OTEM 2032:

Catalyzing the Disruption of Transportation Equipment Manufacturing in Ontario

by

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Abstract

Artificial Intelligence (AI) has created uncertainty. This uncertainty of the impact that AI could have on jobs, people, and life as we know it is often met with sensationalized suggestions such as Elon Musk's assertion that AI is humanity's biggest threat (Higgins, 2017). However, I believe that AI is a technology and merely a tool; it is not a force of nature. Hence, as a resident of Ontario who works in the manufacturing industry, I asked:

"What might we expect of the manufacturing activities of Ontario's Transportation Equipment Manufacturers (OTEMs) during the emergence of AI in the next 15 years?"

I examined this question through a literature survey, scenario planning, and impact analysis.

I developed a scenario-planning matrix that included the two most critical uncertain drivers surrounding OTEMs' business activities in Ontario. These drivers were AI's ability to significantly disrupt the human labour requirement and the outsourcing of manufacturing activities. I explored the relationship between these two drivers and how scenarios could be used to develop resilient strategies. Next steps included using the uncovered parameters in a strategic planning process for OTEMs to develop strategies and create a culture that embraces resilience.

Key words: AI, manufacturing, automation, Ontario, scenario-planning tool

Dedication

This work is dedicated to the Jibodu family.

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1.0 Overview

1.1 Introduction: Made in Ontario

The year 2007 saw declining employment in the manufacturing sector of Ontario, which was asymptomatic of an economy on the brink of a recession. As a matter of fact, by 2014, manufacturing employment would shrink a further 33% (Statistics Canada, 2015). The decline in manufacturing employment was not only affected by the recession, but also by the growing pressures on certain segments of the industry that are labour-driven because productivity is growing faster than sales (Boothe, 2015).

In 2009, labour-driven industry players like automotive parts manufacturers companies were facing significant challenges such as the bankruptcy of one of their major customers General Motors. Apart from challenges faced on the demand side during the recession, such Ontario manufacturers were also confronted with the knock-on effects of the rise in value of the Canadian dollar, increasing energy costs and wages. Furthermore, there was increased competition globally, which was further exacerbated by the lack of investment in technologies and the relatively low productivity in Ontario manufacturers when compared to their global competitors (Ministry of Finance Ontario, 2014).

In Ontario, the key manufacturing industries include: food, chemicals, and transportation equipment manufacturing. The transportation equipment sub-sector is particularly significant to Ontario because it contributes about 35% of total manufacturing sales in the province, making it the largest contributing sub-sector (Statistics Canada & CANSIM, 2017). Some of these transportation equipment manufacturers in Ontario, required to maintain profits, already began moving manufacturing jobs overseas to countries with lower wages, leading to the incredible shrinkage of manufacturing employment. Since the 2007 recession, the shrinking manufacturing employment rates in Canada have normalized while global competitors have seen employment numbers increase (OECD, 2015) since 2011. Even with the reduction in energy costs and the more recent recession in the Oil and Gas industry, manufacturing employment in Ontario has not experienced resurgence. This is because companies who moved their operations out are not necessarily moving them back to Canada given that other economies have developed more favourable conditions for manufacturing (such as lower wages) while also improving their productivity.

In Canada, manufacturing supports $1.74 CAD in output from other sectors for every dollar in final sales of manufactured products, which speaks to its incredible multiplier effect (Boothe, 2015). Hence, it is important to note the significant role that manufacturing plays in our economy. Even though there has been a significant drop in manufacturing employment over the last decade, there are still

numerous growth opportunities for the sector as a whole in terms of revenues, productivity, and creating high-paying skilled jobs within manufacturing. These growth opportunities are currently explored by competing economies around the world as new strategies are being developed for the future of manufacturing.

1.2 Artificial Intelligence (AI): The Effect of Technology

Disruptions of established industries are more commonplace than ever before due to the increased rate of adoption of technology and more specifically computing, information, and communications technology. The increased rate of adoption of these new computing technologies, like AI-enabled technologies, is growing because information and communications technology has increased the rate of exposure that industries have to these technologies. These new technologies are serving as catalysts in creating changes in people's way of life and how our economies operate. The sentiment exists amongst business leaders that the advent of AI is too significant to simply ignore and potentially too disruptive not to proactively prepare for (Domonoske, 2017). The rate at which disruptions are occurring due to technology advancements does not allow for a "wait and see" approach as a strategic option. The author hypothesizes that the catalyst of the next wave of disruptions is going to be AI, which has been evident in the advancement of robots and cars (Del Prado, 2015). This begged the question:

Would Ontario embrace AI as a positive disruption in the manufacturing sector?

1.3 Research Goals

The goal of this paper is to query the preparedness of OTEMs for dealing with the potential disruption that the advent of AI-enabled technologies would have on their business both domestically and abroad. Using a detailed literature review as the starting point, the objective is to test the performance of current strategies being executed by OTEMs in future scenarios that could affect the manufacturing industry within 15 years.

For an OTEM, the resilience and sustainability of their business model is critical, hence this paper would inform the decision-making process for their leaders today as they prepare for a future that could be disrupted by advances in AI. One such critical decision is the resource allocation for capital investments.

Currently, most recommendations to OTEMs and their stakeholders have been for policy changes, education reform, foreign investment, and the adoption of new technologies. These recommendations have led to OTEMs investing in places like Mexico due to the relatively low wages there and favourable trade agreements. However, these investments were disrupted with the regime change in the United States and the election of President Donald Trump in 2016. This illustrates the importance of considering unexpected disruptions when making decisions and ensuring that suitable resilience is built into the strategic decision process.

The author hypothesizes that the advent of AI could be one such disruption that completely transforms the operations of OTEMs and results in new capabilities. Another goal for this paper is to lead to more strategic investments that would boost productivity and ensure the competitiveness of Ontario-based manufacturing companies as AI could disrupt it within 15 years.

1.4 The Research Question

Over the next 15 years, how might OTEMs proactively develop resilient business strategies to mitigate the implications of the emergence of AI-enabled technologies on their manufacturing activities?

1.5 Research Limits: The Human-Jobs Factor

The future of Ontario-based manufacturing is riddled with such uncertainty that some may question the focus on manufacturing in the context of the broader strategy to create jobs and economic opportunity in Ontario.

The advancement of AI in robotic applications and automation means that human workers are not as critical as they once were to the manufacturing process. There is fear with regards to the future of work, especially when one considers the substantial number of people employed in manufacturing roles in places like Ontario. Job creation is usually a key performance indicator for an industry's

health; however, advancements in technologies have signalled that manufacturing in Ontario should not only be judged based on the number of jobs it creates.

While the research performed by the author largely considers the future of the workers in these companies; their role is confined within the boundaries of stakeholders to the OTEMs. Other stakeholders whose interests were considered include: labour unions, retirees, educational institutions, and the government.

The focus of the research is based on the overall health of the manufacturing industry in Ontario within the context of an overall economy and not only on the human jobs that are created or the wages that employees earn. The author is of the view that by not constraining recommendations to creating or protecting human jobs, it will be possible to embrace strategies that create a multiplier effect for job creation in other economic sectors.

1.6 Aspirations of Work

As noted by the author, AI is poised to catalyze a largely irreversible change within numerous industries including manufacturing. It is important that the insights from this research effort can be used to create a set of actionable steps. These will be used to build resilience into Ontario's manufacturing industry in the near term and into the future.

Using the systematic strategic foresight approach to elicit insights, we might discover new strategies and principles that inform Ontario's manufacturing industry as it navigates through uncertainties over the next 15 years. The study aims to gain unique insights and to create a set of potentially unorthodox strategies that can leverage the conditions and strengths peculiar to Ontario. These insights could serve as a competitive advantage for manufacturers in the region.

The insights expected from this work are industry-focused and enacting them into strategies and policies should not only be an industry-driven effort. It would involve supporting efforts from government and educational institutions.

2.0 Research Methodology

The research design consisted of a Literature Review, Scenario Planning, and Impact Analysis.

Literature Review: This review had three objectives:

1) Conduct a historical scan of the manufacturing industry in Canada
2) Conduct a review of the current business activities, strategies and performance of Transportation Equipment Manufacturing in Ontario
3) Conduct a review of current deployment of AI in manufacturing

Scenario Planning: Scenario planning proffers a number of options about how the future might realistically develop upon the examination of trends, drivers and critical uncertainties as inputs. These inputs are then used to tell stories about the future. The 2x2 matrix method was employed following an eight-step process, which was adapted from the 10-step process for scenario planning outlined by Woody Wade (Wade, 2012).

1. Set Research Boundaries
2. Collect Signals and Determine Trends
3. Identify the Drivers
4. Determine the Critical Uncertain Drivers
5. Set Scenario Parameters (Generate 2x2 Matrix)
6. Select Scenarios
7. Assess Implications
8. Identify Signposts

The method deployed for Scenario Planning was the 2x2 matrix, which is one of the most used foresight methods for scenario planning. It is a solid foresight tool that was deployed and completed independently by the author. As a business professional with over a decade in various manufacturing functions spanning several industries, the author incorporated his experience and observations into this section. This experience was used in analyzing the vast amounts of data and wisdom expressed by industry experts as discovered during the environmental scanning to collect signals and determine trends. Sources of this data scanning provided quantitative data in the form of industry statistics as well as qualitative data from expert interviews.

Impact Analysis: The final stage of the research phase was to analyze the results from the literature review process and the findings from the scenario planning process. These results were then assimilated to determine the impact that the advent of AI might have on the manufacturing activities of OTEMs.

3.0 Ontario's Transportation Equipment Manufacturers

3.1 A Brief History About Manufacturing

Manufacturing has always been a mainstay in the modern economy and while some might trace the beginning of manufacturing to the 18th or 19th century, the fact is, we have always made things. Over time we have changed how many things we are capable to making and the methods we use to make them. These changes have occurred in line with the advances in technology, which has altered the processes and output volumes significantly for all manufacturing industries from food production to home goods and chemicals to electronics (J. Smith, 2017).

Figure 1: Manufacturing Process

As noted in Figure 1 above, manufacturing simply refers to the conversion process of raw materials into finished goods. Before advanced machinery and automation, most manufacturing processes were carried out by hand. The manual requirement of manufacturing processes meant that the responsibility of manufacturing fell on skilled tradespeople. These artisans handled the design, production and quality control; hence, the quality and quantity of manufactured goods was constrained to the skill level and availability of the tradespeople. Over time the artisans became "interchangeable parts" in the manufacturing process, which led to reduced downtime, efficient labour usage, and mass production. As mass production became more important, the roles of the artisans would ultimately be diminished as the increased demand for manufactured goods, assembly lines, division of labour, and new technologies (fixtures, jigs, gauges) made it possible for identical parts to be manufactured quickly and correctly by less-skilled workers (Roe, 1916).

By the 19th century, the first Industrial Revolution would transition manufacturing processes away from hand production methods involving humans to machines. The use of machines has since become an important hallmark of manufacturing. Since then, technological innovations such as the information and communication technologies (ICTs) have led to unprecedented levels of connectivity made possible by the Internet. It has customized labour flow and made the segmentation of the various components of manufacturing easy.

Furthermore, the innovations in machine designs have led to the development of robotic systems, which have cut down labour costs, human error, and lag time between steps in the assembly process. Nowadays raw materials from the earth can be extracted from one part of the world, transported and quickly processed at another location, then shipped and manufactured elsewhere. Manufacturers have also improved their processes through systems such as “just-in-time” and “lean manufacturing” which eliminate waste and reduce flow times. Other processes like prefabrication save on time by shipping fully assembled or partially assembled units directly to the site where they will be used.

3.2 What are Manufacturing Activities?

The definition of the business of manufacturing is important because manufacturing is known to cause a multiplier effect in numerous other business processes. The multiplier effect refers to the effects that manufacturing has in spurring on and enabling other business services. It might also be intimated that manufacturing makes manufacturing possible. For example, let’s consider the manufacturing activities involved in making complex products such as cars. For a motor vehicle to be manufactured, several other manufacturing activities occur upstream in order to create the components that make up the vehicle. Complex manufacturing processes involve a supply chain, which is a series of consecutive manufacturing processes, where the output of one manufacturing process serves as the input for the next manufacturing process. These steps are often referred to

as tiers (illustrated in Figure 2 below) of typical automobile manufacturing activities.

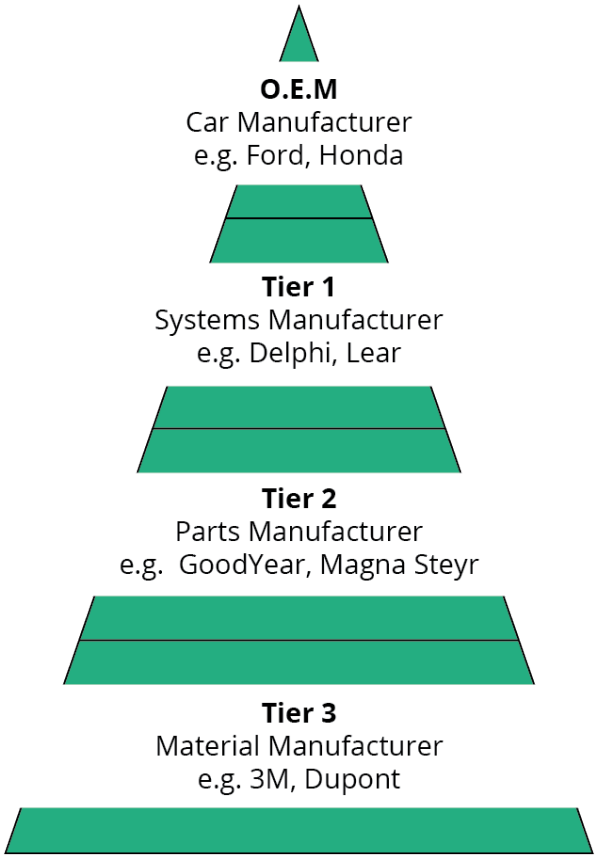

Figure 2: Tiered Manufacturing Supply Chain

The disambiguation about what is considered manufacturing should clarify the significant role it plays in an economy. With many manufacturing companies now engaging in the offering of services, it is becoming increasingly difficult to distinguish between "traditional" manufacturing and a "traditional services" company. When other business practices such as outsourcing are considered, this leads to further questions as to how to clearly define a manufacturing company.

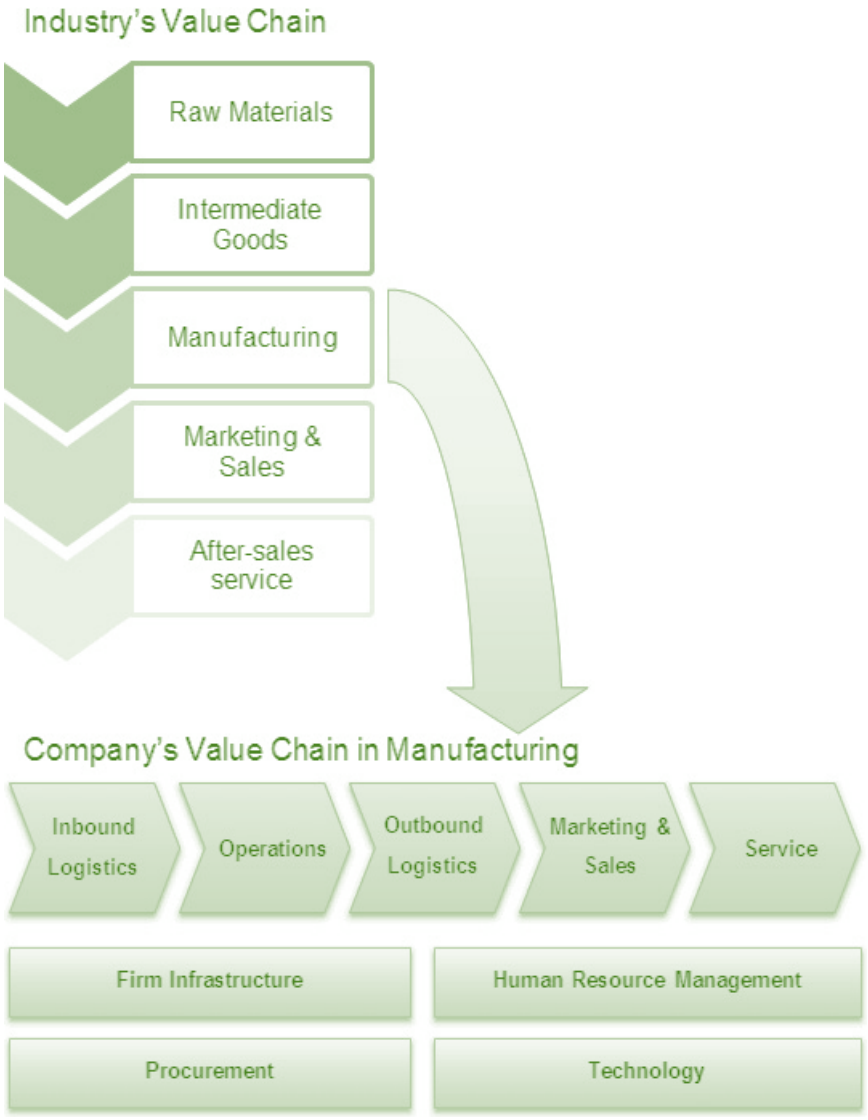

Figure 3 : Manufacturing Value Chain

Manufactured goods drive global trade as well as primary and secondary demand for services, both as a direct input to products and through the services consumed by those employed in the sector, such as marketing and sales. They are noted in the value chain model in Figure 3 above. It is important to note that manufacturing in this paper is defined as the making of tangible goods, referred to as hardware and not intangible goods such as software. This distinction is often

difficult to express because intangible goods are mostly distributed via an interface of tangible goods that are then sold and serviced. When discussing manufacturers in Ontario, the author is referring to all manufacturers, processors, and producers classified by Industry Canada.

One of the most important practices in manufacturing activities is outsourcing. It externalizes the manufacturing process, which is the actual conversion process from raw materials to finished goods. The increased levels of outsourcing create a general sentiment of a shrinking significance of manufacturing as more companies now engage in service-oriented activities. As profitable as outsourcing has been for manufacturers, we note that the actual manufacturing process plays a significant role in design and innovation. Harvard Business School professors, David Pisano and Willy Shih, in their research, made these observations:

> *Once manufacturing is outsourced, process-engineering expertise cannot be maintained, since it depends on daily interactions with manufacturing. Without process-engineering capabilities, companies may find it increasingly difficult to conduct advanced research on next-generation process technologies. Without the ability to develop such new processes, they find they can no longer develop new products. In the long term then, an economy that lacks an infrastructure for advanced process engineering and manufacturing will lose its ability to innovate.*
> (Pisano & Shih, 2009)

As alluring as it might be to specialize only in high-value research, design and development, and to outsource the rigors and labour costs associated with manufacturing, we ignore the circular nature of innovation.

Innovation is largely an iterative process; hence, ignoring the manufacturing function creates avenues for new competitors to emerge as they grow and begin to generate intellectual property of their own. With regards to design and process engineering, intellectual property is a key competitive advantage, which is critical when one considers the product imitation and the cost of efforts required to legally protect one's intellectual property. When referring to manufacturing processes, intellectual property is not often discussed, but as technology becomes more involved, it becomes more critical. Intellectual property is often measured in the number of patents that are held; however, production systems such as the Toyota Production System (TPS) were touted as a huge competitive edge held by the company. Recent moves towards "donating" or "open sourcing" of patents (Tesla) and production methodology (Toyota) don't make the patent and system originators any less competitive (Deep Centre, 2015). The move to open-source a technology typically conceals a much larger public relations strategy that effectively places the patent holders as innovative thought leaders and could also create avenues for revenue generation in the form of licensing fees.

3.3 The Current State of Manufacturing: Ontario vs. The World

In Ontario, some sectors of manufacturing have seen their global competitiveness hampered (Oschinski et al., 2014). Most labour-intensive manufacturing processes are not competitively carried out in Ontario due to economic forces that are reshaping and have an important impact on the industry. Thus, while

manufacturing is and will remain an important sector in developed economies like Ontario, its relative importance declines with the growth of the services industry (De Backer, Desnoyers-James, & Moussiegt, 2014). Even though Ontario is a manufacturing activity powerhouse, the services sector is the largest part of Ontario's economy. It employs 79% (or 5.3 million people) of the province and makes up 76.9% of the province's economy. Examples of Ontario's major services sector include business & financial services, professional & scientific technical services, and arts & culture (Ontario, 2017).

Historically, in most Organisation for Economic Co-operation and Development (OECD) countries, as manufacturing grows, the service industry grows until an inflection point that sees manufacturing decline even as the service industry growth continues. Most OECD economies like Ontario move to take steps that solidify the service industry to meet the growing consumer demand for services. The effects of this manufacturing decline are partially offset by the overall growth of the economy and when compared with the service sector, are evident in Ontario and across many OECD economies. This is not the case globally. While employment in manufacturing has declined in Ontario, it is still a strong source of employment globally (Dooner, 2014).

In Canada, the stagnant contribution of manufacturing to the Gross Domestic Product (GDP) employment growth has led to the popular narrative of manufacturing's decline. Currently in 2017, manufacturing represents about 10% of GDP (Statistics Canada, 2017b) and an equivalent share of employment (Statistics Canada, 2017a). However, there is a strong manufacturing presence for even the fastest growing firms in Canada and manufacturing sales in Canada totalled about $615 billion dollars in 2016 with Ontario contributing about 49%, $301 billion dollars (Statistics Canada, 2017). Furthermore, the strong performance of the consumer retail and wholesale sectors are dependent on the sales of manufactured goods. The origin of these manufactured goods is changing, as most of them are being sourced globally and sometimes imported by local manufacturers.

Global sourcing is practiced by numerous businesses that aim for price competitiveness. Some Ontario manufacturers achieve this by building manufacturing plants in locations around the world that are closer to the raw material inputs of their plants or locations closer to their customers. The biggest driver for global sourcing is the lower wages available especially in labour-intensive manufacturing sub-sectors. Some Ontario manufacturers, such as Canada Goose, have kept their labour-intensive manufacturing processes within Canada as this provides a competitive advantage that is strongly tied to their brand promise of having products that are "Made in Canada." This brand promise

serves as a major competitive advantage for them as they sell globally and combat imitations that are rampant in the textile industry (Schaan & Wood, 2014).

Some other manufacturers have moved production back to Canada, citing corrupt governments, increase in wages, and increased transportation costs. A number of manufacturers have found it more competitive to manufacture their goods in North America. Local production has become more feasible due to the trends towards automation, which has increased production efficiencies, creating a downward pressure on labour demand in Ontario. The weak labour demand is even present in sub-sectors of manufacturing companies that are experiencing sales growth. The Ontario manufacturing sector has seen revenues rebound from their 2009 lows with the average annualized growth of 1.56% (Deep Centre, 2015).

Manufacturing is typically subject to the economic forces of supply and demand, so as demand continues to grow due to the ever-increasing world population, and global GDP, it is expected that globally the need for manufactured goods will continue to grow. Today; however, Canada's manufacturing firms face significant and increasing challenges to their competitiveness in supplying the demand for these manufactured goods. Many of these challenges are driven by a handful of forces at work globally that are contributing to a re-shaping of the manufacturing industry - raising competitive intensity and consequently raising the bar on the

capabilities that firms must bring in order to remain competitive. Internationally there are three major themes driving change in the manufacturing sector and creating both challenges and opportunities for Canadian firms:

- Growing trade liberalization and global disaggregation of supply chains
- Sustained levels of global financial uncertainty and volatility in inputs
- Primary demand growth slowing in developed countries and shifting towards emerging markets

(Dooner, 2014)

These global forces are affecting even the most robust local manufacturers and supply chains in Ontario and these effects are being felt quite strongly within the OTEM Sector. The transportation equipment manufacturing sector is one of the pillars of Ontario's economy. Some details about it are noted below:

1) Highest Sales in Manufacturing Sector
2) 21% of all manufacturing jobs are in this sector
3) Growth Sector with Large Margins Capable of Capital Investments
4) Largest Procurement of Robots
5) Highly Technical and Globally Competitive Industry

The industry is also quite peculiar because since 2009, the transportation equipment sector has seen increasing revenues and above average increases in employment numbers when compared with other manufacturing sectors (OMAFARA, 2016). Transportation equipment manufacturers in Ontario include global giants like Magna International and Bombardier. However, Ontario manufacturers are not known as global leaders in productivity and efficiency. Most leaders in those manufacturing metrics are based in Europe and the USA

(OECD, 2017) where most technological advances and productivity gains are currently being experienced due to the fact the companies in those countries have embraced high levels of automation and higher energy efficiency (Oschinski et al., 2014).

3.4 Advanced Manufacturing Technologies: AI

AI is the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, and decision-making (McCarthy, 2007). These are things normally done by people and, in particular, are associated with people acting intelligently. AI is often discussed relative to human intelligence, but it is a broad field of study that is filled with ambiguity and sometimes, confusing terminology due to its general definition.

Two classifications of AI that are broadly used include Artificial Narrow Intelligence (Weak AI), and Artificial General Intelligence (Strong AI) (Kurzweil, 2005). Weak AI refers to machines that can perform intelligently in specific, pre-programmed areas, while Strong AI, which is currently hypothetical, refers to machines that are capable of intellectual tasks such as reasoning, planning, learning and communication that any human being is capable of (Morse, 2015). Another hypothetical classification of AI is Artificial Super Intelligence, which

refers to a machine that would be much smarter than the human (Dickson, 2017). In the research performed for this report, the author considered advances in the application of AI technologies that would enable machines to act intelligently and propagate intelligent automation.

One of the areas of AI research is Machine Learning. This provides computers with the ability to learn without being explicitly programmed (Samuel, 1959). Machine Learning focuses on the development of computer programs that can teach themselves to grow and change when exposed to new data (Rouse, 2017). Machine Learning has been embedded into the development of new machines such as the self-driving Google car, amongst numerous applications. The application of Machine Learning is moving further upstream into the manufacturing processes of goods in the future. It is expected that manufacturing will undergo a significant shift unlike any other since the Industrial Revolution (Brynjolfsson & McAfee, 2014).

The Industrial Revolution marked a major turning point in history that radically changed work as we know it and was a major driver of economic and social changes over the course of the century it took to spread throughout the world. It remains to be seen whether the impact of AI would be as significant or whether it serves as an incremental change to the industrialization process. The earlier stages

of assembly lines comprised mostly of people, but on the onset of industrialization people were either being replaced or aided by machines capable of performing single repetitive tasks. These machines boosted efficiency and productivity; however, machines require maintenance and most are designed and programmed to perform singular tasks (Wohlers, 2008) unlike humans, who can learn new skills and perform multiple complex tasks.

Machines that perform tasks are commonly referred to as robots. A robot is a conduit for AI, not AI itself. The development and deployment of robots and robotic systems has grown significantly due to the exponential rate of technological advancement, with the developments in sensor technology as a significant driver. With the advent of AI and specifically the progress made in Machine Learning, robots that were once limited to singular tasks are now being developed to be able to learn new tasks without the need of reprogramming (Urban, 2015). These types of advancements and the impact from the application of these new technologies and more intelligent machines in the manufacturing process were the focus of the scenario planning process.

4.0 OTEM 2032: Scenario Planning

4.1 Rationale

The expected capabilities of AI are yet to be fully realized and some experts believe AI will be smarter than humans within 30 years (Pressman, 2017). Others expect it to permeate wide segments of daily life by 2025 (A. Smith & Anderson, 2014). Meanwhile, AI's current capabilities have astounded many onlookers like when IBM's Watson won against two of Jeopardy's greatest champions (Markoff, 2011) and technologies like driverless cars and autonomous vehicles are currently generating interest. These feats do not clearly indicate the future implications of AI; however, researchers have begun exploring implications on the future of work, such as the popular book Race Against the Machine (Brynjolfsson & Mcafee, 2012). Out of 1,896 experts who responded to a 2014 Future of the Internet survey, about half (48%) envisioned a future in which digital agents such as AI have displaced a significant number of workers (Rainie & Anderson, 2017). This is one of many scenarios, but it does not fully address the unique complexities and economic conditions of OTEMs.

Using scenario planning as a foresight tool in addressing the noted research question for OTEMs will help manufacturers and government officials (at federal, provincial and local levels alike) to better prepare for the future. Even though there are both short and long-term strategies already in place and numerous

recommendations, there are still numerous difficult choices to be made, especially in an era of constrained resources. These choices surround questions involving:

1) *Which industries are to be prioritized, manufacturing or services?*
2) *Which kinds of jobs will people do?*
3) *Which modes of transportation would dominate?*
4) *How are demographics, economics, and travel behaviour likely to interact over time?*
5) *Which investments should be funded?*
6) *Which are the most important trends to monitor over time?*

These are all complex questions, particularly because industry incumbents and policy makers experience frequent disruptions. The current rate of disruption is allowing for substantial change (which tended to happen relatively slowly) to happen at a much quicker pace. The effects of disruption are felt much more severely sooner, due to the shorter time horizons, which means reactive policy made less effective.

4.2 Scenario Planning Process and Results:

The scenario planning process used involved eight steps outlined in the methodology section of this report. The detailed results from each of the steps are presented in the following sections.

1. Set Research Boundaries

The scenario process started by defining the four key study parameters to determine the scope of the study:

- The Lens: Emergence of AI

- The Industry Scope: Transportation Equipment Manufacturing
- The Geographic Scope: Ontario
- The Time Horizon: 15 years (2032)

The Lens - Emergence of AI

Globally, the deployment of Information and Communication Technologies (ICTs) has paved the way for the emergence of AI. This emergence is often referred to in various forms and misnomers, such as: big-data, smart data, data mining, smart systems, intelligent systems, robotics, internet of things, algorithms, digitization, computerization, deep learning, machine learning, analytics, decision-making, machine-to-machine communication, technology-enabled, advanced systems, autonomous, and automation (McCarthy, 2007). All the various forms of AI simply indicate the enhanced learning, communication, and decision-making capabilities of computers. These technologies in their different forms would simply be referred to as AI-enabled technologies.

The Industry Scope – Transportation Equipment Manufacturing

Manufacturing is a critical engine of the economies of both developed and developing countries. In Canada, manufacturing represents about 17% of GDP and an equivalent share of employment. Manufacturing supports $1.74 CAD in output from other sectors for every dollar in final sales of manufactured products, which speaks to the incredible multiplier effect that it has. Therefore, it is

important to note the significant role that manufacturing plays in our economy as the health of our manufacturing sector is important to sustaining the burgeoning service sector.

This sector as a whole is broad and diverse with each sub-sector sharing overall similarities in processes, but also having their own unique constraints and driving factors. Even though energy prices may affect the food, clothing, chemical, and transportation equipment manufacturing industries, factors like climate change have more adverse effects on food manufacturing. When we use a scope of AI, it is important to identify the sub-sector of Transportation Equipment Manufacturing, which is the most important customer of industrial robots and an industry that is synonymous with automation and robots.

Transportation Equipment Manufacturing is a sub-sector of the entire manufacturing sector. It is a major component accounting for large shares of cross-border trade, manufacturing sales, manufacturing gross domestic product, and employment. This industry sub-sector is comprised of the automotive, rail, aerospace, and the marine sectors. For analytical purposes, the scope of study is limited to only the automotive (motor vehicles), rail, and aerospace sectors. Discussions about Transportation Equipment Manufacturing are often dominated by the automotive sector, which is usually divided by analysts into two categories:

assembly and parts. Assemblers include the likes of General Motors and Ford, while suppliers include Magna International and Linamar Corporation. Bombardier heavily dominates the rail and aerospace sectors in Canada.

The framing around transportation equipment brings into question the concept of mobility. In this analysis, mobility provides the supply and demand of economic constraints on the transportation equipment sector. Consequently, local factors that affect mobility of people and products, such as demographic trends, also heavily influence the transportation equipment sector. As these trends mature, our mobility requirements might evolve over the next number of years, which is the reason the entire sub-sector of transportation equipment manufacturing is being discussed as opposed to focusing solely on the currently dominant automotive industry. This level of understanding of mobility requirements would influence our discussions of transportation equipment manufacturing.

The Geographic Scope - Ontario

Ontario contributes about 70% of the Canadian GDP generated by the Transportation Equipment Manufacturing sub-sector. The significance of Ontario as a province cannot be understated. The governmental structure of Canada places the responsibility for mobility and industries at the provincial level, which results in Ontario's policies having a significant influence on their constituents.

The analysis would therefore revolve around factors unique to Ontario, such as demographics, energy & environmental policies, infrastructure, transportation & road regulations.

By aggregating the industry and geographic scope, it can be surmised that the analysis revolves around OTEMs. However, OTEMs are not necessarily Canadian-owned Corporations operating locally in Ontario. Some of them are foreign-owned, while others are international subsidiaries of larger global organizations. Some Canadian-owned OTEMs also engage in manufacturing activities outside of Ontario and outside Canada as a whole. The term OTEMs is all encompassing, but this study revolves around the local impact of the manufacturing activities of these OTEMs.

The Time Horizon (15 years)

The time horizon of about 15 years provides a long enough period to apply foresight techniques to the increased number of possibilities that arise when studying the future. The goal is not to predict the next 15 years, but to look at how AI and other factors would affect OTEMs when combined in diverse ways. By examining the present time, it is possible to gather various signals and trends that may become driving forces used to develop future scenarios as they either increase or decrease in relevance and occurrence.

2. Collect Signals and Determine Trends

It is not predetermined that the future will be limited by the past neither is present circumstance a perfect indicator of the future. Disorder, disruption, externalities, emergence and its effects are inevitable. The information that was collected from the literature review was useful in gaining a perspective on the current state of manufacturing in Ontario. However, scenario planning for a 15-year timeline required a different form of research that was focused on collecting signals of change. The present state of affairs have been captured by various thought leaders and institutions that have conducted extensive research and interviews with manufacturing industry leaders in Ontario and Canada as a whole. The current state of manufacturing is littered with various signals of change such as the Industries 4.0 initiative in Germany (MacDougall, 2014). These signals have culminated into full-blown trends, such as those towards smart manufacturing happening globally. The objective of this review was to, therefore, capture these signals and highlight trends in order to create scenarios for the future.

Scenario planning proffers a number of options about how the future might realistically develop upon the examination of signals, trends, drivers, and critical uncertainties as inputs. These were then used to tell stories about the future.

Signals

Signals represent indications and evidence of change. A signal can take many forms, such as a news headline, new educational course on offer or other such "signs of the times." Just about any indication of cumulative change may be significant. In order to identify signals, an environmental scan within and around the set research boundary was performed. Various online news sources, videos, and books were discovered using keyword searches, reviewing online signal collection forums, databases, and websites related to the research boundary.

Before aggregating the various signals that were discovered, the strength of the signals was determined by assessing the stage of adoption and evaluating the general awareness within public forums. Of the 486 signals collected, 168 were tagged as weak signals, which is essentially a sign of change that is not yet generally appreciated. In some cases, the majority of experts or people would generally dismiss it as being irrelevant. The weak signals such as the new class of machine learning called Deep Learning (Deng & Yu, 2014) and new classifications of AI (Ban Yuli, 2017) could often only be discovered from specialized or sometimes obscure sources and independent researchers with mostly isolated mentions and coverage. Whereas the strong signals such as autonomous/self-driving vehicles like Tesla have significantly more mainstream media mentions and general public awareness.

Overall a total of 486 signals were reviewed from online resources such as Policy Horizons, web databases used for aggregating signals of change in transportation, and resources from other educational institutions. The signals that were collected from these various sources were aggregated into a total list of 140 signals (including 35 weak signals), which formed the basis of a trends analysis.

A combination of weak signals and strong signals could highlight the emergence of an overarching trend. This signal collection exercise resulted in a seemingly limitless supply of information. The relevant information was filtered using the STEEP+V (Social, Technological, Environmental, Economic, Political and Values) framework to guide the process and aggregate the findings in order to determine whether any trends were emerging.

Trends

Trends are patterns of change that indicate significant, directional shifts across the spectrum of lived experience and observation. From the list of signals, the author performed further analysis to determine important trends that have potential for growth and significant long-term impact. Multiple sources were reviewed to determine if linkages and patterns began to emerge from the various signals over time. These patterns provided insights that were aggregated to determine if the signals were pointing to a particular pattern and creating a trend. The author

reviewed the trends to determine whether their impact was increasing or decreasing by scanning sources (such as policies), news articles, and industry reports within the manufacturing, transportation, mobility, and AI sectors. The trajectory of the trends was assessed based on its state in 2017 and the author noted that with a time frame of 15 years, a trend that currently consists of weak signals might prove to have a significant impact in 2032 and another trend that has strong signals might see their potential effects wane over time.

Typically, trends are aggregated using the STEEP+V framework. Most of the trends cut across multiple elements of the framework. Some of the important trends and their trajectories were noted:

Human Resources Trend - Economy, social and values:

- Drive for Efficiency and Productivity: *Increasing*
- Lower Education Attainment: *Increasing*
- HR Analytics: *Increasing*
- Income Inequality: *Increasing*
- Aging Workforce: *Increasing*

Technology Trend:

- Deployment of Automation & Robotics: *Increasing*
- Ubiquitous Connectivity: *Increasing*
- Big Data: *Increasing*

- Privacy Concerns: *Decreasing*

Economic Trend:

- Outsourcing and the Rise of Emerging Markets: *Increasing*
- Currency Volatility and Volatile Commodity Pricing: *Decreasing*
- Global Financial Uncertainty: *Decreasing*
- Disaggregation of Supply Chains: *Increasing*
- Start-Up "Unicorns" (Billion dollar valuations): *Increasing*

Government Policy Trend - Politics, economy, environment:

- Trade Liberalization: Taxes, Tariffs and Grants: Decreasing
- High Energy Pricing: Increasing
- Extensive Environmental Policies & Taxes: Increasing
- Infrastructure Development: Increasing
- Hyper-Regulating Disruptive Start-Ups & Technologies: Decreasing

3. Identify Drivers

This list of trends was analyzed to determine causal relationships and thereby identify the change drivers. Drivers are underlying causal forces at work within systems leading to more visible manifestations of change, which are apparent in trends and their signals. The analysis was carried out by asking what factors contribute to trends. For instance, some trends discovered in relation to human resources included immigration policy changes to allow faster immigration processes for skilled workers, companies investing heavily in automation

solutions, increased levels of outsourcing, stagnant productivity levels, later retirement age, increased promotion of trade schools and an increasing wage gap. When this set of signals and ensuing trends were analyzed, it was found that these manifestations were emerging mostly due to shortages in skilled labour. These shortages have a direct and causal relationship with the trends identified. As such, they are causing those trends to increase.

The author reviewed each of the four clusters of trends, sequentially. The human resources trends were reviewed together, then the technological trends, then economic trends, and finally the government policy trends. For each cluster of trends, the author then determined what drove them. Some of the drivers that were discovered from this approach include:

- Trade Liberalization: Taxes and Tariffs
- Advancements in AI and Automation Technologies
- Skilled Labour Shortages
- Globalization and Emerging Markets
- Regulation of Start-Up Technologies

4. Determine the Critical Uncertain Drivers

The author performed an impact analysis to score and rank the potential importance and impact the drivers could have on OTEMs. This scoring and ranking system was informed by the author's decade long involvement and

experience in the manufacturing industry of Ontario and the review of literature sources. The selected drivers were all determined by the author to be propelling the trends forward in 2017, but that trajectory is not guaranteed going into the future and generally difficult to call, i.e. highly uncertain. It was therefore important that the drivers were evaluated to determine the level of uncertainty.

This analysis of the trajectory of the driving forces was done by an educated decision-making process that involved measuring current impact that such drivers are having based on the disruptions and changes that are being reported in various parts of the world today and their possible impact in the future. Industry experts usually perform this process of selecting the drivers. Practitioners from the selected industry and the most important drivers might vary depending on the criteria determined by each participant to evaluate importance. In the absence of access to industry practitioners, the author relied on information presented by OTEM leaders in available sources, such as annual reports, conference commentary, and media reports. These drivers may not highlight the most pressing concern of every individual OTEM, so the author relied on such sources to assess the level of uncertainty and impact related to each of the noted set of drivers while making use of the various sentiments and trends gathered from research.

Additional sources used in this assessment included opinion editorials, blogs, news reports, interviews, and press releases put forward by several leading OTEMs and their stakeholders. This review enabled the author to evaluate the uncertainty levels of each driver from an industry-wide perspective.

The analysis concluded by ranking each driver on a scale of 1-10 (with 10 being the highest), to numerate the level of impact and uncertainty. The drivers with the highest levels of both impact and uncertainty were noted as the most critical uncertain drivers, which could have a significant disruptive impact because they were both highly impactful and unpredictable.

The top three critical uncertain drivers determined were:

1. Advancements in AI and Automation Technologies
   Uncertainty: Would automation & robotics destroy, replace, create or simply assist a significant number of human jobs?
   Impact: AI and automation could affect productivity, efficiency, energy management, job skills requirement, and job availability within the business activities of OTEMs.

2. Globalization and Emerging Markets
   Uncertainty: Would global demand for manufactured goods grow via new emerging markets? Could this demand be met via exporting from established manufacturing centers or would global demand be curtailed due to infrastructure and economic constraints?

Impact: The growth and viability of emerging markets could affect OTEMs' abilities to grow their business revenues and affect the viability of manufacturing centers that have been established locally in the countries they are head-quartered in or internationally.

3. Trade Liberalization: Taxes and Tariffs

   Uncertainty: Would global trade (which is heavily influenced by taxes and tariffs) be restricted or liberated by new government policies?
   Impact: This would affect the ability of OTEMs to access foreign markets to receive supplies and parts and also to sell their finished goods and make revenue.

It was important to validate the critical uncertainties that were determined independently by the author based on the author's review and expertise. A preferred method to do this would have involved a survey, or interview with industry experts, managers, decision-makers, and representatives of OTEMs and their stakeholders, who could be invited to perform the trends and drivers' analysis exercise that was performed by the author. Such an exercise is important in the foresight process in order to eliminate the author's bias from being reflected in the drivers identified as most critical and uncertain. In the absence of access to such expert resources within the available timeframe for this project, the author leveraged related work that had been undertaken by other researchers who had insights provided directly from industry personnel and used similar foresight tools and scenario planning methodologies. These sources include Peter Schwartz's Inevitable Surprises (Schwartz, 2004), the World Economic Forum's

Seven Challenges to Globalization (Leonard, 2015) , The RAND Corporation's Future of Mobility 2032 (Zmud, Ecola, Phleps, & Feige, 2013), Foresight Alliance's Automation and Work: Understanding Local Impacts (Justman, 2016), and IVEY's – The Future of Canadian Manufacturing: Global Context (Dooner, 2014) amongst other sources. These resources were cross-referenced amongst each other and also with the author's selected set of critical uncertain drivers to determine which drivers would be selected as the most critical uncertain drivers. The two most critical uncertain drivers that came out of this process were:

1) **The Drive for Automation & Robotics (AI):**

The selection of this particular driver as one of the most critical uncertain drivers enables the assessing of the extent to which the advancement and adoption of AI technologies disrupt human work. This critically uncertain driver is expected to have significant impacts on the future of work, changing the roles, and number of human workers that will be deployed in organizations. This driver has been studied by numerous researchers assessing the future of work and is often presented as one of the most uncertain drivers because there is yet to be a consensus as to the extent of disruption that is expected. One of the uncertainties includes whether AI would disrupt human workers or merely help human workers perform their duties more efficiently. Other uncertainties are whether the expectations we have of AI would be encumbered by policy interventions,

infrastructure constraints or technological shortcomings. Some considerations include the cost and benefit of investments in AI if global demand is not high enough and the cost of the social impacts such as unemployment rates that could be a result of using technology. Furthermore, would unemployment only affect blue-collar workers or would the advancements in AI affect white-collar work as well?

The relative infancy of AI in terms of its' deployment in enhancing manufacturing technologies, such as automation efforts and robot deployment, would be important for OTEMs to assess. For instance, from such an analysis an OTEM might decide whether to delay purchasing robots or equipment that may not be AI enabled in favour of AI-enabled technologies in the near future. By constraining this uncertainty within the next 15 years, an OTEM might be able to assess and measure the pace at which this critical uncertain driver is progressing over time and make strategic decisions for resource allocation.

Due to the extent of possible impacts and questions that could be asked from analyzing this critical driver, the author decided to focus on the question of whether AI enabled technologies would be a highly disruptive force for human work within OTEMs business activities. This is because the human work component of OTEMs business activities is critical and it currently impacts the relatively high costs of production, efficiency, productivity, capability, and capacity of OTEMs. Studying this driver

would generate significant implications for OTEMs and impact their business.

2) Globalization and Emerging Markets:

Examining this critical uncertain driver enables a better assessment of the role that OTEMs play in the Gross Domestic Product (GDP) and employment of people in Ontario. This would better help assess the role that local manufacturing activities (within Ontario) play in an increasingly global economy. For instance, if an Ontario-based multi-national firm gradually employs more people outside of Canada and increasingly generates more of its revenue from sales by its foreign subsidiaries, the impact of that company's prosperity is not reflected adequately in the local economy of Ontario and Canada as a whole. In such a situation, the local economy would not reflect that OTEM's global success. However, if that OTEM was able to satisfy the global demand for their products from operations locally (within Ontario) through exports, any prosperity gained by that company would be reflected locally and contribute to the GDP of manufacturing in Canada.

Currently, the expectation for growth in demand for manufacturing products is for it to be generated from emerging markets. Some of these

markets have favourable economic conditions that have allowed OTEMs to set up manufacturing centers within these countries in order to satisfy the demand for their products. These economic conditions include low wages, low energy prices, and government incentives. Various OTEMs find it economically viable to export globally from these foreign locations. Furthermore, some of the goods sold to OTEMs' business customers locally (within Ontario) are actually produced globally by OTEMs and imported into Ontario. OTEMs have recently grown their investments in manufacturing activities globally (outside of Ontario) while others have committed to investing in manufacturing locally (within Ontario).

This driver is extremely significant when one considers the impacts that emerging markets would have on OTEMs businesses. Emerging markets currently serve as the main avenues through which OTEMs can grow their business revenues. Some of these emerging markets have protectionist regimes that require OTEMs to set up manufacturing activities locally, while others have significant infrastructure deficiencies and lack in the necessary pool of skilled workers that would be required in a manufacturing center. It would be important to evaluate how all these economic factors contribute to where OTEMs situate their manufacturing activities because these economic factors are significantly impacted by political factors. For instance, political factors such as the trade agreements

that govern international trade – imports and exports. These trade agreements are now subject to increased levels of uncertainty due to recent political events: the United Kingdom's (UK) exit from the European Union (EU), the Trans Pacific Trade Deal (TPP), which had been negotiated for over six years then neglected, as well as the North American Free Trade Agreement (NAFTA)- that had been in effect for over 22 years- is set to be re-opened for negotiation. Such significant events have created increased levels of uncertainty on key factors that affect where an OTEM would situate their manufacturing centers. It is important to examine whether manufacturing activities would increasingly progress locally (within Ontario) or globally (outside Ontario) over the next 15 years.

5. Set Scenario Parameters (Generate 2x2 Matrix)

The critical uncertain drivers were selected due to their high potential impacts on OTEMs and high degree of uncertainty. Two opposing and extreme conditions for both drivers were then evaluated to create the required tension between the extremes for creating divergent future scenarios.

To what extent will the adoption of AI technologies disrupt human work – High vs. Low?

Employment automation does not happen overnight - it is an incremental process that is not only affected by the speed and effectiveness of technological

advancements, but also the appetite for change and the financial capability of the OTEMs to adopt these new technologies in order to fulfil their strategic objectives. The author therefore examined divergent extremes of this scenario within the context of 15 years. The two extremes were tagged with the marker *High Levels of disruption of human work* and *Low Levels of disruption of human work.*

High Levels of disruption could be accompanied with significant deviations from current levels of human employment in manufacturing activities that are attributed to the adoption of AI technologies as opposed to any other economic factors such as a recession. Such a disruption could be accompanied by significant job losses at an annual actualized decline rate greater than 10%, which would lead to a steep decline in industry employment. This condition could include unemployment, significant changes in roles, responsibilities, skill-requirement and importance of human workers. This condition could ultimately be epitomised by a significantly reduced number of human workers; hence, AI would be deemed to destroy human jobs in manufacturing activities because significantly fewer humans could be needed to manufacture the same volume of goods due to the prevalence of AI technologies.

On the other side of the spectrum, Low Levels of disruption by AI could be accompanied with similar levels of human involvement in manufacturing

activities as we have today. These human workers might be disrupted by economic conditions, but they won't be disrupted as a result of the adoption of AI technologies. Such a condition could be characterized by job growth, improved efficiencies, and human deployment of technologies within manufacturing activities.

The advancements in AI required to accompany High Levels of disruption and Low Levels of disruption would also differ significantly. In 2017, Artificial General Intelligence (Strong AI) is considered to be hypothetical. AI-enabled machines are not able to exhibit intelligence in cognitive applications and mimic human intelligence in multiple applications. However, there are strides being created in Artificial Narrow Intelligence (Weak AI), which has seen several applications and what some believe a convergence with Strong AI. One distinguishing note between Strong and Weak AI is that Strong AI, which mimics human intellect, is capable of intelligence in multiple areas and the same human brain is capable of learning and unparalleled creativity that isn't governed by rules. However, the intelligence capacity of Weak AI is currently limited to singular tasks. For example, the chess playing AI that is capable of expert-level chess playing is not simultaneously capable of playing monopoly, playing checkers, or making conversation; which is a capability within human intelligence or Strong AI if it is attained by a machine.

Attaining Strong AI is therefore not required to achieve high levels of disruption in the manufacturing sector. Major disruptions would occur with continuous advancements in Weak AI if it has the potential to create machines that are more intelligent and adept at expert level performance in more complex applications. With more of such advancements in the future, AI could perform both simple and complex manufacturing activities from material handling to general assembly, scheduling, and quality control operations. Furthermore, advancements in Machine Learning could enable multitasking robots and ones capable of adding skills that infringe on skilled work and machines less reliant on any human input or supervisory oversight. Such technologies could be highly disruptive in a manufacturing setting and provide avenues for cost savings.

What role will local manufacturing play in an increasingly global economy - Local vs. Global?

OTEMs have long been involved in local (within Ontario) and global (outside Ontario) manufacturing activities. With primary demand growth slowing in developed countries (North America) and shifting to emerging markets such as Asia, it would be important to consider if within 15 years most of OTEMs' manufacturing activities would occur locally or globally. These two extremes serve as the markers for this critical uncertain driver as it denotes the location for manufacturing activities that in turn reflect on the GDP and potential employment of the manufacturing sector in Canada.

The condition of local manufacturing could involve OTEMs investing locally into new manufacturing centers within Ontario. Most of their product sales could occur within Ontario or via exports from these manufacturing locations in Ontario. This condition could be characterized by favourable economic factors within the province that support such manufacturing activities. Some of these economic factors could include favourable trade agreements, access to skilled workforces, and low energy prices.

On the other side of the spectrum, global manufacturing activities could be accompanied with OTEMs operating more manufacturing centers outside of Ontario. In this context, outside of Ontario does not include relocation to another province within Canada, but it denotes relocating manufacturing activities outside of Canada; which is why it is noted with the marker "global." It is also important to note that global relocation includes manufacturing activities happening in other North American countries like the United States of America and Mexico and not only locations in the emerging markets. This condition is characterized by a significant reduction in the GDP and potentially in employment numbers attributed to the manufacturing industries in Ontario, even though OTEMs still generate significant revenue from their global operations.

Once the two extremes for the two critical uncertain drivers were created, a matrix was formed in order to create four permutations that depict possible combinations between both drivers. These four permutations are noted in a 2x2 matrix. The four regions that emerged from the 2x2 Matrix are:

High disruption of human work by AI & Local Manufacturing Activities	High disruption of human work by AI & Global Manufacturing Activities
Low disruption of human work by AI & Local Manufacturing Activities	Low disruption of human work by AI & Global Manufacturing Activities

Table 1: 2 X 2 Matrix

The conditions that exist within these four regions of the 2x2 matrix were to be used as the basis from which four unique scenarios would be created. These scenarios would then be constructed to illuminate the world using the signals, trends, and drivers that appeared during the scenario planning process.

6. Select Scenarios

After creating the 2x2 matrix, scenarios conforming to the four separate quadrants are then created in the foresight scenario planning process. Scenario creation is a process that is best accomplished as a collaborative exercise. This allows various stakeholders the ability to contribute expert insights that deeply enrich the scenarios and as a result a better understanding of the implications and

impacts. Due to the absence of a suitable pool of stakeholders to collaborate on the scenario creation process, the author elected to review published literature of scenarios that have been created by reputable foresight researchers, government think-tanks, and consultants who have created scenarios for the future.

To select a suitable scenario resource, the author evaluated the sources based on the following criteria:

1) Relevance to the research question
2) Relevance to the selected timeframe
3) Use of similar scenario planning techniques
4) Use of foresight methodology in scenario development
5) Consistency with identified sets of trends and drivers
6) Data driven references and sources.
7) Applicable to OTEMs

Based on these noted criteria, the author concluded on using scenarios that were developed by Foresight Alliance. In their report *The Futures of Work*, Foresight Alliance created a large group of scenarios that fit within the timeframe selected for this study and had a global focus. The work, which was sponsored by the Rockefeller Foundation, was performed using the foresight framework to generate validated scenarios in the report. The report was prepared to analyze the impacts of these scenarios on the poor and vulnerable population. However, the signals, trends and drivers used to generate the scenarios could also be used to analyze the impact on OTEMs because there was significant correlation between the signals, trends and drivers that were generated by the author and those used in the Foresight Alliance report.

The Foresight Alliance research generated several scenarios, which were constructed by analyzing numerous uncertain drivers. Some of these drivers include the prevalence of manufacturing work as opposed to agriculture work; the adoption rate of AI by employers; and the attainment of significant technological innovation that would make AI technologies displace human workers, assist human workers, or be so challenging to implement that it doesn't displace human workers. The Foresight Alliance report included several scenarios that could be used in this study by the author. The scenarios from the Foresight Alliance report were plotted within the 2x2 matrix developed by the author in order to determine which one of the scenarios are best aligned with and are relevant to OTEMs. From this graphical analysis of the Foresight Alliance deck in relation to the author's 2x2 matrix, four scenarios were selected corresponding to the four combinations of the critical uncertain drivers.

The scenarios selected included:

1) Technological Unemployment Looms
2) Work will be "Taskified"
3) Manufacturing Work Shrinks
4) Manufacturing Centers will be Fluid

Scenario 2x2 Matrix	Local Manufacturing Activities	Global Manufacturing Activities
High AI disruption of human work by AI	**Technological Unemployment Looms**	**Work will be Taskified**
Low disruption of human work by AI	**Manufacturing Work Shrinks**	**Manufacturing Centers will be Fluid**

Table 2: Manufacturing activity location and AI advancement 2x2 Matrix

The last two steps of the scenario planning process, which involve the analysis of the implications of each scenario and a review of possible signposts, are explored in detailed in the following chapter.

5.0 Scenario Discussion

The scenarios created by the Foresight Alliance were very detailed, but did not include all the pertaining signals and drivers highlighted by the author through independent research. The author's research included industry- and geography-specific scanning performed during the scenario planning process. The author constructed scenario summaries to contextualize the future world depicted in each scenario for OTEMs. These summaries included important context for the social and the regulatory environment within the scenarios. In addition to the summary statements appended to each scenario, the author also created a backcasting of key events and turning points that could occur in the future and lead to the emergence of the scenarios. These summary notes were prepared to be used in conjunction with the scenario deck to give a better dimensional context pertaining to OTEMs and aid the analysis of the implications and impacts that these scenarios could have.

Although the Foresight Alliance scenarios were aligned with the critical drivers executed by the author, they were each developed mostly around a singular

critical driver, and their narrative mostly addressed conditions directly correlated to those singular drivers. However, the future scenarios are more complex and it is expected that the drivers would also influence several other trends and conditions that affect OTEMs. Summaries were prepared to highlight some of these.

5.1 Scenarios Analysis

1) Technological Unemployment Looms
High Disruption of Human Work by AI Enabled Technologies
Local Manufacturing Activities

In this scenario selected from the Foresight Alliance scenario deck, the main drivers of robotics and big data are AI-enabling technologies. The scenario describes a world in which the proliferation of these technologies would strongly affect job markets and change the way that work is done. The scenario description highlights a world where "digital automation technologies will increasingly shift the economic playing field away from both capital and labour." Cheap labour has long been the biggest advantage of overseas manufacturing centers such as China; however, this scenario describes a situation where digital automation technology would help local manufacturers level the economic playing field from a production cost perspective. Furthermore, the scenario describes a situation where "people with ideas, not workers or investors, will be the scarcest resource." Scarcity of workers, especially skilled labour and cheap low-skilled labour, has long been a great disadvantage for local manufacturing in the developed world. This scenario describes the ability of AI technologies to solve this issue.

The described scenario is based on the acceleration of current trends, which also aligns with the research that was carried out. In Canada, robot sales surged by 49% to about 3,500 units in 2015, a new peak (IFR, 2016). It is also noted that technologies such as 3D Printing, which facilitates rapid prototyping, have boosted creativity and the fact that industries are recognizing the role of local manufacturing in design and innovation.

The scenario also describes a world of technological unemployment, which is already becoming evident today, but in 2032 the effects are expected to be more significant. Fewer employees are used today to attain better productivity than in previous years due to increased efficiency, which is evident in how local manufacturing revenues have increased since the recession, but the employment numbers did not increase. The scenario describes a world where the net effect would destroy the jobs faster than new ones are created. This speaks to the increased adoption of AI technologies to boost local manufacturing output that has already begun and is set to intensify over the next 15 years as the technologies gain new capabilities and higher efficiencies.

<u>Other Trends in this Scenario:</u>

SocioEconomic - High demand for manufacturing & new transportation technologies, cheap capital, and low interest rates

GeoPolitical - Few environmental regulations, low energy costs in Ontario, regulations favouring exporters, a devalued Canadian currency, increase in Foreign Direct Investments (FDI), and favourable access to North American markets

Implications:

From the scenario description, the following conditions were implied:

1) Economic Disruption:
   a. The job market will be in disarray
   b. Rising unemployment
   c. Disappearing low-skilled jobs

2) The Rich get Richer:
   a. Companies with capital or access to capital will flourish, as they will be able to procure needed technology to compete
   b. Companies who had invested early in automation and have advanced manufacturing plants would flourish
   c. Companies that invest in research and development will boom
   d. Innovative companies will expand and the laggards will be left behind
   e. Innovative companies will have access to investors and great vats of capital
   f. Companies will offer low paying and less secure work

3) Work Will Be Redefined:
   a. Highly trained and highly skilled workers will be well compensated
   b. Some skilled workers will become obsolete
   c. Continuing education and retraining programs will be in high demand
   d. Income disparity within corporations will be very significant
   e. Creative professions and emotional work sectors will see an increase in employment numbers and incomes

4) Government Intervention:
   a. Basic living income will be a necessity for some
   b. Taxes might increase to pay for government programming
   c. More privatization as corporations take on government responsibilities

Signposts:

The results of the backcast for key events and turning points that could be realized within the next 15 years and indicate the emergence of this scenario

2018 •	United States-Mexico Relationship Deteriorates: Tensions that arise with the renegotiation of North American Free Trade Agreement (NAFTA) strains business relationships for United States firms operating in Mexico, creating more opportunities for Canada
2022 •	Productivity Gains: Canadian Manufacturing sector indicates three consecutive years of OECD leading productivity gains due to the deployment of technical innovations that closes the production cost gap for manufacturers
2025 •	Southern Ontario Boom: Kitchener-Waterloo region boasts several successful AI start-ups as the region regains global popularity reminiscent of BlackBerry's most successful period
2027 •	Competitive Hydro Price Rates: Manufacturers would have access to wholesale market pricing for electricity from clean energy producers
2030 •	Canada's First Maglev Network: The construction of a major transportation network for trans-provincial magnetic levitation trains

Figure 4: Backcast of Technological Unemployment Looms Scenario

2) Work will be "Taskified"
High Disruption of Human Work by AI-enabled Technologies
Global Manufacturing Activities

In this scenario selected from the Foresight Alliance scenario deck, a wide gamut of AI-enabled technologies - machine learning, robotics, big data, automation, robotics, *datafication*, sensing - are listed as the drivers. The inclusion of these technologies as drivers indicates a very high adoption of AI technologies. Workers wind up supporting the automated systems that are poised to replace them, which is a strategy that is deployed heavily in the manufacturing industry. Certain parts of manufacturing work are routine & repetitive and most of the work on assembly lines is broken down into multiple discrete tasks as described in the scenarios. This task-centric approach to work (which follows from the principles of division of labour and also decimated skilled-trades in the first Industrial Revolution) is the strategy used to increase the use of automation. As rightly described in the scenario, it involves the acceleration of current trends.

These trends are common-place in the manufacturing industry, as it was this same strategy that was utilized when Canadian workers were used to train workers overseas, who ended up replacing them or when common worker errors are aggregated as input data into automated quality control systems. This scenario builds on those trends in a future that is enabled by *datafication*.

Datafication of manufacturing work would require the input of large numbers of workers who would perform work that cannot yet be done by automated systems. Currently, the large pool of workers in overseas manufacturing outfits would form a fantastic data source for algorithmic systems to tap into. The vast amounts of data they would be able to provide might indicate that these would be the sites for such technologies to be used and harnessed. Additionally, the relaxed labour laws and relatively cheap labour would allow manufacturing companies to take advantage.

Manufacturing companies operating globally in this scenario would also benefit from high adoption of AI, as they wouldn't have to risk their own workers' safety and incur travel costs that would be required to establish overseas locations. Hence, the correlation of high adoption of AI technologies in the form of "*taskified*" jobs fits into a global manufacturing scenario.

<u>Other Trends in this Scenario:</u>

SocioEconomic - High demand for manufacturing & new transportation technologies globally, increased levels of education, global prosperity & emerging markets with a burgeoning middle class

GeoPolitical - Restrictive environmental regulations & high-energy costs in Ontario, heavy taxation on corporations, restrictive access to emerging markets, and sovereign states

Implications:

From the scenario description, the following conditions were implied:

1. Artificial Intelligence Everywhere:
    a. Robots will have taken over
    b. Robot development will take precedence
    c. Disappearing low-skilled jobs
    d. High skilled work has been replaced with numerous steps of low-skilled work, which would then be given to robots
    e. Disappearing high-skilled work
    f. Access to large, complex, and organized data would be extremely important

2. Human Relays
    a. There will be major disruption of human work, but other jobs will be created
    b. Human workers would function as input parameters for robot development
    c. Jobs that require a complex variety of skills, dexterity and intelligent actions will remain
    d. Available jobs will have a task-centric approach aimed more at data collection for AI development (the jobs will be temporary and monotonous)
    e. Desk jobs as well as factory work will be disrupted
    f. Freelance work will increase
    g. Robots will be trained by humans to do the work that humans used to do
    h. Increasing debt levels as people take loans in order to retrain for higher-skilled jobs that also end up getting disrupted

3. New Players
    a. Companies with access to large labour force would aid robot development and automation as human inputs will be used to train robots
    b. Companies would hire workers to train their robots by serving as data sources and then sell these robot services to organizations

c. Robot placement would be the new job placement
d. AI technology and development companies would become some of the largest in the world
e. AI technology companies would become some of the largest employers in the world
f. Companies with access to codified data for their systems would succeed

4. Limitless
   a. The technological possibilities of AI would seem limitless as the system would keep improving itself
   b. Increased efficiencies would be attained
   c. Location of human workers would be less important than access to suitable technology and internet communication infrastructure

Signposts:

The results of the backcast for key events and turning points that could be realized within the next 15 years and indicate the emergence of this scenario

2020 •	Millennial become MTurkers: Amazon Mechanical Turks (MTurks) are human intelligence task agents responsible for carrying out tasks that machines cannot yet carry out. Turkers are used to train machine-learning algorithms by performing micro tasks and are embraced globally as part of the gig economy
2022 •	WorkFusion goes public with a successful IPO: WorkFusion deploys AI solutions to digitize work operations
2025 •	Apple purchases IBM: Global technology icons IBM and Apple are important companies focused on AI technologies
2031 •	Magna expands facilities in India: Magna International continues their global expansion within India

Figure 5: Backcast of Work will be "Taskified" Scenario

3) Manufacturing Work Shrinks
Low Disruption of Human Work by AI Enabled Technologies
Local Manufacturing Activities

In this scenario, the key drivers to the shrinking manufacturing work are HR analytics, inequality, and drive for efficiency. Although most AI-enabled technologies are not discussed as drivers, the scenarios discuss the fact that automation would require a skilled workforce. This is an indication that the level of automation that is attained in this scenario is enough to add labour cost savings, but not significant enough to eliminate the need for skilled workers. To compete, countries in the developing world will still need to acquire and maintain more advanced skills. Aside from this lack of skills limiting the effectiveness of developing countries as manufacturing centers, the scenario also indicates that as the developing world opened up to trade, they found themselves susceptible to deindustrialization from their more advanced counterparts and end up as net importers of manufacturing.

The requirement for developing countries to continue importing manufacturing would only be more significant as the gap in productivity might be too large for them to attain. The scenario also presents data indicating that developing countries would not see more labour cost savings from robotics and have difficulties attracting the right workforce for manufacturing activities. The scenario also backs this up by citing India's inability to attain the heights of

manufacturing employment that were once attained historically by the now developed countries. It is indicated that going forward, manufacturing may not play as significant a role in the economic development of nations. It might be deduced that local manufacturing in North America would still be a burgeoning industry.

Furthermore, the scenario describes a situation where the growth in consumption of manufactured goods is not enough to justify the increase in manufacturing activities in these overseas locations. The increased demand that is expected in these areas of the world would be met with more efficient production that will exist elsewhere in the developed world. These indicators presented in the scenario suggest how globalization might boost local manufacturing and exports from Ontario with less focus on developing the manufacturing sectors of the developing economies and in emerging markets.

Other Prevalent Trends in this Scenario:

SocioEconomic - Political instability in the developing world, demographics, and immigration

GeoPolitical - Lower energy costs in developed nations due to advancements, relaxed environmental restrictions, and policies.

Implications:

From the scenario description, the following conditions were implied:

1. Peak Manufacturing & Decline in Global Demand:
    a. Less than expected demand for manufacturing goods even in emerging economies
    b. Peak manufacturing (employment and output) is attained much earlier than anticipated
    c. Growth in consumption of manufactured goods will continuously lag behind growth in consumption of services
    d. Service industry would attract more of the workforce

2. Skills Shortages & Shortage of Low Skilled Work
    a. Manufacturing jobs would require higher levels of skill and training so there would be fewer opportunities for people with limited skills and education
    b. Available jobs in lower-income nations would shrink leading to increased unemployment
    c. Countries with low-skilled labour force would not be able to attract corporations because of the reduced demand in low-skill labour and increasing important
    d. Technology would only affect low-skilled work and skilled workers would be in high demand

3. Free Trade
    a. Countries would be open to trade
    b. Countries would focus on their specialities such as resource extraction as opposed to embracing industrialization
    c. Countries would import the goods that they need from trading partners and other economies
    d. Countries that embrace trade would import de-industrialization
    e. Countries without existing infrastructure and well-developed supply-chains would not be able to compete globally and

4. New Priorities
    a. Quality concerns, environmental standards and efficiency take priority over cheaper labour costs
    b. Companies that are quality and sustainability leaders would succeed

c. Companies with a highly trained and highly skilled workforce would succeed
d. Focus would be on automating low-skilled jobs, which would already be in short supply
e. Focus would be on training, attracting and retaining a highly skilled workforce with government programs installed to assist
f. More high-skilled work would be created

Signposts:

The results of the backcast for key events and turning points that could be realized within the next 15 years and indicate the emergence of this scenario

2019 •	FDI Records: FDI into Ontario from Asian countries including India reaches a new record high
2022 •	Singularity is regulated: Funding for AI research into Strong AI reduces amid regulatory barriers and government oversight into AI development because of public fears. Advancements in Weak AI suffer as a result
2025 •	Tesla Out: Tesla's operations in China are bought out by Chinese rivals as Tesla is essentially kicked out of China
2031 •	Magna closes facilities in China: Magna International scales back on their global footprint

Figure 6: Backcast of Manufacturing Work Shrinks Scenario

4) Manufacturing Centres will be Fluid
Low Disruption of Human Work by AI-enabled Technologies
Global Manufacturing Activities

Firstly, it is noted that the low disruption by AI technologies does not indicate the absence of AI technologies in manufacturing work. AI-enabled technologies are

currently being used (and increasingly so), but these technologies still face some significant challenges before they displace significant amounts of manufacturing work due to the complexities and skills involved in such work. The rate at which AI technologies would be able to displace manufacturing work would depend on how rapidly they are adopted and how they are deployed. The scenarios noted indicate drivers that include AI technologies, but also factor in other important drivers such as local demand, the limits of labour-costs, and infrastructure development projects, which all affect the manufacturing sector.

In the Manufacturing Centres Will Be Fluid scenario selected from the Foresight Alliance deck, the drivers noted are: automation, globalization, robotics, ubiquitous connectivity, and drive for efficiency. However, the key driver discussed in this scenario is the impact of globalization, whose efforts are leading to significant infrastructure developments in places like India and parts of Africa. Some of these infrastructure developments are even being led by China, who sees these other locations as emerging markets for trade and business. These markets would also be in line to absorb the manufacturing jobs that could be exported from China as wage increases drive down China's international competitiveness in the manufacturing sector. The significant impact of the wage increases in China (noted in this scenario) highlights the inability for AI technologies to effectively disrupt human jobs, creating the need for lower wage work that could be available in other parts of the world. This scenario highlights the various tensions at play as

to why developing parts of the world are aspiring to take on responsibility of manufacturing output and how OECD member countries are championing such efforts.

Also noted above are how labour costs weren't the only dominant factor and indications that the shifting locations are also influenced by labour availability, supply-chain logistics, and demand. The non-cost factors such as regulatory issues are also included. In this scenario, these factors are driving manufacturing to generally being redistributed nearer to consumers. A large portion of consumers of manufactured goods is located in North America and the scenario introduces the concepts of re-shoring, i.e. returning manufacturing to developed economies. Re-shoring efforts have been examined and been promised by governments as a means to return jobs back to places like Ontario. However, in a scenario where AI-enabled technologies don't disrupt human jobs, overseas locations would be more favourable for manufacturing activities due to their advantage of lower wages; which coupled with encouraging trade agreements, allow for manufactured goods to be imported and exported.

The other concept of next-shoring, which is manufacturing in proximity to demand and innovation, is also poised to play a significant role. Most of the new demand for manufactured goods is supposed to be created in emerging markets as

their middle-class grows in the coming decade. As demand grows for manufactured goods, manufacturers might be inclined to move their manufacturing activities into these emerging markets in situations where protectionist regimes or unfavourable trade agreements restrict market access. Trade agreements are usually longstanding arrangements; however, disruptions in political regimes around the world could lead to renegotiated trade agreements and with it increased levels of fluidity in manufacturing activities.

Other Prevalent Trends in this Scenario:

SocioEconomic - High demand for manufacturing & new transportation technologies globally, increased levels of education, global prosperity & emerging markets with a burgeoning middle class

GeoPolitical - Restrictive environmental regulations, impact of lower energy costs in developing nations, restrictive access to emerging markets via exports, and international trade agreements and partnerships

Implications:

From the scenario description, the following conditions were implied:

1. Price Wars
    a. Cheaper labour cost would be favourable in a market that is facing tight pricing constraints and increasing competition
    b. Low-skilled workers could demand higher salaries than they did in 2017 with wage increases and minimum wage programs implemented to combat inflation
    c. Currency exchanges would increasingly affect manufacturers' financial performance

d. Currency disparities coupled with tariffs would create advantages for some and disadvantages for others
e. Countries with lower wages would attract manufacturing jobs as companies would diversify into new countries looking for price advantages

2. Global Moves
   a. Companies would diversify into new countries seeking access to emerging markets and increasing product demand
   b. Countries with low labour costs would be the most appealing, but countries with established infrastructure would be the winners
   c. Companies would look to diversify not only into new products, but new markets in order to combat risks and have alternatives and backups
   d. Trade agreements, tariffs and taxes would play a significant role in establishing global investments and partnerships

3. Chinese-led
   a. Foreign investments made by China into developing countries would yield dividends from existing relationships
   b. Political stability would be important for Chinese investors to maintain their investments in these markets
   c. Chinese-built infrastructure would be important to the expansion and industrial development of new markets
   d. Chinese influence on manufacturing activities around the world would be very significant

4. New Ground
   a. Otherwise untapped human resources in Africa would be key to industrial development in the region
   b. Increase in productivity due to new educational programs and equipment investments in new regions would be profitable
   c. Companies with expertise in global logistics and managing global operations and supply-chains would succeed
   d. Manufacturing would be redistributed nearer to the consumers as smaller operations could be deployed around the world

Signposts:

The results of the backcast for key events and turning points that could be realized within the next 15 years and indicate the emergence of this scenario

2019 •	Africa enjoying increased FDI from North America: FDI into African countries from North America increasing amid regional political stability in the continent
2022 •	Minimum wage increase in Ontario: An unexpected minimum wage increase rocks Ontario's industries as inflation rises
2024 •	Service Focused AI: AI technologies being developed for service jobs as manufacturing applications prove costly to maintain
2029 •	Population growth in Africa stagnates: An unexpected stagnation of the average fertility rate in Africa

Figure 7: Backcast of Manufacturing Centers will be Fluid Scenario

5.2 Measuring Impact: Parameters

All OTEMs are not created equal. In fact, some OTEMs were founded and established by Canadians and boast of deep ties to the local communities in Ontario, while other OTEMs are foreign-owned and operate as international subsidiaries of larger organizations. Most OTEMs earn a significant portion of their revenues from North American markets and operate most of their manufacturing centers within North America. However, export sales play a significant part in an OTEM's financial bottom-line because products are often exported to locations in neighbouring countries and worldwide.

Over the last decade some Canadian-owned OTEMs have established and grown international manufacturing operations while increased Foreign Investment in Canada has seen foreign-owned OTEMs increase their manufacturing activity in Ontario. In general, OTEMs have experienced significant prosperity and some have grown to exert worldwide influence. However, there is a wide range in company size as some OTEMs are much smaller in terms of influence, employee size, and revenue generation. When one considers the impact that the advent of AI would have on OTEMs, it is important to know that the impacts would not be evenly distributed across the entire industry because some companies would be able to adapt and manage better than others. For instance, some OTEMs have diverse operations, while others are specialized. Some OTEMs have complex manufacturing processes while others are dependent on skilled labour. The rest require large low-skilled labour forces.

The risk profile and resilience of these OTEMs to various scenarios, which may occur in the next number of years, is very different. In order to measure the resilience of OTEMs to varying conditions, we should to first measure the impact that a particular scenario could have on an OTEM's business activity and viability in the future. The impact of the OTEMs in each scenario was evaluated using similar performance metrics OTEMs currently use in evaluating their overall business performance. The performance metric mostly used is Financial Performance (FP). However, this implication analysis was performed using a

more comprehensive approach that includes the Social Performance (SP) and Environmental Performance (EP). This framework is commonly referred to as the Triple Bottom Line (TBL/3BL) and it provides a better overall evaluation of the sustainability of OTEMs and their resilience in the face of future uncertainties.

Most large OTEMs have embraced business sustainability reporting frameworks and metrics and have been influencing smaller OTEMs who are members of their supply chain to embrace and track these metrics. By including metrics for social and environmental performance, the implications take into account the effects of government policies and people groups that may influence or also be affected as the scenarios unfold. By evaluating the impacts based on the TBL, it is possible to have a clearer perspective of an OTEM's resilience regardless of size.

The three Bottom Lines (FP, SP, EP) are actually a summation of performance indicating metrics. The Key Performance Indicating (KPIs) metrics as reported by OTEMs and highlighted in the text below were the subject of the impact analysis.

Performance Evaluation Criteria:

(KPI)s used in the impact analysis highlighted in **bold**.

The FP can be evaluated by reviewing the following metrics -

Profits, Currency Exchange Rates, Financial Stability, Innovation, Efficiency, Productivity, Inventory, Sales, Cost of Sales, Energy Prices, Human Resources, **Market Share**, Product Development, **Product Quality**, and Capacity for Investment.

The SP can be evaluated by reviewing the following metrics -

Pensions, Unions, **Employee Retention & Loyalty**, Attracting Talent, Brand Awareness, Brand Perception, Philanthropy**, Job Skills Growth**, and **Health & Safety**.

The EP can be evaluated by reviewing the following metrics -

Emissions Targets - Greenhouse Gases, Water Usage**, Waste Streams, Energy Consumption**, and Sustainability.

5.3 Measuring Impact: Insights

In order to effectively measure the potential impact that each scenario would have on the business activities of OTEMs, a fictitious company profile was created in order to describe some current business models, metrics, and strategies reported by several top-performing OTEMs in 2017. However, by the year 2032 (in which these scenarios reside), the reported metrics for the OTEMs would be different.

The impact analysis was carried out to determine the expected results that this company would attain in a future scenario based on their current performance and strategies. Furthermore, the effect each scenario would have on any given company would be different as it is dependent on the company's current strategy, business model, target market, technology dependency, and investments amongst others. The process for impact evaluation is flexible and can be applied to any OTEM because we can expect to evaluate impact in conjunction with the company's unique standing. For the sake of this analysis, the OTEM profile created represented a large OTEM. This particular company profile was intended to represent a Tier 1 supplier because they are arguably the most important members of the supply chain. Tier 1 suppliers have a large footprint as an intermediary in complex manufacturing processes as they supply components directly to the OEM that set up the chain. Tier 1 suppliers are usually the largest and most technically capable companies in the supply chain and employ a large number of people. These Tier 1 companies are also looked to as industry leaders responsible for propagating the industry's quality, manufacturing, and business standards to Tier 2 and 3 suppliers. For this impact analysis, the fictitious company profile created was called Lane Corp.

Lane Corp.

Description

Lane Corp., established 1960, is a global automotive supplier. The Company's operates predominantly in North America, Europe, and Asia. The Company's product capabilities include producing body, chassis, exterior, seating, powertrain,

electronic, active driver assistance, vision, closure, and roof systems and modules, as well as vehicle engineering and contract manufacturing. The Company has over 320 manufacturing operations and approximately 100 product development, engineering and sales centers in over 30 countries. In North America, there are 160 facilities and over 70,000 employees. In Europe, there are 150 facilities and 48,000 employees. In South America, there are 10 manufacturing plants and 2,400 employees. In Asia, there are 54 manufacturing locations and 20,000 employees.

Summary

Country of Ownership: Canadian
Annual Revenue: $30 Billion (2015)
Global Revenue: North America: 73.5%, Europe: 20%, Asia: 5%, RoW: 1.5%
Operating Markets: 45% Europe, 16% U.S.A, 14% Asia, 12% Canada, 10% Mexico, 4% Other
Number of Employees: 140,000
Unionized: Yes

Strategy and Business Insights:

- Lane Corp's low investment in research and innovation worries investors
- Lane Corp. commits $4 million in Artificial Intelligence Research Institute
- Lane Corp. announces innovation outreach initiatives with universities, start-ups and other industries
- Lane Corp. announces funding for studies in Advanced Driver Assistance Systems and Electrification of Powertrain Products
- Lane Corp. opens six new plants in China
- Lane Corp. sells interiors business
- Lane Corp. strategy points to focus on production processes and projects driven engineering
- Lane Corp. sponsors Special Olympics World Winter Games
- Lane Corp. wins innovation award

- Lane Corp criticizes Ontario's new labour laws and initiatives: Fair Workplaces, Better Jobs Act, 2017
- Ontario hydro rates expected to increase 6.6% in 2022, 10.25% in 2028
- Lane Corp. invests approximately $300 million in Ontario annually

Impact Analysis:

The impact of the implications noted in each future scenario was analyzed using the noted company profile for Lane Corp. in order to determine how, based on the parameters of the information provided, Lane Corp. might perform given the different scenarios.

SCENARIO	FINANCIAL PERFORMANCE	SOCIAL PERFORMANCE	ENVIRONMENTAL PERFORMANCE	RESULT
Technological unemployment looms	Positive	Net Zero	Positive	**WINNER**
Work will be taskified	Positive	Negative	Negative	**LOSER**
Manufacturing work shrinks	Negative	Net Zero	Positive	**LOSER**
Manufacturing centers will be fluid	Negative	Net Zero	Negative	**LOSER**

Table 3: Impact Analysis – Lane Corp

Financial Performance (KPIs – Profits, Market Share, Product Quality)

The Financial Performance of Lane Corp. is expected to be relatively strong in both scenarios that include high disruption of human work by Artificial Intelligence regardless of whether manufacturing activities take place within Ontario or if they begin to take place on a more global scale.

Profits are expected to be strong as revenues in both scenarios would be expected to increase. This is primarily because Lane Corp. should be able to attain higher efficiency and productivity from AI-enabled manufacturing activities instead of a large human work force. A reduction in their workforce would be made possible and with it the costs such as salaries and benefits. Investments in AI-enabled technologies could yield high financial performance in those 2 scenarios.

Conversely, the financial performance in the other two scenarios, which intimate that AI-enabled technologies do not disrupt the human component of their work, could mean that Lane Corp. would see no increase in their profits as their current investments in these technologies wouldn't be able to yield respectable returns. There might be more negative impact if manufacturing becomes a more global exercise, as Lane Corp. would need to invest more significantly in foreign markets in order to increase its market share. This increase in market share might come at a cost of decreasing in product quality because process improvements won't be able to mitigate the fallibility of potential human-error and variability.

Furthermore, their business could also be subject to human-related limitations such as the potential labour disputes and potential shortages in highly skilled labour. While there might be an increase in revenue and market share, there will be a negative impact on profits if AI-enabled technologies do not significantly disrupt human work.

Having a strong local manufacturing presence is more favourable for Lane Corp., in both scenarios regardless of the disruption that AI-enabled technologies would have on human work. Local manufacturing allows Lane Corp. access to a highly skilled labour force and a route to benefit from its annual investments in Ontario while offering a better control of its manufacturing processes and technologies. It should also be noted that the local demand for Lane Corp's products is supposed to stay relatively stable over the next 15 years and in the event that favourable trade agreements are available, Lane Corp. could still benefit from exporting their products globally. The scenarios involving local manufacturing dependency would make Lane Corp. susceptible to policy decisions and global competition from other nations, which could adversely affect its ability to increase market share and profits locally and globally.

It is worth highlighting that considering Lane Corp's current strategy, which includes a global footprint of manufacturing activities, Lane Corp. would fare best

financially in a scenario that involves high disruption of human work and global manufacturing activities. The global manufacturing expertise that Lane Corp has been able to develop over decades of global operation would serve it well in mitigating policy related disruptions such as increasing energy costs, which could erode profits. It is important; however, to note that Lane Corp. might stagnate if it doesn't embrace innovation and increase investments in advanced technologies.

Social Performance (Philanthropy, Job Skills Growth, Health and Safety)

The Social Performance of Lane Corp. varies significantly from scenario-to-scenario because the effects of an AI disruption on human work and the location of manufacturing activities ties directly to the key performance indicators (KPI).

The scenarios involving local manufacturing in Ontario negatively impact the employee retention metrics for Lane Corp. regardless of whether or not AI disrupts human work. The reasons for this negative impact differ. The difference comes when one examines each KPI across scenarios because it is noted that employee retention is negatively impacted by AI disruptions. On the flip side, a lack of AI disruptions does not positively impact employee retention because the overall scenario indicates a shrinking of manufacturing work. Even though Lane Corp. would keep a number of human workers, this number could likely reduce due to the overall reduction in manufacturing output required per worker. In both

global manufacturing scenarios, there is a net effect in the number of employees gained that is negated by the number of employees lost. For instance, in the global manufacturing activities scenario involving AI disruption of human work, there will be a loss of full-time employment roles that will be replaced with more temporary and part-time roles, which will have a negative impact on the prospect on job skills growth.

Job skills growth also varies from scenario-to-scenario and is not determined solely by the effect of local or global manufacturing nor is it determined by the disruptions by AI technologies. Depending on which AI technologies are deployed by Lane Corp., there might be more valuable work created for human workers, or more temporary and rudimentary work created especially in a scenario facilitating global operations. Most notably, in a scenario where overall manufacturing work shrinks, there won't be an impetus in the development of job skills in local manufacturing operations because there is no demand to drive the development of skills and further innovation from Lane Corp. In the scenario where new operations are being established in global locations, there will be a necessity for job skills growth within those manufacturing operations and Lane Corp's global supply chain in order to attain the required quality and health & safety standards.

The health & safety standards attainable when there are fewer human workers involved in manufacturing activities would be significant for Lane Corp. Hence, there is a strong impact in both scenarios where AI disrupts human work as better standards would be attainable regardless of whether the manufacturing activities take place locally or globally. When new facilities and operations are established in the scenario where manufacturing centers are fluid, the health & safety performance could be quite poor when not aided by technologies due to skill level of the new workforce.

Overall, the social performance of Lane Corp. is expected to be positively impacted in a scenario where Technological Unemployment Looms even though there is disruption of human work and focus on local manufacturing activities in Ontario. The negative impacts this scenario would have on Lane Corp's ability to retain employees could be offset by the improved health & safety attainment and job skills growth. If manufacturing work were to shrink, the short-term impacts on Lane Corp's social performance may not be immediately experienced; however, the long-term impact of that scenario could be negative.

Environmental Performance (Emissions Targets [GHG], Waste Streams, Energy Consumption)

The Environmental Performance of Lane Corp. is most impacted by scenarios involving more local manufacturing activities simply because the concentration of manufacturing activities in a centralized location provides the best means to monitor, control and equalize most environmental standards. It is important to note that these metrics, standards, and targets are subject to policy changes & modifications and were evaluated based on the expected conditions that exist in each scenario.

Lane Corp's emissions targets could be adversely affected in the scenarios involving global manufacturing where AI-disrupted work and human work became "*taskified*." This relative lack of impact is because the advent of AI does not necessarily improve the GHG emissions from manufacturing activities. The scenarios that realize a positive impact on GHG emissions are expected when manufacturing work shrinks or the manufacturing centers are more fluid and capable of being located closer to the locations where the manufacturing goods are to be consumed. This reduces the overall carbon footprint of the manufacturing activities. In the other scenario, where global manufacturing activities are promoted, Lane Corp. might regress in their emissions targets simply due to the expansion of their manufacturing activities and the effects of operating a global supply chain and delivery system. This global expansion of manufacturing activities could also negatively impact their waste streams.

The waste streams generated by Lane Corp could be of either hazardous or non-hazardous waste. Regardless, it is best reduced through operational efficiencies that are attainable in both scenarios where AI technologies affect human work and reduce the number of human workers required in manufacturing activities. If AI-enabled technologies weren't disruptive to human work; the process limitations of humans would not necessarily be negative on the generation of waste. There would be no significant improvements unlike the potential improvements in energy consumption.

The impact that the settings could have on the energy consumption metrics of Lane Corp. varies from scenario-to-scenario; however, one is expected, be it positive or negative. The negative impact on energy consumption is expected in both scenarios involving global manufacturing activities because both scenarios generally reflect the increase of manufacturing activities, which is an energy intensive process. This energy intensity is expected to be exacerbated even further when one considers the energy requirements of the AI-enabled machinery that could be replacing human workers in the Work will be "*Taskified*" scenario. The negative impact of more machinery could be counterbalanced in the scenario which involves local manufacturing activities, where Technological Unemployment Looms, because of nuances involving the type of energy that is been consumed. In that scenario, within Ontario, it is expected that the energy consumed could be cleaner forms of energy including wind and solar. These

energy sources are also available in global manufacturing locations, with variations in cost and supply.

Overall, Lane Corp's environmental performance may be impacted negatively in most scenarios involving more global manufacturing activities mostly due to the different market conditions and constraints at global manufacturing sites. The negative impact would not be evenly distributed as the results might vary across countries. Lane Corp's environmental performance will be judged based on international standards and global impact and not individually from location-to-location.

When the overall performance of Lane Corp. is considered on a scenario-to-scenario basis, it is expected that Lane Corp's strategies would perform best in the Technological Unemployment Looms scenario. Its performance in the other scenarios is not as strong; with the indicators suggesting that global manufacturing scenarios would yield the poorest performance. Though Lane Corp. has made investments outside of Canada, their strategy is simply too vulnerable and not resilient enough to combat externalities that are involved in operating globally. Furthermore, the results of the analysis also suggest that Lane Corp. could succeed as long as Ontario remains a viable manufacturing center.

There are; however, externalities that could affect the emergence of such a scenario.

5.4 Recommendations

The research process and results attained generated numerous recommendations for strategy development and resilience building. As the author acknowledges that each OTEM has different business conditions and constraints, generic recommendations such as those encouraging training programs, technology investments, trade programs and policy guidelines were not applicable. Instead the following two recommendations are suggested for OTEMs to implement, as they are the best practices that resulted from this research.

1) Multi-Dimensional Analysis: The New Standard

Scenario planning methodologies that involve more than one parameter should be the standard for any strategy development exercise. This research was carried out with a focus on AI, but by including the critical uncertain driver of whether manufacturing activities would continue in Ontario and monitoring the effects on a time scale, created a three-dimensional analysis that added significant depth to the results. These results, which could go ahead to influencing strategy development, would lead to significantly more comprehensive strategy development.

The author would like to establish that the future is not a story that involves a single narrative, but rather a sequence of intersecting narratives that are often unevenly distributed and unfolding at different times. Any strategy developed by OTEMs should ensure that their businesses would remain resilient on the onset of an unfavourable scenario and thrive in more favourable settings. These resilient strategies are only attainable when developed with multi-dimensional parameters that factor in changes over time.

2) Resilience: From Continuous Improvement Culture to A Future-Oriented Culture

As an operational manager in the manufacturing industry, the author is well versed in the governing paradigm of continuous improvements. This paradigm has created a continuous improvement culture in the manufacturing sector and plays a significant role in decision-making and strategies. However, the author would like to propose a new governing culture to replace continuous improvement- one that would revolve around resilience.

Resilience is a business-sustainability-oriented culture that would not only include all the important aspects of continuous improvement, but seeks to prolong the effects of continuous improvement and ensure that improvements are attainable

over a longer period of time. The time factor is important when one considers a resilient culture, because it is a future oriented culture that fosters creativity, engagement, and inquisition- which are always at the forefront of innovations. By incorporating this culture into an organization, the responsibility for innovation shifts from a short-sighted, cyclical, bonus-inspired culture of incremental advancements to a potentially transformational culture that challenges the how and why of decision-making. The author's advocacy for a culture focused on resilience is mostly inspired in order to foster engagement and participation at all levels of the organization.

The responsibility for innovation is often left to certain innovation clusters, consultants, and teams that are led by senior management. These teams often meet opposition during the implementation stage of change management. Currently, change management experts encourage stakeholder involvement from all levels of an organization. The author hypothesizes that the implementation phase of a change process would be more effective were it preceded by establishing a culture of resilience. For instance, as the author experienced in the process of this research, involving management staff (who aren't directly involved in change-making within their companies) was met with varying levels of enthusiasm and interest, but ultimately met with apathy. This proved to be a key finding as it signified the current stage the threat of AI currently is at. AI is currently met with uncertainty, but there is seemingly no impending threat. A

resilient culture is one that recognizes that decisions made concerning AI technologies today could affect future outcomes and would be more likely to engage in the ongoing discourse today. This conversation is happening at high-levels of government, amongst think-tanks, strategic consultants, and advisors, but it is not prevalent amongst those that could be the most severely affected. The author hypothesizes a culture change is required in the manufacturing industry and amongst OTEMs, to one that is focused on resilience because it can enable them to implement their strategies and improve their business outcomes.

5.5 Next Steps

The impact analysis performed by the author only represented the impacts directly related to OTEMs and their core business. OTEMs are; however, only one member of the numerous stakeholders that would be affected by any disruption that AI would potentially have on manufacturing activities. Other groups that would be impacted include, the workers, unions, the communities, and supporting business service groups that rely heavily on OTEMs business activities. The impact that disruptions in OTEMs business activities would have on the government of Ontario cannot be understated because OTEMs contribute significantly to the local economies of Southern Ontario and their local employees are members of the tax base. These results only reflect a subset of the cascading impact that potential disruptions of OTEMs business activities by AI technologies could potentially have.

The process to analyze the impacts on all these other stakeholder groups could follow the same general process applied by the author in determining the effects of AI disruptions on OTEMs. The process will generally involve deciding on applicable metrics for each stakeholder group and weighing how these metrics could be impacted on the onset of any of the four scenarios. For statistical relevance, the process would be best implemented by involving a significant population of the stakeholders and most importantly by getting the inputs of the leaders and representatives of the stakeholders.

At the onset of this research, the aim was to synthesize insights, results and actionable items that would be useful in decision-making; however, the results of the research yielded a potentially more impactful resource. This defining result was the foundational information and adequate parameters that any stakeholder in OTEMs business activities can use to evaluate how the most critical uncertain drivers surrounding AI might impact their business. By carrying out impact analysis using the information uncovered in this research, any OTEM stakeholder would be able to devise strategies, goals, and objectives that would be inherently more resilient to potential disruptions that might occur within the next 15 years as a result of the advent of Artificial Intelligence.

6.0 Conclusions

6.1 Resolution

The result of this qualitative research project was defining the parameters and setting the conditions for any OTEM to wind-tunnel their current strategies against the selected scenarios and analyze the impacts that it would have on their business. By applying this methodology and using the parameters set, OTEMs would be able to build more resilient businesses and reduce their future uncertainty using this multi-future approach.

AI-related technologies do not need to be met with unrestrained support nor should they be met with unrestrained fear and skepticism. The reaction to these technologies depends on the impacts that are expected and whether any stakeholder believes they will be on the winning or losing side of technological advancements. With the tools that are presented in this research, any stakeholder can measure this potential impact adequately and adjust their current strategies adequately in order to remain competitive and relevant over the next 15 years.

6.2 The Role of Leadership

We can't choose the futures that we are faced with, but we can choose how we prepare and how we deal with them. The concept of choice is worth mentioning when one considers decision making- a burden that is often left to our leaders.

The leaders are often selected by a democratic process or by appointment and are expected to make the choices that determine the outcomes for several stakeholders. These stakeholders have great expectations of their leaders, but the concept of choice might prove to be an illusion especially when the leaders that are set are often not one's preferred choice.

In Ontario, mechanisms and complex levels of laws and governance are in place to ensure that decisions and policies made by elected officials benefit a broad array of stakeholders. There is skepticism because most stakeholders are not involved (or rather choose not to be involved) in the decision making process, but only exercise their opinions when they evaluate the impacts of the decisions. For instance, at the time of publishing this research paper, the Liberal Government of Ontario announced increases in minimum wage levels within the province. This increase was met with backlash from Magna International as they feel that such an increase could threaten their business viability. Other Ontario government policy driven changes surrounding cap and trade rules to govern greenhouse gas emissions, and increases in hydro prices, have also been met with similar opposition. It is a natural reaction to change proposals; however, could our leaders navigate a better way to effecting changes that aren't always reactionary?

Business leaders often also display reactionary responses. Business leaders of foreign companies that operate in Ontario are relatively quick to close operations once financial objectives are not met or policies are no longer in their favour. Again, these decisions often affect numerous stakeholders that often have no choice and are facing limited advocacy when they engage with these organizations. The advocacy group for the most vulnerable stakeholders are Unions, which have grown in importance since The Industrial Revolution. However, unions have been noted to be in decline and are merging in order to regain strength and maintain bargaining power.

Power is another important concept when one contemplates adjustments and it reflects the ability to effect change, which can either be positive or negative depending on who is in possession of power. There is no greater example of this than considering the Presidency of Donald Trump in the United States. The powers of the office of the President of the United States are significant; however, if not for legislative contingencies that had been built into the constitution, Donald Trump could have caused significant disruption. The most disruptive policy suggestions are yet to come into full effect and the cascading impacts are yet to be realized. These threats have been destabilizing most especially for those with the least amount of power.

In the author's view, there is no greater threat and no greater opportunity than investment into our leaders. They hold the power and are given decision-making authority and inherently control the future with their decisions today. Consequently, in as much as the focus is placed on the decisions that are made, it is important to acknowledge the impact of those that make the decisions especially when we consider a potentially disruptive technology such as AI.

AI is neither good nor bad; however, the manner with which those technologies are deployed would determine the impacts and the outcomes. Unfortunately for such a potentially disruptive technology, reactionary responses and policies would not be effective. The role of our business and political leaders has therefore, become more important. Decisions can no longer be made in silos and behind closed doors. Decisions can no longer be made without the input of those likely to be most affected by them. These people need to be encouraged to develop a culture of resilience, which would encourage them to engage and participate in the change making process. The author believes this would create distributed leadership and distributed power, which could lead to more resilience and success in a future filled with uncertainties.

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