

Automation Adoption & Implications for the Automotive Workforce

**BOSTON
UNIVERSITY**



**CENTER FOR
AUTOMOTIVE
RESEARCH**



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Executive Summary

The automotive industry is currently undergoing a period of rapid technological change. The ecosystem of this vast industry is expanding with the addition of advanced technology, which is speeding up and enhancing traditional processes to be more efficient, as well as with new market entrants. Many automakers and suppliers continue to face both challenges and opportunities as the industry progresses through this era of rapid innovation in automation and artificial intelligence in the manufacturing setting. Automotive companies widely report difficulty in finding enough qualified, skilled employees. Meanwhile, automation and artificial intelligence could potentially revolutionize manufacturing and change both the number of future workers required and the skills those people will need to possess.

This study, conducted by Case Western Reserve University in partnership with Boston University, Center for Automotive Research, New York University, Precision Metalforming Association, and multiple part supplier associations, investigates two questions related to the adoption of new technology to implement automation and artificial intelligence (AI) in the manufacturing setting. These questions are: 1) what drives the adoption of new technology, and 2) how does a firm's relationship with technology and its employees affect this adoption. Researchers conducted over two dozen site visits, which resulted in over 120 firms' participation in three benchmarking surveys.

The significant research findings include:

- Companies continue to experiment with various technologies – none of the companies have finalized which avenue is the best in terms of the numerous technology pathways to Industry 4.0¹;
- Firms continue to benefit from workers who are *kaizen*-minded²;
- Companies are not taking advantage of all the benefits and capabilities that new machines offer – especially in terms of data analysis and utilization;
- Firms continue to find it hard to attract qualified talent at current wages; and
- The myth that robots are taking over all the jobs is not valid. This research determined that robots are more efficient when used for routine tasks and that highly skilled jobs will surface as a result of the increased reliance on factory automation.

¹ The merger of cyber-physical systems that incorporates data to manage manufacturing processes.

² continuous improvement

Background

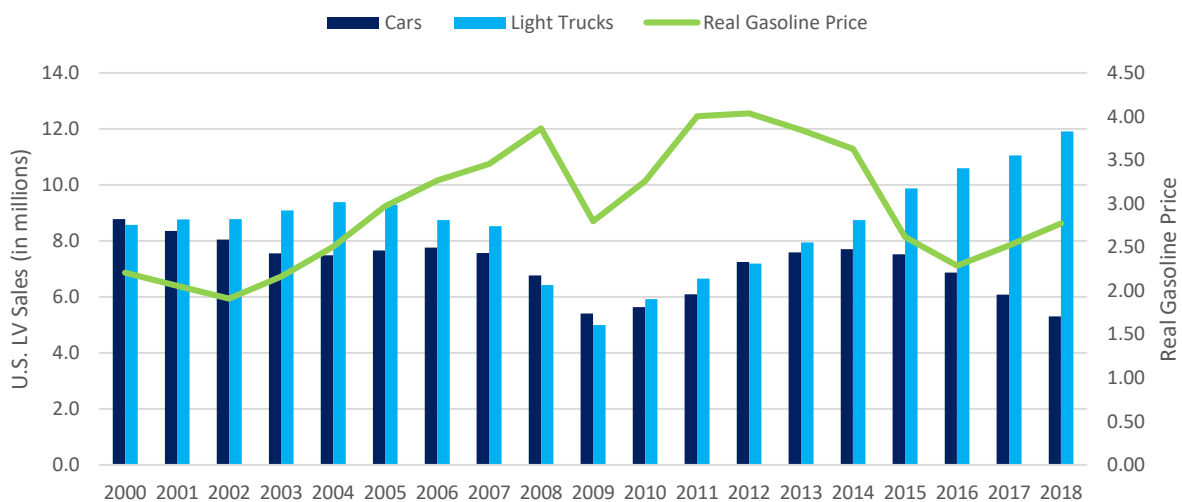
State of the U.S. Automotive Industry

To understand the current environment of the U.S. automotive industry, researchers analyzed the sales and production of light vehicles, employment trends in motor vehicles and parts, and significant drivers of change in the industry.

SALES AND PRODUCTION OF LIGHT VEHICLES

During the recession years, car sales increased and reached higher levels than light truck sales in 2008, 2009, and 2012 – as shown in Figure 1 below. This market adjustment corresponded to relatively higher gasoline prices during the same period. As the gasoline price approached over \$4.00 per gallon, consumers sought out vehicles with better fuel economy. Two things happened when the market began to recover: 1) consumer preference began to shift toward light trucks, and 2) cross-utility vehicles (CUVs) that have relatively higher fuel economy but are classified as trucks gained substantial market share. Light trucks (including CUVs) have become the most in-demand segment across the United States, contributing to the growth in light truck demand over the last five years. However, overall 2019 sales are down 2 percent year-over-year due to an overall market slowdown.

Figure 1: U.S. Light Vehicle Sales, 2000 to 2018



Source: (Wards Auto Intelligence, 2019), (U.S. Energy Information Administration, 2019)

Due to the recent shift in consumer demand, light truck production now comprises nearly two-thirds of all light vehicles produced in the United States. Since 2014, consumer demand has made the midsize CUV the most popular vehicle segment.³

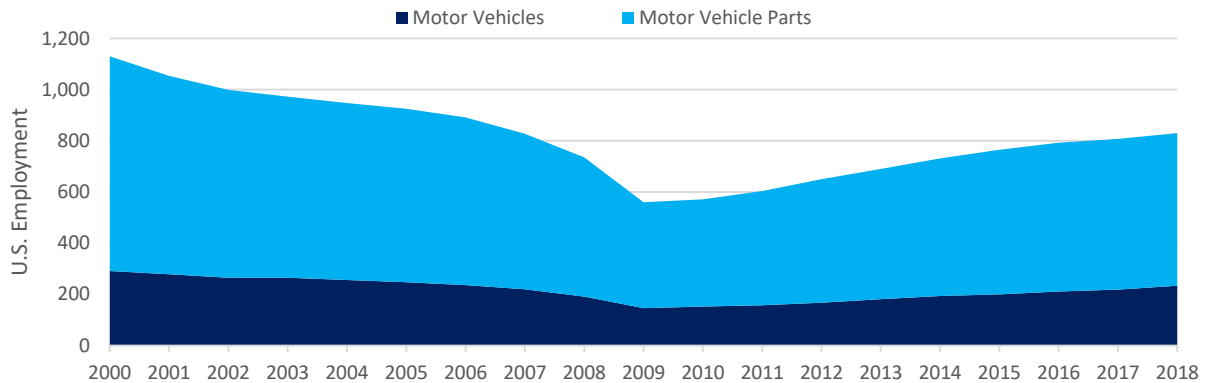
EMPLOYMENT

While employment in the U.S. motor vehicle and parts sectors has been growing in the post-recession period, it has not returned to the most recent peak achieved in 2000, as shown in Figure 2 below. Motor vehicle manufacturing employment is about 200,000 lower than it was in 2000, and parts employment is down by approximately 60,000 employees. Motor vehicle assembly employment is still 10,000 lower

³ In 2014, light trucks surpassed passenger cars in production volume.

than it was in 2007, right before the recession, and parts employment has just barely surpassed the pre-recession level. There are many reasons why output growth has far outpaced employment growth. Productivity gains from operational efficiencies and automation are contributing factors, but so is outsourcing and the fact that new automotive suppliers may not necessarily fall into the traditional automotive parts industry codes.

Figure 2: U.S. Employment, 2000 to 2018



Source: (Bureau of Labor Statistics, 2019)

SIGNIFICANT DRIVERS

The automotive industry has seen a substantial period of growth since the last recession leading to low unemployment levels and record-breaking sales years. During this period, there have been significant drivers causing shifts to the automotive industry’s environment. Including, but not limited to, the following factors:

- Stagnate LV sales in the U.S. for the past several years
- Consumer shift in demand from sedans to CUV’s
- Continued technological advancement in the electrification and automation of vehicles
- Automation adoption in the manufacturing environment
- Uncertainty in the automotive industry – corporate restructuring, trade implications, recession on the horizon
- Talent shortage and skills gap
- Non-traditional entrants in the automotive industry

This report will focus on one driver in particular – automation in the manufacturing environment. The adoption of this technology is still in the early phases across the industry. Many employers are still testing various automated technologies to calculate what system works best for their organization. Also, according to the data analyzed in this report, firms who are adopting this technology do not seem to be using the equipment to its full capability. Instead, companies tend to use automation to substitute for the shortage of workers they are unable to find at wages they are willing to pay. The following reviews emerging technologies surrounding Industry 4.0, highlights the aggregated results of the surveys conducted for this project and analyzes implications of this research for the overall industry.

Emerging Technology in the Manufacturing Environment

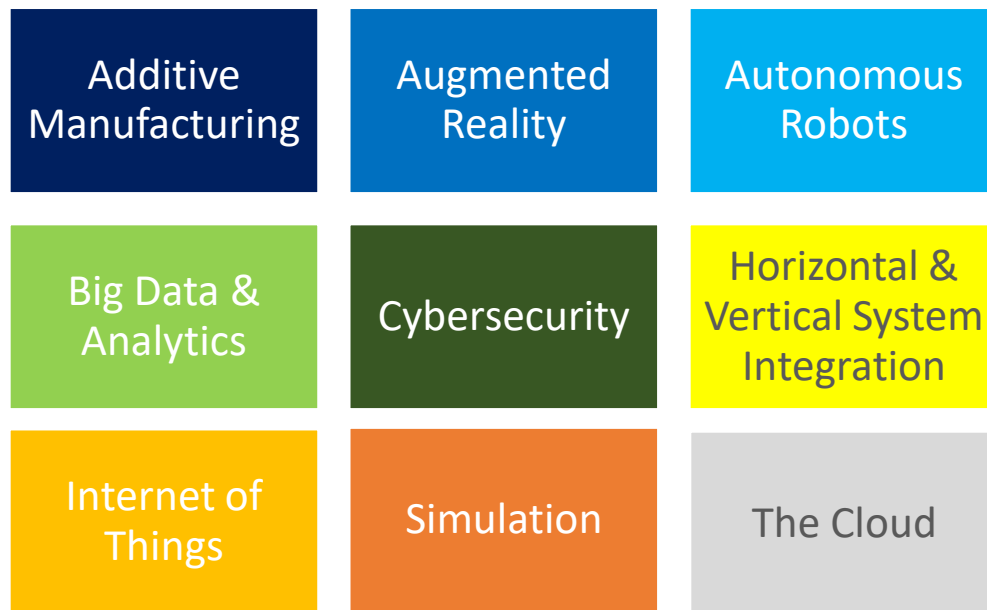
OVERVIEW OF INDUSTRY 4.0

Industry 4.0 describes the current trend of automation and data exchange in the manufacturing environment. Also known as the fourth industrial revolution, the basic principle is that by connecting machines, workpieces, and systems, businesses are creating intelligent networks along the entire value chain that can control each other autonomously. Prof. Dr. Henning Kagermann, Prof. Dr. Wolfgang Wahlster, and Dr. Johannes Helbig, members of the *Industrie 4.0 Working Group*, are considered the founders of the term “Industry 4.0” coined in 2011 at the Hanover Fair in Germany (Earls, 2015).

Advanced digital technology is already used in manufacturing, but with Industry 4.0 and the merger of cyber and physical systems, the adoption of new technologies will further transform production.

Industry 4.0 is expected to lead to greater efficiencies and to change traditional production relationships among suppliers, producers, and customers – as well as between humans and machines. According to the Boston Consulting Group, nine technology trends act as the building blocks of Industry 4.0 (Boston Consulting Group, 2019). These nine technologies are shown in Figure 3.

Figure 3: The Nine Technology Building Blocks of Industry 4.0, 2019



Source: (Boston Consulting Group, 2019)

Each of the technologies listed in Figure 3 plays a significant role in the establishment of Industry 4.0 throughout manufacturing facilities in the automotive industry, and the next section describes each in greater detail.

Additive Manufacturing:

Automotive companies are increasingly relying on additive manufacturing (i.e., 3D printing) for prototype and test parts, 3D visualization and modeling, as well as for tooling, gauges, jigs, and fixtures. For most production parts and component applications, additive manufacturing is on a long-term development pathway. To achieve broader use in original equipment automotive and parts manufacturing, 3D printing cycle times will have to improve significantly (Dziczek, 2017).

Augmented Reality:

Augmented-reality can support tasks in the manufacturing system by enhancing technology through a digital overlay of information over equipment. This technology can support a variety of services, such as selecting parts in a warehouse or sending repair instructions over mobile devices. Currently, this technology is in the early stages of development; with time, companies will begin to use augmented reality for real-time decision making.

Autonomous Robots:

Autonomous robots are automatically controlled, reprogrammable, and multipurpose machines. Manufacturers use these machines for a variety of routine, programmable tasks across their facilities. Automakers are also beginning to adopt collaborative robots (“cobots”) that work side-by-side with humans to augment their capability or the precision with which humans can perform their work tasks.

Big Data & Analytics:

Big data and analytics include the collection and evaluation of data from equipment, systems, and management systems that will be necessary to support real-time decision making.

Cybersecurity:

In an Industry 4.0 manufacturing environment, the amount of connectivity between different systems will increase. As this connectivity increases, the need to protect industrial equipment and manufacturing lines from cyber threats also increases dramatically. As a result, high levels of cybersecurity, reliable communications, as well as sophisticated identity and access management of machines and users, are essential.

Horizontal & Vertical System Integration:

Industry 4.0 will enhance the integration of companies, departments, functions, and capabilities. These entities will become much more cohesive as data-integration networks evolve and enable genuinely automated systems.

Internet of Things (IoT):

Industry 4.0 means that more devices will have embedded computing capabilities. These capabilities will allow equipment to communicate and interact with other machines and will enable real-time responses and decision making.

Simulation:

Simulations can be utilized more extensively in plant operations by leveraging real-time data as well as having the ability to mirror the physical world in a virtual model. Increased use of simulation technologies will allow operators to test and optimize the machine settings, thereby driving down machine setup times and improving quality (Boston Consulting Group, 2019).

The Cloud:

Enhanced data sharing across sites and company boundaries will mean that machine data and functionality will go in “the cloud” (data centers that are available to many users over the internet). The cloud enables more data-driven services for production systems (Boston Consulting Group, 2019).

Underneath these larger building blocks, automakers have begun adopting various automated equipment to ease the manufacturing transition to Industry 4.0.

Table 1 below is an overview of the types of automated technology that industry respondents in this study reviewed.

Table 1: Automated Technology

TECHNOLOGY	DESCRIPTION
SENSORS	Mechanical devices sensitive to light, ultra-violet light, temperature, or the like that transmit information to a measuring or control instrument
MACHINE VISION	Technology that enables a computing device to inspect images
ROBOTS	An automatically controlled, reprogrammable, and multipurpose machine
AUTOMATED PARTS TRACKING	Utilization of bar codes, RFID technology, or another system to track the movement of materials
OTHER EQUIPMENT WITH PROGRAMMABLE CONTROLS	Equipment not otherwise specified that uses programmable controls
AUTOMATED EQUIPMENT (NOT PROGRAMMABLE)	Automated equipment that is not programmable, e.g., a transfer press
COLLABORATIVE ROBOTS (COBOTS)	Robots that work directly with a human as a guide or assistant
AUTOMATED GUIDED VEHICLES (AGVS)	A transport system capable of functioning without a human driver

Methods

This project consisted of three phases. The first phase involved writing and validating three distinct surveys – Human Resources, Plant Operations, and Sales. Once the researchers developed the survey instruments, these documents were distributed to several key industry stakeholders to provide input into the format and the array of questions. Pre-testers were asked to keep in mind the purpose of the study, “What drives adoption of new technology?” and “How does a firm’s relationship with technology and its employees affect this adoption?” Once the researchers finalized the survey instruments, the second phase was to distribute the survey to various automotive companies across the industry. Researchers conducted over two dozen site visits, which resulted in over 120 firms’ participation in the three benchmarking surveys. The last phase of the project was to analyze the results and produce individual benchmark reports for participants.

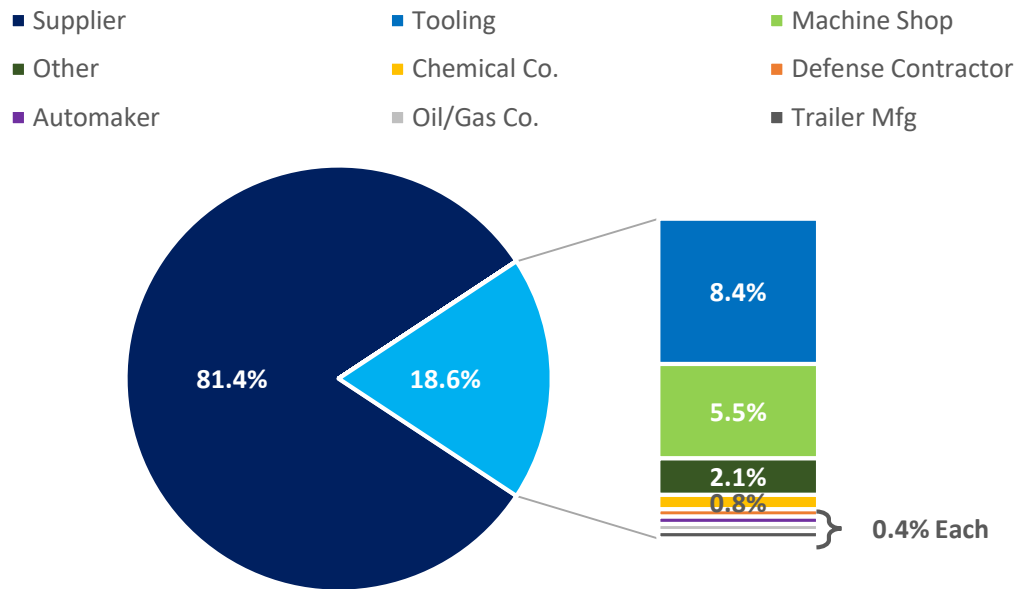
This paper provides an overview of the principal findings generated from the study and highlights potential challenges and opportunities in the adoption of automated technology in the manufacturing setting for the automotive industry.

Survey Results

Respondent Characteristics

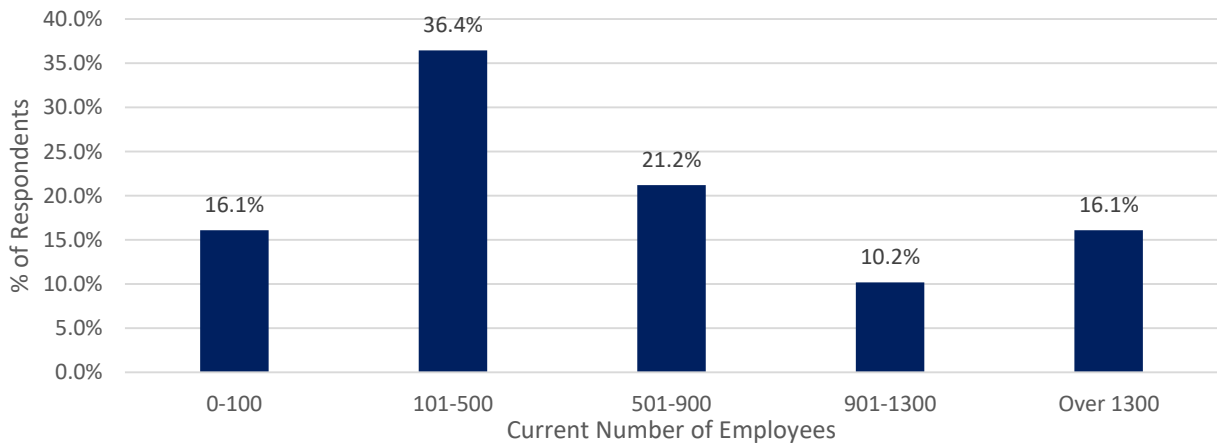
The survey drew responses from a variety of firms throughout the automotive industry. Companies varied by type of work, number of employees, type of ownership, and other characteristics. The following charts provide a brief overview of the distribution of firms surveyed for this project.

Figure 4: Types of Companies Surveyed



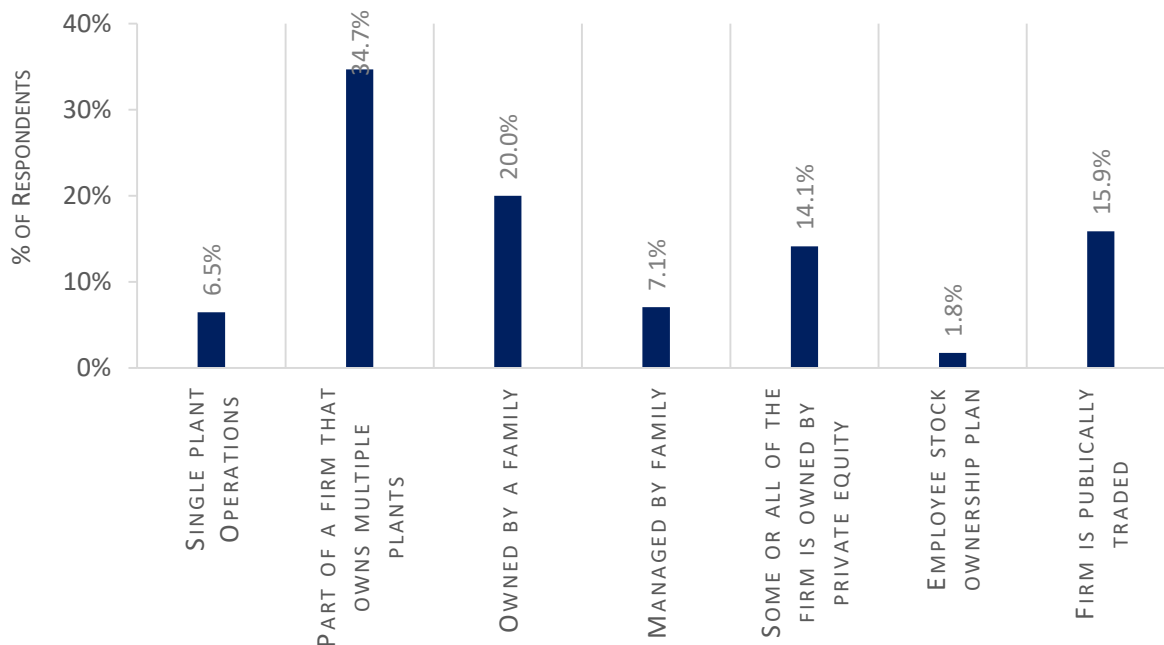
Supplier firms accounted for more than 80 percent of survey respondents. The remaining 18 percent of respondents fell into the following types of companies: tool & die firms (8.4 percent), machining companies (5.5 percent), other firms (2.1 percent), chemical companies (0.8 percent), defense contractors (0.4 percent), automakers (0.4 percent), oil and gas companies (0.4 percent), and trailer manufacturers (0.4 percent).

Figure 5: Number of Employees



Nearly 40 percent of respondent firms responded that the company’s facility had between 101-500 current employees. Also, 35 percent of the firms that participated in the survey own multiple plants.

Figure 6: Type of Ownership



The following section breaks down the significant findings of each survey and discusses several challenges and opportunities that surfaced throughout the research project. The three surveys capture a broad overview of the firm. This approach was appropriate because it is challenging to consider workforce policies in isolation from other firm characteristics. Product and operational strategies affect these policies surrounding a firm’s workforce. The resulting data and insights from interviews inform a more textured understanding of the current technology adoption across the industry and the implication of this technology adoption on employees.

HR Survey

Over 130 companies participated in the HR section of this study. HR survey questions focused on the following topics: occupational breakdown of employees, distribution of temporary versus permanent employment, education levels of the workforce, employee responsibilities, engagement levels, training and compensation, and company policies.

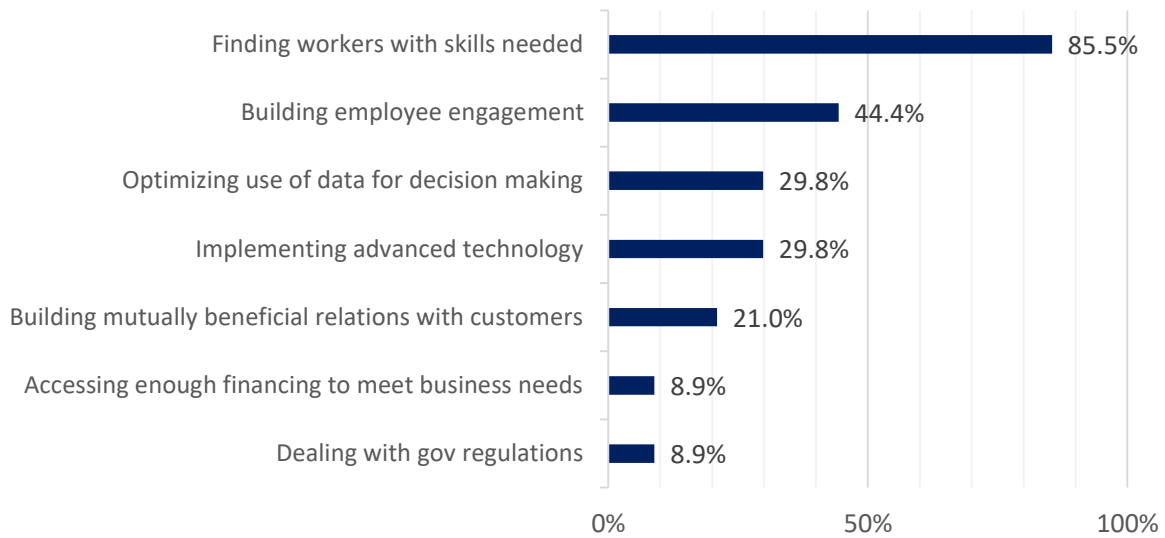
KEY FINDINGS

The key takeaways from the HR section of the project include:

1. Labor continues to be a key challenge.

When asked to list the three most significant challenges faced within their plants, over 85 percent of respondents listed finding workers with skills needed as the number one challenge at their facility. The next most important challenge cited was building employee engagement, with over 44 percent of respondents listing this as a concern.

Figure 7: Important Challenges at Plants, Average Survey Respondent



Respondents discussed that attracting individuals into the automotive industry and specifically in the manufacturing environment is difficult. Many younger generations think of the automotive industry as old, dirty, and outdated. However, this industry is surrounded by innovation, with the advancement of technology moving at a rapid pace. Respondents would like to see more outreach to upcoming generations to pique their interests at a younger age and to show that the automotive industry is a creative and challenging industry in which to work. Also, respondents would like these individuals to know that this industry is continuing to develop its ecosystem and that there are many possible ways to shape the future of manufacturing.

Survey respondents also cited attracting and retaining qualified talent as a challenge. With the continued adoption of technology within manufacturing facilities, working with advanced technology systems will require a higher skill set. Yet, wages are often lower in real terms than in the past (Dziczek, 2017).

2. Robots are not taking over all the jobs.

Robots are best suited for routine tasks. Therefore, repetitive jobs that do not benefit much from critical thinking will be among the first to be displaced. Firms using these high-tech machines are likely to create additional jobs (e.g., performing routine maintenance on robots/automated equipment, programming, and analyzing data) in the manufacturing environment. As we discuss below, firms still benefit from having “kaizen-minded” workers on their shop floors.

3. When the economy falters, there is a possibility that jobs may not all return in the recovery.

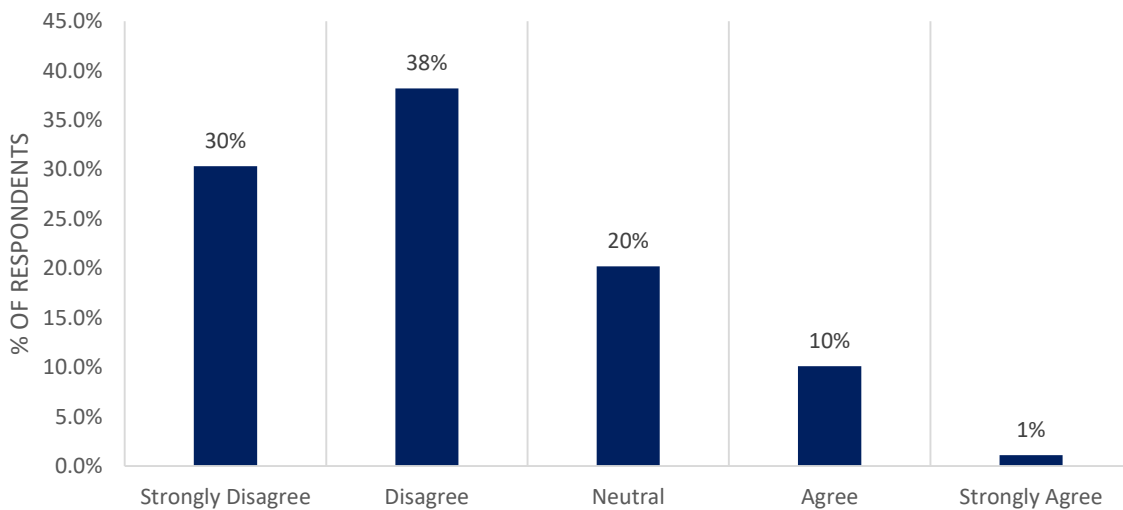
As firms implement more advanced technologies and learn to reap the full benefits of automation and Industry 4.0 systems, they may require fewer workers to produce the same output in the future. An economic downturn may exacerbate this technology-based productivity trend.

4. Firms still benefit from *kaizen*-minded workers.

Kaizen is a Japanese word that refers to continuous improvement activities that involve all functions and all employees. *Kaizen*-minded workers hold the belief that everything can be improved – no matter what the process is or how it functions, there can always be continuous improvements to the system.

In Figure 8 below, the chart shows the percent of respondents who answered whether or not the company found that the use of information technology (IT) reduced the need for shopfloor workers to have analytical skills. As shown in this figure, the majority of respondents noted that they strongly disagreed or disagreed with this statement. This response from participants shows that companies still rely heavily on their workers' perspective when it comes to the work environment and that the use of automation did not discourage workers.

Figure 8: Impact of IT on Analytical Skills



Firms benefit from creating mechanisms for workers to build on the contextual knowledge about the production process that they have the most access to in their work. For example, our regression analysis found that the impact of robots on quality is higher in plants where production workers routinely use quality assurance data to recommend improvements at the plant. Such plants experienced quality improvements of nearly 20 percent when they adopted robots, compared to only 8 percent quality improvements in plants without worker involvement.

Plant Operations Survey

Nearly 130 companies participated in the plant operations section of this study. Questions in this section revolved around the following topics: top challenges faced at plant, technologies and adoption rate, programming rate for equipment, the impact of automation at the facility, and data collection and usage.

KEY FINDINGS

1. Experimenting with various technologies

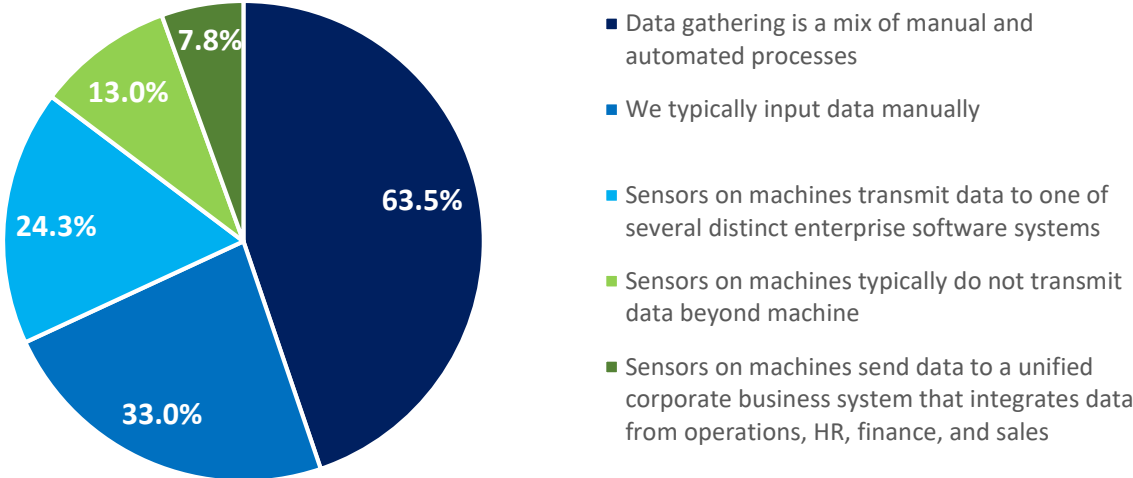
Of the respondent companies that participated in the survey, none have settled on one type of technology that their organization feels is superior to the rest. All of the organizations are experimenting and developing many different technology solutions (e.g., sensors, machine vision, robots, automated

parts tracking, other equipment with programmable controls, automated equipment (not programmable), collaborative robots (cobots), and automated guided vehicles (AGVs)).

2. Manufacturers are not using data as best as they could.

With companies moving to a more automated environment, there are tremendous opportunities to utilize the data gathered from these updated machines. Figure 9 shows that companies are not using the data produced by newer machines and equipment to its fullest extent. One interviewee stated that the company is using its new equipment in much the same way as it used the old machines. Companies are not taking advantage of all the capabilities and benefits of their new equipment. Less than 8 percent of respondents reported that they are fully utilizing the sensors on machines to send data to a unified corporate business system that integrates data from operations, HR, finance, and sales.

Figure 9: Data Utilization in the Manufacturing Environment



Sales Survey

More than 130 companies participated in the sales section of this study. The sales survey questions focused on the following topics: R&D spending as a percent of sales, percentage of new products, average piece price, unit costs, competitors, and customer relationships.

KEY FINDINGS

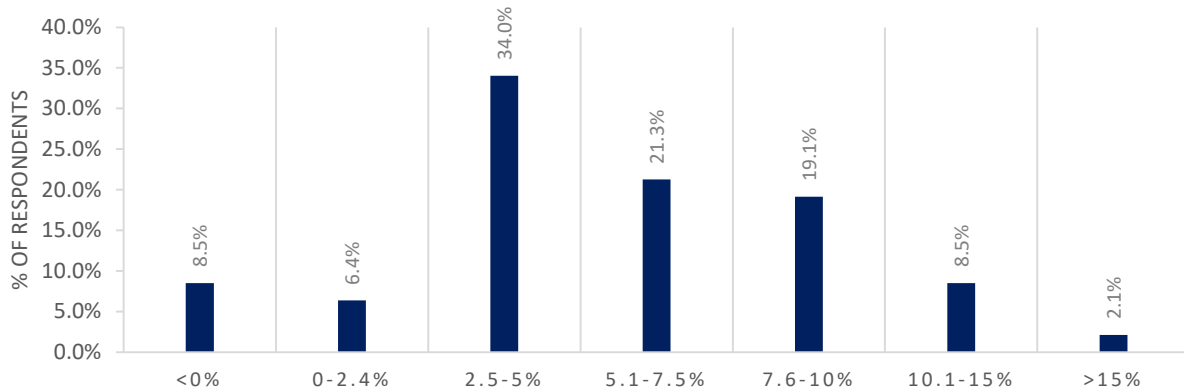
Business Traits:

Pre-Tax Profits

A firm’s pre-tax profits are an indicator of a company’s efficiency and financial performance. The majority of firms in this study – 34 percent – had a pretax profit rate between 2.5-5.0 percent, as shown in

Figure 10 below. On average, surveyed firms have a 5.1-7.5 ratio of pre-tax profits as a percent of sales.

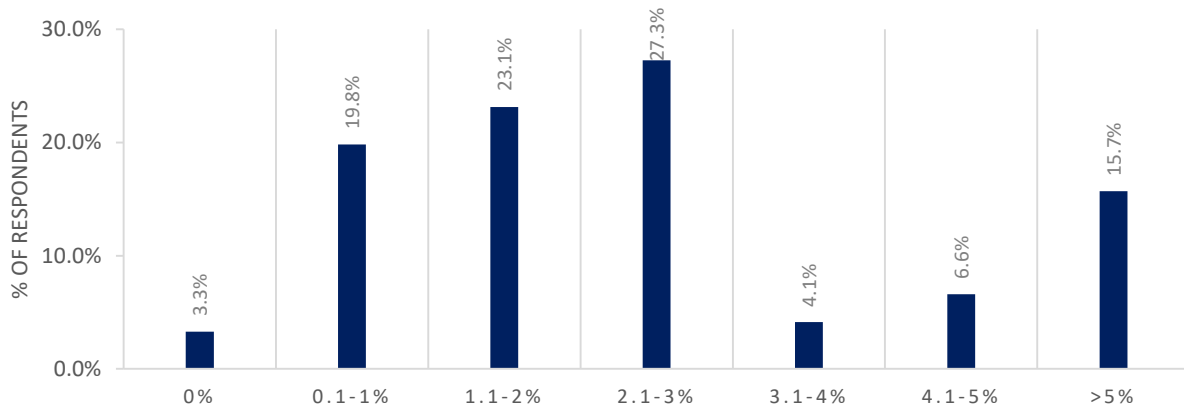
Figure 10: Pre-tax profits by Survey Respondents



R&D Spending

Research and development spending is an essential indicator of a firm’s emphasis on long-term initiatives and product and process innovation. Figure 15 depicts R&D spending as a percentage of sales. On average, surveyed firms allocate 2.1-3.0 percent of R&D spending as a percent of sales.

Figure 11: R&D Spending as a Percentage of Sales



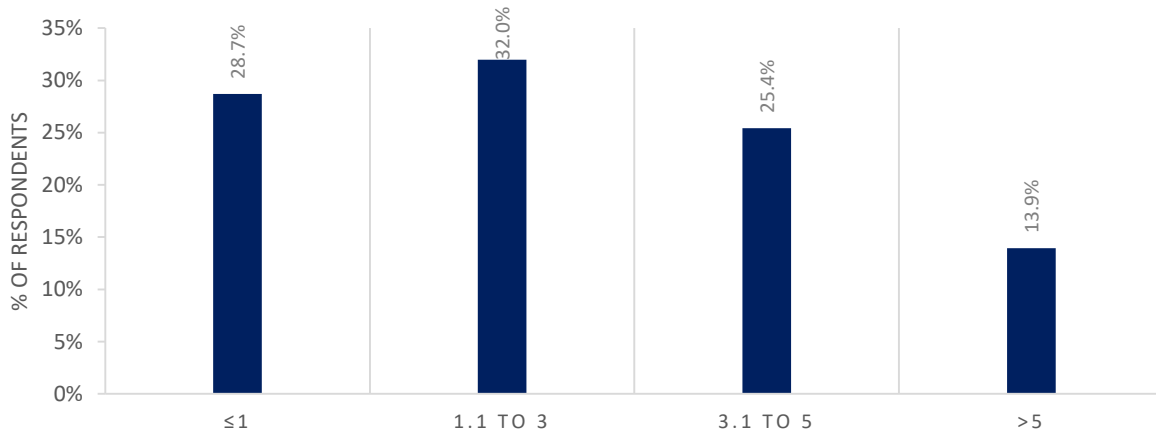
1. New Products/Pricing:

Having the flexibility to expand or shift product offerings through innovation and diversification can prove a vital source of revenue and a crucial competitive advantage for many firms. Researchers asked survey respondents to describe the percentage of their total sales arising from products their firm did not sell three years ago as an indicator of reliance on new products as a revenue stream. According to survey respondents, less than half of a firm’s total products are new – with the average respondent stating new products account for 11-30 percent of total sales. In addition to new products, another critical factor measured throughout this project was the average piece price of a firm’s main products. This factor can serve as a useful indicator of both the types and values of the items it produces, as well as the complexity of its production processes. Overall, for all firms surveyed, the average piece price for major products ranges between \$11-\$50 USD.

2. Competitors:

Researchers asked respondents to describe the number of other firms that would be potentially able to supply their product without significant new investment. On average, surveyed firms have roughly three competitors that could easily compete with them. The number of potential competitors is significantly lower than researchers found in a similar survey in 2014; in that study, firm respondents reported that an average of 8 competitors could easily supply the same product that they produce. Current and potential competition is a critical interest to firms and is a factor in how much pricing power and profit margin a firm can generate.

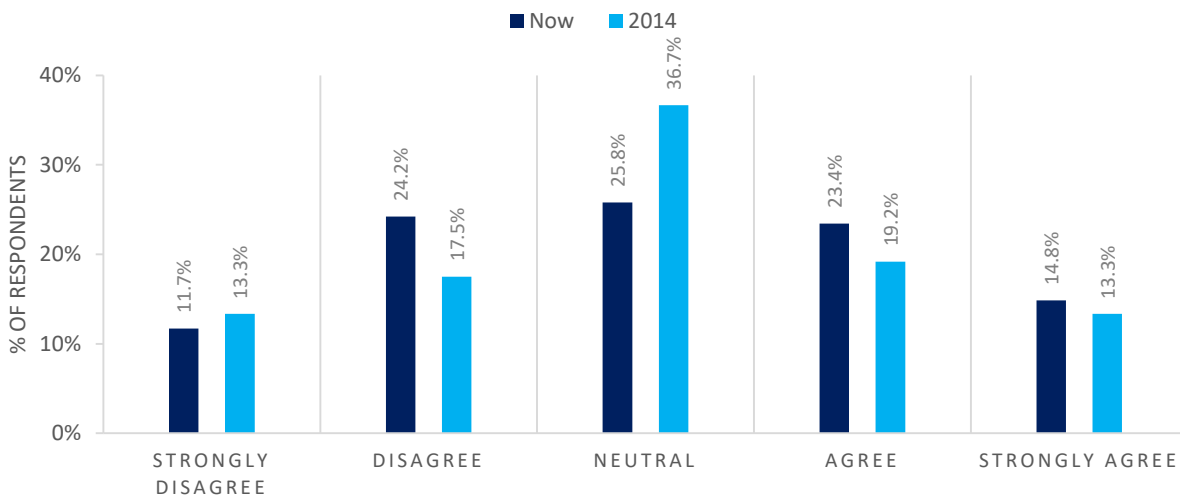
Figure 12: Average Number of Competitors



3. Customer Relationship:

The information that suppliers provide to their customers can serve a variety of purposes. To gauge the level of collaborative problem-solving amongst companies, the research team asked firm respondents to indicate the extent to which they agree with the following statement: “We feel that our customer often uses the information we provide to check up on us rather than to solve problems.” Figure 17 displays these results:

Figure 13: Customer's Relationship on Collaborative Problem Solving



Conclusion

The automotive industry is rapidly transforming with a massive amount of advancement in technology development and processes. However, the automotive industry is still in the early stages of having an Industry 4.0 manufacturing environment, and challenges and opportunities of technology adoption and deployment continue to arise.

With their facilities adopting new technology and machines, companies need to utilize all the benefits this equipment can provide. Data utilization, in particular, is one huge opportunity for companies to address in the short-term. There are a select few companies that recognize the importance of data in the manufacturing process, and the vast majority of survey respondents are not taking full advantage of the benefits provided through data analysis at their facilities.

The number one challenge survey respondents reported was finding qualified talent. Due to the rapid pace of innovation across the automotive industry, academic institutions are struggling to advance curriculum to match in-demand skills from the industry. Educational institutions and industry need to partner with one another to close this talent gap for the future workforce.

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