Technology and Labour in the Local Manufacturing Sector

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Acknowledgements

This report is focused on gaining a better understanding of the impact that some emerging technologies in the manufacturing sector is having on employment throughout the communities of Peterborough, Northumberland, Kawartha Lakes and Haliburton.

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Ontario

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Executive Summary

Technology and labour in the local manufacturing sector is a report focused on getting a better understanding of how emerging technology in manufacturing is having an impact on employment in the Ontario counties of Haliburton, Kawartha Lakes, Northumberland, and Peterborough.

The report aims to address questions regarding whether jobs could be lost to automation and other developments in technology. From the research carried out in this report it seems unlikely that impending technological changes in manufacturing will have a drastic negative impact on employment in manufacturing.

To arrive at this conclusion the research began with an environmental scan intended to document emerging technologies as well as the potential impacts they could have on employment. This environmental scan is presented with a perspective that attempts to tie each technology to the local manufacturing sector.

A list of potentially relevant emerging technologies is presented with descriptions and estimated ranks that describe the potential impact they could have on local employment in manufacturing.

The ranks are arbitrary and used to help order the presentation of the technologies. These ranks are based on estimates about the expected impact on local manufacturing employment, how long the technology will take to be broadly adopted, and how directly it is related to manufacturing.

The research then progressed to a series of consultations of local manufacturing companies. The consultations showed where the environmental scan was not revealing the whole story.

These consultations, primarily phone interviews, were semi-structured interviews that tried to first understand an overview of the manufacturing company specifics and then see how automation and technology have been applied on the ground.

The two distinct research methods are then compared to each other to look for areas that overlap. This comparison reveals cases of over stated importance in the environmental scan, additive manufacturing / 3D printing for example, and cases of understated importance, such as developments in sensor technology.

These discussions also reveal how important location is to employment in manufacturing. When staffing is considered, human resource workers need to figure out if there are local workers who can do the job first. In cases where there is no supply of local labour, staffing decisions begin to include relocation costs, global wages, and worker location preferences.

Electrical power represents another broad topic that has a lot to do with employment in local manufacturing. A large majority of the emerging technology discussed in this report is power intensive.

The impact that growing demand will have on electricity prices is still unknown but as it gets higher, manufacturers will have a new consideration as they explore options for automation. It can be difficult to see electrical rates as a significant cost when incremental improvements draw so little power but they add up and will add up faster if power costs rise. Power intensive industries or industrial processes already understand how big an impact electricity price can have on the bottom line. What is hard to estimate is when other sectors will have to take this cost into account, when it will become a deciding factor between using labour and automation, and when productivity gains do not match the costs of operating an automated facility.

Introduction

Technology change has been a constant throughout history. The 80s had worries about the effects of computers on the employment of people who work in an office; the late 19th century caused a panic as the might of the industrial revolution took hold, so much so that the literature of the day offered up examples in abundance.

Author Maya Jansanoff describes an example from the writing of Joseph Conrad around the time when steam power threatened employment in shipping that had historically relied on many sailors to rig vessels.

“The heirs of Conrad’s technologically displaced sailors are to be found in industries disrupted by digitization.” (Jansanoff, 2017, p. 400)

What needs to be addressed when voices are raised about impending damage from technology is if the concerns of the day are justified. Historically these fears seem to be overstated.

One of the most dramatic of adjustments that can be traced to technology change were the unions that came to be as a response to the industrial revolution. Even the unions were not wholly adopted but they did set the ground work for social safety net creation, workplace safety standards, and employment security concerns.

Today, locally, the adoption of technology in the manufacturing industry is being done on a much more benign level than the industrial revolution. The technology detailed in literature does not match the technology that is being adopted by the local manufacturing industry. Changes in the manufacturing industry are focused on incremental, nondisruptive, changes.

Insights like these were exactly what this report intended to find. The report was conceived in a way that tried to compare perceptions to local realities. This was done by first examining emerging technologies. The environmental scan section of the report aimed to develop an understanding of what was emerging, what the emerging technologies aimed to do, and what impacts these technologies could have on employment in manufacturing.

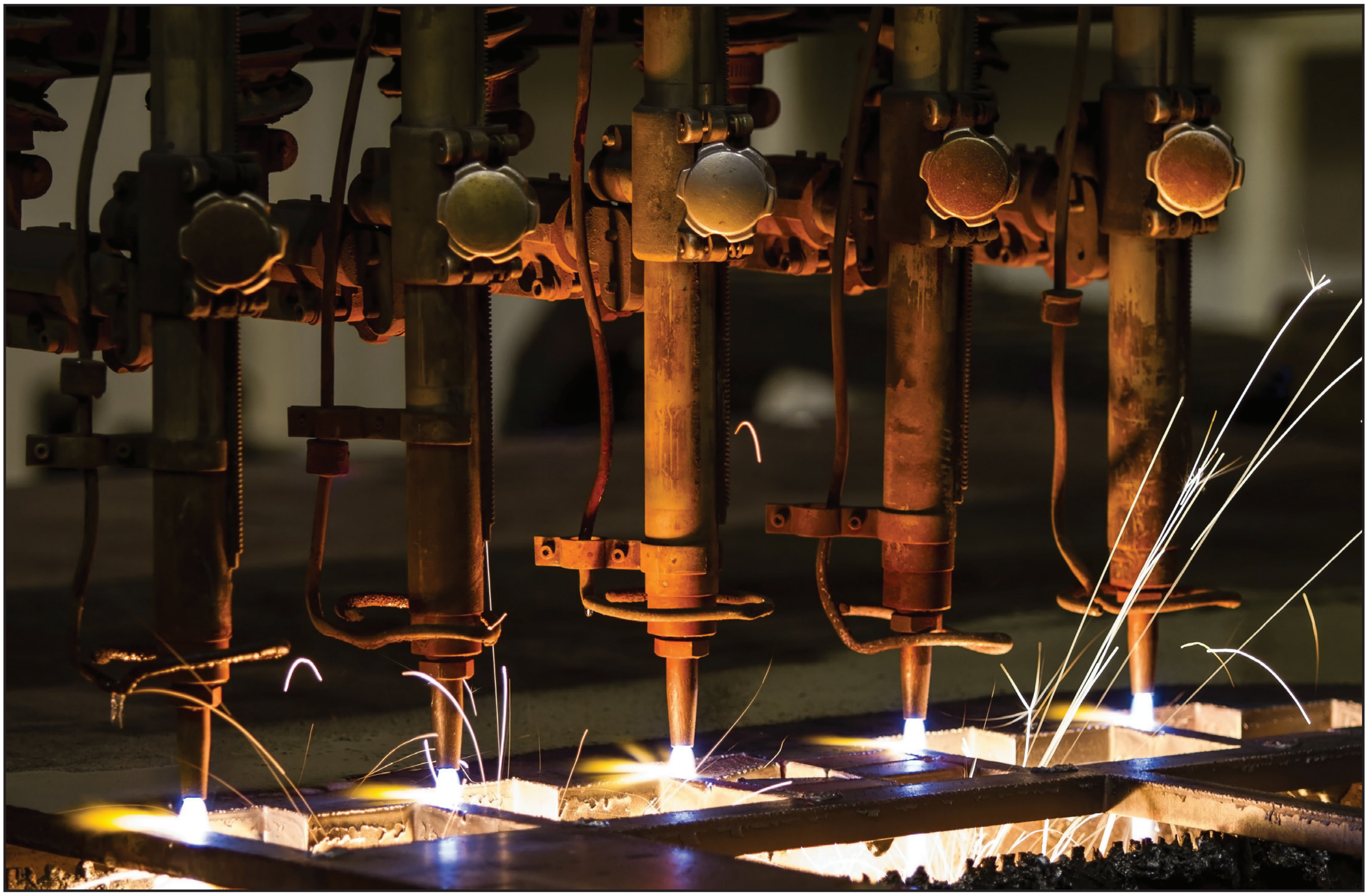
The second section of this report is the results of consultations with local manufacturing companies. The goal of this second portion of the report was to take the knowledge from the environmental scan and test it against realities on the ground. In this way the fears of the day are first understood and then checked to see if they can be justified.

The resounding answer is no, the fears are over stated.

The final part of this report observes the similarities and differences between the environmental scan and the consultation results. It considers some technologies specifically and identifies technologies where the environmental scan overstated or understated their importance. This section also adds to the discussion by bringing together some trends which point to the importance of location and electrical power in the host of factors influencing employment in local manufacturing companies.

A result coming from the consultations that has a large impact on the assessment that fears of technology creating unemployment are over stated is that there were no cases of employers who were looking to replace workers with automation. Discussions of automation centered on supporting existing workers, and improving the health, safety, and productivity of those workers.

Employment decisions of employers were focused on the employee fit and competence; employers don’t keep bad employees so those they have are by and large good employees.



Environmental Scan

Introduction

The main goal of starting the major work on this report with an environmental scan was to gain an understanding about what technology is emerging around the world. This environmental scan has ideally reduced the odds that a technology that is set to transform manufacturing was not considered in the report. Collecting information about technology was informed by both research and current news and events. Although the news sources offered only a glimpse of what is going on in the technology world, they do serve as a source to understand what is considered important and what a technology might do once it has been proven and applied.

Reading Discussions

Almost all of the reading about technology proved to border on alarmist. Authors had a bias toward playing up the impending effects of emerging technology and focused on the potential for transformative disruptions instead of incremental changes. There was also a trend in the written work on technology to assume that the adoption of a technology was frictionless and, that there were no operational problems that stand in the way of the actual application of technology.

Some of the technologies that were discussed in the literature involved highly technical topics. For example, exploring quantum computing and communications leads quickly back to papers written by Einstein in the 1930's; exploring BitCoin, crypto currency, and block chain technology can lead to technical discussions about encryption methods. The technical nature of some topics adds to the uncertainty about how much of an influence they could have on employment in manufacturing. A part of this uncertainty is tied to trying to understand enough about a technology to be able to evaluate the claims being made about what it may or may not be able to do.

Software is a major theme in the literature about technology advancement. Cars now have thousands of lines of code embedded on delivery. Artificial Intelligence and crypto currency are both branches of writing computer code.

Self-driving cars and automated manufacturing operations are the visible results of instructions which have been written in one programming language or another. If these trends are on target then looking forward, in a policy position, from a manufacturing perspective; and from an educator perspective, could require an understanding of code in order to even have informed discussions about the decisions to be made.

Overall, the body of work that was found suggests that notions of automation replacing workers is unfounded. The automation of tasks and duties will happen all over and it has been happening for about two centuries now. This means that all workers will have changes in what skills they use to get the job done. A crude example can be made comparing cleaners from pre-industrial times to those of the late 20th century.

In pre-industrial days the only requirement to clean might be to use a broom, but in the late 20th century a host of chemicals has been added to the tools used by cleaners. These chemicals require at least enough knowledge and skill in using to be able to handle bleach safely.

Rational for Technology Ranking

The environmental scan has proven to be an interesting research project in and of itself. The most important revelation of conducting the scan is the need for a formal method of evaluating emerging technology for inclusion or exclusion from the list of what will or will not have an effect on local employment in the manufacturing industry. In the past, forecasts of technological development have had a mixed record of success. Because of this the report assumes that some of what was found about emerging technology will be wrong while some of what was found will be right.

As the environmental scan was carried out, the following criteria were used in an attempt to gage the effect an emerging technology may have on local employment in the manufacturing industry:

- If the technology was realized in full, how big an impact would it have on local employment in the manufacturing industry?
- How long will it take for the technology to be realized in full?
- How directly will the technology impact the local employment in the manufacturing industry if it is realized in full?

Environmental Scan

The environmental scan was undertaken in order to gain insight into the emerging technologies which could have an impact on employment in local manufacturing. Technologies of particular interest were those that:

- Will have a large impact on manufacturing employment;
- Are at, or near, a point of being broadly adopted; and
- Will have a direct impact on manufacturing.

Large Impact

A good example of technologies that will have a large impact on manufacturing employment are those directly related to the manufacture of goods. The continuing development of additive manufacturing processes, alternately know as 3D printing or rapid prototyping, is an excellent example of a technology that will have a large impact on employment due to radical changes in how products are made.

Proximity to Broad Adoption

Forecasting technology developments has long been a challenge. There are examples strewn along the path of development that looked promising but then failed to make the projected impact. This is sometimes the result of forecasts being made early in the development of those technologies. For example, hydrogen cars looked promising around the turn of the century yet the development stalled long enough that another technology, electric cars charged from existing electricity grids, seems to have supplanted fuel cells.

Direct Impact

Not all technology developments that might have an effect on manufacturing employment are directly related to manufacturing. Advancements in payment methods, logistics, and organizational structures are technologies which can have sizable impacts, even though the connection to manufacturing is not immediately evident. The internet coupled with broad connectivity represents this type of technology.

Through access to online retailers, online payment methods, and even scores of product reviews, the demand for products has shifted and the way people consume has changed. These changes in demand for products also changes the demand for workers to make those products.

Indirect changes are expected to be less likely to have an effect on manufacturing employment and the changes are expected to take longer to materialize. These factors contribute to weighting technologies accordingly.

List of Emerging Technologies

The list of emerging technologies are ranked in order of their expected impact on manufacturing employment. The ranking is based on the environmental scan carried out over the course of this project and has taken into account the expected size of the impact, how far along the development of the technology has progressed, and how close the technology is to local manufacturing employment.

The ranking gives each technology a rank between 1 and 10 (noted in square brackets), with 10 being technologies expected to have the largest impact on manufacturing employment.

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- **Additive Manufacturing (3D Printing) [9]**
- **Labour Contracts / Labour Law (minimum wage, precarious work legislation) [8]**
- **Digital Consumption [8]**
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- **Augmented / Virtual Reality [3]**
- **Computer code / code in cars [2]**
- **FinTech [2]**
- **Chip design [2]**
- **Currency [1]**
- **Genetics [1]**
- **Biotechnology [1]**
- **Quantum computing [1]**
- **Quantum communications [1]**

Descriptions of Emerging Technologies

Electric Cars [10]

The eventual spread of electric cars seems to be a given. What is less certain is the speed of this change and the extent to which internal combustion engines will be replaced. Much like the music and book industries, the car industry should expect a decline and eventual stabilization of cars powered by internal combustion engines. Oil and gasoline are still excellent ways to store and transport energy and it is unlikely that demand will fall to zero in a short timeframe.

A challenge which will be quick to hit manufacturing employment is the effect that large uptake of vehicles powered by electricity grids could have on the price of electricity. The response of manufacturing companies to this shock could be negative, if the firms decide to offset increased energy costs with decreases in labour costs. Firms that are prepared for such a spike may be able to actually increase employment if the business model can be optimized to use labour over electric power. Use of robotics to sweep floors adds uncertainty based on power costs while a person doing the same thing is a fixed cost. The risks are made all the more stark considering wages have been slow to rise while energy costs can fluctuate daily.

Additive Manufacturing (3D Printing) [9]

This technology has been in development for around 20 years and began under the title ‘rapid prototyping’. The evolution to 3D printing occurred as it began to be used for simple finished product production. The expansion of material ranges and alternate techniques to accommodate the production of metal finished products has added to the viability of using this technique to manufacture finished goods. As the range of finished products has expanded, it is clear that the term ‘3D Printing’, which draws on similarities to desk top printing of ink on paper directed by a personal computer, is to some extent a misnomer. ‘Additive manufacturing’ is a more apt description of the technology since it has developed to the point where it is clear that the creation of commercial finished products in this way will be, if it isn’t already, a viable business.

What to Watch

Material options remain a hurdle to the adoption of this technology. Machines, which can add multiple material types in the same way that printers use different colours, will have a profound impact. Similarly, the production of products using a range of colours will add to the versatility. Material properties will need to be better understood should the technology be more broadly adopted. This is particularly important for the creation of components where failure becomes a safety concern, like the creation of parts in the automotive industry. Size constraints do factor into the technology. The machines marketed to the public for personal use are able to produce products with dimensions measured in inches while industrial development is moving toward the production of products measured in feet. At the highest end of the scale is a printer being operated by the Australian company Titomic. In May 2018, the Financial Times newspaper reported that one of the printers they have made can create bus-sized parts, up to around 9m in length. The parts include “complex aircraft wing parts” and bike frames it can print “in around 25 minutes”. (Smith, 2018)

A development with recycling minded technology could see the material inputs for production be the processed waste from past consumption. The use of shredded 2L pop bottles to create new products comes to mind as a potential revolution in both production and waste management.

Big Changes

An article published by the Economist in 2010 pointed out that there are potential savings of 20% less power used and 50% less material waste in the production of products using additive manufacturing compared to current manufacturing methods. If this report is correct those who are able to begin manufacturing with additive technology will have large savings in costs. (Economist Staff, 2012)

Another possibility often discussed in articles about additive manufacturing is that products could be built to order. If this is a real possibility then inventory costs could see drastic reductions.

A labour market change associated with additive manufacturing is that there might be a shift in demand away from machine operators, and toward drafters and repair and maintenance technicians.

Labour Contracts / Labour Law (minimum wage, precarious work legislation) [8]

Minimum wage will have a clear impact on the cost structures and staffing decisions of manufacturing companies. It is less clear what the impact of changes to the laws surrounding private contractors, temp workers, contract workers, part-time workers, etc. might be. These areas are under scrutiny around the world as 'the gig economy', with Uber leading the way, is bringing up more questions about how worker rights are being eroded through creative use of precarious employees.

These changes are less technological than they are consequences of changing technology and the improving use of technology that already exists. Uber, Wayz, Airbnb, Expidia, and Amazon are products of advances in communications more than anything else. Uber simply would not work without mass smart phone use.

Digital Consumption [8]

With an economy based on the consumption of physical things, changes in consumer spending toward virtual 'objects' could disrupt sales of local manufacturers. If this is the case, current demand for the goods of manufacturers would change because of the reduced amount of disposable income that is spent on physical products.

Early indications that consumers are willing to spend on virtual goods and services began nearly 10 years ago. One of the first companies to draw large revenues from the sale of virtual goods was Zynga, the software company behind Farmville. In that title customers bought upgrades for their virtual farm which was, in theory, visited by friends. These purchases were frequently cosmetic in nature, clothing styles and colour change options could be bought to add a style and personalization to the farm. The adoption of micro payment options by banks world-wide, along with the massive expansion of data enabled mobile devices, has further spurred the ability of consumers to purchase virtual goods.

A multi-polar geopolitical balance [8]

War and the fear of war change consumption patterns. Trade disputes and arms races are difficult to predict, massive when enacted, and hinge on variables outside of the rational economy.

A war footing, in a 1914 or 1939 way, changes a full economy and all that is being produced by manufacturers. The trade in military and para military equipment saw a ramp up before both wars and new industries were created using the tools of the old industries.

A more speculative area of influence on the manufacturing labour market can be seen through the changed consumption patterns of a society that is nervous about conflict. It is hard to say which direction this would change but it does need to be mentioned as a point of completeness.

In both the 1914 and 1939 cases the world was awash with new innovations in technology which was most strikingly embodied by communications changes. The telephone, train and combustion engine, in 1914, and the radio, in 1939, moved information faster and further than was ever imagined. Authors of the day lament the speed the world moved at and the unsustainable pace.

The technology driving the world at this point is the internet. Although second nature to many, it has not been until recently that masses have joined the internet age.

Mobile internet access improvements that came with the iPhone on June 11th, 2007 have only recently become available for mass consumption. Before affordable smart phones, with affordable data plans, internet connection was a good consumed by the world's richest people.

The past decade has really seen the advent of global interconnected communication. Every conflict, in nearly every corner of the world now takes mere seconds to reach billions of people.

It is this new, stark, immediate, graphic reality which is influencing people. Who's to say how it will influence their consumption? Does the feeling of constant and uncontrollable conflict cause consumers to contract, to try and pull away from the world, or does it push escapist consumption?

Physical security [8]

If consumers are worried about their own safety they will buy different products and services. Bunkers being bought in the cold war, guns to ward off crime, security firms and equipment to ward off terrorists. There is no doubt that mass sentiment can move a nation but predicting the direction is difficult. This faces many of the same issues as geopolitical unrest. Is there more crime or is it just reported more often and in less time? Will consumption be changed or will it remain the same?

Sensors [7]

The costs associated with adding sensors to a product have dropped enough to become all but trivial. This has added two dimensions to the economy, one is that responsive technology is now a reality in a host of products that would not have been possible before, the other is that data can be collected on a number of different fronts. The article by Schutze (2018) published in the Journal of Sensors and Sensor Systems has a history of the development of sensor technology over the past two centuries which adds perspective to further discussions about the developments in sensor technology.

Analytics [7]

Analytics is less a new innovation than it is an innovation that has become newly relevant. For manufacturers, process optimization, supply chain, and similar statistical analyses have become newly relevant due to the increases in computing power and the amount of data available.

Education and training [7]

Debates about education and training are ongoing with a particular focus on notions of skills gaps, workers who are undertrained and technology changes which have moved faster than curriculum updates. The types of solutions to these problems are still being explored and tested. One article suggests “manufacturers should invite the public to visit their facilities and see what they can offer prospective workers.” (Kaslow, 2012) which shows the type of innovative approaches that are being tried to better align public knowledge, curriculum development, and manufacturing needs.

Self-driving Cars [7]

This could have a massive impact on manufacturing through many different channels. Changes in consumer behaviour and economic operations could be substantial if self-driving cars have a big impact on the demand for cars. Logistics will also be effected where the delivery and optimization of distribution networks gets reworked to take advantage of the technology.

Big Data [7]

Big Data is a driving force behind the increased influence of analytics. The term is used to emphasize how much more data has become available over the past decade than was available before. This size change is multiple orders of magnitude, enough to make daunting analysis of data sets that had been struggling to attain big enough sample sizes to draw statistically significant conclusions.

Internet of Things [6]

‘The internet of things’ concept is familiar to those who are fans of science fiction, a fully automated house where everything can be controlled by remote. This has everything to do with the substantial expansion of wireless networks both at home and around cities. The connectivity can be used for control, task scheduling, and simply improved standards of living. Connected consumer products will also be able to collect and forward data that producers can use in the design and refinement of their products.

Manufacturing could be impacted in a number of different ways. The products being produced might need to change to incorporate connectivity or the demand for them may shift due to changes in consumer spending patterns. The manufacturing process might change due to new connected technology adding options for process control and optimization that were not there before.

Artificial Intelligence (AI) [6]

How artificial intelligence will impact manufacturing is difficult to figure out when so many possibilities exist for its eventual spread across society. The exact nature of how artificial intelligence will impact manufacturing has a lot to do with the form the technology takes.

At the heart of the issue is exactly what qualifies as artificial intelligence.

Arcade games offer the best method of describing how current discussions of AI are

evolving. The earliest games had nothing even close to AI; Frogger, Space Invaders or Donkey Kong pit a player against repeated unchanging patterns. As games developed the challenges took on random elements to keep a player guessing in stages. Pac Man shows this stage of evolution. In the game, a player navigates different mazes while being pursued by ghosts. The movement of the ghosts has a random component as they must navigate twists and turns in the maze and are confronted with options about the direction of travel.

As games evolved, the complexity required to direct computer lead opponents became more and more advanced. Examples of early complexity can be seen in the many different sports games where the computers behind the games are responsible for controlling both the opposing team and the actions of a player's 'teammates'. The complexity involved in this iteration of AI needs more than the random selection of a few choices. For a game to be able to have even the simplest team it must contain a complex set of decision making options. In the past, these examples have been called AI but they all lack the ability to adapt. This adaptive nature of artificial intelligence is able to create software that learns in a rudimentary way. The learning component is where the term 'machine learning' comes from. It is intended to convey that key trait of emerging AI technology, adaptability.

Privacy [6]

Concerns about privacy abound. The focus is on consumer data and what has been collected by a growing host of connected consumer products.A difficulty here is that privacy has a cultural component where the privacy concerns of one person are law and order issues to another. Shifts in what amount of privacy is acceptable will have an impact on the data collection options for manufacturers as well as the amount of connectivity that manufactured goods can have.

Cyber security [6]

As manufacturing operations become more connected to the internet, the security of these connections become more important. Concerns can include payment methods, security camera control, and even some amount of process control. The gains from increased ability could be measured against risks from others being able to hold manufacturing at ransom.

Nanotechnology [6]

Nanotechnology is the creation and use of microscopic machines for a variety of uses. If this technology takes off, it will have a large impact on manufacturing but at this point, it seems fairly distant. The theory is that microscopic machines will be able to build things by manipulating matter at the molecular level. It is unclear if this technology could be used to compete with current manufacturing or if it could be used to replace workers. There is another possibility which is that the technology could be used to improve current manufacturing processes, such as the creation of drill bits that last longer.

Cloud Computing [5]

Cloud computing is the notion that a majority of software and the data files of a company could be stored on remote computer servers. A major benefit to this method of using computers is that data and software access is independent of location.

From a design perspective, the computer aided design (CAD) software could be installed on the remote server so that any computer with internet connectivity could be used to modify designs, allowing workers to be able to modify designs instantly while meeting with a customer. The storage component means that the design files will also be housed in a central accessible location for easy reference and modification.

Cloud computing could shift IT costs of manufacturing from the purchase and maintenance of computer resources to the purchase and maintenance of internet connection technology and the purchase of software licenses. This has the potential to streamline business in the design, sales, and manufacturing areas. In a seamless vision of the technology a disparate design team keeps all of the documents online that are used by plants in locations across the globe..

Machine to machine communications [5]

This involves connecting machines to each other. It is slightly different than the internet of things because it isn't about creating a network but is more about pairing machines so they can coordinate.

A good example of these types of communications would be the use of autonomous robots that move pallets of supplies around a shop floor. With machine to machine communications, these robots will be able to figure out pathing to avoid other robots or to avoid large machines that might block a path for parts of their ordinary operation.

Aerial Drones [5]

Drones represent the convergence of a number of technology innovations. Battery improvements in weight, power output, and duration were essential so that they don't need gas engines. The shrinking size and weight of video camera technology has made it possible to give drone operators a view from the perspective of the vehicle which makes controlling easier than with past remote control flying devices.

The spread of mobile touch screens is an essential part of the control of drones since users need something that can communicate remotely and can display the camera view. Current applications focus mostly on delivery of goods yet other applications, such as mapping uses and agricultural inspection, are being tested by companies.

Agricultural Technology [4]

Most advances in agricultural technology will likely lower food prices. This can influence the amount of disposable income that consumers have to purchase the products of manufacturing companies.

A growing wave of tech savvy farmers are now able to circumvent traders that had monopolistic positions on global market moves. This could have a significant impact on the role of middle men in the distribution and sale of agricultural products. Another part of the benefits of technology for farming is access to better forecasting information.

Consumer / retail relationship [4]

The way people buy has an impact on manufacturing from a demand perspective. The growing pressure on department stores in North America, evidenced locally by the closure of Eaton's and most recently Sears, will have impacts on supply lines for many manufacturing companies. This could result in more demand for products, as small retailers try and stock up to fill the gap left by department stores, or less demand, if a part of the failure of department stores was the reduced demand for the goods they stocked.

Mobility [4]

The use of portable technology could have many impacts on the manufacturing workforce. It is uncertain if developments such as just-in-time workers will become a new component of manufacturing but the increasing ease of transporting technology could have unforeseen results.

Ubiquitous technology access [4]

There is a growing trend toward assuming everyone has access to a working smart phone. This type of assumption has many different implications which could result in changes to the manufacturing workforce. One possible example could be the creation of programs for use on smart phones which connect with machines being used in manufacturing. If nothing else, this idea would open up the large segments of the workforce who come pre-trained on some elements of the software used to operate machines. In other words, the skills an average person gains from using a cell phone become transferable skills if the operation of manufacturing machines requires using a cell phone or a like machine with similar software.

Robot Tax [3]

A tax based on the amount of employee hours that are cut as a result of automation has been floated as a possible counterweight to jobs that are automated out of the production process. This idea seems a bit absurd when imagined from a historic perspective. Would it have been a good idea to tax tractors because of the farm hands they replaced? What about the amount of jobs lost as trucking replaced trains, or trains replaced horses.

Automation is not a new shock to the economy, it has been a constant for something near 500 years. A tax on automation is almost like a tax on innovation. Luckily, this idea does not seem to have much traction.

Shared Economy [3]

Uber and Airbnb offer services where people are able to rent their two biggest assets out short term. This and other innovations are organizational in nature but might represent a pressure on the demand for manufactured goods.

Uber and similar dispatching software could reduce the demand on cars yet it seems a long way from being that important at this point. Locally this might not have a large impact. Connections to the manufacturing in Oshawa might result in a spillover increase in skilled labour supply if the shared economy becomes big enough to effect the demand for cars.

Could other capital investments face reduced demand as deals are struck between end users? This is another idea that could happen but looks like it is a ways off. Tool libraries have emerged in urban areas and have some amount of success. Exactly why they are working is an uncertainty at this point. There are space and cost constraints which might be drivers in urban areas. The size of the potential market could also be an important element of the business model.

There are other considerations about a sharing model that need to be decided before it can be implemented. The increased administration of using shared capital investments might be more costly in the long run than any savings that would be gained from the initial agreement. It's hard to see how sharing is much different than co-ops.

Lastly, the car ownership model of the past decades offers some amount of insight into how this sharing economy could play out. Those who have used public transit and/or rental cars, or car sharing like zipcar can attest to the sizable constraints that arise as scheduling and coordination become essential elements of a trip. Car ownership is more costly than not owning but the convenience of having a car available when you need it is evidently worth the cost.

Co-Working [3]

A number of innovations in organization and structure involve extending the idea of sharing economy to encompass office space. There are more than a few successful co-working companies that have been started in the past decade and some have hit their stride enough to expand nationally and internationally. The idea is that members contribute to the company in order to have office space and a selection of resources available on demand. These arrangements are used by a number of different types of workers from start-up companies to expanding companies to contract workers who want more flexibility.

In the case of WeWork, a co-working company, the description of their business and how it has expanded alludes to some specifics about what the company is actually providing. Being hired to build offices for enterprise companies as well as describing the host of services each site offers makes the company sound like a group that specializes in office design and management.

From an economics perspective, this arrangement could be seen as an additional layer of risk sharing. A traditional model of corporate real estate has the building owner taking a risk that they will be able to fill enough of the building to make a return on investment. All the while those renting the space take the risk that they will be able to generate enough revenue with the rented space that they will be able to make a profit. With a co-working space the tenant takes on the risk of finding others to fill the space.

The risk is then broken up into smaller chunks which are taken on by the members of the co-working space who each contribute a fraction of the rent.

Manufacturing could see co-working arrangements where machines and not cubicles are rented to skilled labour who have need for small capacity production. This is not an option that is clearly in the realm of either possible or probable. The current structure of manufacturing suggests that there is little demand for this service. Investment in the creation of a product is rarely done piecemeal. The closest manufacturing equivalent are companies that advertise the machines they have and will run them for customers to do small run tasks.

Augmented / Virtual Reality [3]

The use of augmented reality technology is much the same as the more familiar heads-up-display. This technology adds information to the real world. Most often it is seen to be done through a set of glasses or a screen. As the technology develops there may be uses for manufacturing. Virtual reality seems more of an option that can be used at the design stage of manufacturing. It could be used for product design, for understanding workshop design concepts, or even for exploring modifications to existing machines.

Computer Code / Code in Cars [2]

Computer code has become an imbedded part of many products of today. In a 2017 CNN article (Valdes-Dapena, 2017) the CEO of GM pointed out that a modern car has thousands of lines of code contained in the finished product. The main pressure this will put on manufacturing is through the increased supply / demand balance for those with computer coding skills. CNC machines require an amount of coding to run and supply of coders could be tight until education groups are able to respond to the demand.

FinTech [2]

Financial Technology innovation is primarily going to impact manufacturing through financing operations. This is unlikely to have an immediate impact on labour concerns in the local manufacturing industry.

Chip design [2]

Google has developed a new computer chip specifically to be used in AI training (Metz, 2018). This chip rivals the central processing unit (CPU) and the graphics processing unit (GPU), two standard chips in use in computers today.

Microsoft has opted for the less specialized option of using a chip that can be changed to suit needs, in effect choosing versatility over specialization. This will give Google an advantage in speed and power usage but not an ability to change should requirements change.

This is a substantial change in the electronics industry because chip development and design has been limited to a very small number of very big players (Intel, NVidia, Motorola to name a few). Should the efforts by leading software companies spur a round of chip design improvement, there are a number of other areas where electronics could benefit.

As for local manufacturing, this seems unlikely to have a large effect beyond the potential to see productivity improvements through increase speed of internet using tools.

Currency [1]

Bitcoin and the block-chain distributed ledger technology it is built on are waiting in the wings to really take off.

Mass adoption of this technology could lead to a number of attempts at changing what currency is used, by whom, and how. In the long run, this might have some amount of effect on the settlement of payments in manufacturing but at this point it seems too speculative to have a sizable impact on how business is done locally.

There is also a chance that models of electronic currency that have a ‘mining’ component could drive electricity prices up for everyone. It is uncertain to what extent these operations are influencing the demand for power in Ontario.

Genetics [1]

The study and improved knowledge of genetics could easily open up the world of health and wellness science. In the long run, it is possible that genetics will allow the design of people to include faculties that are advantageous to manufacturing. At this point, it seems the main benefits will come from increased health of workers in manufacturing.

Biotechnology [1]

Drug developments have had big impacts on living standards but marginal effects on manufacturing labour. A healthier workforce is in no way a bad thing, but it hardly seems to be the type of thing that will cause a disruption.

Quantum Computing [1]

New computing technology promises to speed all things computing. The results could be systemic for the computer programing industry but until the technology is both proven and broadly adopted, manufacturing labour supply and demand are unlikely to be affected.

Quantum Communications [1]

The use of quantum entanglement as a communications method is set to become a monumental breakthrough should it prove viable. The technology makes use of advanced particle physics to transmit information over long distances at incredible speeds. Although only beginning to be realized as a potential communications channel, the Chinese government claims to have proven communications between a satellite and the ground using quantum communications (Castelvecchi, 2017).

Much like quantum computing, this technology seems both distant and not directly relevant to local manufacturing.

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Industry consultations

Introduction

The challenge with consultations is one that is frequently encountered when doing research on business, being able to connect with busy employers, due to their time constraints and priorities. We are thankful for all of the businesses who made time to talk about how they have seen technology change, what they do, and to speculate about how it will continue to impact manufacturing employment. The consultations were fruitful and served to add context in exactly the way that was envisioned as this project was conceived.

There were few surprises over the course of the consultations. Many of the technologies seen as distant from the manufacturing sector did not even arise in discussions. A number of the technologies that were expected to be on the mind of local manufacturing companies were indeed on the radar.

Software figured prominently into discussions as improvements in supporting payment and order tracking software has been one of the newer investments for a number of companies. The drive toward machines that can be programed, such as CNC machines, is in the middle of being applied across companies. In some cases, the development or improvement of software was discussed but few companies have made dedicated efforts to improve software on their own initiative.

The drive for automation focused most often on the optimization of manufacturing processes using existing capacity. The targets most often focused on steps in the process that involved leg work, literally in the case of companies exploring autonomous vehicles to move components around the shop floor. Moving works in progress from one station to another, a task currently filled by machine operators, frequently came up as the ideal place to automate. If that step could be automated it would increase the amount of time an operator is actually using the machine, keeping the same labour but increasing production levels.

The developments in sensor technology, including the quality increases and cost decreases, was the biggest instance of a technology having been underestimated in the environmental scan. Visual sensors were of particular interest to manufacturers as an important step in being able to include robotics in the flexible changing environment, common in local manufacturing companies. Improved sensors add flexibility to robotics by adding an ability of those automated steps to adapt to slight variations in the process if they are encountered.

Additive manufacturing was the most overstated technology from the environmental scan, when compared to the conditions on the ground. In some cases, there was not much interest in the technology while other cases described challenges with the quality of output from 3D printing processes.

It's possible that a large barrier that this technology faces is the amount of time that needs to be invested just to see if it is viable. Another possibility is that the technology needs people who are experienced enough with additive manufacturing to be able to identify the incremental improvements that could be made.

Consultation Findings

Over the course of the consultation process, 51 different local stakeholders were contacted. This resulted in 16 direct consultations, 31 of the attempts at contact had no responses while 4 declined interviews.

The interviews were all semi-structured and most took place over the phone. The interview question guide can be found in appendix A. The semi-structured nature of the consultations meant that not all the questions were asked in exactly the form found on the question guide. The most common way that the consultation unfolded was to begin the conversation and flow into details about automation through questions aimed at better understanding the business of the person being interviewed. As the conversations reached a lull the question guide was then consulted to ensure sufficient information had been collected to be able to answer all of the questions. If that wasn't the case, the outstanding questions were asked.

After a review of the notes from the consultations, a set of discussion points have been put together in order to help cover major topics of interest.

Two Steps to Improvement

A good place to start is the observed fact that there are two steps for existing manufacturers to adapt new technology. The first step is that manufacturing companies need to know that a technology exists before they even begin to consider if, and more importantly, how the technology could improve their business. The second step is the "how" stage, implementing technology so that it integrates into the existing work flow. This step can be what limits new technology adoption.

Screens

A technology that has had an impact on the manufacturing processes is the development of cheap screens, television sized and desktop computer sized. This cost reduction means that staff on the floor can get real-time updates about what stages of production are doing what.

Another use is to keep workers thinking about production targets for the shift, day, or week. This lets workers see right away when they have a good day and it lets them know that if production is getting behind that they should make an effort to speed things along.

Flexibility

The majority of the local manufacturing companies do business in a way that requires them to be able to shift production between different products. Unlike the assembly line made familiar by automakers or industrial breweries, these manufacturing companies require technology that can be used in different ways or in different locations. The ability to be used for the full set of products being manufactured at a location is something that makes a technology a more, or less, attractive investment.

Sensors

The topic of sensor technology came up a number of times as the costs associated with this technology have dropped.

The sensor type most commonly mentioned was a visual sensor that can 'see' objects in their surroundings. These sensors had two main applications, for quality assurance and for the automation of steps in a process where there is variation in positioning of parts that needs to be detected. Additionally, there were a set of manufacturers who felt visual sensors could enable the automation of moving a product from one machine to the next machine, a task that machine operators currently perform.

Cutting edge technology

The choice about the adoption of a technology is not just determined by if a technology exists or not but if it is affordable enough that adoption requires nearly no thought.

Locally, this is an important consideration of manufacturing companies. There is no need to invest heavily to have the most up-to-date technology when a manufacturing company is able to operate profitably with the technology that they already have.

When incremental improvements do happen they are driven by considerations other than a need to 'keep up with the Joneses'.

A 'set it up right the first time' mentality

Technology use was noted to be path dependent to some extent. The automation and innovation that occurs at existing companies builds on what has been done before, which built on what was done before that. This leads to the example of one company operating machines built in the 1930s which then feed processed product parts into modern CNC machines.

If path dependent technology adoption is the sizable force that it appears to be then a 'set it up right the first time' mentality will reward those who are able to make it happen.

Technology as a cost control part of manufacturing

To some extent, there was evidence of technology being used as a method of cost control. One example is a vending machine that dispensed supplies to workers when they swipe an ID card. This tracking encourages workers to be aware of how much they use, identifies those who are going through excessive supplies for assistance, and drastically cuts down the chances of petty theft.

Bottlenecks

Process improvement in differing scales, with LEAN or SixSigma on the high end of resource investment and a new machine on the lower end, seem to be the driving area of technology investment in this area. Inventory management and logistics make up a part of this drive. Much of this work is the paired identification of slow steps in manufacturing and then the innovation needed to open up the process.

A major factor that keeps companies from being able to clear bottlenecks is being able to devote the resources, either the time of existing employees or capital needed to hire consultants or new employees, to both evaluate and solve problems.

Technology Investment: a Resource Allocation Problem

Once companies have enough spare capacity to re-invest, that is when the decisions about where to go next begin. How much time do they spend researching options or evaluating those they know about did not come up in the consultations.

Employment, or human resources, is a part of the capacity equation but it isn't a consideration of to hire or fire an employee. Instead it might be better to think of the spare capacity derived from process improvements as free employee hours. These hours are then re-assigned to new tasks which can increase output or quality. In some cases, spare capacity in the form of employee hours can be used to expand the business. An extreme example, illustrative but not from these consultations, is how the Post-It notes were developed by a 3M employee who was using the extra human resource capacity to produce research and development. This could just as easily have been focused on process improvement.

Software Technology

There has been a drive for companies to automate parts of the accounts receivable process in addition to a number of other parts of the manufacturing process. Software was one of the most prevalent areas of technology improvement and innovation that was discussed in consultations.

Smart Machines

The advent of embedded network connectivity in newer machines means that they can be connected and monitored, if not controlled, from a central location. This technology is not as much new as newly available. The impact on workers has to do with the ambitions of individual manufacturers.

The uptake of the technology will require network technicians who can ensure the functioning of the connectivity and the implementation and maintenance of the internal networks that are needed to operate a connected environment. Control of machines and modifications to any control packages will require software operators, those who can figure out and use the software provided. It is possible that software developers could tailor the existing software to specifications. These same software developers could work on innovative software unique to a manufacturing group by manufacturers who feel comfortable going this direction.

Over time, the monitoring of machines will produce a collection of production data in high volumes. Using this data could be valuable but it requires those with the analytical skills to be able to use the data to reveal areas for improvement or optimization. A consideration is that the analysis might require some knowledge or experience in the industry for the best results. If this is the case, then it suggests that re-training existing staff in an analytical capacity might prove more advantageous than hiring an analyst who is only familiar with the use of numbers in a disconnected way.

Smart Products

Much like the growing prevalence of connected production machinery, there is a move toward creating products that are expected to be connected as they are being used. Early connectivity efforts that have been tested on consumer products focused on simply embedding RFID chips in order to track products more effectively as they navigated the supply chain and to a lesser extent after they were sold. Terms such as 'the internet of things', frequently used in the shorthand IoT, have developed to describe the second generation of connectivity. Early examples include mostly household products that connect to the internet through home connections. The thinking behind this connectivity has yet to become fully realized but suggestions include being able to check if the oven is off from a phone (and turn it off if it is not), or having refrigerators that track what's in the fridge (and what's spoiled), or home security systems which can let home owners check up on the home remotely.

Over the course of the consultations it became clear that these examples were not applicable locally but that modifications of the same technology were viable in the near future. Manufacturing companies that create machines for other companies can embed technology to their products that will keep them connected to the machines they create after the sale and installation. Allowing the original manufacturing companies to dispatch technicians when maintenance or repair is required.

Manufacturing companies that are making products that end up in the inventory of other companies have a slightly different advantage to be gained from this technology. Instead of repair and maintenance, a company that tracks sales after the fact can get automatic notification when a customer is running low on inventory. Depending on the relationships with each customer, this information can be used in different ways. One possibility is to set an inventory level that triggers an automatic order for re-stocking the product. Another possibility is that low inventory levels notify the manufacturer and this trigger can be used to schedule production runs in anticipation of an order.

Software Operators / Developers

There are two distinct branches of people who know software, those who know how to use software and those who know how to design software. Most of the technology that was discussed over the course of the consultations had some amount of interaction with software of one kind or another. What wasn't exactly clear is how much the focus on software required design, or code, skills and how much simply required the wherewithal to navigate software in order to accomplish the needed tasks.

When looking at workers, who are needed for software operation, there will be those who have the specific knowledge of the exact software being used and there will be those who are just good at figuring out how to use any software. This distinction is important because there will inevitably be a tight supply of people who know specific software packages, especially those that are very industry specific. One way to expand labour supply is to be cautious at the time of implementing software. If the software is not widely used, or if it is built in house, then finding software operators requires flexibility. The challenge with being flexible when searching for an operator under these conditions becomes a challenge of evaluating which workers can or can't learn software quickly.

Analysts

The analysis of data is a skill that can be tough to evaluate, in part because it requires a good idea about what type of analysis needs to be done. Initially, the analysis of data will likely consist of finding low hanging fruit, easy to identify and hard to refute. As initial analysis is done, the clear insights become less and less numerous. Once this begins to happen the skills of analysis change to become more focused on rigorous statistical analysis.

The amount of data will dictate what is needed in terms of analysis as well. If the amount of data becomes too large, the ability of MS Excel to deal with the information declines. At the extreme end of this problem, is the cap on the number of rows in MS Excel, a problem encountered if doing substantial analysis of the census, for example. In less extreme cases, excel just begins to show why it is not a database software. As data sets get larger, dedicated data management software becomes more valuable. MS Access could be considered the first step beyond excel since it is easy to use and easy to integrate with other Microsoft products. Beyond MS Access are programs such as SQL (Structured Query

Language) which is the go-to for data management work.

What can be done with an analysis depends on the details of what data has been collected. The large companies around the world have spent decades studying process optimization, logistics and implementation. These are areas where analysis will have the biggest impact. Other segments of manufacturing can also be well suited for analysis, sales data and purchase data are some areas where analysis could reveal savings or opportunities.

Machine Operators

One of the most noted applications for automation was in the operation of specific machines. These applications are not to replace the machine operators but to maximize their time operating the machines. The simple task of moving a part that is in production from one machine to another was broadly seen as a bad use of a machine operator time. Instead, the desire was that machine operators spend all of their time running, maintaining, or repairing machines.

Another key for machine operators is to be able to switch the machine from one task to another. This can be where knowledge of CNC (computer numerical control) becomes a required skill of a machine operator.

Financing Costs

An overall theme of the discussions of technology with local manufacturing companies was the use of a variety of technologies to improve processes, eliminate bottle necks, and other forms of incremental improvement. These areas for improvement have a lot in common with the optimization drives that international corporations have been implementing for a number of years. LEAN manufacturing and the Six-Sigma were driven in part by a desire to cut financing costs associated with supply chains. For large companies, the value in reducing this cost is very real.

Not all manufacturing companies are going to have the same potential to see improvements from the analysis of financing costs, but some will.

Culture of Trust

There was not one consultation where an employer was looking to automate as a way to replace workers. Reasons for automation were nearly exclusively in support of workers. There were cases of using technology to improve the health and safety of workers, reducing absenteeism and keeping worker productivity from falling due to preventable repetitive strain. A more common reason for looking at improving technology was to be able to increase output with the same number of people. There was some mention of using technology to fill vacancies that could not be filled.

So long as the understanding that workers are valued is well communicated with the workers, a culture of trust will develop. In a work environment where there is trust and respect, the workers will become active participants in the identification of where technology might be used to increase their own productivity. The culture needs to be well entrenched, because when there is suspicion about the motivations of management, the workers are less likely to offer up suggestions for improvement for fear of reduced hours or the outright elimination of jobs.

Discussions/Appendices

Revisiting the Environmental Scan

After completing the consultations with local manufacturers, the initial ranking of estimated impact of technology on employment in manufacturing is worth revisiting to update with the new information. Below is a discussion of the most significant changes to the original list along with discussions about what influenced the changes.

Additive Manufacturing (3D Printing)

The biggest surprise finding over the course of the consultations was the low penetration of additive manufacturing in local manufacturing businesses. There were some companies that were more aware of the technology or had been using it to a very limited extent. Those companies that were aware of the technology were mostly focused on ability to use additive manufacturing for rapid prototyping and not for the creation of finished products.

Concerns about material choice and finished product quality were voiced by manufacturers. Getting a better understanding of the range of materials available could be adding another step to the process of technology adoption that is unique to this form of manufacturing. In addition to the first step of knowing about the existence of a technology, manufacturing companies must also learn about the scope of options available when using the technology (in this case those options are different materials available). The quality of finished products has to do with the initial rough stratified nature of printed objects. If the technology advances in the same way as printing and screen technologies, there will be a continued advancement in the resolution available. Assuming the development is similar to the printing of photographs, in time there will be a point where it is very hard to tell the difference between analogue and digitally created products.

What is clear is that there are groups that have been able to perform some incredible feats of manufacturing using an additive approach. The drivers of the technology right now are aviation and auto manufacturing where even small improvements in manufacturing processes can be worth millions of dollars. It is possible that this technology is much more distant for local manufacturing because it requires so much time invested in learning what is possible before the more pragmatic investment required to implement a new manufacturing process. Like screens and sensors, a substantial decrease in costs could see the viability increase; likewise, proven improvements in quality will go a long way in showing the technology as a viable option.

A multi-polar geopolitical balance and other political concerns

It is still challenging to consider political developments technology. Initially, this thinking was developed as an extension of the notion that process optimization, supply chain management, and payment processing are, being generous, organizational technology. An idea that was considered was to try and qualify technologies as either soft (a new process) or hard (a new CNC machine). This idea was not pursued because of the work involved in trying to create another arbitrary metric with limited value.

What has become glaringly clear is that the intangible ‘technology’ of legislation is poised to have a major impact on manufacturing globally. There will be winners and losers, who these will be is an issue of speculation rooted in both research and ideology.

The consultations done as a part of this report were completed before the protectionist rhetoric hit the level it is at as of this writing. What seems clear from the debate is that, for better or worse, policy is about to trump technology as a driver of local manufacturing employment.

Sensors

The improvements and cost reductions associated with sensors of all types look like they are having the biggest impact on technology changes locally. The use of sensors, especially visual sensors, is opening up the possibilities for automation at a very tangible level. An implication of this advancement is an increased need for the associated technologies, motors and actuators to automate, computer connectivity to control the technology, and most importantly, people who have the computer skills needed to operate newer high tech machines.

Analytics and Big Data

Using sensors and connecting more of the manufacturing process to computer resources will have an added effect of creating reams of data which can be used to further improve manufacturing. This data needs to be organized and stored before it can be analyzed. The impact on employment will be to create jobs in information management as well as analytics.

For manufacturing companies to take full advantage of these developments, they need to know what to store, how to store it, and what to do with the information once it has been collected.

To some extent, analytics is a second stage of automation. Locally, companies are pushing into areas where the processes become more and more digital. Getting the manufacturing process running with a robust digital component is the first step, one that needs those who can identify what can be automated as well as being able to implement the automation.

Once this is complete, the analysis of manufacturing processes could lead to process optimization for SMEs in a way that had only been done by large multinational companies in the past.

Education and Training

The limit on technology adoption with local manufacturing companies appears to be driven by the supply of skilled workers. The skills in question are those related to traditional manufacturing (machinists, welders, tool and die workers), engineers trained in industrial applications (mechanical, electrical, and chemical engineers all study process control), and workers who are skilled at the installation and management of information technology infrastructure (network installation and operation professions). These represent some of the immediate needs of manufacturing.

Looking forward suggests that there will be a need for workers who are then skilled at maintaining, running and optimizing existing manufacturing processes. For this second stage of automation, the requirements for traditional manufacturing workers and engineers who focus on the design of industrial processes could be expected to ebb slightly. Skills needed for the second stage of automation might be best described as desk skills. These are skills which are focused on using computers to collect information about manufacturing, to analyze the collected data, and, arguably the most important part, understand how to act on the analysis of the data collected. The collection and analysis of data requires organization as well as a knowledge of manufacturing to identify what data is most valuable to collect. The analysis of data requires skills that change with the complexity of analysis required. Early analysis tends to require identifying and acting on low hanging fruit, clear areas for improvement with big impacts. The low hanging fruit of analysis can usually be done by anyone with a strong background in any type of math who has the organization and problem solving skills needed to do analysis. Familiarity with Microsoft Excel or another spread sheet software will be the minimum, but other analysis software could also be used.

Advanced analytics requires a more focused understanding of math, statistics in particular, in order to model and optimize processes.

In the past, these rolls have been filled by students who have post-secondary education in actuarial sciences. The analysis software used for more advanced analytics changes in addition to the skill set. Spreadsheets begin to become less useful as data sets get bigger and calculations require accuracy that is only available in statistical analysis software (SAS, SPSS, R).

The biggest challenge with education and training faced by local manufacturing companies is that the skills needed to automate and analyze manufacturing processes are in demand around the world, by employers with extremely deep pockets. The global demand tends to be less focused on occupations, training or experience (not to say these don't play a part) than it is on a small set of very transferable skills. Going back to the case of graduates of actuarial sciences, these graduates can use the statistical analysis skills they have learned to optimize manufacturing processes, manage investment portfolios of high net worth individuals, or to research optimal insurance premiums. In the case of computer programmers the skills are identified by the language of choice, Java or C or Python, as well as specific development packages (dialects if you will). Programming is almost fully transferable since banks, car companies, municipalities, retailers, transit companies; almost every industry, wants an app or a web page… ideally both that seamlessly work together.

Co-working and the Shared Economy

These concepts were not specifically referenced over the course of the consultations with manufacturing companies. What did come up was the notion of consortiums of manufacturing companies. This idea was described as a number of companies who pool extra capacity to start new ventures.

This cooperation has many similarities to the descriptions of co-working spaces or shared economy ventures. For example, the ride sharing service Uber makes use of private cars and car owners who have some free time, spare personal capacity if you will, to offer rides to paying customers.

Cooperation in an effort to use spare capacity in a productive manner has both challenges and opportunities. The opportunities are that they offer potential for revenue maximization as well as chances to reach into markets that would be unavailable to a single member of a consortium. The challenges are rooted in relationship management. Cooperation involves more coordination, consensus building and communication than operating in a top down business with clear organizational structures.

Artificial Intelligence and the Google Flail-Bot

Some of the most discussed issues with emerging technology in the past three to five years are centered on the strides made in artificial intelligence. The spread of these ideas along with very impressive demonstrations of the technology have caught the imagination of the mass media and the creators of cultural content like film and TV producers. There is little evidence that AI is set to make an impact on local manufacturing employment in the foreseeable future.

One difficulty with evaluating the potential for the application of artificial intelligence to local manufacturing is understanding what it is and how it could be applied. Speculative fiction depicts artificial intelligence as a technology that can be built to emulate human intelligence from inception. In these cases, the artificial intelligence is indistinguishable from a human intelligence from the moment the power begins to flow. This does not seem to be the case in any way.

The term artificial intelligence is closely related to machine learning. As the second term alludes, the machines need to learn before they become even passably competent at any task.

A good demonstration of the learning process for one AI is demonstrated in a set of videos released by DeepMind, the Google related research group studying AI. In these videos (links can be found in appendix B) the AI has been given control of virtual bodies and tries to get them to move forward. The AI is given no instruction other than this. The learning is done by trial and error, lots and lots of trial and error. The results can be comical, especially as the human like body flails arms around for some unknown reason, but eventually the AI figures out locomotion.

In this way, an AI is not unlike a human baby who has control of limbs, eyes to see and ears to hear, but no context what so ever. Human children take years to master walking so it should be no surprise that an artificial intelligence might take weeks or months to 'figure out' locomotion.

Keeping employment and manufacturing in mind, this line of thinking might suggest a new occupation emerges where an employee is an Artificial Intelligence Trainer. The task of this employee would be to take 'baby' artificial intelligence packages and to develop them for the task they need to do. At this point, the possibility seems on the edge of plausible but it is worth keeping in mind when thinking about artificial intelligence.

Understanding Technology

The preceding section illustrates a large barrier in all forecasting of how technology could impact employment in local manufacturing. Artificial intelligence, quantum computing, crypto currencies, and other technologies are complex and speculative. Since these technologies are still in development, no one knows how they will work or if they will work at all. Even developers of technology themselves can only speculate about what the finished product will be and how it will work, since if this was known, the development stage would be complete.

This complexity of many new technologies, especially when they seem quite speculative, makes it difficult to allocate time to discussions of the technologies. Pursuing this line of reasoning might be a topic that could be explored further at some other time. Research could look at developing a way to evaluate emerging technology in order to prioritize time spent following up on the topic. This research could include a section that looks at technologies that did not get adopted and tries to figure out why they did not.

Location

As the manufacturing shifts and evolves, responses around the world have varied. Understanding the impact of technology on manufacturing is one element of the employment picture but it is not the only element. Location choice has many dimensions for both employers and employees. Are manufacturing companies leaving the area? How does an area attract manufacturing? Can an area attract manufacturing? Is there a brain drain? Is there a skills gap?

Flat v. Spiky

The advent of the internet lead to discussions about distributed work and the emerging possibility that location no longer mattered. Workers could connect to the internet, do their job, and log out from anywhere in the world. A seminal work on this topic is Thomas L. Friedman's "The World is Flat". In this book he explores the concept of remote working in detail.

Unfortunately this theory of a level playing field where no location has an advantage beyond the speed of internet connectivity has not been playing out in demographics. In his book, "Who's Your City", Richard Florida examines the trends in migration which suggest that the world's biggest urban areas are just getting bigger. His observation of evidence points out that instead of being location agnostic, people are choosing to concentrate.

The reasons for this concentration are less clear. Florida draws on his past work, much of which is encapsulated in his book “Rise of the Creative Class”, to discuss theories about the importance of place. He has looked at much of the choice of a place to live from a lens of encouraging innovation but the basic question that is trying to be answered is what drives people to live where they live.

This is an important consideration for local manufacturing companies because technology only moves if there are people to move it. Employers have been reporting trouble finding workers with the right skills off and on for the past decade or more. If this is a trend that is persistent then local manufacturing companies will have to address the question of where people live in order to figure out why skilled labour is not choosing to live near them (assuming there is the skilled labour in another place).

A more traditional view of economics has one possible answer. In labour market economics, the supply of workers is driven by the wage offered. If wages are low, there will be more demand for workers than there are workers willing to supply that labour. If wages are high, there will be more workers looking to supply the work than there are employers willing to pay them. In this case, the answer to any labour supply issue is to raise wages. Unfortunately the real world economy has many more factors contributing to the balance of supply and demand for workers.

Power

As a closing discussion, the subject of power, electricity and electric grids is apt. On the supply side of this economic market are the power generation facilities of all kinds. Inefficiencies and mismanagement could be raising the costs of power. Unfortunately, this is a partisan political issue and it is difficult to sort out fact from rumors, speculation, and partisan propaganda. To do so would require a study in and of itself.

The demand side of the power market is easier to evaluate. Demand looks set to continue to increase. Nearly every technology examined over the course of writing this report is a powered technology. These emerging technologies are in addition to the steady adoption of mobile technology. Although the impact is unknown, what is known is that almost every adult and many children are now carrying a mobile device that needs to be charged every day or two.

Of all the technologies examined, it is the mass adoption of electric cars that could have the biggest impact on electricity prices in the future. What’s more is that this transformation could happen suddenly and soon. Crypto currencies are of less concern locally, but present an emerging high-impact technology. The current models for these currencies are very power intensive. The mining of currency is actually the completion of a mind boggling math problem.

These problems take so long to figure out that banks of computers run at full speed nonstop to find solutions to the problems. The power required to run the computers is so high that even a single computer set to mine from a person’s house will drastically increase both the power bill and the temperature of any room they occupy. A story written for the March / April issue of Politico magazine documents an extreme case of a small town in Washington State that became the location of choice for hundreds of crypto currency miners. It shows some of the many challenges that come from running thousands of computers at full steam.

As yet it is hard to say if any of these developments are having any impact on demand for power in Ontario but it seems likely that they will have an impact over time.

Oddly, the increasing demand for power from so many directions might decrease the viability of automation for local manufacturing companies as worker’s wages are much more predictable than the fluctuations of power costs.

Appendix A – Consultation Question Guide

Introduction

Have you got some time to talk about automation and what that means to you?

Possible follow-up questions

What is automated and what's not? Why?

What jobs are on the increase due to automation in your facility, in your industry?

What tasks are automated? Why?

If you could invest in a technology upgrade without concern for capital investment what would it be? Why?

Are there factors other than cost that stand in the way of upgrading technology at your firm?

Appendix B – Links to the Google 'Flail-bot' Videos

A light hearted demonstration of artificial intelligence (AI) learning to walk.

The following links are visual demonstrations of artificial intelligence training runs. These videos are recordings of an AI controlling virtual objects and learning how to move forward and adapt to different obstacles. An interesting note is to watch the human shaped test where the AI has 'learned' to walk with arms flailing all over the place.

It shows how an AI may discover new things that humans have not even considered as well as the fact that an AI is only as good as the model that is made available to it by human designers.

The DeepMind link is a complete video released by the developers of the AI. It is a more technical video while the second link is from a technology magazine, has fewer technical details, and has a soundtrack.

DeepMind Upload

https://www.youtube.com/watch?v=hx_bgoTF7bs

Tech Insider Upload

https://www.youtube.com/watch?v=gn4nRCC9TwQ

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