3. Employer Responses to Auto Industry Changes

As discussed in the previous chapter, the automotive industry has been impacted by the introduction of green technology in its vehicles, production equipment and facilities. The recent economic crisis has also had a significant financial impact on the industry—driving two major domestic automakers and a large number of automotive suppliers into bankruptcy. Many suppliers did not survive the crisis, and all remaining automakers and suppliers are facing critical financial and capacity constraints. In addition, the automotive industry faces an uncertain future with regard to government fuel economy, emissions and safety standards, and the level of consumer demand for green vehicles.

Despite the financial constraints and market and regulatory uncertainty, automakers and suppliers are investing in greener products, processes and equipment. Automaker announcements made in 2010, and thus far in 2011, total $4.3 billion in green investments in Indiana, Michigan and Ohio alone (see **Table 3**). Suppliers are investing in green research, technologies and products, as well.

The federal government is backing green investments in the tri-state region's automotive industry. Over $8.4 billion of the $25 billion available to automakers through the Department of Energy's Advanced Technology Vehicles Manufacturing Loan Program (Section 136) has been awarded (see **Table 4**). Ford will invest a share of its $5.9 billion in funds from this program in Michigan, Ohio and three other states, to produce more fuel efficient vehicles. Of the more than $2.3 billion in American Recovery and Reinvestment Act (ARRA) awards to automakers and suppliers for electric drive vehicle, battery, and component manufacturing, approximately $1.4 billion went to companies and facilities in Indiana, Michigan and Ohio.[7]

Investment is an important leading indicator for hiring. Spending on research and development and new products drives increased engineering and technical employment; investment in plants and equipment leads to hiring additional hourly and skilled trades workers throughout the region.

[7] U.S. Department of Energy, http://www.energy.gov/recovery/data.htm.

Table 3: Green Automaker Investment in Indiana, Michigan and Ohio, By Company and By State, 2010-2011 Announcements

Company	Indiana (in millions)	Michigan (in millions)	Ohio (in millions)	Tri-State Total (in millions)
Bright		$11.0		$11.0
Chrysler	$1,271.3	$302.0		$1,573.3
Ford		$1,183.5	$420.0	$1,603.5
General Motors	$111.0	$613.2	$186.2	$910.4
Honda			$70.0	$70.0
Subaru (SIA Toyota)	$81.0			$81.0
Think	$43.5			$43.5
Total	**$1,506.8**	**$2,109.7**	**$676.2**	**$4,292.7**

Note: More detail is available in Appendix B.
Source: Center for Automotive Research

Table 4: American Recovery and Reinvestment Act (ARRA) Awards for Electric Drive Vehicle, Battery and Component Manufacturing

Program	Amount Awarded	States Benefitting	Companies
Cell, Battery and Materials Manufacturing Facilities	$1.2 billion	**MI**, **IN**, OR, FL , TN, GA, PA	A123, Dow Kokam, LG Chem, GM, JCI, Enerdel, Saft, Exide/Axion
Electric Drive Component Manufacturing Facilities	$465 million	**MI**, **IN**, MD, ND, CO	GM, Delphi, Allison Trans., Ford, Remy, UQM Technologies, Magna E-Car
Advanced Vehicle Electrification	$254 million	AZ, CA, OR, WA, TN, **MI**, KY, **IN**, IL	Nissan/ETEC, Chrysler, SCAQMD, Cummins
Advanced Battery Supplier Manufacturing Facilities	$235 million	NC, SC, NV, NY, IL, **OH**, OR, LA, AR, CT	Celgard, Toda, Chemetall Foote, Honeywell, BASF, EnerG2, Novolyte, FutureFuel, Pyrotek, H&T Waterbury
Advanced Vehicle Electrification and Transportation Sector Electrification	$71 million	**MI**, MO	GM, Ford, Smith Electric Vehicles
Advanced Electric Drive Vehicle Education Program	$39 million	**MI**, WV, SC, **IN**, CO, GA, MO, MA, VA, CA	WVU, Purdue, Colorado State, MUST, WSU, MTU, UM, National Fire Protection Association, Reynolds CC, City College of San Francisco
Electric Drive Subcomponent Manufacturing Facilities	$32 million	SC, VT, PA	KEMET, SBE, Powerex
Transportation Sector Electrification	$22 million	OR	Cascade Sierra
Advanced Lithium-Ion Battery Recycling Facilities	$9.5 million	**OH**	TOXCO

Source: U.S. Department of Energy

3.1 Automakers and Tier 1 Suppliers

Indiana, Michigan and Ohio are the heart of the U.S. automotive industry. The tri-state region is home to the global headquarters of Chrysler, Ford and General Motors, and the North American headquarters of Honda. In addition to these companies, Mitsubishi, Subaru and Toyota produce vehicles in these states, and nearly every global automaker or top supplier has a research and development or engineering presence in the region. The three states currently account for 46.9 percent of U.S. automotive production, manufacture 62.2 percent of all U.S.-built engines and 75.1 percent of all U.S.-built transmissions.[8] Over 84.5 percent of all private automotive research and development in the United States is located in Indiana, Michigan and Ohio, with 73.4 percent in Michigan alone.[9] The green transformation of this industry presents considerable opportunity for these three states. However, there is formidable risk should new green automotive technologies produced outside the region supplant those currently being manufactured in Indiana, Michigan and Ohio.

Interviews were conducted with manufacturing and engineering human resources managers at the major vehicle manufacturing firms in the United States, as well as with the union that represents most hourly workers at the Detroit Three automakers, the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America

[8] Source: IHS Global Insight, 2010.

[9] National Science Foundation/Division of Science Resources Statistics, *Survey of Industrial Research and Development: 2007*, Table 32: Funds for industrial R&D performed in the United States, by industry and company size, by state: 2007 and Table B-8: Funds for industrial R&D, sales, and employment for companies that performed industrial R&D in the United States, by expanded industry and company size: 2007.

> *Automakers indicate that trends in greening the products and processes of producing parts and components are having a much more profound impact on engineering and technical staff than on production and trades workers.*

(UAW). The UAW considers the issue of green jobs critical and is working to make sure any new content related to greening the vehicle takes place in the United States.

While the drive to improve fuel economy is not new, government standards that must be met and the speed of change have changed significantly in recent years. For the production workforce, green jobs are those that are tied to making green products. Automakers indicate that trends in greening the products and processes of producing parts and components are having a much more profound impact on engineering and technical staff than on production and trades workers.

Table 5: Projected Major Automaker Employment in Indiana, Michigan, Ohio and the United States in 2010, 2015 and 2020

		2010	2015	2020
Indiana	Hourly	15,143	18,544	16,757
	Salaried	1,279	1,548	1,495
	Total	16,422	20,092	18,252
Michigan	Hourly	54,568	80,173	75,829
	Salaried	48,283	57,737	55,037
	Total	102,851	137,910	130,866
Ohio	Hourly	31,474	34,637	35,186
	Salaried	6,217	6,632	6,519
	Total	37,692	41,269	41,704
Tri-State Region	Hourly	101,186	133,354	127,771
	Salaried	55,779	65,917	63,051
	Total	156,965	199,271	190,822
U.S. Total	Hourly	144,917	179,982	170,450
	Salaried	79,268	91,262	87,938
	Total	224,185	271,245	258,388
Tri-State as a Percent of U.S.	Hourly	69.8%	74.1%	75.0%
	Salaried	70.4%	72.2%	71.7%
	Total	70.0%	73.5%	73.9%

Source: Center for Automotive Research

3.1.1 Employment Outlook

A common thread in the industry and union responses is that the light vehicle sector is a major contributor to greenhouse gas (GHG) and fuel consumption reduction, and as such, the companies and the union feel that almost every job in the auto industry is a green job. It was difficult to disentangle employment effects of overall changes in the industry from those that are as a direct result of the greening of the product and the process. U.S. vehicle sales are highly cyclical. In order to maintain the constant labor cost per vehicle, automotive manufacturing companies adjust their labor force according to the supply and demand of vehicles. **Table 5** shows a projection for hourly and salary automaker employment in the tri-state region and the U.S. for the top five automotive manufacturing companies in the United States.

U.S. vehicle production, as estimated by IHS Global Insight, shows steady increases through 2015. Increasing vehicle production impacts employment in Indiana, Michigan and Ohio differently; this is due to the differences in each state's automotive firms, type of facilities and occupational mix. The tri-state region's hourly and salaried employment levels are expected to increase through 2015 due to the output recovery of domestic automotive manufacturing firms. Michigan is projected to benefit the most, with a 34 percent employment gain, because it has a higher concentration of domestic automotive manufacturing factories and non-manufacturing facilities. Indiana automotive employment is expected to rise 22 percent, and Ohio's by 9 percent in the 2010-2015 period.

Between 2015 and 2020, overall U.S. automotive employment is expected to decrease by about 5 percent. Indiana and Michigan are expected to mirror the national trend with employment declines in this period. Indiana's 10 percent employment decline is related to expected production cutbacks at two of the state's automakers; while Michigan's 5 percent employment reduction is closely tied to cuts in the domestic manufacturers' overall output levels. During this same period, Ohio employment is expected to increase slightly (by 1 percent) due to firm mix and the forecast for products that are expected to be allocated to Ohio's automotive manufacturing facilities.

3.1.2 The Greening of the Automotive and Tier I Supplier Production and Trades Workforce

Respondents reported that while there is a perception of green impact on workforce skills, the changes for individual production employees are not revolutionary. For skilled trades workers, the changes are greater; these changes may require different skills to maintain LEED-certified manufacturing facilities, as well as more complex manufacturing equipment. No automaker or supplier tracks production or skilled trades training by any green category.

Respondents indicated most training for production workers that could be considered green is actually part of new product training. They report that a change under the hood impacts only a few processes on the assembly line. In some areas, such as machining fuel injection parts for diesel engines or building hybrid transmissions, the tolerances may be tighter or there might be more content, but the work itself is essentially the same. The most common green training for production workers involves recycling and proper use of products (primarily those required for cleaning or lubricating). Green practices, such as recycling scrap, are prevalent throughout the industry. Automakers and suppliers seek production workers who can contribute to the company's overall continuous improvement efforts. Many times, these efforts produce greener outcomes; for example, a company might see lower energy usage from turning off equipment when not in use. Respondents reported that workers involved in hybrid or electric vehicle production do undergo additional safety training having to do with working in a high-voltage environment; this training, on average, takes less than a day.

There are two exceptions that may require new production and skilled trades worker skills and training: the introduction of new lightweight materials and battery manufacturing. Lightweight materials require new ways of forming and joining parts; lightweighting is a developing area, and the training impact for the workforce has not yet been fully realized.

Battery manufacturing, while it is new to the auto industry, is not a new industry. Workers in these plants must have a basic knowledge of how to work in a process environment, versus a discrete parts production environment. The training for workers in these plants is more geared toward operating equipment than manual assembly. Production and skilled trades workers in these firms generally undergo a longer period of initial training, including more intensive health and safety curriculum, an understanding of basic chemistry concepts, and instruction in clean room procedures required in these environments.

"There are two exceptions that may require new production and skilled trades worker skills and training: the introduction of new lightweight materials and battery manufacturing."

> *Maintaining LEED-certified buildings, green plant and equipment—such as rainwater collection or solar panels—and more complex manufacturing equipment does require additional skills.*

For the skilled trades workforce, the changes are greater. Maintaining LEED-certified buildings, green plant and equipment—such as rainwater collection or solar panels—and more complex manufacturing equipment does require additional skills and training. Newer manufacturing plants are being built with environmental design, energy and water conservation in mind. Environmental and sustainability goals impact the skilled trades workforce; most automakers offer training in hazardous materials and waste, waste water, and power plant maintenance. Increasingly, new equipment purchases are moving toward electrical and electronic machines (rather than hydraulic) and that is changing the mix of skilled trades workers required.

3.1.3 Up-Skilling of Incumbent Workers

As discussed in the previous section, respondents report that much of the green training curriculum for hourly workers is centered on technology changes in the product and is categorized as product training rather than up-skilling.[10] Respondents reported that hourly worker training consists of the mandatory subjects—such as health and safety, equal employment opportunity, or quality—as well as problem solving, continuous improvement and teamwork. For skilled trades and maintenance personnel, incumbent worker training focuses on cross-training for higher trades utilization (percent of time spent working). At the Detroit Three automakers, the primary driver of cross-skilling and additional training for skilled trades workers is the reduction in the number of skilled trades classifications. Respondents related that the most effective training results in workers putting their new skills to work on the job immediately.

Several automaker respondents commented on the lack of available funding for incumbent worker training. For companies, the majority of the cost of training is the wages paid to workers while they are in training. There are few government programs that pay a wage subsidy for incumbent worker training.

3.1.4 Job Classification Impact of Green Initiatives

No automaker reported any changes in occupations or job classifications of production or skilled trades workers related to greening the product or process. The mix of skilled trades classifications may change as more electrical and electronic equipment is employed and as more focus is placed on the environmental aspects of managing water and waste streams.

3.1.5 The Greening of the Automotive Engineering and Technical Workforce

The automakers reported that engineering and technical workforce skills will change the most as a result of the greening of the product and manufacturing processes. There are wholly new green areas, such as hybrid powertrain engineering, requiring both new skills and more workers. There are other areas (e.g., controlling tailpipe emissions) where the automakers indicated that although the standard has changed, more people or a different set of skills are not necessarily required. Some areas of vehicle engineering and design, such as noise, vibration and harshness (NVH), have a different focus when a large V-6 or V-8 engine is replaced by an electric motor, but the fundamental skill base and demand for workers in this area will remain the same. Respondents reported the following categories where engineering and technical workers are in demand as a result of greening the product and process:

[10] As stated earlier, this report uses the term skill and skills in several different and significant ways. Skills or skill sets can refer to a broad range of requirements for an occupation, from interpersonal competencies to hours of experience in an apprenticeship to advanced academic training. "Up-skilling" uses the term skills in this broad sense. Up-skilling is a term that employers were comfortable with and used frequently in interviews to describe any type of skill set enhancement or improvement, from on-the-job training to academic certification, for all classes of occupations.

- Increasing electrification of the vehicle drives the industry's need to hire more ***electrical engineers***.

- Since electric and hybrid variants use electric motors to power the vehicle, ***powertrain engineers*** with related experience are in great demand.

- The expanded use of batteries in alternative powertrain vehicles and resins in vehicle body, parts and components has greatly increased the need for ***chemical and electrochemical engineers***.

- Lightweighting the vehicle and the design of raw materials that are robust and meet required vehicle specifications—as well as the development of new forming and joining processes to implement a wider variety of vehicle materials—drives the need for ***materials engineers***.

- Advanced powertrains—whether internal combustion, hybrid or electric—all rely heavily on computer controls and software. Electronics and software also enable green transportation through optimum route scheduling and congestion avoidance. Respondents indicated strong demand for ***software and electronics engineers***, as well as those with experience integrating a vehicle's electronics with its mechanical components.

- Mechanical engineers will continue to be needed, but the mix will shift as the vehicle becomes less mechanical. Respondents reported a need for workers with cross-functional skills, such as ***mechatronic engineers***.

- Increasing vehicle complexity has meant that the various systems of the vehicle (such as steering, braking, powertrain, etc.) must not only function within each system, but also when systems interact; this complexity is driving the rising need for ***systems engineers***.

- Greener products, processes and manufacturing plants increase the need for ***environmental engineers*** to design, implement, and maintain energy conservation, water systems, waste systems, paint systems, cleaning systems, heating/cooling systems and alternative building power systems.

Despite the industry's move toward greener products and processes, respondents don't foresee hiring sustainability engineers. Rather, they would prefer to hire engineers who have integrated sustainability practices into a core engineering discipline. The automakers and upper-tier suppliers also expect that all engineering and technical new hires will have some form of practical experience, either through work at another employer, a co-op or an internship. The automakers and upper-tier suppliers prefer to hire candidates with five to 10 years of industry experience for most positions and seek seasoned candidates for leadership or specific technical jobs.

3.1.6 Up-Skilling of Incumbent Workers

Incumbent worker training related to green ranges from 10 to 30 percent of the automakers' annual training offerings to engineering and technical workers. Most automotive supplier respondents offer a curriculum of internal corporate training and tuition reimbursement to incumbent engineering and technical workers. Few offer specific up-skilling opportunities in green skills, however.

Respondents stated that they seek to hire engineering and technical employees who are open to lifelong learning. All of the automakers and Tier 1 suppliers have a formal review process for salaried employees' skill assessment.

Several automakers indicated that they continued investing in skill upgrades throughout the downturn in the industry (but this was not reflected in interviews with the auto suppliers). While some companies froze their tuition assistance programs in 2008-2009, all are now back in operation; education and training partnerships with outside institutions are also being restarted.

> *Since lower-tier suppliers struggled to serve the 11.6 million unit market of 2010, there is significant concern about their ability to add capacity fast enough to meet market demands (that may reach 15 million units) in 2011.*

Respondents noted that many of the skills necessary for building green vehicles using green processes should not require a full-blown degree program. In a technically mature workforce, most incumbent engineering and technical workers have a degree; many have graduate degrees. Companies are looking toward certificate programs to help these engineering and technical workers gain the skills they need.

All of the automakers have some form of connection or partnership with one or more of the recipients of the Department of Energy grants for electric drive vehicle, battery and component manufacturing education.

3.1.7 Job Classification Impact of Green Initiatives

The automakers and Tier 1 suppliers indicated that job classifications are not changing much. The duties associated with existing job classifications are changing, as is the mix of job classifications as different areas of engineering become more dominant.

3.1.8 Up-Skilling of Other Automotive-Related Workers

In the course of the automaker interviews, nearly every automotive respondent mentioned how the changes in vehicle technology impact the skills of workers outside the auto manufacturing industry. Advances in green vehicle technology is expected to impact:

- ***Dealer service personnel***, who must learn how to maintain, diagnose and service the new vehicles and technologies.
- ***Dealer sales staff***, who must learn how to sell based on the return-on-investment and field customer questions on charging stations, range anxiety and other issues related to electric vehicles.
- ***Public safety, medical and first responders***, who must know how to safely interact with these vehicles and their passengers in emergency situations.
- ***Electricians, home inspectors and construction workers***, who must install and certify installations of home charging units for plug-in electric vehicles.

Respondents also noted that their companies all have partnerships with municipalities, utility companies and others to plan for infrastructure investments and other aspects of the future of green transportation.

3.1.9 Analysis of Lower-Tier Supplier Viability

This analysis provides an assessment of the automotive supplier sector's current state, highlights viability risks in the near future and suggests changes that can avert a possible crisis among lower-tier suppliers.

The Challenge to Ramp Up Production

Automotive sales and production have not recovered from the recent economic crisis as quickly as many analysts had forecast. While this was a concern throughout the industry, it appears in retrospect that it may have been a blessing in disguise for lower-tier suppliers. The gradual recovery has allowed these firms to resume production and add capacity at a pace that did not overwhelm their reduced resources—particularly the availability of financial capital.

Automotive sales and production have recently experienced significant growth, and many observers have begun sharply increasing their forecasts. Initially around 13 million units, forecasts for 2011 U.S. light vehicle sales have been revised to levels as high as 15 million units. Since lower-tier suppliers struggled to serve the 11.6 million unit market of 2010, there is significant concern about their ability to add capacity fast enough to meet market demands (that may reach 15 million units) in 2011.

Evidence of Stress among Lower-Tier Suppliers

Automakers have suffered a rash of production interruptions due to a lack of supply from lower-tier suppliers. Fears of further production disruptions have been widespread; automakers and Tier 1 suppliers have announced initiatives to prevent these shortages, including financial support for troubled lower-tier suppliers.

Another critical indicator that lower-tier suppliers are straining to meet current production volume demands is a reported gradual increase in quality problems. Given the demanding service environment of automotive components and the potential for increased recall and warranty costs, this development may be cause for concern.

Interviewees are also worried that with this strain, their capacity to perform product development, employ more sophisticated production techniques, and achieve the continuous quality and productivity improvements called for in the industry may be compromised.

Risk to Automotive Suppliers That Are "On the Bubble"

Interviewees indicated that the healthiest of lower-tier suppliers are overwhelmingly likely to survive and be successful in the future. They are expected to continue to receive both orders from customers and the credit necessary to add capacity for new orders. There is concern, however, that 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

"The healthiest of lower-tier suppliers are overwhelmingly likely to survive and be successful in the future."

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.

3.1.10 Responses to Supply Chain Vulnerability

Interviewees indicated that their firms are aware of the issues described above, and they are taking steps to minimize supply chain disruptions and to assist lower-tier suppliers.

One major change involves addressing the complete set of factors affecting cost and profit margin (including quality, logistics costs, warranty expenses, as well as the initial cost of components) instead of focusing only on piece price considerations. While such sentiments have been heard throughout the industry in the past, interviewees stated that, due to new urgency from the recent economic crisis, this change is being taken much more seriously today. Interviewees in some (but not all) firms said, for example, that purchasing staffs are increasingly evaluated and compensated based on total landed cost and warranty implications.

They also indicated that, in order to ensure decisions are made based on a broad set of considerations, purchasing teams often include more engineering and quality assurance staff than in the past.

3.2 Supply Chain Transformation among Small Firms

Like the rest of the automotive industry, the supply chain had already undergone significant transformation before the onset of the recent crisis. The crisis both accelerated the transformation and

> *A large majority of these small supplier firms temporarily suspended or reduced production and laid off workers.*

gave it new dimensions. Below, we describe how the crisis has affected employment, investment and supplier-customer relations. We then explain three distinct clusters of firm practices that have emerged in the wake of the crisis.

The goal of our analysis is to examine overall firm strategy in a way that generates useful workforce development recommendations. Our findings indicate that workforce development is only highly effective as part of a comprehensive firm strategy that includes complementary strategies for product and process. Our study encountered some firms that made investments in either skills or technology, but were not able to maximize the profitability of such investments for lack of a comprehensive strategy. Other firms did not invest much in any of these areas, keeping their costs down in the short run, but perhaps jeopardizing their viability (and the jobs and compensation of their employees) in the long run.

To produce the findings below, our team first interviewed dozens of first-, second- and third-tier suppliers in the tri-state area and the Southeast. Using a survey crafted from these interviews, we then collected data from hundreds more firms nationwide.[11] Below, we discuss our findings regarding small suppliers (those whose firms employ less than 500). Such firms account for almost one-third of total employment in the auto supply chain; almost without exception, these firms are second- and third-tier suppliers.

> *Firms are now more likely to invest in quick, cost-saving measures and more likely to defer investment in workforce skills.*

[11] See Appendix C for more information about the survey methodology.

3.2.1 Employment

A large majority of these small supplier firms temporarily suspended or reduced production and laid off workers (91 percent either laid off employees or cut working hours). Eighteen percent of our sample reported shutting down at least some production. Firms used a variety of strategies in implementing layoffs: 76 percent of plants laid off production workers, while only 33 percent laid off managers; 31 percent laid off their newest hires first, while 52 percent based layoffs on performance, laying off the worst performers first; 41 percent minimized layoffs by reducing hours.

Even as sales and profit margins have continued to rebound since 2010, employers have been hesitant to reinstate many of the recently eliminated positions. Eighty-three percent of our survey respondents expect a sales increase of 5 percent or more in the next 12 months, but only 55 percent expect to increase employment by 5 percent or more.

Interviews suggest that many managers are still concerned about the rebound's permanence. Some firms plan to permanently scale back employment. Nevertheless, we find evidence of a slight decline in reliance on temporary workers. Of survey respondents, 41 percent reduced employment of temporary workers by more than 5 percent between 2007 and 2010, while only 2 percent increased temporary employment by more than 5 percent during those years.

3.2.2 Investment: During and After the Crisis

The economic crisis has altered criteria for investment, in most cases by shortening required

> *Pre-crisis investments in IT appear to have contributed to many firms' abilities to survive the crisis.*

payback periods or altering investment priorities. Firms are now more likely to invest in quick, cost-saving measures and more likely to defer investment in workforce skills. Some firms invested in marketing efforts, such as new websites or new sales programs, to diversify out of automotive work. Others took advantage of competitor bankruptcies by buying used equipment or taking on work previously done by these former competitors. Our survey found that 33 percent postponed investments in R&D/product development and 74 percent postponed investment in equipment. Also, 35 percent postponed training while only 9 percent increased training. The crisis could have been a time for further transformation of the workforce (e.g., training workers in new methods described elsewhere in this report), but firms laid them off instead, largely due to lack of capital.

In terms of information technology investment, almost half (45 percent) already had an enterprise information system in place by 2007. Three percent of firms implemented such a system since 2007. However, many firms we interviewed appeared to lack consistent and proactive systems for maximizing the effect of IT systems. Similarly, only 5 percent of survey respondents with an Enterprise Resource Planning (ERP) system felt their systems were highly integrated with those of their key customers, while 44 percent felt they were partially integrated, 31 percent felt they were minimally integrated, and 21 percent felt they were not integrated at all.

3.2.3 Investment Before the Crisis

Investments made before the onset of the manufacturing crisis are very likely to have exerted powerful impacts on the fate of a firm. Our interviews found evidence of different pre-crisis investments having helped some firms survive and causing others to fail. For instance, pre-crisis investments in IT appear to have contributed to many firms' abilities to survive the crisis. This technology includes ERP and computer-aided design (CAD) systems, as well as other types of sensors and IT. While only 17 percent of respondents said their firms used such systems to fully integrate project management, finances and employee skills, the vast majority of firms had systems that helped them manage their businesses. Only 14 percent of firms reported having IT systems that were inaccurate or too difficult to use. Firms that benefit from IT generally fit into one of two groups: those who see technology as a replacement for skilled labor, and those that see such technology as complementary to new workforce skill sets. Firms in both groups managed to survive the crisis.

Similarly, investing time and money into diversification before the crisis appears to have been important to survival. While such a strategy does not always require large investment, diversifying into new industries often does involve investing in new equipment and workforce skills, or enduring some initial period of lower profitability. It is clear that after the crisis, auto suppliers are more likely to have diverse product lines and a wider range of customers. Of our survey respondents, only 35 percent indicated that at least 80 percent of their business comes from the automotive sector, compared to 55 percent in 1993. Thus, despite the considerable barriers to diversification about two-thirds of our respondents are actively trying to expand business outside of automobiles.

Conversely, some firms made very untimely investments just before the onset of the crisis. While these may have been sage investments in a normal year, our interviews suggest that poorly timed investments also played a large part in bankrupting some firms that may have otherwise survived the crisis. In contrast (as we discuss below), other firms that did not invest managed to survive the crisis because they had very low fixed costs.

3.2.4 Customer Relations

Changes are also visible in the relationship between suppliers and customers. For some supplier firms, relations with customers have improved as excess capacity was reduced. Many automakers and first-tier suppliers began investing more time vetting suppliers, taking a stronger interest in suppliers' internal structure, perhaps because the costs of doing business with the wrong firms—and having to change suppliers—are seen as especially dangerous now.

Other firms, however, described stretched-out payment terms and demands to hold more inventory. These diverging experiences are reflected in our survey data. For example, 24 percent of survey respondents think that their customers are amenable to suggestions for design modifications. On the other hand, two-thirds expect their customers to want some or most of the savings from these suggestions.

3.2.5 Characteristics of Surviving Firms

Cluster analysis of our survey data indicates that although the above trends and commonalities are visible on the industry-wide scale, three distinct firm types are nonetheless visible. These groups were not born in the wake of the crisis, but we believe the crisis drove many firms to pursue a strategy more similar to one of the three described below.

- ***Cost-Cutting:*** These firms survive by seeking basic cuts wherever possible, such as reducing employment or forgoing equipment investment, without transforming operations. Many firms making these cuts have remained profitable in the post-crisis marketplace, but an unintended consequence of this model may be limited future investment and growth. One firm engaged in "clever cost-cutting" by reducing fixed costs, finding ways to substitute stamped, bent parts with cast parts and reducing automation and taking advantage of low cost labor. However, this model could make the firm vulnerable to competition from low-wage countries. An "agile production" model in which they introduced new products frequently and delivered them quickly to firms in a variety of industries could allow this firm to compete in the long run. However, to implement this model would require near-simultaneous investments in marketing, IT, training and equipment—investments that the firm is not contemplating. Our survey results suggest that about 40 percent of small, lower-tier firms in the auto supply chain are in this category.

- ***Unsystematic Reliance on Craft Skill:*** A second set of firms includes those which go beyond simple cost-cutting by seeking to add value through reliance upon craft skill and some more advanced efficiency techniques. They pursue these strategies as options unrelated to one another, as opposed to regarding them as interdependent components of a long-term improvement process. They do not seek to empower their skilled labor by further integrating them in firm-wide decision-making processes. One such firm is a tooling company with broad capacity but facing intense competition from China. This firm's customer bidding process does not allow rational scheduling and specialization. This firm is unsure whether to deepen its U.S. capacity and focus on just-in-time delivery and facility with lightweight materials or focus on product design and increase its manufacturing in China. About 40 percent of our sample falls into this category.

- ***Continuous Improvement Culture:*** A third, smaller subset of firms pursues practices popularized by Japanese firms that involve all employees in continuous improvement efforts. Decisions are characterized as long-term rather than immediate-term, and firms enjoy such positive outcomes as flexibility from diverse supply chains, agility to benefit from changes in the marketplace without disruption, high productivity and value-added per worker, and agency over the firm's future direction. Workers benefit through access to more robust skill sets, better wages and improved job security. Among our survey respondents, 34 percent had programs for production workers, such as quality circles or autonomous teams, 10 percent of which adopted these programs during the downturn.

Table 6: HR Manager Perspective on Skill Shortage by Type of Worker

	Percent of Firms Reporting a Lack of Skills in This Area		
Skill Set	**Operators**	**Skilled Trades & Technicians**	**Engineers**
Literacy/numeracy	22.2%	2.5%	1.2%
Analytical skill	29.6%	12.3%	7.4%
Manual dexterity	2.5%	1.2%	1.2%
Knowledge of specific equipment (e.g., Minster 200-ton press)	17.3%	16.0%	7.4%
Knowledge of specific software (e.g., Catia 5.0)	23.5%	22.2%	11.1%
Ability to work in teams	14.8%	8.6%	4.9%
Communication skills	24.7%	17.3%	11.1%
Problem-solving skills	34.6%	16.0%	7.4%
Understanding of company goals	22.2%	12.3%	8.6%

Source: Survey Data, Case Western Reserve University, 2011

On the other hand, 4 percent dropped such programs during the downturn. One such firm is a stamping company that, with help from a Japanese automaker, has invested a great deal in information technology, incorporating sensors into every step that might benefit from them. The firm reports to have survived the crisis because of its retained earnings and deep cuts, but it has now depleted its reserves and because of HR cuts, it has no ability to plan for retirements or engage in succession planning. About 20 percent of our sample is in this category.

We note that in none of the strategy bundles was investment in training and skills an important feature. On the contrary, small, lower-tier firms have managed to survive without making the types of human capital investments being anticipated by automakers and Tier 1 firms, leaving the supply chain in a vulnerable state vis-à-vis big shifts in demand.

3.3 Implications on Supply and Demand for Skills

Our survey and interviews have attempted to clarify which types of jobs remain in the U.S. and whether workers are available to fill those jobs. Ongoing incorporation of IT, stagnant domestic demand for autos, and increased sourcing of materials and subassemblies from overseas are all factors that reshape the automotive workforce. While these macro trends are important determinants of jobs, so is firm strategy. Even within quite narrow industries, firms organize production quite differently, with implications for productivity, wages and skill demands.[12]

3.3.1 Production Workers

At the lower end of the skill spectrum, employers seem to have as difficult a time hiring workers as at the higher end, if not more. For operators, problematic skill areas include analytical, problem-solving and communication skills, as well as knowledge of specific software (see **Table 6**). Indeed, of the firms that expect to hire production workers in the next four years, half think that they will have trouble finding good candidates. That said, our survey data shows that firms paying market wages have less trouble finding qualified candidates, especially if those firms fall in the top 20 percent of the wage distribution.

Some employers connect with local public schools to recruit and train students for work after graduation as one strategy for finding workers. As with high-skill labor, there appear to be regional differences in how firms recruit and train lower-skill workers. In the Midwest, as firms contract, programs to attract and develop workers have all but disappeared. Even the best firms have eliminated career planning

[12] Dan Luria reported a similar finding in "New Labor-Management Models from Detroit?" *Harvard Business Review*, Sept.-Oct. 1986.

for production workers. By contrast, in the Southeast, we see state government taking over much of the traditional in-house human resources function for firms. 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.

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 low-skill workforce training.

3.3.2 Skilled Labor

This section addresses two types of skilled workers: 1) workers in the "skilled trades" who undergo a four-year, accredited training program plus on-the-job training, and whose certification is regulated by states and 2) technicians, who have some training but less than the skilled trades workers and none of the formal certification of the skilled trades.

Some work requiring skilled trades, such as tool and die-making, has been off-shored to lower-wage countries like China and Mexico. However, since these jobs are complex, 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 off-shored work eventually returns to the United States. In our survey, 4 percent of respondents reported that they brought operations back from abroad.

While firms rely on skilled trades, many firms assume that shortages are unlikely to surface in the short or medium term because overall demand for skills remains weak. Thus, a third of our respondents do

"A third of our respondents do no active succession planning, including some small firms that depend upon long-serving employees."

no active succession planning, including some small firms that depend upon long-serving employees. Our survey finds that 64 percent of firms prefer to hire employees who plan to stay until retirement, but only 40 percent of these firms conduct active succession planning. This is true even for firms that were productive and profitable in the past.

Some high-skill jobs are moving from the tri-state region to the Southeast. While tri-state factories were closing during the recent crisis, foreign automakers had recently opened 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 firm's new Alabama plant, one supplier stated, "Typically the people with the highest mechanical competency without being degreed, like in the trades, they would come from the Midwest. Ohio, Michigan, Indiana, Iowa."[13]

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 was required for automobile work. 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 and technical colleges. Such initiatives have not only closed or filled the initial skills gap in South Carolina, but have produced enough high-skill workers to make the state attractive to new aerospace manufacturing.[14]

[13] Pre-survey interview transcript: Firm 1 (149), 8-24-2010.
[14] One example is Boeing in the Charleston area where Firm 3 is already located.

More recently, there is some indication that the practice of recruiting skilled workers from the tri-state region to the South has reduced or eliminated the need for the community college training programs mentioned above. This suggests that while in-house and community college training programs are effective in the South, such programs are more costly than recruiting existing workers with skill and experience. Southern firms now display a preference for recruiting existing talent from the tri-state area.

3.3.3 Engineers

With regard to scientific or engineering workers, where we might have expected to see newer technologies present a skills problem for employers, we instead found that firms were able to recruit well-trained workers from local higher education institutions. Local public universities and colleges seemed capable of supplying firms with the skills demanded, such as chemistry and material science skills for the tire industry. To supply burgeoning industries like fuel cells, existing firms applied their existing technologies to meet the needs of new clients. In part, this match of supply with demand for people with skills in new technologies occurs because firms are not demanding many such people. Demand is low because firm owners are not aware of how they might productively integrate such people and/or the profit margins they expect would not make such investments pay off. This lack of investment is both a cause and effect of many components of advanced vehicles being sourced from Europe or Asia.

Table 7: Tri-State Auto-Related Educational Programs by Major Program Categories

Category	Number of Programs
Electronic	337
R&D for Chemical Process	287
Manufacturing	182
Automotive Engineering	178
R&D–Physics	148
Electrical	134
Drafting and Design	117
Automotive Service	91
Manufacturing Engineering	87
Automotive Industry Management	57
Welding	56
Machining	53
Industrial Maintenance	52
Specialized Automotive Service	48
Energy Production–Alternative Energy	33
Auto Body Repair	21
Alternative Fuel Vehicles Service	16
Research Centers	10
Alternative Fuel Vehicles Engineering	8
Tool and Die	8

Source: Center for Automotive Research

3.3.4 Managers

For the first time in recent memory, many firms laid off managers (33 percent of our sample), 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, 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—work that had previously been performed by production workers who had been laid off.

3.4 Educational Programs

As the jobs and skills change, so too must the educational offerings. To estimate the ability of the educational infrastructure to adapt to changing industry needs, CAR created a database of institutions of higher learning within the tri-state area offering programs related to advanced manufacturing or occupational training in the automotive or automotive services industries. This database, compiled in 2010, includes specific details for the institutions and their program offerings. Over time, it is anticipated that some programs will be scaled back or discontinued while others will be created or expanded.

The intent of assessing the region's automotive educational programs was to:

- Determine the current automotive education and training infrastructure
- Assess how schools and programs respond to industry and employer needs

To assess auto-related program offerings in the tri-state region, CAR examined the offerings of nearly 900 accredited postsecondary institutions. More than one-third of these institutions offer programs related to the engineering, design, production and maintenance of automobiles. For each institution, researchers analyzed program descriptions and placed each auto-related major into one of 20 primary categories (see **Table 7**).

In total, there are more than 1,900 programs offering degrees and certificates relevant to the automotive industry. These degrees include certificates, associate of science, bachelor of science, master of science, and doctor of philosophy (Ph.D.) degrees (see Appendix A for more information).

Using the database constructed for this project, educators at schools with programs of interest were identified, contacted and interviewed. A number of recurring themes emerged from these interviews, as discussed below.

Industry-Education Interaction

- Automotive programs all have industrial advisory boards comprised of local businessmen and leaders bringing real-world expertise.
- Local companies present real-world problems and provide learning environments for courses such as senior design.
- Some schools offer programs commissioned by companies, such as Michigan Tech's distance learning program for displaced automotive engineers and Purdue's hybrid vehicles course for Delphi workers.
- Company demand for student interns is so high that virtually every student who seeks an internship is able to find one.
- Faculty efforts at networking with industry colleagues and community leaders are common, but take place on an individual ad hoc basis.

Community-Education Interaction

- Schools interact with the community providing resources or hosting events for the general public (e.g., the "Electric Vehicle Hub" being developed by Indiana schools, car shows, public seminars and competitions).
- Outreach to high schools occurs fairly often, with faculty in universities producing course modules or facilitating workshops for high school teachers.
- Recruiting events offer additional opportunities for connecting with the public.
- Start-up companies using technologies developed at universities also create connections between the school and the community.

Funding

- Grants for expanding green vehicle education programs are available.
    - Michigan Tech was able to leverage its experience educating displaced workers and, with money from the Michigan Academy of Green Mobility and the U.S. Department of Education (DOE), it offered additional hybrid engineering classes for unemployed and employed engineers as well as college students.
    - Several schools came together to form the Indiana Advanced Electric Vehicle Training and Education Consortium (I-AEVtec), receiving $8.1 million from DOE for various projects related to energy-efficient vehicle education.

"Some firms are not demanding skills in areas where they should."

The tri-state region has a strong automotive-focused educational infrastructure. Schools, colleges, universities, departments and faculty in this region work closely, albeit rather informally, with industry to ensure the programs and curricula remain current with industry needs. The building blocks of the future skilled automotive workforce are in place, and could be improved by formalizing connections to industry and facilitating communication between education, workforce development and industry partners.

3.5 High-Road Production Strategies

U.S. firms cannot compete in the long term by cutting wages and benefits alone. Instead, they should build on their strengths by drawing on the knowledge and skills of all workers. The U.S. 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. Specifically, a successful high-road production strategy usually seeks to achieve a high-value-added business model through investment in smart and flexible workers, efficient process, product innovation, and advanced equipment. 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.

Workers, particularly low-level workers, have much to contribute because they are close to the process: They interact with a machine all day, or they observe directly what frustrates consumers. For example, a study of steel-finishing lines 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.[15] 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, workers in high-road facilities, such as the one run by members of the United Steelworkers at Mittal Steel in Cleveland, solve problems more quickly because they communicate with each other directly in a structured way.

The continuing use of 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 who 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 (to produce more customized products), their operations strategy (using their new IT capability to 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 time required to change over to making a new product—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.

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

[15] Casey Ichniowski, Kathryn Shaw, and Giovanna Prennushi, "The Effects of Human Resource Management Practices on Productivity: A Study of Steel Finishing Lines," *American Economic Review* 87 (3): 291-313.

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.

Thus, our study finds the need for a broader approach to determining skill shortages. Management at the firms we studied know what skills they would like, but often base these estimations on an incomplete understanding of the potential for complementary changes (as in the agile production example above). In some cases, top management has had no formal education since high school and lack the knowledge of how to do formal strategic planning. Thus, 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 overestimate their chances of encountering certain skills naturally, which is to say without investing in the post-hire training that would yield the desired skills.

Second, some firms are not demanding skills in areas where they should. Understanding of skill 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 develop future ones. Assessment of skill 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 setup for new product. Such skills would afford these firms the flexibility and speed to manufacture a wider variety of products more effectively.[16] The agile production model described above also requires new skills from production workers, managers and trades workers.

In short, this study points to the conclusion that regional skills markets are not best shaped by asking only managers for their assessment. Instead, policymakers should also shape the curriculum of workforce training programs, and in doing so should operate under the premise that skills can be added to every job.[17] These observations also point to the necessity of training for managers as well as production workers. Institutes that train managers already exist in some regions. For instance, the federal Manufacturing Extension Partnership (MEP) instructs firm leadership in ways to develop new products, find new markets and operate more efficiently. The Edison Centers in Ohio and the Michigan Manufacturing Technology Center pursue similar objectives. A number of studies have found that MEP is sufficiently effective to pay for itself through increased federal tax revenue, because it makes firms more profitable.[18] Expanding such programs to serve a greater percentage of the auto industry would result in more firms adopting strategies geared toward long-term success as opposed to reactionary cost-cutting.

[16] Firm 18 had specialized set up operators, leading to downtime; at Firm 10, operators were involved in many aspects of complex setups.

[17] A production worker is often stereotyped as someone who pushes the same button every 20 seconds, day after day, year after year, but even in mature industries, this situation rarely occurs. For example, temperatures change, sending machines out of adjustment; customers change their orders; a supplier delivers defective parts; a new product is introduced. All of these contingencies mean that the perfect separation of brain work and hand work envisioned by efficiency guru Frederick Taylor does not occur.

[18] Susan Helper, "The High Road for U.S. Manufacturing," *Issues in Science and Technology,* Winter 2009, http://www.issues.org/25.2/helper.html.