Case Study Assessment of Economic Development surrounding Autonomous Vehicles : A comparative analysis of Michigan and Ontario

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Abstract

The Memorandum of Understanding between Michigan and Ontario is an opportunity for Ontario to increase its competitiveness in the region. OEMs and technology companies in Ontario need to seize the opportunity of the Superclusters Initiative, to achieve the required competitive advantage. Partnerships between technology firms in both regions are essential for Canadian part to acquire the expertise from the pioneers in Michigan. Collaboration between Michigan and Ontario in aspects of regulations ruling AVs testing, as well as technological infrastructure is a major step for Ontario to take advantage of Michigan's experience in these areas. Social acceptance for AVs is the cornerstone for both regions, in their endeavors towards competitive advantage. Unlike Michigan's clusters, clusters working in the development of AVs in Ontario are lacking interconnectivity between them. The situation is more like a collection of short stories in Ontario compared to a novel of connected parts in Michigan. The ultimate goal for all stakeholders in Ontario is to compile and link these short stories to make a novel of their own.

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Introduction & Research Question

This paper highlights the economic effects of the signed memorandum of understanding between Michigan and Ontario, surrounding the development of autonomous vehicles in each jurisdiction. A new model will be used to assess the competitiveness of Original Equipment Manufacturers (OEMs), Technology companies, and government policy. The three components of this model will be analyzed using Porter's Diamond model, to determine the strengths and weaknesses of each jurisdiction.

The Great Lakes – St. Lawrence region is a major driver for economic development in North America, with an estimated economic output of $US6 trillion the region accounts for nearly a third of combined Canadian and American economic activity and employment(*BMO Special Report*, 2017).

On a global scale, if the region considered as a country, it will be ranked as the third economic output after USA and China, and it will surpass Japan, Germany, United Kingdom, and France which shows the economic importance of the region (*BMO Special Report*, 2017).

On August 2016, the governments of Ontario and Michigan signed a memorandum of understanding to drive growth and increase the competitiveness of the Great Lakes auto industry (*Memorandum of Understanding*, 2016). One of the potential focus areas included in this memorandum of understanding was technology advancement including connected cars, and autonomous vehicles (*Newsroom : Ontario and Michigan Partner for Auto Industry Growth and Innovation*, 2016).

The central research question for this paper is "Can a formal memorandum of understanding with a strong cluster elevate a weaker cluster partner; The Michigan - Ontario Autonomous Vehicles experience?".

Context

From a policy perspective, economic development is efforts that seek to improve the economic well-being and quality of life for a community by creating and retaining jobs and supporting or growing incomes and the tax base (*What is Economic Development? | Salmon Valley Business Innovation Center*, 2011).

Autonomous Vehicles (AVs), self-driving vehicles, driver-less vehicles, driver-free cars, and robot cars are all names for the material discussed in this paper. They are vehicles equipped with computer technology that intends to partly or entirely replace the driving tasks, that used to be conducted by a human driver.

This new concept of vehicles will act as a disruptive technological change in the automotive industry, which will change the traditional way people used to think about vehicles forever. In fact, this concept is not new as it started far back as in the early 1920s (Weber, 2014) and began to rise to the surface in 1980s concurrently with the establishment of the automated highway systems (Fenton & Mayhan, 1991; Ioannou, 2013). Pioneer pilots of AVs mainly came from the U.S. and Germany during 1980 to 2000 (Anderson et al., 2014; Lantos & Márton, 2010). AVs use different technologies to navigate by themselves on the roads without any human intervention. The technology behind AVs consisted of two major divisions of technologies. The first division is Global Positioning System (GPS) which is used to identify vehicle position to the transportation infrastructure. The second division is the systems of sensors, and this includes Light Detection and Ranging (LIDAR) which assist the vehicle in finding its way in the dark and low-visibility situations, RADAR, and camera (Menon, 2015). These advanced technologies work collaboratively to achieve the automated driving mission.

Connected Vehicles (CVs) are an associated automobile technology seen as precursors and prerequisites to full AVs. The main difference between CVs and AVs is the presence of an active human driver in CVs, whereas AVs can fully drive themselves without any human intervention (Barnes, 2017). CVs can communicate and share information with other CVs through the technology of Vehicle-to-Vehicle (V2V), and with the transportation infrastructure through the technology of Vehicle-to-Infrastructure (V2I) (Anderson et al., 2014).

AVs have different levels of automation. The industry organizations have created two standards to categorize these levels which are Society of Automotive Engineers (SAE) International and The US National Highway Traffic Safety Administration (NHTSA). Both of these standards classified the automation into six levels. Figure 1 (Ticoll, 2015) shows the definition of each level and the functions performed within each of these levels, as well as, mapping the NHTSA levels to the SAE levels.

This paper will refer to the SAE International standard as it is the adopted standard by The Government of Ontario in its AV pilot regulation of October 2015 (*Otario Regulation 306/15: PILOT PROJECT - AUTOMATED VEHICLES*, 2015). According to SAE International, the level of automation escalates with higher levels of automation and that results in less human control over the vehicle.

In Figure 1 (Ticoll, 2015), level 1 includes vehicles that need driver assistance. In this level, the automation system is functioning either on steering or acceleration/deceleration, but not both. The highest Advanced Driver Assistance System (ADAS) in level 1 includes Adaptive Cruise Control (ACC), pre-collision braking, and lane departure warning. Level 2 is higher than the previous level with partial automation where the vehicle system can take control of both steering and acceleration/deceleration. In 2015, Tesla took a proactive step as a pioneer company on introducing vehicles with level 2 automation system (*Your Autopilot has arrived | Tesla*, 2015).

At both level 1 and level 2, the vehicle performs predetermined driving tasks and warns the driver to take over control in some circumstances. That means the overall responsibility is on the driver to keep an eye on the road and the surrounding traffic. At level 3 the vehicle automation system has the full-time control in particular modes such as highway driving and dedicated AV lanes, or unobstructed city streets (*White Paper Automated Vehicles in Canada*, 2016). Most of the ongoing pilot testing is at this level of automation, ranging from local trials to transcontinental road trips (*Daimler's Freightliner Tests Self-Driving Truck in Nevada - Bloomberg*, 2015; *Delphi Drive*, 2015; *Mission accomplished: Audi A7 piloted driving car completes 550-mile automated test drive | Audi USA*, 2015).

There is a safety issue associated with this level of automation which is the driver's responding time when asked to take back control. According to studies, drivers might not be able to respond to a 2 seconds emergency while the results showed gradual improvements to 5 seconds and 8 seconds respectively (Ticoll, 2015). The response time for such emergencies should be 5 seconds or less (Mok et al., 2015) which gives a sign for attention to safety requirements at this level.

Level 4 and level 3 have some similarities like taking the full control in particular modes but, the main difference here is that no driver participation needed in level 4 full control modes. In this level, the full control mode is related to driving in certain locations such as dedicated freight routes, bus ways, or AV car lanes (Ticoll, 2015).When the vehicle departs the full automation locations, it reverts automatically to level 3 which means it might require the driver assistance at emergency situations (*White Paper Automated Vehicles in Canada*, 2016).

The highest level of automation is level 5 where the vehicle has full control on all driving modes irrespective of geography, road type, traffic conditions, weather, interactions or events (Ticoll, 2015). At this level, no need for steering wheels and floor pedals as these parts were related to human control over the vehicle, and as a result of that there will be no existence for drivers as all of the vehicle's occupants are passengers. The biggest challenge lies in levels 3, 4, and five where the vehicle automation system is supposed to take the responsibility of monitoring and responding to the surrounding driving environment.

Literature Review

The comparison between Michigan and Ontario stemmed from the geographical proximity, and the role of Canada and USA as major manufacturing powerhouses that accounts for more than 26 percent of vehicle production in North America (*Newsroom : Ontario and Michigan Partner for Auto Industry Growth and Innovation*, 2016).

In July 2015, the University of Michigan opened Mcity in Ann Arbor, the world's first controlled environment to test connected and automated vehicle technologies, which was designed and developed by Mobility Transformation Centre (MTC), in partnership with the Michigan Department of Transportation (MDOT) (*U-M opens Mcity test environment for connected and driverless vehicles | University of Michigan News*, 2015).

The Mcity testing facility sits on a 32-acre site that costs $US10 million and will provide a pilot testing environment for AVs with a maximum speed limit of 64 km/h (*Mcity Sets Stage for Self-Driving at Willow Run? | Industry content from WardsAuto*, 2015). To cope up with the expected need for higher-speed testing tracks, The American Center for Mobility announced on May 2017 the beginning of the first construction phase of a new testing site, that will be constructed on 335-acre historic Willow Run site in Ypsilanti Township in Southeast Michigan (*The Project | American Center for Mobility*, 2017). The total cost of the project will be $US110 million, and the first phase of construction is planned to finish and open for testing by December 2017 (*The Project | American Center for Mobility*, 2017).

In December 2016, Michigan Governor Rick Snyder signed the Senate Bill 995 – The Bill is now PA 332 of 2016 - which allows operation of AVs on Michigan roads, taking in consideration all the required safety measurements (*Snyder - Gov. Rick Snyder signs landmark legislation to allow operation of autonomous vehicles on Michigan roadways*, 2016). The bill allows for AVs platoons, where vehicles travel together at electronically coordinated speeds, as well as authorizes on-demand AVs networks (*Snyder - Gov. Rick Snyder signs landmark legislation to allow operation of autonomous vehicles on Michigan roadways*, 2016).

Also, Michigan Governor signed three other bills as part of the AVs package which are SB996 (now PA 333), SB 997 (now PA 334), and SB 998 (now PA 335) (*Green Car Congress: Michigan governor signs legislation package allowing operation of autonomous* *vehicles on state roadways; enabling platooning*, 2016). PA 333 outlines specific parameters for entities that wish to offer on-demand autonomous vehicle networks to the public (*Senate Bill No. 996*, 2016). PA 334 recognizes the American Center for Mobility at Willow Run in statute and removes barriers to operating at the facility (*Senate Bill No. 997*, 2016). PA 335 exempts mechanics from any damages to vehicles that result from repairs, if the repairs are following manufacturer specifications (*Senate Bill No. 998*, 2016).

On January 2016, Ontario became the first province in Canada to create a pilot regulatory framework to test automated vehicles on its roads (*Newsroom : Automated Vehicles Coming to Ontario Roads*, 2016). Ontario committed to $2.95 million in funding to support Ontario industry and academia through the Ontario Centers of Excellence CV / AV Program, to bring academic institutions and business together to promote and encourage innovative transportation technology (*Newsroom : Ontario First to Test Automated Vehicles on Roads in Canada*, 2015).

Ontario pilot program brings a range of expertise from the research, manufacturing, and technology sectors which are The University of Waterloo, the Erwin Hymer Group, BlackBerry QNX, Continental, X-Matik Inc. and Magna (*Newsroom : Ontario and Michigan Launch Canada's First Cross-Border Automated Vehicle Test Drive*, 2017). In a proactive step to capitalize on the economic potential of AVs, The Province of Ontario is investing $80 million over five years to create the AV Innovation Network, in partnership with Ontario Centres of Excellence (*A Stronger, Healthier Ontario*, 2017). This investment will support research and development in industries related to AV; create sites across the province to develop, test and validate the new technology, including a demonstration zone in Stratford; and attract and grow talent in the AVs sector (*A Stronger, Healthier Ontario*, 2017).

Stratford's designation as demonstration zone for AV pilot testing based on its advanced high-speed Wi-Fi broadband company, Rhyzome Networks, that works on developing Dedicated Short Range Communications technology, a highly efficient two-way short-range communications system which is essential for the development of ADAS and their evolution to fully AVs (*Stratford takes the wheel for autonomous vehicle training | IT World Canada News*, 2017).

On the third of August 2016, Governments of Michigan and Ontario have signed a memorandum of understanding regarding the regional cooperation and competitiveness of the Great Lakes automotive industry (*Memorandum of Understanding*, 2016). The memorandum focused on three main areas which are, supporting technology advancement including connected and autonomous vehicles, lightweight materials, and alternative fuels; enhancement of interconnected automotive supply chain and supporting information and technology transfer between automotive suppliers; sharing best practices in industry strategy, regulatory and policy approaches, and workforce skills development (*Newsroom : Ontario and Michigan Partner for Auto Industry Growth and Innovation*, 2016).

On May 2017, Government of Canada launched a historical job-creating innovation superclusters initiative with a budget of $950 million to attract large and small companies that collaborate with universities, colleges or not-for-profit organizations - as a consortium - to turn ideas into solutions that can be brought to market (*Government of Canada launches historic job-creating superclusters initiative - Canada.ca*, 2017). This initiative will select up to five superclusters that accelerate Canada's global advantage in highly innovative industries such as advanced manufacturing, agri-food, clean technology, digital technology, health/biosciences, clean resources, as well as infrastructure and transportation (*Government of Canada launches historic job-creating superclusters initiative - Canada.ca*, 2017).

This unique initiative will invest these funds between 2017 – 2022 to bolster the businesses that have the potential to become engines of economic growth, as well as, fostering stronger connections and opening the door to new forms of industry partnership (*Government of Canada launches historic job-creating superclusters initiative - Canada.ca*, 2017). Also, it will represent a significant commitment to partnering with industry and supporting the success of leading domestic and global companies that choose to innovate in Canada (*Innovation Superclusters Initiative - Canada.ca*, 2017).

On the thirty-first of July 2017, Ontario and Michigan launched Canada's first cross-border automated test drive through southern Ontario and Michigan (*Newsroom : Ontario and Michigan Launch Canada's First Cross-Border Automated Vehicle Test Drive*, 2017). The test drive began in Detroit and crossed into Windsor before going north to Sarnia and returned to Michigan (*Newsroom : Ontario and Michigan Launch Canada's First Cross-Border Automated Vehicle Test Drive*, 2017). This cross-border demonstration allows Ontario's Magna International, Michigan Continental Automotive North America, the Michigan Department of Transportation (MDOT), and the Ontario Ministry of Transportation (MTO), to test automated driving technology in a variety of settings (*Joint News Release - International Autonomous Drive to Highlight Great Lakes Region's Leadership in Mobility*, 2017).

Methodology & Framework

This paper discusses the implications of the memorandum of understanding between Michigan and Ontario, surrounding the area of autonomous vehicles, on the economic development and growth in both jurisdictions. This topic has not been discussed before in much details which make this paper an addition to this knowledge area.

In this paper, a new model will be used to analyze the issue and the implications related to it. This model consists of the three main pillars needed to assess the inputs and endeavors made by each of these pillars to improve the economic effects of autonomous vehicles in each jurisdiction.

Figure 2 depicts the model used which constitutes of government policy, original equipment manufacturers (OEMs), and technology companies. The strength of each element and interconnectivity between elements are essential to achieving the required competitive advantage and economic development as the final result of that.

The reference to assess each of these pillars will be Michael Porter's theory of clusters. According to Porter's theory, clusters are geographic concentrations of interconnected companies and institutions in particular field, and it encompasses an array of linked industries and other entities important to competition such as components, machinery, services, and providers of specialized infrastructure (Porter, 1998).

In The Competitive Advantage of Nations (Porter, 1990), the effect of location on competition modeled through four interrelated influences depicted in a diamond-shaped model, which has become common in referring to the clusters theory (Porter, 1998). As shown in Figure 3 (Porter, 2000), the diamond model is a framework that consists of four elements which are factor (inputs) conditions, the context for firm strategy and rivalry, demand conditions, and related and supporting industries (Porter, 2000). In addition to those elements of Porter's diamond model, there are two significant influences which are government and chance that may have an impact on the level of success achievement. In the next lines, I will explain each element of Porter's diamond model.

Firstly, factor conditions which refer to the situation in a country regarding production factors like skilled labor, infrastructure, etc. (Recklies, 2015). These factors grouped into categories based on quantity and cost, quality, and specialization. Some factors affect the quantity and cost such as natural resources (materials, space, etc.), human resources (e.g. cost of labor, level of qualification), capital resources, physical infrastructure, administrative infrastructure, information infrastructure, and scientific and technological infrastructure (Porter, 2000). These factors are not necessarily nature-made or inherited, but it may develop and change taking into consideration the vital role played by political initiatives, technological progress or socio-cultural, in shaping these changes in factor conditions (Recklies, 2015).

Secondly, the context of firm strategy and rivalry refers to the rules, incentives, and norms governing the type and intensity of local competition (Porter, 2000). Firm's management structure, working morale, interactions between companies, and cultural aspects play a significant role in providing advantages or disadvantages for particular industries (Recklies, 2015). Clusters play an integral role in changing rivalry from concentration on the cost to differentiation in different aspects of competition, and that happens through shifting the notion of competition from imitation to innovation and from low investment to high investment not only in physical assets but also intangibles like skills and technology (Porter, 2000).

The third element is demand conditions which mainly concerned with moving firms from imitative, low-quality products and services to competing for products that make the required differentiation from competitors (Porter, 2000). The presence or emergence of sophisticated and demanding customers put pressure on firms to innovate and differentiate themselves (Porter, 1998). Clusters of linked industries play a central role in giving rise to demand-side advantages (Porter, 2000).

The last element of Porter's diamond is related and supporting industries, and these are industries that can use and coordinate particular activities in the value chain together, or that are concerned with complementary products such as hardware and software components (Recklies, 2015).

Findings

In this section, the three pillars of the AVs clusters' model will be assessed in reference to Porter's diamond model, to find an answer to the central research question of this paper.

As mentioned previously, the model consists of three pillars which are Original Equipment Manufacturers (OEMs), Technology companies, and government policy. These three components will give us an indication of the degree of competitiveness of each jurisdiction, and as a result of the competitiveness analysis, the answer to the research question and policy recommendations will be extrapolated.

Factor Conditions:

Starting with Ontario, Ontario is the only province or state in North America with five foreign based global OEMs which are Chrysler, Ford, GM, Honda, and Toyota, having a total of twelve plants in the province (*Automotive | InvestinOntario*, 2017). Ontario produced 15% of all of North America's light vehicle production over the past five years, achieving an increment in the production of 4.6% between 2015 and 2016 (*Automotive | InvestinOntario*, 2017). Also, automotive parts manufacturers such as Magna International, Linamar Corporation, Martinrea International, and Arvin Sango play a significant role in Ontario's economy (*The Automotive Industry in Ontario | Invest Canada Alliance*, 2015).

Meanwhile, Ontario pilot program has attracted a range of expertise from the research, manufacturing, and technology sectors which are The University of Waterloo, the Erwin Hymer Group, BlackBerry QNX, Continental, X-Matik Inc. and Magna (*Newsroom : Ontario and Michigan Launch Canada's First Cross-Border Automated Vehicle Test Drive*, 2017). In spite of having this decent amount of OEMs in Ontario, the province is still struggling to get a position in the coming revolution of AVs. The reason behind that is, OEMs in Ontario don't actually design, manufacture, and build a car which will affect negatively on its competitive advantage. In terms of physical infrastructure, Ontario has designated Stratford as a demonstration zone for testing the AVs (*Stratford takes the wheel for autonomous vehicle training | IT World Canada News*, 2017), taking in consideration that the city has the advantage of having a well-established Wi-Fi broadband company which is the backbone for different sorts of connectivity needed between AVs (V2V) and with the surrounding infrastructures (V2I).

On specialized factors within the province borders, there are crucial investments taking place in a sophisticated R&D infrastructure facilities such as the McMaster Automotive Research Centre (MARC), the Waterloo Centre for Automotive Research (WatCAR), the University Of Ontario Institute Of Technology, and the Fraunhofer Project Centre at Western (*Automotive | InvestinOntario R&D*, 2017). In addition to R&D facilities and infrastructure, Ontario has a unique advantage which is the brains that lead this innovative revolution. Ontario is the home of two of the three fathers of Artificial Intelligence (AI) and deep machine learning – the backbone and the fundamental science of technology behind AVs – who are Professor Geoff Hinton at the University of Toronto (*Artificial Intelligence at U of T*, 2017) and professor Yoshua Bengio at McGill University (*Machines That Dream: an Interview with Yoshua Bengio*, 2016). Also, direct automotive industry employment in Canada is at least 130,000, and the majority of these jobs - at least 124,000 - are located in Ontario (Sweeney & Mordue, 2017).

Looking at the current situation of technology companies, Ontario is considered the first technology hub in Canada and the second in North America after the Silicon Valley (*Automotive | InvestinOntario R&D*, 2017). Ontario took the lead for several reasons such as presence of more than 19,000 IT companies that hire more than 260,000 IT workers, feeding the technology marketplace with 39,000 STEM grads annually, and having 44 colleges and universities that support the auto and IT industries and supply the market with experts and professionals in cloud computing, data analysis, robotics, software development, telecommunications and security, and satellite technology (*Ontario from Lab to Line*, 2016).

Regarding government policy, Ontario is the first province in Canada to have a regulatory framework that allows testing of automated vehicles on its roads (*Newsroom : Automated Vehicles Coming to Ontario Roads*, 2016). The automated vehicle pilot project is the only one of its kind in Canada that allows companies and researchers to test the self-driving technology on public roads as long as they receive a permit and always have someone in the driver's seat ready to take over if something goes wrong (Owram, 2017).

According to Ontario regulation 306/15 which legislates pilot project of automated vehicles, it is required for the automated driving system to comply with any requirements of the Motor Vehicle Safety Act (Canada) that apply to automated driving system for the vehicle's year of manufacture, as well as complying with SAE Standard J3016 (*Otario Regulation 306/15: PILOT PROJECT - AUTOMATED VEHICLES*, 2015).

On the other hand, Michigan is the home to the big three automakers in the USA, General Motors, Chrysler and Ford (Ba, DeLaite, Kapashi, & Taparia, 2009). Also, automotive is the dominant cluster in Michigan which is accountable for production of 208,976 vehicles in 2016 that constitutes 20% of motor vehicle production of the USA (*Michigan Governors Economic Outlook Briefing*, 2016). Also, automotive cluster in Michigan is providing vehicle and parts manufacturing jobs for 165,000 employees, which constitutes a proportion of 21% of the total employments offered by automobile sector in the USA (*Michigan Governors Economic Outlook Briefing*, 2016).

On specialized factors, Michigan has various efforts in the development of AVs arena. One of these endeavors is University of Michigan's Mobility Transformation Centre (MTC), which is a major public-private R&D initiative. A selected group of companies is the founding partners to MTC, including a broad variety of different sectors such as auto manufacturing, suppliers, insurance, telecommunications, data management, mobility services. . . etc. (*U-M Mobility Transformation Center announces founding corporate partners | UMTRI - University of Michigan Transportation Research Institute*, 2014). The founding partners with MTC – also known as founding members of MTC leadership circle – are Delphi, DENSO, Ford, GM, Honda, Toyota, Nissan, Robert Bosch, Verizon Communications, Xerox, Iteris, State Farm Mutual Automobile Insurance Company, and Econolite Group (*U-M Mobility Transformation Center announces founding corporate partners | UMTRI - University of Michigan Transportation Research Institute*, 2014). The Founding members of the Leadership Circle are each committing a total of $US1 million over three years to create a vibrant R&D ecosystem, and to support the MTC and its programs (*U-M Mobility Transformation Center announces founding corporate partners | UMTRI - University of Michigan Transportation Research Institute*, 2014). Also, MTC has launched its Affiliates Program with 27 initial members from a wide range of industries, including automotive manufacturing, vehicle communication devices, chips and hardware, and insurance, as well as companies engaged in such technologies as advanced modeling, big data acquisition, and intelligent transportation systems (Lampe, 2015).

When looking at physical infrastructure, MTC designed and developed Mcity in Ann Arbor – in collaboration with MDOT – which is the world's first controlled environment to test connected and automated vehicle technologies (*U-M opens Mcity test environment for connected and driverless vehicles | University of Michigan News*, 2015). Mcity is a $US10 million unique 32-acre off-roadway cityscape including a broad range of complex scenarios that vehicles encounter in the urban and suburban environment with speed limit of 64 km/h (*The Project | American Center for Mobility*, 2017). In May 2017, The American Center for Mobility announced the beginning of the first construction phase of a new testing site to cope up with the future need for higher testing speeds (*The Project | American Center for Mobility*, 2017). The total cost of the project will be $US110 million, and the first phase of construction is planned to finish and open for testing by December 2017 (*The Project | American Center for Mobility*, 2017).

Regarding government policy, Michigan has enacted Senate Bills SB 995, SB 996, SB 997, and SB 998 - now known as Public Acts PA 332, PA 333, PA 334, and PA 335 respectively –, in what so called AV legislation package(*Green Car Congress: Michigan governor signs legislation package allowing operation of autonomous vehicles on state roadways; enabling platooning*, 2016; *Snyder - Gov. Rick Snyder signs landmark legislation to allow operation of autonomous vehicles on Michigan roadways*, 2016). These bills pave the way for the development and testing of AVs on Michigan roads, through the allowance for AVs platoons and providing authorization for on-demand AVs networks (*Snyder - Gov. Rick Snyder signs landmark legislation to allow operation of autonomous vehicles on Michigan roadways*, 2016). Also, it recognizes the American Centre for Mobility in statue and removes barriers to operating at the facility, as well as exempting mechanics from any damages occurs to vehicles that result from repairs, in case these repairs are following manufacturer specifications (*Senate Bill No. 997*, 2016; *Senate Bill No. 998*, 2016).

Context for Firm Strategy and Rivalry:

According to Porter's diamond model, the context for firm strategy and rivalry is mainly concerned with rules, incentives, and norms governing the type and intensity of local rivalry (Porter, 2000). The main variable that controls the competition between companies within the cluster was the price which means companies need to hold down wages and involve minimal investment (Porter, 2000) to achieve that competitive price. The new concept of rivalry in the advanced economy is different, as it shifts rivalry from low wages to low total cost, and this can be achieved through upgrading the efficiency of manufacturing(Porter, 1990). This modern concept evolves rivalry from cost to include differentiation, and to achieve that differentiation competition must shift from imitation to innovation (Porter, 1998).

In the traditional automobile industry, technology companies are not playing a significant role within the industry. As a result of that, OEMs and technology companies are not competing. After the advent of autonomous vehicles, technology companies will have a significant participation in the automotive industry, concerning hardware and software parts. This new situation will necessitate creating a form of an interrelationship between OEMs and technology companies, which is a partnership rather than competition.

The rationale for the partnership between OEMs and technology firms is quite straightforward. OEMs have an extended experience when it comes to aspects of design, manufacturing, assembly, and testing of vehicles. Furthermore, technology firms will fill the technological gap related to self-driving software, mapping systems, network and connectivity, data management, and information security.

Besides the OEMs and technology companies partnerships, carmakers sector have different models for partnerships such as the association between two or three OEMs, in R&D partnerships or joint development agreements (*Autonomous Vehicle Partnerships: How Tech Companies and Automakers are Collaborating to Innovate the Future*, 2016). When it comes to software development, this model is less likely to succeed unless one of the partners has owned a technology firm. Furthermore, R&D partnerships or joint development agreements between OEMs and academic or government institutions is another model, where these research institutions share mutual interests in autonomous technology and possess similar capabilities as technology companies (*Autonomous Vehicle Partnerships: How Tech Companies and Automakers are Collaborating to Innovate the Future*, 2016).

The collaborative environment in Ontario is quite promising, as it brings together OEMs, technology firms, and academic institutions. The best practical example is the Ontario-made Lexus RX 350 project, where Ontario's Auto Parts Manufacturers Association (APMA) brought together 13 firms representing a broad range of the technology spectrum (*Driving innovation: collaboration creates the connected car | InvestinOntario*, 2015). The technology companies working on the project include QNX, TE Canada, MIS Automotive, IMS, Pravala Networks, Alcohol Counter Measure Systems, Weather Telematics, Lixar IT, BRAKERS Early Warning Systems Inc., Leggett & Platt Automotive, Magna, XYZ Interactive, and Rogers (*Driving innovation: collaboration creates the connected car | InvestinOntario*, 2015). In addition to technology companies, a huge factor in the success of the project is the relationship with the University of Waterloo (*Driving innovation: collaboration creates the connected car | InvestinOntario*, 2015).

Demand Conditions:

Regarding demand conditions, firms need to move from imitation, low-quality products to differentiation through upgrading the efficiency of manufacturing and innovation (Porter, 1998). The presence of sophisticated and demanding customers plays a major role in pushing firms within the cluster to innovate new solutions and products to satisfy their customers' needs.

As shown in figure 4, the current core value chain of the automotive manufacturing industry includes design, suppliers, assembly, retail, customers, and servicing (Nicoll & Stranatic, 2015). The advent of AVs might disrupt and rearrange this value chain, for instance, some software initiatives are expected to emerge such as positioning and collision avoidance, infotainments, security and privacy, and convenience options (Nicoll & Stranatic, 2015).

Traditionally, the significant capital investment required to setup manufacturing facilities, acting as a major barrier for Tier twos to enter into the OEMs supplier chain (Nicoll & Stranatic, 2015). As a result of that, components' manufacturers in Tier two are discouraged from contacting the OEMs directly. The Tier one works with OEMs to build bigger products, integrating sensors, software, semiconductors chips, and other parts from Tier twos (Murray, 2017). The current arrangements will not be the case with AVs, as the second tier can provide their software and electronic components directly to the OEMs, due to the lower upfront capital cost required (Nicoll & Stranatic, 2015).

According to UK-based Juniper research, predictions show that 20 million AVs will be on roads worldwide around 2025 (*WardsAuto Big Story*, 2017). The prospected customers for AVs fall into four demographic groups which are Pre/Boomers [1], Gen X [2], Gen Y [3], and Gen Z [4]. Each demographic group shows different expectations, preferences, and needs when it comes to AVs, which means firms need to engage with each of these groups to understand their needs and achieve the targeted level of competitiveness. The customers might need to know and experience the AVs to eliminate their angsts and concerns about safety and reliability.

Ontario's population reached 14.1 million in April 2017 (39.4% of Canada's population), and it is expected to grow to 15.8 million by 2026 (*Demographic Quarterly: Highlights of First Quarter 2017*, 2017). By 2026, the expected population of Ontario will be divided between Pre/Boomers, Gen X, Gen Y, and Gen Z with percentages of 21%, 24.8%, 27%, and 27.2% respectively (*Demographic Quarterly: Highlights of First Quarter 2017*, 2017).

On the other hand, Michigan's population is 9.9 million as of July 2016 records (*U.S. Census Bureau QuickFacts selected: Michigan*, 2016), and it is expected to grow to around 10 million by 2020 (*Michigan Population 2017 (Demographics, Maps, Graphs)*, 2017). According to United States census bureau, Michigan's demographic structure for 2015 was divided between Pre/Boomers (28.5%), Gen X (26.6%), Gen Y (19.2%), and Gen Z (25.7%) (*American FactFinder - Results*, 2015).

The data above shows the expected demographic composition of AVs which ranges from seniors who are led to AVs with their diminishing capacity to drive, to younger

[1] Pre/Boomers: Born before 1965 (*Generational Breakdown: Info About All of the Generations*, 2016)
[2] Gen X: Born between 1965-1976 (*Generational Breakdown: Info About All of the Generations*, 2016)
[3] Gen Y: Born between 1977-1995 (*Generational Breakdown: Info About All of the Generations*, 2016)
[4] Gen Z: Born 1996 and later (*Generational Breakdown: Info About All of the Generations*, 2016)

generations who are interested in models that provide access to mobility and allow them to remain productive and connected.

Currently, after sale servicing is offered by dealerships and auto body shops. Due to the emergence of better quality sensors, data collection, and over-the-air software updates, after sale service for AVs could be performed remotely without the need for the physical presence of the vehicle at service locations (Nicoll & Stranatic, 2015).

Related and Supporting Industries:

The key players in the development of CVs / AVs fall into three broad categories that constitute our model used in this paper which includes OEMs, technology companies, and government policy. OEMs need to collaborate with technology companies to achieve the required competitiveness in AVs market. The advent of AVs will be a great opportunity for different sectors working within the technology domain such as hardware manufacturers, software and applications development, telecommunications companies, and startup businesses that provide supporting services. Figure 5 depicts auto manufacturers and suppliers, combining market players active in Ontario and major market participants globally (Nicoll & Stranatic, 2015).

In Michigan, the autonomous vehicles marketplace has major non-OEM entities that play an essential role in AVs development such as major Tier 1 suppliers, Technology companies, and industry groups (*Automated Vehicle Industry Activities in Michigan*, 2017).

Michigan has many Tier 1 suppliers such as founding members of MTC at the University of Michigan, Robert BOSCH, Delphi, and Denso (*U-M Mobility Transformation Center announces founding corporate partners | UMTRI - University of Michigan Transportation Research Institute*, 2014). Also, it has many technology firms working in differents aspects of technology. NVIDIA is working on the development of integrated graphics chip array known commercially as the self-driving super computer (Clark, 2016). Besides that, there are some specialized companies on areas of digital mapping for transportation applications and Human-Machine Interface (HMI) software like HERE and LUXOFT (*HERE makes HD map data in US, France, Germany and Japan available for* *automated vehicle tests*, 2015; *Luxoft Develops Human-Machine Interface (HMI) for Rinspeed Budii Autonomous Electric Vehicle Concept | Business Wire*, 2015).

Drew Technologies provides products and services related to system integrations of automobiles and data systems (*Drew Technologies*, n.d.). Furthermore, the state of Michigan has some global consulting firms that offer prototyping workshops along with labs for testing connectivity, autonomous, and cyber security technologies like P3 Management Consulting and Engineering solutions (Roberts, 2016).

Policy Implications

In the previous section, the three pillar model constituting the participant clusters in the development of AVs had been assessed in light of the four components of Porter's Diamond model. This assessment showed different degrees of competitiveness in the three pillars in both jurisdictions under study in this paper.

Starting with the first pillar which is OEMs, Michigan has a well-established OEM cluster equipped with human resources, physical infrastructures, and R&D facilities and institutions. On the other hand, Ontario is not less than Michigan when it comes to R&D efforts but, Ontario is missing two essential and basic components that affect negatively on its competitive advantage. These two critical components are the localization of the auto industry and improvement of technological infrastructure. Now Ontario is mainly assembling vehicles rather than manufacturing them, reducing its competitive advantage in the region compared to its neighbor Michigan.

The advent of AVs is a disruptive evolution in the automotive industry, and as a result of that vehicles will witness a radical change in its technical features. As a consequence of this change, OEM legacy and experience in the traditional vehicles industry will no longer be an advantage, which would be the right time for Ontario to enter strongly into the vehicles manufacturing sector. The Superclusters Initiative for Advanced Manufacturing is a great opportunity for Ontarian businesses to collaborate, as it can be a springboard towards manufacturing the first Canadian AV, and will result in a more competitive advantage for the Canadian cluster as a whole.

The second missing component that will hinder the AV development in Ontario is the technological infrastructure. When comparing Mcity and Willow Run testing fields with Stratford demonstration zone, it will be obvious how big the gap between Ontario and Michigan especially in issues related to connectivity between vehicles and the surrounding infrastructures.

The second pillar is technology companies, and both Michigan and Ontario are saturated in this area. The main difference between Michigan and Ontario is the number of participants in the development of AVs. Unlike Michigan, Ontario has only three tech companies participating in the AVs pilot testing project which is Blackberry QNX, X-Matik Inc., and Magna. The Superclusters Initiative for Digital Technology can play an essential role, as a motivating factor for technology companies based in Michigan or elsewhere globally to establish their new Canadian based business units, in collaboration with Canadian startups. As a result of that, Ontario will achieve a higher competitive advantage in the region through collaboration with stronger clusters.

The third and last pillar is the policies and regulations made by governments of Michigan and Ontario to ease testing and development of AVs. When comparing the policies and regulations developed by the governments of both regions concerning testing of self-driving vehicles, we find that the policies are more flexible and liberalized on the US side than in Canada. To elevate the innovation environment in Ontario, regulators need to amend the Motor Vehicle Safety Act or issue a new act especially for testing and development of AVs. To benefit from the memorandum of understanding signed between the two jurisdictions, regulators in Ontario can save time and gain efficiency through collaboration with MDOT and NHTSA.

The biggest concern for businesses, governments, and policy makers is the demand conditions and public engagement in both regions. The cooperation between all participating parties in both jurisdictions is needed to ensure public engagement and awareness of the benefits of the technology, through awareness campaigns, hands-on experience, and motor shows that demonstrate features and technologies included within AVs.

Figure 6 illustrates the current situation in Michigan and Ontario. When looking at the three clusters constituting AVs' model, the clusters in both of Michigan and Ontario show promising indicators for competitive advantage and economic development. Although Ontario clusters have the competitive strength in individual perspective, they lack interconnectivity and collaboration in between them.

The situation in both regions is more like a collection of short stories in Ontario compared to a novel of connected parts in Michigan. The ultimate goal for all stakeholders in Ontario is to compile and link these short stories to make a novel of their own.

Conclusion and Recommendations

In conclusion, the answer to the research question of this paper, Can a formal memorandum of understanding with a strong cluster (Michigan) elevate a weaker cluster partner (Ontario) in AVs experience?, is a positive answer but this answer should be underpinned with some steps to be taken by stakeholders in Ontario.

Canadian companies and start-ups need to seize the opportunity of the Superclusters Initiative for Advanced Manufacturing to establish the first Canadian manufacturing line for self-driving vehicles, which will lead to a higher competitive advantage in the region.

The digital technology supercluster initiative is a great opportunity for technology firms in Ontario. Now three tech companies are participating in the AVs pilot testing project which is Blackberry QNX, X-Matik Inc., and Magna. To ensure greater participation in the pilot project, the Government of Ontario can link the funds granted by the supercluster initiative with joining the pilot project. Technology companies need to forge a consortium that consists of big firms like Magna and Blackberry QNX, start-ups with different specialties in technologies related to AVs, and academic institutions. Such consortium would elevate the competitive advantage of Ontario in the tech part related to the development of AVs. Also, development of partnerships between Ontario's tech consortium and technology companies from Michigan will ensure expertise exchange between technology firms in both regions.

Ontario government needs to relook at the existing regulations related to the Motor Vehicle Safety Act especially for the testing of AVs. The collaboration between transportation authorities in Ontario and Michigan, to amend these regulations will elevate the environment of the development of AVs. Also, this collaboration may extend to include improvement of the technological infrastructure, taking advantage of Michigan's experience in this area in both Mcity and Willow Run testing fields.

The engagement of public and prospective customers is the cornerstone to achieve the competitive advantage for both of Michigan and Ontario. Both governments in collaboration with businesses and stakeholders need to work towards achieving this engagement, through awareness campaigns, hands-on experience, and motor shows that demonstrate features and technologies included within AVs.

Glossary

ACC : Adaptive Cruise Control.

ADAS : Advanced Driver Assistance System.

APMA : Auto Parts Manufacturers Association.

AV : Automated/Autonomous Vehicle.

CV : Connected Vehicle.

GPS : Global Positioning System.

HMI : Human-Machine Interface.

LIDAR: Light Detection and Ranging.

MDOT : Michigan Department of Transportation.

MTC : Mobility Transformation Centre.

MTO : Ontario Ministry of Transportation.

NHTSA: The US National Highway Traffic Safety Administration.

OEMs : Original Equipment Manufacturers.

SAE : SAE International (formerly the Society of Automotive Engineers).

V2V : Vehicle-to-Vehicle.

V2I : Vehicle-to-Infrastructure.

V2X : Vehicle-to-Vehicle or Vehicle-to-Infrastructure.

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Level	Name	Narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of *dynamic driving task*	System capability (*driving modes*)	BASt level	NHTSA level
***Human driver* monitors the driving environment**								
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a	Driver only	0
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes	Assisted	1
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes	Partially automated	2
***Automated driving system* ("system") monitors the driving environment**								
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes	Highly automated	3
4	**High Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes	Fully automated	3/4
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**	-	

Figure 1. SAE International: six levels of driving automation (Ticoll, 2015)

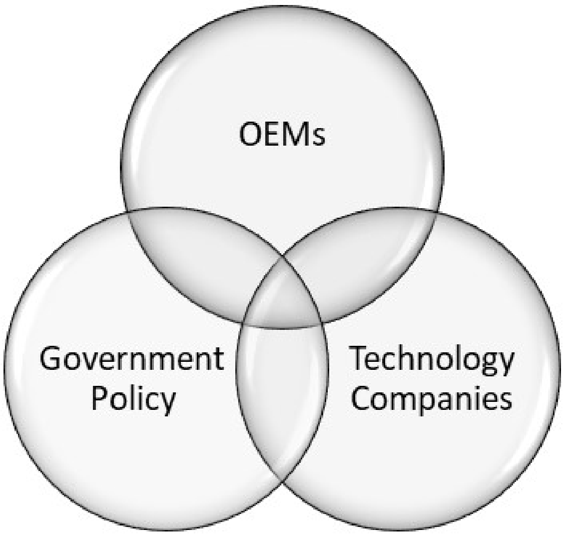

Figure 2. Autonomous Vehicles Clusters Model

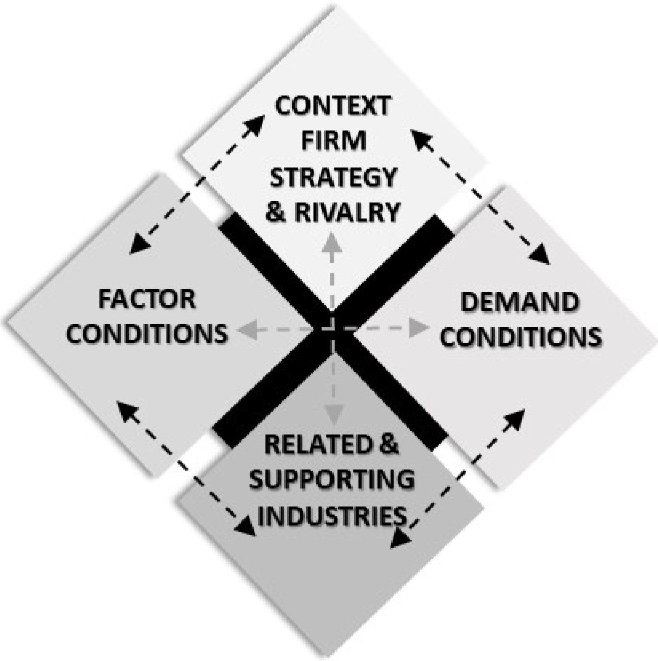

Figure 3. Porter's Diamond Model (Porter, 2000)

Figure 4. The OEM value chain (Nicoll & Stranatic, 2015)

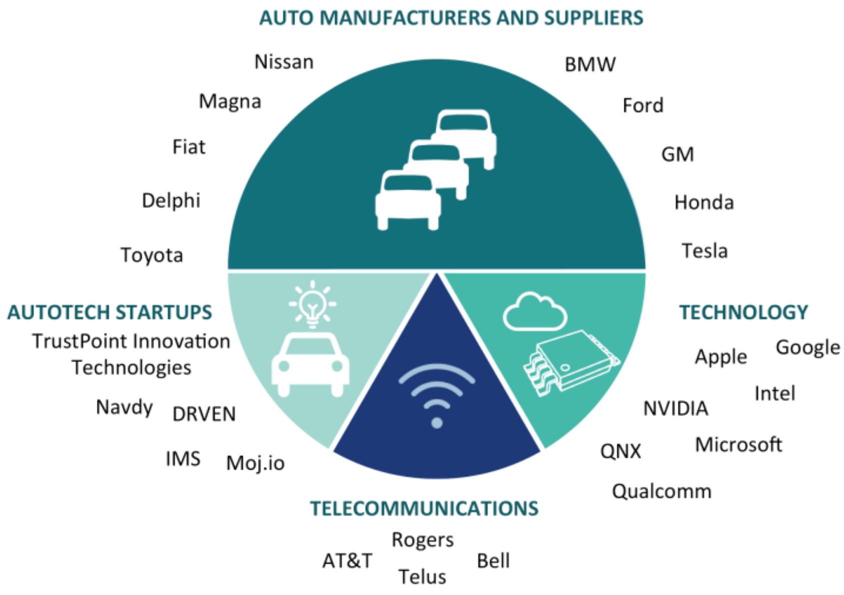

Figure 5. Key players in the connected car space (Nicoll & Stranatic, 2015)

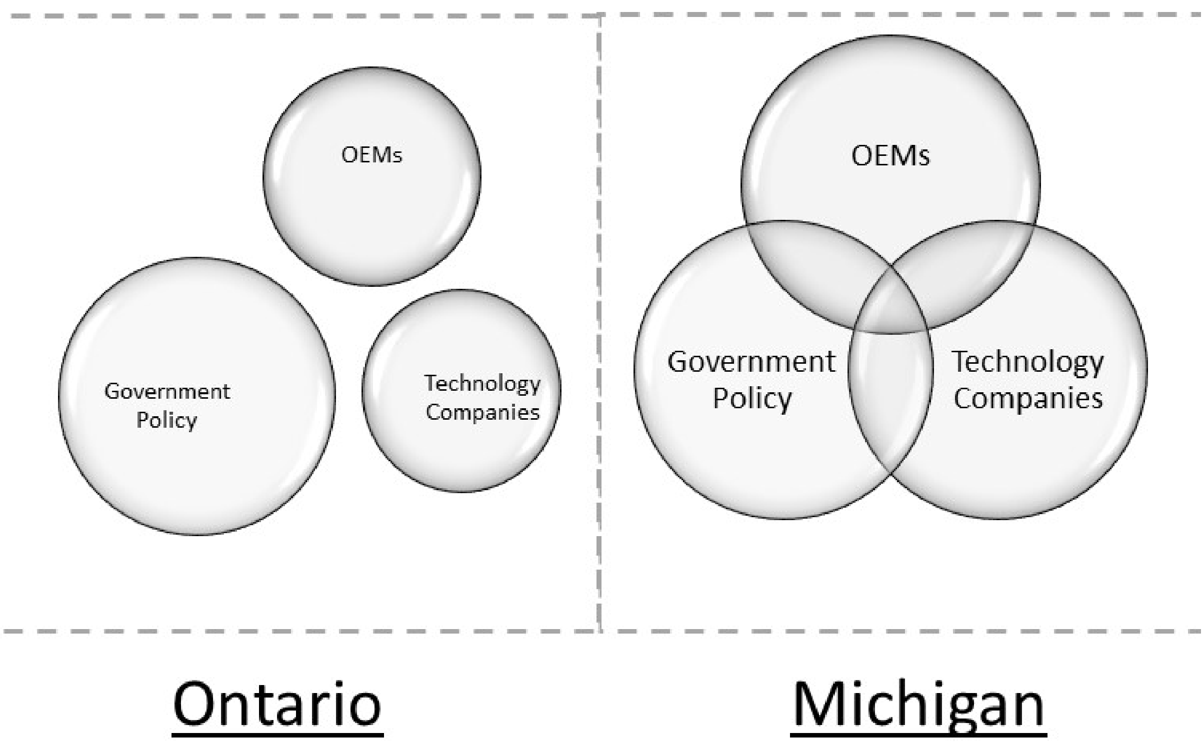

Figure 6. Autonomous Vehicles Clusters Model in Michigan and Ontario