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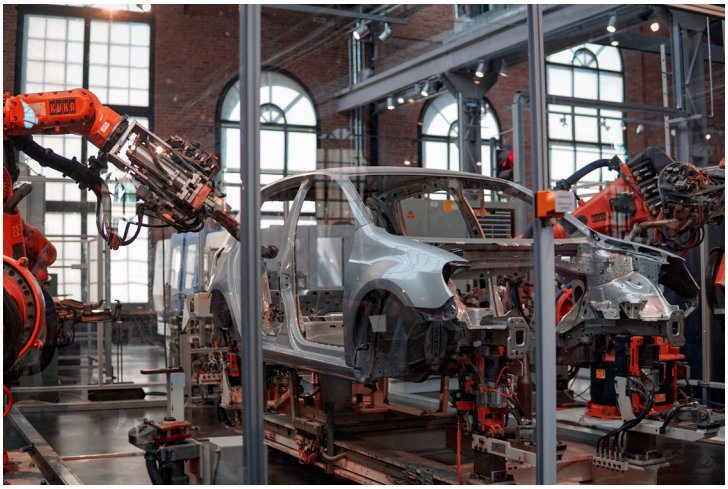

Artificial Intelligence, Manufacturing, and Workforce Development in Indiana

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Executive Summary

Domestically, industries are racing toward adoption of digital transformation to empower their data-driven manufacturing strategies. The increasing digital transformation seen in manufacturing is being enabled by the Industrial Internet of Things (IIoT) and big data, which are bringing the potential and benefits of Artificial Intelligence (AI) into focus. With less than 6% of data generated currently being used, AI offers manufacturers the opportunity to capture insights from the data to facilitate data driven processes and operations to achieve new levels of efficiency, productivity, precision, and performance across the manufacturing lifecycle.

As industries and their operations look toward becoming data-driven in all aspects of their business from product design, smart production, supply chains, to services, making sense of the data and deriving insights from it is where AI comes in and creates an impact. Data and AI will not displace workers, rather it is intended to augment and empower the workforce to create new forms of value and opportunities in manufacturing.

According to a 2019 Deloitte survey on AI Adoption in Manufacturing, 87% of industries surveyed say they have adopted or planned to adopt AI within 2-years. Deloitte, along with other organizations such as MAPI, NAM, McKinsey among others, all report similar national trends in AI adoption.

This study conducted by Purdue University on the current state of digital transformation and AI adoption suggest that Indiana may be an outlier. For Indiana, just 3.6% of industries surveyed have mapped data from their manufacturing use-cases to AI applications. Over one-fifth, or 21.4% of industries surveyed, are planning to adopt AI in the next 18 months and nearly 36% of industries are interested in learning more. And 39% of industries have no plans of engaging with this technology. With 25% of Indiana's economic output is based in manufacturing, AI will provide broad-based economic impact by transforming industrial operations to create additional business value.

Key Findings

AI is making advances in manufacturing in Indiana, although the state is lagging compared to national and global trends.

A clear AI strategy and business case for adoption is lacking.

There are significant technical barriers to overcome, including a more streamlined access to higher education resources.

AI skilled talent and resources are in short supply.

A need exists to expand AI data availability, including in rural areas.

Key Recommendations

Create Understanding on the Importance and Capabilities of AI in Manufacturing: For AI adoption to grow sustainably in Indiana, manufacturers require a better understanding of why AI is important, its capabilities, common applications in manufacturing, its benefits, and the business impact of using this technology.

Support Industries in their Journey toward AI Adoption: Help manufacturers evaluate their current process and operations for improvement; assess their resources and capabilities for AI adoption; evaluate and select AI solutions and understand the limitations; develop business impact, ROI & payback analysis; deploy AI solutions; and provide a clear path to scale.

Educate and Train the Current and Future Workforce: Prepare workforce with technical and human-centric skills needed to work with AI, integrate AI education in academic disciplines; and leverage on AI to make learning more effective and inclusive.

Invest in AI Resources for Manufacturers: A resource center could provide an environment for industry engagement to facilitate AI adoption in manufacturing at scale, and to bring operational, technological, and economic impact across a wide range of manufacturing industries in Indiana.

Expand AI-related Data Availability to Include Rural Areas and Streamline Purdue University's Manufacturing Programs and Resources: While several manufacturing-related efforts currently exist, strengthening and streamlining these could prove beneficial to manufacturers. Efforts need to be made to gather more rural-centric data to better identify and address their needs, including the delivery of education and technical assistance.

Realign Entrepreneur Resources to Better Assist AI Startups: Efforts should be made to identify and support these startups so their services can lower a significant AI-adoption barrier for manufacturers.

Introduction

According to the Boston Consulting Group, new digital industrial technology—also known as Industry 4.0—is transforming organizations through the adoption of faster, more flexible, and more efficient processes. The backbone of this transformation is the digitization of the industry that allows data gathering through a network of physical devices that are embedded with software, sensors, and network connectivity that collect and exchange data. This network of physical devices is called the industrial internet of things or IIoT.

IIoT can make objects 'smart' by enabling them to transmit data and automate tasks, without requiring manual interventions. IIoT platforms are designed to collect and process large volumes of data and make this information available. In manufacturing, IIoT capabilities enable end-to-end connectivity across all operations to create an enterprise-wide integrated manufacturing system.

Data analysis, through machine learning and other artificial intelligence (AI) algorithms, can generate valuable insights and offer predictive modeling capacity. Some examples can include identifying previously unknown patterns as well as anticipating, optimizing, and/or responding to changes or actions in real-time. In addition, manufacturers have begun using the capabilities of AI in a wide variety of applications to bring improvements to such things as product design, production process improvement, quality control, predictive maintenance, supply chain optimization, and inventory management, among others.

But what exactly is AI? For purposes of this study, AI is defined as a series of computer programs (algorithms) designed for specific tasks that analyze significant amounts of data to generate useful information, including limited decision-making. In addition, we view AI as a human-centered partnership model of people and AI working together to enhance cognitive performance, including learning and decision making.

Potential Economic Impact of AI for Manufacturing

A report from the MAPI foundation argues that AI is but one facet of a broader trend toward manufacturing digitalization that also includes the internet of things, cloud computing, wireless communications, big data analytics, and robotics[1]. Regarding the impact of AI, the global consulting firm PwC found that its potential contribution to the global economy by the year 2030 will be around $15.7 trillion dollars, of which $3.7 trillion will take place in North America[2]. It is important to note that this impact will come from a variety of industries, not only manufacturing.

Accenture's research has shown that AI could add an additional U.S. $3.8 trillion GVA (Gross Value Added) in 2035 to the manufacturing sector—an increase of almost 45 percent compared with business-as-usual. Despite this economic impact potential, the MAPI study found from their nationwide survey that only 5% of its members have mapped where AI opportunities exist and subsequently

[1] https://mapifoundation.org/manufacturing-evolution
[2] https://www.pwc.com/gx/en/issues/data-and-analytics/publications/artificial-intelligence-study.html

developed a clear strategy to generate the data that AI requires. On the other hand, some 56% of its members have stated they have no AI data plan in place. The report concluded that significant technical and workforce barriers remain regarding AI, including interoperability between equipment and a lack of employees with needed AI-skills. Regarding AI adoption among Indiana manufacturers, a survey conducted by Conexus Indiana found that a little less than one-fifth are planning to implement AI by the year 2025.[3]

To summarize, adoption of AI and related technologies (e.g., internet of things, big data, connectivity, etc.) has ample room for growth in Indiana. In addition, it is critical that workforce development needs be understood and addressed. For these reasons, this study identified the following research questions focusing on Indiana manufacturers:

1. What roles will AI augment, replace/eliminate, or create in your organization?
2. What skills are going to be needed for the roles that will be augmented and/or created?
3. What skillsets overlap may exist between those roles eliminated and/or created/augmented?
4. What strategies are currently in use for developing AI talent?
5. Are existing workforce development policies benefitting or harming the current level of manufacturing skills related to AI?
6. What are the barriers, if any, to adopt AI across manufacturing?
7. Are there any differences between large, mid-tier, and small manufacturers in regards to AI-related skills and adoption?
8. What skills are needed for citizen data scientists and/or advanced developers (i.e., data scientists) when it comes to AI in manufacturing? With the availability of cloud-based services, how will this impact the adoption of AI in manufacturing?

Methodology

A mixed methods research design was utilized consisting of an analysis of both primary and secondary data sources that would help produce a richer set of information for examining the research questions presented in the previous section. This multi-phase research design was approved by Purdue University's Institutional Review Board. The first phase of the research consisted of the development of a survey instrument and the analysis of a secondary dataset. Both the survey and secondary data were intended to inform and guide the development of key questions to include in a series of focus group sessions that would allow more in-depth information to be captured on key AI topics.

The 21-question online survey conducted over the period of one month gathered data on business name, industry type, business size, level of manufacturing-related skills, data collection, reasons to adopt AI, AI-related skills among different workers, AI applications, and reasons why AI had not been adopted, among other items. The intent was to identify adopters versus non-adopters and gain a better understanding of the workforce development needs of adopters and the barriers of non-adopters.

A preliminary list of manufacturers in Indiana, most with less than 100 employees, was obtained from the Dun and Bradstreet dataset. More than 500 personalized emails were sent to general managers, production/operations managers or supervisors, human resources, research and development, engineering, and/or facilities and maintenance employees. In addition, the Manufacturing Institute's Center for Manufacturing Research[4], the Purdue Manufacturing Extension Partnership, and the nonprofit Conexus[5] Indiana were tapped to help distribute the survey among its members. The exact number of manufacturers reached was unknown, therefore the response rate could not be calculated. A total of 36 valid responses was received.

Parallel to the design and implementation of the online survey, an innovative and proprietary dataset from Economic Modeling Specialists, Intl. (EMSI) was purchased. EMSI has been working on skills clusters and skills shapes pertaining to major career areas and roles. For example, human-computer interaction is a role within the major

[3] https://www.conexusindiana.com/report-charting-indianas-path-from-early-adoption-to-widespread-application-of-industry-4-0-technologies
[4] Special thanks to Chad Moutray, Director of the Center for Manufacturing Research, Manufacturing Institute for his help and expertise.
[5] Special thanks to Mitch Landess, Vice President of Innovation and digital Transformation, Conexus Indiana for his help and expertise.

category of robotics and signal processing. This method of analysis looks beyond the traditional labor market analysis based on occupations and focuses more on the set of skills needed to carry out various roles. EMSI was asked to identify the skill clusters and skill shapes for major metropolitan areas of Indiana, specifically AI (artificial intelligence) manufacturing-related skills noted in jobs postings. Analysis of jobs postings can serve as a valuable proxy for determining the demand for skills in the labor market. Similarly, analysis of resumes can show the supply of that skill in the labor market. The skill demand minus skill supply can offer insights on skill gaps or surpluses in the region. The mapping of skill demand and supply is known as the skill shape.

EMSI commenced this research by identifying 31 AI and data science related skills included in job's postings and available in the EMSI Skill Library. This library is comprised of approximately 30,000 different types of skills. At the time of this research, during the summer of 2020, EMSI had analyzed two years of manufacturing-related jobs postings in Indiana and elsewhere. EMSI and its research partners[6] have been exploring jobs postings and skills as new ways of representing labor market information. For example, in *The New Geography of Skills*, researchers have developed a case that regional skill shapes should be the basis for developing new learning ecosystems that are customized for the regional labor markets.[7]

The advantages are twofold. First, the traditional labor market data—that relies on industry sectors and occupations—are updated once a decade, resulting in workforce development classifications not aligning with current industry demand. Second, the demand and supply for skills in a region can change within months and such a granular timescale might require non-traditional labor market information. As mentioned previously, AI will not only bring advanced technologies to manufacturing but will also require new skills for the workforce. EMSI used Natural Language Processing (NLP) and other methods to identify the natural clustering of skills and develop templates for skill shapes. The information on skill-demand is gleaned from the jobs' postings, whereas the information on skill-supply is obtained from repositories of resumes and online professional profiles.

For purposes of this project, EMSI identified five major categories under two major career areas—production and manufacturing as well as architecture and engineering. The five major categories include Robotics and Signal Processing, Modeling and Simulation, AI and Data Science, and Engineering, and Production. Further, EMSI identified specific roles within these areas and mapped skills shapes in Occupations included in these roles for different metropolitan areas of Indiana. Note that roles and their combination of skills could be unique to the metropolitan areas. The research could not isolate data for rural areas because the demand for AI skills was not prevalent in jobs postings by manufacturers located in rural and nonmetropolitan areas of Indiana.

The second phase of our mixed methods approach included focus groups sessions that were designed based on information secured from the survey and from our dataset analysis. However, the COVID-19 health crisis and the low response rate from the survey prompted a change in strategy. Rather than carry out focus groups sessions, we opted to conduct an introduction to AI event in partnership with Conexus Indiana where 18 manufacturers participated. Relying in part on the information gathered during this event, a series of key informant questions were developed and interviews scheduled. These key informants either completed the survey, participated in the event, and/or were recruited with the valuable help of our partners (Purdue Manufacturing Extension Partnership and Conexus Indiana). A total of seven 40-to-60-minute semi-structured key individual informant interviews were completed. These were recorded with the consent of the participants, transcribed, and analyzed to identify common themes.

[6] Strada Foundation.

[7] Weise, Michelle R., Hanson, Andrew R., and Saleh, Yustina. The New Geography of Skills: Regional Skill Shapes for the New Learning Ecosystem. Indianapolis, IN: Strada Institute for the Future of Work, 2019.

Results and Findings

This section discusses the results of our three data gathering strategies (the EMSI dataset, the survey, and the key informant interviews) and then addresses the research questions outlined above. We begin with a discussion of the results of the EMSI dataset analysis.

Economic Modeling Specialists, Intl. (EMSI) Dataset

This innovative database mapped the skill shapes (demand/supply, specific skills, importance of a skill in the role, and number of jobs postings) for specific roles in select metropolitan areas of Indiana. Table 1 shows the major categories and roles and themes by specific metropolitan areas in Indiana. In contrast to Robotics and Signal Processing, Modeling and Simulation, and AI and Data Science, where AI-related skills were prevalent in jobs postings, there were some appearances of AI-related skills in jobs postings for the Engineering category and hardly any in the Production category.

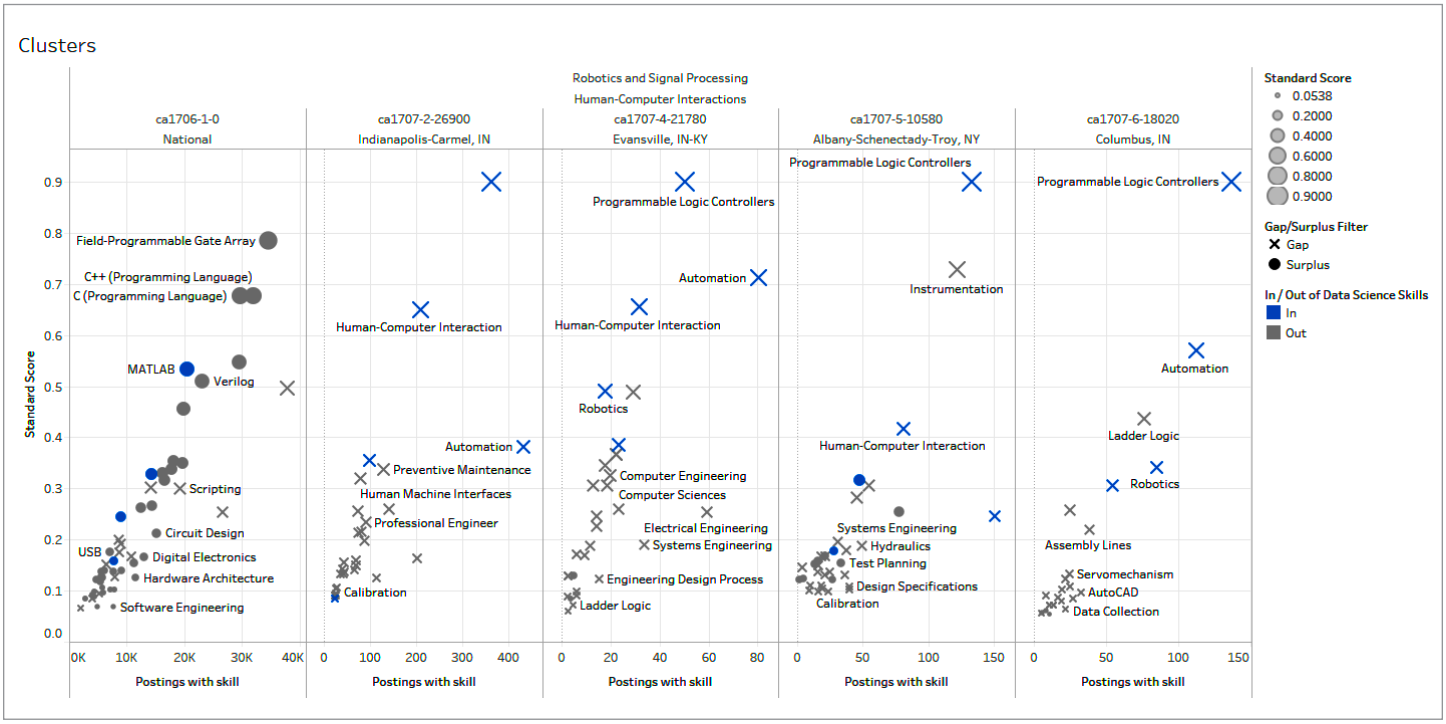
TABLE 1. EMSI Roles and Skill Clusters

Major Category	Roles/Themes	Indiana Metropolitan Areas
Robotics and Signal Processing	Human-Computer Interactions	Human-Computer Interactions
	Engineering and Systems Design	Columbus
	Computer-aided Design and Machining	Fort Wayne, Indianapolis-Carmel, Lafayette-West Lafayette
Modeling and Simulation	Robotics and Control Systems	Fort Wayne
	Engineering and Systems Design	Columbus
	Computer-aided Design and Machining	Fort Wayne, Lafayette-West Lafayette
AI and Data Science	Machining and Lean Manufacturing	Columbus
	Engineering and Systems Design	Columbus
	Production and Software Development	None
Engineering	Aerospace and Chemical	Indianapolis-Carmel and Columbus
	Control Systems and Automation	Evansville, Fort Wayne, Indianapolis-Carmel
	Digital Signal Processing	Fort Wayne and Columbus
	Electronic	Fort Wayne and Indianapolis-Carmel
	Robotics and Programmable Logic Controllers	Columbus, Indianapolis-Carmel, Fort Wayne and Evansville
	Computer-aided Design and Machining	Fort Wayne, Lafayette-West Lafayette
Production	Machining and Lean Manufacturing	Lafayette-West Lafayette, Columbus, Evansville, Fort Wayne
	Welding and Mechanical Assembly	Columbus, Indianapolis-Carmel, Fort Wayne

Figure 1 illustrates the human-computer interactions role within robotics and signal processing category. The vertical axis of the Tableau dashboard shows the standardized score. If the score is high, the specific skill is in greater demand within the role. If the score is low, the specific skill is a niche or boutique skill. A cross means that there is a gap for that skill in the labor market. A circle means that there is a surplus of the skill in the labor market. The horizontal axis shows the number of jobs postings.

With that in mind, Figure 1 shows that automation, human-computer interaction, robotics, programmable logic controller, etc., are highly sought-after skills in Columbus, Evansville, and Indianapolis metropolitan areas. However, the cross shows that a gap exists for these skills in the labor market. At the same time blue color shade means that these skills were relevant for AI and mentioned in the job's postings. This means that practically all skills in human-computer interactions for various metropolitan areas in Indiana are lacking in supply. To conclude, Figure 1 reveals that the AI skills are in demand within human-computer interactions in manufacturing jobs, but almost every metropolitan area has gaps because of the lack of workers with these specific skills in the labor market.

FIGURE 1. Human-Computer Interactions/Robotics and Signal Processing *Source: EMSI*



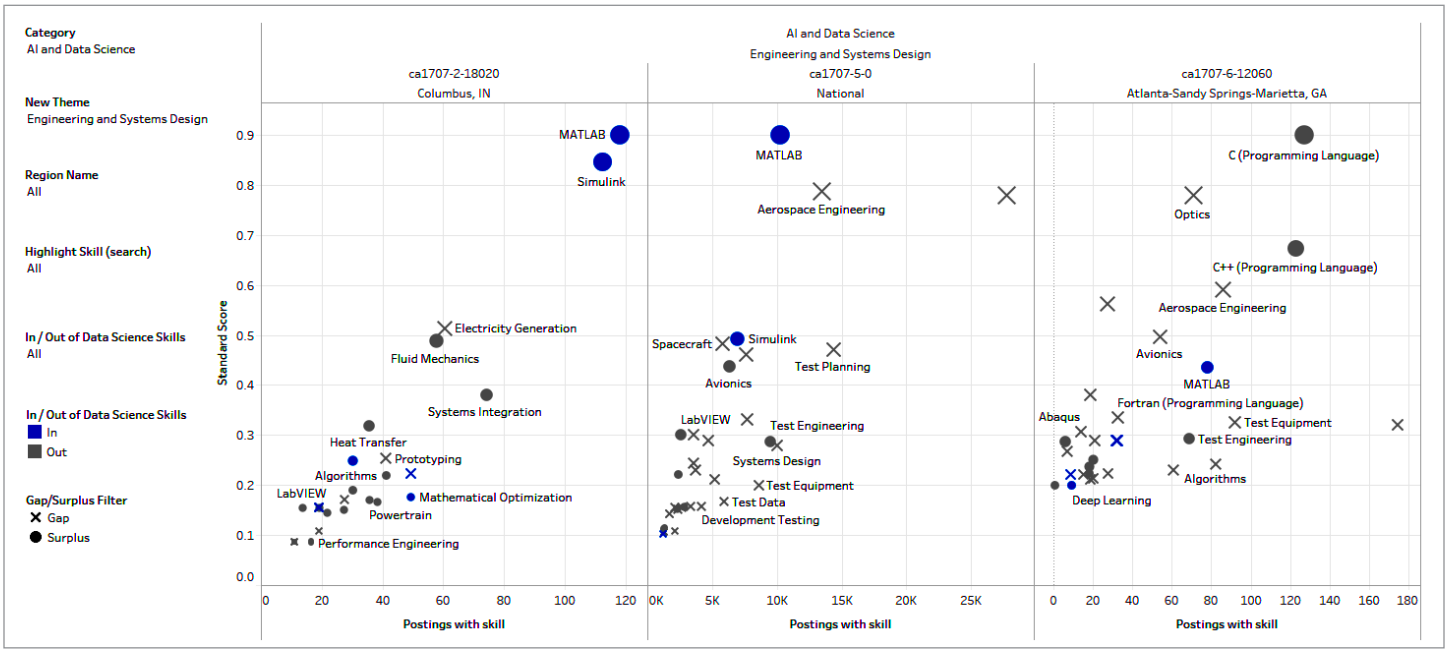
In the same vein, Figure 2 displays the skills shape or map for AI and Data Science and Engineering and Systems Design related roles in Indiana. In this case, Columbus, Indiana has a surplus of skills in Matlab and Simulink that are highly sought-after for these roles. AI and machine learning capabilities have been integrated into Matlab and Simulink, which is a well-known platform in engineering and science disciplines.[8] In sum, AI-related skills are being requested in manufacturing-related jobs postings in Indiana. However, only certain metropolitan areas exhibit demand for such skills.

The jobs postings from rural and non-metropolitan areas were displaying little demand for AI-related skills in production and manufacturing-related job advertisements. Hence, EMSI could develop dashboards for metropolitan areas, but could not develop similar dashboards for rural and non-metropolitan areas. This indicates that rural manufacturing in Indiana is far less advanced in the application of AI and data science compared to the state's metropolitan areas or the rest of the country.

[8] https://www.mathworks.com/campaigns/offers/ai-with-matlab.html

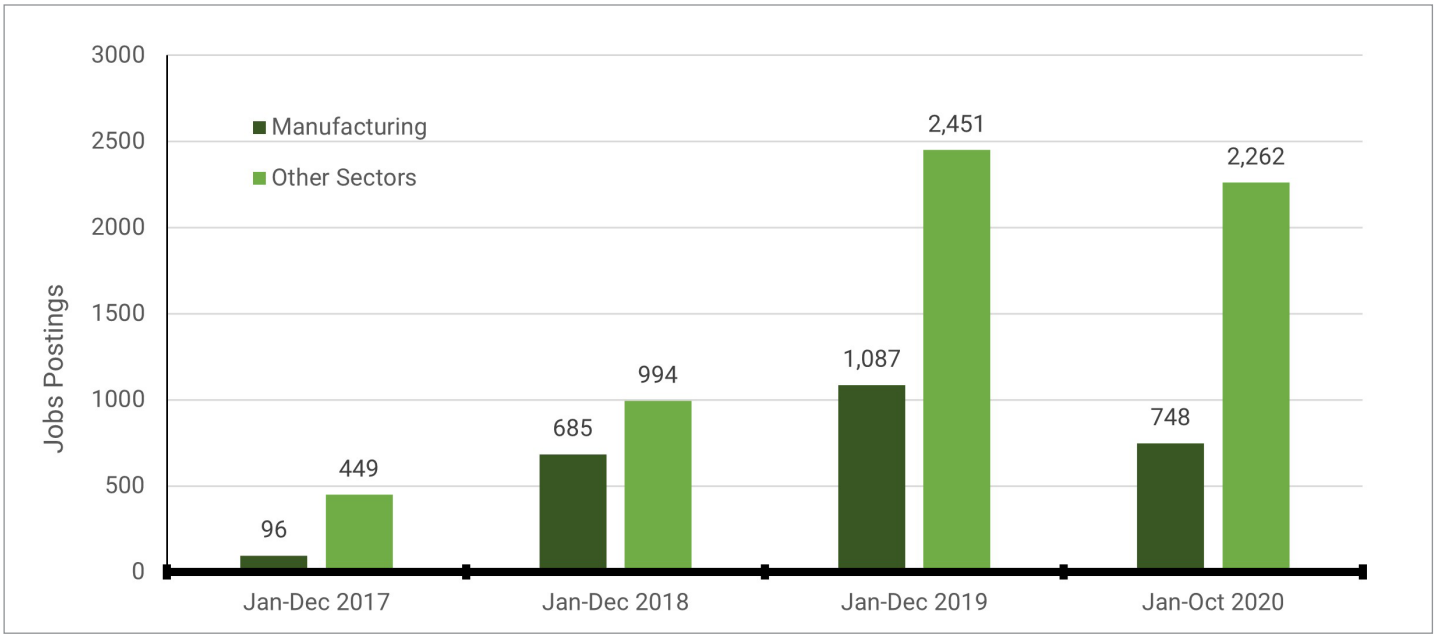
FIGURE 2. Engineering and Systems Design/AI and Data Science

Source: EMSI



On a related effort, PCRD used EMSI Analyst Labor Market Application to compile counts of jobs postings mentioning "artificial intelligence" and at least one out of 31 AI-related skills for the state of Indiana. Figure 3 shows the total postings (these can include more than one posting per unique job) for manufacturing and other (non-manufacturing)[9] sectors in Indiana. Manufacturing postings asking for AI-related skills and mentioning "artificial intelligence" lagged other sectors, which included 19 non-manufacturing industry sectors. However, the trend was increasing prior to the COVID-19 pandemic.

FIGURE 3. AI-related Total Postings in Indiana



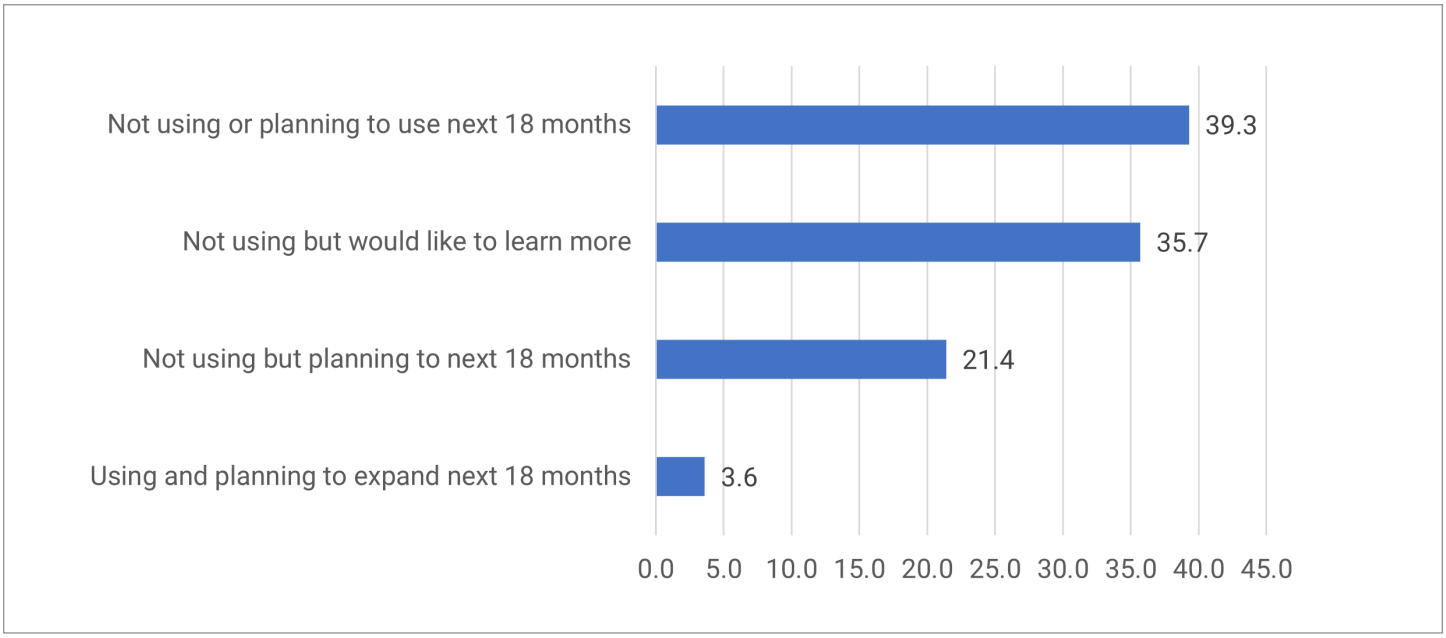
[9] Non-manufacturing sectors include Agriculture, Forestry, Fishing and Hunting; Mining, Quarrying, and Oil and Gas Extraction; Utilities; Construction; Wholesale Trade; Retail Trade; Transportation and Warehousing; Information; Finance and Insurance; Real Estate, Rental and Leasing; Professional, Scientific, and Technical Support; Management of Companies and Enterprises; Administrative and Support and Waste Management; Educational Services; Health Care and Social Assistance; Arts, Entertainment, and Recreation; Accommodation and Food Services; Other Services (except Public Administration); and Government.

In summary, AI and data science skills exist throughout Indiana but are not yet prevalent in all instances of the production, manufacturing and engineering careers analyzed. Also, production and machining manufacturing in the state is less advanced in the application of AI and data science—as are nonmetro areas of the state—compared to the rest of country. These findings support the national and Conexus surveys discussed previously.

Survey

A total of 36 survey responses were received. While it was hoped that more responses would be secured, the information collected from the survey respondents proved to be valuable and important. Nearly half of the survey respondents (47%) had less than 50 employees and more than one-third (36.1%) were engaged in metal working/fabrication. When asked whether the business is using or has intentions to use AI, Figure 4 shows that close to 40% of respondents did not use AI and are not planning to use AI in the next 18 months. Nearly 36% were interested in learning more while just over one-fifth (21.4%) are planning to adopt AI in the next 18 months. Lastly, less than 5% said they are using AI and are planning to expand in the next 18 months.

FIGURE 4. Percent Survey Responses and AI Adoption (n = 28)



Given that data is critical for any AI implementation, the survey asked about the type of data being captured and how frequently. Figures 5-7 show the share of respondents collecting data by area and method. Figure 5 shows that more than half of respondents said they are collecting data manually from machine data, quality, inventory, and employee-tracking. Figure 6, on the other hand, shows that more than half of the respondents said they are collecting data automatically from finance/budgeting. Lastly, Figure 7 shows that around one-third of respondents indicated they are not collecting any data from machine data and asset-tracking while more than half said the same from cameras. Close to one-fifth did not collect data from supply chains and 14% from employee-tracking.

FIGURE 5. Percent Survey Responses Collecting Data Manually by Area (n range: 24-49)

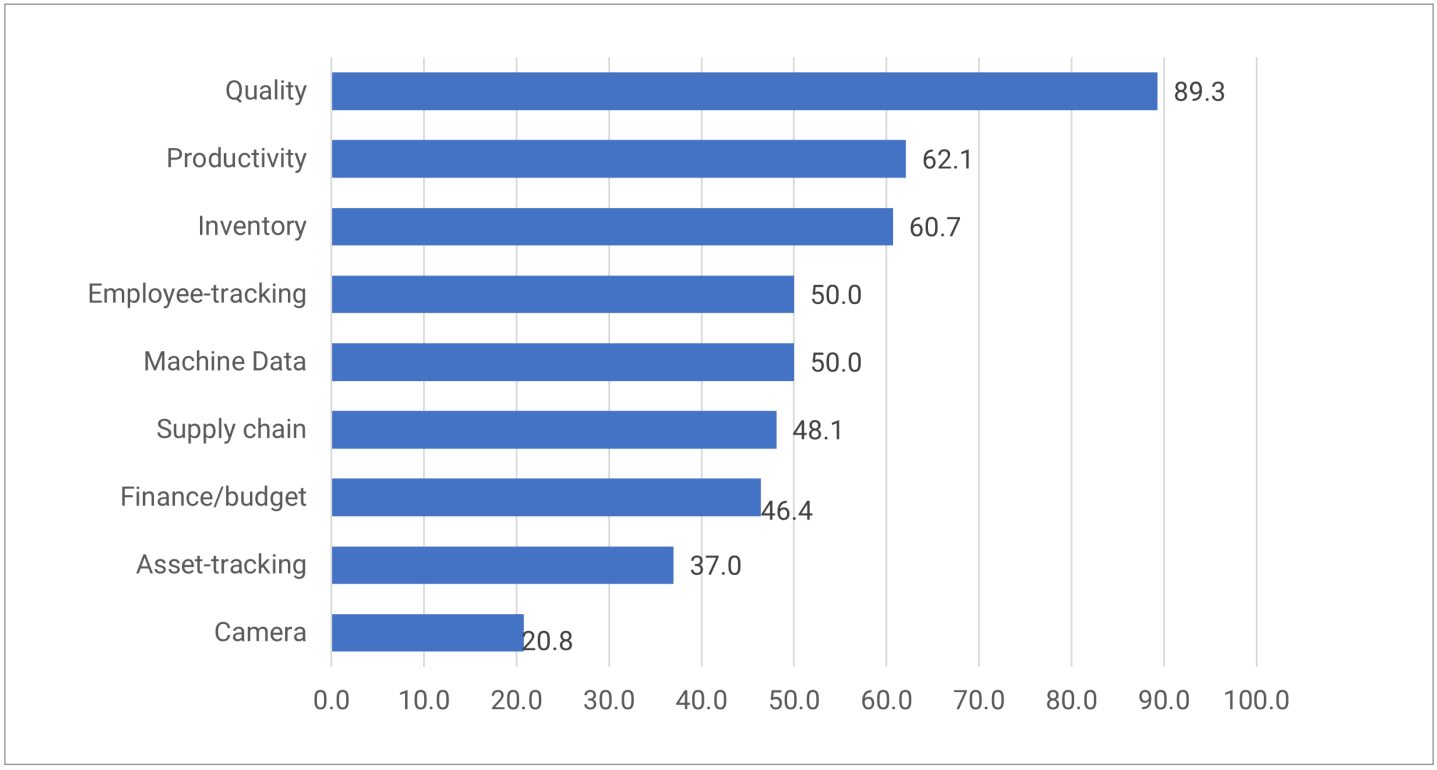


FIGURE 6. Percent Survey Responses by Data Automatically by Area (n range: 24-49)

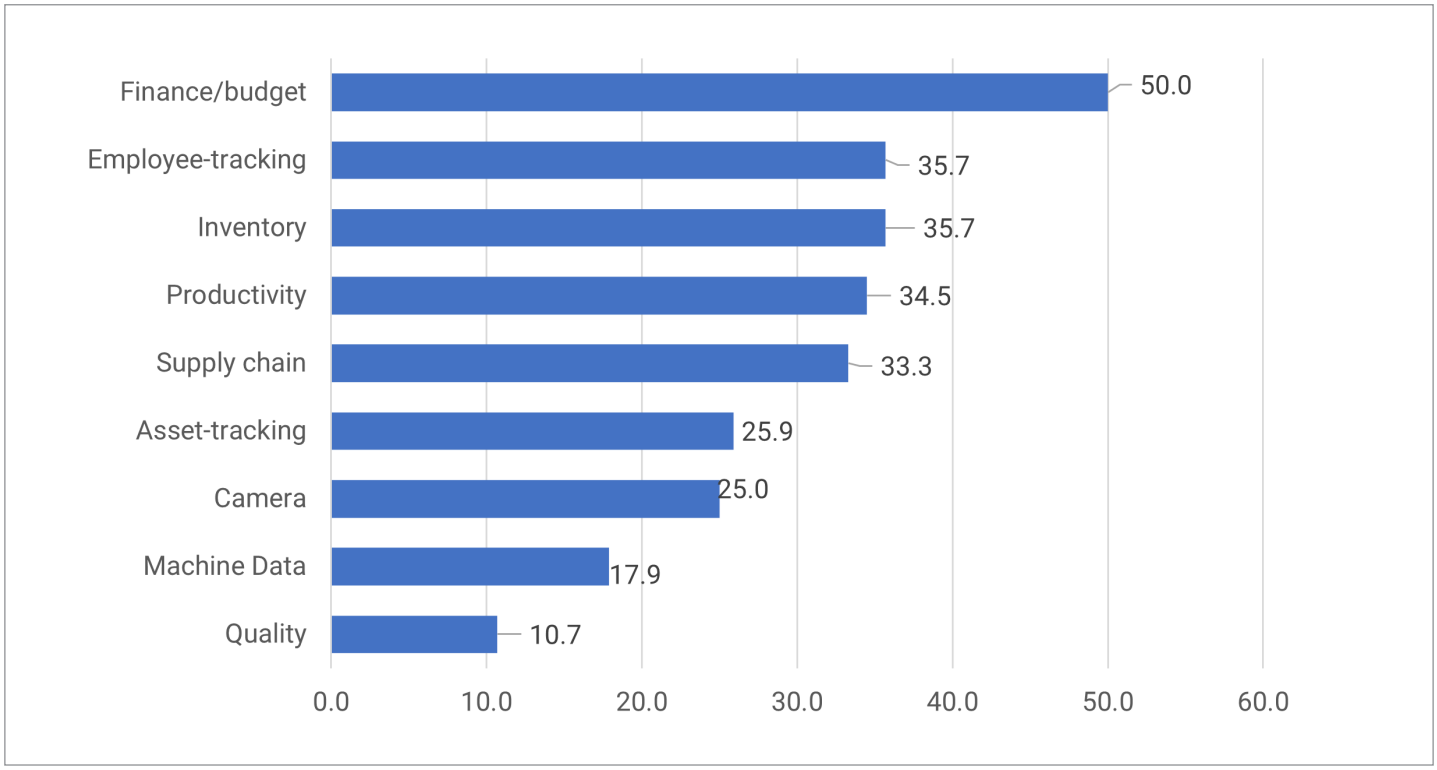


FIGURE 7. Percent Survey Responses Not Collecting Data by Area (n range: 24-49)

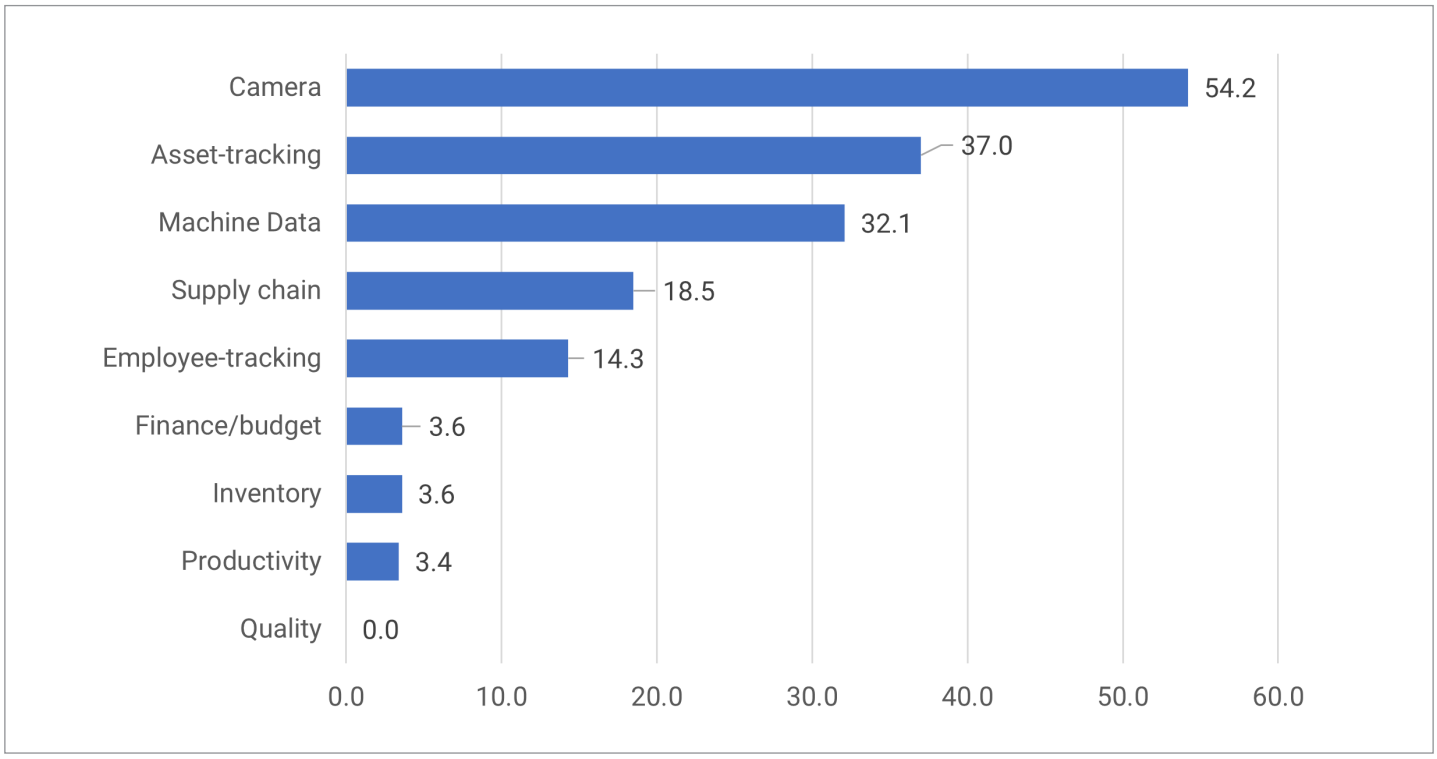
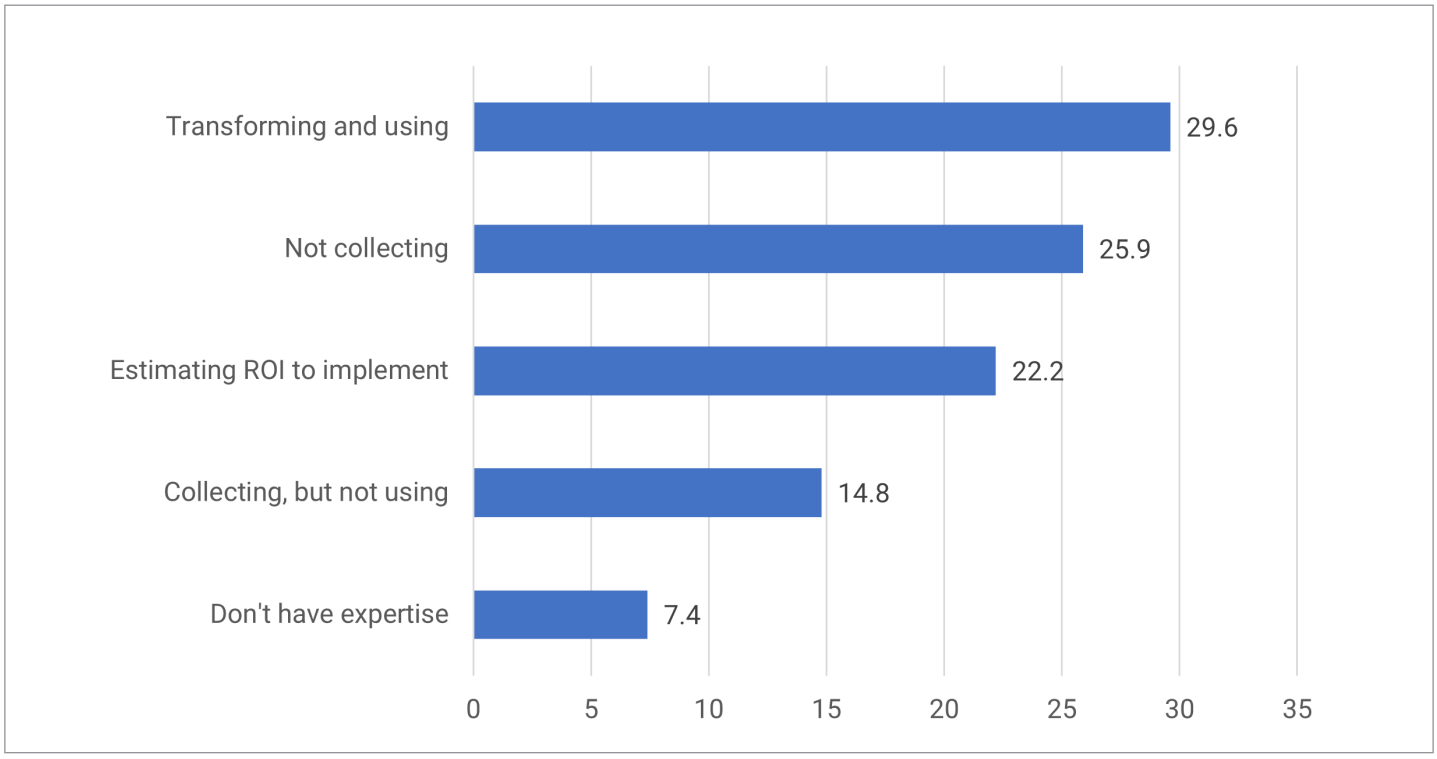


Figure 8 examines if and how data are being used to improve operations. Results show that, one-quarter of respondents are not collecting any data, close to 15% is collecting but not using the information to improve operations, over 22% is estimating the return on investment to improve operations, 7.4% stated they did not have the expertise, and almost 30% are transforming and using data to improve operations.

FIGURE 8. Percent Survey Responses of Using Data to Improve Operations (n = 27)



The survey identified 14 AI barriers and asked respondents to indicate their level of agreement/disagreement with each of the possible barriers. Table 2 shows the percent of respondents agreeing or strongly agreeing with each barrier (sorted in descending order).

More than half of respondents agreed on eight of the 14 barriers listed and all were related to such issues as an unclear business case, lack of awareness or strategy regarding AI, lack of financial resources, as well as talent concerns.

TABLE 2. Percent Responses Agreeing or Strongly Agreeing

AI Barriers (n range = 24-26)	Percent Agree/Strongly Agree
Have not mapped AI opportunities	66.7
Not familiar with AI systems	66.7
Lack of AI talent	62.5
No strategic approach	58.3
Skeptical of AI return on investment	56.0
AI benefits not clear	54.2
Interested, not sure where to start	54.1
Lack of financial resources	54.1
Majority of data is not conducive to AI	42.3
Concerned about cybersecurity	40.0
Data is not compatible with each other	37.5
Lack of senior leadership buy-in	29.2
Concerned about eliminating jobs	20.9
Internet connectivity is lacking	20.8

Key Informant Interviews

A total of seven key informant interviews were conducted and recorded. Interviews were semi-structured, and the series of questions developed to guide the interviews were shared with participants ahead of time. However, conversations were not limited to these questions and the interviews were conducted in such a way that more detailed information around AI and its challenges and barriers was gathered. Approximately 7 hours of interviews were transcribed and analyzed. Two main themes emerged from these interviews along with valuable insights: 1) challenges and limitations of AI and 2) ways to support AI adoption.

1) Challenges and limitations of AI

Perhaps the most recurrent insight was around the lack of awareness, including technical support and a clear-cut business case for AI. As one participant put it:

> *"... how can you get an ROI [return on investment] out of something that nobody knows anything about?"*

Or as another participant explained:

> *"... if we knew we were going to get value of it, I could see other data points that we could get throughout our manufacturing process pretty easily."*

Likewise, the cost of implementation was a concern, especially given that the value is not clear. One participant said:

> *"Money is important, you know. Projects are being scrutinized a lot."*

Regarding technical support, one participant shared:

> *"The AI strategies and ideas are there, but the problem is the technical support and research data to implement it."*

This same participant later added:

> *"I do not have access to any kind of basic research."*

In addition, and related to technical support, is how to best leverage what already is in place. For example, one participant noted:

> *"... what I have seen come out of it is the challenges of training and support of the operating system."*

Another participant noted that a key barrier to adoption is "cleanliness of data." For example, the name of a specific company may be spelled "14 different ways in the database."

Another main challenge and limitation to AI adoption was talent. Participants indicated that it is not very clear where they can start to learn more about AI-related talent. One participant stated when asked about AI talent:

> *"You know, it can be overwhelming to understand who I should talk to."*

Another participant made a statement supporting this sentiment:

> *"Probably not having enough awareness or knowledge of all the programs that the state offers. From my experience, our HR department works somewhat with the state, but I will be honest, I think most of it has largely been on the entry level positions in filling production type positions, not pursuing skilled positions."*

Another participant concluded:

> *"Our local workforce offices? I am sorry, just not helpful, just not helpful at all."*

2) Ways to support AI adoption

Participants provided very valuable insights as to how AI adoption could improve. For example, a basic AI 101 step-by-step guide would be very useful. As stated by one participant:

> *"Indeed, an AI 101 that touches on the basic technological principle, shares some concrete business case examples with specifics (and preferably not speaking only about fortune 500 companies because that does not relate well to most SME out there), and provides some recommendations for getting started (prerequisites, training needs, process/methodology, tools, budget)"*

Regarding educational/training curriculum, one participant suggested focusing on different levels within the organization:

> *"I think education maybe a different level of depth. You know, obviously, if you want to educate your middle management or your top management, you do not ever settle debts that if you want to start. You know, if you decide I want this person here to become kind of a subject matter expert and you know that takes time, obviously not just the training is going to do that but correct having these different types of curriculum would be interesting, you know."*

Several participants noted the difficulty of knowing if their business is "ready" for AI adoption. In this respect, they mentioned that an instrument to assess the readiness of companies would be extremely useful. Similarly, any competency assessment to identify the readiness of current employees to be reskilled or upskilled to AI-related skills would be valuable as well. As stated by one participant:

> *"They [employees] would be very receptive to it, because now you know it is if you can make my job easier. I am all in. If you could make my numbers better, I am all in. If you can make my quality better, I am all in. So, anything that would enhance that and then you know, let us face it, give them the opportunity to prosper."*

Lastly, participants also shared what would be helpful regarding AI talent. For example, a participant stated:

> *"Need for systematic/centralized hub to seek the right talent. That partnership [with industrial associations, higher education] is where we are going to draw that talent from [apprenticeship programs]."*

Another participant stated the need to vet potential partners/vendors involved in AI:

> *"Help vet potential partners. You know because if I go do a Google search right now, I will find 100 of them. I do not know which ones are good, right? And which*

> *ones are good for our industry. Our size and feel of a company. Because for me to go out to Oracle or Microsoft or somebody like that, I am not getting any attention and I am not going to pay the paycheck to get it from them, right?"*

Conclusion

As the digitization of the economy continues, it is critical for manufacturers in Indiana to remain competitive by adopting industry 4.0 technologies, including artificial intelligence (AI). According to the Purdue Center for Regional Development's "2019 Manufacturing in Indiana" report, manufacturing was responsible for more than half of the export value compared to all other industries, accounted for one-quarter of the state's GDP, and represented one-fifth of all earnings. In other words, manufacturing is a critical industry for the state's economy and quality of life.

In addition, there is demand already for AI-related skills in some metropolitan areas of the state. However, the supply of people with these skills is lacking. This could be a significant issue down the road as more AI-skills are demanded, especially when manufacturers in more rural areas of the state begin adopting AI. After all, in 2019 almost one in four jobs in non-metropolitan counties of the state were manufacturing jobs.

Before discussing key barriers and a path forward, it is worth highlighting key limitations of this study. First, the survey sample was convenient and not scientific. While the survey was distributed to multiple groups through multiple partners, it did not meet the random criteria entirely. Second, the number of manufacturers participating was lower than expected (close to 50). For these reasons, caution should be exercised when generalizing the findings. Regardless of these limitations, valuable information was obtained.

When initially designing the research method for this project, the focus was to better understand the barriers faced by manufacturers not adopting AI, then more importantly, to identify needs AI adopters have regarding workforce development and talent retention and attraction. However, results from the survey and later supported by the key informant interviews, coupled with findings from state and national studies, forced us to recalibrate and focus primarily on the barriers faced by non-adopters. This is one main finding of this study: most manufacturers participating in this study are struggling to adopt AI.

Key Barriers

We now move into a summary of the key barriers identified through the survey and key informant interviews. The first is lack of access to knowledge and technical expertise. While Purdue University and other higher education institutions in the state generate valuable AI knowledge and technical expertise, manufacturers that participated in this study found it difficult to access this critical know-how or technical assistance.

Efforts like the Purdue Manufacturing Extension Partnership, the Indiana Next Generation Manufacturing Competitiveness Center, and the Purdue Manufacturing Gateway, among others, are very important and should work in a more coordinated and cohesive way to address the AI needs of manufacturing-related companies. In addition, partnerships with existing manufacturing groups—such as Conexus Indiana—should be strengthened to allow better dissemination of information and best practices and to help remain attuned to the obstacles and needs being experienced by these groups.

Second, most if not all the manufacturers that participated in this study acknowledged that they are indeed generating digital data. However, some of the data generation was included in the machines being used and not necessarily with an AI strategy in mind. As such, it is not clear what needs to be done next to prepare these data for AI use. Again, participants were not sure how or where to even start regarding data gathering, compatibility, and readiness for AI use.

Third, and perhaps the single largest barrier to AI adoption among participants of this study, is the lack of a business case, including a clear AI strategy for their business. This finding supports other state and national studies where an unclear business case serves as a significant barrier to adoption. Most participants are aware of AI (in general terms) and its potential. However, it was not clear to them how it would be of specific benefit

to their company and more importantly, how the company could justify such investments. In other words, what would be the benefits of adopting AI for their business? Related to this issue, and what could perhaps help build their business case, is having the ability to draft and implement an AI strategy for their business.

Although very few participants in this study have adopted AI, useful insights were obtained. Their main concerns centered on talent recruitment and retention. The existing WorkOne network has been useful to a certain extent, but they felt more needed to be done to help manufacturers find AI-talent. On the other hand, they found apprenticeship programs to be useful. Some participants also mentioned that a competency assessment would be of value to help them identify existing employees that can be upskilled or reskilled with AI-related skills.

In summary, while manufacturers are aware of AI and its potential benefits in general terms, adoption levels by those participating in this study were low. Multiple barriers were identified and among those few adopters, talent was the critical concern.

A Path Forward for Indiana Manufacturers

While every business aims to optimize its operations for productivity, as evidenced from this study, very few have taken advantage of the advanced practices. The technologies to power the future of manufacturing are already here and manufacturers in Indiana must prioritize preparing their enterprises to capitalize on the digital transformation through data and AI. Investments and efforts need to be made to better gauge adoption of AI among Indiana manufacturers to better align resources and technical assistance.[10]

We offer several recommendations to facilitate AI adoption at scale for Indiana manufacturers:

(1) Create Understanding on the Importance and Capabilities of AI in Manufacturing: The notion of AI is still concerning to most, particularly in the Midwest, based on the perceived similarities to automation which has displaced many workers during the 3rd industrial revolution. For this reason, for AI adoption to grow sustainably in Indiana, manufacturers require a better understanding of why AI is important, its capabilities, common applications in manufacturing, its benefits, and the business impact of using this technology. Also messaging, discussions, and transparency is necessary to communicate how jobs or roles will be transformed using AI, helping workers understand how AI augments and enhance their capabilities, and vice versa. For example, a step-by-step guide around mapping AI opportunities should help companies begin strategizing on AI for their business. This can then lead to more awareness and a more informed business case for the technology. Given that more than half of respondents said they were interested or planning to adopt AI in the next 18 months, a need for this type of guide is clear.

(2) Support Industries in their Journey toward AI Adoption: Provide services to support AI adoption. This includes helping manufacturers evaluate their current process and operations for improvement; assess their resources and capabilities for AI adoption; evaluate and select AI solutions and understand the limitations; develop business impact, ROI & payback analysis; deploy AI solutions; and provide a clear path to scale. Likewise, support industries to develop a change management strategy to prepare their organizations for a future with AI. Help top management understand how AI could transform their organization, create roles or teams to support related efforts, build a culture that is receptive to AI, and exhibit leadership for sustainable AI practices.

(3) Educate and Train the Current and Future Workforce: Training and reskilling the current and future workforce by equipping them with the required skills is critical. Prepare the workforce with technical and human-centric skills needed to work with AI, integrate AI education in academic disciplines; and leverage AI to make learning more effective and inclusive.

[10] A recently published Brookings report made a similar recommendation: State of renewal: Charting a new course for Indiana's economic growth and inclusion (brookings.edu)

A centralized database of available AI talent would be extremely useful. Participants in this study mentioned that apprenticeships are great and is the source of their talent. However, there is no database of AI apprenticeships and potential talent available. A centralized database could go a long way in helping provide opportunities for potential AI talent and to identify and retain this talent.

(4) Invest in AI Resources for Manufacturers: A resource center could provide an environment for industry engagement to facilitate AI adoption in manufacturing at scale, and to bring operational, technological, and economic impact across a wide range of manufacturing industries in Indiana. Because AI implementation relies so much upon data, specialized digital infrastructure, skills, and the financial resources to adopt this important innovation, small and medium-sized enterprises are particularly at a huge disadvantage. In addition to providing the basic services, these industries could benefit from a common digital platform that hosts a repository of AI tools, ideas, and best practices for the manufacturing community to collaborate, share, and validate ideas for maximizing the synergy among all stakeholders.

(5) Expand AI-related Data to Include Rural Areas & Streamline Purdue University's Manufacturing Programs and Resources: Some manufacturers that participated in this study indicated they do not know where to start when seeking information from Purdue University, especially around manufacturing and artificial intelligence. While several manufacturing-related efforts currently exist, strengthening and streamlining these could prove beneficial to manufacturers. In addition, existing AI skills and jobs data in manufacturing exclude rural areas. Most data available to identify demand and supply of AI-related skills in manufacturing come from metropolitan areas of the state. The fact that rural data is lacking implies that rural manufacturers are not posting jobs that require AI skills or have very low demand for these types of skills. Efforts need to be made to gather more rural-centric data in order to better identify and address their needs, including the delivery of education and technical assistance.

(6) Realign entrepreneur resources to better assist AI startups: Given that many aspects of AI (data management and interoperability, predictive maintenance, product design, algorithms, etc.) may not be developed in-house by manufacturers, the opportunity and potential for AI startups is significant. Efforts should be made to identify and support these startups so their services can lower a significant AI-adoption barrier for manufacturers.

> *While every business aims to optimize its operations for productivity, as evidenced from this study, very few have taken advantage of the advanced practices. The technologies to power the future of manufacturing are already here and manufacturers in Indiana must prioritize preparing their enterprises to capitalize on the digital transformation through data and AI.*