Perceptions of Midwestern Manufacturing of Sustainable Practices During Disruptive Times

by

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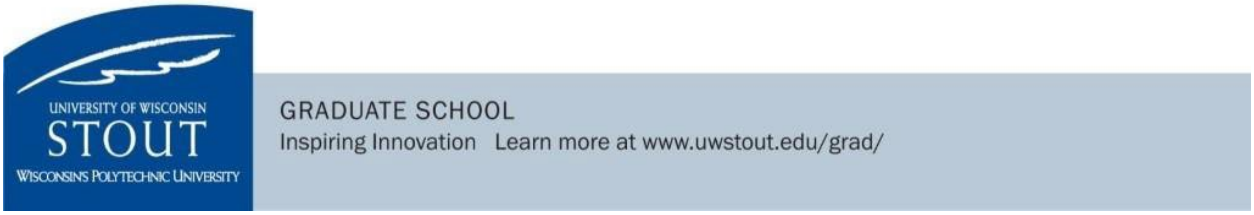

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Johnson, Peter L. ***Perceptions of Midwestern Manufacturing of Sustainable Practices During Disruptive Times.***

Abstract

The United States manufacturing industry has had challenges affecting the sector for decades. The COVID-19 pandemic brought new challenges that impacted the manufacturing industry. Across the globe, government leaders have led conversations about the challenges facing manufacturing and have implemented strategies to solve and manage these challenges in the future. Research has shown that smaller manufacturing companies have been left out of these conversations. Manufacturers in the upper Midwest of the United States have had no voice in these discussions. This study aims to gain insight into the challenges faced by the U.S. manufacturing industry in post-COVID-19 pandemic manufacturing from the perspective of manufacturing industry leaders in the Midwest and how they plan to meet them. In addition, this study sought to understand how manufacturers will prepare for future disruptions. Qualitative interviews were conducted with eight manufacturing leaders working in the upper Midwest of the United States. Participants were asked a series of open-ended questions to gain an understanding of their perceptions of the challenges and solutions facing the manufacturing industry. The findings used interpretational analysis to identify patterns of perception and themes that help understand the objective of this study.

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There are so many people to thank for this research and personal academic milestone. I would like to thank my amazing wife, Hannah, and daughter, Evelyn, without their support, patience, and shared sacrifice this would have never been possible. My parents, Duane and Leona Johnson, have always offered love, support, and encouragement that made my goals reachable. I am grateful for the contributions provided by the dissertation committee for their guidance, wisdom, and support, as well as all the people at the University of Wisconsin Stout that joined me on this journey. Thank you to all the participants in this study, who took the time and effort to provide a glimpse into your lives. Thank you for your insightful conversations and the interest you have taken in my academic journey and research.

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Chapter I: Introduction

The average American rarely thinks about manufacturing and the ones that do question whether the U.S. manufacturing industry is "dead or dying" or whether U.S. manufacturing should be or can be saved (NashHoff, 2012). Countries worldwide continue to implement strategic initiatives in pursuit of becoming the world's leading manufacturing country. Germany, Switzerland, Canada, and China are countries leading the way, trying to become the world's manufacturing leader. The German government launched its "Industry 4.0" initiative which is based on its "High Tech 2020" strategy intending to drive digital manufacturing. In Switzerland, the Swiss government has invested in its "Smart Factory" initiative with plans to transform how products are made using smart technologies. Canada has implemented a "Manufacturing our Future" initiative to ensure Canada's manufacturing industry survives and thrives in the future. The Chinese government has put into place the "Made in China 2025" initiative, which sets out to modernize China's industrial capability using intelligent manufacturing and securing itself as the global manufacturing powerhouse of the future. Each initiative is a demonstration of a government's understanding that "throughout history, at the center of any thriving country has been a thriving manufacturing sector." (Trump, 2016, p 1).

"Who says that America cannot lead the world in manufacturing again!" says President Joe Biden (Biden, 2023, p 1). The manufacturing industry has been the driving force in the U.S. economy over the last century. It has been important to the United States economy since the Industrial Revolution changed how families provide for their needs (Kudryashova, 2022). There is no better example of the drive, talent, and strength of the U.S. manufacturing industry than to look at the 13 million strong and growing manufacturing workers (Timmons, 2023, 5:55). They

are the economic engine behind a country that is a beacon for freedom and an example of democracy for the entire world (Timmons, 2023, 6:03).

How vital the manufacturing industry is to the United States becomes clear when a disruption occurs. A disruption is any disturbance that interrupts the norm and forces a change and a reaction that affects the way of life (Merriam-Webster, n.d.). Access to skilled workers, global competition, and natural disasters are examples of disturbances that have disrupted the manufacturing industry for decades. A disruption in manufacturing creates a loss of jobs, a reduction in income, and a loss of a certain lifestyle. As manufacturing plants close, people lose their identity, their expertise and knowledge are lost, and their heritage of being makers and creators, which once defined what manufacturing means to their community, becomes a memory (NashHoff, 2012).

The types and extent of disruptions have increased and impacted all facets of the manufacturing industry (Hantrais & Letablier, 2020). The most significant disruption, due to its impact on the entire world, was the COVID-19 pandemic. The COVID-19 pandemic shook the paradigms of the manufacturing industry, as the disruption of imposed government mandates for the personal safety of the workforce (Auzina-Emsina & Ozulina, 2021) and the sudden disruptions to all areas of supply and demand (Drake, 2021) brought manufacturing to a halt. The addition of new disruptions to past and ongoing challenges in manufacturing, such as increased global competitiveness, lack of a skilled workforce, and a battle for manufacturing dominance, has forced manufacturers to look for solutions on how to survive disruptions and promote sustainability amid sudden change (Tomac et al., 2019).

With no historical event to reference for guidance, U.S. manufacturers were left to determine their own strategies and solutions for dealing with disruptions. Various inventions and

innovations have been promoted to solve the manufacturing industry's issues. "The gaps in innovation, the efficiency of resource utilization, and degree of digitalization have become obvious (solutions), and the task of upgrading and accelerating technological development is urgent" (PRC State Council, (2015). As manufacturers seek to address areas of vulnerability, the value of a high-quality skilled workforce increases. The ability to have a skilled workforce capable of interacting with new technologies will be critical to sustaining the manufacturing industry against future disruptions (Xu et al., 2018). The solutions offered towards sustainability include the use of new technologies, artificial intelligence, automation, robotics, Industry 4.0, and SMART manufacturing (Grace et al., 2018), and questions remain around the reality and reasonableness of their effectiveness for smaller local Midwestern manufacturers.

> Despite everything that is happening, like the threat of an economic recession and global conflict, many U.S. manufacturers are leading the way, and although our country will have to make audacious and sometimes uncomfortable changes to disruption, including economic, political, and global challenges, the state of manufacturing in America remains steadfast and resolute (Timmons, 2023, 7:25).

In remaining steadfast and resolute, a clear understanding of the trends and challenges facing U.S. manufacturers is necessary to devise suitable interventions, strategies, and solutions that will promote the sustainability of the manufacturing industry, work to solve past issues, as well as prepare against future disruptions.

Background of the Problem

The manufacturing industry is a critical component of the world economy. According to the World Trade Organization (2020) in the World Trade Statistical Review, the wealth generated from worldwide trade on the manufacturing and distribution of goods has increased

from $4.8 trillion in 2000 to $12.75 trillion in 2019. China's manufacturing industry accounts for 27% of its domestic output and is nearly 20% of the world's total manufacturing output. U.S. manufacturing accounts for 12% of its domestic output and 18% of the world's output. The manufacturing sector in Japan is responsible for 19% of the country's output and 18% of the world's manufacturing output according to World Trade Organization (2020). China, the United States, and Japan are responsible for nearly half of the world's manufacturing output. The manufacturing industry employs more people than any other sector in the world, providing them with a reliable income and the means to maintain a certain quality of life, improve their local economies, and boost overall economic growth.

The U.S. manufacturing industry is led by states in the upper Midwest region. A statewide comparison shows that Indiana, Michigan, Wisconsin, Ohio, and Minnesota are leading contributors to the manufacturing sector's Gross Domestic Product (GDP), with contributions well above the national average. The upper Midwest states derive nearly 20% of their GDP from the manufacturing industry. The urban areas in Wisconsin and Minnesota and surrounding Midwest states have a commonality. The urban areas provide most of the manufacturing jobs and the highest concentration of people. The rural areas more readily rely on the manufacturing industry for jobs, as nearly a quarter of their population work in the industry (Conroy et al., 2018). While large manufacturing companies get the most attention, most manufacturing companies in the Midwest are small. Most have 50 or fewer employees, and many have less than ten employees. Manufacturing companies with more than 500 employees make up less than 1.5% of companies in Wisconsin, the Midwest, and the broader U.S. (Conroy et al., 2018). Large manufacturing companies are sparse in the Wisconsin and Minnesota areas of the Midwest and provide about half of the manufacturing jobs (Conroy et al., 2018). The

manufacturing industry is essential to these states, the Midwest, and the world, as it affects everyone and every area of life.

A disruption to the manufacturing industry impacts everyone. Leaders across the globe are continually working to protect their citizens and their way of life. For decades the potential for nuclear war, terrorism, and cyber-attacks has led countries to plan and prepare for such attacks, but this time a tiny biological substance shut down the entire planet. The world changed when the World Health Organization (WHO) discovered the COVID-19 virus (Lai et al., 2020).

The COVID-19 pandemic made worse the challenges facing the manufacturers. Governments across the globe imposed "stay-at-home" orders to slow the spread of the virus. The traditional manufacturing of goods crept to a stop and exposed old and new issues in traditional manufacturing (Lai et al., 2020). In a sector that was already struggling to find skilled workers, the increase in government-mandated safety protocols further disrupted the industry. Workers' safety became the focus and top priority (Kapoor et al., 2021). The sudden need to quickly manufacture safety products brought questions on whether the manufacturing industry had the versatility to adapt and meet the new demands. The COVID-19 pandemic disruption exposed vulnerabilities in the manufacturing industry. Supply chain disruptions, changes in consumer demand, localizing manufacturing, alternative work schedules, and employee safety became new issues in debates and discussions (Esmaeili-Najafabadi et al., 2019). Past issues resurfaced as the worker shortage, the skills gap, ever-advancing technologies, and invention and innovation continue to disrupt the manufacturing industry. Such issues and trends have manufacturers evaluating the future of the manufacturing industry and how to become more sustainable against future disruptions.

Manufacturing in the future, as identified in China, Canada, Switzerland, and other world power strategic plans, will include new technology, smart systems, Industry 4.0-5.0, robots, virtual worlds, and automation as the tools used in developing solutions against future disruptions (Cheshmehzangi, 2021). The changes that industry leaders were forecasting in the future are happening now, and manufacturers are forced to adapt to continue operations in a disruptive world (Kapoor et al., 2021). However, local manufacturers' voices have been left out of these discussions.

Statement of the Problem

The COVID-19 pandemic created new challenges in addition to existing ones that need to be clearly identified and addressed to help the industry remain sustainable and competitive in the future.

Problem Statement 1

Although researchers have worked to define the issues facing the manufacturing industry, a clear understanding of the issues from the perspective of local manufacturing leaders is lacking and needed for planning and preparation against future disruptions.

Problem Statement 2

The COVID-19 pandemic exposed vulnerabilities in U.S. manufacturing, such as the overdependence on imports and foreign supply chains (Handfield et al., 2020), the shortages of skilled workers (Deloitte & The Manufacturing Institute, 2020), and the lengthy and costly process of adjusting to ongoing disruptive new technologies. New and emerging technologies with increased innovation could bring sustainability to U.S. manufacturing against future disruptions. However, there is a gap in the literature indicating the reasonableness of these

solutions in application to local manufacturing environments, as local manufacturing leaders have been left out of the conversation.

Problem Statement 3

No historical event provides a comparable guide on moving forward from a disruption of this magnitude. The road map to building resilience against disruptions in manufacturing does not exist. Global perspectives suggest Industry 5.0, smart technology, robotics, artificial intelligence, and automation are possible solutions to these issues, but questions linger on if they are realistic solutions for local manufacturers in the Midwest.

Purpose of the Study

This study aims to gain insight into the challenges faced by the U.S. manufacturing industry in post-COVID-19 pandemic manufacturing from the perspective of manufacturing industry leaders in the Midwest and how they plan to meet them. In addition, this study sought to understand how manufacturers will prepare for future disruptions. The results from this study could inform and guide manufacturers on future planning and preparations for the industry's sustainability against disruptions.

Research Questions

The research questions for this study were designed to gain an understanding from the perspective of U.S. manufacturers on the effects the COVID-19 pandemic had on the manufacturing industry. Each question looks to uncover the challenges and solutions them as seen from Midwest manufacturers.

1. What challenges has the COVID-19 pandemic exposed and created for Midwestern U.S. manufacturers that need to be addressed to be sustainable in the future?

2. What are plausible solutions to the challenges facing Midwestern U.S. manufacturers that may help build resilience against disruptions in the future?
3. The “Smart” or “Intelligent” future of manufacturing is predicted to be happening now, and is their use along with the newest and emerging technologies such as robots, automation, and Industry 4.0 by Midwestern U.S. manufacturers realistic and effective to manage challenges from disruptions in the future?

Significance of the Study

The COVID-19 pandemic was a disruption that brought immediate attention to the challenges in the U.S. manufacturing industry and has permanently changed how the industry will navigate future disruptions. One-half of the manufacturing industry in the Midwest is comprised of small local manufacturers (Conroy et al., 2018). The literature review for this study shows a gap in the research and that the Midwest manufacturers' perspectives are missing. A clear understanding of the challenges facing local manufacturers is necessary to devise suitable interventions against future disruptions that will ensure the sustainability of manufacturing in the future. This study looks to fill in the gaps and gain perspective from the leaders within the manufacturing industry in order to gain insight into the challenges in manufacturing, how they dealt with the challenges, and how their insights can be shared to navigate and provide sustainability for the manufacturing industry against future disruptions.

Assumptions of the Study

The first assumption is that the research represents the views and perspectives of the participants and not the researcher. The goal of the research is to experience the participant's reality as it relates to the research topic because it has been developed through their interactions

in their world. It is assumed that the data collected is based on the participant's experiences, and the meaningfulness of their experience is transferred to the researcher (Santosh, 2021).

Another assumption is that the participants will provide meaningful and truthful perspectives related to their specific places of employment. The participants in this study are in senior-level leadership positions in the manufacturing industry and will provide the honest feedback needed for this research. The assumption for this research is that their perspectives have not been influenced by conversations with other leaders outside of their company.

There is an assumption that each manufacturer deals with similar issues and that multiple perspectives will provide similar themes and issues that can be categorized and referenced. The accuracy of the study will involve verifying themes through the triangulation of multiple manufacturers and their shared experiences (Denzin & Lincoln, 2005).

Limitations of the Study

As with many studies, the current study's design is subject to limitations. The research in this study is new, and there is a limited amount of prior research available. There is limited access to data. The newness of the study requires a look into current literature found online, in blogs, journals, and magazines. These literature sources provide the most recent information that may have been unavailable in prior research.

The manufacturing industry has changed from the COVID-19 pandemic, and it continues to complicate the return to predictable manufacturing. The perspectives of manufacturers may change as new and unforeseen issues arise. The changes in the perspectives may influence how the original formulation of the aims and objectives are interpreted. Manufacturers may perceive things differently as new information becomes available. The aim of the research may be a bit broadly formulated as the needs in manufacturing change quickly. To reduce the influence of

new information and newly discovered changes, the research must focus on addressing the clearly identified problem. The outlying influences that affect the research will open the door for future research.

The time constraint for performing the research is a limitation. The research was performed over a limited time to gather data for this study. The ability to reevaluate and readdress the manufacturers' perspectives would provide a perspective over time that would help overcome the limitations. The relationships and themes revealed by local manufacturers may not be in direct alignment with manufacturing worldwide. The foreseeable needs and how the future of manufacturing in the U.S. will look post-COVID-19 pandemic may vary by geographical location.

The research sample size and selection may be a limitation of the study. The sample size is from the manufacturing industry in the Upper Midwest. The sample is drawn from manufacturers that employ up to 100 employees. The manufacturers in Northern Wisconsin and Minnesota are representative of the Midwest but may be limited in their adaptability to the world.

In the essence of completing the research in a timely manner, the sample was taken from manufacturing leaders that have been working with the researcher over the past decade (Robinson, 2014). The professional led to some personal friendships with the participants and provided the researcher with timely access to data for the research. The relationships are a limitation. The manufacturers used for this study provide opportunities for comparisons and applicability of the research between manufacturers across the Midwest and worldwide.

Definition of Terms

The following terms and definitions are given to provide a better understanding of the concepts and issues that will be discussed throughout the study.

COVID-19 Pandemic

COVID-19 is the “Severe Acute Respiratory Syndrome Coronavirus Type 2” (SARS-CoV-2) infectious agent responsible for the “Coronavirus Disease 2019” (Tao et al., 2022). The COVID-19 virus quickly spread across the globe becoming a worldwide pandemic.

Disruption

Disruption is a disturbance or problem that interrupts an event, activity, or process (Merriam-Webster, n.d.). Any issue or event that interrupts the production, sale, or distribution of products and radically changes the way all companies in that industry operate (Sako, 2022).

Goods

Goods are the physical objects that are found, grown, or produced to meet people’s needs and wants (Little & Willliam, 2016).

Heartland

Heartland is the most important part of the nation, an area where a particular industry is of utmost importance and is the driving center of the nation’s success (Cambridge Dictionary, 2023).

Industry 4.0

Industry 4.0 is a new phase in the industrial revolution that focuses on interconnectivity, automation, machine learning, and real-time data is now available for manufacturers. Industry 4.0 is the digitalization of the manufacturing industry that fully encompasses the Internet of

Things (IoT) and smart manufacturing to provide a better-connected ecosystem for manufacturers. **(**The fourth industrial revolution; Nikolic et al., 2017).

Industry 5.0

Industry 5.0 is Industry 4.0 with the addition of the human touch. It is people working alongside robots and smart machines. A collaboration of the cognitive computing capabilities of the digitalization of manufacturing, smart technologies, and processes, with human intelligence and resourcefulness (Formosa, 2021).

Industry Internet of Things

Industry Internet of Things (IIoT) refers to the IoT concepts used in industrial applications and environments. The IIoT is used to improve manufacturing procedures and processes by integrating sustainable and efficient “smart” technologies in an industrial environment (Al-Fuqaha et al., 2015).

Innovation

Innovation is the step-by-step process in which an existing product, process, or idea is further developed. Innovation involves improving product functionality and design changes to increase and improve the marketability of the product, process, or idea (Johnson, 2011).

Internet of Things

In an Internet-enabled era, mobile applications and devices are continually sharing information across IoT networks. The IoT is the thousands of connections between common objects and the internet. It is the seamless connectivity among “smart” devices that collect information from the surrounding environments, process the data, and performs the desired activities (Sisinni et al., 2018).

Invention

Invention is the creation of new products or processes, which may be derived from previous products or processes with new and sufficient changes. Invention explores the limits of possibility, with uncertain and unknown outcomes (Johnson, 2011).

Manufacturing

Manufacturing is the production process in converting raw materials, parts, and components into finished goods using physical and economic resources including tools, equipment, machinery, and human labor, as well as “Smart” technology, robots, and computers (Khoo & Hock, 2020).

Manufacturing Workforce

Manufacturing workforce is a group of highly educated people that can learn and develop the skills needed to perform complicated tasks, quickly make decisions, and adapt to changes in a specific manufacturing environment (Institute of Labour Science and Affairs, 2014).

Midwest

As defined by the federal government, the Midwest comprises the states of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin (Encyclopedia Britannica, 2021).

COVID-19 pandemic

A COVID-19 pandemic is an epidemic occurring worldwide, crossing international boundaries usually affecting or influencing many people (Last, 2001).

Rust Belt

The term “Rust Belt” refers to what once served as the hub of American Industry. Located in the Great Lakes region, the Rust Belt covers much of the American Midwest (map).

Also known as the “Industrial Heartland of North America”, the Great Lakes and nearby Appalachia were utilized for transportation and natural resources (Mahaney, 2010).

Supply Chain

A supply chain is a set of three or more entities, organizations, or individuals directly involved in the upstream and downstream flows of products, services, and information from the source to the customer (Mentzer et al., 2001).

Virtual Environments

Virtual environments provide an experience for a user to experience an environment other than the one they are actually in. The experience is a sensory experience in which users are role-playing as they interact within a fully developed and customized environment. Virtual environments are created using digital virtual and augmented realities and devices (Schroeder, 2008).

Upskilling

Upskilling are new skills and technologies that are being introduced into manufacturing at a rapid pace. Employees need to be lifelong learners, moldable, retrainable, and reskilled for the next position. Upskilling employees provides them with the opportunity to improve, learn, and develop the skills they will need to participate in the future workplace (Li, 2020).

Chapter II: Literature Review

The purpose of this study is to gain insight into the challenges that the U.S. manufacturing industry is facing in post-COVID-19 pandemic manufacturing from the perspective of midwestern manufacturing industry leaders and how they plan to meet the challenges. Studies have revealed that despite having dealt with past disruptions the ability of local manufacturers to sustain and survive future disruptions remains. This study examines the issues facing the manufacturing industry moving forward in the post-COVID-19 pandemic era and the solutions for sustainability and survival against disruptions in the future. The review of the literature will provide support for the study and its research methodology.

Industrial Manufacturing Defined

The United States Bureau of Labor Statistics (2022) defines manufacturing as the transformation of raw materials, substances, and components into new products. The NAIC and IBISWorld Industry Market Research (2021) includes in their definition the operators who are engaged in the transformation of raw inputs into new products using mechanical, physical, or chemical processes, as well as the assembling of component parts into new complex goods. Manufacturing is the process of converting raw materials into usable goods to generate wealth and produce value for the industry (Khoo & Hock, 2020). The manufacturing industry is a complex system for generating wealth, influenced by consumer demands, supply chains, and revenue streams, and valued on the efficiency with which a company can convert the costs of production into the delivery of finished goods (Manyika, et al., 2017).

The Industrial Revolution ushered in the mass production of goods, the assembly line, and the use of mechanization and machines to manufacture large quantities of goods at a lower cost. It changed the nature of work and how people provided for their families. Many workers

left their farms, moved to cities, and took jobs in factories where they helped produce all types of goods. Towns across the U.S. embraced the manufacturing industry. The workforce took pride in their work, felt called to their job, and often referred to it as their calling in life (Bunderson & Thompson, 2009). Employees viewed their work as meaningful and important, regardless of how unpleasant the jobs and working environment could be (Thompson & Christensen, 2018).

Over the past four decades, the Industrial Heartland has changed. At one time the industrial heartland was the most important part of the nation, an area where a particular industry was of utmost importance, and the center of the nation's success (Cambridge Dictionary, 2023). The rural communities, small towns, and cities throughout the Midwest have suffered from the deindustrialization and disinvestment of manufacturing. The once vibrant heartland built on industrial manufacturing is now full of deteriorating factories, empty parking lots, dilapidated housing, and vacant lots acting as reminders of how important manufacturing is to the U.S. economy and its citizens (Russo & Linkon, 2009).

Manufacturing Matters

> Manufacturing is the main pillar of the national economy, the foundation of the country, a tool of transformation, and a basis of prosperity. Since the beginning of industrial civilization, it has been proven repeatedly by the rise and fall of world powers that without strong manufacturing, there is no national prosperity. Building internationally competitive manufacturing is the only way to enhance its strength, protect state security and become a world power… the manufacturing sector has maintained rapid development and has built an industrial system that is both comprehensive and independent. It has greatly supported industrialization and modernization and

> significantly improved the country's overall strength. It has supported the country's position as a world power (PRC State Council, 2015, p. 2).

Manufacturing plays an integral role in the U.S. economy and the opportunities it provides for citizens to achieve and sustain the socioeconomic level to which they have grown accustomed. The economic goal of a country is to increase wealth and improve the overall standard of living for its citizens. Manufacturers are continuously working to improve the efficiency in the development of their products and effectively meet consumer demands, all the while providing citizens with opportunities to earn higher incomes and improve their standard of living. The standard of living is important because it is determined by the level of wealth people possess and how easily they can access their wealth. It varies on the availability of necessities, comforts, goods, and services needed to maintain socioeconomic classes (Kudryashova, 2022). The standard of living is based on the actual costs of goods and services associated with living and the rate and efficiency at which goods and services are consumed (Hoffer, 1929). Poverty rates, access to quality healthcare, and unemployment are indicators of levels of standards of living (Falcettoni &Nygaard, 2020). Improvement in any of these areas will improve the standard of living.

The ability of a country to provide sustainable economic growth increases the average household income, lowers poverty rates, and improves the standard of living (Kudryashova, 2022). The Gross Domestic Product (GDP) is the market value of all goods and services produced within a country’s borders over a specific period. The overall domestic production of a country can be used as a comprehensive evaluation of a country’s economic health. To calculate per capita GDP, the average income per person, the GDP is divided by the country’s population. The increase in average income and increased GDP are signs of positive economic health. The

GDP is used to measure and compare the standard of living in different countries and is a valuable tool for comparing the health of their economies. Countries with higher GDP tend to have higher household incomes, lower poverty rates, and better economic health.

Countries can raise their standard of living and increase their society's wealth by increasing the value of their dollar and the purchasing power of that dollar. The number of goods and services that one unit of their money can buy is purchasing power. Countries increase purchasing power through innovation and invention, increasing productivity, and creating new value. The manufacturing industry raises the standard of living more than any other sector (Gold, 2016). The President and CEO of the Manufacturers Alliance for Productivity and Innovation (MAPI) Stephen Gold (2016) proposes that a strong manufacturing base leads to the creation of new value through research and development, innovation, productivity, and the addition of more jobs.

A strong U.S. manufacturing base provides sustainability and stability for the U.S. economy. For every dollar of domestic manufacturing added to the U.S. economy, another $3.60 of activity is generated elsewhere in the economy. For every manufacturing job in the U.S., three to four jobs are created in nonmanufacturing industries (Gold, 2016). The U.S. Census Bureau (2021) estimates that 61% of export dollars come from manufacturing goods, making it a 902-billion-dollar industry. The County Business Patterns, a branch of the U.S. Census Bureau (2021), has identified the manufacturing industry as the fifth largest employer in the U.S., employing 11.9 million workers. The real impact of manufacturing becomes clear when one multiplies 11.9 million jobs by three to four to get the real number of jobs the manufacturing industry creates (Gold, 2016). Thus, the manufacturing industry plays a critical role in the U.S.

through its ability to create jobs, increase wages, create wealth, and raise the standard of living through increased productivity and strong economic growth.

Societal Disruption and the Manufacturing Community

The COVID-19 pandemic upended every aspect of American life, costing thousands of jobs, and reintroducing decades-old issues that continue to disrupt the industry (Drake, 2021). The COVID-19 pandemic caused U.S. manufacturers to deeply investigate the strategic organization and operations of their companies. It is the largest disruption in manufacturing since the end of World War II (Okorie et al., 2020). Government officials and U.S. government policymakers mandated stay-at-home orders. Manufacturers were forced to reorganize and redesign the workplace to meet new safety policies. Remote working environments, social distancing requirements, and innovative workspace designs were implemented by manufacturers to provide safe working environments for their workers. Workers were required to wear masks as part of the Personal Protective Equipment (PPE) requirements, and new cleaning practices were implemented in every aspect of the industry (Garlick et al. 2020). The disruption caused by the new requirements hindered production, reduced product output, and caused inefficiencies throughout the production process (Meenakshi & Neha, 2020). The disruption affected everything and everyone.

Understanding Disruption

Understanding disruption is the key to reducing its effect on its environment. Disruption occurs when something unexpected happens. The unthinkable something has happened and is forcing a response or reaction. The disruption can come from anywhere: technological, political, economic, or social arenas. The need to understand disruption is crucial to navigating through them.

Disruption is not new to the world, and the events turning into COVID-19 pandemics seem to be increasing (Badkar & Greeley, 2020). The world has experienced disruptions caused by natural disasters, wars, elections, and other events. In the 21st century alone, natural disasters such as the 2003 European heat wave, the 2004 Indian Ocean Tsunami, the 2011 Japan earthquake and tsunami, and the 2005 Hurricane Katrina in the United States have caused and continue to cause disruption. War has been causing disruption for thousands of years. War upends every aspect of life. The 21st century has had its share of wars. The 2022 Ukraine-Russia War, the 2021 Israel-Palestine crisis, and the war in Afghanistan (2001-2014) are three of the many wars that have caused and are causing disruption. The Ukraine war is causing political unrest between countries across the world. Political unrest has created disruption through political party changeovers, through changes in trade and investment agreements, and through political leaders maneuvering to gain leverage and control of local and world markets.

Global trade has caused worldwide disruptions to the manufacturing industry for decades. The competition over supply and demand issues between countries is in constant flux. Trade wars and agreements create tensions across countries around the world. Trade wars have created tension between China and the United States (Okorie et al., 2020). U.S. manufacturers began moving their companies out of China long before the COVID-19 pandemic and have created logistical issues in the supply chain concerning the importing of manufactured goods to the U.S. (Cai & Luo, 2020).

Disruptions are often associated with negative events, but present opportunities for positive change (Doern, 2016). Disruptive technologies are often cheaper, simpler, smaller, and better utilized in new markets (Musandiwa & Ngwakwe, 2020). New technology continues to change how society operates, how people work, and how people play. Invention and innovation

are constantly creating disruption. Henry Ford used invention, innovation, and new technology to disrupt the manufacturing and travel industries (Tomac et al., 2019). The manufacturing industry is still changing today. New technology continues to improve, change, and disrupt the manufacturing process, the job market, and the skills workers will need to possess to do their jobs. Computers, networking, and automation are disrupting every aspect of life, as they are implemented to improve and make life easier and more efficient.

"Disruptions are extreme, unexpected, and unpredictable events that require an urgent response." (Doern et al., 2019, p 401.) Disruptions take on many forms, can be good or bad, and provide the opportunity for positive and negative solutions and outcomes. The need to understand the disruption and the uniqueness of the disruption is crucial to navigating through them, especially in cases that have never been seen before.

The COVID-19 pandemic

There is no disruption in history that shut down the entire world like COVID-19. The "Severe Acute Respiratory Syndrome Coronavirus Type 2" (SARS-CoV-2) is the infectious agent responsible for the "Coronavirus Disease 2019" (Tao et al., 2022). The COVID-19 virus spread quickly across the entire world and became a global COVID-19 pandemic. The highly infectious transfer rate of the virus overwhelmed the world and led to an unprecedented shortage of resources. The world has experienced past disruptions, but none compared to what the world experienced due to the COVID-19 virus. The COVID-19 pandemic created a disruption of unprecedented size in the manufacturing industry. Every sector was affected due to the sheer number of people infected by COVID-19. Traditional methods of manufacturing struggled to keep up with the sudden demand for resources. PPE, vaccines, and other manufactured devices were suddenly needed to contain the virus and keep people alive, and there was no way to get

them (Manero et al., 2020). The COVID-19 pandemic created the greatest worldwide disruption of this lifetime, affecting everyone, all manufacturers, retailers, and suppliers across the globe (Lai et al., 2020).

The Global Supply Chain

The ability to sustain trends built on global trade and open economies remains a central issue to economic growth and recovery from the COVID-19 pandemic. Countries with open economies that provide access to free trade and movement of capital resources tend to hold down inflation and boost purchasing power over countries with closed economies, thus resulting in higher economic and productivity growth.

The disruptions affecting the global economy can be traced back to events within the supply chains (Handfield et al., 2020). Manufacturers spend thousands of dollars forecasting and calculating the availability of the supplies and the efficiency within the supply chain to get them (Kontuš & Mihanović, 2019). Supply chains provide the resources needed to continue making products. A disruption in the supply chain affects the ability of manufacturers to get the materials they need for production, the parts needed to fix the machines, and the resources needed to manufacture and distribute goods (Grzybowska & Stachowiak, 2022).

The cost is too great for manufacturing to come to a halt (Matos et al., 2020). The supply chain disruptions led to the development of a touchless society and simultaneously caused disturbances in supply, demand, revenue, and productivity (Esmaeili-Najafabadi et al., 2019). The COVID-19 pandemic caused a major shift in consumer demand creating massive disruptions to supply chains. There was a sudden and massive need for certain goods and an inability to produce and deliver them. An increase in canceled orders, poor revenues, and a falling stock market pushed the manufacturing sector into its own COVID-19 pandemic (Handfield et al.,

2020). The disruption was further compounded by the government-mandated shutdown of facilities, social distancing, and increased production costs that were creating panic in an industry already reeling from supply and demand issues and economic uncertainty (Khoo & Hock, 2020).

The Wuhan region of China provides the materials and supplies that nearly 5 million businesses rely on, and around 94% of the top companies in the world have experienced supply-chain disruptions due to the COVID-19 pandemic (Ivanonv, 2020). The COVID-19 pandemic brought out the vulnerability with having a single supply chain. There are only a few countries that produce the computer chips needed for manufacturing computers, and the lead time to manufacture the computer chips is over twenty-six weeks and increasing (Matos et al., 2020). These chips are used in everything from automobiles to handheld computing devices. The only access to these chips is through a single supply chain. The increasing demand for computer chips and the COVID-19 pandemic halting production of them created a worldwide disruption in the production of these goods. Manufacturing came to a standstill on any product needing a computer chip. The exposed weaknesses within the current supply chain forced manufacturers and distributors to review their supply chains in the future. With the increasing shortage of parts, manufacturers are working to find alternative suppliers and supply chains to make up for the shortages (Matos et al., 2020). Supply chain disruptions continue to influence manufacturing around the world, with every country feeling the effects of supply chain issues.

The U.S. Supply-Chain Disruption

The COVID-19 disruption has pushed U.S. manufacturers to reduce their reliance on the global supply chain and turn to local suppliers to meet demand. The COVID-19 pandemic forced the isolation of countries through the closing of borders causing manufacturers to have to adjust

to meet consumer demands (Belhouideg, 2020). U.S. manufacturers have typically found ways to survive disruptions. The COVID-19 pandemic has changed how companies compete, where they compete, and the tools that they use to compete. The supply chains are changing to improve resilience in U.S. manufacturing (Cai & Luo, 2020).

U.S. manufacturing's dependence on China for their supply chains became an issue. China's inability to deliver the products has become a growing trend and has caused major disruption in U.S. manufacturing. The interruption in the supply chain forced U.S. manufacturing facilities to run at partial or limited capacity and revealed the need for established backup contingencies (Esmaeili-Najafabadi et al., 2019). The COVID-19 pandemic brought about an awareness of the need to manufacture more products within the U.S. and has gained support from community leaders to bring manufacturing back to the United States (Remko, 2020). Bringing manufacturing back to the United States is a difficult process. Many manufacturing companies have their supply chains fixed in foreign regions, with international leaders suggesting that they will never allow them to return to Western countries (Handfield et al., 2020).

Manufacturers are looking to improve industry response against the next COVID-19 pandemic ((Lai et al., 2020)). Building resilience by improving supply chains has gained a lot of attention. (Kumar & Managi, 2020). U.S. government officials and policymakers have called for enhancing the management of supply chains to reduce the impact of a disruption (Cai & Luo, 2020). U.S. manufacturers have maintained single supply chains because it was the most profitable and cost-effective way to get the supplies needed in the development of their products (Shi & Ni, 2021). Manufacturers need to be intentional in creating multiple supply chains to avoid supply issues that can occur from having a single source (Namdar et. al., 2017). Building

resilience within supply chains will improve the sustainability of U.S. manufacturing in the future, reducing the probability of another COVID-19 pandemic upending American life in the future.

Current Trends in Manufacturing

Manufacturing in the U.S. came to a complete halt as the COVID-19 pandemic shut down the entire industry, causing a disruption unlike any other seen in this lifetime (Lai et al., 2020). Workers were mandated to stay at home. Unemployment rates skyrocketed. Supply chains were completely disrupted. Consumer demands changed and manufacturers were unable to manufacture products needed worldwide. Fear and uncertainty gripped the entire world and left the manufacturing industry wondering how to move forward in a post-COVID-19 pandemic era. The manufacturing industry is building back fast seemingly undeterred by the turbulence from the COVID-19 pandemic. Current trends in manufacturing focus on improving the workforce, innovation and invention in manufacturing, and preparedness toward future disruption.

The Manufacturing Workforce

There was a time in history in which every product was hand-made, one-of-a-kind, and made one at a time. Production was slow and costly. The finished product was expensive to purchase. Manufacturing provided the ability to produce products at a high rate. The introduction of factories, assembly lines, sewing machines, steam power, and the adaptations of raw materials influenced new manufacturing trends. History is quick to acknowledge key individuals who were responsible for advances in manufacturing. The inventors, engineers, and titans who built the industry are easily identified in history, but manufacturing is what it is today because of the millions of workers who labored in the mills, factories, and mines. The shortage of workers has

been a challenge in the manufacturing industry for decades (Harris et al., 2020), with currently more than 650,000 job openings in the U.S. (Brett, 2022).

The Aging Workforce. The labor shortage is amplified by an aging workforce (Harris et al., 2020). The number of Americans over the age of 60 will increase by 70% by 2025. The challenge of addressing an aging workforce is how to accommodate them. It is fundamental to know the characteristics of older workers and what needs to be done to properly support and guide them in performing their tasks (Strasser, 2018). The prolonged shortage of skilled workers supports the development of human capital. Preparing workers as human capital requires reinventing a manufacturing system to enable employees to perform the manual and mental tasks needed for the job. The recruitment, training, and retraining of an aging workforce will require flexible work practices, intentional job design, and an adjustment of attitudes toward aging workers (Bogataj et al., 2019). The aging workforce will continue to alter consumer demand as the shift to meet the growing medical needs to accommodate healthy seniors continues. The global economy will become centered around issues dealing with the health of an aging generation (Burk, 2015).

The Quitting Workforce: "The Great Resignation". In 2021, a strong labor market showed signs of recovery, but employers were having difficulty finding workers. Employers began increasing wages, adding bonuses, and other incentives to attract employees, but the number of people quitting or changing jobs continued to increase. According to the U.S. Bureau of Labor Statistics (2022), more than 4.3 million people quit or changed jobs in December of 2021. The number of people quitting or changing jobs has been termed "The Great Resignation."

The Bureau of Labor Statistics Job Opening and Labor Turnover Survey program began in December of 2000 and monitors the rate at which employees are leaving their jobs. In January

of 2001, Job Opening Labor Turnover Survey reported the quit rate in the United States was 2.4%. This is about the same as the 2.5% quit rate in March of 2021. The quit rate quickly rose to 3% in November 2021.

The great resignation is not a new issue. In October 2009, following the U.S. economy crash of 2008, the resignation rate was at 3.5 %, lower than the quit rates in the 1960s and 1970s (Gittleman, 2022). The great resignation has influenced every decade and has once again surfaced, as the %age of workers leaving their jobs increased to a twenty-year high (Parker & Horowitz, 2022). The explanations for the most recent resignations are contributed to COVID-19 pandemic-related issues such as stimulus payments, health concerns, childcare issues, and changing attitudes toward work (Tessema et al., 2022). The issue is human capital. The top reasons U.S. workers have left their job in 2021 were low pay, lack of opportunity for advancement, and how they felt about their workplace (Parker & Horowitz, 2022). An organization's approach to these issues reflects how they value its people, and what they are willing to do to invest in its workforce as human capital.

The Manufacturing Workforce "Skills Gap". The skills gap is an issue that has been greatly exemplified due to the COVID-19 pandemic. The skills gap is a significant gap between an employee's current abilities and the skills the company needs the employees to have to achieve its goals (Wingard & Farrugia, 2021). Sustainability for an organization becomes an issue when it can no longer grow or remain competitive because it is unable to fill critical jobs with employees who have the right knowledge, skills, and abilities (Li, 2020). The skills gap is causing major disruption in the manufacturing industry. The skills gap continues to widen with little end in sight (Deloitte & The Manufacturing Institute, 2020). There are not enough people with the skills needed to fill these positions (Fenlon & Fitzgerald, 2019).

The COVID-19 pandemic disrupted the education and training sector affecting close to 1.6 billion students worldwide (Lee et. al., 2021). The COVID-19 pandemic hindered the skilled training of all workers. The technical and trades colleges and apprenticeships were challenged with the delivery of practical training in distance learning environments (Li, 2020). Practice is a critical dimension in skills training. The work-based learning component in which trainees participate in practical training through apprenticeships and labs came to a halt. The disruption from the lockdowns imposed a partial or total closure of many work-based learning opportunities (Lee et. al., 2021).

The "Skills Gap" Myth. There are some people who believe that the skills gap does not exist and is just a myth. The skills gap denier believes that the gap in employee skills is the result of high unemployment rates rather than its cause (Hyslop-Margison & Welsh, 2001). The inability of people to find jobs is about the lack of good-paying jobs and less about the mismatch of skills (Mishel et al., 2014). There is a lack of evidence supporting employee skills shortages and the real challenge is the inability to knit together the supply skills with demand skills in the labor market (Weaver & Osterman, 2016). People have been unable to find work because they lack the specific credentials required to do the job (Yglesias, 2019). The skills gap is nothing more than a way of shifting attention away from companies earning major profits and bonuses, and less about sharing the wealth with employees and investing in highly skilled employees (Krugman, 2014). The world has plenty of workers who possess the skills needed to perform the required task, yet employers are selective about what skills they want their employees to possess. Employers demand lots of experience and educational credentials rather than investing in training workers (Yglesias, 2019). Employers have offered six-figure signing bonuses and flexibility in work schedules to attract talent in a tight labor market (Loten, 2019), yet knowing

that the credential requirements they are requesting may not exist. This allows them to look elsewhere for employees. Millions of jobs are not lower skills positions but are highly credentialed positions (Loten, 2019). The skills gap deniers point to the increasing use of H-1B programs to fill jobs in the manufacturing workforce. The H-1B workers are replacing skilled American workers at a much lower cost to the company (Malkin & Miano, 2016). The skills gap believer and denier must acknowledge the statistics that show over 7 million manufacturing jobs remain open and the inability to fill these positions remains (Paul, 2020).

The Manufacturing Jobs Image Problem. Stanley Black & Decker is the world's largest tool manufacturer with nearly 50 manufacturing facilities across America, performed an in-depth research study examining the shortage of workers in careers in manufacturing (Brett, 2022). The CEO of Stanley Black & Decker, Jim Loree, referred to the shortage of workers as a problem that has existed long before the COVID-19 pandemic and is certainly being made worse by it. The study found that young people are not seriously considering jobs in the trade with less than 16% of responding youth considering a skilled trade career (Brett, 2022).

A Stanley Black & Decker study revealed that students have a lack of exposure to manufacturing careers (Brett, 2022). Manufacturing jobs have an image problem. They are considered dirty jobs that nobody wants. This is a trend stemming from the prior generations of parents and grandparents who desired to have their children partake in different working environments than they worked in (Bragazzi et al., 2020). They sought to improve the next generation's standard of living through careers that focused on education and offer better working environments. The pathway to a better working environment was through a strong education. The U.S. education system encourages high school graduates to pursue college after high school, as college degrees have been associated with a higher class. Further stereotypes

have labeled young people who do not go to college as “failures” (Fiori, 2003), and a “failure” in the family interrupts socioeconomic status. The appearance that goes along with a specific social class creates an image problem. Jobs in the manufacturing industry are viewed as dirty work. Dirty work refers to tasks and occupations that are viewed as disgusting, distasteful, or degrading (Deery et al., 2019) and jobs that nobody wants to do. Mike Rowe, an actor, who is an advocate for careers in the trades and has a television show named, “Dirty Jobs,” which is complete with disgusting, distasteful, and degrading “dirty work” (Deery et al., 2019). Rowe has experienced the shortage of qualified workers firsthand, as he travels around working these jobs. The image surrounding these careers is that the jobs are dirty, located in non-desirable working environments, and meant for the lower socioeconomic class. An emphasis on a college degree has been encouraged by parents and educators to help maintain social status, with minimal information provided to students about careers in manufacturing. The Stanley Black & Decker study shows that 37% of students surveyed have never had a conversation about careers in manufacturing. The dirty jobs perspective of a career in manufacturing has led to a lack of exposure to careers in manufacturing. The image problem and lack of exposure to careers in manufacturing have led to people being unaware that these jobs exist, and what they have to offer.

Manufacturing in a Global Economy

The global market has been disruptive for decades. The competition and demand for supplies between countries fluctuate as the demand from each country changes. The trade wars between U.S. and China have created tension between countries across the world (Okorie et al., 2020). U.S. manufacturers began pulling companies out of China long before the COVID- 19 pandemic began and have created logistical issues in the supply chain concerning the import of

manufactured goods (Cai & Luo, 2020). Each challenge has substantially grown because of the COVID-19 pandemic and is increasingly disrupting the manufacturing industry.

Reaction to Disruption in Manufacturing

Manufacturers have been slow to learn from past disruptions and remain ill-prepared for the challenges of future disruptions (Handfeld et al., 2020). Their response to disruption has been reactive and not proactive (Sacco et. al., 2021). As the COVID-19 pandemic swept across the globe, industry leaders were forced into determining how to keep people safe while keeping essential businesses operating. The COVID-19 pandemic was a new phenomenon unlike anything that has been seen before (Kim, 2021). The speed at which the virus was transmitted and the number of people it affected infiltrated every aspect of life (Silva, 2020). The COVID-19 pandemic proved that waiting at the finish line for a successful vaccine was inefficient, disruptive, and costly. Doctors and government leaders have a renewed focus on being proactive against the next potential COVID-19 pandemic and are using the knowledge and expertise learned from the COVID-19 pandemic to plan for new challenges or the next COVID-19 pandemic (Silva, 2020).

There have been numerous studies addressing the safety challenges created during the COVID-19 pandemic (Kim, 2021). Researchers are examining all aspects of the COVID-19 pandemic, including the restrictions, limitations, policies, direct effects, secondary effects, and the impacts that the COVID-19 pandemic had on providing safe working environments across the country. Government policies and mandatory safety measures have had a notable impact on the manufacturing industry and the economy (Auzina-Emsina & Ozolina, 2021). The COVID-19 pandemic forced manufacturers into short-term fixes to keep their employees safe. Manufacturers were introduced to social distancing, masking, and remote work schedules. These

protocols were complex and costly but were needed as manufacturers reacted to the COVID-19 pandemic. The research and development that was done to slow and stop the spread of the virus were rushed and quickly implemented to meet the instant need for individual safety. The quick reactions from testing the blood draw, invasive procedures, and forced flexibility were costly and unsustainable to maintain post-COVID-19 pandemic (Click, 2020).

Product-To-Service Manufacturing

Manufacturers have moved from being product-centered to a service-centered industry (Kianto & Andreeva, 2014). The shift is due to the sudden change in consumer demand during the COVID-19 pandemic. The COVID-19 pandemic forced manufacturers to choose between continuing to increase production and keeping with maintaining competitiveness in a global market or changing their business model to meet the immediate, complex needs, and expectations of the consumer. The ability to adapt and change the manufacturing process is a costly and difficult process and is highly influential on profits.

Consumer demands are influencing the change to a service-oriented U.S. manufacturing industry. Consumers are interested in what a product does for them and less about the product itself. They are willing to pay for a service rather than purchase the product. For example, people will purchase an Uber service instead of buying an automobile. A company with a product-centered focus works towards developing a superior product by improving processes and efficiency, while a service-centered company focuses on meeting the immediate needs of the customer (Kianto & Andreeva, 2014), at a much lower cost. Product-centered companies have traditionally focused on the materials and processes to efficiently create new products in the most cost-effective way. Past strategies in manufacturing have focused on the product and the lean manufacturing strategies used to reduce costs in production.

The shutdowns created uncertainty with consumer demand and manufacturers had to rely on becoming service centered to compensate for the disruption in production (Rapaccini et al., 2020). Strategies in the future will focus on improving the quality of the consumer's experience with the product and the service the product provides. Consumer demand is moving the manufacturing industry away from being centered on product development and towards an integrated product-service model, a combination of physical goods and services.

Social Distancing, Remote Work, and Mandatory Shutdowns

The COVID-19 pandemic brought about the need for an integrated product-service model, and a focus on safety. The COVID-19 pandemic was a new phenomenon unlike anything that has been seen before (Kim, 2021). The speed at which the virus was transmitted, and the number of people affected infiltrated every aspect of life. The workplace became a focus and concern for worker safety. The response to the COVID-19 pandemic stemmed from government policy and mandatory shutdowns which had a notable impact on the manufacturing industry and the economy (Auzina-Emsina & Ozolina, 2021). The COVID-19 pandemic forced manufacturers to determine how they were going to keep their employees safe while keeping their companies operating. This was a difficult task as there is no historic event throughout history to reference for direction on how to move forward. The COVID-19 pandemic pushed the boundaries for safety to new levels, expanding beyond the traditional procedures for safe working spaces and machine tool safety, and included multiple levels for keeping employees safe (Chenani et al., 2021). The immediate response involved mandating social distancing, masking, and working remotely. The limitations associated with social distancing, masking, and remote work required manufacturers to implement changes to their physical working environments (Juergensen et. al., 2020). Changing the physical space for maintaining production is difficult as it is costly and

creates issues with sustainability. The implementation of the remote working environment became an issue as it occurred too quickly and created a new way people approached work (Rapaccini et. al., 2020). Workers preferred to stay working remotely, which added to the issue of an industry still reeling to find workers.

The manufacturing environment in the future will be designed with the safety of employees in mind. Social distancing, remote working conditions, and a safe working environment will become fundamental criteria for manufacturing companies in the future (Kapoor et al., 2021).

The Future of Manufacturing

Manufacturers remain focused on globalization, financial growth, and the resources used to produce goods and services. Globalization and financial growth are considered the main contributing factors to economic growth and development (Pelinescu, 2015). Manufacturing is the process of turning raw materials into finished products using human resources, materials and processes, machine technologies, system technologies, and environmental and societal technologies (Panagiotopoulou et al., 2022). The COVID-19 pandemic accelerated the issue of manufacturers needing to investigate how to remain sustainable in the future. Improvements to any of these areas increase the survival and sustainability of the industry. Improvements in human capital, invention and innovation, machine technologies, and systems are being implemented to increase sustainability in a post-COVID-19 pandemic world.

Humans as Resources

In a world dominated by information, data, and advancing technology, people are the most valuable resource to an organization (Pasban & Nojedeh, 2016). People accumulate knowledge, learn from experiences, and can develop skills over a lifetime. People create the

culture within the organization. Organizational culture is a combination of shared history, expectations, unwritten rules, and customs that influence people's workforce behavior (Kianto & Andreeva, 2014). Employers that recognize their role in helping individuals continuously upgrade their skills, raise their income, and improve their records of success continually create value for their organization (Pasban & Nojedeh, 2016). People provide value as human capital to the organization.

Human capital has a complicated role in manufacturing. Human capital is an intrinsic talent with the ability to mold, moderate, and change (Ozyilmaz, 2020). A person is a collection of features and living traditions, with different levels of creativity and energy, that they bring and can invest in their work. Human capital is the collective knowledge, attributes, skills, experiences, and health of the people who make up the workforce. (Madgavkar et at., 2022). The acquisition of human capital affects the efficiency of the work being done, the level of engagement of employees with their work, and their overall performance in the workplace (Ozyilmaz, 2020).

Employers investing in training and skills related to job performance and engagement are increasing the value of the organization. Investing in human capital improves the cognitive ability and attentiveness of the workforce, which improves performance (Harris et al., 2015). Increasing and improving the collective body of knowledge, technical skills, creativity, and experiences of the workforce will strengthen and improve the organization (Hendricks, 2002).

The urgency of increasing human capital in the workplace is on the rise (Pelinescu, 2019). Human capital has value in increasing the GDP and has brought about the concept of a knowledge-based economy. A knowledge-based economy is based on the use of knowledge and information in production and distribution (Ozyilmaz, 2020). The knowledge-based concept uses

the literacy of people to generate new content, products, and services. A knowledge-based economy recognizes the role of innovation in the economic development of intellectual capital with a focus on the development of human capital (Ozyilmaz, 2020). The COVID-19 pandemic exposed the need for the development of people, as human capital, to provide sustainability to the manufacturing industry. Improving human capital in manufacturing is the main factor in the economic growth and development and sustainability of the industry in the future (Pelinescu, 2019).

Invention in Manufacturing

Invention is the process of creating something that has never been made before (Cambridge Dictionary, 2022). Invention is something entirely new or something that has never been accomplished before (Herbert, 2022). The United States is a world leader in the invention of new products. Transistors, color televisions, and video recorders were all invented in the U.S. Inventors are celebrated for their newest ideas and are continually searching for the next breakthrough idea. They are constantly looking for the “aha moment” that is going to help solve the next problem. The United States favors a manufacturing process that gets the product to the consumer as quickly as possible and rectifies any flaws along the way. Other industrial countries tend toward a slow and steady pace for improvement, and work to rectify any flaws along the way. In comparison to other industrial countries, U.S.-made products have nearly double the defects. Japan spends nearly one-third of its Research and Design funding on the invention and planning of new products and two-thirds of the funding on the manufacturing processes used to make the product (Liu et al., 2021). The ratio is reversed in the U.S., whereas, U.S. manufacturers strive to get their products to the market first and protect their intellectual property from competitors (Liu et al., 2021).

The COVID-19 pandemic accelerated investment in the invention of new materials, new processes, and new operations. The COVID-19 pandemic brought a need for new vaccines and new PPE. These new approaches to safety have turned the attention of inventors toward developing the products to meet those needs (Cukier, 2021). The government restrictions forced mandatory shutdowns that affected all areas of production and created a shortage of materials (Lai et. al., 2020). The cost for materials used in manufacturing skyrocketed and manufacturers had to look for ways to reduce costs. Repurposing and improving the materials, processes, and operations for changing resources into usable materials and products are important to the sustainability of the manufacturing industry.

Invention of Materials: Process and Operation in Manufacturing

Materials are natural resources or components that can be manipulated into new materials. The transformation of natural resources into new material involves transforming the structure of raw materials into usable form, and the process of forming the material into a new product. The transformation of material into new products is called process, and the physical transformation of the material is called operation in the manufacturing industry.

Material process involves the chemical transformation of raw materials into a usable material. A chemical reaction is used to change the structure of the material and create an entirely new material. The chemical reaction is usually irreversible. An example would be turning iron ore, chromium, silicon, and nickel into stainless steel billets or pieces. In usable form, the material goes through a process involving the physical transformation of the materials called operation. The operation process involves the forming of the material into a new product. The operation process deals with the physical changes of the materials and are done with machines that form the material into a usable product (Musandiwa & Ngwakwe, 2020). The

development of materials for manufacturing is a tedious, time consuming, and expensive process (Musandiwa & Ngwakwe, 2020). Improving materials is key to sustainability in manufacturing, including improvements in the methods for process and operation used for creating new materials and products. Improvements in any of these areas will increase accessibility to the materials and reduce costs for production.

Material, process, and operation are important in manufacturing and the development of a product. The invention of a new material, a new method for process or operation, and new practices to improve quality, increase operational efficiency, and control the costs of production are important facets in the sustainability and future of manufacturing. The right improvements reduce defects due to quality issues, decrease setup time to production, eliminate downtime due to faults, breakdowns, and unnecessary delays, and ultimately improve production and consumer satisfaction. The improvement of processes and operations reduces costs, improves the quality of materials, and reduces dependency on imported materials providing sustainability for future manufacturing.

Innovation in Manufacturing

The COVID-19 pandemic created opportunities for increased innovation to combat the COVID-19 pandemic. Innovation connects the dots between inventions, identifies areas for improvement, and fills the gap in market demand (Herbert, 2020). The Cambridge dictionary defines innovation as “to use a new idea or method,” to bring something new to the market, manipulate inventions that already exist, and use them to create products or processes that are useful in the world (Herbert, 2020). Disruptive innovations are breakthroughs that change an industry’s pattern (Christensen et al., 2015). Innovations can take on different forms depending on the situation and require different strategic approaches for implementation. Innovation is the

process of creating and commercializing new products (Liu et al., 2021), or the integration of new skills and knowledge in reaction to a disruption (Hermawati, 2020).

Prior to the COVID-19 pandemic innovation was being used by manufacturers to improve workers' performance in their daily jobs, improve efficiency in production, and integrate new technological innovations in manufacturing (Goodrich & Schultz, 2007). Lean manufacturing strategies have been implemented for decades to reduce costs and increase profits. Lean manufacturing strategies with invention and innovation are being used to reorganize working environments, reduce worker requirements, promote social distancing, and maximize workplace safety requirements while maintaining production (Ali Abdallah, 2021). U.S. manufacturers are using "Smart" innovation and the invention of new technologies, robotics, and artificial intelligence to sustain and increase production while keeping workers safe and out of dangerous areas (Sisinni et al., 2018). The COVID-19 pandemic has accelerated the trends already in use within the industry, with more emphasis on the transition to disruptive technologies (Ali Abdallah, 2021).

Innovation has traditionally been a slow process in the United States. Every modification that an engineer or designer makes to a product or process requires a complete re-alignment of resources to maintain performance and product functionality. In manufacturing, the ability to 'pivot' the manufacturing process from one task to another has typically required a long and costly re-creation of the manufacturing process (Dooley & Som, 2018). Manufacturers need to be able to more easily pivot or repurpose their production lines for sudden disruptions in consumer demand (Rapaccini et al., 2020).

Traditionally, manufacturing has been reluctant to share information as manufacturers have tried to keep innovative ideas within the company. The COVID-19 pandemic has shown the

need for people to work together both inside and outside of an organization. Open innovation is openly sharing knowledge across stakeholders and profiting from innovation (Obradovic et al., 2021). Open innovation is disruptive in that it requires the breaking of organizational boundaries both internally and externally in the exchange of ideas that will improve organizational performance in meeting new consumer demands (Patrucco et al., 2019). Current research studies show that the open innovation model improves organizational performance in terms of profitability, research, development, consumer satisfaction, and product innovativeness (Harris et al., 2020; Liu et al., 2021).

Innovation provides change to organizations through improvements in the production process, and the addition of technology, elevating an organization's overall ability to innovate (Cukier, 2021). Disruptive innovation is changing the way organizations operate. Remote working, social media platforms, and user connectivity are expanding the context of disruptive innovation (Gunasekeran et al., 2022). The technological advancements in digitalization, big data, 3D printing technology, and IoT, Artificial intelligence (AI), virtual reality (VR), Augmented reality (AR), and internet-based digital platforms are transforming the manufacturing industry and the social relationships within and around the manufacturing industry (Nambisan et al., 2019).

Integrated product and service-centered manufacturing companies in the future will have innovative production strategies designed using the relationships and collective knowledge within the workforce, production and consumption occurring simultaneously (real-time production), and continuous feedback and communication between all stakeholders (Kianto et al., 2010). The future of manufacturing will require proactive planning for maintaining operations, the use of innovation and inventions to keep people safe while increasing production,

and a business model that is adaptable and proactive for sustainability against disruptions in the future.

Advancing Technology and the "Smart" Revolution

The advancement of technology and the digital revolution are continually disrupting the manufacturing industry (Nyagadza et al., 2022). Technological advancements are occurring faster than the industry can incorporate them, more frequently than at any time in history, and will grow exponentially in the future (Ramanathan et al., 2017). The ability of manufacturers to keep up with the newest trends has been highly disruptive in both operational costs and employee recruitment. College graduates are hesitant to work for companies as concerns increase regarding whether corporations have the means needed to invest in the newest technologies (Cai & Luo, 2020), and these technologies are considered critical for maintaining operations (Juergensen et al., 2020). Across the world, new technologies threaten to replace nearly 50% of all jobs over the next quarter century (Ramanathan et al., 2017). Research from the Future of Humanity Institute at the University of Oxford points to new technologies, such as AI, automation, and robotics gradually outperforming and replacing humans in the future (Grace et al., 2018). This research shows that there is a 50% chance of AI having higher performance rates than humans in all tasks in the next 45 years, with full automation of human jobs within 120 years (Grace et al., 2018). The cost of purchasing the new technology is only the beginning, as the financial burden of immediately training a highly skilled digital workforce (Kamarthi & Li, 2020) is an issue.

Artificial Intelligence, Automation, and Robotics

AI, automation, and robotics are growing trends in manufacturing. Recent developments in AI, robotics, and automation are reshaping the face of manufacturing (Manyika et al., 2017).

The use of AI will continue to grow in manufacturing (Lee, 2016), and yet there is no standard definition of AI or what it involves (Boulton, 2018). The difficulty in defining AI stems from the difficulty in defining human intelligence. Intelligence is the ability to process information in a complex environment (Nakashima, 1999). Artificial is something that is produced or something that does not occur naturally. AI can process information in the environment in which it exists, including working with machines that can perform like humans and require some sort of intelligent source to function (Lee, 2016). Humans design AI systems to process the environments they are in by interpreting things around them in that environment (Hu et al., 2019). The High-Level Expert Group on Artificial Intelligence (2019) defines AI as all stages of processing of information, from the collection and interpretation of data in a perceived working environment, processing and reasoning the data, and deciding the best actions to take to achieve the task or goal. AI provides the ability for live-action processing by analyzing the changes in the environment and determining how it is affecting the previous actions in the process (High Level Expert Group on Artificial Intelligence, 2019). AI is proving to be extremely useful for performing tasks faster and with fewer errors than humans (Boulton, 2018). Improvements in the advancement of AI continue to prove that it can be more capable and more intelligent than humans in some areas (Bolton et al., 2018).

University of Phoenix Research Institute claims robots will continue to become a familiar presence in the workplace and will continue to replace humans in dirty, dull, and dangerous jobs, because they will simply be able to perform these jobs more safely, reliably, and ultimately cheaper (Voronin et al., 2021). Industrial robots are machines equipped with sensors and tools that can adapt to a wide variety of production tasks. Robots are seen as substitutes to replace or assist humans in performing repetitive manufacturing tasks (Voronin et al., 2021). Automation

will change the daily activities of everyone (Drakaki et al., 2022). A report by McKinsey & Company suggests that half of the existing workplace activities will become automated and replace existing technologies, saving billions of dollars worldwide while creating new types of jobs (Manyika et al., 2017).

The new automation technology will affect individual activities in manufacturing rather than the entire occupation (Drakaki et al., 2022). The immediate impact on manufacturing is partial automation. Partial automation will replace humans in the physical operations that exist in highly structured and predictable environments. Human-robot collaborations do not pair well with uncontrolled working environments (Voronin et al., 2021).

AI, robotics, and automation will target high and low-skilled occupations. New technologies bring excitement to the workforce, but also anxiety and fear of lost employment and income (Manyika et al., 2017). The growth of AI in the manufacturing industry has brought fears of the loss of employment for some workers (Atkinson, 2017). The potential for AI, robotics, and automation to cause mass unemployment has been debated for years. The current human labor market is not enough to sustain the advancing manufacturing market and will need every available worker in addition to robots to overcome the labor shortage (Autor, 2015). AI, robots, and automation are possible solutions to the aging workforce and lack of skilled laborers in manufacturing, and manufacturers will need to align employees and their skills with the automated jobs that complement the work the machine can do (Manyika et al., 2017).

SMART Manufacturing: Digitalization, Industry 4.0, and the IoT

Long before the COVID-19 disruption shut down the world, the “Smart” manufacturing revolution was underway. It is imperative to understand the disruptive nature that digitalization, Industry 4.0, and the IoT will have on the future of manufacturing (Marivate et al., 2021). The

4th Industrial revolution is referred to as Industry 4.0 and is accelerating the use of computer technology within manufacturing processes. There is little control over the constant advancement of technology and the disruptions that come from it (Xu et al., 2018). The speed of change that Industry 4.0 is bringing has revolutionized the manufacturing world by providing manufacturers with opportunities to utilize advanced tools and technologies throughout the lifespan of the product. (Xu et al., 2018). As the life span of products decreases, the manufacturing industry is pressured to make new products faster and cheaper (Mateus et al., 2019). Industry 4.0 has enabled manufacturers to increase operational visibility, reduce costs, expedite production times, and deliver exceptional customer support.

The combining of robotics and automation with computer technology has created a technological revolution that has brought the manufacturing of goods closer to the consumer (Sako, 2022). This allows the consumer to get the product more quickly. Industry 4.0 focuses on using technology to optimize the means of production. Additive manufacturing or 3D printing is one of the pillars of Industry 4.0. The COVID-19 pandemic demonstrated that additive manufacturing is a promising open-source solution during emergency situations (Salmi et al., 2020). With new technologies such as 3D printing for prototyping, Industry 4.0 is removing barriers and providing a pathway to get products more quickly from the inventors to the consumer market. The introduction of new digital technologies and machines with Industry 4.0 into the manufacturing industry will improve job performance, reduce costs, and improve quality (Maskuriy et al., 2019). Industry 4.0 has tremendous potential to improve productivity and sustainability in the manufacturing industry (Lee, 2016). Innovation never stops as Industry 5.0 has entered discussions. Industry 5.0 connects man and machine using smart systems. Industry 5.0 describes a world in which individuals move between digital domains and offline realities

while using smart technologies to do their jobs (Mateus et al., 2019). The addition of human-robot collaborations in manufacturing will reduce the workload for the employee and provide for a faster, more efficient, and cost-effective means of production (Ogenyi et al., 2021).

The IoT is the next generation of the internet connected to and integrated with a wide variety of technologies (Li et al., 2020). IoT is the connectedness of billions of devices connected around the world collecting and sharing data through the internet (Hussein, 2019). The internet is a network of connected computers that communicate by linking entities and sharing and producing information. The IoT's advanced network of connectedness is disruptive and will continue to change every aspect of our lives (Khan et al., 2022). The well-organized and fully integrated architecture of IoT is the force behind the creation of "smart" systems and it will expand into every imaginable environment. Smart homes, smart networks, smart automobiles, and smart self-driving systems have already been implemented into our global society (Bolton et al., 2018). Nanotechnology is being integrated into the IoT. The IoNT is being engineered by integrating nano-sensors into objects and using a nano-network to transmit data (Hussein, 2019). Nanotechnology is disrupting the medical field as it provides tracking of patients, staff, and situations in real time to improve the healthcare industry (Miraz el at., 2018).

The Iot is a growing trend in the manufacturing industry. Referred to as the Industrial Internet of Things (IIoT), the IIoT is the interconnection of complex systems enabling manufacturers to make informed, strategic decisions, using real-time data to achieve their goals, including cost reduction, improving efficiency and safety, and product invention and innovation (Khan & Altayar, 2021). The IIoT is an extension of the IoT in industrial sectors that focuses on machine-to-machine communication, big data, and machine learning (Drakaki et al., 2022). It goes beyond the normal consumer networking of devices and intersects information technology

with operational technology. IIoT is the networking of operational processes and industrial control systems to improve the monitoring and control of the physical infrastructures and devices used in manufacturing operations (Khan & Altayar, 2021).

The IoT is disrupting the world of manufacturing. The ability to connect the production processes with cyber-physical systems and information technologies is the pathway to creating "smart" cities and systems (Husein, 2019). Smart systems track real-time data using sensors to make decisions from the data at incredible speeds. This will continue to disrupt the manufacturing industry as the need to produce things faster and more efficiently will continue. The innovation of smart systems and IoT will optimize all aspects of manufacturing in finance, production, and human resources (Khan & Altayar, 2021).

Smart Manufacturing with Big Data

The development of Industry 4.0 technologies and the latest advancements in information and communication technologies, AI, and the field of computational statistics provide U.S. manufacturers with the ability to deal with a large amount of data and use it to ensure that all equipment and processes are functioning at the highest levels. (Advincula et al., 2020). Industry 4.0 is the use of smart systems and machines to analyze big data to predict future events and provide optimal solutions to guard against future disruptions (Liao et al., 2017). Predictive manufacturing systems are intelligent smart systems used in manufacturing (Drakaki et al., 2022). They provide the ability to predict and forecast disturbances to develop preventative measures to improve sustainability during disruptions. Industry 4.0 applications utilize AI and big data to view data in real time, monitor for potential outbreaks, forecast future trends, and brief and update institutions (Qin et al., 2020). Smart, data-driven manufacturing provides the means for predictive maintenance. Predictive maintenance is used by manufacturers to diagnose

and fault test critical processes throughout the industrial production environment (Drakaki et al., 2021), and is used to optimize production processes, including monitoring, controlling, and diagnostics and scheduling to address manufacturing challenges (Drakaki & Tzionas, 2017).

AI and Big Data are the bases for predictive analytics. They enable the monitoring of the performance of equipment and automate data collection using IoT technology. Predictive analytics provides manufacturers with a better understanding of how their entire system works, when and where it will fail, and how to perform predictive maintenance to reduce disruptions in the manufacturing process (Nikolic et al., 2017). Predictive manufacturing, analytics, and real-time maintenance are the future of manufacturing and are how smart cities and smart networks can use advanced protocols for data sharing during disturbances and emergencies. They provide the flexibility within a manufacturing system to respond quickly to sudden disturbances using less time, cost, or loss of performance (Bokrantz et al., 2016). AI and Big Data provide evidence-based predictions that can be used in local decision makings and policy creation to better manage situations (Allam & Jones, 2020). The further development of Industry 4.0 technologies will continue advancing predictive manufacturing and will be used to provide solutions to the uncertainty and unseen issues related to productivity, efficiency, flexibility, and safety of future disturbances (Drakaki et al., 2021).

Manufacturing in a Virtual World

Innovation with smart manufacturing is entering the realm of the virtual world. The use of VR and AR is causing disruption in the manufacturing industry. VR is a computer-generated simulated environment in which users are fully immersed in a virtual world (Lee, 2016). VR and AR are areas of information technology that provide indirect experiences within a virtual space and combine the interactions using human sensory systems with modeled constraints developed

from the real world (Choi et al., 2015). Manufacturers simulate real-world environments to help overcome barriers traditional training and planning are unable to overcome (Price et al., 2018). The development of 3D virtual worlds to mimic and be exact replications of a workspace, a building, an office, or industrial property is revolutionizing the way industry repairs equipment and improves organizational and operational processes (Tao et al., 2022). The virtual worlds are fully interactive and immersive providing real-world training programs in safe environments (Rogers et al., 2021). AR and VR support is carried out by technicians to administer repairs and install equipment from a remote location. AR and VR have made it possible for technicians to provide assistance to customers by sending AR and VR-enabled devices to them and walking them through the troubleshooting and repair processes (Martirosov & Kopecek, 2017). The use of VR and AR in virtual world environments is changing training in manufacturing. It reduces the cost of training making it more convenient and efficient than traditional methods of training and repair of equipment (Choi et al., 2015). AR and VR are valuable tools for sustainability in the event of another COVID-19 pandemic.

Organizations that invested in the digitalization of manufacturing wished that they had gone farther sooner, and companies that did not invest in digital capabilities have suffered with sustainability. The digitalization of manufacturing is critical to creating flexibility across the supply chain in the most cost-effective and efficient way. The COVID-19 pandemic disrupted the entire world. The sudden need for PPE became a necessity to keep companies up and running. The normal supply chain was disrupted, and companies had to turn to alternative means to acquire PPE. The establishment of advanced manufacturing facilities, Makerspaces, and Fabrication Labs (Fablabs) across the country provided an alternative method for producing PPE (Petch, 2020). They used 3D printing which is a process in which material is deposited in a series

of successive thin layers to create a three-dimensional object (Advincula et al., 2020), to manufacture the needed PPE. The 3D Computer Aided Drafting (CAD) community (invention) provided the 3D plans, and anyone with access to a 3D printer (innovation) was able to manufacture the needed PPE. The internet provided the means of connecting the right people, products, and machines to manufacture and deliver PPE (Salmi et al., 2020). This led to the development of 3D printing farms needed to mass produce the products in demand. As secondary and post-secondary institutions shut down to slow the spread of the virus, several 3D printer manufacturers and instructors transitioned their spaces from prototyping labs to mass production labs, or 3D printing farms (Loy & Novak, 2021). Open innovation, digitalization, and IoT made it possible to localize the production of PPE. The use of digitalization along with the IoT provides the ability to produce parts quickly, be manipulated and adapted to disruptions, and bring all stakeholders together to quickly react to the issues causing disruption (Salmi et al., 2020).

The Future of Manufacturing in the United States

Safety will remain a top priority in the future of the manufacturing industry, as workers are the most valuable and important resource in manufacturing. Safety in manufacturing has expanded beyond the traditional procedures for a safe workspace and machine safety, and now includes employee health (Taherzadeh et al., 2022). In addition to social distancing and masks, manufacturing will continue to improve their ventilation structures, increase opportunities for remote work possibilities, and continue to improve sanitation procedures. The new approaches to safety-focused manufacturing will be the new norm in the manufacturing industry. The short-term fixes will become long-term fixes and become the backbone of the post-COVID-19 pandemic platform in manufacturing.

Manufacturers who choose to continue the traditional manufacturing path will lose the competitive edge to companies driven by innovation and the ability to use the invention to develop innovative products (Musandiwa & Ngwakwe, 2020). The advancement of AI, the IoT, automation, and robotics will continue to shape how manufacturers educate and train their employees (Manyika et al., 2017). The manufacturing industry is continually changing and advancing, and the skillset that they need their employees to possess must advance with the change (Ross, 2019).

The information age is replacing the jobs created by the industrial age (Gasteiger et al., 2022). The loss of industrial-age jobs has less to do with government policy and trade agreements than they do with the need for knowledgeable workers (Lund, 2022). Knowledge is an integral part of sustainability, and it cuts across all boundaries. The need for knowledgeable workers needs to be linked to where a company chooses to invest. Choosing to invest in their workforce provides focus, creativity, and leverage to achieve the organization's objectives. The main assets and primary drivers of the industrial age were the machines and capital to keep advancing and progressing. People were necessary but replaceable. The management style of the industrial age is ineffective in the new economy. The "great resignation" added to the lack of skilled laborers is fueling the change. Management can no longer use the threat of termination as motivation to get employees to perform the physical labor needed for production. Manufacturers are now challenged with how to motivate their workers to release their human potential (Ross, 2019).

Manufacturers will have to shift their focus to include the needs and experiences of the workforce in the workplace. The need for manufacturers to upgrade their worker's skill sets will continue to be a prominent issue. Manufacturers are looking to hire new employees to fill these

needs, and have their sights set on highly data-focused or skilled laborers. These employees are difficult to find, as the ongoing shortage of skilled laborers plagues the manufacturing industry. Upskilling and cross-training to expand employees' skill sets can offset the number of new hires needed to keep operations running smoothly. Upskilling involves teaching current workers new skills and improving their knowledge to help them continue to work in the same profession. Upskilling employees requires an ongoing investment. As the worker shortages continue to increase, manufacturers may have no other choice in meeting their employee needs to meet their needs (Ross, 2019).

The least educated employees performing menial tasks will give way to the advancement of digitalization and new technologies in the workplace (Atkinson, 2017). The advancement of new technologies will continue to shift the manufacturing industry, and manufacturers will have to rethink education, training, and other challenges the COVID-19 pandemic exposed (Manyika et al., 2017).

Summary

Manufacturing is important to the U.S. economy and has been since it moved being based farming and agriculture to an economy based on the manufacturing of goods (Khoo & Neha, 2020). The health of the manufacturing industry can be seen in the standard of living of its citizens (Kudryashova, 2022). U.S. manufacturers have endured disruptions throughout history, but nothing has interrupted production like the COVID-19 pandemic. The COVID-19 pandemic forced manufacturers to make changes to the workplace that hindered production, reduced product output, and impacted profits (Meenakshi & Neha, 2020). The mandated shutdown of borders disrupted supply chains and effected every economy (Handfield et al., 2020).

As the manufacturing industry responded to the COVID-19 pandemic disruptions, the ongoing issues the industry was dealing with became amplified. Issues of worker shortages (Harris et al., 2020) and the aging workforce (Institute for the Future, 2020) became more evident. The need for workers who have the right knowledge, skills, and abilities grew exponentially, and the inability to find them made it difficult for industries to continue production (Li, 2020). The %age of workers leaving their jobs increased to a 20-year high (Parker & Horowitz, 2022). Manufacturers responded by implementing multiple levels for keeping employees safe and retain them (Chenani et. al., 2021). Manufacturers focused on the needs of their employees before moving on to production needs. The focus of manufacturing moved to being service centered (Kianto & Andreeva, 2014), to meet the immediate needs of the consumer and improve the quality of consumer's experience with their products and services (Rapaccini et al., 2022).

The COVID-19 pandemic disruption accelerated investment in the invention of new materials, new processes, and new operations (Cukiwer, 2021) as manufacturing industries sought sustainability. The technological advancements in digitalization, big data, 3D printing technology, IoT, AI, VR, and internet-based digital platforms have transformed the manufacturing industry and the social relationships within and around the industry (Nambisan et al., 2019). The next industrial revolution will provide an active role in artificial intelligence, digitalization, and machines, and their integration with humans will include improvements to the quality of the workplace (Xu et al., 2018).

Current research reveals safety for workers will be a top priority for manufacturers in a post-COVID-19 pandemic era (Taherzadeh et al., 2022). Upgrading worker's skills sets will be another priority. Manufacturers are looking to upskill current workers or hire high quality

workers with upgraded skills sets (Ross, 2019). New technologies will continue to shift the manufacturing industry as artificial intelligence, digitalization, and machines are integrated with humans in the workplace (Xu et al., 2018). Product life cycles will continue to decrease, as the pressure for companies to make new products faster and cheaper will continue. Invention and innovation are redefining the role of the employee and the workplace in the manufacturing industry (Mateus et al., 2019). The redesign of the work environment to a "smart" workspace that uses IoT, virtual worlds, digitalization, and new technologies to maximize the use of human-robot collaborations will be the new norm in manufacturing. Collaborations in which humans and robots share the same workspace are already trending in Industry 4.0 (Voronin et al., 2021). The addition of human-robot collaborations will provide a faster, more efficient, and cost-effective means of production, which will reduce the workload for the worker (Ogenyi et al., 2021).

The research above provides a projection into the future of manufacturing in a post-COVID-19 pandemic world. Projecting the future of manufacturing in the United States is difficult to do. The disruptions in the future will continue to force the manufacturing industry to adjust and to adapt for sustainability in the future. The collaborations between humans and robots will continue to increase as ways to make our lives easier will be in discussions for decades (Lee, 2019). The idea of a "Smart" manufacturing world which operates on Industry 4.0 and new technology is common throughout the literature, but questions remain about the future of this reality for local manufacturing companies. The gap in the research is the lack of input from local manufacturers and their perspectives of the COVID-19 pandemic and the future of manufacturing. Local manufacturers can provide the insight for planning and preparing for the next disruption.

Chapter III: Methodology

The purpose of this study is to gain insight into the challenges that the U.S. manufacturing industry is facing in post-COVID-19 pandemic manufacturing from the perspective of midwestern manufacturing industry leaders and how they plan to meet the challenges. In addition, this study sought to understand how manufacturers will prepare for future disruptions.

A clear understanding of the challenges manufacturing leaders face in a post-COVID-19 pandemic world is necessary to be able to devise appropriate interventions that will ensure the adaptability, profitability, and sustainability of manufacturing in the future. The research in this study looks to fill in the gaps of the research by gaining insight from the local manufacturers that have been left out of the conversation on the challenges that need to be addressed in manufacturing in a post-COVID-19 pandemic world.

This chapter outlines the methodology and research design used for this study. The complexities of gaining insight from the perspectives of the participants would be difficult to explain and measure using a quantitative approach and is why a qualitative research method was used for this study (Denzin & Lincoln, 2005). A qualitative research method is used to gain an understanding of the opinions, experiences, perceptions, and interpretations as lived by the participant (Creswell & Poth, 2016). Qualitative research is concerned with subjective phenomena, and a desire to understand the issue from the participants themselves (Hammarberg et al., 2016). A phenomenological study describes the common meanings across several individuals and their lived experience of a phenomenon (Creswell, 2018). The phenomenological researcher wants to understand how the world appears through the individual eyes of each

beholder (Trochim, n.d.). A qualitative approach provides the best method for the complexity of this project.

Research Questions

The following research questions were used in this study.

1. What challenges has the COVID-19 pandemic exposed and created for Midwestern U.S. manufacturers that need to be addressed to be sustainable in the future?
2. What are plausible solutions to the challenges facing Midwestern U.S. manufacturers that may help build resilience against disruptions in the future?
3. The “Smart” or “Intelligent” future of manufacturing is predicted to be happening now, and is their use along with the newest and emerging technologies such as robots, automation, and Industry 4.0 by Midwestern U.S. manufacturers realistic and effective to manage challenges from disruptions in the future?

Research Design

The purpose of this study is to gain an understanding of the challenges and possible solutions facing U.S. manufacturing from the local manufacturing leader’s perspectives. As participants share their real-life lived experiences, the researcher gains meaningful insight into the actual perceptions of the challenges in manufacturing and how they perceive dealing with them.

The research design is the pathway or guide the researcher used to obtain the outcome at the end of the study. The research design for this study was determined by its focus on the perceptions of the participants. Hence, this research uses a descriptive research design. This study was designed to explore beyond the simple survey responses of “yes or no” and gain deeper insight into the participant’s thoughts and interpretations, including their perceptions of

the factors that cause them to think or behave in certain ways (Creswell, 2018). This design offers researchers an accurate account of an event or situation of described relevant aspects of phenomena of interest from an individual's perspective (Sileyew, 2019).

Techniques used in qualitative research design include discussions investigating the beliefs, attitudes, and perspectives of the participants (Leinginger, 1994). Discussions take place through individual and small groups, semi-structured and in-depth interviews used to seek out their views on a specific topic or gain their understanding of an experience or event from their perspective (Cohen & Crabtree, 2008). Personal interviews provide the opportunity to ask participants broad open-ended questions and add depth over a simple survey. A structured interview ensures clarity in the questions and allows for follow up inquiries to promote greater understanding and shared meaning. The purpose of a structured interview is to reduce the role of the researcher and introduce objectivity (Lichtman, 2011). The researcher's stance is obsolete objectivity, as the researcher is the instrument for gathering data and provides analysis of the data (Denzin & Lincoln, 2005. The data is compiled from the spoken words and physical reactions of the participant that a simple survey does not provide (Creswell & Poth, 2016). The researcher is the instrument for data collection. The researcher gathers the words, thoughts, and ideas of the participants, analyzes their body language, emotional state, and feelings, and constructs the meaning behind them (Creswell, 2018). Face to face interviews provide the researcher the opportunity to interact with the participants and reduce the number of unusable answers (Gall et al., 2007).

Inductive reasoning is at the center of qualitative research design (Day, 2021). The goal is to develop an understanding of the perceptions participants have about the issue (Biklen & Bogdan, 2007), and through inductive reasoning look for meaning from within them (Maxwell,

2004). The information gathered can be used to make predictions about situations based on existing knowledge and experiences (Hayes & Heit, 2018).

The research design for this study takes advantage of humans as social and emotional beings with an inherent need to socialize and an ability to communicate meaning and information at a high level (Halcomb & Davidson, 2006). Humans have the ability to communicate with words, emotions, and expressions that add depth to a study. The researcher needs to handle the participants and the data with care. Qualitative research should be ethical, important, and intelligibly described by using appropriate and rigorous methods (Cohan & Crabtree, 2008). In qualitative research design, the researcher studies people in their constructs, within the context of their past and experiences (Knapik, 2006). The goal is to capture real-life experiences, which will never be identical from one participant to the next. The participants, settings, and environment that make up the overall culture in the study are not reduced to individual variables but are viewed holistically (Marshall & Rossman, 2011). The way of explaining a phenomenon will vary according to cultural significance and the degree of engagement within the culture. By building consistency, trustworthiness, applicability, and credibility into an appropriate and rigorous research design the researcher can defend the integrity of their work (Leininger, 1994).

A qualitative research approach is the correct approach for this study as it involves performing extensive research through the interviewing of participants, transcribing the interviews, and developing meaning from the transcriptions (Sileyew, 2019).

Participant Selection and Description

Participant selection was performed using a sample of convenience. The ability to interview every manufacturing leader in the Midwest was not possible or feasible due to the size of the population (Etikan et al., 2016). A random sample may not be purposeful or strategic

enough to gain the data representative of the population (Etikan et al., 2016). A convenience sample allows researchers to target members of the population that meet certain criteria, such as accessibility, geographical location, and time availability to better manage the study (Trottier, 2010). The short time frame for this study supported the use of convenience sampling. The researcher chose participants they knew would provide good data for the study.

The research was conducted utilizing qualitative interviews with eight leaders working for local manufacturing companies in the Midwest. Regarding the concept of saturation, the point at which there is no new information or themes emerging in the data, the number of participants selected in the study were based on Creswell's (2018) recommendation for a phenomenological study of between five and 25 interviews. The participants in this study were chosen by the researcher from individuals that have been working in the manufacturing industry for over a decade. The researcher has both professional and personal relationships with the participants, as the researcher has worked with each participant both professionally and academically in both educational and industrial environments. Many of the participants have developed personal friendships with the researcher. Each participant was chosen because of their relationship with the researcher and the researcher's knowledge of the valuable insight they were able to provide to the research about the challenges local manufacturers are dealing with. The participants have all been living and participating in the day-to-day operations in the world of manufacturing. The aim of the research is to get their perspectives of the manufacturing industry in a post-COVID-19 pandemic world.

Interview Setting

For this study, the researcher used a qualitative research interview to gather data from 8 semi-structured interviews with self-selected participants. The interview process allows the

researcher to collect stories and assemble narratives from the participants who live and experience manufacturing every day (Creswell, 2018). Their stories occur from within their workplaces and provide a narrative through the conversations and interactions between the researcher and the participant (Lichtman, 2011). Each of the participants consented to participate in this project and indicated their approval of the early draft of my analyses. Participants were encouraged to share whatever they felt was relevant to the research questions.

The interviews were conducted in a face-to-face environment. Each of the manufacturing companies have over 10 employees and less than 100 employees. The sample for this study is a sample of convenience. The researcher selected the individuals that were available and accessible for the time frame of this research (Etikan et al., 2016). The interviews took place at the participant's place of employment. The researcher travelled to the participant's places of work and the interview was conducted in their working environment. The goal was to interview them in a place the participants were comfortable in and were less likely to have distractions. The data for this research was recorded for accuracy during the interviews.

The qualitative research interview provides rich and valuable information that is important to the study. How the researcher's approach used the data for research is important. Before interviews can begin, researchers must carefully develop a plan for data collection (Manderson et al., 2001). The plan is the "road map" to guide the interview process and allows researchers to plan specific research questions to guide the interviews and gain the relevant data they need for the study, while keeping out their biases. The participants were asked a series of open-ended questions from an interview schedule (see Appendix A). Researchers use reflective practices to manage the data obtained in qualitative research to better organize their data (Halcomb & Davidson, 2006). The process involves recording interviews with concurrent

observations, note taking and reflection, and evaluation of the recordings. Qualitative data management, which encompasses human subject protection, confidentiality, and data storage, ownership, and sharing, is a critical process in the study (Lichtman, 2011). To properly manage the security measures that go along with qualitative data management, researchers must develop a plan for collecting data (Halcomb & Davidson, 2006). The use of technology in this study includes a digital recorder and REV transcription.

Participants

The participants for this study are employees from manufacturing companies in the Upper Midwest. Each participant holds a leadership position in the company they work for. The companies manufacture large ships, production attachments, medical devices, and hunting supplies. They are the hard-working middle-class people that make up a large portion of the Midwest.

Participant A is the plant general manager of operations for the manufacturing of medical devices. The company operates with approximately 500 employees. Participant A manages the entire production floor, monitors staff, and maintains the inventory. They organize and maintain the supply inventory, facilitate the repair of equipment, and manage the entire production process.

Participant B is the lead foreman for the manufacturing of attachments used in the decommissioning industries. The company operates with 115 employees, with job duties of welding, fabrication, and sales. In 2021, the company generated approximately $33.28 million dollars in sales.

Participant C is the safety engineer in the ship building industry. The safety engineer is responsible for developing policies that ensure a safe working environment. They inspect the

equipment, the workplace, and buildings, and identify areas that can potentially cause health and safety hazards. The small company generates around $16.8 million dollars in revenue each year.

Participant D is the Vice President of Engineering for a manufacturing company that builds material handlers for the scrap industry. The V.P. is responsible for the overall direction and operations of four smaller companies that are housed in the same building. The company has approximately 85 employees. The company generates 28 million dollars in revenue each year.

Participant E is the quality control engineer for a company that produces sporting goods used in the hunting industry. The company focuses on the development and creation of equipment used for hunting. The company employs approximately 50 employees and generates around $10 million dollars of revenue a year.

Participant F is the Vice President of Operations in the aluminum ship and boat building industry. Participant F is responsible for the oversight of the entire company. These boats are built for the Coast Guard and the U.S. Army. The company generates around $3.2 million dollars of revenue a year and employs around 20 employees.

Participant G is the Chief Executive Officer of a company that manufactures industrial equipment for many industries. The company builds heavy equipment for electric utility, tree care, lights and signs, and other contractor markets. The company provides their services to over 100 countries throughout the world.

Participant H is the Vice President of Operations for a company that manufactures industrial equipment for baking. As a professional engineer, the V.P of Operations manages the production and operations processes. The company generates about $15.26 million dollars in revenue each year and employs 80 total employees.

Instruments for Data Collection

The instrument for this study was developed through the research objectives and literature review. To increase reliability, a focus group was used to generate and pilot the initial instrument and the interview questions. The researcher randomly chose participants from the population to review the questions and make sure that they questions were clear, reliable, and understandable (Cohan & Crabtree, 2008). Traditional data collection is time consuming and can be a costly process, so an online qualitative research method was used to garner responses from the focus group. Working online allows the respondents to remain anonymous in their responses and therefore more likely to provide the most honest responses. Working online provides a way to alleviate moderator bias, eliminating things like body language, tone of language, and other sources of bias (Seymour, 2001). The focus group provided guidance on the clarity of the instrument and provided the opportunity to identify any weaknesses in the instrument (Gall et al., 2007).

Interviews are used when the researcher strives to understand the interviewee's perspective of a phenomenon rather than generating generalizable understanding of a group of people (McGrath et al., 2019). To gain an understanding of the perspectives of local leaders on the challenges, building resilience, and digital manufacturing, interview questions were developed in correspondence with the problem statements and in alignment to the research questions (see Appendix B).

Data Analysis

The collected data was transcribed and categorized in terms of research questions and emergent themes. Adapting the interviews to written form provided the researcher the tools needed to analyze the told experiences for common themes and interpret the meanings of the

data collected (Creswell & Poth, 2016). The researchers focused on describing what all the participants have in common as they experienced the COVID-19 pandemic and how they worked through it (Creswell & Poth, 2016). The specific interview questions were matched to answer the research questions. A coding method was used to organize the data into a limited number of themes and issues around these questions. Analysis of the data was performed through the evaluation of the narrative from the recorded interviews, and conclusions were drawn from them (Creswell, 2018).

Validity and Reliability

There are threats to validity with qualitative research and the inductive reasoning model. Researcher bias in which the researcher either consciously or unconsciously focuses on data that supports the researcher's existing beliefs and expectations (Creswell, 2018), can be minimized by being alert to one's own biases and subjectivity (Glesne, 1999), although a researcher may not be able to control for subjectivity, it can be monitored. By monitoring one's subjectivity, one can learn more about personal values, attitudes, beliefs, and interests and better control it. The monitoring process will also increase one's awareness of the ways that subjectivity might distort your findings (Glesne, 1999). To control researcher bias, researchers should report potential biases and explain how their personal values may have influence the data collection and analysis. Validity in qualitative research is the result of integrity rather than indifference (Maxwell, 2004).

Another threat to validity is the influence of the researcher on the setting or the individual studied. This issue is referred to as reactivity or the changing of behavior because of the interview. The goal of qualitative research is not to try and eliminate this, but to understand it and use it productively. It is important to understand how the researcher is influencing what the

subject is saying, and how this affects the inferences that can be drawn from the findings (Maxwell, 2004).

One way to improve validity in this research was to increase the amount of time spent with the participants. By extending the time spent with each participant, the researcher would have been able to better observe the physical and emotional reactions to the question thus increasing the quality of the data collected. Persistent observation, triangulation of data, and peer debriefing all help control validity. Each of which are used to obtain data that is true and authentic and making the study more credible. The triangulation of data is the use of multiple sources, methods, or investigators to see where the comparisons cross and achieve the same results. By interviewing multiple participants, the researcher was able to triangulate and compare the results and identify patterns that led to similar results improving validity. Emotional bias may threaten validity. Emotional bias can be countered through peer debriefing. Peer debriefing is having a peer who is not involved in the study examine the research methods to rule out emotional bias and test the research design.

External validity comes into question when determining if the research can be generalized to the larger population. Convenience sampling can create biased research (Mackey & Gass, 2005). In qualitative work, the sample size is often small, unique, and topic specific (Maxwell, 2004). The participants and their perceptions are bound in time and context, as they are studied in their own right and in their own importance (Guba & Lincoln, 1999), suggesting it is unable to be generalized. This has resulted in some indecision on whether researchers should abandon the assumption that generalizations should be sought (Maxwell, 2004). To counter bias in convenience sampling, the researcher must ensure that the knowledge gained is representative of the population from which the sample was drawn (Etikan et al., 2016).

In further response, Maxwell (2004) states that generalizability is based on the development of the procedures used to draw a collection of ideas that may be used in generalizations. Researchers are not looking to duplicate the results but are looking for ideas and perceptions in the research that can be used elsewhere (Glesne, 1999). Increasing the generalizability of the research involves the sharing of information back and forth between the researcher and participant to make sure that the research was interpreted correctly and with the intended information. The dependability and credibility of the findings and interpretations depend on careful attention to establishing trustworthiness between groups (Glesne, 1999).

Research Procedure

Due to the newness of the topic, there was limited research available on the topic. The research began with a digital search looking for articles published in peer journals, conference proceedings, and government policies. Search restrictions were applied to include articles that were published after 2017, with a focus on articles published after March of 2020, when the COVID-19 virus was declared a COVID-19 pandemic by the World Health Organization. A keyword search was used to extract relevant articles from the database. The keyword selection criteria were based on the research questions and ultimately focused on terms relating to Coronavirus, COVID-19, COVID-19 pandemic, manufacturing, post-COVID-19, post-COVID-19 pandemic, threats, and challenges. An inclusive shortlist was created which included whitepapers, case studies, and articles that reported insight on COVID-19 challenges manufacturers have been facing, both pre and post COVID-19 pandemic, and the strategies that were being applied to meet these challenges.

The method for this study is fluid. As a researcher learns about the setting, subjects, and other data through the direct interview process, the methodical plans evolve (Santosh, 2021). A

detailed procedure may not be entirely formed prior to data collection. The methodology can change and evolve from the data collected. After the study is completed, then a full set of procedures can be described (Biklen & Bogdan, 1998). The dynamic nature of the research precludes any formal step-by-step process. The research process is moldable and adaptable to new data and trends that emerge and allows the research questions to be narrowed or redefined.

The research for this study was derived from interviews with leaders in the manufacturing field. Once written permission was established to conduct the research, the researcher setup interviews with eight manufacturers located in the Great Lakes region, Midwestern, United States. The participants were given an overview of the research. The interviews took place at the participant's place of employment. After a short introduction to the research, the researcher read each question to the participant and listened to their response. Each interview lasted between 30 and 45 minutes and was recorded for accuracy and transcribed into a narrative format using Rev.com. The transcripts were reviewed for themes that aligned with answering the research questions using a graphic organizer to assist in finding similarities and patterns of perception. Interpretational analysis is used to describe and explain the phenomenon being studied (Gall et al., 2007). The results were compared across each of the participant's data to see what aligned, what was different, and what themes emerged across all participants. The results were summarized.

Summary

The purpose of this chapter was to present the methodology, instrumentation, data collection, and analysis of the study. The qualitative research method allowed for the collection of human data and provided the researcher with the opportunity to revisit answers and seek out clarification and continuation on others. This method along with the open-ended interview

questions allowed the participants to provide feedback that was beyond words, as their physical, emotional, and body reactions added to the spoken words. The interview questions were developed and streamlined using a focus group of the participants. This allowed for any clarification of the questions before used in the population of this study. Additionally, included in this section are the validity and reliability of the study. The data was compiled, analyzed, and interpreted by the researcher using interpretational analysis, while noting the existing limitations in the study. Through the evaluation of the collected data, patterns of perceptions and relevant themes were identified and provided insight to the research questions. The analyzed data is presented and explained in Chapter Four.

Chapter IV: Presentation of the Findings

This chapter explains the data collected through the study's research design. When seeking to understand the perspectives of people, qualitative research is a better approach than the rigidity of quantitative research. A qualitative approach provides an openness to explore topics previously thought to be inaccessible using traditional scientific means. This is particularly so in phenomenological research as the researcher may not know what they are looking for and will ultimately find. The researcher seeks to uncover and draw out an understanding of how a person feels and perceives on a topic. However, implementing a qualitative approach is not an easy process. Researchers must look long and hard to find material to assist them in developing their research design. For these reasons, several lines of inquiry were used to create the environment and questions needed for participants to share and express their true feelings, opinions, and perspectives as the provided answers for this study.

Research Methodology

This chapter outlines and describes the data collected during a series of interviews with local manufacturing leaders in the Midwest. The data collection was subjected to interpretational analysis. The questions from the interview schedule (see Appendix A) were designed to elicit insights from local leaders on the challenges facing midwestern manufacturers. The interview questions were designed to explore the perspectives of manufacturers on the issues they have identified and are dealing with caused by disruptions, including the COVID-19 pandemic.

The research methodology in this qualitative phenomenological study was comprised of interviewing eight local manufacturing leaders in the upper Midwest region of the United States to grasp their understanding of the challenges that the U.S. manufacturing industry is facing in

post-COVID-19 pandemic manufacturing and how they plan to meet the challenges. In addition, this study sought to understand how manufacturers will prepare for future disruptions.

Research Questions

The research questions for this study were designed to gain an understanding from the perspective of U.S. manufacturers on the effects the COVID-19 pandemic had on the manufacturing industry. Each question looks to uncover the challenges and solutions them as seen from Midwest manufacturers.

1. What challenges has the COVID-19 pandemic exposed and created for Midwestern U.S. manufacturers that need to be addressed to be sustainable in the future?
2. What are plausible solutions to the challenges facing Midwestern U.S. manufacturers that may help build resilience against disruptions in the future?
3. The “Smart” or “Intelligent” future of manufacturing is predicted to be happening now, and is their use along with the newest and emerging technologies such as robots, automation, and Industry 4.0 by Midwestern U.S. manufacturers realistic and effective to manage challenges from disruptions in the future?

A clear understanding of the challenges and how to meet the challenges from the perspectives of local Midwestern manufacturing leaders could be used to inform and guide manufacturers on future planning and preparations against future disruptions.

Subject Selection and Description

For this study, eight midwestern manufacturing leaders were selected to be interviewed. The participants were chosen as a sample of convenience and are located within an hour of the researcher. The participants are acquaintances to the researcher and have developed professional

working relationships over the last decade. Each of the participants were contacted and provided consent to conduct research.

Instrumentation

The instrument used in the data collection for this study (see Appendix A) was a series of open-ended questions with follow-up questions as needed that examined the manufacturing leaders' experiences and views across several areas. The names and job titles were left from the study to help create an environment in which the participants could share freely without limitations. The first five questions were designed to get the participant to respond about the issues and challenges facing their local manufacturing industry, as they related to disruptions. The next group of four questions looked to uncover the local manufacturers perception on how to work through challenges and build resilience against future disruptions. The last group of questions focus on the use of new technology, intelligent manufacturing, and "Smart" technologies as plausible solutions for the manufacturing industry.

Data Collection Procedure

The data collected for this study was from eight face-to-face interviews with leaders working in the field of manufacturing. Once written permission was established to conduct the research, the researcher setup interviews with eight manufacturers located in the Northeastern Minnesota and Northwestern Wisconsin region of the United States. The participants were given an overview of the research and IRB protocols and consent forms were explained and permission to interview was granted. The interviews took place in an environment that the participant felt comfortable in, with six of the eight taking place at their place of employment. After a short introduction to the research, the researcher read each question to the participant and listened to their response. The researcher asked follow-up questions to improve clarity on initial responses.

Each interview lasted between 30 and 45 minutes and was recorded for accuracy and transcribed into a narrative format using Rev.com. The researcher used an iPhone 7 Pro as the digital recording device for the recording of the interviews and the Rev application software to record and transcribe the conversation.

At the conclusion of the interviews, the digital audio files were verified, coded, relabeled, and uploaded to a password protected location on the researcher's computer.

Data Analysis

The transcripts from each interview were read through multiple times. The participants' responses were reviewed and grouped according to themes that aligned to the research questions (see Appendix C). The results were compared across each of the participant's data to see what aligned, what was different, and what themes emerged across all participants. The emergent themes and subgroups were given descriptive labels, and the groups were reanalyzed and reorganized to describe and explain the phenomenon being studied. The researcher used a graphic organizer to assist in finding similarities and patterns within the interviews. Interpretational analysis was used to describe and explain the themes and patterns of perception (Gall et al., 2007). The graphic organizer consisted of a basic table with the interview questions listed in a vertical column and each of the participants listed horizontally across the top. The graphic organizer provided a visual representation of the corresponding themes, where the data was aligned, and where it was different. The graphic organizer provided a visual comparison of responses for reduction purposes in identifying patterns in the themes.

As a result of how the data was coded and analyzed using the graphic organizer, outlines, and interpretational analysis, the findings in this chapter are presented in a manner consistent with the research questions, and how the ordered questions in the interview schedule aligned

with the research questions. The value and relevance of the participant's testimonies were revealed when the data from multiple sources were examined, compared, and contrasted for themes revealed in their shared experiences.

The first five questions on the interview schedule were designed to gather data on the challenges local U.S. manufacturers are facing the industry in the present and the future. A clear understanding of the challenges that local manufacturers are facing is needed for developing procedures and plans for sustainability against future disruption. The researcher asked the participants to explain the challenges that local U.S. manufacturers in the Midwest are facing and as needed used the first five questions to improve the depth of the responses. The first of these questions sought to uncover the challenges that the COVID-19 pandemic created for the manufacturing industry. Question number two was designed to uncover prior challenges exposed and amplified during the COVID-19 pandemic. Question three looked to uncover the ongoing issues that have disrupted the industry from the COVID-19 pandemic. Question four looked to expose the hidden challenges, and question five investigated the ongoing issues that have been around long before the COVID-19 pandemic and continue to be issues for manufacturers.

The second research question looked to develop an understanding of how the manufacturing industry is working through the challenges and how they plan to build resilience against future disruptions. The participants were asked to describe how U.S. manufacturers approach the challenges and build resilience in times of uncertainty and against future disruptions in manufacturing. Questions six through nine were designed to help the participant expand on and provide depth in answering the second research question. Question six asked the manufacturers about the methods their company uses to anticipate and prepare against disruption. Question seven sought to understand how the company builds resilience against

disruptions. Question eight looked for insight into what is missing from the company that is needed to build resilience and solve the issues the manufacturers is facing. Question nine aimed to uncover whether the participant perceives the industry returning to pre-COVID-19 pandemic normalcy.

Research Question 1

Research question 1 asked, "What challenges has the COVID-19 pandemic exposed and created for Midwestern U.S. manufacturers that need to be addressed to be sustainable in the future?" A disruption can impact every aspect of the manufacturing sector. The COVID-19 pandemic disruption permanently changed the manufacturing industry. One challenge that was agreed on by the manufacturing leaders is that U.S. manufacturing in the Midwest is "booming". The participants repeatedly agreed that "business is booming, and the challenge is keeping up." The participants described disruptions in production, consumer demand, supply-chains, adaptability, the inability to find good workers, and advancing technologies as the main challenges Midwestern manufacturers are facing.

Supply Chain and Adaptability

All the participants identified supply-chain and adaptability as the top post COVID-19 pandemic challenges. The "ability or inability to adapt to a disruption remains challenging." U.S. government leaders challenged manufacturers with adapting their companies and shifting production to meet the needs of making safety devices due to the COVID-19 pandemic. The ability to adapt their companies for production was a challenge. All but one of the manufacturers were unable to adapt and produce the health care safety devices needed during the COVID-19 pandemic. The companies are set up to manufacture large pieces of equipment, and production of the smaller safety pieces was not feasible. Four of the companies shut down production during

the COVID-19 pandemic. Most of the manufacturers agreed that their employees wanted to work and were undeterred by the COVID-19 pandemic. Their employees participated in all the safety requirements and production continued as best as it could.

The one manufacturer that was able to adapt and shift production to meet the government's challenge had issues when the COVID-19 pandemic ended. Only one of the companies successfully converted their assembly lines over to make the medical devices needed for keeping people safe. The other participants described the cost of converting their companies as too expensive, or not feasible as their companies were set up for welding and fabricating large metal products. As the safety mandates were lifted and the need for safety devices went away, manufacturers no longer needed the workers to produce safety gear. One manufacturer went to great lengths to mass produce the medical safety devices, as they forecasted the world would always need these devices. As the COVID-19 pandemic came to an end, the manufacturing of these devices became unsustainable. The demand for the items went away, and the company was forced to lay off their workforce, including the participant.

The manufacturers were forced to adapt to find alternative methods of getting the supplies they needed for production. The "inability to get the parts, materials, and tools needed for operations continues to slow production," because issues in the supply-chain continue to struggle to keep up with demand. To quickly solve issues in the supply-chain, manufacturers increased their requests to keep more supplies in house. Manufacturers were willing to pay more to get the supplies needed to keep operations going. This strategy created issues as businesses throughout the supply-chain were unable to keep up with increased demand. The costs across the supply-chain increased with demand, and the willingness to pay more for the products needed in

production created inflation issues. The costs due to inflation were passed on to the final product and the consumer.

The Workforce Challenge

Manufacturers agreed that the inability to find workers continues to be a challenge. The COVID-19 pandemic added to the worker shortage issue. At the beginning of the COVID-19 pandemic, manufacturers had workers quitting their jobs. Multiple participants agreed that the COVID-19 pandemic was used as an "excuse for some workers to quit." Manufacturers felt that quitting due to the COVID-19 pandemic had more to do with workers "being unhappy about their current working conditions and used it as an excuse to move to a different job."

Another challenge that surfaced during the COVID-19 pandemic was the requirement of rotating workers due to the reduction of people allowed in an area. Manufacturers needed more workers to keep them from crossing over into other areas. One participant described having to hire new staff to keep up with production and stay within the safety protocols. "We were simply throwing bodies at it." This created a different challenge at the end of the COVID-19 pandemic as fewer workers were needed as government restrictions went away.

The manufacturers that invested in their employees had the least number of workers quit. Out of the eight participants interviewed, the manufacturers that emphasized their employees as the top resource in the company had zero workers quit. Three of the manufacturers described the quit rate issue as "related to the government subsidizing their employees' incomes as the issue behind the quit rate." They questioned government funding and believed that the funding may be too generous. Participants described the top prior and ongoing issues local manufacturers continue to deal with, as the inability to find skilled workers and retaining the

ones they have. “The worker shortage issue has been an issue for decades, and the COVID-19 pandemic amplified the issue.”

New and Emerging Technologies

The inability to find skilled workers is causing other issues. The equipment used for production is advancing at a rapid pace and making it nearly impossible to train the workers with the appropriate skills. One participant described having the robotic arms and computer run equipment to speed up production, but the inability to find skilled workers has forced the company to suspend the use of the robotic arms. Multiple participants pointed out the benefits of using the new machines. The machines allowed them to produce products three to ten times faster. Nearly all the manufacturers that bought new equipment in the last decade described the equipment as having intelligent capabilities and the ability to be operated using Industry 4.0. Even though the equipment is “Smart” technology and has Industry 4.0 capabilities, most of the small manufacturers are self-described as Industry 1.0 or zero.0. The infrastructure of seven out of the eight manufacturing facilities is not ready for a high level of integration, largely due to the inability to be fully connected and integrated across all platforms and lack of internet.

Exposed Hidden Challenges in Manufacturing

Multiple participants struggled to identify hidden challenges that were uncovered by the COVID-19 pandemic. The hidden challenges were described “as not really hidden”. The challenges the manufacturing industry are facing have “always been in the back of their minds.” The idea of a worldwide COVID-19 pandemic impacting the entire world “was not new and quietly appeared in the background of conversations for decades.” The COVID-19 pandemic sped up the urgency for manufacturers to find solutions for these “hidden” challenges.

The demand to go “green” is a challenge for manufacturers. There is a rise in “conscious consumerism,” and purchasing decisions are made towards products that are made in “sustainable,” “ethical,” “environmentally friendly,” “green,” and “cruelty free” environments. Consumer demand is increasing for “green products developed in green environments.” Manufacturers are facing challenges of verifying ethical and sustainable practices within their supply chains as well.

Before the COVID-19 pandemic, “we were never a company that gave much thought to efficiencies and waste.” The COVID-19 pandemic exposed the amount of money that the company was losing to waste. The company was challenged with “fixing the efficiency problems to keep up with the increase in demand for our product,” and keep our customers from “getting angry with us.” One of the biggest issues was how to deal with large numbers of workers out for long periods when your sales orders are at their highest.” The challenge of cross training and communication across the workforce was an issue.

A common hidden challenge that multiple participants identified is the lack of affordable housing. It has been an issue for decades in Northern Minnesota and Wisconsin. One participant described the lack of housing as a “known truth” and is considered “tied to the lack of workers.” It is a problem to bring in “prospective employees when they are unable to find places to live due to the unavailability of homes.” One participant pointed out that “70% of the homes in the area are vacation homes and owned by individuals that live in different areas.” The shortage of homes keeps housing prices high and makes them “unaffordable to the people living in the area.” One participant’s company has chosen to bring employees up from Mexico on short term work visas. The housing issue has become such a problem the company has these employees “commute back and forth from the next city over sixty miles away to find available housing.” The housing

shortage problem is further compounded by supply chain issues. The inability to get the construction supplies needed to build new housing is an ongoing issue, and the construction companies that can get the supplies are unable to find workers. The challenge is a never-ending circle between supply-chain issues and worker shortage.

Lean Manufacturing strategies turned into a hidden challenge the COVID-19 pandemic brought to the forefront of manufacturing. Lean manufacturing is a process of scaling back resources and supplies to keep costs down by maintaining a lower overhead. The majority of manufacturers in the Midwest are one or two product companies. These companies produce one or two parts and work to sell millions of parts a year. Dependance on the single supply chain disrupted their "just in time manufacturing model" as they were unable to get the product to produce their parts. The lean manufacturing model became an issue when manufacturers ran out of the parts needed to maintain operations. It takes a lot of space, management, and capital to keep a warehouse full of supplies for production. Manufacturers became accustomed to getting the product right before they needed it for production. This process is a very efficient way to run. There was no way to predict the move to lean or "just in time manufacturing years ago would cause issues in production."

The validation of the part or material is a hidden issue. The production of medical devices requires "specific validation of the material or part used in medical devices." The validation process is costly and a challenging process for approval. The manufacturers have been hesitant to add supply chains because of the cost associated with validating supply chains. The manufacturers making products other than medical devices added that "a quick adaptation to convert and make medical grade devices is not possible." The process is difficult, costly, and nearly impossible to do on short notice.

Each of these challenges are ongoing challenges for the manufacturers in this study. The supply-chains, workers, housing, technology, intelligent or smart manufacturing, and adaptability during disruption were identified as the overarching and ongoing challenges manufacturers are facing.

Research Question 2

Research question 2 asked, "What are plausible solutions to the challenges facing Midwestern U.S. manufacturers that may help build resilience against disruptions in the future?" The manufacturing leaders agreed on the importance of setting up their companies in a position to be adaptable in times of disruption. Regardless of where the disruption is coming from, the ability for the manufacturing company "to adapt and maintain production is a top priority."

Forecasting future events and disruptions is one method that the participants used to prepare against a disruption. Forecasting involves "looking at past and future trends and predicting the needs of the company." The COVID-19 pandemic has changed how some manufacturers are approaching forecasting. In the past, manufacturers had confidence in a single supply chain and there were no signs of issues with having a single supply chain. The Russian-Ukraine war greatly disrupted the single supply-chain. Suppliers were forced to stop and leave the area. The "war was a disruption that added to the supply-chain issues" created during the COVID-19 pandemic. When the "Chinese government forced manufacturers to close their facilities, U.S. manufacturers became aware of the need for multiple supply chains." Manufacturers were used to requesting supplies from the cheapest supplier to make their parts as the customer needed them or "just in time." Forecasting is still a necessity, but manufacturers are "limiting their forecasting to six months at a time" and putting in "dual source" supply chains. By using multiple sources to supply the manufacturer's needs, companies keep more than "one

avenue for sourcing their materials." The drawback with forecasting out four to six months is that manufacturers are "taking on the costs of holding and storing the supplies" they need but over a shorter period. This is less efficient than the "lean manufacturing" model used in the past but provides a "safety net in case of disruption."

The participants all agreed that the use of more equipment is a way of building resilience against future disruptions. The COVID-19 pandemic created supply chain issues with being able to get the parts and tooling needed to replace broken down machines for production. "Having multiple machines to keep operations going is important in the future." The shortage of technicians available to come and fix the machines in the assembly lines is an issue. The COVID-19 pandemic added to the problem as the technicians were unable to enter the facilities due to safety concerns, exacerbating the problem. To enable their facilities to stay operational, manufacturers are putting in additional equipment. "Having two assembly lines manufacturing parts will better ensure that one will always be operational" and buy time for the technicians and parts to arrive.

One of the participants described how their company relies on bringing other manufacturing industry leaders into their workplace to role play disruptive scenarios. As a group, they "brainstorm and think through the scenarios, what the scenario might look like, the effects of the scenario, and how to reduce the disruptiveness of the scenario on production." The manufacturers would forecast what the disruption would do, what they would do, and plan how they would react. The scenarios consisted of malware attacks, machine failure, and even half the production floor burning down.

The role-playing scenario allows the company to "look at disturbances from their customers point of view." The participants all agreed that "building resilience against disruption

requires looking at what their companies can do to support their customers." The ability to plan, act, and mitigate the risks associated with disruption helps to build trust and reliability with their customers. "Building trust and reliability is important to building resilience" as they provide "stability against disruption." Companies that invest in these areas help to "reduce the anxiety and uncertainty of a disruption" because they know they have the support of each other.

Inflation has been impacting everyone, and "the companies passing the costs on to their customers quickly have less negatively impacted their relationships with their customers and with their companies. The manufacturers that have been "slow to pass on the costs have struggled to maintain operations and remain profitable." One participant described the importance of being "upfront about these issues and keeping the communication lines open between companies."

The manufacturing industry will never return or resemble pre-COVID-19 pandemic ways. The participants agreed that the manufacturing industry is always changing and will never be as it was. This was not viewed as a negative. Seven of the eight participants acknowledged that their companies are ahead of pre-COVID-19 pandemic levels of production. "Manufacturing in the U.S. Midwest is growing, and production is increasing." The need for skilled workers is increasing. The ability to find quality skilled workers has been an issue for all participants. Some companies have invested in reaching out to high schools, improving the industry related classrooms and labs, and helping students to "understand the benefits of working in a career in manufacturing." They have opened apprenticeships, scholarships, and are active in advisory boards to guide the decision-making process for schools and the community. "It is important to get the younger generation excited about careers in manufacturing."

One company is continuing to provide pathways for migrants to work on short visas. The number of people wanting to work in the United States continues to grow. This company specializes in clearing a pathway for these workers to come and work for them.

The participants described the use of new technologies including robots, automation, AI and Industry 4.0 as solutions to the challenges they face and building resilience against future disruptions. Robots and automation are viable options for improving and building resilience in the manufacturing industry. “They may even solve issues related to lack of workers.” Robotic arms provide an efficient way to weld, but questions remain on their return on investment. One participant shared how their company has over one hundred robot arms. The addition of the new technology reduced the number of needed workers. The company presently needs ten workers, which is an improvement from the thirty it had needed. One participant spoke positively of the potential adding new technology and the capabilities it would bring. Another company purchased two robotic arms a decade ago and they helped boost production. All participants agreed that there is potential for new technology to improve manufacturing.

Multiple participants brought the idea of improving Lean Manufacturing to be resilient against potential disruptions. During the COVID-19 pandemic, manufacturers thought that they “were being resilient by having large amounts of inventory and a larger than necessary workforce.” It worked well until the disruption went away. “Improved Lean Manufacturing strategies can combat this.” Eliminating waste allows the company to be “nimble as the market changes.” There will always be potential for disruption, and leaders may be unable to predict what those disruptions might do to the company. Therefore, the need to react quickly when a disruption occurs while accurately predicting what might happen is a necessity. “It is the difference between turning an ocean liner around versus a speed boat.”

A simple answer or solution to the challenges created from disruption does not exist. Throughout the conversations, participants used the term adaptability in working towards finding solutions and building resilience against further disruption. The “ability to be adaptable during a disruption and keep manufacturing operations going is what is important.”

Research Question 3

Research question 3 asked, “The “Smart” or “Intelligent” future of manufacturing is predicted to be happening now, and is their use along with the newest and emerging technologies such as robots, automation, and Industry 4.0 by Midwestern U.S. manufacturers realistic and effective to manage challenges from disruptions in the future?” The use of robotics, automation, artificial intelligence, and intelligent manufacturing were all a part of the discussion as solutions to the challenges against disruption. Each participant viewed the use of these new and emerging technologies as important to the future of manufacturing. To better understand the participants’ perspectives on these issues, the participants were asked to describe the current manufacturing ecosystem. Each participant’s ecosystem was unique. Although each participant’s company manufactures different parts, their ecosystems were similar, but different. One company has over one hundred robotic arms and multiple assembly lines and stations. The company has great internet and potential for the development of a “Smart” facility. However, most of the companies are not capable of operating as a “Smart” facility. The infrastructure that is in place does not have the capacity for a “Smart” facility. All participants have automation and all, but one company use robotic arms in production. One of the participants described the past use of two robotic arms, but they had to take them out of production because of lack of skilled workers in robotics. The operator retired and they have yet to be able to replace them. The manufacturing

companies make one or two parts or a particular piece of equipment. All but one of the companies has shown tremendous growth post-COVID-19 pandemic.

The participants each emphasized the need for workers. The lack of skilled workers is missing in the ecosystem. The new and advancing technologies are interesting and important to the future of manufacturing, but nothing can replace the skilled worker. The addition of new equipment and technology has created issues. Safety has always been an issue. The question is how to make the work environment safe for humans and robots to function in the same space. One participant added that safety is the biggest challenge. COBOTS, which is a reference to robots working alongside people, are still in the testing phase. There is limited data on the safety of robots in a manufacturing environment, and every manufacturing environment is different "limiting the accuracy of the data as related to their facility." One participant pointed out that the Occupational Safety and Health Association is unable to keep up with regulation to keep COBOTS environments safe. Another responded that "safety was the biggest concern about using robots" and has prevented them moving forward with the use of them. The task of "caging off motion control areas for employee safety limits the functionality of robot-human collaborative environments," and the "greatest challenge is making sure that employees are always safe" in these environments.

The robots, automation, and Industry 4.0 have created an environment that has the capability to live stream data to improve performance and efficiency. There is a "lack of a proven track record that supports a fully intelligent manufacturing system." The data provided these companies is coming from the people that produce the equipment. There is "limited data that shows a solid return on investment." Participants agree that it still comes down to return on investment. One participant described the purchase of two new robotic arms that increased

production by eight hours. The machines can do many of the tasks that used to take fourteen hours and complete them in six hours. The machines are capable of being fully implemented Industry 4.0. They are “Smart” ready. The cost to upgrade the facility to handle two machines in a “Smart” environment was eight million dollars. The return on investment is poor, as it would take decades to make up the costs for implementation. The robotic arms are unable to complete the entire tasks. In one welding environment, the participant explained that they have a skilled welder go around and “weld the areas the robot cannot reach.” The system is not ready to complete the entire manufacturing sequence. The participant with a hundred robotic arms explained that they still need workers to handle the material. The “automation is too complex for a robot to put the material in the correct place without a worker to properly check alignment.” Workers are needed to complete these tasks. One manufacturer described a problem that arose with having a “smart” environment, because the company was purchased by a larger company that was already setup in a “smart” environment. The larger company tried to turn all their companies into one “Smart” environment so that they could “all communicate in the same platform.” The process overwhelmed the employees causing many workers to quit their jobs for other jobs. The infrastructure of all the companies combined was unable to handle a complete smart system.

“Some manufacturing environments do not lend themselves to automation.” A participant pointed out that in one of their assembly lines two screws had to be installed by hand. “Two workers installed the screws with a handheld screwdriver.” The material was soft, and the delicate procedure required a limited amount of pressure. The ability for a worker to “feel the correct pressure was something a robot could not do.”

Technology is advancing at such a fast rate that many manufacturers would have to be constantly going back to the designers to upgrade product design for automation. This is a costly process that requires “going back to step one and redesigning the entire process.” The ability to redesign the product each time a new technology comes available is not feasible. The move to a “new technology or system must be thoroughly evaluated as cost effective” before any implementation can occur.

AI and virtual worlds are finding a place in manufacturing. Currently the use of AI and virtual worlds are being used by repair technicians to service some of the manufacturers. The inability to get technicians to the manufacturing plants forced companies to adapt to and use virtual worlds in some settings. One participant described using a software that “scans the work environment, recreates it in a virtual setting, and allows the technician to diagnose and repair the machines remotely.” The process still requires a worker at the plant to install or repair the equipment. The virtual world is amazing, as it provides an “accurate portrayal of the manufacturing facility, the equipment, and the manufacturing world.” The use of virtual world software to test production runs is also effective in “testing parts for failure in a nondestructive environment.” The part is digitally created and can be placed under a virtual load. The use of this environment to “check clearance on cutting procedure helps to sustain equipment and reduce the costs for replacement tooling.”

The participants agreed that there is “value in the use robotics and automation for increasing production and profits.” AI and virtual worlds are slowly creating opportunities for testing and provide for the “reduction of waste and the elimination of costly mistakes” in production. “Industry 4.0 and intelligent manufacturing are not yet realistic in Midwestern manufacturing.” The limited accessibility to internet and lack of infrastructure to support

“Smart” manufacturing or intelligent manufacturing is not yet in place. One participant added that the “use of new technology can only do so much” and the “greatest resource to the company is still the skilled worker.” The inability to find the workers to operate the new and advancing technologies and systems is still “the greatest limiting factor in their implementation.”

Summary

The data collected through the interview process identified significant themes in the challenges, solutions, and use of “smart” manufacturing with new technologies for resilience against future disruptions. Manufacturers in Midwest United States continue to face many of the same issues that have continually been issues in the past, as well as a plethora of new challenges, including the impact of the War in Ukraine, labor shortages, and inflation. Unfortunately, as with many aspects of pre-COVID-19 pandemic manufacturing, the stability the industry enjoyed for many years is unlikely to be restored. Manufacturers have continued to operate in the same old crisis management mode, which relies on when things “return to normal.” There will “not be a return to the conditions that existed before the COVID-19 pandemic” and before the war in the Ukraine. Manufacturers need to have greater flexibility in an unpredictable world. The changing landscape of the manufacturing presents challenges, as well as opportunities for growth. Manufacturers that adapted quickly positioned their companies to survive and even thrive during after the COVID-19 pandemic ended.

The supply chain, increasing sales and production, skilled worker shortage, and new technologies are challenges facing the manufacturing industry. New “green consumerism,” housing shortages, and employee safety add new levels of challenges to an industry trying to build resilience against future disruptions. The global supply chain has been permanently disrupted forcing manufacturers and suppliers to adapt to new and continuing challenges. The

COVID-19 pandemic created shortages, increased costs, and other unprecedented supply chain challenges. The inability for workers to go to work gave way to shortages in raw materials and components, as supply was unable to keep up with demand. The shortages gave way to inflation as price increases effected every level of the supply chain.

The demand to go “green” is a challenge for manufacturers. The rise in “conscious consumerism,” and purchasing decisions are towards items being made in “sustainable,” “ethical,” “environmentally friendly,” “green,” and “cruelty free” environments. The “green” agenda will continue to be a challenge for manufacturers.

The shortage of skilled workers is an issue made worse by the COVID-19 pandemic. Every level of the supply chain was impacted by the shortage of workers, from truck drivers to port delays. Manufacturers were faced with surging labor costs to maintain operations. They offered increases in pay and sign-on bonuses to entice workers to try and obtain and retain a sufficient workforce to keep operating at full capacity.

Disruptions continue to affect the manufacturing industry and through “adaptability and flexibility” midwest manufacturers continue to survive and even thrive in the new environment. The historically successful Lean Manufacturing strategies used for “just-in-time” manufacturing fell short as inventory ran low. Increasing warehousing and inventory are once again being used to offset supply chain issues. Bringing manufacturing back to the United States or “re-shoring” can be used to “shorten the supply chain” and reduce the impact from a disruption. Manufacturers are implementing “stress-testing” strategies to forecast issues in the supply-chain and “dual sourcing” to keep more pathways open in their supply chains. Manufactures continue to deal with difficulties in the hiring and retention of workers. They often hire and promote people that need training to get the skills needed for the job. The manufacturers that have

invested in their employees have found ways to implement effective and meaningful training opportunities to get them to the skill levels the company needs. The investment in people as a solution for building resilience against future disruption is a common theme echoed throughout the interviews. The value of the workforce could be seen in every aspect of the participants' responses.

The fusion of digital manufacturing techniques, "Smart" manufacturing and "Industry 4.0," with traditional manufacturing techniques will continue to disrupt and change manufacturing. Each of these areas will play a significant role in the future of manufacturing as they provide for faster and more efficient production and safer working conditions. Implementing the new technologies is a challenge. The shortage of workers to operate the equipment, and the lack of infrastructure to accommodate the "smart" manufacturing capabilities is an issue. The lack of internet and accessibility is an issue. The future possibility for its use has "great promise and potential" for providing resilience against disruptions in the future. The companies investing in the improvement of their infrastructure and their workers will have success with "Smart" manufacturing and the use of new technologies in the future.

Chapter V: Discussion, Conclusion, and Recommendations

The intent of this study was to gain an understanding of the challenges in manufacturing from the perspective of upper Midwestern manufacturing leaders whose voices, according to the literature review, have yet to be included in the conversation. The research study was comprised of interviewing eight local manufacturing leaders in the upper Midwest region of the United States to gain an understanding from their perspective of the challenges the U.S. manufacturing industry is facing in post-COVID-19 pandemic manufacturing and how they plan to meet the challenges. In addition, this study sought to understand how manufacturers will prepare for future disruptions.

Research Questions

The research questions for this study were designed to gain an understanding from the perspective of U.S. manufacturers on the effects the COVID-19 pandemic had on the manufacturing industry. Each question looks to uncover the challenges and solutions them as seen from Midwest manufacturers.

1. What challenges has the COVID-19 pandemic exposed and created for Midwestern U.S. manufacturers that need to be addressed to be sustainable in the future?
2. What are plausible solutions to the challenges facing Midwestern U.S. manufacturers that may help build resilience against disruptions in the future?
3. The “Smart” or “Intelligent” future of manufacturing is predicted to be happening now, and is their use along with the newest and emerging technologies such as robots, automation, and Industry 4.0 by Midwestern U.S. manufacturers realistic and effective to manage challenges from disruptions in the future?

This chapter aims to draw understanding to the study's research questions and contextualize the broader meaning derived from the perceptions of Midwestern manufacturing leaders used in this study. The researcher chose qualitative research as the best method to understand the research questions. According to Creswell (2018), a phenomenological study "describes the common meaning of several individuals of their lived experience of a concept or a phenomenon" (p. 57).

The researcher used personal and professional contacts from manufacturing leaders in Minnesota and Wisconsin, in the upper Midwest regions of the United States, to select a convenience sample for the study. Eight manufacturing leaders from eight different manufacturing companies provided answers to a series of open-ended questions from an interview schedule, which established their perceptions of the challenges facing the U.S. manufacturing industry, and how they plan to meet the challenges in preparing for future disruptions. The interviews were transcribed and coded using interpretational analysis to identify themes and patterns of perception among the manufacturing leaders.

Summary/Discussion

The outcome of this study was to gain insight into the challenges faced by the U.S. manufacturing industry from the perspectives of local Midwestern manufacturing leaders and how they plan to meet the challenges. According to the literature review in this study, the perspectives of Midwestern manufacturing leaders are missing from the research. Understanding their perspectives and examining what shapes them could help inform and guide manufacturers on planning and preparation against future disruptions.

The study's first research objective was to develop an understanding of the challenges the COVID-19 pandemic exposed and created for Midwestern U.S. manufacturers that need to be

addressed to be sustainable in the future. Challenges and disruptions can be used interchangeably to describe “the extreme, unexpected, and unpredictable events” that have impacted U.S. manufacturers (Doern, 2016, p 401.) The challenges facing the U.S. manufacturing industry described by the local manufacturing leaders parallel the disruptions described in the literature review. The challenges are often described as good or bad, and positive or negative are bound within the context and eyes of the manufacturer. The COVID-19 disruption boosted sales for some manufacturers. It was an unforeseen challenge that seemed unprecedented when the entire world closed its doors. In reality, "nothing ever stops." The government mandates that were put into place requiring “social distancing” disrupted global manufacturing operations, but manufacturing in the Midwestern United States adapted and excelled. The government mandates forced people “to get outside and away from other people.” The manufacturers developing outdoor-related equipment described their sales as “the highest they have ever been." Adapting to the sudden challenge of maintaining production and “keeping their customers happy" kept manufacturing going. One of the overarching themes the manufacturers repeatedly brought up was “the need for adaptability and the ability of a manufacturing company to adapt to any disruption.”

The supply chains have been a challenge for manufacturers. “The ability or inability to adapt to get the materials needed for production was a challenge,” along with the events that affected the supply chains (Handfield et al., 2020). Lean Manufacturing strategies became an issue that affected the supply chains. “Lean Manufacturing strategies have been used to reduce overhead and improve efficiency in the production process.” The Lean Manufacturing strategies limited the number of supply chains the companies had in place. The cost of developing and maintaining dual or multiple supply chains was considered too high and did not provide the

highest profit margin the companies desired. The COVID-19 pandemic brought attention to the necessity of having more than one supply line for maintaining operations during a disruption. The cost is too great for manufacturing to halt (Matos et al., 2020).

The workforce has been a challenging issue in manufacturing for decades. "The inability to find good workers has been challenging." Manufacturers have been dealing with an aging workforce, a workforce that lacks the proper skills, and a workforce that is quitting. There seems to be a shortage of people. "Some workers show up, work for a week, and never return." The need for skilled workers varies by manufacturer. The manufacturers are looking for workers with specific skills. The skill set is specific and limits overqualified workers for the position. The broader skillset and experienced workers require higher pay. The manufacturers are looking at their "return on investment," desiring cheaper laborers with a specific skill set to keep their profit margins higher.

Employee retention is a challenge. The COVID-19 pandemic created a sudden need for more workers. Manufacturers started using sign-on bonuses to attract prospective employees. Employees have been quick to move jobs to get the extra money. Manufacturers were suddenly challenged with trying to hire new workers and retain current workers. The competition between manufacturers for workers continues, and the hiring bonuses are increasing the costs of production.

The inability to find good workers has manufacturers looking for alternative means of production. Robotics and automation have increased production and increased profits. Using robotics and automation in manufacturing requires workers to have different skillsets. The need for workers continues to be an issue, as the skillsets needed keep changing with the advancement of manufacturing operations.

The use of new technologies and "Intelligent" manufacturing is challenging because of how quickly it is advancing and changing. There is a lack of infrastructure that can handle this level of manufacturing. With most Midwestern manufacturers set up to make only one or two products, the ability to adapt and retool is a near-impossible challenge. The infrastructure was designed for the highest return on investment. "Two workers installing screws with a handheld screwdriver has a higher return on investment than the costs of integrating new equipment." The cost to move to a "fully integrated and smart manufacturing facility would cost over eight million dollars for one facility." The cost of connecting one machine to the system was two million dollars. The other challenge is the need for more internet and access to storing data. The manufacturers would still need to find workers to analyze and interpret the data.

Some challenges are hidden behind other challenges. Validation of parts and equipment for the healthcare industry is expensive. Validation is a required process for anything used in health care. Manufacturers must get the material, machines, tools, and even the space they use for manufacturing validated before they can begin producing healthcare products. The request by government leaders to quickly adapt to make products for the safety and welfare of the citizens because of the COVID-19 pandemic was a costly challenge. Only one company successfully adapted its manufacturing facility because it already made healthcare products. The return on investment was poor, and the company closed after the COVID-19 pandemic.

More housing is needed for manufacturers trying to attract workers. The housing market in the upper Midwest has been an issue for decades. Many local homes are often second homes to people living outside of the area. The availability of homes is minimal, as they are bought up quickly by people looking for vacation homes. The costs of housing are over-inflated. The salaries provided for the workers do not align with the costs of home ownership.

The challenges described by midwestern manufacturing leaders align with the challenges listed in the literature review. The COVID-19 pandemic exploited and introduced new challenges that have multiple levels of challenges that disrupt manufacturers in many ways.

The study's second research objective was to develop an understanding of the: *plausible solutions to the challenges facing Midwestern U.S. manufacturers that may help build resilience against disruptions in the future.* The overarching question in finding solutions to the challenges is how to adapt to disruption. "Adaptability to a disruption will either make or break a company." The COVID-19 pandemic brought out the need for manufacturers to work together to plan and strategize for the next disruption. To be adaptable to disruption, manufacturers need to know what adaptability looks like in a disruption. "There needs to be a proactive effort of all stakeholders to promote regional and local manufacturing." The sharing of resources, research and development, engineering capabilities, and access to advanced materials, tools, and equipment is needed to retain and grow the Midwest's manufacturing industry.

Forecasting is strategy manufacturers use to predict what the company needs will look like in the future. In the past, manufacturers have forecasted years into the future. The COVID-19 pandemic has manufacturers looking at forecasting out four to six months. The shorter forecasting period allows manufacturers to adjust their supply chains as disruptions occur more frequently worldwide.

Manufacturers are now looking at single supply chains and how multiple supply chains will be more effective in getting supplies during a disruption. The ability to get certain parts is an ongoing challenge for some manufacturers. The use of single supply chains is over. Manufacturers are setting up multiple supply chains to overcome any disruption to a single supply chain. They are looking for ways to bring the production of supplies back to the

Midwestern United States and reduce the dependence on supply chains in other countries. Some manufacturers in the upper Midwest are getting their iron ore from local mining pits and making it into the materials they need for production. This farm-to-table strategy reduces the costs of importing materials and reduces the possibility of disruption in the supply chain.

Manufacturers rely on the expertise of other manufacturers in the area. Manufacturers are inviting others to their facilities to role-play specific disruptions. The role-playing strategy provides them a platform to engage in activities that simulate a disruption. Manufacturers test their strategies in a practical scenario. Manufacturers learn from each other on what works well and what areas need improvement.

There are no simple solutions to the shortage of workers. The literature review describes an increase in new technology and "smart" or "intelligent" manufacturing as solutions to the shortage of workers. The literature describes "smart" factories in the future that eliminate the need for workers. Robots and automation will be embedded throughout the manufacturing plants and perform all the jobs and tasks required in the manufacturing process. The manufacturers in this study believe that there is merit to aspects of the "smart" factories in the future. Manufacturers are using computer software, simulation, and robotics to improve production. The merit of "smart" manufacturing is providing a work environment that inspires workers through innovation and invention. The COVID-19 pandemic required a sudden urgency to provide a safe working environment for their workers. A safe work environment instills trust in the workforce. The manufacturers finding success with the workforce are building trust with them. They are removing the fear of failure, the fear of being laid off to make profit goals, and establishing a company that is moving forward together. They are establishing environments that encourage

trying new things through invention and innovation for the betterment of the workforce and the company.

Manufacturers are searching and investing in multiple areas to find solutions to the shortage of workers. They are investing and partnering with the local high schools to change the manufacturing industry's image. Careers in the manufacturing industry provide a pathway to the lifestyle many young people want. Manufacturers are expanding their search to take advantage of migrant workers. They are providing the tools and resources to bring them up to work in their companies. Manufacturers provide housing and transportation and help them find successful employment in the unfamiliar Midwest.

The manufacturers that are having the most success in this area focus on the human side of the workforce. Manufacturers that recognize that people are the most important asset to their companies are investing in their people. People want to feel a part of something. Manufacturers described the challenge of new workers working for a week and quitting because “they are not making a difference in the world.” The next generation workforce desires a sense of belonging and seeks trust and cooperation in their employer. They “want to make a difference” in the world. Manufacturers are bringing in and training their own. They are helping their workers gain the skills they need and are promoting them within the company. Workers are gaining a sense of worth in the company and are performing at a high level as everyone is invested in the company.

The study's third research objective was to develop an understanding of *whether the global perspective of "Smart" or "Intelligent" manufacturing that uses the newest emerging technologies such as robots, automation, and Industry 4.0 to manage challenges in the future is realistic and applicable to manufacturing in the Midwestern United States.* Technology will constantly be advancing and changing. "Technology is advancing at a rate that is impossible to

keep up with." "Smart" or "intelligent" manufacturing will revolutionize manufacturing. For years there have been predictions about how the use of robotics, automation, and "Smart" manufacturing will change the world. As seen in the literature review, half of the existing jobs in manufacturing will become automated and replace existing technologies (Manyika et al., 2017). Manufacturers have provided examples of how new equipment has increased production and "taken jobs that took a day to manufacture down to a couple of hours." Manufacturers have explained the benefits and the ramifications of the impact of new emerging technologies and “smart” manufacturing will impact manufacturing in the Midwest. Technology will affect individual activities in manufacturing but is unable to run the entire organization (Drakaki et al., 2022). Technology will continue to improve specific tasks but is only ready to take on some of the tasks required for production. The technology is capable of “welding multiple beads in a row but is unable to finish the tasks needed for production.” Workers will “always be needed in the manufacturing process.” Manufacturers must align employees and their skills with automated jobs that complement the machine's work (Manyika et al., 2017). The manufacturers that have chosen to train their workers for these environments are having the most success retaining them.

The more advanced robotics and automation become, the need for human-robot collaboration in the work environment increases. Manufacturers have referred to these collaborations as COBOTS. Manufacturers have struggled to produce a work environment that can guarantee the safety of the workforce. Robots require safety devices to keep the machines from swinging into the workers or workers reaching into unsafe spaces. There is "only so much control over an environment." Human-robot collaborations do not pair well with uncontrolled working environments (Voronin et al., 2021). "Relying on machines to handle things on their own can be scary, knowing machines can malfunction." The technology is available for a

customer to "simply pick the features you want, and the system gets unlocked for the customer to utilize." Knowing that something or someone else "can be in control of the equipment the workers are operating" is unsettling when trying to create the best working environment.

“Every blessing is a curse, and every curse is a blessing” best describes AI and “Smart” technologies.” They are some of the scariest trends for manufacturers today and some of the most promising. In one example the manufacturer described the slow and steady speed at which the industry advances. The systems that run the machines are still operating on a Windows 95 platform. The platform is considered safe and reliable, as people are not hacking old systems. The system went down, and the programming was older than some of the programmers. AI was used to create a program that would go in and fix the old program. AI was able to perform a task that the programmer could not do. Humans designing AI systems is changing manufacturing. The ability to train AI systems to process the environments they are in by interpreting things around them in that environment (Hu et al., 2021) is invaluable in manufacturing. AI and "smart" technologies are scanning parts and helping manufacturers identify where parts are out of specification. Computer programs are "simulating forces on products to make the designing process faster." It allows the manufacturer "to create stronger components at a less expensive price."

Manufacturers are using certain aspects of new technologies, robotics, and automation to improve the manufacturing process, increase productivity, and reduce waste. The costs for many manufacturers to become fully integrated and "smart" is too high. The advancement of machines and robotics is speeding up production. However, the costs are too high for integrating the new products into an infrastructure that is unable to handle the capacity of a "smart" facility.

The possibilities of their use in the future are realistic. There is a need to use new technologies and “smart” systems to keep manufacturing competitive in the future. College graduates have been hesitant to work for companies as concerns increase regarding whether corporations have the means to invest in the newest technologies (Cai & Luo, 2020). The younger generations see security in companies investing in new technologies. The "return on investment" will continue to be an issue until the infrastructure of the companies and the Midwest are improved. The advancement towards the use of new technologies and "smart" manufacturing will continue to create challenges, including the availability of the number of highly skilled workers to implement this type of technology.

Conclusion

Manufacturing in the United States is not dead or dying and is strong and growing. The issues and challenges disrupting U.S. manufacturing will continue. Disruptive technology, supply-chain issues, natural disasters, and issues related to the workforce will continue. The world is full of disruptions that are trying to reduce our chances or opportunities for success. Disruptions will come from every area in life, the ups and downs within the economy, the uncertainty of the stock market, and new technology that renders the current manufacturing model obsolete. It could be competition from other manufacturers trying to take over the industry and taking away jobs and incomes. At the minimum, the disruptions are taking away the workers' growth and stealing the business from manufacturers. We have no control over these forces. They are constant and will continue to create disruption. Disruptive technology will never fully replace the worker, but it will change the factory floor. Disruptive technology will be used to keep the workers safe and secure from future disruptions. The skills workers need to possess will change as technology changes.

U.S. manufacturers in the Midwest are finding inventive ways to solve the shortage of workers. Manufacturers have expanded their search for workers across borders, and are bringing migrant workers to their facilities, paying for their travel, housing, and training. They recognize the value that migrant workers have in keeping their companies operational. Investing in migrant workers builds community in their home countries as well as in the local community. Manufacturing leaders are recognizing the value of the workforce outside of their companies and their importance to community.

The common factor in each is the need for good people. The people are the most valuable component of an organization. They are human beings, who survived the trauma and impact from the COVID-19 pandemic and are bringing their experiences and feelings into the workplace. The COVID-19 pandemic exposed that the needs of the workforce have changed. A new focus on the workers and their feelings is changing the manufacturing working environment.

Manufacturers are adapting their work environments to create a work climate and culture reflective to their workers' needs. The working environment must be set up to make workers feel safe. A safe environment encourages worker engagement to be innovative and inventive. It is an environment that removes the barriers of always looking over one's shoulder worrying about what they are doing wrong and being laid off to make quota, and instead builds trust and cooperation with its workers. Workers feel valued within the company.

The manufacturers having the most success focus on the human side of their workforce and are finding ways to make them feel valued within the company. The personal interviews in this study provided a tremendous window of observation that allowed the researcher to sense and see the participants reactions that went along with their responses. Their facial expressions and voice variances added meaning to their responses, further revealing their view of people being

the most important asset to their companies. They legitimately care about their people and desire to see them succeed.

Manufacturers are choosing to invest in their people and are creating safe work environments that meet their workers needs and wants. A safe work environment has the resources to be safe in the next COVID-19 pandemic, while maintaining the freedom to be innovative and inventive. People perform at higher levels when they work in an environment that inspires them and removes fear, including the fear of failure or being laid off just to meet unreasonable goals. Manufacturers are building confidence, trust, and loyalty in their workforce, and in turn the workers give back to the company. As workers gain experience, they are included in organizational decision making, building community, and helping people feel that they are a part of something. The next generation workforce desires a sense of belonging and seeks trust and cooperation in their employer. Manufacturers are helping their workers gain the skills they need and are promoting them within the company. Workers are gaining a sense of worth in the company and are in turn performing at a high level as everyone is invested in the company.

The primary variable for success and sustainability of the industry comes from within the organization. Remarkable things happen when manufacturing leaders put the safety and lives of the workers within the organization first, even choosing to sacrifice their comforts and even the results to create an incredible working environment. When the workers feel safe in the work environment, they will work tirelessly in the face of disruptions and seize opportunities that allow them to try and fail, learn, and grow, building their self-confidence and helping them to achieve more.

Recommendations

In this section, the researcher will offer recommendations derived from this study. After disseminating the qualitative data and reflecting upon the shared perspectives, the researcher hopes that the conversations, feedback, and experiences collected as a researcher, institutional leader, teacher, and skilled laborer will offer meaningful insight into the challenges and opportunities to overcome these challenges within the manufacturing industry.

Manufacturing in the Midwest

Manufacturing is strong and growing in the Midwest. The majority of the manufacturers are small. The supply-chain issues will continue as disruptions continue. Bringing manufacturing back to the Midwest will provide jobs and the supplies needed to keep other manufacturers operational. By investing in each other, manufacturers could obtain new technologies that would increase production and cut down on supply chain issues. Schools and colleges could continue to collaborate to produce parts as they did during the COVID-19 pandemic. The opportunity to train and develop future workers while meeting the needs of local manufacturers is a win for all stakeholders.

Workforce Training

It has been the experience of the researchers that manufacturing leaders who invest in their workforce have fewer issues with employee retention, regardless of the disruptions around them. Manufacturers who invested in the training and development of their workforce described employees as having a higher level of engagement and productivity at work. Workforce training allows manufacturers to train and retrain their workers to their employment needs. Invest in the workers and help them become who they want to be and what the company needs them to be.

Safe Workplace Environment

Cultivating a workplace environment that is inclusive and safe should be a top priority for manufacturers. As a skilled worker that spent time in the trades, the researcher has experienced the negative influence of sacrificing employees to make the end-of-the-year goals. A safe workplace environment provides more than just the safety requirements OSHA requires. Workers are looking for a place to belong and feel valued. Workers are unable to perform at their highest ability when having to wonder if they will be laid off. Manufacturers must remember that they work with people in a community and are important active members contributing to the community. A safe workplace environment provides the security needed for employees to explore innovation and invention. Employees need to be able to try and fail as necessary, learning as they work to advance the company. Manufacturers need to invest and create safe workplace environments.

Grow Your Own Leaders

Grow your own leaders is an idea based on being the leader you wish your leadership would be. It means going out and doing what the company leadership needs to do. Be the leader that you wish you had. Manufacturing leaders that allow their workers to bring to the table areas of improvement are finding great success. The openness builds trust and cooperation in maintaining the industry and ultimately growing future leaders for the industry.

Future Research

Further research can be done to uncover greater depth in manufacturing in the Midwestern United States. Adding a quantitative or mixed-methods approach to the study would add further depth to this study. Small Midwestern manufacturing companies perform the majority of small batch manufacturing in the Midwest. Research into the development of

additional small batch manufacturers and their use to localize manufacturing. Research could be gathered on the materials used in manufacturing and evaluated against the supply chains to determine the best product lines for the local manufacturers. Additional research on successful strategies for attracting and retaining employees could also benefit manufacturers seeking to build a strong and stable workforce. Identification of specific skill sets needed to implement the new technologies could be beneficial for educational institutions as they plan programming for building the workforce of the future.

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Appendix A

Interview Schedule

I am going to read you some questions regarding your personal experiences, observations, and insights on the challenges the manufacturing industry is facing, what you perceive as the solutions to the challenges, and how you perceive the use of “smart” manufacturing and new technologies will be used in manufacturing. Your answers are intended to be open-ended, and your identity will be kept strictly confidential, so I encourage you to speak openly and as freely as possible. At any time, you can request to have your testimony withdrawn from the study or terminate this interview.

This interview will be recorded for the accuracy of your answers. With your permission, I will start the recording and begin the interview.

***Start recording

What challenges has the COVID-19 pandemic exposed and created for Midwestern U.S. manufacturers that need to be addressed to be sustainable in the future?

1. What challenges did the COVID-19 pandemic create for your company?
2. What prior challenges did the COVID-19 pandemic exemplify for your company?
3. What ongoing issues that have resulted from the COVID-19 pandemic?
4. Have there been any hidden challenges that have been exposed within your operations?
5. Describe any ongoing issues that have compiled because of recent disruptions? (Supply-chain issues, worker shortage, worker quality, etc.)

What are plausible solutions to the challenges facing Midwestern U.S. manufacturers that may help build resilience against disruptions in the future?

6. What methods does your company use to anticipate and prepare for disruption?
7. How does your company build resilience against potential disruptions?
8. What is missing within your company that is needed to build resilience against future disruptions that is not in place?
    i. Why is it missing from your company?
9. Will the manufacturing industry ever return or resemble pre-COVID-19 pandemic normality?
    i. Is it possible to return to pre-COVID-19 pandemic normality?
    ii. Should it return to pre-COVID-19 pandemic normality?
10. What do you see as solutions to building resilience in the global supply chain?
11. Will there be a return of domestic U.S. manufacturing? (Should there be?)
12. What are some of the solutions that you identified for current challenges?
    i. What does an All-American supply chain look like?
    ii. How do we strengthen the resilience of America's supply chain?
    iii. What do you see as the challenges to rebuilding U.S. domestic supply chains?

The "Smart" or "Intelligent" future of manufacturing is predicted to be happening now, and is their use along with the newest and emerging technologies such as robots, automation, and Industry 4.0 by Midwestern U.S. manufacturers realistic and effective to manage challenges from disruptions in the future?

13. What is your local industrial manufacturing ecosystem as it exists today?
14. What do you see is missing from the ecosystem to make it uniquely competitive today and in the future?

15. What do you see as the most troubling trends in manufacturing today and in the future?
16. What do you see as the most promising trend in manufacturing today and in the future?
17. How has the ever evolving and advancement of new technologies impacted local manufacturing and in what ways?
18. Are these new technologies and intelligent manufacturing that includes AI, Robotics, and Industry 4.0 reasonable, realistic, and possible solutions for local U.S. manufacturers in the Midwest?

Thank you, this concludes my questions. I may contact you in the future to ask additional questions. I appreciate your willingness to assist with this research.

***Stop Recording

Appendix B

Table of Specifications

Problem Statement 1. The COVID-19 pandemic created new challenges in addition to existing ones that need to be clearly identified and addressed to help the industry remain sustainable and competitive in the future. Although researchers have worked to define the issues facing the manufacturing industry, a clear understanding of the issues from the perspective of local manufacturing leaders is lacking and needed for planning and preparation against future disruptions.	**Problem Statement 2.** The COVID-19 pandemic exposed vulnerabilities in U.S. manufacturing, such as the overdependence on imports and foreign supply chains (Handfield et al., 2020), the shortages of skilled workers (Deloitte & The Manufacturing Institute, 2020), and the lengthy and costly process of adjusting to ongoing disruptive new technologies. New and emerging technologies with increased innovation could bring sustainability to U.S. manufacturing against future disruptions. However, there is a gap in the literature indicating the reasonableness of these solutions in application to local manufacturing environments, as local manufacturing leaders have been left out of the conversation.	**Problem Statement 3.** No historical event provides a comparable guide on moving forward from a disruption of this magnitude. The road map to building resilience against disruptions in manufacturing does not exist. Global perspectives suggest Industry 5.0, smart technology, robotics, artificial intelligence, and automation are possible solutions to these issues, but questions linger on if they are realistic for local manufacturers in the Midwest.
Research Question 1: What challenges has the COVID-19 pandemic created and exposed for United States manufacturers in the Midwest that need to be addressed to be sustainable in the future?	**Research Question 2.** What are plausible solutions to the challenges facing Midwestern U.S. manufacturers that may help build resilience against disruptions in the future?	**Research Question 3.** The "Smart" or "Intelligent" future of manufacturing is predicted to be happening now, and is their use along with the newest and emerging technologies such as robots, automation, and Industry 4.0 by Midwestern U.S. manufacturers realistic and effective to manage challenges from disruptions in the future?
Interview Questions		
1. What challenges did the COVID-19 pandemic create for your company?	6. What methods does you company use to anticipate and prepare for disruption?	13. What is your local industrial manufacturing ecosystem and infrastructure as it exists today?
2. What prior challenges were made worse by the COVID-19 pandemic?	7. How does you company build resilience against potential disruptions?	14. What do you see is missing from the ecosystem to make it competitive today and in the future?
3. What ongoing issues have resulted from the COVID-19 pandemic?	8. What do you see is missing within your company that is needed to build resilience against future disruptions? - Why do you suppose it is missing?	15. What do you see as the most troubling trends in manufacturing today and in the future?

4. Have there been any hidden challenges that have been exposed within your organization or operations?	9. Will the manufacturing industry ever return or resemble pre-COVID-19 pandemic normality? - Is it possible? - Should it return?	16. What do you see as the most promising trends in manufacturing today and in the future?
5. Describe any ongoing issues that gave compiled because of recent disruptions? Examples to go off: - Supply-chain? - Worker shortage - Skillset, etc.	10. What do you see as solutions to building resilience in the global supply chain?	17. How has the ever evolving and advancement of new technologies impacted local manufacturing and in what ways? - Positively? - Negatively? - Needs to change?
	11. Will there be a return of domestic U.S. manufacturing? - Should there be?	18. Are these new technologies and intelligent manufacturing, including Artificial Intelligence (AI), Robotics, and Industry 4.0 reasonable, realistic, and possible solutions for local U.S. manufacturers in the Midwest?
	12. What do you see as the solutions to building resilience against disruptions? - What does an All-American supply chain look like? - How do you see strengthening the resilience of U.S. supply chains? - Challenges to rebuilding U.S. supply chains?	

Appendix C

Themes

	Research Question 1: What challenges are local U.S. manufacturers facing that need to be addressed?					**Research Question 2:** How do U.S. manufacturers in the Midwest build resilience against disruptions in the future?							**Research Question 3:** Is the use of the newest and emerging technologies, robots, automation, Industry 4.0, and "Smart" universe, by local manufacturers realistic and effective to manage challenges from disruption in the future?					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	Supply chain Worker safety Adaptability Blind Decision Making Sales Boost	Worker short. Skilled Workers Automation Robotics	Bonus jumping Supply-C Housing Inflation	Hiring bonuses Inflated Pay Age WF	Supply shortage Worker shortage	Forecasting Employee Trust	Flexibility Validation Listening	Workers Infrastructure	Costs	Partially Automated Some Robots No AI or Smart	Maybe, In Some Areas	Shorter/Better Forecasting Close to home Supply Chain Skilled Training	Few Robots Limited Internet Smart Not Feasible	Infrastructure Knowledgeable Workers Strong Intern.	Lack of Workers Tech Adv. To Fast	Increase in Sales and Demand	Can't keep up. Increases Production.	Yes More Skill workers
B	Supply chain Worker safety Adaptability Extra Orders Inflation	Finding Good People Connectiveness Poor Internet	Over-hire Supply-C Housing	Hiring bonuses Inflated Pay	Supply shortage Worker shortage	Short Forecasting Employee Value	Flexibility Dual Sourcing	Workers Infrastructure	Costs Availa.	Partially Automated No Robots, AI, or Smart	No, Not like it should,	Shorter/Better Forecasting Close to home Supply Chain	No Robots Lack of internet	Infrastructure Knowledgeable Workers Strong Intern.	Lack of Workers Tech Adv. To Fast	Increase in Sales and Demand	Improves efficiency Production	Yes In time.
C	Supply chain Worker safety Adaptability Job loss Inflation	Finding Good People Automation Robotics	Supply-C	Hiring bonuses Inflated Pay	Supply shortage Worker shortage	Read and React Scheduling	Investing in Workers Flexibility Open Door	Skilled workers Infrastructure	Costs Skill Workers	Automated Some Robots Some Smart No AI Smart Potential Smart	Probably Not	Shorter/Better Forecasting Close to home Supply Chain	Robots Internet Security Strong	Infrastructure Knowledgeable Workers Strong Intern.	Lack of Workers Tech Adv. To Fast	Increase in Sales and Demand	Expensive and Costly	Yes, with Improve Infrastr.
D	Supply chain Worker safety Adaptability Pay increases	Finding Good People Retention	Over-hire Supply-C	Quitting	Supply shortage	Lean Manuf.	Validation Dual Sourcing	People Infrastructure	Costs Availa.	Partially Automated Some Robots No AI or Smart Potential Smart	It would be nice to see more	Shorter/Better Forecasting Close to home Supply Chain Skilled Training	Few Robots No Smart Cap.	Infrastructure Knowledgeable Workers Strong Intern.	Lack of Workers Tech Adv. To Fast	Increase in Sales and Demand	Expensive Limited Return on Investment.	Yes, improve Infrastru. More Skill workers
E	Supply chain Worker safety Adaptability Inflation	Finding Good People Automation Robotics Training People	Supply-C Housing Inflation	Age WF	Supply shortage Worker shortage	Forecasting Employee Build Trust	Multi Sourcing Using Empl.	Workers Infrastructure Training	Not sure. Workers	Partially Automated Some Robots No AI or Smart	Yes, some	Shorter/Better Forecasting Close to home Supply Chain	Few Robots No Smart Cap.	Infrastructure Knowledgeable Workers Strong Intern.	Lack of Workers Tech Adv. To Fast	Increase in Sales and Demand	Can't find skilled workers to operate it.	Yes More Skill workers
F	Supply chain Worker safety Adaptability Pay Scale	Finding Good People Automation Robotics	Supply-C	Age WF	Supply shortage Worker shortage	Forecasting Employee Trust	Multi Sourcing Using Empl.	Investing in Workers Ecosystem	Costs Availa.	Partially Automated No more Robots No AI or Smart Skilled workers	No, I don't think so.	Shorter/Better Forecasting Close to home Supply Chain Training	Few Robots No Smart Cap. No workers	Infrastructure Knowledgeable Workers Strong Intern.	Lack of Workers Tech Adv. To Fast	Increase in Sales and Demand	Improved production time. Expensive Maintain	Yes, Some day. More Skill workers
G	Supply chain Worker safety Adaptability Layoffs	Finding Good People	Supply-C Housing Inflation	Age WF	Supply shortage Worker shortage	Forecasting Employee Build Trust	Multi Sourcing	Good workers	Costs Workers	Partially Automated Some Robots No AI or Smart	Some	Shorter/Better Forecasting Close to home Supply Chain Skilled Training	No Smart Cap. Internet Good Infra Good	Infrastructure Knowledgeable Workers Strong Intern.	Lack of Workers Tech Adv. To Fast	Increase in Sales and Demand	Good and Bad. Potential Costs to high	Yes More Skill workers
H	Supply chain Worker safety Adaptability Finding good workers. Advancing Tech Sales Boost	Finding Good People Training People Retention		Age WF	Supply shortage Worker shortage	Lean Manuf.	Investing in Workers	Skilled Workers Training Infrastructure	Automat	Partially Automated Some Robots No AI or Smart	Some, I wish more	Shorter/Better Forecasting Close to home Supply Chain	Old and limited Smart Potential Not feasible	Infrastructure Knowledgeable Workers Strong Intern.	Lack of Workers Tech Adv. To Fast	Increase in Sales and Demand	Increase production Potential to be great. Costs high	Yes More Skill workers