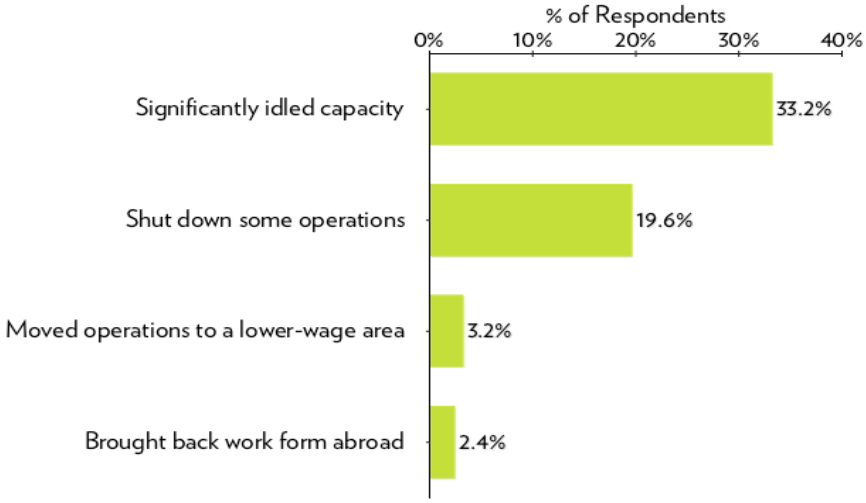
response to 2008-2009 crisis

While the decline in employment and establishments was already ongoing for over a decade when the financial crisis occurred, the period just before the fall of 2008 was one of expansion. Interviewees reported difficulty meeting surging demand in 2007-8 and expressed frustration with having to hire less-than-qualified workers then . When the crisis hit, firms employed a variety of tactics to weather the downturn. Our sample is necessarily biased towards survivors as only surviving firms were around to take our survey. Thus the responses to the crisis observed in our data are all strategies that are consistent with firm survival. (However, as we shall discuss, the fact of short-term survival does not mean that these strategies are optimal for firms, workers, or society.)

In our interviews of tier-1 supplier purchasing managers, they reported less-than-expected impact on business during the financial crisis, measured both in their own ability to meet the needs of their customers and in the ability of their suppliers to remain viable.[23] While there were certainly supplier bankruptcies, there were fewer than top-tier suppliers expected. That said, going forward, these firms were concerned about consolidation among suppliers which is already leading to higher input prices[24] and about supplier unwillingness to increase capacity.[25] Our interviews and analysis of government and survey data all suggest a consistent picture of the capacity squeeze. (See Figure 10 for representative data, for motor vehicle parts producers (NAICS 3363). Firms in this industry cut employment 25-30% in early 2009 and had not restored many jobs by spring 2011, leaving employment in the industry down by about 20% compared to mid 2008. However, light vehicle sales recovered more quickly; in mid-2011 they were only 12% below their level of mid 2008. As a result of the extremely tight capacity (especially in the lower tiers, existing workers were working a lot of overtime), some first-tier suppliers reported having to increase inventory levels in order to meet production schedules; several also reported rising defect rates in the parts they received from their lower-tier suppliers.

Our qualitative and quantitative research shows that not all the firms used the same strategies to survive the crisis in 2008-09. While only 12.1 percent of the firms in the sample report no significant changes to their business, the majority of plants implemented a variety of survival strategies. This section summarizes the responses to the auto crisis focusing on operations, employment and investment.

Figure 11: Changes to Operations



4.1. Production Response

First, as demand dropped suddenly, more than a third of firms were forced to idle plants, with almost a quarter of firms shutting down a portion of their operations. In the short term, at least, price does not seem to have been a factor, as only a tiny fraction of firms shifted work around geographically. Also, idling capacity and shutting down some operations, does not seem to have affected firms' recovery, as neither is correlated with profitability or sales growth.

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23 Firms 6, 23, 26

24 Firm 24

25 Firm 6

4.2. Employment Response

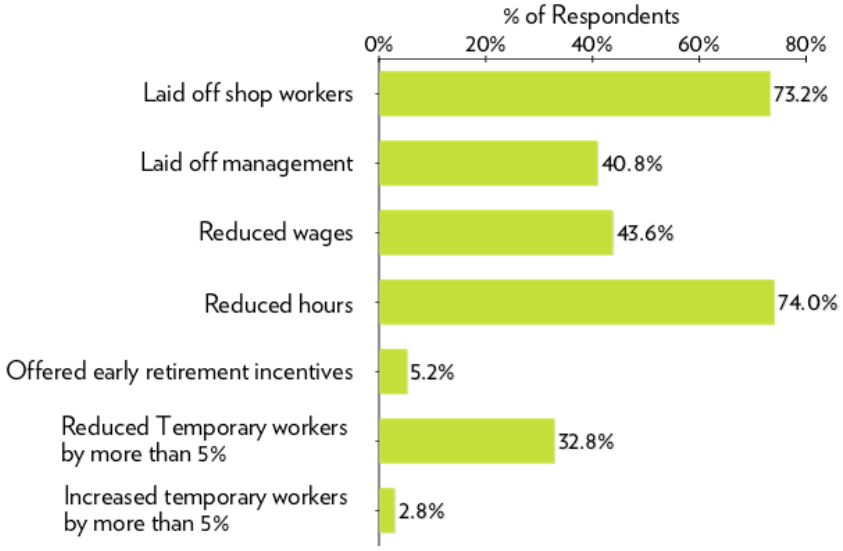
In response to the dramatic fall in auto sales in 2008-9, 73% of our respondents laid off production workers (as Figure 12 shows). About 40 percent of firms laid off managers. Laying off production workers (but not managers) correlates with slower sales growth, suggesting firms may have been hurt by laying off too many workers. Temporary workers seem to have served as a buffer against layoffs, as more firms cut temps than hired them. 74.0 percent reduced working hours in order to avoid layoffs, but 82% of these firms ended up doing layoffs as well. Only 21.3 percent of firms avoided both layoffs and short working hours.

4.3. Financial Response

One of the most severe and immediate consequences of the national banking crisis was a sudden contraction in bank lending economy-wide. Several interviewees reported having credit dry up overnight. One theme that emerged throughout multiple interviews was that credit problems added an element of randomness to the crisis, causing some seemingly robust firms to falter unexpectedly. As one tool and die maker explained about peer companies that had recently gone out of business,

> *"These are four companies that I respected and as of 2000 they were some of the leaders in our industry. They were all very capable, well established and well financed for most of their history. They had a highly skilled workforce, modern equipment and the latest technology. Ten years ago no one would believe that they would all four fail to survive."*[26]

Figure 12: Changes to employment in response to crisis



As Figure 13 shows, almost two-thirds of our survey respondents reported reduced access to credit.[27] While 38 percent of respondents said they would not have invested even if they had gotten credit because of the decline in sales, diminished credit caused many firms to cut back significantly; 43 percent of those whose access to capital was reduced cut back their operations as a result of the credit crunch; 44 percent reduced their investment. Meanwhile, firms that experienced a problem with credit continued to drive down costs; reduced access to credit is correlated with a firm's ability to reduce costs.

4.4. Investment Response

A matter closely related to the financial response to the crisis is firms' investment response. Several interviewees said they would have a difficult time justifying any investment that would not pay for itself within six months.[28] Another manager, who had had his eye on a new ERP package, decided to postpone that investment until business improved.[29] A change in

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26 Firm 29

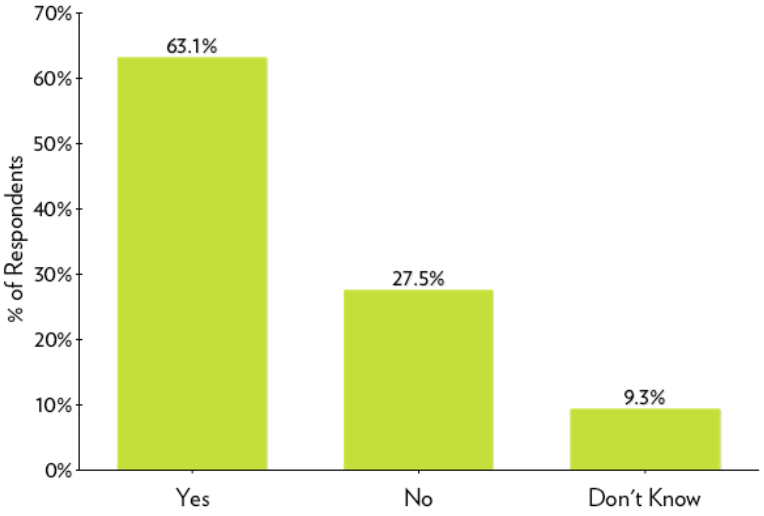
27 To measure access to credit, we asked survey respondents: "During the auto crisis of 2008-2009, was your firm's access to capital reduced?" Answer choices are indicated in Figure 13, below.

28 For example, Firms 9 and 22.

29 Firm 7

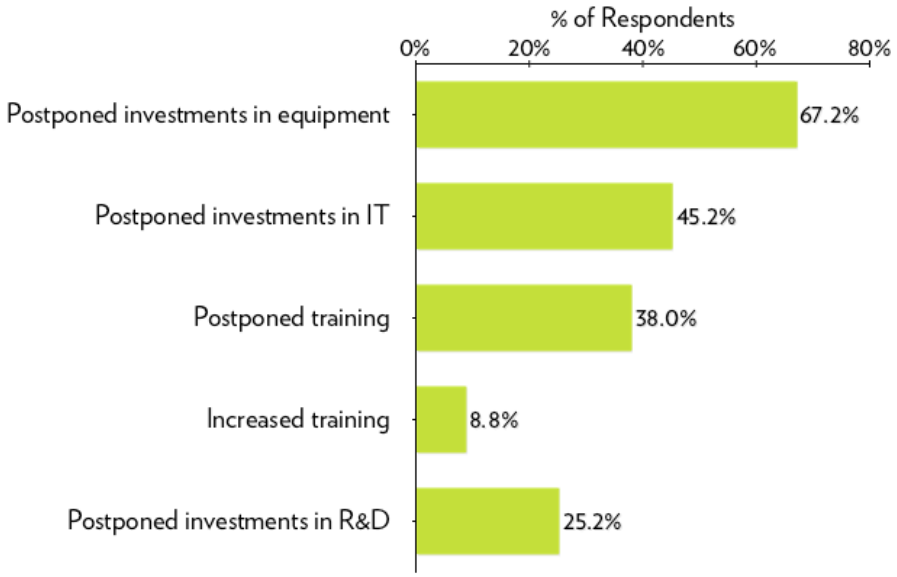
investment strategy appears in our survey, as well. Most of our respondents postponed investment in production equipment (67.2 percent) and IT (45.2 percent); firms that postponed equipment investments were also less profitable.[30] While most firms also put research and development (R&D) and product development on hold, postponing R&D investment does not appear to have hurt firms at least in the short run, as postponement of R&D spending is correlated with slightly faster sales growth. A small fraction of firms, just 8.8 percent, increased investment in training.

Figure 13: Access to capital



While deferring investment during a downturn seems reasonable, it might not be efficient. According to our interviews, some lower-tier suppliers invested less than they could have done because their customers would disapprove of their level of debt. OEMs and tier-1 suppliers were understandably wary of doing business with highly leveraged lower-tier suppliers and would pull their business from suppliers they felt were over-leveraged.[31] One concern, however, is that firms that borrowed for sound business investments, such as workforce training or process improvements would be treated the same as firms making unsound investments, thereby deterring good investments along with the bad. (To read more about bankrupt firms, please see Appendix D.) In theory, a downturn is an excellent time to make investments in training, because workers are not needed for immediate production. However, the depth of the crisis and lack of pre-planning for such an eventuality meant that managers were too busy to organize such training, and/or lacked the cash to continue paying workers.

Figure 14: Changes to investment strategy in response to crisis



4.5. Attitude Toward Crisis

Finally, attitudes towards the crisis differed widely among managers. In our interviews, several managers expressed the belief that swings in demand were common and to be expected. A few even felt that the crisis provided an opportunity to implement long-needed changes and to compete for "take over work" from former competitors that went out of business.[32] Some firms predicted that the crisis would have a long term negative effect; at least in the short run, they seem to be correct as these firms have experienced slower growth during the recovery.

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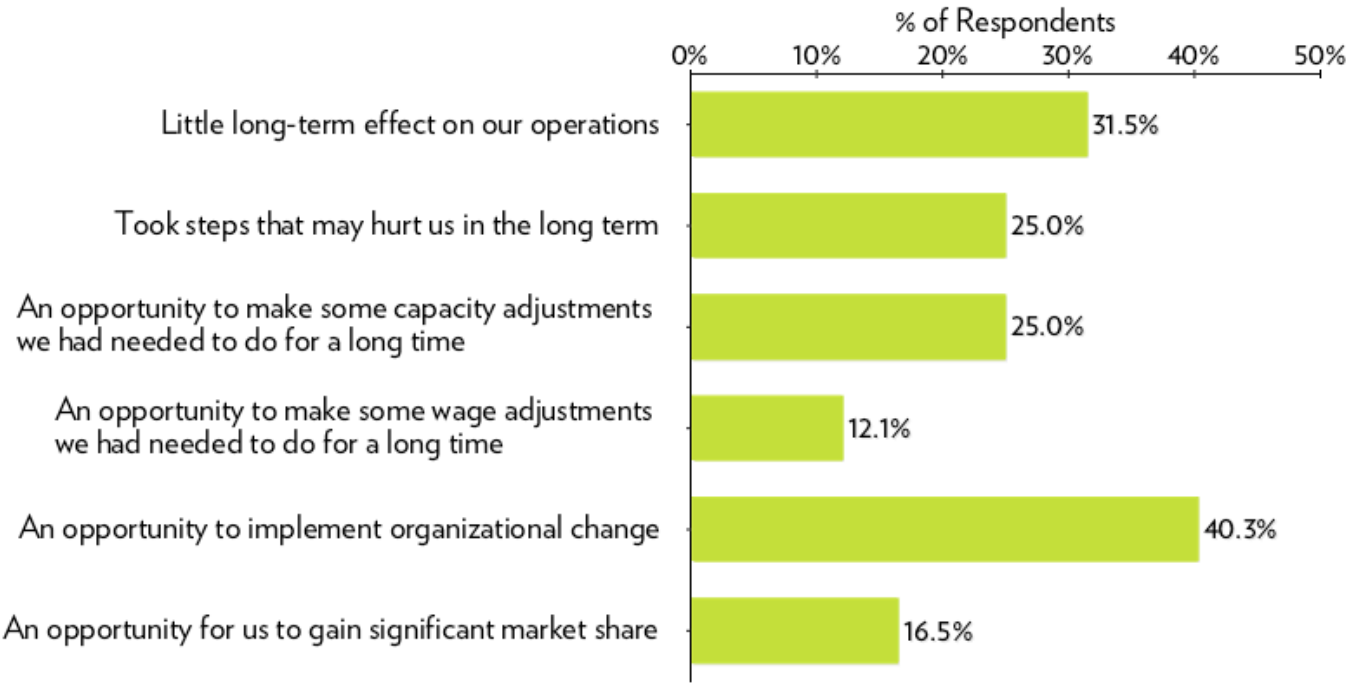
30 It is possible that causality runs the other way; firms that were profitable in the past had cash to invest. In future research, we will examine this possibility.

31 Source: Tier-1 interviews

32 Firm 9

While 31.5 percent of the firms indicated that the crisis had little long-term effect on operations, 25 percent expressed worry that their actions may result in long-term ill effects. On the other hand, significant numbers of respondents also thought of the crisis as opportunity to make some adjustments for capacity (25 percent) and wages (12.1 percent), to implement organizational change (40.3 percent) and to gain significant market share (16.5 percent).[33]

Figure 15: Impact and attitudes towards crisis



33 Percentages do not sum to 100 because respondents were asked to "check all that apply."

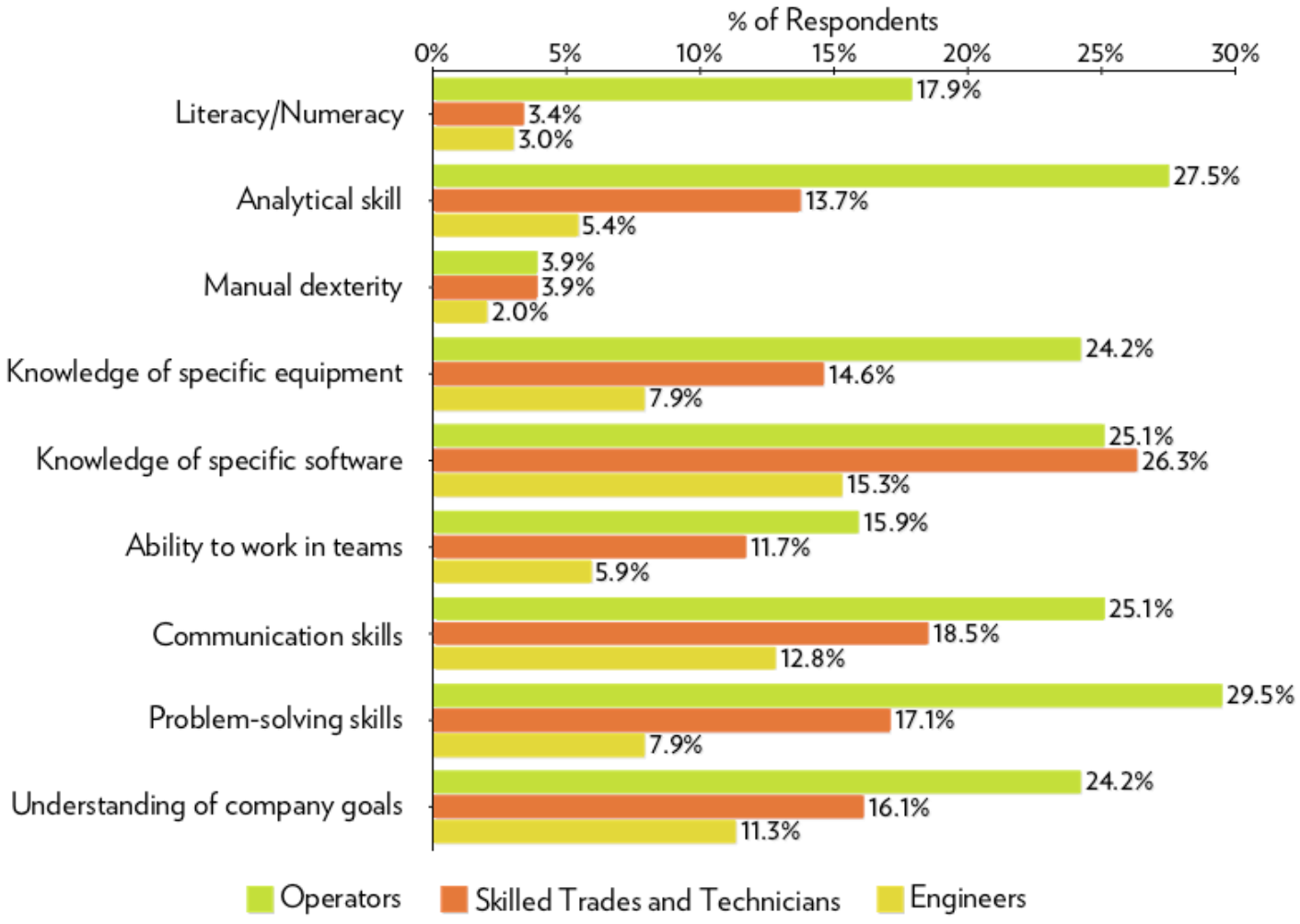
skill availability + hr practices

Changes in the US auto industry can create shifts in demand for skills. Ongoing advances in automation, IT, and exotic materials; reduced bargaining power of unions; slowing domestic demand for autos; changing customer purchasing strategies; and increased sourcing of materials and sub-assemblies from overseas are all factors that are reshaping the automotive workforce. As we discuss below and in the conclusion, technical advance alone does not determine job content. Factors such as managerial visions and incentive structures within and between firms have an important influence on what skills firms demand, and on what skills are available. Thus it is incorrect to say that in the future, technology "will require" a certain level of skill. It may be that a technology is socially beneficial, but market failures prevent or slow its adoption. If the forces we describe that lock many parts of the US supply chain in a low-skill, low-investment equilibrium are not addressed, we may well observe such an outcome, with a smaller auto industry and lower-paid, lower-skill workers as a likely consequence.

5.1. Skilled Trades and Technicians

Our survey asked human resources managers about perceived skill shortages for three types of workers: operators, skilled trade workers/technicians and engineers. Figure 16 shows that management reports that skill shortages among employees at the higher end of the skill spectrum are less prevalent; we will discuss these first.

Figure 16: Proportion of firms anticipating difficulty finding workers with indicated skills by job classification



According to our interviews, a couple of factors can account for this relatively low reported skills shortage among trades workers. First, as noted above, firms have been outsourcing high-skill jobs, such as tool and die-making, to lower-wage countries like China, reducing demand for these skilled trades within the US. Specifically, our survey indicates that 56.9 percent of tool and die plants have off-shored some work as a response to the crisis or beforehand, whereas 41.6 percent of non-tool and die plants respondents have done so. Tool and Die plants have off-shored to high wage countries (41.2%) such as Western Europe and Japan, to low wage countries (41.2%), and to both high and low wage countries (25.5%).[34]

A second reason that management may be unlikely to perceive shortages in the short or medium term is that managers have gotten used to a situation in which the industry is shrinking faster than workers are retiring. Thus, many firms in the tristate area have closed their apprenticeship programs, because "we can always find experienced workers off the street."[35] Many of these firms simply are not looking very far ahead; they sometimes depend upon long-serving employees who are regarded as indispensable and who are expected to remain employed for the foreseeable future. Even in cases in which particular workers are described as invaluable, active succession planning is rare (as we discussed in section III).

A related phenomenon is the movement of high-skill jobs from the Midwest to the Southeast. While Midwestern factories were closing during the recent crisis, foreign automakers were opening new factories in the Southeast. Our research indicates that many of these new plants drew skilled labor from the Midwest. In reference to the high-skill labor at his new plant in a Gulf state, one supplier explains that

> *"Typically the people with the highest mechanical competency without being degreed, like in the trades, they would come from the Midwest: Ohio, Michigan, Indiana."*[36]

The crisis has altered such dynamics; access to high-skill labor was a larger problem for Southeastern plants before the most recent economic downturn. When foreign automakers began opening factories in South Carolina earlier in the decade, for example, the available skills did not match what the companies expected, given their operations policies. Trained to serve the needs of naval shipyards, the available workers required training specific to electronics or other automobile-related work. As a result, firms launched both in-house training programs and training programs in cooperation with community colleges. Such initiatives have not only closed the initial skills gap in South Carolina, but have produced enough high-skill workers to make the state attractive to new aerospace manufacturing.

More recently, however, there is some indication that skilled workers recruited from the Midwest have reduced or eliminated the need for the kind of community college training programs used earlier to create workers in the skilled trades. This suggests that while in-house and community college training programs are effective, they are more costly than recruiting existing workers with skill and experience. Southern firms now display a preference to recruiting existing talent from elsewhere. For example, one firm we interviewed in the South[37] has a community college classroom building across the street from its factories, but now recruits workers from the Midwest rather than hire locally and train them at the facility across the street.

We compute a reported skill shortage index based on the number of skills that surveyed human resources executives indicated many of their employees lack, with zero representing no reported skill shortages and eight representing reported shortages in all skill categories measured in our survey. Map 2 uses this index to depict average reported skill shortages for skilled labour, by county, in the tri-state region of Michigan, Indiana and Ohio.

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34 However, these jobs are also sufficiently complex that off-shoring can be more difficult, time-consuming and costly than firms initially expect. Thus, even as quality increases at off-shore locations, some high-skill work remains on-shore and some initially outsourced work eventually returns to the United States. Interviews conducted as part of our research by personnel from Polymer Ohio confirm that firms are increasingly interested in bringing mold-making back from China for these reasons.

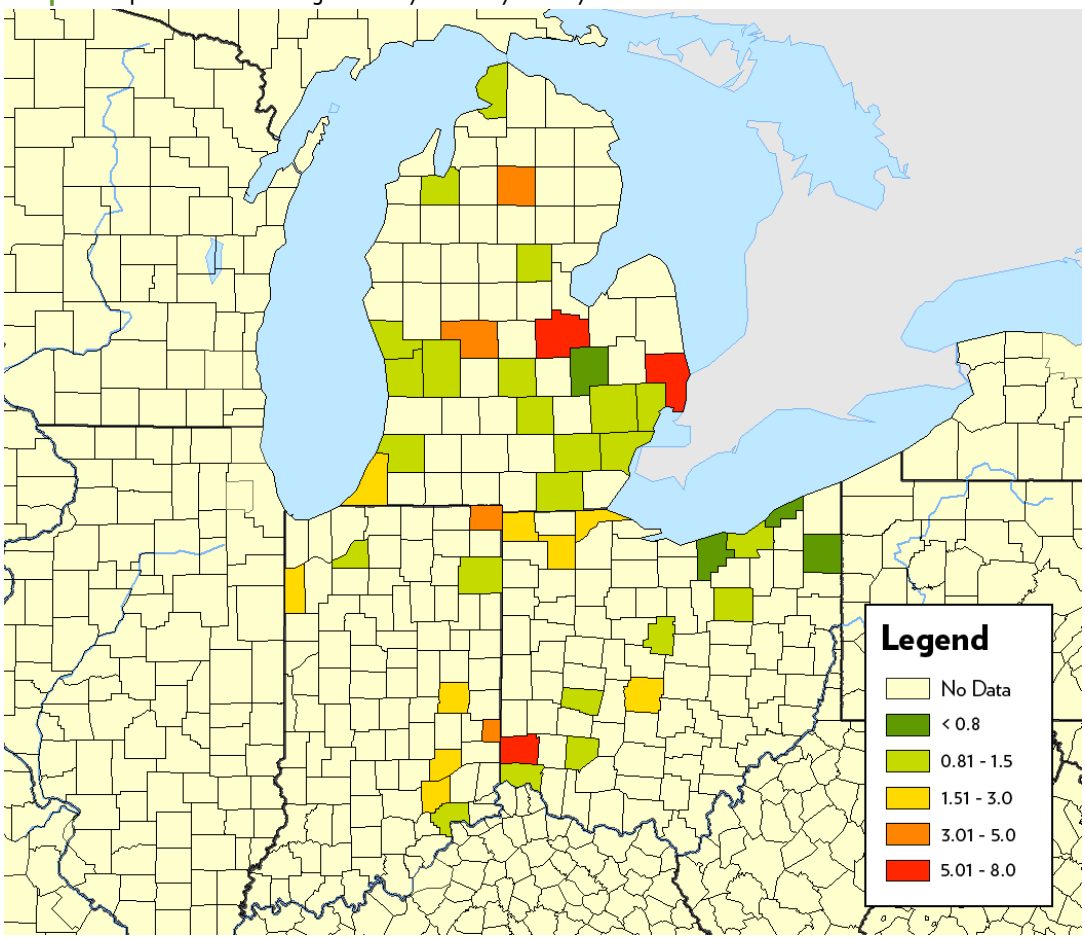
35 Firm 7

36 8-24-10 interview transcript.

37 Firm 17

The map shows that in most traditional auto producing areas (the areas around Cleveland, Youngstown, Detroit and Lansing) managers report only moderate skill shortages. (On average managers feel the skilled tradespeople they employ lack at most 1 of the skills listed above). Shortages are worse (managers perceive their tradespeople lacking 1.6- 8 skills) near Toledo and Cincinnati and in newer auto-producing areas in central Michigan, Indiana and central Ohio. We have less survey data for the southeast, but with the exception of southern Kentucky, managers are confident that employees have the skills they need.

Map 2: Reported skill shortage severity index by county: skilled labor

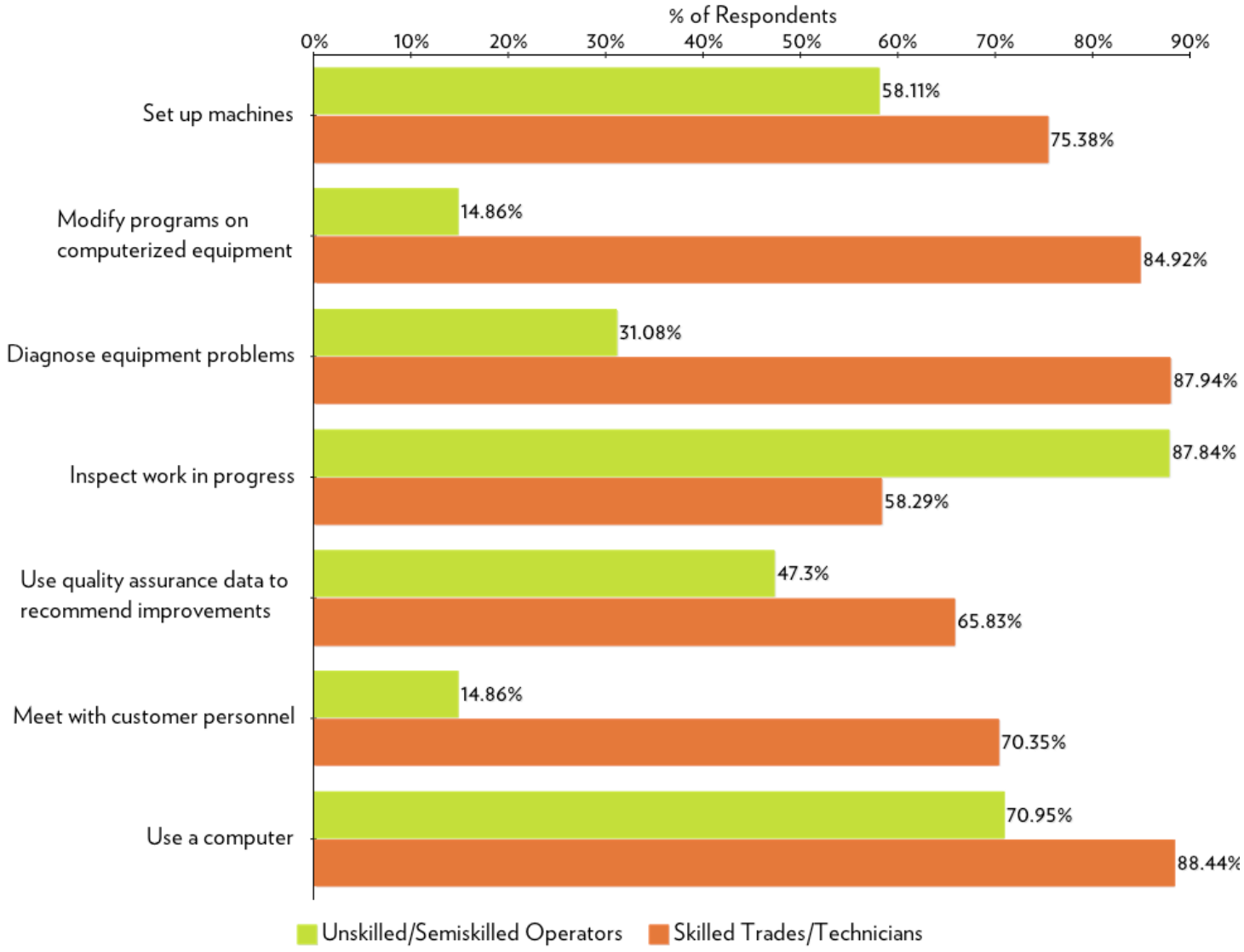


5.2. Production Workers

Perceived skill shortages are greatest at the lower end of the skill spectrum. As shown in Figure 16, such skill shortages for production workers are less pronounced among basic skills such as manual dexterity (3.9 percent) and literacy/numeracy (18 percent) than they are among: advanced skills such as analytical skill (27.5 percent) and problem-solving skills (29.5 percent); knowledge of specific equipment (24.2 percent) and software (25.1 percent); and relational aspects among workers, including communication skills (25.1 percent) and understanding company goals (24.2 percent).

Moreover, many plants have adopted computers in ways that have changed job requirements for shop floor workers. Figure 17 shows the range of tasks assigned to production workers by skill level. All of the tasks, except inspection of work in progress, are assigned more frequently to skilled workers and technicians than to unskilled or semi-skilled workers. Skilled workers and technicians are frequently asked to use a computer, diagnose equipment problems and modify programs on computerized equipment, while unskilled workers are assigned work-in-progress inspection, using a computer and machine set-up.

Figure 17: Responsibilities of skilled and unskilled workers



Our data also show that the wage for low skill workers is correlated with difficulty in hiring qualified workers. In other words, firms that are willing to pay more are more likely to find qualified workers. Some of our interviewees wanted to find workers who would work in a hot environment, lift parts and have 10th-grade math skills -- all for a wage less than the local McDonald's offered. Table 4, below, lists hourly wages by skill level and shows the wide range of wages offered.

Table 4: Hourly Wage by Occupation

	Unskilled & Semi-Skilled	Skilled and Trades	Engineers
Minimum	7	10	11
Mean	12.6	19.3	28.8
Median	12	19	27
Max	20	36	100

As with skilled trades and technicians, systems for hiring and training vary regionally. In the Midwest, our interviewees said that their firms expect to conduct all hiring processes and some basic skills training internally, sometimes connecting with local public schools to recruit and train students for work after graduation. Although there are exceptions, Midwestern

firms are generally not investing much in advanced training for production workers, as these firms assume they will be able to find workers who already possess these skills.

In contrast, we see state government taking over much of the traditional in-house human resources function for firms operating in the Southeast. One firm described state-run manufacturing programs in Alabama and Georgia as offering a litany of free services. This firm was attracted to these states' willingness to tour potential plant sites by helicopter; provide training videos and other training materials tailored to the relevant type of work; run job advertisements in newspapers; conduct initial hiring of production workers; and conduct basic introductory training for the resultant hires.[38]

In tandem with this trend, our survey data indicates that workers in Michigan, Indiana and Ohio earn higher wages on average than workers in the other 47 states. The firm-wide average hourly wage in these three states is $17.90, whereas the firm-wide average for the rest of the country is $1.80 lower, at $16.10. This wage gap is present but less pronounced among semi-skilled workers, where we find a modest but statistically significant difference of $0.90 per hour ($13.00 in Michigan, Indiana and Ohio versus $12.10 in the rest of the country).

At least six factors likely play a role in these regional wage differences. First, firms in Michigan, Indiana and Ohio may be comprised of more skilled laborers and engineers. Next, regional differences in the cost of living may contribute to these wage variations. Third, firms in these three states may, on average, occupy higher positions of the automotive supply chain, as they are geographically closer to Detroit. Higher positions on supply chains may afford them higher profit margins and higher wages. Fourth, the average worker in these three states may be older. Fifth, our data indicates that firms in Michigan, Indiana and Ohio are over three times more likely to be at least partly unionized than firms in the other 47 states. The rates of unionization in our sample are 12 percent for firms in Michigan, Indiana and Ohio and only 3.5 percent throughout the rest of the country. Finally, our data also indicates that 92 percent of employees in Michigan, Indiana and Ohio have a high school education, whereas 85 percent of employees in other states do. Thus, it seems that Midwestern firms paying market wages have sufficient access to production workers, whereas Southeastern states have adapted by increasing the role of government to take over previously private-sector activity. In neither region do many firms prioritize investment in training for production workers.

Table 5, below, shows the number of hours of training workers received in a "typical (non-crisis) year." While the average amount of training seems fairly similar across worker type (25.3 hours for managers to 32.7 hours for unskilled workers), the variation among firms for each type of worker is quite large. For example, unskilled workers in the bottom quartile get just 4 hours a year on average, while those in the third quartile get 40 hours, a difference of a factor of 10. Even this higher level of training is often inadequate to improve skills; in many industries (such as stamping), government-mandated refresher safety training by itself is nearly 40 hours.

Firms that do a lot of training do so at all levels, as training is positively correlated among skill levels. And while training by itself did not correlate with greater sales growth during the recovery or higher profitability, training of unskilled workers was correlated with the share of a firm's business in the auto supply chain.

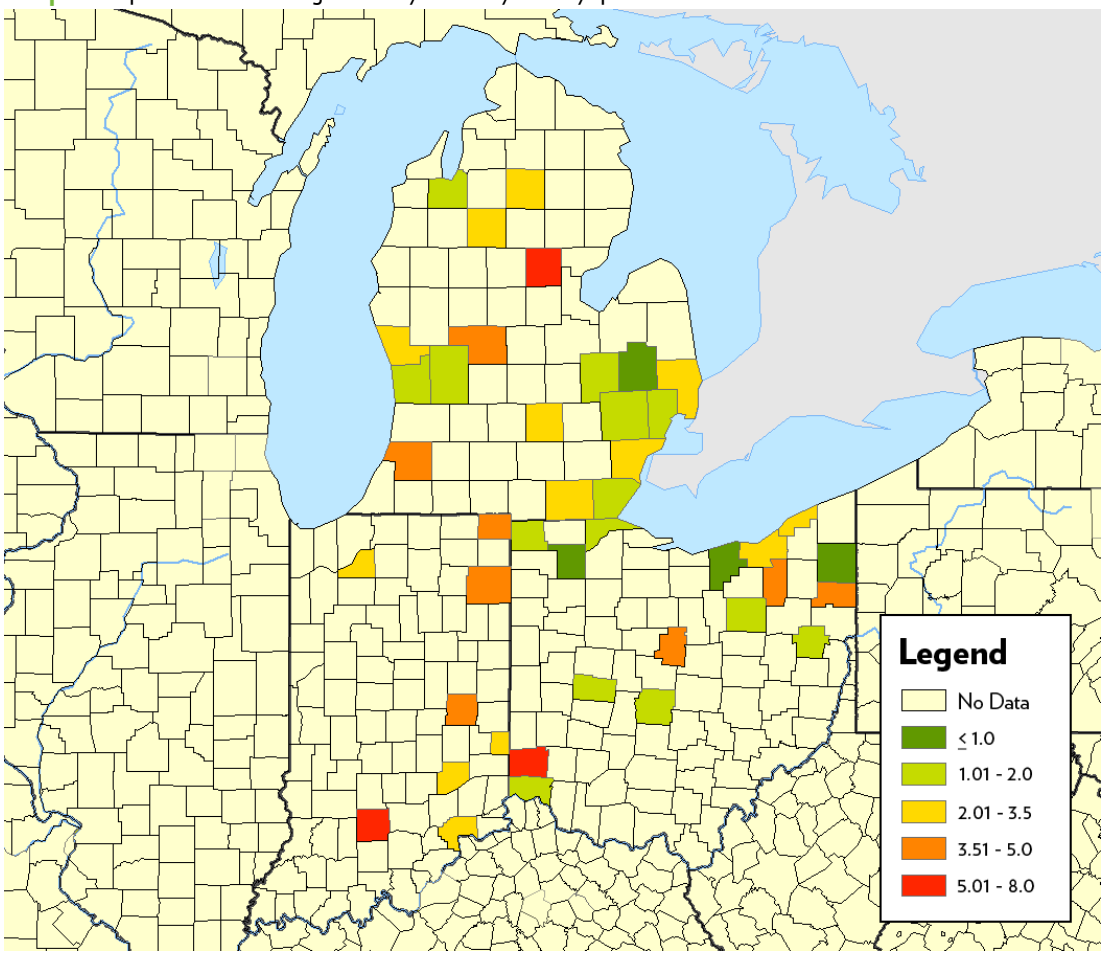
Table 5: Hours of Training by Occupation

	Unskilled & Semi-Skilled	Skilled and trades	Engineers	Management
Minimum	0	0	0	0
Mean	32.7	30.1	26.2	25.3
Median	15	20	10	10
Max	1,000	500	500	500

38 Firm 1

Map 3, below, illustrates reported shortages of overall production worker skill, by county, for the tri-state region of Michigan, Indiana and Ohio. Although the perceived shortage are more severe, (on average firms feel their production workers lack more than two skills) the story is broadly similar to that for skilled trades, in that most traditional auto-producing areas perceive their workers as more qualified than do managers in new areas.

Map 3: Reported skill shortage severity index by county: production workers



5.3. Engineering Skill

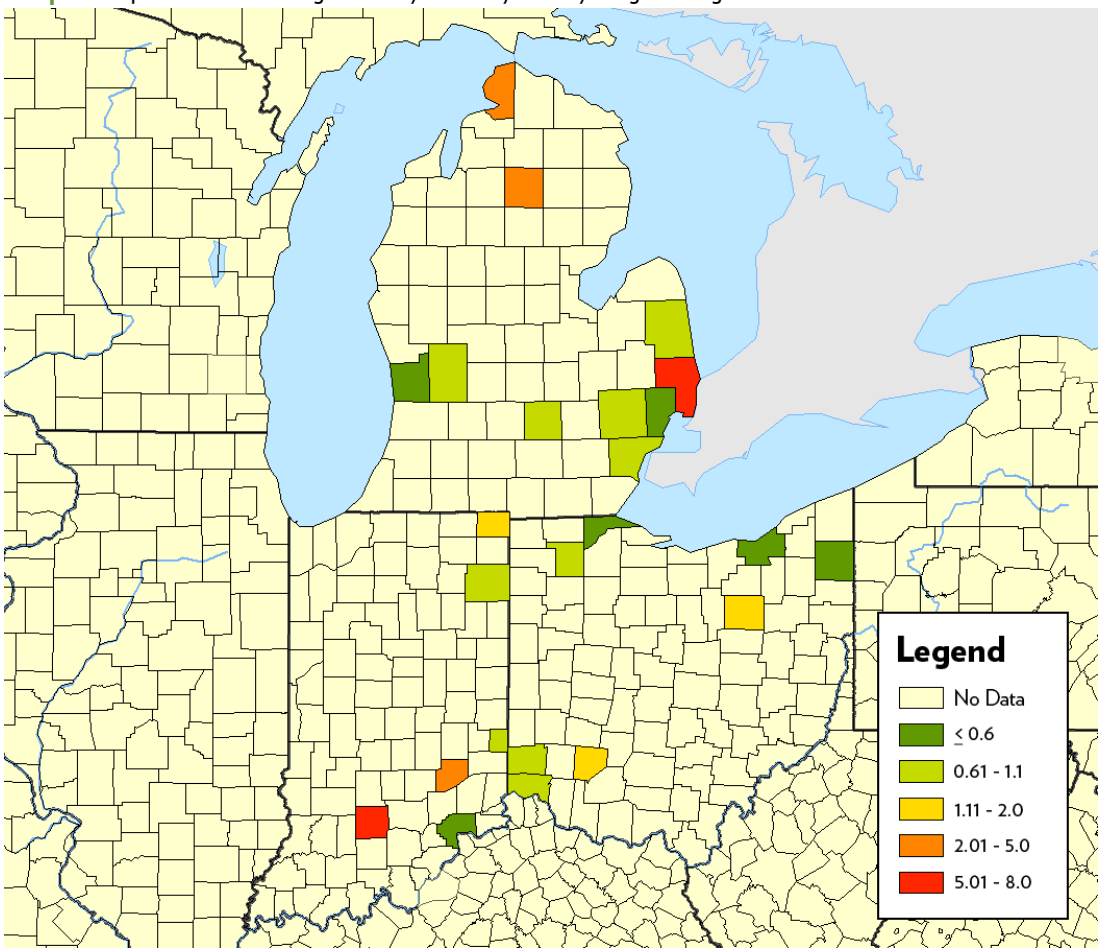
We might have expected to see newer technologies present a skills problem among workers with scientific and engineering backgrounds, yet we instead found that firms were able to recruit workers with bachelor's, master's, and doctoral degrees from local higher education institutions. Local public universities and colleges seemed capable of supplying firms with the necessary skills, such as chemistry and material science skills for the tire industry.[39] To supply burgeoning industries like fuel cells, existing firms applied their existing technologies to meet the needs of new clients.[40] That is, even where production technology or client technology was new, managers believed that they had found ways to apply existing expertise (or in some cases to acquire new expertise) to meet this new demand. On the other hand, however, some firms did not report skill shortages simply because they had not updated their practices or products in a way that would demand new skills. For example, firms that required workers to inspect their own work were more likely to find fault with the basic skills of their production workers.

39 Firm 9

40 Firm 7

Map 4, below, shows reported shortages of overall engineering skill by county for the tri-state region of Michigan, Indiana and Ohio.

Map 4: Reported skill shortage severity index by county: engineering skill



5.4. Managerial Skill

For the first time in recent memory, many firms (40.8 percent of our sample) laid off managers, albeit reluctantly. We sensed that employers felt that replacing these workers later would be difficult, possibly because existing workers were acquainted with the processes, procedures, systems and workplace culture and any new hire would have to go through the costly process of learning it all from the start. Thus, while certain administrative functions (such as payroll) were readily outsourced[41], others involving greater interaction with the firm's business (such as human resources or sales and marketing) were not. Instead, in some cases, many of these workers were retained, often at reduced hours or wages and sometimes put to work doing production.[42]

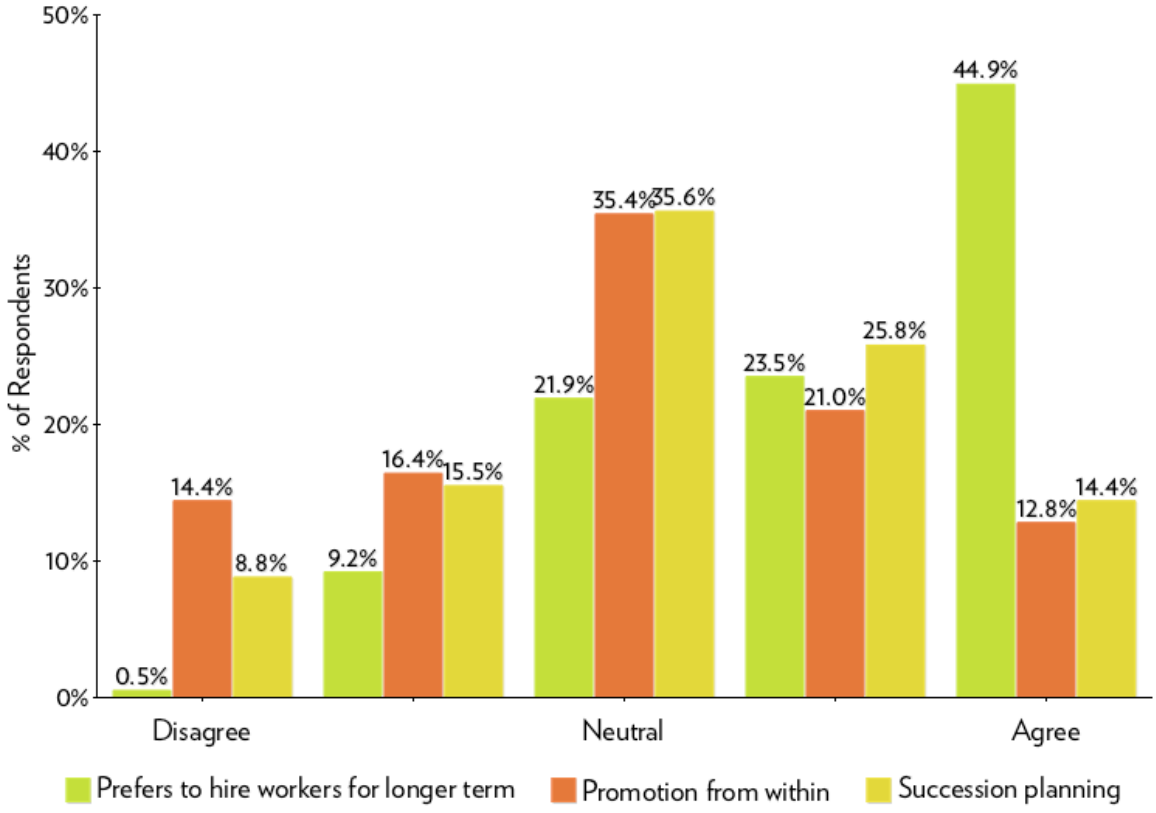
41 Firm 7

42 Firm 10

5.5. Progressive HR Practices

Figure 18, below, illustrates how firms utilize three HR practices: hiring workers for the long-term, succession planning and promotion from within.[43] Of these practices, a majority of firms reported wanting to "hire workers who wish to stay with our company until retirement." Promoting from within and doing succession planning are highly correlated with each other, and are less common than hiring workers for the long term. Thus, there is some inconsistency in HR practices in most firms: they prefer long-term employees, yet do not help their workforce to construct a career path within the company. However, this inconsistency did not appear to hurt firms in the short run; firms with progressive practices generated neither higher short-term profitability or faster growth during the recovery.

Figure 18: Use of progressive human resources management practices



43 To discern preferences related to long-term workers, we asked surveyed firms to indicate their level of agreement with the statement: "We prefer to hire workers who wish to stay with our company until retirement." Refer to footnote 18 for further details on survey questions used to measure succession planning and internal promotion initiatives.

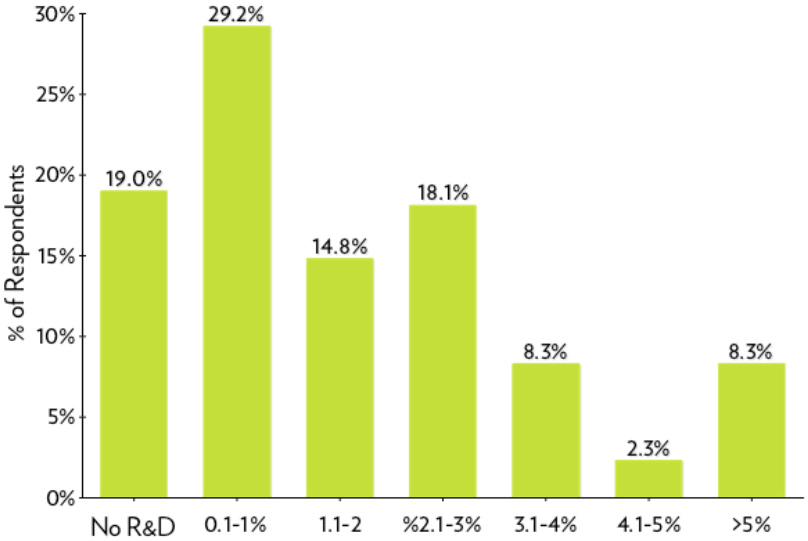
innovation, investment and green

6.1. Product Innovation

Most of the firms we interviewed eschewed the term "innovation" as too sophisticated to describe their on-going efforts to reduce cost and remain competitive. For example, one fairly typical firm[44] seemed to be constantly developing and extending its process. A stamper (a firm whose main line of work is to transform flat sheet metal into shaped parts by "stamping" it under pressure) developed the ability to stamp very thin material. Additionally, for a non-auto customer, they adapted their generations of experience with metal tooling to cut plastic. Expanding also into welding, the firm developed a way to make an auto part using two stamped pieces that it joined together. The welded assembly replaced a more costly cast part that its customer was importing from a low-wage country. The experiments and development of new processes are carried out by the same engineers and technicians that maintain existing production lines and develop its traditional tooling, which helps explain why the firm lacks careful formal accounting of research and development (R&D) as a separate activity.

While we suspect under-reporting, or under-accounting, of spending on R&D in general, some firms we interviewed are not only conscious of their R&D activities, they apply for federal R&D tax credits[45] or government grants to manufacture components for "green" electric vehicles[46]. In figure 19, which shows R&D spending as a percentage of sales, four in five respondents claim to spend at least some money on R&D-- but only 8% of respondents spend more than 5% of sales. In some cases, these firms were doing cutting-edge work that generated many patents. For example several firms we interviewed are engaged in nanotechnology; another had licensed technology from a national lab to heat up metal and spray it in precise form; implementing the technology at larger than lab scale required a large number of process changes.

Figure 19: R&D spending as a percentage of sales



To estimate innovative activity, we asked several other questions relating to cost reduction (figure 20) and the percentage of sales from products that include some innovation by the firm (figure 21). Because commodity prices increased over the period 2009-2010, it is not surprising that over a third of respondents report higher unit costs. However, we can then attribute cost reductions, experienced by about one in six firms, to innovation. Also note that a majority of firms sells products that involve some of their own (self-reported) innovative input. While these measures of innovation did not correlate with sales growth, they did correlate with profitability.

44 Firm 7

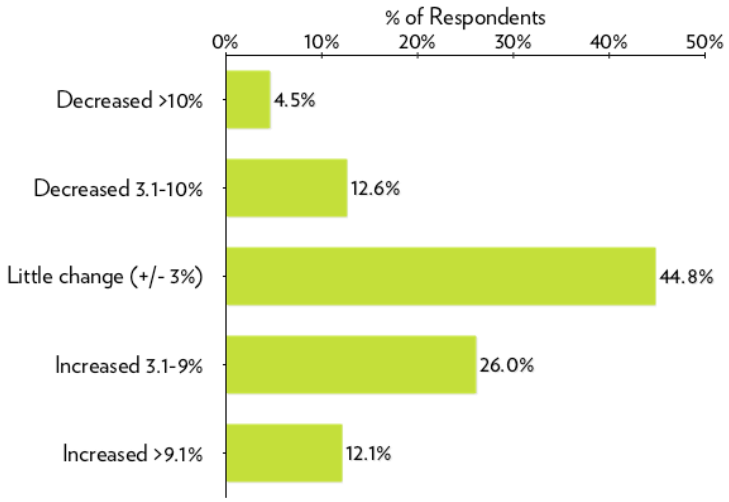
45 Firm 1

46 Firm 13

6.2. Process Improvement & the "Lean Production"

By the early 1980s, Japanese automakers began to surpass domestics in terms of quality, and consequently began to seriously threaten their market share. It eventually became clear that the success, of Toyota especially, was a function of its excellent operations and focus on process improvement. With the launching of a US based joint venture between GM and Toyota in 1984, and Honda's Marysville Plant in Ohio in 1982, the "secrets" of Japanese automakers started to become known to domestic OEMs and their suppliers. Honda in particular made great efforts to teach these methods to their US suppliers. In addition, a group of researchers at the MIT Sloan School of Management also studied and codified the Toyota Production System, and coined the term "Lean Manufacturing" to describe it.[47]

Figure 20: Annual change in unit cost (2009—2010)

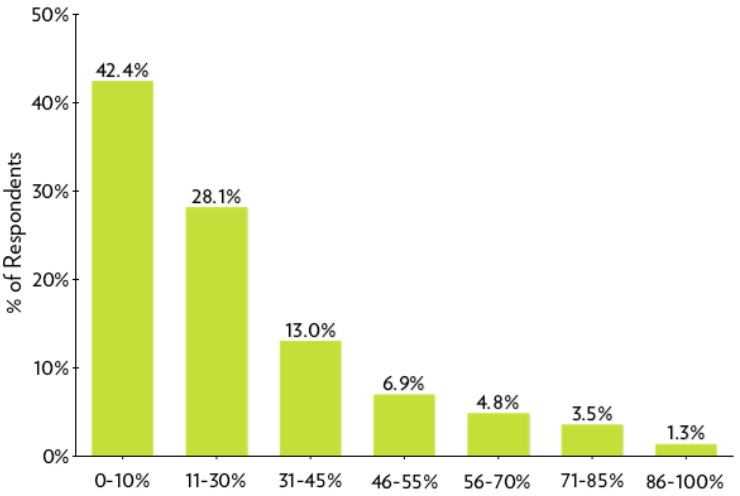


The ideal of Lean Manufacturing (or simply "Lean")[48] is the elimination or minimization of waste. Waste is all production inputs that do not enhance quality and add value, as defined by the end customer. That is, it seeks to maximize the ratio between value and the work done to create the value. Though there are different ways to approach this goal, they are compatible if they are consistent with the following two principles:

(1) Decision making about improvements is based on first-hand experience and observation. Improvement opportunities and solutions are discovered by people that work on the process, people that "go and see" the process, and people that 'listen' to the process as it 'speaks' through the data.

(2) The means to minimize waste, and thereby maximize value per unit input, is to optimize flow - be it flow of material, effort, value, information, or knowledge.

Figure 21: Percentage of sales from products involving in-house innovation



In our interviews, we encountered widespread use of the term "lean," but we also encountered wide variation in its intended meaning. We discern three general senses in which it is used: Just in Time Production, Continuous Improvement, Resource Reduction.

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47 See Womack, James, Dan Jones and Daniel Roos, The Machine that Changed the World (New York: Rawson, 1990). One author of the present study (Helper) was a member of this research team; another (Peshek) is certified as a Lean Six Sigma Black Belt.

48 It should be noted that though the Toyota Production System and its culture are the initial inspiration and are an ongoing exemplar of "Lean," the firm - like all other firms, being made up of humans - does not always live up to its ideals. This has been explicitly admitted by Toyota executives regarding a spate of recalls in 2009-10. Indeed, implicit in the idea of "Continuous Improvement" (see below) is the idea that ideals will never be met - even by Toyota. Additionally, we note that it would be a mistake to assume that Detroit OEMs are operationally in a distant second class.

Just in Time Production:
This operational sense of "Lean" is the one popularized by *The Machine that Changed the World* by Womack, Jones, and Roos. This sense of "Lean" refers to techniques to meet the goal of waste reduction as developed by Toyota and, to some extent, Honda.[49] Initiatives that we witnessed included:

- Efforts at inventory reduction
- More logical organization of the shop-floor
- Data driven decision-making
- "Visual management" of work areas
- More precisely timed production and delivery
- Reduced production volumes & quicker changeovers
- Preventative Maintenance programs & systems
- Automated inspection

These efforts varied greatly in cost and complexity. Firm 16, for example, replaced equipment with various models from a single maker, so that employees—charged with both running and maintaining their machines—could become intimately familiar with that brand, and seamlessly switch among machines of various sizes. With reduced inventories, they had to be more flexible and responsive to customer demands. Firm 1 had, over the years, invested millions of dollars as they, in the pursuit of zero defects, updated tooling with rather sophisticated sensing & IT systems.[50] In contrast, Firm 8 simply changed the location of material closer to the machine where it was to be used, and called it "Lean."

In light of this last example, we note that there is a large difference between appropriating a Lean *tool* (very common in our interviews) and adapting an entire *system* for process improvement (quite rare).

Continuous Improvement Culture:
A small subset of interviewees described "lean" as the creation of a continuous improvement (or "kaizen") culture. Firms in this group pursued philosophies and practices that entail a radical rethinking and re-valuation of a firm's human resources. Ideally, this approach (as codified in *The Toyota Way* by Liker) entails empowering *all* employees to participate as equal partners in continuous improvement efforts.

Firms that are Lean in this sense have "Quality Circles" or some sort of autonomous teams dedicated to process improvement and quality. Teams are made up of volunteer workers that are trained to identify and solve work-related problems. They are formal groups that meet continuously (not just for the duration of a project), and regularly on company time, often once a week. Management is to take their suggestions based on the fact that they know the process best and have the tools to discover the best solutions.

Through the systematic democratization of information, and systematic inclusion of employees in problem identification and solving, they are transformed into true human resources, upon which the organization can capitalize in the race toward perfection. Otherwise, their extensive experience and knowledge goes to waste, problems persist in the long run, and gains are lost. Workers benefit through access to more robust and flexible skill sets, better wages, some control over the firm's future direction, and a dignified and engaging day-to-day work experience. Again ideally, the entire company culture is pervaded by a sense of teamwork in pursuit of common goals.

Firm 4 made considerable effort to promote the notion that their production workers should think like managers and that everyone should treat each other as colleagues. Though difficult for some workers to believe, let alone embrace, patient

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49 While there is no doubt that the Toyota Production System is more closely allied with "Lean" and much more studied, there is no doubt that Honda has had a lasting impact, especially in Ohio and Indiana.

50 On our tour of this facility, one member of the research team who shall remain nameless inadvertently caused a defect to be reported. When she waved her hand over a box of parts, a sensor interpreted this action as trying to add more parts to the box without completing a required process step.

and persistent demonstration by management they would in fact listen, has reshaped the firm's culture. Several firms held weekly meetings to discuss product and process ideas, and Firm 16 held a briefing each morning during which employees seem encouraged to provide critical feedback. At the same daily meeting, large charts of production and quality information (seen on walls at quite a few "Lean" firms) were discussed.

Of these firms, several explicitly articulated that "Continuous Improvement" means exactly what it says: constantly getting better, even when things are good and there are no 'fires to put out.' When less systematic firms, such as Firm 8,[51] were asked about improvement, they spoke of addressing urgent problems that sprung up, simple cost cutting and monitoring, or simply replied, "Quality is assumed." By comments like this (heard several times), firms seemed to mean merely that their customers demand parts that meet specifications. They did not seem to grasp the notion that the quality of the production system that produces such parts is an issue distinct from part quality. For example, if quality is "built in" through a process that generates few defects, costs will be lower than if quality is "inspected in" by workers who sort through parts, sending ones that meet specifications to the customer, and sending defects to the scrap heap. For those firms that call Lean a "religion,"[52] however, Continuous Improvement has no end-point and is a continuous way of doing business. And indeed, even with these fine organizations, room for improvement was observed by our team.

Resource Reduction:
Unfortunately, many people, seemingly having picked up on an industry buzzword, used the term "lean" to describe simple reductions in cost without a change in process. When asked about adoption of "Lean Manufacturing," instead of talking about transforming operations or culture, they reported reductions in headcount or worker compensation, putting off investments in equipment, and finding ways of producing the same product with less input. An executive at Firm 8 pointed to his Spartan front offices as "Lean."

This so-called "Leaning" strategy is at odds with to Continuous Improvement Culture in that this way of thinking neglects the distinction between resources that cost and add value for the customer, and resources that cost but do not add value. That is, by focusing on easily measured costs (such as direct labor costs or piece prices) this view overlooks the most precious Lean resource: human intelligence informed by experience. Furthermore, decisions are motivated by the need for immediate gains, rather than based on an intentional plan for the future of the firm.

By cutting costs, firms using this strategy have remained profitable in the post-crisis marketplace, but this model may prevent future growth. These firms could have trouble making investments and transitioning to a business model that would eventually allow them to create sustainable advantage with respect to competitors from low-wage nations, or stable, high-wage jobs.

Because of the great dissonance between these various uses of the term "lean," we shall eschew use of the term, and instead use the labels we have coined for the different senses in which the term is used.

In spite of misunderstandings, firms do adopt a Continuous Improvement Culture and methods, often with the help of a customer. In an illustrative case of such tutelage and its benefits, an OEM intervened on a quality issue that a small supplier was having with some plastic parts. On an irregular basis, parts would emerge from molding machines with white spots along the edge of the product or molds not completely filled in. These problems, which had long plagued the company, were not solved until the OEM organized problem-solving groups that pooled the diverse capacities and experiences of people in the supplier's plant. They quickly solved the problem. Molding machine operators noticed

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51 In discussing Firm 8's shortcomings with respect to systematic process improvement, we do not mean to overlook the firm's positive aspects, especially with respect to their "distinctiveness," to return to the terms used in section I. Firm 8 has a broad range of capabilities, an enviable safety record, a highly skilled workforce, and serious commitment to training.

52 Interestingly, of the four firms we visited that we thought came closest to this spirit, two were unionized (4 and 10) and two were non-union (1 and 16).

condensation dripping into the resin container from an exhaust fan in the ceiling, quality control technicians then saw that the condensation was creating cold particles in the resin, and skilled trade people designed a solution.[53]

In short, the OEM empowered the employees of their supplier to make improvements continuously. Management at the supplier saw the benefits of actually talking to and respecting their own people, who spend the majority of their lives running the equipment. This approach shortens and localizes the 'supply chain of quality and problem-solving information' by tapping into the best 'suppliers' of such information—the people that actually work the processes. This model continues to work, as the earlier mentioned Firm 1 with the aggressive sensor program developed it under the guidance of the same OEM, with which it continues to interact extensively. Much of the dissemination of these practices has happened through indoctrination of suppliers by their customers.

Table 6: Process improvement methods and management-worker relations

Survey Questions	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
We have a preventive maintenance plan for each of our machines.	4.5%	13.4%	12.9%	24.3%	45.1%
We always perform preventive maintenance tasks as scheduled.	1.5%	15.8%	27.2%	33.2%	22.3%
Each year we expect our shop workers to make substantial improvements in their own method of operations.	2.0%	11.0%	37.8%	37.8%	11.4%
Given the chance, workers at our plant might try to take unfair advantage of management.	28.7%	35.6%	24.3%	8.4%	3.0%
Workers sometimes feel reluctant to share their ideas about improved work methods with management.	19.4%	38.8%	25.4%	13.4%	3.0%
We rarely use data regarding sources of defects in past production to modify our processes.	58.2%	21.7%	12.2%	3.2%	4.8%

(Not applicable (7.6%) is not shown)

Source: Human Resource Manager Survey from Case Western Reserve University

Table 6 shows how pervasive a few practices have become. (From the point of view of "kaizen" it is good to "strongly agree" with the first three statements, and to "strongly disagree" with the second three.) In many firms, we find that process improvements are data driven, preventative maintenance programs are in place and adhered to, and that a sense of teamwork pervades (at least according to management). In an exemplary case, executives at the rather successful Firm 16 valued effective communication and a sense of team so much that they expanded the factory in order to eliminate a second shift, which also eliminated inter-shift communication problems and finger-pointing, and allowed employees to spend more time with their families. The owner was proud that such a move, which leaves capital sitting idle for 16 hours a day, ran counter to the conventional wisdom of "MBAs and accountants."

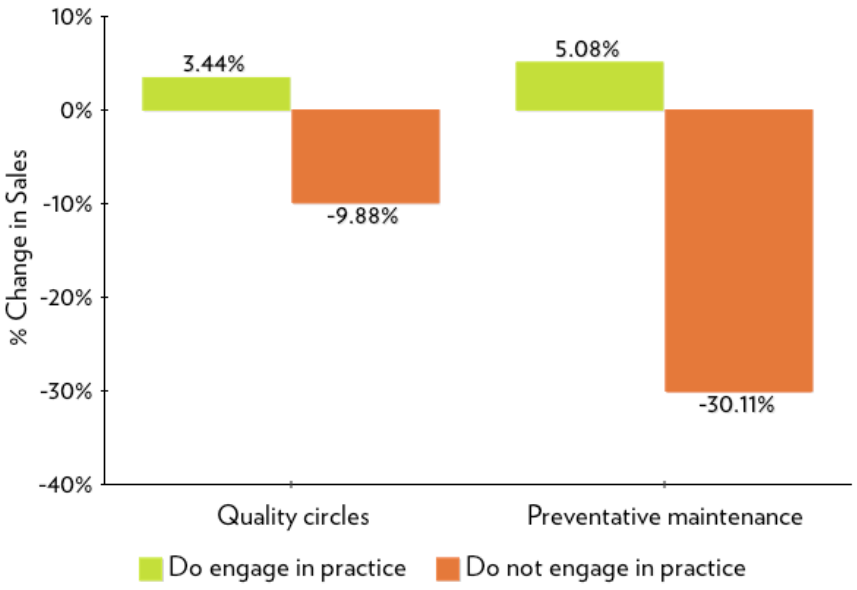
There are positive effects of adoption of such practices. Firm 4 unequivocally credited their survival (in essentially a commodity market with heavy competition from China) with their adoption of a continuous improvement, team culture, visual management of the shop floor, and systematic collection of data regarding defects and their causes. Their belief was confirmed when we checked their 2009 numbers against those they had given for a 2003 study: their Value Added per Employee had risen from $52,500 to $85,227.

Our survey data also suggests positive effects of adopting systematic improvement practices. Figure 22 shows the responses of stampers to questions about specific continuous improvement practices, including formal employee

53 Susan Helper, "The High Road for US Manufacturing," Issues in Science and Technology, Winter 2009, http://www.issues.org/25.2/helper.html.

involvement via quality circles and formal preventative maintenance. We find a statistically significant correlation between adoption of these programs and growth in sales.

Figure 22: Sales change from 2007-2010 in stamping firms practicing quality circles or preventative maintenance.



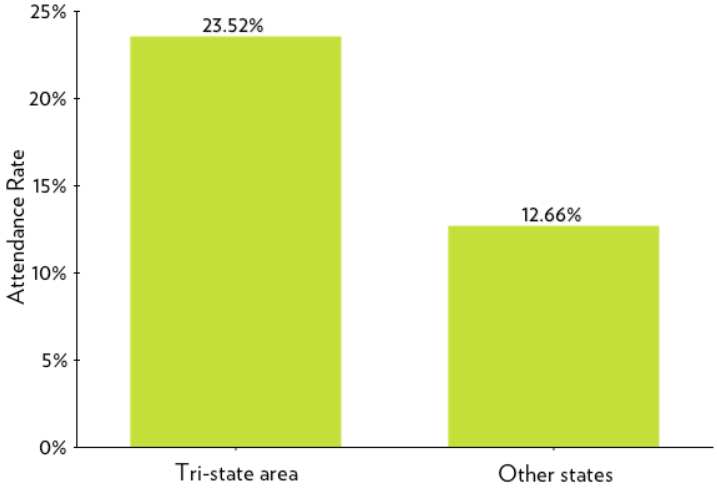
A piece of good news for the tristate area is that the adoption of quality circles/ autonomous teams was significantly higher in Michigan, Indiana, and Ohio than in the other 47 states (figure 23). The bad news is that the rates of participation are so low; on average even for tristate plants, fewer than 1/4 of workers had attended a meeting in the past six months.

Our interviews help to explain why these practices helped firms gain sales quickly. With deep and extensive knowledge of equipment capabilities and production work-flows, Firm 28 was able to quickly respond to a customer's desperate request for 2 million parts needed for a recall; the firm designed tooling and had it running in a press in 5 weeks—a fraction of the normal time. Crediting similar competitive advantages, Firm 1 picked up takeover work when several of their customer's other suppliers perished.

This case brings up a point worth considering. There are a few customer firms (for example, Honda and Toyota) that believe as a matter of principle in the practices and philosophy of continuous improvement. Thus, in addition to the direct benefits of the practices and attitudes, in an indirect sense, their adoption by suppliers may make them more attractive to customers such as these. Long before the crisis, they may have been selected for preferential treatment, in the form of supplier development. During the crisis (and its aftermath), they may have benefited from the effort invested in them by their customers. Indeed, for the firm that got the takeover work, it is hard to distinguish the effect of their excellence from the effect of their having a long standing relationship with the customer that played a major role in bringing them to that state.

As noted above, our results regarding the performance of different practices are only suggestive; in future research we will perform more rigorous tests.

Figure 23: Quality circle/autonomous team participation rates by region



In any case, it is clear that these practices cannot be adopted overnight, and that successful initiatives are part of a long-term strategy. We find no strong evidence that these practices were a common or effective reaction to the crisis. Those that credit their survival to having such programs in place had them well established long before the crisis.

In five out of seven of our interviews with purchasing agents, there was a strong tendency to just assume that their suppliers have adopted some sort of improvement methodology, that "quality is a given"

Several Tier-1 buyers asserted that firms that have survived must be lean. Said one:

> *"If you're a non lean facility today, you probably won't be able to survive … Suppliers don't need to have lean requirements explicitly imposed on them, but their prices need to be aligned, and the only way to get their prices to the targeted level is to be lean."*

The problem with this logic is that a low cost is no more necessarily indicative of operational excellence than a wet section of grass is necessarily indicative of recent rain. In recent years, buyers hailed low-wage countries such as China as the answer, as they do provide the targeted price, but with many hidden subsidies from Chinese taxpayers (which may not last forever) and (as discussed below) many hidden costs imposed on buyers and workers in both China and the US.

Assuming that the only way a domestic supplier could reach the targeted level is through adoption is also problematic in another way. Even if all manufacturers were equal in price, that would not entail that they could not as a whole or individually improve in any respect. That is, perhaps the target price is unnecessarily high (or some other measure of performance is unnecessarily low).

Additionally, as our survey data shows, and as we witnessed firsthand, many firms are not very far along the path at all. In sum, this not uncommon assumption of the buyer is simply not true. The fact is, supplier development programs are expensive, the investment may be risky, and the return is long-awaited. It is much easier for a customer to focus on immediate piece-price than to monitor, let alone help, suppliers in their operations. A fundamental difference here is that US firms think that they can get good performance from suppliers by targeting outcomes, and that from the outcome they can infer the behavior. Toyota and Honda think it is necessary to monitor the methods suppliers use; market incentives on outcomes alone are too blunt an instrument.

This myth is not limited to buyers, however. Current discussions hold that American manufacturing has been made more productive in recent years, and has achieved World Class status. Product design is seen as far more important to competitiveness than incremental process improvement. According to auto icon Bob Lutz (legendary head of product development at both GM and Chrysler):

> *The operations portion of the automobile business has been thoroughly optimized over many decades, doesn't vary much from one automobile company to another, and can be managed with a focus on repetitive process. It is the "hard" part of the car business and requires little in the way of creativity, vision or imagination. Almost all car companies do this very well, and there is little or no competitive advantage to be gained by "trying even harder" in procurement, manufacturing or wholesale.* (WSJ 6.11.11)

It is highly disputable that operations don't matter. Consumer Reports selects car models that they recommend to new car buyers based on cost, reliability, and road test scores. Consumer Reports recommended 65 percent of new car models produced by firms in Japan, and 67 percent of those produced by Korean firms. Germany and the United States lag behind with 41 percent and 46 percent of their car models recommended respectively. Consumer Reports also ranked all of the Japanese and Korean manufacturers above average in reliability, while only 22 percent of American and 33 percent of German automobile manufacturers have above average reliability ratings. The US manufacturer with the highest average reliability ranking was Ford, in tenth place. Above Ford were seven Japanese firms, Porsche, and Volvo. Problems in the supply chain (such as poor fit and finish, and excessive noise, vibration and harshness) account for a significant part of this poor performance (see Helper 2009, 2011).

There are other signs that the adoption of systematic techniques for process improvement is losing momentum. The idea that simple Resource Reduction amounts to Operational Excellence remains pervasive and widespread. Many firms "wasted a good recession" by not doing the training, nor the projects, that crisis-reduced demand afforded them time to do. Given the connection between quality circles, preventative maintenance and growth, and the seeming ubiquity of a notion of "lean" among interviewees, it is somewhat surprising that two-thirds of our respondents have never

implemented quality circles, interest in teams is falling, and some firms are even moving away from the team approach, as shown in Figure 24.

Additionally, levels of workers' participation remain low. Figure 25 reports the mean value by worker skill level of our participation index for all firms surveyed. This index is calculated based upon the number of tasks that surveyed firms report their workers are required to routinely perform; a value of zero indicates very low participation, while a value of seven indicates the highest possible direct participation level. Note that skilled trades have traditionally worked in teams to solve problems, so their participation is a bit less of an achievement. Much to our disappointment, when we asked a person at one of the best firms we visited about the formal involvement of production workers in process improvement (Firm 1), he scoffed at the idea.

It may be that in the global market place, much more will have to be done in terms of the adoption of systematic improvement practices if the US auto supply chain is to prosper. The entire industry needs to eliminate its complacency and false sense that it has achieved a once-and-for-all arrival to a point where quality is good enough.

Adoption need not be expensive: change of firm culture can be rather cheap, but management is going to have to give up control of some of its fiefdom. The firm that credited kaizen with its survival against Chinese competition spent a maximum of $108,000, as compared to sales of $15 million. (Some of this expense was covered by government funding. Workforce Investment Act money was used by two firms we interviewed [Firms 4 & 10]).

Figure 24: Adoption of quality circles/autonomous teams

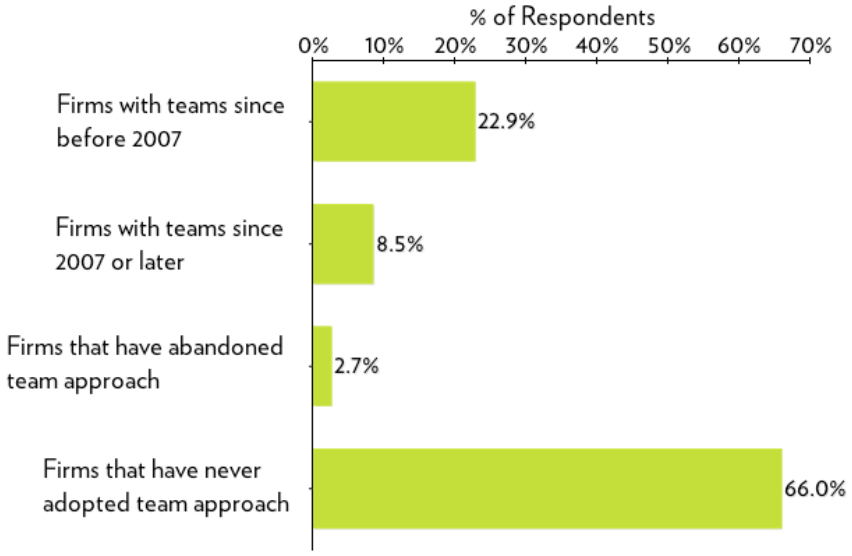


Figure 25: Direct participation index by employee skill level

6.3. Information Technology

The continuing use of information technology (IT) will be critical in improving manufacturing practice, but it will not necessarily boost productivity unless it is accompanied by a decentralization of production, a key element of high-road production. Our fieldwork found examples of firms[54] that are thriving due to their adoption of an agile production model in which they produce for quick delivery a variety of products for a variety of industries. They adopted advanced IT-enhanced equipment while also changing their product strategy (e.g., to produce more customized products), their operations strategy (using their new IT capability to

54 Firms 1 and 10

reduce setup times, run times and inspection times) and human resource policies (employing workers with more problem-solving skills and using more teamwork).

The success of the changes in one area depended on success in other areas. For example, customizing products would not have been profitable without the reduced change over times —a reduction made possible both by the improved information from the IT and the improved use of the information by the empowered workers. Conversely, the investments in IT and training were less likely to pay off in firms that did not adopt the more complex product.

Among various types of IT, our study asked specifically about implementation of Enterprise Resource Planning (ERP) systems, which is software that can time production volumes and shipments for maximum efficiency. A firm's implementation of ERP provides a good illustration of how investment in IT systems alone is less effective than when combined with worker empowerment and communication. While we find that very few firms adopted ERP systems during the crisis (49 percent of firms delayed IT investment; see Figure 13), almost half of respondents already had ERP technology, as shown in Figure 26.

Figure 26: ERP use and date of adoption

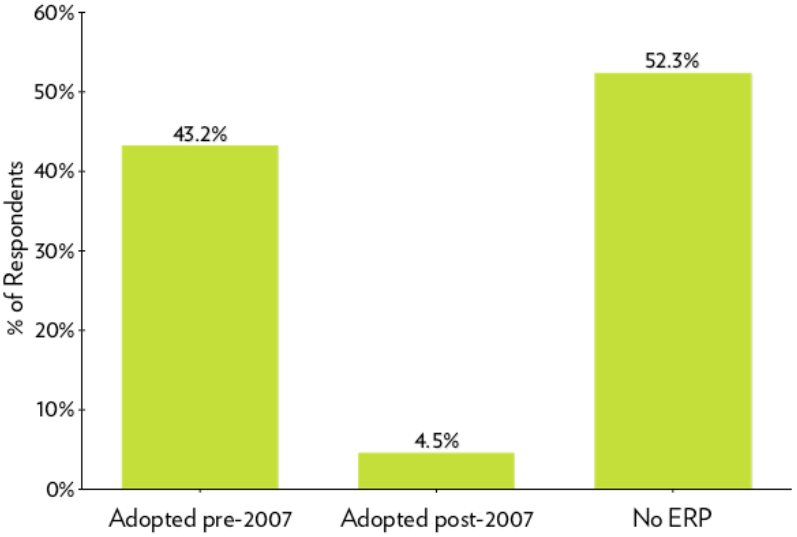
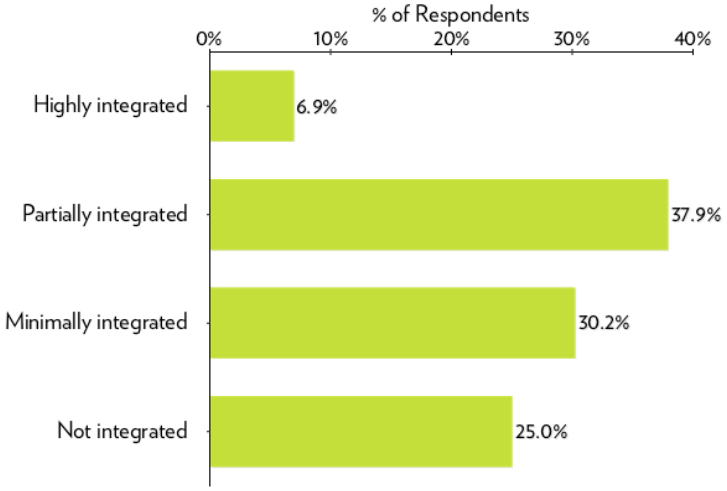


Figure 27: Rate of firms' ERP integration with customer ERP systems



However, only a minority of ERP users are integrated with their customer's ERP, as shown in Figure 27. This lack of thorough integration may inhibit the effectiveness of ERP systems.

Figure 28 shows that about half of firms rate their ERP and IT effectiveness positively. Here, a response of "strongly agree" indicates that management feels their firm harnesses the potential benefits of ERP and other IT effectively. A response on the opposite end of the spectrum indicates that ERP or other IT is ineffective and therefore impedes efficiency or is generally ignored.

Finally, while some firms may invest in technology to substitute for workers, or to "de-skill" jobs by altering job tasks so that less-skilled workers can perform them, we find that most respondents view IT investment as a complement to worker skills rather than a substitute. That is, most firms are implementing IT in a way that enhances workers' skills. Figure 29 shows that a minority of firms believe that shop floor IT reduces the need for workforce skills. Instead, over two-thirds of firms using IT do not see it as a strategy for replacing skilled labor, but instead see it as complementary to workforce skills.

6.4. Energy Efficiency

Another form of incremental improvement that can yield big benefits (particularly if avoided costs to the environment are considered) is reducing energy use. In our survey, we ask respondents about four activities that improve energy efficiency. Table 6 shows that half of our respondents conducted an energy audit and over 40 percent installed energy-efficient lighting. While one quarter of firms did no energy improvements, more than half the remaining firms implemented more than one energy efficiency improvement (see Figure 30).

Table 6: Ways to improve energy efficiency

Installed energy-efficient lighting	41.7%
Conducted an energy audit	51.0%
Installed weatherized doors or windows	11.7%
Installed insulation	28.6%
Others	12.1%

Source: Plant Manager Survey from Case Western Reserve University

6.5. Environmentally Friendly Products

Opportunities for manufacturing "green" products have received much policy attention in recent years. However, our interviewees were often skeptical about the strength of the underlying demand. Firms logistically capable of diversifying into the solar, wind and biomedical or alternative fuel industries stated that they simply did not think enough customers existed or would continue to exist after government incentives went away. Additionally, one individual said that even once a firm finds customers in solar, the process is not easy; "this [solar] market is like the Wild West: it is too early to tell who are going to be the winners and who are going to be the losers."

Figure 28: Rating of ERP effectiveness and IT effectiveness

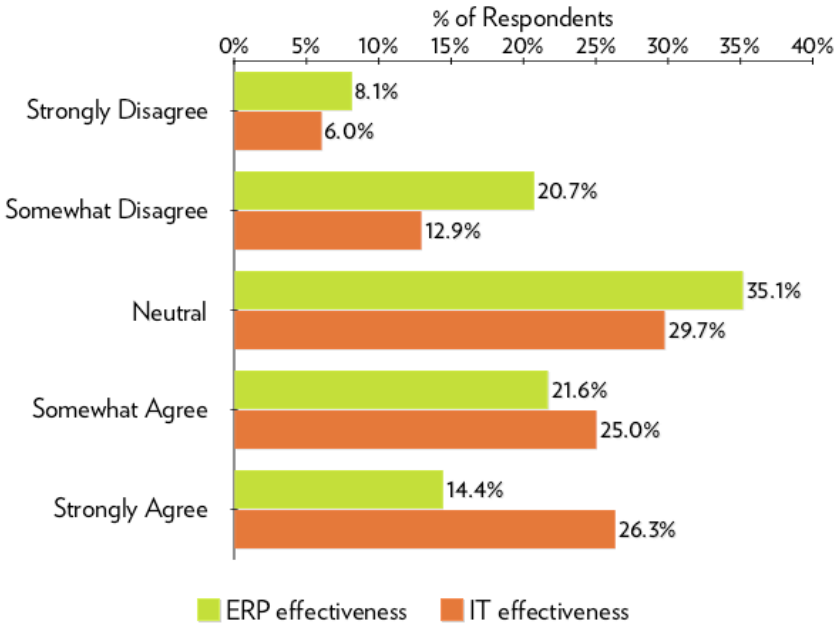
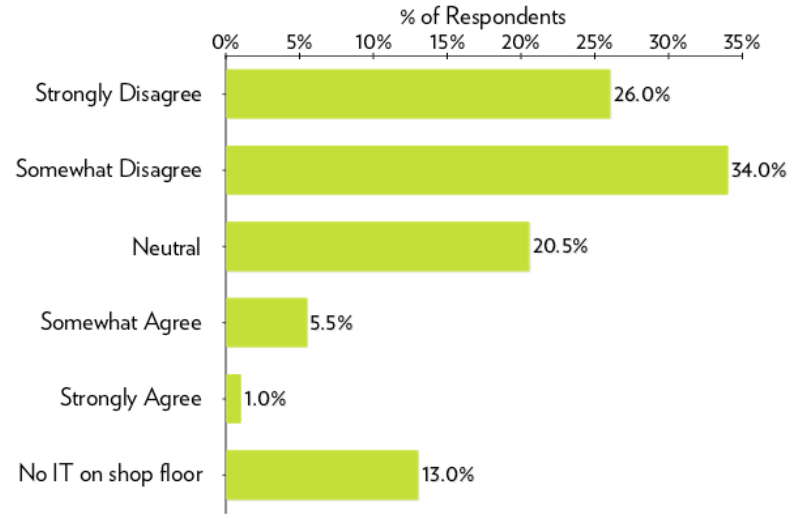


Figure 29: Does shop floor IT reduce the need for workforce skills?



That said, we did interview managers who developed new techniques that were applied to new energy technology, such as fuel cells.[55] Their firm modified an existing process for use with new materials. However, while they found a customer, financing the new, dedicated million-dollar piece of equipment the customer's part required was proving quite problematic.

55 Firm 7

Figure 30: Number of energy-saving practices implemented

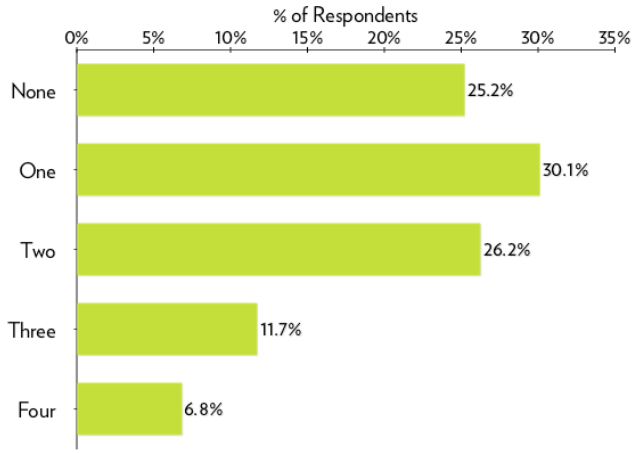
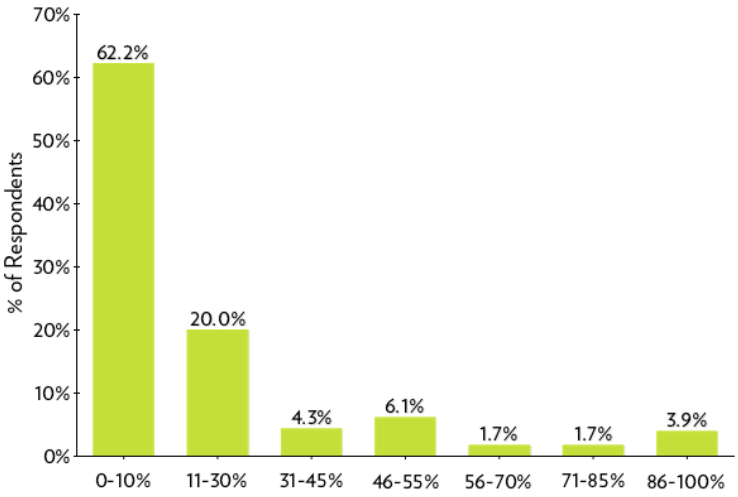


Figure 31: Percentage of sales derived from environmentally friendly products



customer relations

We have shown that a number of types of policies (such as introducing innovative products, performing preventive maintenance, organizing quality circles) are correlated with improved firm performance in areas such as increased sales growth, higher profit margins, and reduced employee turnover. Yet, these policies are not widely adopted. In the next three sections, we examine four reasons why this might be so:

1) Customer purchasing strategies in many cases do not allow suppliers the financial or organizational resources they would need to implement such practices (explored in this section);

2) Firms adopt some of these strategies (of making profits by shifting costs to other parties, rather than by maximizing the size of the pie as a whole) with their own suppliers (explored in section VIII)

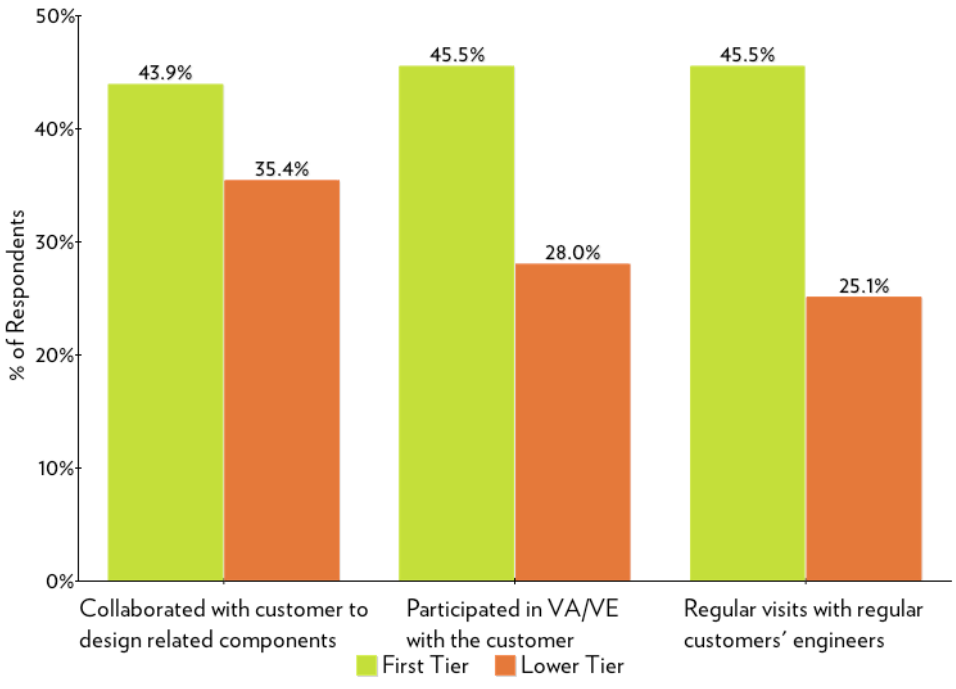
3) Public policies do not do enough to "pave the high road" (which has benefits that spill over to workers and communities) and block the low road (which has costs that spill over to others) and

4) These policies are not applicable to all firms; they pay off only in certain industries or with certain managers and all firms who would profit from the policies have already adopted them (also explored in section VIII).

7.1. Collaboration with customers

At all levels of the supply chain, firms participated in some product development activities, with less than 20 percent reporting no involvement in both tier-1 and lower tier firms. However, tier-1's, which constitute about a quarter of our respondents, seem to have more intensive engagement with their customers than do firms in lower tiers. (See Figure 32, which graphs three of the collaboration questions we ask in the survey.)

Figure 32: Rate of participation in collaborative activities for first-tier and lower-tier Suppliers



Collaboration is correlated with sales growth: firms that participated in "value analysis/value engineering" (VA/VE) with customers experienced greater sales growth. Also, firms that contributed to product design produced more innovative goods, which correlated with higher profits.

Some tier-1 suppliers we spoke with said they were willing to pay more for more highly engineered products. Moreover, suppliers that engaged in collaborative activity experienced greater customer loyalty; collaboration was correlated with a lower expectation that a customer would switch to a lower-cost competitor, with the customer even helping the supplier in some cases to meet a competitor's lower price. Interestingly, this collaboration may come at some cost to the supplier: 80 percent of respondents reported not being compensated directly for their design contribution.

Instead, suppliers are frequently told that they should achieve a return on their design by folding it into the piece price. However, given fierce competition and uncertain sales volumes, this is often easier said than done.

7.2. Incentives in Customer Relations

In interviews with lower-tier suppliers, we find that some feel that relationships between suppliers and their customers have improved since the depths of the crisis. Not only have some poorly managed firms gone out of business, but suppliers that picked up new business from bankrupt peers seem aware of their new leverage. These firms are more choosy about whom they take on as customers: our interview data showed that significant numbers of firms had turned down work (many for the first time) that they did not think offered enough of a return.

Of course, this is a two-way street, as first-tier customers are investing more time seeking and vetting new lower-tier suppliers, even in the face of staffing cuts, because the cost of doing business with the wrong supplier is seen as especially high now.[56] Two of the seven mega-suppliers we interviewed had explicitly moved toward a purchasing model where they tried to measure the "total cost of ownership" (not just the piece price) including the extra costs imposed by apparently cheap suppliers that cause defects. In contrast, other suppliers feel that their customers continue to take advantage of them, and try to make profits by squeezing their margins.

Figure 33 shows what respondents believe a major customer's response will be if a respondent's competitor offered a lower price for a product of equal quality, in both 2007 and 2010. In both periods, an equal number of respondents believe their customer would help them retain their business as would switch as soon as possible. However, these perceptions have changed over time.

Figure 33: Customer's response to a supplier's competitor offering a lower price

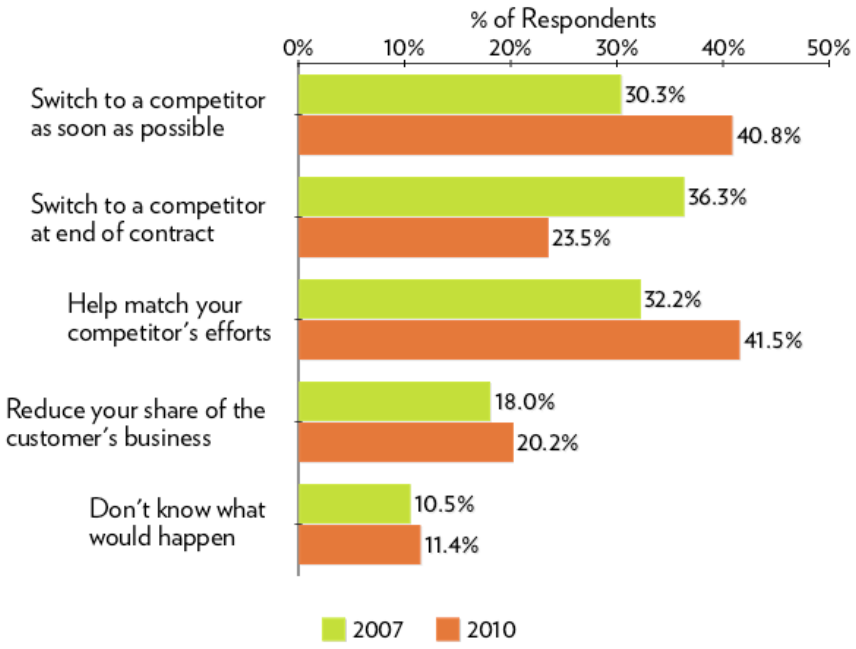


Figure 34: Belief that the customer will treat the firm fairly

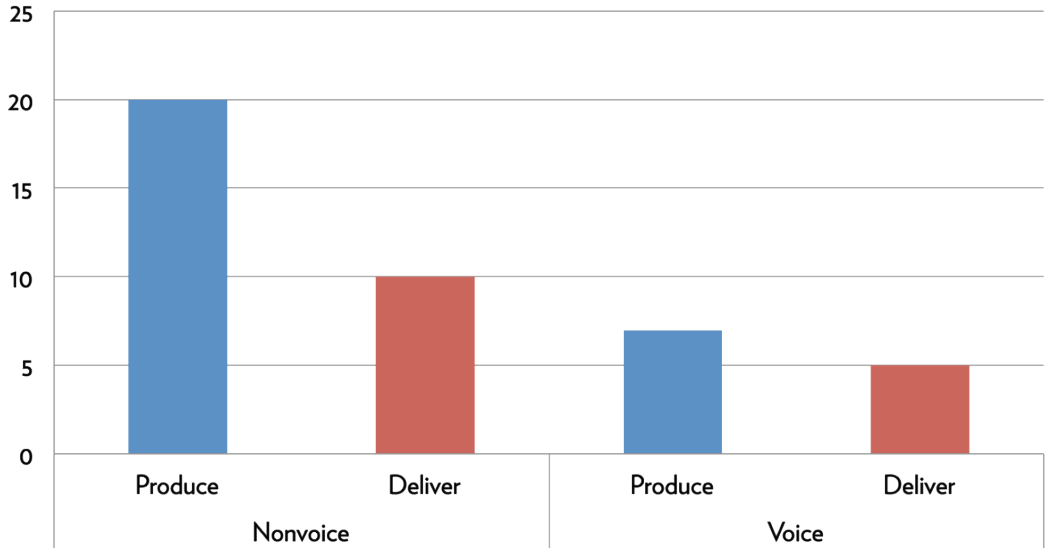
56 Firms 6 and 23

Despite the prevalence of design and other firms of collaboration, suppliers on average feel quite lukewarm in their beliefs about whether their customer "will treat them fairly"; both first and lower-tier averages are right about 3—"neither agree nor disagree" on a scale ranging from 1 ("strongly disagree") to 5 ("strongly agree").

These levels of trust appear to have consequences. Above we showed that regular performance of preventive maintenance was significantly correlated with sales growth. However, only 33% of those who don't trust their major customer (they answered "1" or "2" to the question above) usually perform preventive maintenance. In contrast,80% of those who do trust (answered. 4 or 5) do preventive maintenance. Yet, only 40% of suppliers trust their customer to treat them fairly.

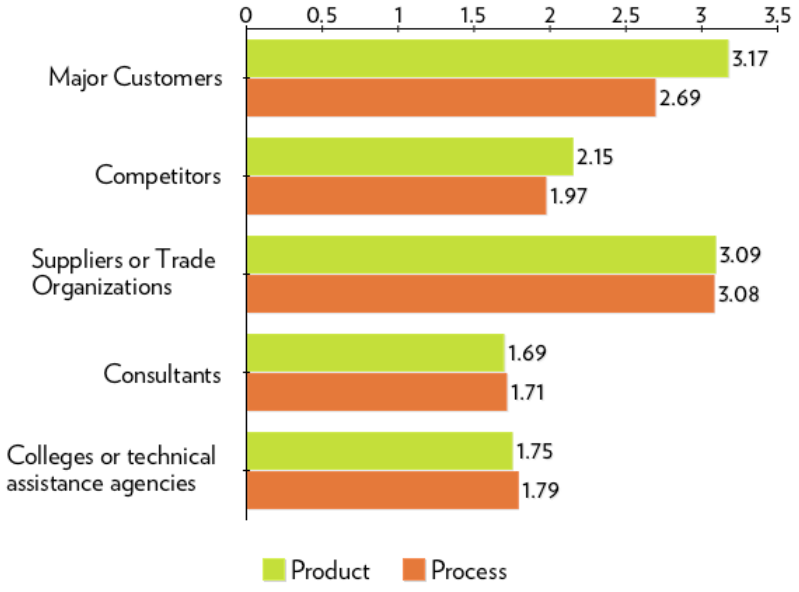
We also found that firms with collaborative ("voice") relationships (defined as relationships where suppliers participated in VA/VE and had at least a 1-year contract), were able to hold less inventory, as figure 35 shows.

Figure 35: JIT production versus JIT delivery (size of lots measured in days they would last the customer)



Firms believe that customers are the most useful source of information for products. However, this is not a ringing endorsement of customers on average, since the mean rating is 3.17, about halfway between 1 "if you receive no useful information on a topic from a source" and 5 "if you receive a great deal of useful information from that source." See Figure 36, at right, which depicts respondents' perspectives on where useful information is likely to originate. Interestingly, one of the least popular sources of information is colleges.

Figure 36: Respondents' perspectives on origins of useful information (1=disagree to 5=agree)



One of our most innovative interviewees[57] was an entrepreneur commercializing a new technology developed by a federal research lab. The technology has taken years to develop, as

57 Firm 15

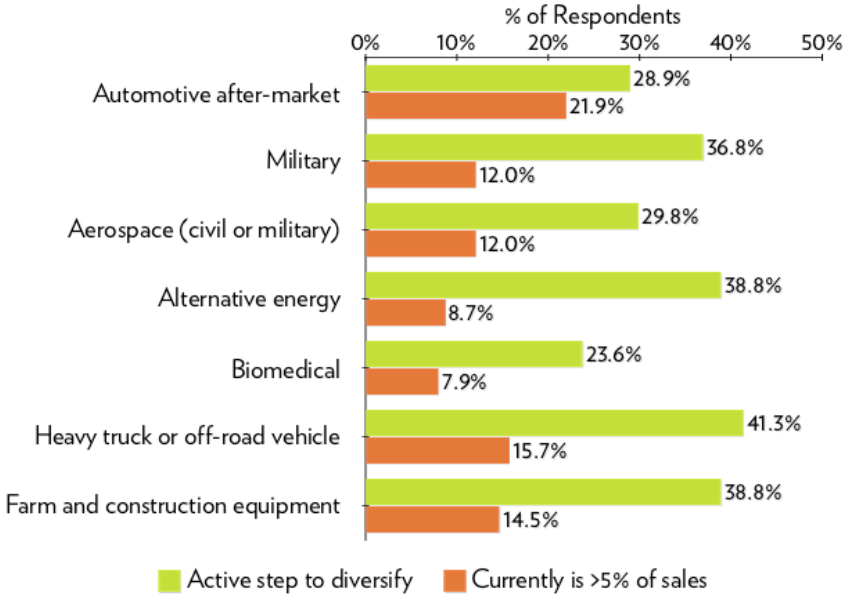
the entrepreneur is mostly self-funded and even now struggles to find widespread use. Nonetheless, the promise of the technology itself is exciting and will no doubt eventually find a market. Better communication between scientists and entrepreneurs might speed the commercialization of new technologies.

7.3. Diversification

Although many firms in the automotive supply chain are dependent on auto-related business (36 percent of firms surveyed are over 80 percent auto-dependent), most firms believe it is valuable to diversify away from automotive work, with 78 percent of respondents having taken action to increase sales from outside the auto industry. In Figure 37, the green bars show the percentage of auto suppliers in our sample that report taking steps to diversify; the orange bars show the percentage of auto suppliers that currently derive over five percent of sales from such industries. In all cases, more firms wish to diversify into a given market than currently participate in it. Tier-1 suppliers, which rely on the health of lower-tier suppliers, agree that suppliers with diverse customers are stronger than those that are dependent on a few customers. Five of the seven tier-1 buyers that we interviewed have an explicit policy not to give a supplier business amounting to more than 30 percent of the supplier's total sales.[58]

However, our research finds a number of explanations for why automotive suppliers often find it difficult to diversify into other industries.

Figure 37: Diversification by automotive suppliers into other industries



First, some suppliers we interviewed mentioned part size as a technical barrier to diversification. Many automotive suppliers manufacture small parts in large volumes and felt they would have to invest in new equipment if they were to manufacture the larger parts required for some non-automotive products such as airplanes or wind turbines, or the small, intricate parts used in the biomedical industry. Also, the automotive business model (traditionally) has been based on economies of scale—that is, high volume of a few parts. In this case, firms can take a long time to set parts up, because change-overs are few. In low-volume industries, a agile production model (described in section VI) is critical.

Second, industry culture and specifically the norms of customer-supplier relationships, can also stymie diversification. Suppliers report overwhelmingly that typical automotive first tiers and OEMs in the US demand frequent, often annual cost reductions of their suppliers. Thus, automotive suppliers may be used to winning contracts by offering the lowest piece-price bid for a job. Firms accustomed to automotive customers may have trouble understanding how to win contracts in other industries, especially when low cost is not always seen as the most important variable. For instance, in our interviews with the Ohio Aerospace Institute we learned that aerospace suppliers are most likely to give contracts to customers whose piece-price estimates are in line with the customer's own calculations—not lower than them—and that contracts are given based on shop capability over price. Automotive suppliers are described as often being unaccustomed to the degree of design collaboration, ongoing project support or financial scrutiny that is more normal in the aerospace industry. Also, aerospace product cycles are much longer, so 'doors to that market' (new projects) open less frequently.

58 Firms 6, 23, 24, 26, 27

Third, industry standards, certifications and competence with different materials may present technical challenges that prevent diversification into certain markets. While automotive standards are certainly higher than some markets, products for defence, biomedical and aerospace generally require a greater degree of precision and often a higher surface quality. Pre-production part validation processes can be considerably more arduous. Biomedical products, in addition to often being quite small, may require a "clean room" to manufacture. While many firms have auto specific certification of their quality management systems from the International Organization for Standardization (ISO), acquiring and maintaining certifications for other markets can be very costly and time-consuming. The new tooling and training involved in working with new materials also requires time and capital investment. Still, it is very likely that material weight will become more important in both aerospace and auto products. Much of the product improvements will be made with new materials, such as composites. Because the aerospace industry has long led the auto industry in developing lightweight materials, it may be profitable for firms to diversify into aerospace and to lead autos into the future.

Fourth, because of the investment required, time is an important barrier for most types of diversification. According to the Ohio Aerospace Institute, it takes an average of four years for an automotive supplier to see profits from diversifying into aerospace. Relatively few automotive firms we talked to are willing to invest in an endeavor with such a long-term payoff; many firms stated that in the post-recession environment, investments must pay for themselves in a matter of months in order to be justifiable. We observed that such high investment thresholds may produce a "catch-22" situation throughout the industry. Firms realize they want to diversify away from automotive when automotive is not going well for them, which tends to be the same time that a firm is least financially capable of investing in diversification. Similarly, firms that are very profitable in the automotive industry and therefore most capable of diversification may be less likely to seek it, as they feel less need to seek alternate strategies to profitability.

Despite these barriers and the lack of correlation between diversification and profitability and sales growth, many firms clearly think diversification is in their best interests. The main reasons firms cite for wanting to diversify are better profit margins, the ability to benefit from growing markets, more stability when automotive manufacturing dips and better relationships with customers. In total, 68.2 percent of respondents indicated that they are actively seeking to diversify into at least one of the six industries listed above. Finally, while much of the diversification our study observes likely reflects intentional planning by particular firms, the universe of automotive suppliers may also be growing more diverse if auto-dependent firms disproportionately go out of business, especially in crisis years.

To conclude this section, we believe there is suggestive evidence from our survey that automotive customers' focus on short-term measures has reduced suppliers' incentives and ability to invest in practices that would be efficient in the long run.

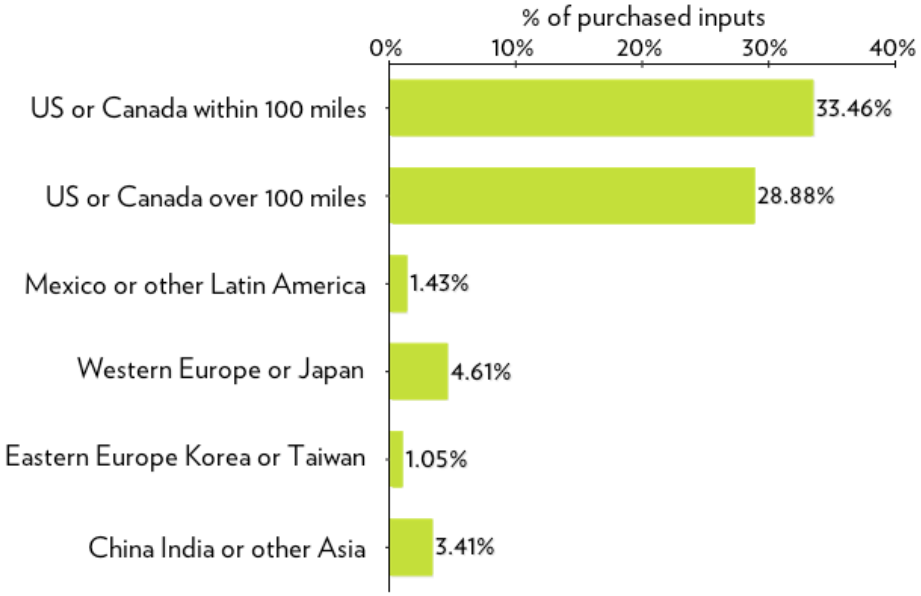
location of suppliers

Next, we look at sources of supply for our survey respondents. Figure 38 shows that when firms source inputs, they most commonly choose firms within 100 miles. This local sourcing both reflects and accounts for the density and robustness of supplier networks in Ohio, Michigan and Indiana. The importance of Just in Time delivery has meant that the percentage of parts produced in North America in a car assembled in North America is fairly high (70-80%).

A smaller number of firms source inputs from firms overseas. Note that these percentages represent the share of respondents doing any outsourcing rather than the value of the work outsourced. Thus the amount of work being sent to a foreign country might be high if a few firms do a lot of it.

Figure 39 shows the change in sourcing behavior. The results indicate that more firms have increased than decreased sourcing from each area, suggesting that firms are diversifying their source base geographically. (Note, again, that these numbers represent the percentage of respondent firms sourcing materials from these various regions and not the *value* of the materials being purchased.) The greatest increase in sourcing location occurs domestically and to lower-cost regions like China, India and elsewhere in Asia. Some of the tier-1 suppliers we interviewed refer to these regions as "lower cost countries" (LCCs), though typically, a more apt term might be "lower wage countries." Indeed, while some tier-1 interviewees had specific, often aggressive, targets for minimum amount of materials that had to be sourced from so-called LCCs, others[59] have begun to calculate "total landed cost," which takes into account delays, poor quality, rework, transportation and costs communicating and developing supplier processes. As a result, these suppliers have begun to source some inputs previously sourced off-shore to suppliers closer by.[60]

Figure 38: Input sourcing by geographical location of suppliers



Our interviews are consistent with the findings of a recent study by Polymer Ohio, whose members likewise find that molds made off-shore in lower-cost countries are sufficiently problematic that sourcing on-shore is becoming preferable for many firms. Helper[61] provides a list of some examples of hidden costs that arise in offshoring.

Moreover, the recent Japanese tsunami and the subsequent nuclear disaster has highlighted the risks associated with suppliers that are not only distant geographically but whose production is concentrated in a single location. One of our

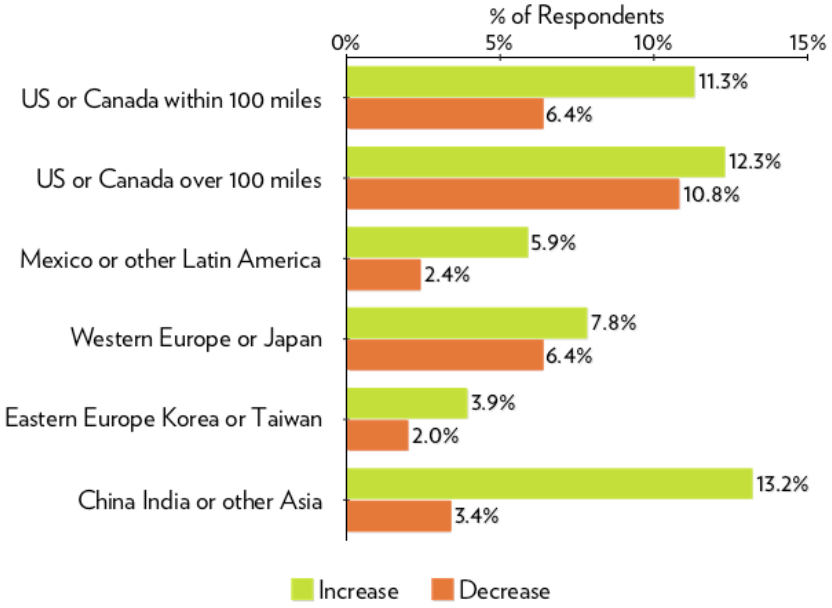
59 Firms 23, 25, 27

60 Firm 25

61 http://www.issues.org/25.2/helper.html

tier-1 interviewees, for example, noted that the tsunami had a bigger impact on their business than the financial crisis.[62] One reason, according to a recent Congressional Research Service report, is that several inputs, especially electronic parts but also a specific type of paint, are produced in only one place in the entire world: in Japan near the reactor meltdown. As a result of the tsunami and nuclear meltdown, Japanese automakers shut down; many of their plants around the world, closed others early for their annual summer shut-downs and reduced production up to 70 percent at plants that remained open.

Figure 39: Change in input sourcing by geographical location, 2007-2011



62 Firm 23

conclusions + policy recommendations

Throughout our research, we have found evidence of two possible futures for America's automotive industry. In some senses, the recent history of the supply chain is a story of how external forces seem to prevent progress at each tier. Lower tier firms say they cannot invest in 21st century equipment or workforce training because complex investments will not pay for themselves in six months. Suspicion, rather than collaboration, frequently characterizes relationships between small suppliers and their customers. As noted in this report's discussion of customer relations, 40.8 percent of firms in our sample think the customer for whom they produce their key product would switch to another supplier as soon as possible if the other supplier offered a similar product for a slightly lower cost. Only 30.3 percent of these firms think a key customer would have done so in 2007, before the recession. Many small firms we visited also shared stories of frequent blaming wars that erupt when downstream firms discover flaws in components. When firms expend energy on discrediting one another instead of working to address the root causes of future problems, the immediate result may be profitable for one firm or another, but the eventual pattern of behavior is both wasteful and debilitating to the broader network.

Many first tier suppliers are quick to explain that, in their opinion, they have few options but to place such stress on piece price in choosing suppliers. When asked how much effort his company would spend helping a supplier resolve a production problem in order to add value or reduce cost, one large first tier supplier explained that working with the supplier would likely require more time and money than the firm was willing to spend on sourcing. The firm's representative repeated the common mantra, "our hands are tied." The chain reaction is clear: among lower tier suppliers, "hands are tied" by customers who will end relationships if given the smallest incentive to do so; among large suppliers, "hands are tied" by the major automakers like the Detroit Three, who demand regular price reductions. Among the Detroit Three, "hands are tied" by intense competition from foreign automakers that have, in recent decades, been able to build more desirable cars that require less maintenance and can demand higher prices.

Naturally, one might wonder why foreign automakers can outperform the Detroit Three in this way. The answer our study's findings suggest is that the very nature of the American supply chain's business norms described above not only result from the Detroit Three's difficulty outperforming foreign competitors, but also cause it. Under this system, instead of developing better products, working with suppliers and customers to solve trans-tier problems and thinking critically about how to remove inefficiencies from processes that span multiple firms, each level of the supply chain generates profits by squeezing value from the tier under them. Essentially, this path is a recipe for industry-wide stagnation and declining relevance. The extreme stress put on piece price may seem rational to firms concerned about immediate profits, but perennial tunnel vision for low piece prices does not translate into a vehicle that runs better or even costs less to produce. Unfortunately, this American system of supply chain relations is so firmly entrenched in the business models of so many firms that it is incredibly difficult for large portions of an industry to simply change the way they do business. For this reason, our study finds much evidence that one possible future for US automotive industry is a continuation of this self-defeating cycle.

Yet our study uncovers evidence of a second path as well. With foresight and long-term thinking, some firms—both large and small—have completely revamped their strategies for profitability, adding value to products instead of simply cutting costs to remain attractive to price-focused customers. Individually, these firms have found that they fare better when they can link their product strategy, manufacturing process and workforce development strategy in a way that allows them flexible or "agile" production. When an individual supplier successfully adopts this type of agile production strategy, the firm typically benefits by outperforming competitors in quality, problem solving and just-in-time production and delivery. Agile production can broaden a firm's field of potential customers, affording it more freedom to choose which customers it wants to do business with. The result can be larger profit margins for the firm and higher wages for workers. When this course of action occurs on a multi-firm level, the effect can be that firms share cost savings from identifying and eradicating inefficiencies that they might not have been able to address single handedly. Another possible effect is that

firms are more likely to collaborate when designing parts that will eventually constitute a single system, such as an exhaust system, resulting in vehicles that work better.

Our study's findings suggest that the recession increased the prevalence of collaborative relationships in some ways. While many firms think their key customers are now more likely to take their business elsewhere without much deliberation, as mentioned above, many firms also think a key customer is now more likely to help them match a competitor's efforts in the instance that the competitor offered a similar product at a lower cost (32.2 percent of firms think the customer would have helped them in 2007, whereas 41.5 percent think the customer would help them today). One possible explanation for this trend may be simply that the recession taught firms they are more likely to survive if they work together to reduce costs. One executive we interviewed stated passionately that he thought the pool of suppliers still alive in the wake of the recession was comprised more heavily of those who cared about the industry.[63] A first tier supplier we talked with said they did not realize how poor the financial condition of many of their suppliers was until the recession hit and that after this they re-examined their strategy to share more profits with suppliers, keeping them healthier.[64] We think the consolidation of many first tier suppliers is also driving this trend: now that some first tier firms have merged with others to become more powerful, they can assert more leverage with large automakers and may be willing to spend more time collaborating with their own suppliers, focusing more resources on building system-wide approaches to product design. Two of the seven mega-suppliers we interviewed had explicitly moved toward a purchasing model where they tried to measure the "total cost of ownership" (not just the piece price) including the extra costs imposed by apparently cheap suppliers that cause defects.

Certainly, firms choosing collaboration and investment have much to look forward to, but this option is not always clear to firm management for reasons described below. It is clear, however, that US firms cannot compete by cutting wages and benefits and imitating low-cost production strategies characteristic of firms operating in China and other low wage countries. Instead, they should build on their strengths by drawing on the knowledge and skills of all workers. The US auto supply chain could prosper by adopting a high-road production recipe in which firms, their employees and suppliers work together to generate high productivity. Successful adoption of these policies requires that everyone in the value chain be willing and able to share knowledge. Involving workers and suppliers and using information technology are key ways of doing this.

It is presently unclear which path the industry will lean toward in the future. Although high-road policies have social benefits, markets alone fail to provide the proper incentives for firms to adopt high-road policies for two main reasons. First, the high road works only if a company adopts several practices at the same time. It must improve communication skills at all levels, create mechanisms for communicating new ideas across a supply chain's levels and functions and provide incentives to use them.

Second, many of the benefits of the high-road strategy accrue to workers, suppliers and communities in the form of higher wages and more stable employment. Profit-maximizing firms do not take these benefits into account when deciding, for example, how much to invest in training. Many firms will provide less than the socially optimal amount of general training because they fear trained employees will be hired away by other firms. In contrast, relatively weak environmental and labor laws in the US and in low-wage country trading partners allow low-road firms to have artificially low costs because they can shift the costs of environmental degradation and poor worker safety and health to others.

We explored the possibility that these policies are not applicable to all firms; that they pay off only in certain industries or with certain managers and all firms who would profit from the policies have already adopted them. Clearly some policies work better in some cases than in others, but we doubt that this is the whole story. Our visits over several years to the same firms before and after their adoption of such policies showed real performance improvements. This view is consistent with the findings of studies reviewed in Applebaum et al.

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63 Firm 5

64 Firm 23

9.1 Sources of Perceived Skill Shortage

Thus, our study finds the need for a broader approach to determining skills shortages. Management at the firms we studied knows what skills it would like, but often bases these estimations on incomplete understandings of current and future skills requirements. That is, management often omits important considerations when assessing a) the skill sets that will benefit the firm most, b) the workforce skills the firm lacks or will eventually need and c) how to best obtain those skills.

This conundrum exists for two main reasons. First, some firms are unwilling to pay the necessary wages for the skills they desire, thereby concluding the existence of a skill shortage when in reality one may not exist. Similarly, some firms may not know the magnitude of a potential return on investment, when hiring a worker (one with ERP skills, for example) would not pay off unless the firm redesigned its entire production process to emphasize quick changeovers to new products.

Second, some firms are not demanding skills in areas where they should. Understanding of skills requirements are infrequently rooted in long-term planning; as noted above, our study encountered an aversion to even the most basic forms of succession planning, i.e., planning to replace current skills let alone future ones. Assessment of skills needs is more frequently rooted in a general sense for what seems profitable at the moment. Yet our study encountered many instances in which firms could likely improve both short- and long-term operations by demanding additional skills. For instance, the production workers at some firms that claim no skills shortages are not trained in shop floor set-up for new product. Such skills would afford these firms the flexibility and speed to manufacture a wider variety of products more effectively. The agile production model described above also requires new skills from production workers, managers and tradespeople.

Thus, after analyzing our interview and survey data, we would argue that asking managers if they have workers with the right skill is not sufficient for designing training policies. There are two reasons why this is so. First, managers at low-wage firms report that they have trouble finding workers with the skills they need, whereas firms paying average or higher wages for similar workers report no such shortage. In this case, the solution to the perceived shortage is not new training programs, but a higher wage. In other cases, it would be efficient (both firms and workers could benefit) to have a more highly trained worker, yet firms do not demand such workers, perhaps because they don't know about this payoff, or because workers (not owners) would capture much of the benefit. We see both possibilities in our data. For example, there are two non-overlapping groups that complain that a significant number of their production workers are insufficiently numerate or literate : those who pay below-average wages, and those who require workers to inspect their own work. In the second case, from our plant visits we can see that some firms that would benefit from having workers do their own inspection do not ask this of workers, and so inefficiently claim that they do not face a skill shortage.

Thus, our study suggests that regional skills markets are not best shaped by asking only managers for their assessment. Instead, policymakers should help shape the curriculum of workforce training programs (including by convening other stakeholders) and in doing so should operate under the premise that skills can be added to every job. As shown in the summary report of our Driving Change project,[65] the Labor Market Information Offices in Ohio, Indiana and Michigan have already started down this path. Additionally, we believe the following steps would be effective.

9.2 Strategic Management Training Programs

Above all, federal and state level policy should aim to help firms become more competitive with a bias toward high-road strategies that benefit consumers, workers, and communities as well as firm owners. If firms can make wise investments, they can reduce layoffs even during cyclical market fluctuations. Our study found that time and again, industry-wide

65 This report is available at http://drivingworkforcechange.org/reports.asp

downturn forced firms into short-term thinking, causing them to abandon strategic planning and make decisions that will cause future problems and inhibit growth. When firm management are able to craft strategic plans that will not be derailed by periodic industry-wide downturn, firms will be more likely to avoid "double-edged swords" such as delaying investment in training and equipment. Policy that promotes this type of strategic planning will help prevent the industry from failing to invest in present and future skills needs and will produce significant tax revenue for all levels of government.

One agency that helps firms with integrated adoption of the multiple complementary policies necessary to improve performance the Manufacturing Extension Partnership (MEP), a federally supported network of non-profit institutions that provide support and guidance to small to mid-sized manufacturers. Organizations such as MAGNET and TechSolve in Ohio, the Michigan Manufacturing Technology Center and the Indiana MEP Purdue Technical Assistance Program offer a wide variety of services to industry. Similar programs have proven effective in Ontario, Canada and Catalonia, Spain and should be expanded in regions of the US, including Michigan, Indiana and Ohio. Strategic training for management can not only equip decision-makers with better appreciation for why investing in workers expands a firm's opportunities to be profitable, but can also help management understand how to integrate complementary investments. Often, a firm must make corresponding investments in equipment, IT software and workers if it is to reach a new plateau of competitiveness and thereby maximize the return on each of these investments. For instance, transitioning between two of the clusters described in section three of this report would almost certainly require simultaneous investment. One first tier supplier in Ohio reported that with guidance and support from the Ohio Department of Development, it was able to achieve and profit from this type of simultaneous investment.

As noted above, training managers to recognize the long-term benefits of workforce investment is a necessary first step. Even so, curriculum at existing workforce training courses offered by institutions such as community colleges and unions should be updated so that workers receive training that corresponds to comprehensive firm strategy. Specifically, competitive firms will need cross-functional workers accustomed to system-wide thinking. Production workers will need strong foundations in areas that have traditionally encompassed multiple job categories. In a state of the art plant, all facets of manufacturing including product design, equipment maintenance and plant architecture are designed as a complete process and workers will need to understand how each element relates to firm strategy.

To the extent that investment in people becomes a more important source of competitive advantage, traditional methods of investment financing become less adequate. One of the impediments is that banks are hesitant to make loans for training because training does not automatically increase a manufacturer's collateral in comparison to other types of investments such as buying capital equipment or an acquisition.

9.3 Work-sharing

Recent research on the long-term effects of job loss indicates that a worker who has been laid off experiences continued income loss for 15 to 20 years relative to peer workers who were not laid off.[66] This income loss amounts to about 30 percent of the worker's initial annual income in the first years and persists at about 20 percent of initial income for up to 20 years thereafter. For workers laid off in 1982, such income losses are calculated to have averaged from $10,000 to $18,000 annually (in 2000 dollars), with lifetime financial losses averaging between $110,000 and $140,000. During periods of mass layoff akin to what we have seen in the past three years, these losses represent hundreds of billions of dollars of taxable income.

As von Wachter notes, extending unemployment insurance, assisting in job searches and funding worker retraining can be effective at stunting the continued effects of displacement, although displacement appears to be so costly to workers that

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66 von Wachter, Till, Jae Song and Joyce Manchester. "Long Term Earnings Losses due to Mass-Layoffs During the 1982 Recession: An Analysis Using Longitudinal Administrative Data from 1974 to 2004." Mimeo, Columbia University; 2009.

it may be worthwhile considering policies helping to prevent or reduce layoff in the first place.[67] Aside from helping firms compete in the ways described above, government can help firms avert layoffs by allowing and promoting worksharing programs for firms at risk of layoffs. Worksharing programs are agreements between firms and state governments wherein a firm reduces each employee's hours to avoid layoffs and workers collect unemployment insurance for their unworked hours. Neither Ohio, Michigan, nor Indiana allow work sharing presently, nor did they allow it during the recession. A 2010 study from Policy Matters Ohio suggests that based on national averages, at least 23,000 Ohioans would have likely participated in worksharing programs if the state had allowed the practice in 2009.[68] We recommend that legislators in Ohio, Michigan and Indiana create worksharing programs, especially given that President Obama's 2012 budget includes funding to help create worksharing programs in states that currently lack them.[69]

9.4 Access to Credit

Suppliers that are especially hurt by lack of access to credit are firms considered to be "on the bubble" financially—those who are close to financial health, but considered less desirable as suppliers or as loan opportunities for lending institutions —may be at significant risk. These firms have more trouble accessing credit and face the risk that their clients may move work away from them toward healthier firms. If many Tier-1 suppliers make similar sourcing decisions, their actions (ironically meant to stabilize their supply chains by purchasing from more viable suppliers) could collectively threaten a large portion of the supply chain and risk significant supply chain disruptions.

It seems clear that there was a credit crunch in 2008-9; some firms with potentially profitable investments were unable to get credit; lack of access to working capital caused even some apparently well-managed firms to go bankrupt. The extent to which a credit crunch continues to exist today seems less clear. It is NOT a market failure if a bank refuses to lend money to a firm that is unlikely to pay it back . It is more probable that the bigger issue firms face is a lack of demand. Firms in all industries suffer from a lack of aggregate demand, with measured unemployment rates at 9%, and rates including discouraged workers far higher. Efforts to invest in "green" technology for the auto supply chain suffer in addition from the fact that gasoline is artificially cheap, since drivers do not pay true cost of the environmental degradation they cause.

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67 von Wachter, Till. "Jobs' Deficit and Job Growth, Unemployment and the Consequences for Workers." Employment Policy Research Network Policy Brief. January, 2011.

68 Schiller, Zach. "Worksharing: A Tool to Avoid Layoffs in Ohio." Policy Matters Ohio. April, 2010.

69 Baker, Dean. "Work Sharing: The Quick Route Back to Full Employment." Center for Economic and Policy Research. June, 2011.See also http://www.ilo.int/wcmsp5/groups/public/---ed_protect/---protrav/---travail/documents/publication/wcms_145335.pdf

appendix a

Our research was conducted in three phases. A nationwide survey was combined with a series of detailed firm interviews to provide us with a broad-based understanding of the present state of the US automotive supply chain. The following sections provide a brief outline of the methodology employed at each stage of this study.

Pre-survey Interviews

We conducted a series of interviews with predominantly second- and third-tier automotive suppliers throughout July and August of 2010. These wide-ranging conversations helped us frame and understand the most significant issues facing suppliers, and informed the nationwide survey we then built. During this phase of the study, we conducted interviews in Ohio, South Carolina, Michigan, and Tennessee. Our interviewees were mostly company presidents and sales managers, and most interviews included a comprehensive tour of production facilities. Apart from the geographic bias towards firms in the states in which we chose to conduct interviews, we believe that most, though not all, of the firms interviewed at this phase of the study enjoyed above average success.

Nationwide Survey, Stage 1

Combining our interview experiences with academic expertise from around the country, we designed customer relations, human resources and plant operations surveys built around the most important issues raised during the pre-survey interviews. Throughout the survey development process, we received input from economists and other researchers at numerous universities. We then pre-tested the surveys at eleven Northeast Ohio suppliers before finalizing the design used in our nationwide campaign.

We assembled our database of automotive suppliers by collecting firm information from 11 sources. Our two primary lists of firms came from ELM International and the Analyst Resource Center (ARC). The other nine lists came from the Michigan Manufacturing Technology Center (MMTC), the Original Equipment Suppliers Association (OESA), the Precision Metalforming Association (PMA), the Industrial Fasteners Institute (IFI), Ohio's Manufacturing Advocacy and Growth Network (MAGNET), the Automotive News Top 150 Suppliers list, Polymer Ohio, the National Establishment Time Series (NETS) database, and the Michigan Automotive Research and Development Facilities Directory.

We then used North American Industry Classification System (NAICS) codes, exhaustive internet-based research process and both manual and automated de-duping procedures to refine our database to the set of US establishments likely to be automotive parts suppliers. A 2010 publication by the Center for Automotive Research, "Contribution of the Automotive Industry to the Economies of All Fifty States and the United States," helped us determine which specific NAICS codes best indicated that a firm supplies to the automotive industry. Our sampling framework was designed to be as comprehensive as possible, including firms that we were unable to conclusively determine to be automotive suppliers yet were indicated as likely to be such by one or more of our data sources. Each plant location and division headquarters was considered an individual observation in our database. Our final stage-one sample consisted of 17,271 plants

We contracted with Datastat, a Michigan-based survey research firm, to contact these plants and coordinate survey administration; undergraduates at Case Western Reserve University and Ohio State University were also hired to make calls. First, Datastat sent postcards and emails to each plant in our sample informing them of their eligibility to participate in our study. They then contacted each firm by phone, attempting to obtain the name and email address of a management-level sales, human resources, or plant operations contact. Each plant location was contacted up to eight times. Once such a person was identified, they were quickly sent an email containing a URL linking to each of the three surveys. Each survey link was unique and specific to each location in our database. Each contact was asked to personally complete the survey or surveys relevant to his or her position, and forward the remaining surveys to the appropriate individuals at that workplace. As an incentive, respondents were promised a personalized benchmarking report based on their responses and aggregate survey results.

Our procedure allowed us to identify firms that no longer or never were a part of the automotive supply chain, as well as firms which had ceased operations. Of firm locations attempted, 33.05% yielded either verbal confirmation that the operation had gone out of business, or a disconnected phone number, indicating the operation had likely gone out of business. Another 5.31% of locations called yielded refusal to participate, and our callers had verbal confirmation that the plant did not participate in the automotive supply chain and was thus ineligible to participate in our study at 2.61% of locations attempted. Of these ineligible plants, 52.08% reported that the plant had never supplied to the auto industry, 33.33% reported that the plant used to supply to the auto industry but no longer does, 8.33% reported that they did not know whether the firm used to supply to the auto industry, and 6.25% reported that automotive end-users constituted only a tiny portion of the plant's products. Stage one of our nationwide survey was conducted between March and June of 2011 and yielded one or more surveys from 598 automotive supply plants.

After calling through the database of 17,271 plants and eliminating those that were no longer in business, refused to participate, or were ineligible to participate,we were left with roughly 6673 units in the U.S. that supply parts or equipment used in the manufacture of new cars and light trucks. This figure is an underestimate of the number of establishments in the supply chain, since some locations in our database were sales offices that represented multiple automotive manufacturing plants. Thus this number of units that we contacted cannot be compared to the number of establishments discussed in our "Industry Snapshot" above.

Nationwide Survey, Stage 2

Following the completion of stage one of our nationwide survey of suppliers, we conducted approximately 30 post-survey interviews. While similar to our original round of interviews in structure, we focused more heavily on issues surrounding outsourcing and re-shoring and selected a greater proportion of firms located in southern states. Based on these interviews, other feedback and the results of our stage one survey, we developed abridged versions of our customer relations, human resources and plant management questionnaires. These shortened surveys focused on only the most critical questions and were designed to be able to be completed in approximately 10 to 15 minutes.

Abridged customer relations, human resources and plant operations surveys were printed and distributed by mail to eligible firms by Datastat, our Michigan-based survey contractor. Each survey included a postage-paid return envelope and information on accessing an alternative web-based version of the abridged survey. Computer-aided telephone interviewing (CATI) was also employed to elicit responses from firms not completing either a paper or web-based survey. As an incentive for participation, we promised survey participants a personalized benchmarking report and the chance to receive a $100 cash prize as incentives to respond.

Tier-1 Interviews

As noted in the introduction,there are a few very large suppliers (with annual sales measured in many billions of dollars and plants located around the world). In order to gain a more specific understanding of how these mega- suppliers were affected by the crisis and what factors drive their behavior now, we worked with the Center for Automotive Research (CAR) to conduct a series of post-survey inter views with large first tier suppliers. In the spring of 2011, researchers at CWRU and CAR interviewed executives at seven such suppliers. These interviews followed a consistent format, and focused on the effects of the recent economic crisis, the relationship between first tier firms and their suppliers, the effect of technology on manufacturing, and the relative importance of practices such as just in time manufacturing and value stream mapping. Specific points of interest included whether the economic crisis had changed first tier firms' strategies of principles guiding relationships with their suppliers, whether the increasing percentage of computerized automotive content had affected first tier firms, whether first tier firms have been off-shoring or re-shoring work, the effects of and attitudes toward unionization (of both first tiers and their suppliers), and how important it is for a first tier firm's suppliers to participate in non-automotive industries.

appendix b

Figure 2 of this report presented overall trends of employment and establishments in industries associated with automobile manufacturing, and figures 3 and 4 presented these trends for the tri-state region and other regions. Along with these figures, we described employment and establishment trends in these two regions, and explained which industry classifications we used to identify automobile manufacturing.

B.1. Motor Vehicle Parts Manufacturing (NAICS 3363)

Motor vehicle parts manufacturing (NAICS 3363) comprised 61 percent of total automotive employment and 42 percent of total automotive establishments in 2001. However, NAICS 3363 had dropped to 56 percent of automotive employment but slightly increased to 44 percent of automotive establishments by 2009. During this same period, employment in motor vehicle parts manufacturing fell by 46 percent, while the number of automotive parts establishments shrank by 12 percent. While there are still about twice as many auto parts establishments outside the tri-state area as within it (Figure A.2), the tri-state region employed slightly more automotive parts workers in 2001. However, employment inside and outside the tri-state region had equalized by 2003. Since then the employment in the tri-state region has fallen more than the employment in other states (Figure A.1). Specifically, automotive parts employment fell by 35.5% in the tri-state region and by 29% in other states from 2007 to 2009. The number of automotive parts establishments fell by 5.4% in the tri-state region and 4.1% in other states between 2007 and 2009, while it fell by 21% in the tri-state region and 8% in other states between 2001 and 2009.

Figure B.1: Employment in motor vehicle parts manufacturing industry by region

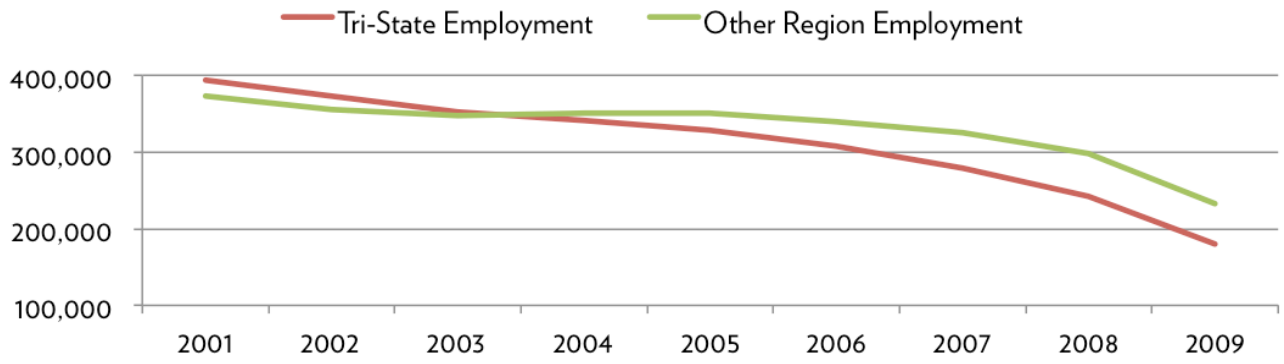
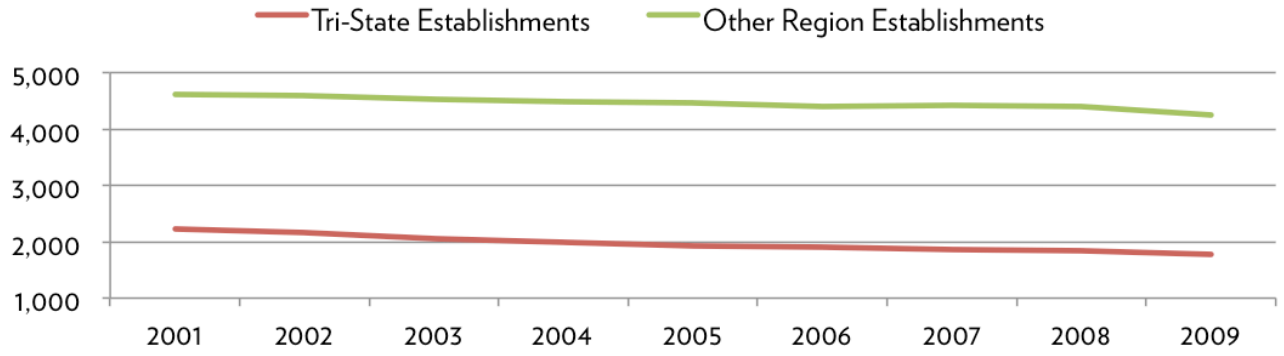


Figure B.2: Establishments in motor vehicle parts manufacturing industry by region



B.2. Motor vehicle body manufacturing (NAICS 336211)

The motor vehicle body manufacturing industry (NAICS 336211) comprised about 6-7 percent of total automotive employment and establishments between 2001 and 2009. In 2001, employment in the tri-state region constituted 29% of body manufacturing industry employment. This figure had fallen to 23 percent by 2009. Body manufacturing employment in the tri-state region shrank 31% from 2007 to 2009, and shrank 47% from 2001 to 2009. Body manufacturing employment outside the tri-state area experienced two major periods of decline: a 19% reduction between 2001 and 2003 and a 16% reduction between 2008 and 2009. Between 2007 and 2009, the number of auto body manufacturing establishments shrank by 5% in the tri-state region and 1.3% in other states.

Figure B.3: Employment in motor vehicle body manufacturing by region

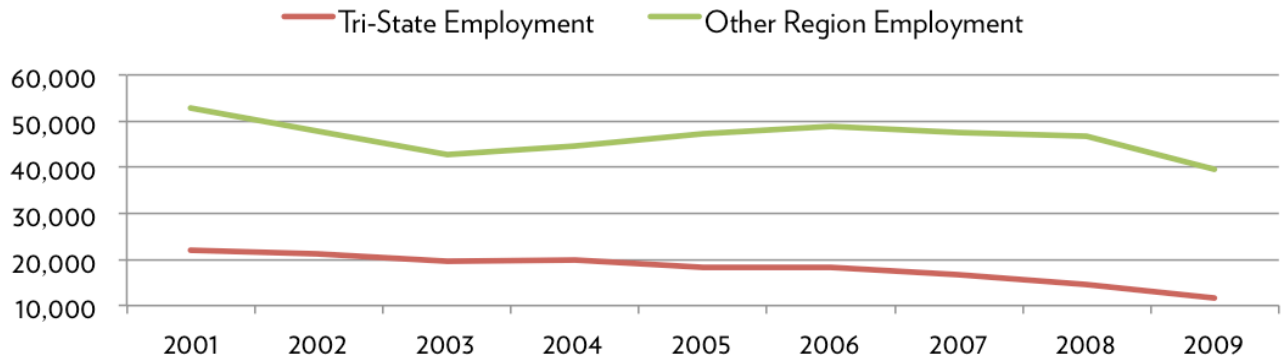
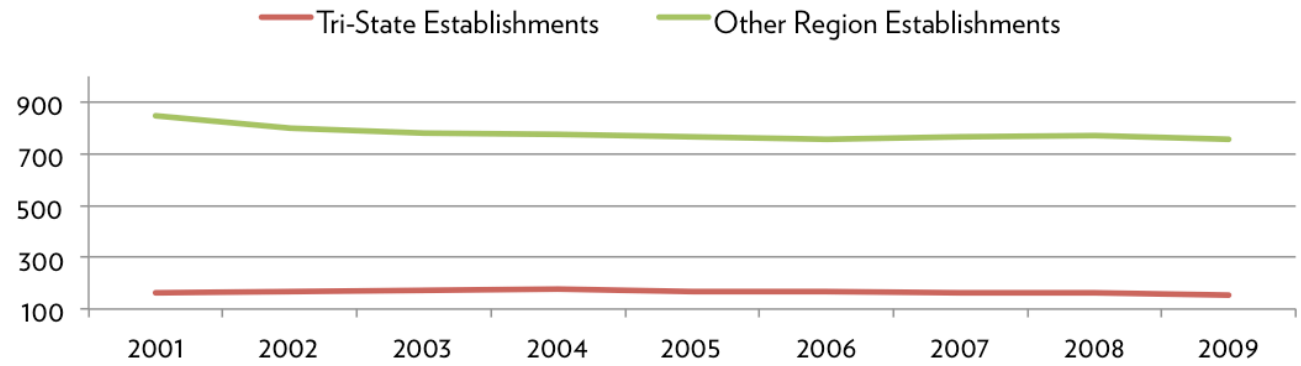


Figure A.4: Establishments in motor vehicle body manufacturing by region



B.3. Rubber and plastics hose and belting manufacturing (NAICS 326220)

The rubber and plastics hose and belting manufacturing industry (NAICS 326220) constituted the smallest industry relevant to our study, comprising of only 2 percent of the total automotive employment and establishments in 2001. Employment in the tri-state region represented 24 percent of the industry employment in 2001 and 20 percent in 2009, while establishments in the tri-state region constituted about 19 percent of the industry throughout that time period. Similar to previous patterns, the largest decline occurred between 2007 and 2009, finalizing a 27 percent employment reduction in the tri-state region and an 18 percent employment reduction in other states. Conversely, the number of the establishments in the tri-state region shrank by 16 percent from 2007 and 2009, whereas the number in other states only shrank by 1.5 percent during that time.

Figure B.5: Employment in rubber and plastics hose and belting manufacturing by region

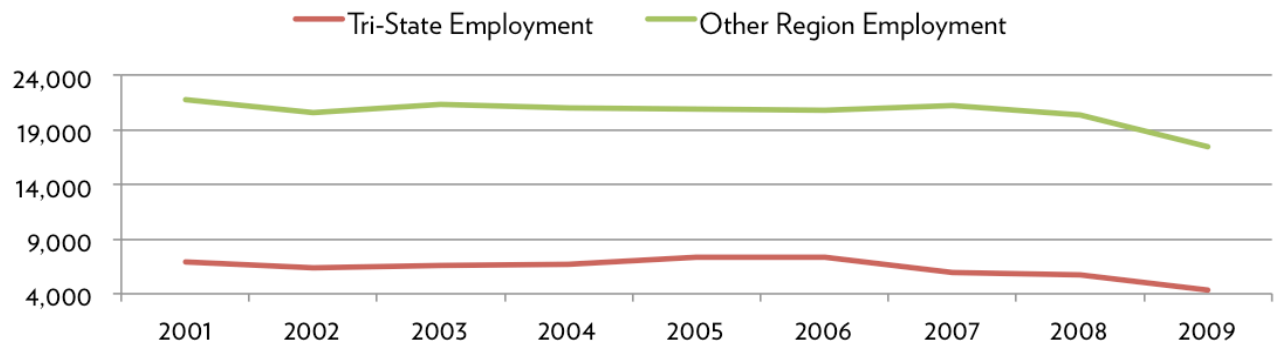
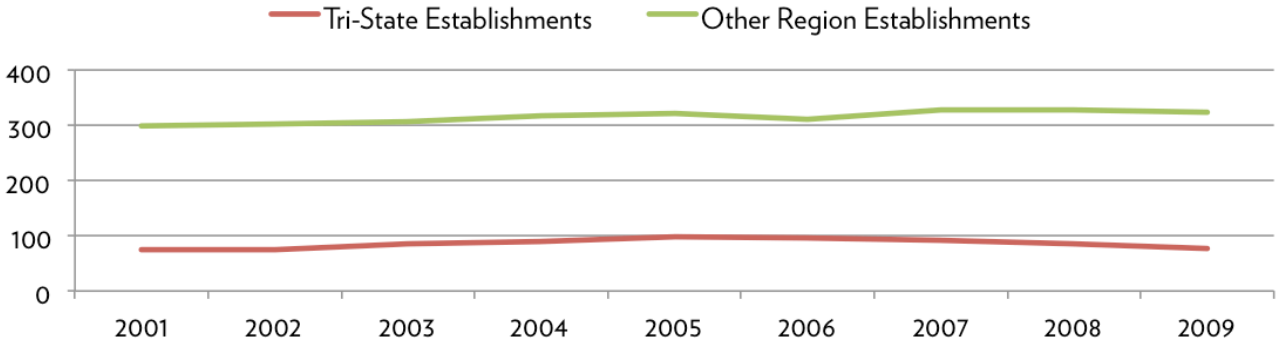


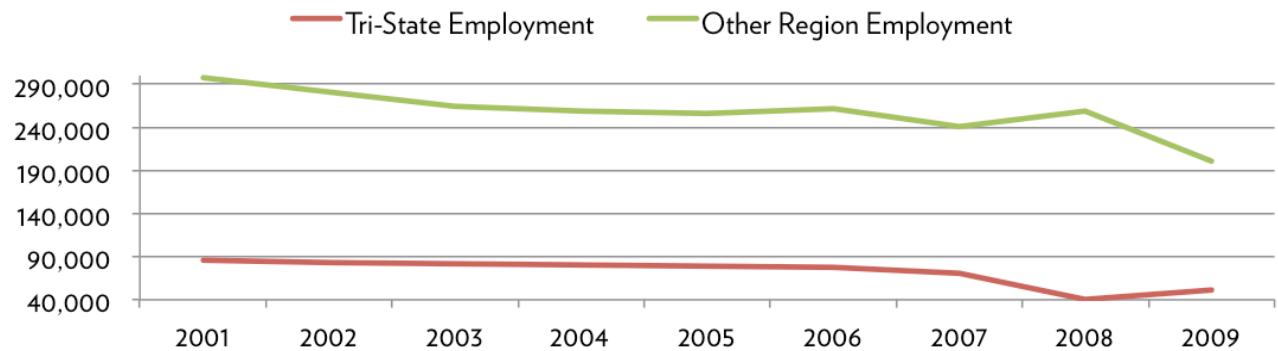
Figure B.6: Establishments in rubber and plastics hose and belting manufacturing by region



B.4. All other plastics product manufacturing (NAICS 326199)

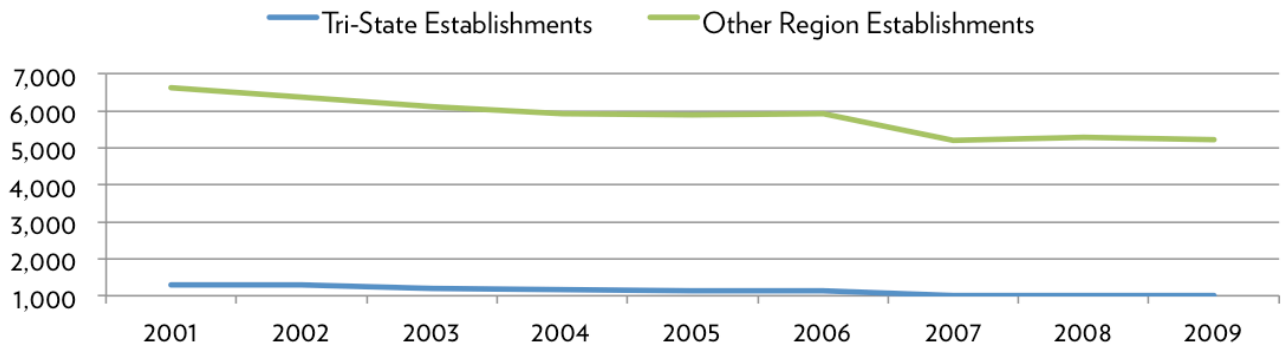
In 2001, all other plastics product manufacturing (NAICS 326199) accounted for 31 percent of the total automotive manufacturing employment and 49 percent of auto manufacturing establishments. By 2009, these portions had changed only slightly to 34% of employment and 46% of establishments. Consistent with the patterns visible in other automotive industries employment in this industry both inside and outside of the tri-state region declined from 2001 through 2009, amounting to a 41% reduction in the tri-state region and a 32% reduction in other states. For the same period, the number of "all other plastics" establishments reduced by 22% inside and outside the tri-state area. The largest reduction in employment for both regions occurred between 2007 and 2009, during which time the tri-state region experienced a 26% reduction and the rest of the country experienced a 22% reduction.[70]

Figure B.7: Employment in all other plastics product manufacturing by region



70 Again we note that because 2008 Ohio employment figures for NAICS 326199 are unavailable in the QCEW, the figure in the tri-state region has employment of Michigan and Indiana. So any comparison using 2008 tri-state employment is not meaningful.

Figure B.8: Establishments in all other plastics product manufacturing by region



appendix c

This section presents mean annual pay per employee by detailed NAICS codes. First, as noted in section two of this report, we observe a significant gap in real wages, and average wages in the tri-state region were higher than those in other areas. The following graph suggests that this trend is driven primarily by wages in the motor vehicle parts manufacturing industry (Figure A.9). Furthermore, an average annual salary differential exists even within the tri-state region: $68,836 for auto supply workers in Michigan, $56,249 for auto supply workers in Indiana, and $53,493 for auto supply workers in Ohio. Second, although wages in specific industries showed some level of variation, particularly for the rubber and plastics hose and belting manufacturing industry (NAICS 326220) and other plastics product manufacturing (NAICS 326199), an initial wage gap between the two regions in 2001 reduced in 2009 (or, even reversed in such industries).

Figure C.1: Mean annual pay per employee by region in motor vehicle parts manufacturing industry (NAICS 3363)

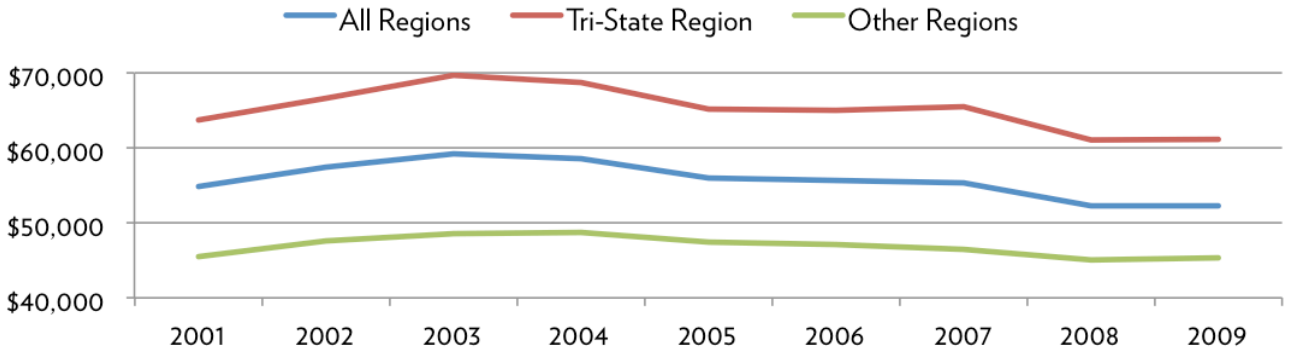


Figure C.2: Mean annual pay per employee by region in motor vehicle body manufacturing (NAICS 336211)

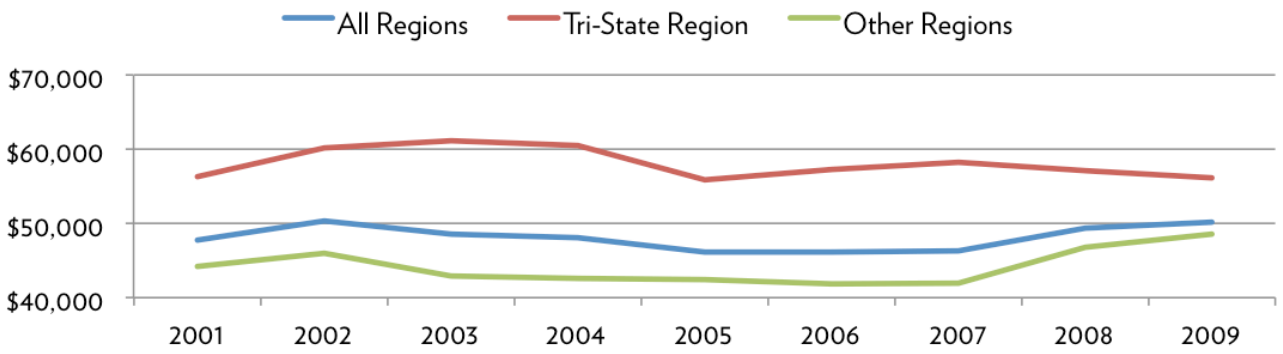


Figure C.3: Mean annual pay per employee by region in rubber and plastics hose and belting manufacturing (NAICS 326220)

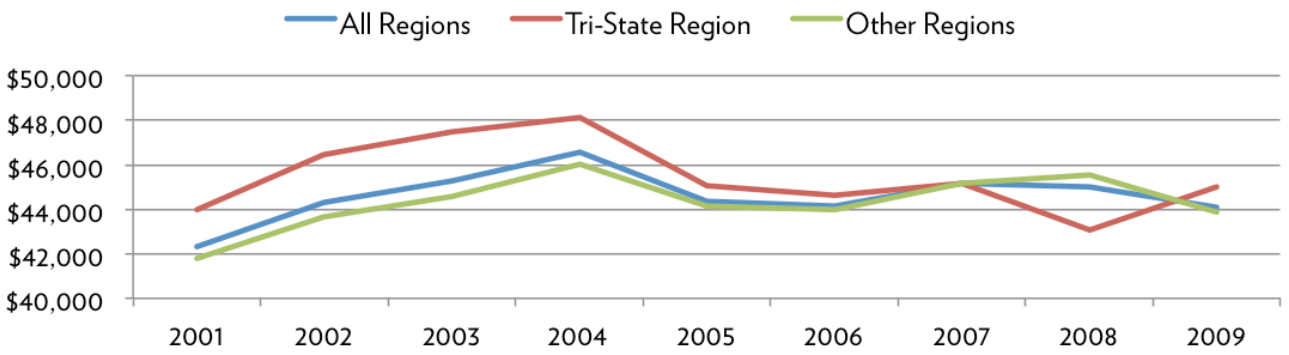
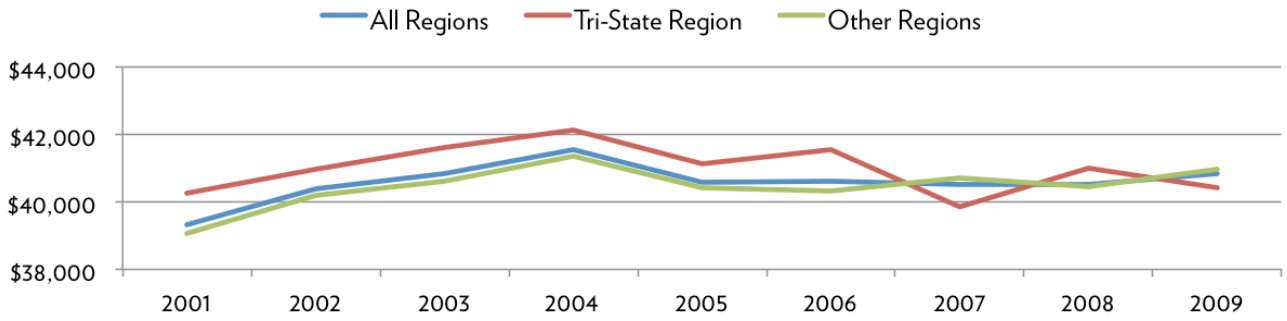


Figure C.4: Mean annual pay per employee by region in all other plastics product manufacturing (NAICS 326199)



appendix d

The Case Western Research team collected data only from firms that survived the crisis. In order to fill this gap, we studied 72 large tier-1 suppliers that filed for Chapter 11 in order to find trends within the firms that went bankrupt. This section presents the trends that we found among the 72 firms and short case studies. Unlike the rest of the report, the names of the firms are used in this appendix as the information was gathered from public sources .

One of the main reasons that suppliers went under during the recession is that they had highly leveraged growth earlier in the decade. One example was the supplier Tower Automotive, which was a global designer and supplier of stampings and assemblies for top automotive companies. During the 1990's Tower made multiple acquisitions in North America, Europe, Asia and South America. Tower's highly leveraged growth during the 90's along with rising commodity prices and falling sales during the early 2000's created an unsustainable debt load and caused Tower to file for Chapter 11 bankruptcy in 2005. Other such examples include companies such as Federal Mogul and Collins & Aikman.

Another reason is that the suppliers relied too heavily on a specific manufacturers, the lack of diversity made them especially vulnerable to changes in sales. An example is Amcast Industrial Corporation, which relied on GM for as much as 80 percent of its business. When GM stopped buying from Amcast they couldn't acquire business from other manufacturers and industries fast enough and were forced to close. There were also examples of suppliers collaborating directly with auto manufacturers to produce specialized products. Examples of such suppliers include American Specialty Cars (ASC), which had invested $250 million to produce vehicles specifically for GM, one of which was the Chevrolet SSR truck. However, GM cancelled the development of the vehicles and low SSR sales bankrupted ASC. Even firms that were already somewhat diversified had a very difficult time expanding into non-auto industries. For example, Specialty Devices had the bulk of its business in the auto industry, however, it also supplied the aerospace & defence and mining & blasting industries. However, with the drop in auto sales, Specialty Devices was unable to refinance its debt and filed for bankruptcy.

Yet another reason firms went bankrupt was because of failed offshoring attempts. One example is the supplier Ward Products who provided antennas to Ford and DaimlerChrysler. Ward relocated it production facility from Amsterdam, NY to Tijuana, Mexico in order to reduce labor and operating costs. However, according to its bankruptcy filing, production problem and inefficient inventory management made relocating very costly and caused Ward to close.

acknowledgments

The authors would like to acknowledge the numerous people that have contributed to this study and this report. Some are named below, but many are not. Many experts in industry, government and universities provided valuable data and insights that not only guided the formation of conclusions, but also, at a more fundamental level, inspired the asking of the right questions. Additionally, in spite of the perennial demands of the business of manufacturing, many firms took considerable time to share their experiences. Many opened their doors to us, let us talk to workers, and allowed us to concretely experience the challenges and triumphs of their world first hand. To all of these people we are deeply indebted.

Authors

Susan Helper – Principal Investigator
Kyoung Won Park – Post-Doctoral Fellow
Jennifer Kuan – Post-Doctoral Fellow
Timothy H. Krueger – Policy Analyst at Policy Matters Ohio
Brian Peshek – Project Manager (Lean Six Sigma Black Belt)
Alex Warofka – Information Technology & Research Assistant
William Eisenmenger – Information Technology & Research Assistant
Joy Zhu – Research Assistant

Research Assistants and Project Support

Yugarshi Mondal – Research Assistant
Jonathan Evans – Research Assistant
Wenjing Li – Research Assistant
Di Tang – Research Assistant
Natalia Cabrera – Research Assistant
Chris Murphy – Research Assistant
Teresa Kabat – Project Administrator
Scott Kroehle – Call Center Manager

Survey Distribution and Data Collection

DataStat, Inc.
Marielle Weindorf – Senior Research Director
Momoko Rai – Project Manager
David Atwood – Project Director

Advisors and Contributors

Till von Wachter – Columbia University
David Greenstreet – Carnegie-Mellon University
Thomas Klier – Federal Reserve Bank of Chicago
Nicholas Berente – University of Georgia
John Paul MacDuffie – Wharton School at University of Pennsylvania
Takahiro Fujimoto – University of Tokyo and MMRC
Daniel Heller – Yokohama National University

Policy Matters Ohio
Amy Hanauer – Executive Director
Wendy Patton – Senior Associate

Center for Automotive Research (CAR)
Kristin Dziczek – Director, Labor & Industry Group
Jay Baron – President, Chairman and CEO
Bernard Swiecki – Senior Project Manager, Sustainability & Economic Development Strategies

Precision Metalforming Association (PMA)
William Gaskin – President
Allison Grealis – Director of Member Services

Industrial Fasteners Institute (IFI)
Robert J. Harris – Managing Director
Joe Greenslade – Director of Engineering Technology
John O'Brien – Manager of Automotive Parts Division
Don Cunningham – President of Semblex, Inc.

Polymer Ohio
Wayne Earley – CEO
Kevin Cunningham – Manager, Outreach Program
Craig Nickoloff – Manager, Programs and Communications
Dr. Robert Judd – Ohio University
Dr. Diana Schwerha – Ohio University
John Hickman – Vice President of Programs
Barr Klaus – Vice President of Asset Based Company Attraction

Manufacturing Advocacy and Growth Network - MAGNET
Mary Ann Pacelli – Senior Consultant
Fatima Weathers – Chief Operating Officer, Executive Vice-President

Ohio Aerospace Institute
Donald W. Majcher – Vice President of Technology & Innovation Partnerships
Monica Dumitriu – Program Manager for Technology & Innovation Partnerships

Michigan Manufacturing and Technology Center (MMTC)
Dr. Daniel Luria – Research Director

Original Equipment Suppliers Association (OESA)
Dave Andrea – Senior Vice President of Industry Analysis and Economics

Japan Auto Parts Industries Association (JAPIA)
Ted Kawashima – JAPIA North American Office
Akito Ozeki – JAPIA Tokyo Office

National Tooling and Machining Association (NTMA)

Reshoring Initiative
Harry Moser – Founder

Cuyahoga Community College
John Gajewski – Executive Director

ATF, Inc.
Jason R. Surber – President

Gerstenslager Co
Steve Demoro – Director of Sales, Engineering & Materials

Exact Tool & Die
Frank Chesek – Owner and President
Mark Klepper – Vice President of Sales

Ohio Department of Jobs and Family Services—Labor Market Information Bureau
Keith Ewald – Bureau Chief of Labor Market Information
Lewis Horner – Assistant Bureau Chief
Mary Miller – Project Manager

Indiana Department of Workforce Development—Research and Analysis
Vicki Seegert – Manager of Business & Workforce Studies
Charles Baer – Manager of Economic & Market Analysis
Kimberley Linville – Project Manager

Michigan Department of Technology, Management, and Budget—Bureau of Labor Market Information and Strategic Initiatives
Richard Waclawek – Director
Bruce Weaver – Economic Manager, Labor Market Analysis

Indiana Business Research Center, Kelley School of Business, Indiana University
Jerry Conover – Director
Rachel Justis – Managing Editor
Carol O. Rogers – Deputy Director and Chief Information Officer
Timothy F. Slaper – Director of Economic Analysis