Regional Resilience and Ontario's Automotive Cluster: Its Future in the Digital Age

David Wolfe and Elena Goracinova

Innovation Policy Lab, Munk School of Global Affairs
University of Toronto

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Introduction

There is growing recognition, in both corporate and public policy circles, that the Province of Ontario is a jurisdiction with superior automotive R&D capabilities and high-quality production operations, related to its strength in both traditional engineering disciplines, as well as emerging digital technologies. In a recent public speech, the President of GM Canada noted that Ontario assembly plants are unparalleled in the skills of the work force and for the quality of production, not only for his company, but for all five Original Equipment Manufacturers (OEMs) with operations in the province. Notwithstanding these strengths, the automotive sector in the province faces serious head winds. In a recent submission to the federal Innovation Agenda review process, the Canadian Automotive Partnership Council (CAPC), representing the OEMs, said that “In face of these global manufacturing head winds, innovation must become THE pathway to automotive industry growth in Canada . . . . (but) we have not historically focused on Canada as a growth location for invention, research & development (R&D) and engineering of new automotive products and technologies” (Canadian Automotive Partnership Council 2016).

This agenda represents a fundamental change in perspective for the relationship between the multinational enterprises (MNEs) that have dominated the auto sector in Ontario since the 1920s and the innovation and production capabilities of the host location. Current research on the changing calculus of MNE’s global strategy with respect to host locations suggests this is part of a broader pattern of change in the way in which MNEs allocate research and production activities to different regional economies as the knowledge base of even the most Fordist industry is disrupted by the effects of the digital revolution. However, the literature on path dependence, regional resilience and new path creation also suggests that there are many potential routes forward for traditional assembly-based manufacturing economies like Ontario; and equally important, many challenges lie in the path of shifting Ontario’s automotive cluster off its historical trajectory onto a new regional growth path.

Substantial uncertainty exists as to whether traditional automotive hubs, such as Automotive Alley that stretches from Ontario through the US Midwest, will remain central to the growing digitization of the automotive industry or whether they will be replaced by new geographies with greater strength in digital technologies, such as northern California, home of Tesla, Google, Cruise and other startups that are moving into the automotive space. In the face of this challenge, many analysts argue for the continued strength of established auto regions based on their deep competences in a wide range of technologies and production techniques essential for automotive production. Their traditional manufacturing competencies afford them a competitive advantage as they adapt to the changing technological landscape through enhanced investments in R&D, next generation manufacturing power train and materials technologies by leveraging the intrinsic research innovation capabilities of their regional public and private research institutions. The literature on path dependence and regional resilience provides a critical perspective on this development by suggesting that the presence of market forces alone is not sufficient to stimulate the diversification of traditional sectors into related industries or to regenerate themselves by incorporating new technologies; rather, it requires the dynamic co-evolution of the institutional setting in which the industrial cluster is located (Boschma 2014).

This paper explores the extent to which efforts currently underway in the southern Ontario automotive cluster to meet the challenge identified in the CAPC submission are laying the foundations for a process of new path creation or modernization and institutional reconfiguration. OEMs have begun to play a leading role in this potential shift toward path modernization with the support of financial incentives from governments. Part of what is starting to occur involves a process of the OEMs looking to upgrade the range of activities that their subsidiaries undertake in Ontario by engaging much more directly with the cutting edge research base of Ontario's post-secondary educational sector. Modernization activities are still in their initial stages and the degree to which OEMs will continue to focus on Ontario as an R&D location is unclear, but the current trend indicates a significant break with the past developmental trajectory of the province's automotive sector.

There are also policy efforts to upgrade the innovative capabilities of the automotive supply base, which face a number of challenges. The supply chain, however, has proven resilient and able to adjust to the diffusion of new ICT technologies, which has been accompanied by growth in the capabilities of new entrants. There is evidence to suggest that firms in the supply chain are moving away from the lower value added portions of the supply chain toward the production of more electrical/electronic components and collaborate with universities and community colleges to a similar degree that OEM plants do. There has also been a recent emergence of ICT firms interested in supplying the automotive sector.

The paper argues that the strength of Ontario's regional innovation system (RIS) and growing OEM R&D investments provide expanding opportunities for the cluster to remain competitive either by: 1) firms upgrading or moving up the value chain by strengthening skills and production capabilities; or 2) modernizing on the basis of connected or electric vehicle technologies or organizational innovations. The focus of the study are the efforts on the part of OEMs and current federal and provincial policies in the form of technology push initiatives, the goal of which is to intensify regional knowledge linkages, although it is not yet clear whether they will be able to help existing suppliers upgrade their operations, or whether new industrial fields will be positively locked-in and continue to grow. However, the willingness of OEMs to connect with the Canadian start-up scene and the resilience of established automotive suppliers indicate the potential for the emergence of a revitalized and innovative automotive ecosystem. The paper begins with a discussion of the evolutionary economic geography literature on new path creation and identifies potential trajectories for the automotive cluster given Ontario's regional innovation system. It continues with an investigation of the initiatives targeting both OEMs and the supply chain and ends with a discussion of the possible trajectory for the future development of the region's automotive cluster.

Path Dependence, Regional Resilience and New Path Creation

A critical issue for the way in which regional economies evolve over time is the relative impact of path dependence on their pattern of development. Within evolutionary economics, the concept has been used to explain why certain technologies prevail in the competitive setting of the marketplace, although they may not always be technologically superior. The evolutionary approach argues that economic systems change over time, but in ways that are shaped and constrained by past decisions, random events and accidents of history. The concept is somewhat counterintuitive in that it purports to explain how structured patterns of development – across time and space – can result from seemingly random or chance occurrences. However, the challenge is to reconcile the significance of random or chance events in endowing a region with its specific industrial structure and institutional capabilities, while allowing for the role of individual and collective agency in fashioning subsequent changes in its broader institutional structures and development strategies.

The path dependent nature of development in regional economies, involves the process by which new paths are created and existing institutional ensembles begin to break down or decay. Central to the question of regional resilience is how adaptable these institutional ensembles are to changes in the principal industries and technologies at the core of the region's industrial structure. The key issue concerns the ability of firms, industries and institutions in a specific region to adapt their existing knowledge base and localized capabilities to the generation and exploitation of new commercially valuable sources of knowledge. "New paths do not emerge in a vacuum, but always in the contexts of existing structures and paths of technology, industry and institutional arrangements" (Martin and Simmie 2008, 186). Resilient regions tend to be those in which existing clusters of firms prove adept at transitioning out of declining industries, while simultaneously exploiting the local knowledge infrastructure to cultivate new, potential growth fields. In both instances, the support of local and regional institutions is critical for those capabilities.

While they don't explicitly reference the concept of path dependency, Maskell and Malmberg's seminal paper extends this point by arguing that the competitive success of firms depends on distinctive, localized capabilities. These capabilities arise from regional assets that are non-ubiquitous, or unique to the region. They can be based on the infrastructure and built environment of the region, its endowment of natural resources, the regionally-specific institutions and the available set of knowledge and skills. A region's institutional architecture accumulates and changes incrementally, and represents the interaction between various elements that have been built up or accumulated over time. Because of these properties, this institutional endowment can become a key part of a region's non-replicable asset base, thereby reinforcing durable local competitive advantages that are difficult for competitor regions to emulate,

> . . . it is the region’s distinct institutional endowment that embeds knowledge and allows for knowledge creation which . . . constitutes its capabilities and enhances or abates the competitiveness of firms in the region. The path–dependent nature of such localised capabilities makes them difficult to imitate and they thereby establish the basis of sustainable competitive advantage (Maskell and Malmberg 1999, 181).

The literature on regional resilience draws extensively upon this perspective on path dependence. The evolutionary approach attaches great importance to the institutional underpinnings of resilience and the extent to which political and civic institutions may frame the responses taken by different regions to the natural, economic and social disruptions they encounter. Finally, it recognizes the extent to which regions are embedded in broader political geographies and that these ‘nested scales’ shape and constrain both the potential for, and the actual way, in which they respond to external shocks (Pike, Dawley, and Tomaney 2010; Bunnell and Coe 2001). Pike et al. draw a distinction between the concepts of adaptation and adaptability. Adaptation is seen as a short-run phenomenon that involves the movement back towards the original path of development based on strong linkages between different social agents and the institutional underpinnings of the regional economy. In contrast, adaptability involves the capacity to shift the growth path of a region towards multiple and alternative trajectories of development, based on the ability to forge new linkages between social agents and alternative or emerging institutional structures. Adaptation involves the region’s ability to adjust to a new competitive dynamic in the global economy in order to maintain a previously successful growth pattern, whereas “resilience through adaptability emerges through decisions to leave a path that may have proven successful in the past in favour of a new, related or alternative trajectory” (Pike, Dawley, and Tomaney 2010, 62; Simmie and Martin 2010). Over the long run, adaptability involves the ability to transform its industrial structure, labour market, productive technologies and supporting institutions to respond to external pressures and take advantage of new economic opportunities.

Another factor that conditions the resilience of regions is their institutional underpinnings. Central to the changing role of the regional scale in facilitating the adjustment to a changing economic environment is how institutional ensembles adapt to changes in the principal industries and technologies at the core of the region’s industrial structure. This concerns the ability of firms, industries and institutions to adapt their existing knowledge base and localized capabilities to the generation and exploitation of new commercially valuable sources of knowledge. Resilient regions are those in which existing clusters of firms prove adept at making the transition out of declining industries or technologies, while simultaneously exploiting their local knowledge infrastructure to cultivate new, potential growth fields. Their pattern of development is strongly influenced by the industrial strengths of the current economy, as well as by the broader set of institutions that have supported those sectors. Those sectors in which an urban or regional economy has historically been specialized will constrain its future ability to grow, or create opportunities for new sectors to emerge. The basis on which those sectors can emerge will be influenced, in turn, by the capacity of firms and institutions within the region to develop and exploit new sources of knowledge and their existing knowledge infrastructure, as well as the talents and skills of the work force (Wolfe 2010).

By example, in investigating institutional changes in Baden-Württemberg's automotive cluster, authors have noted the significance contribution of developments such as the Automotive Simulation Center, aimed at enhancing the degree of science-industry cross-sectoral collaboration in the region. The goal is to coordinate and integrate knowledge using and exploring processes by establishing cognitive proximity among individual actors and communities at the firm level. According to Strambach and Klement, such developments present neither a complete disruption of the established incremental improvement trajectory, nor the rise of completely new actors, but rather a gradual reconfiguration of the institutional architecture of the region (2013). This helps create opportunities to explore new links between complementary industries and technologies to enhance the resilience of the regional automotive industry.

While not framed in the context of evolutionary theorizing about path dependence and regional resilience, recent work on the cluster life cycle adds an important dimension to this analysis. Martin and Sunley (2011) argue that clusters are complex adaptive systems to the extent that either the technological or industrial base of the cluster can change over time. Current cluster firms or new firms entering the cluster may branch out into different product lines or service activities from the ones on which the cluster was initially built. This transition may occur through the process of shifting into related product lines that draw upon the existing knowledge base of the cluster or it may occur through a more radical shift into unrelated products or technologies. As a result, clusters can undergo a significant transformation of their underlying base which may involve a wholesale transformation of the cluster into new and different areas of specialization, although often these draw upon the existing research infrastructure of the cluster or the intrinsic skills base of the cluster labour force (Martin and Sunley 2011, 1304).

Successful clusters are those that make the transition to a new set of technologies or new product range, by shedding the products or technologies in which they are no longer competitive on an international basis or in which their products have become excessively homogenous. The result for successful clusters is the transition to a transformational phase, as the greater degree of internal product and technological variety within the cluster once again leads to an increase in heterogeneity and the renewal of the cluster. At the same time, the cluster can increase its chances of survival through greater heterogeneity by rethinking its strategic position in global value chains or global production networks and moving into a unique set of value added activities that re-establish its competitive strategy and its competitive position among a global hierarchy of interrelated clusters (Menzel and Fornahl 2009, 219; Sturgeon 2003).

Drawing on the work on path dependence, regional resilience and the cluster life cycle, a number of scholars, including Martin and Simmie (2008) and Boschma and Frenken (2005) explore the different trajectories that are possible for regional economies to transform their own developmental paths. Inspired by Boschma's work on related and unrelated variety (2014), Trippl, Asheim and Miorner (2015) suggested that there are three main paths to regional industrial renewal. The first, path extension, occurs primarily through incremental innovations adopted by existing firms in a regional cluster or sector. However, the key challenge for such a form of path development will be whether the incremental innovations are sufficient to offset the challenges faced by the region from new lower cost production regions (in the case of Ontario, the southern US states and Mexico) or newer more innovative production regions (in this case Tesla in California, plus the growing efforts by the OEMs to transform their existing production base in Michigan). Regional economies that are locked into an existing set of production techniques that rely on an existing knowledge base and are limited to incremental innovations may find that they have limited opportunities to rejuvenate the existing sector or cluster, leading eventually to stagnation and regional *path exhaustion*.

The second pattern of path development occurs when local firms and industries are successful in making the transition into related sectors and activities along the lines suggested by Boschma and Frenken in their work on regional branching and related diversification. This type of path development, referred to as *path renewal* involves the transition from existing regional knowledge bases and areas of production expertise or competence into industries or sectors that are closely related to the existing areas of knowledge, competence and expertise.

The third route which they label *new path creation* corresponds to Boschma's concept of unrelated diversification. It involves the emergence of new firms in unrelated knowledge areas with limited pre-existing competence in the production techniques of the existing industry sectors or clusters. New path creation is often based on novel areas of research and as such relies much more strongly on what Asheim and Gertler refer to as the analytical, rather than a synthetic knowledge base (2005), or what Lundvall refers to as the STI mode of innovation as opposed to the DUI mode of innovation (Lundvall 2006). While it is possible for new path creation to occur in older industrial regions, it more frequently occurs in new regions where the novel research is being carried out and where the existing industrial structure is not encumbered with an entrenched mass of incumbents in the sector or cluster. Storper and Walker (1989) describe this geographical dimension of the process of technological innovation as the opening of 'new windows of locational opportunity'.

In recent work with Arne Isaksen, Trippl introduces two new modes of path development to this typology, both of which are highly relevant for the study of the Ontario automotive cluster: *path upgrading* and *path modernization*. Path upgrading involves a major change of a path related to the enhancement of a position within global production networks (GPNs), moving up the value chain based on upgrading of skills and production capabilities; while path modernization involves a major change of a path into a new direction based on new technologies or organizational innovations. The critical issue in analyzing the current development of the automotive sector in Ontario is to determine whether the changes underway reflect a more limited trajectory of path upgrading or whether it has the potential to open up a new direction based on the integration of emerging digital technologies in which Ontario has some strength into the auto sector.

Further light can be shed on the question of alternative developmental paths by looking at recent research on the changing relationship between multinational enterprises (MNEs) and their host locations in the context of the knowledge-based economy. A significant body of research dating back to the 1980s documents the fact that the relations between subsidiaries in host locations and their parent MNEs has shifted as the subsidiaries have been given broader mandates to pursue "asset-seeking" or "asset-augmenting" strategies. In this approach, subsidiaries have been granted increasing scope to pursue competence-creating investment strategies in the view that the host location is not just a market for the home country's products, but a potential source of competitive advantage for the MNE. According to Cantwell, this stream of research depicts "the MNE as an international network for geographically dispersed innovation" which stresses "the dynamic connectedness between local knowledge creation and exchange in each node of the network" (Cantwell 2009, 36). This change has involved a shift in the role of the MNE as an institutional mechanism for transferring new technologies across national boundaries to a role as the creator of new technologies in discrete national and regional jurisdictions (Dunning 1996; Cantwell 2013). For this strategy to succeed, the local subsidiary must become embedded in its own local network of research activity and competence building. As MNEs shift their innovation strategy to one of networked technology creation, they become more interested in producing in locations that provide access to complementary innovation capabilities. From the perspective of the firm, the goal is to link a range of high-value-creating activity across a number of different nodes or centres of excellence that collectively form the international network of the MNE, which results in the construction of an integrated portfolio of locational assets across a range of host countries or regions in which the MNE is effectively embedded. This changing rationale for MNE investments in host countries suggests a new strategy for corporate diversification in which the MNE can create new value by linking a series of interdependent subsidiaries and research centres into an evolving range of complementary activity (Cantwell 2009).

> The trend towards more complex knowledge systems and technology fusion across formerly separate fields of development has generated increasing interconnectedness between intra-firm and inter-firm networks, . . . A rising technological distance of knowledge combinations and greater local subunit creativity leads to search being conducted across organisational boundaries, especially when such search is geographically localised (Cantwell 2017, 48).

Cantwell suggests that there may also be a competitive rationale for industry leading MNEs not to locate their technology development activities in the industrial home base of their major international competitors (2017, 44). This strategy of differentiating their regional sources of research expertise may also create the opportunity for new innovation and development strategies for the regional economies in which the MNE is based. This may be particularly true in the case of new or emerging technologies at the core of the current techno-economic paradigm (ICTs) that are not an area of research excellence for the MNEs home base (Cantwell 2017, 46; Freeman and Perez 1988). This strand of research on the relations between MNEs and host countries suggests a connection with the literature on new path creation. In regional economies able to leverage their research assets and competence building capabilities, there is a potential to attract new investments by MNEs to access local capabilities as a core element of the MNEs global innovation strategies. Regions that prove successful in pursuing this route may be able to leverage new corporate investment to help move onto a path modernization trajectory.

Knowledge linkages and Path Development in Ontario's RIS

To conceptualize current changes within the Ontario automotive cluster, we adopt a typology of the linkages possible within Ontario's RIS. The goal of the typology is to indicate that with growing local and global linkages, both path modernization and upgrading are potential alternatives along which the Ontario automotive cluster can develop. The framework locates the degree of firm-RIS interaction on the vertical axis and two spatial dimensions of knowledge sources: local knowledge networks and global knowledge linkages on the horizontal one. The vertical axis of Table 1 (below) runs from: 1) a territorially embedded RIS where local firms have little connection to regional knowledge organizations, to 2) regionally networked systems where policy interventions aim to strengthen the regional institutional infrastructure support for firms' innovation processes, and finally, 3) regionalized national innovation systems where innovation activity often takes place in cooperation with actors outside the region (Cooke, 1998). The changes discussed below provide some evidence of a transformation of the Ontario automotive cluster from a territorially embedded one to a regionally networked one where local firms are progressively relying on knowledge institutions for research, technology adoption and training purposes in response to policy interventions.

Table 1: Trajectories of Path Development for Ontario's RIS

Governance of Regional Innovation Systems/ Knowledge linkages	Globalized	Interactive	Localized
Territorially embedded	Ontario automotive supply chain (before 2000) →Low value added → Little to no OEM research		
Regionally networked		Ontario automotive supply chain in transition? → supply chain in higher valued added segments → OEM research → new firm entrants	
Regional Nationalized			

The horizontal axis, meanwhile, moves from the local spatial dimension of knowledge to global knowledge linkages, which include knowledge flows from inward foreign direct investment (FDI) to local firms (see Bathelt et al. 2004). Categorizing Southern Ontario as reliant on interactive knowledge linkages implies that in addition to the importance of local networks, inter-firm collaboration and knowledge flows, it is also the case that global knowledge linkages are increasingly relevant as knowledge flows from the MNEs' R&D and foreign training programs to local firms. However, the degree to which local MNE R&D facilities will impact the absorptive capabilities and strategies of local firms remains unclear.

Previous research has characterized Ontario's RIS as beginning to undergo a transition to a more networked one with institutionalized knowledge linkages, but with a considerable way to go to become fully networked (Gertler and Wolfe 2004). The intervening decade has seen that trend intensify and the initial promise it held begin to bear fruit. The current Ontario RIS is characterized by a diverse set of capabilities and a thick organizational landscape, hosts a relatively large number of different industries and a critical mass of knowledge and supporting organizations that promote innovation and development in a wide range of economic and technological fields, with a growing network of intermediary organizations to support the innovation process. It is argued that the institutional and industrial variety in these types of regions have high potential for cross-sectoral knowledge flows and new recombinations of knowledge (Boschma 2014).

Trippl and Isaksen (2016) suggests that diversified and institutionally thick regions are the ones most likely to experience path upgrading and path modernization. This point is consistent with the observations of the automotive sector in Ontario, where John Holmes (2016) has characterized the current choice between path upgrading and modernization for the sector as a choice between resurrection and reinvention. Resurrection primarily involves the competitiveness of the manufacturing base for the OEMs in Ontario, particularly, the advanced processes that utilize robotics, computer systems, complex sequencing and logistics in the production and assembly of automobiles. In contrast, reinvention involves a process of new path creation with respect to auto product engineering and R&D – namely the process of inventing, testing, integrating and optimizing new products and services that is highly dependent on the broader regional `innovation ecosystem': engineering talent, research alliances, IP policies, R&D tax credits and other state support for company based innovation, etc. (Holmes 2016). The second case of new path creation often grows up through the establishment of new firms and spin-offs.

Ontario's RIS provides unique opportunities for new entrants to the automotive industry and for existing firms to upgrade their operations – considering the presence of a strong research infrastructure and diversified industrial structure. Although not entirely the result of policy changes, there is growing evidence to suggest a degree of institutional change is occurring in the automotive innovation system, in the form of an intensification in the relationship between firms and regional innovation organizations. A recent survey demonstrates that around a third of SMEs and OEMs in Ontario engage with the regional knowledge infrastructure. The pace of institutional change is slow and there are continued critiques of lagging R&D investment and hostile OEM-supplier relationship, while innovation in the supply chain remains incremental. In this context, policy efforts aim to target both established automotive firms and new entrants in the electric and connected vehicle market.

There is growing consensus that adaptation in the form of resurrection identified by Holmes will not prove sufficient to secure the future of Ontario's automotive cluster. This is leading to increasing joint efforts on the part of OEMs, business associations (CAPC, the Automotive Parts Manufacturers Association (APMA)) and academics (from the University of Toronto, McMaster University and the University of Waterloo among others) aimed not just at the upgrading, but also at the modernization of the cluster. These emergent investments are often incentivized and supported through federal and provincial policies, which initiatives are at the core of the paper. Overall, actors have worked to upgrade Ontario's thick institutional setting and the capabilities of its knowledge infrastructure – including universities, community colleges and innovation intermediaries, such as the Ontario Centers of Excellence (OCE), but also to create and support the linkages it has with its diverse industry sectors, including automotive firms or potential new entrants from Ontario's dynamic ICT sector. In some cases, this involves establishing new organizations, but also layering new functions on existing institutions (particularly the changing roles of universities and community colleges as they are expected to perform more industry-relevant applied research).

The policy instruments employed often support R&D through financial incentives to individual firms or partnerships and through competition bids, from which only the best projects are selected. Funds used to provide incentives include the federal Automotive Innovation Fund, the federal Automotive Supplier Innovation Fund, the provincial Jobs and Prosperity Fund, Southwest and Eastern Ontario Development Funds, the Ontario's Business Growth Initiative, as well as funding from the Natural Sciences and Engineering Research Council. A significant portion of the funding has been allocated to OEMs, who are reaching out to leading universities and beginning to establish their own research programs and partnerships in association with Ontario's post-secondary research institutions. Policy makers have supported individual investment projects led by OEMs, but also encouraged SMEs to utilize knowledge resources within Ontario.

Although the Ontario automotive cluster is departing from its traditional organization basis, making both path upgrading and path modernization possible, there is uncertainty associated with the two potential trajectories. This is especially the case in light of the focus on R&D activities, while there are few efforts to integrate new technologies into prototype development and there is often no requirement that firms demonstrate the ability to commercialize the technology being funded by drawing on existing expertise in the automotive supply chains. Obstacles to the commercialization of new technologies in Ontario's innovation system include: the past history of limited collaboration between the OEM's and Ontario's research infrastructure; increased pressure on the OEM's to concentrate more of their production and research activities in their home territory; conflictual OEM-supplier relationships; and a relatively weak history of building collaborative innovation networks. Despite these obstacles, we observe growing evidence that Ontario's automotive innovation system is beginning to transition to a different developmental path than it has pursued historically. We turn now to an examination of how these developments are unfolding in Ontario.

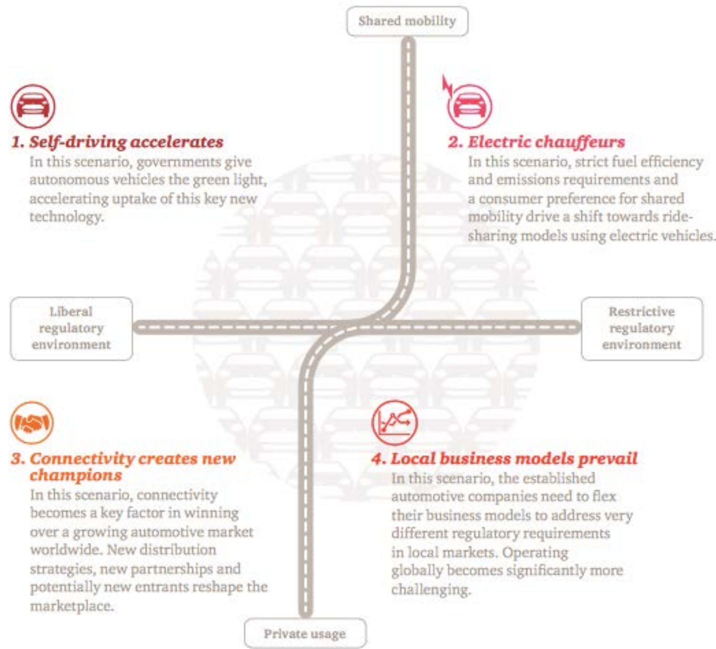
Path Modernization and the Resilience of Ontario's Automotive Cluster

The presence of Ontario's automotive cluster dates to the establishment of Ford's Canadian subsidiary in the first decade of the 20th century and the founding of Sam McLaughlin's Motor Car Company in Oshawa in 1908 (purchased by General Motors in 1918). Ontario has been the site of a significant proportion of North America's auto assembly since the negotiation of the Auto Pact with the U.S. in

1965 and major investments by two Japanese OEMs in the 1980s. However, historically the auto sector was most striking in that the predominance of the 'Big Three' OEMs, plus Toyota and Honda generated virtually no domestic R&D performed in Ontario, despite its significant weight in the provincial economy and the substantial proportion of North American production accounted for by the province. In the words of the current present of GM Canada, Steven Carlisle, we were completely reliant on technology developed elsewhere for the cars we assembled, not a recipe for success in a knowledge-based and innovation-intensive economy. This reliance on foreign technology in Canada's largest manufacturing sector has been identified as one of the key factors explaining the low levels of business R&D (BERD) in Canada (Council of Canadian Academies 2009). However, this same factor has begun to change in the last three to five years as the OEMs reassess the basis of their relationship to the host region of Ontario. This development is in keeping with a broader trend in the changing relationship between MNEs and host regions described by Cantwell and others.

The increased attention to local and regional R&D capacity by US OEMs is part of a broader response by the MNEs to the challenge of responding to the enhanced digital capabilities in automobiles – the emergence of the automobile as a new digital platform in some respects – as well as the pressure exerted by tighter emissions regulations at both the national and supra-national level that is driving research on light weighting materials and alternative energy sources. This pressure is leading to increased R&D activities by the OEMs in a growing range of host jurisdictions, including Ontario, where there is also a move toward higher value added segments of the industry (electrical and electronics parts) by automotive parts suppliers. The increased efforts directed towards R&D by the OEMs in response to the rapid spread of digital technologies across a broad range of industries and the increased regulatory requirements noted above has been supported by a array of new government funding programs to support research in digital technologies, alternative energy sources, and new lightweight materials, especially in the US and Europe (Galvin, Goracinova and Wolfe 2015). The chart below provides a visual representation of how leading consultancy companies envision the future of the automotive (including automotive parts) industry.

Figure 1. Re-inventing the wheel – Scenarios for the transformation of the automotive industry



Source: PriceWaterhouseCoopers: https://www.pwc.com/ee/et/publications/pub/reinventing-the-wheel.pdf)

Automotive R&D in Canada

The OEMs increased research activities in Ontario are grounded in the strong research competencies of its post-secondary research institutions. The capabilities of Ontario's knowledge infrastructure were enhanced significantly with the establishment of AUTO21 in 2000, a nationally funded Network of Centres of Excellence with $80 million in public funding and $60 million in private contributions, which sought to advance automotive research in pursuit of: health, safety and injury prevention; societal issues; materials and manufacturing; powertrains, fuels and emissions; design processes; and intelligent systems and sensors. The program awarded funding to networks that included automotive companies, as well as contributors from various fields of expertise. While the program generated a significant increase in auto related research in the province, the direct benefits as they concern commercialization are less clear. Our interviews with OEMs suggest that they regarded AUTO21 as insufficiently driven by the commercialization concerns of industry. However, a more tangible measure of its long term impact emerges when considering the growing number of automotive researchers in Canada who were part of the network and are available to collaborate with the OEMs in current industry driven research efforts.

Despite the cancellation of AUTO21, there have been a number of new investments in automotive R&D at different levels of government, including both the federal and provincial. Policy instruments that have helped facilitate initiatives include financial incentives to individual firms/partnerships and competition bids. Policies aim to facilitate institutional changes in the knowledge infrastructure, by increasing its linkages with established firms and new entrants to the automotive sector. The goal is to strengthen R&D capabilities, even though funding to upgrade production facilities is present as well. The most recent negotiations with the Big Three, production and R&D commitments, rather than wages, were UNIFOR's (the Canadian autoworkers union) primary focus (Lampinen 2016). This has been accompanied by increased OEM R&D and production investment in Canada, often incentivized with government funding. Guimon (2008) describes this approach as being more flexible and allowing policy makers to respond faster and in a more tailored manner to individual investment projects. Government has also established programs to which companies can apply for funding, often in collaboration with educational institutions. Concepts are developed 'bottom-up' by the potential participants of the proposed innovation network and it is in the very nature of this type of program that solutions can be custom-tailored and innovative (Eickelpasch and Fritsch 2005). Finally, knowledge linkages with the innovation ecosystem are being strengthen as the OEMs connect with the local start-up scene and supply chain companies utilize foreign training programs.

Among the OEMs, GM Canada is unique in that it is substantially expanding its R&D efforts in Canada, increasing its partnerships with Ontario universities, especially in the GTA and exploring partnerships with startup firms through the introduction of its own subsidiaries, such as Maven (a car sharing company), into Canada and its active participation in "Collision Days" at the Corporate Innovation Lab in Waterloo. GM seeks to leverage Ontario's R&D capacity in lightweight materials, mobile connectivity, data analytics, advanced battery technology, cyber security, software development, sensors and artificial intelligence. The company has done so both with and in the absence of government funding, by establishing new research centers, but also by drawing on existing regional innovation support organizations, such as Communitech in Waterloo, and strengthening its connections with Ontario’s leading research universities.

In a recent speech to the J.D. Power 2016 TalkAUTO Canada conference, Steve Carlisle, the President and Managing Director of General Motors of Canada, outlined the basic contours of the research strategy that the company is currently pursuing both in the U.S. and in Canada.[1] The key to the company’s strategy is to disrupt itself before it is disrupted by a wide range of new startup companies. The company’s vision for its future rests on four pillars: it is one that is electric, connected, autonomous and part of the sharing economy. The shift to the connected car is a critical part of that transition. They see digital technology doing to the automobile what the smart phone has done to communications over the past decade. They believe that most new car buyers expect for the automobile to be a mobile device and are moving rapidly to enhance connectivity in their cars. But they also see connectivity and the move to autonomous vehicles as a safety issue with the potential to significantly improve the safety features of their vehicles. So they are actively searching for potential partners and research capabilities that can accelerate their introduction of autonomous capabilities in their vehicles.

GM is expanding its R&D locations beyond its existing Canadian Regional Engineering Centre (also known as the Canadian Technical Centre) in Oshawa, which is responsible for vehicle design and development (particularly on chassis and sub-systems), research regarding product quality and manufacturing, as well as in the areas of ‘connected car’ and green technology research. Because the physical capacity of the CREC is not sufficient to house the entirety of GM Canada’s planned expansion, the company has opened a new Automotive Software Development Centre in Markham, ON, to accommodate its new engineering hires. This will allow the Markham research centre to focus specifically on autonomous vehicle technologies, vehicle safety, infotainment, and connected car technologies. The Automotive

[1] See full speech at: http://media.gm.ca/product/public/ca/en/gm/home.detail.html/content/Pages/news/ca/en/2016/Nov/1109_JDPower.html

Software Development Centre opened late in the fall of 2016 and already has 120 engineers working in it. The Centre is also located close to IBM Canada's software centre in Markham, reflecting GM's intention to explore potential synergies between its existing OnStar technology and IBM's AI technology.

Furthermore, GM has partnered with various organizations in the Ontario innovation system through the Automotive Partnership of Canada – which researches design-to-commercialization of electric vehicles – and the Partners for the Advancement of Collaborative Engineering Education (PACE) – which provides computer-based engineering tools to universities.[2] Further investments include a $1 million research chair in advanced materials engineering at the University of Waterloo, and the Communitech Innovation Lab in Kitchener dedicated to research in urban mobility and connected vehicle innovations. In addition to research, there are also moves to establish a Canadian Innovation Network – or a collection of Canadian universities that will receive funding for the establishment of innovative auto technology programs. This is already underway with the launch of the GM of Canada Automotive Centre of Excellence located at the University of Ontario Institute of Technology (UOIT) in Oshawa, ON. As part of an independent test facility designed to aid in the research and development of next generation vehicles and automotive products, the centre was founded through a $120 million investment by GM Canada and the PACE initiative, the Government of Ontario ($58 million) and the Government of Canada. In addition to these initiatives, GM Canada has also been actively exploring the possibility of increasing its partnership and involvement with other universities in Ontario and the GTA.

There is evidence that GM is not only seeking to draw on research in academic institutions, but also to bring its own subsidiaries like Maven to Canada and to link key GM decision makers with innovative Canadian startups and SMEs. One of the institutions that GM Canada has taken advantage to build its relationships with startups and SMEs in the emerging IT-automotive sector of the economy is the "Collision Day" held at 2908@Communitech in Waterloo in October. General Motors Canada joined the Communitech Corporate Innovation Lab in February 2016 with the opening of its "2908

[2] PACE is geared towards educating and inspiring students to work collaboratively in a global setting.

Innovation Lab." The purpose of the "Collision Day" was to enable Canadian startups and SMEs to explore potential growth opportunities with GM as it develops new technologies and partnerships to enable its future in the emerging environment for automobiles that it defines as increasingly electric, connected, autonomous and part of the sharing economy.

Although some of the most significant R&D investments are being made by GM, other automakers, including Toyota and Fiat Chrysler, have also received support from government in their efforts to expand their Canadian R&D capacity. The $10-million Green and Intelligent Automotive (GAIA) research facility was established in the University of Waterloo Faculty of Engineering with $1-million initial funding from Toyota Motor Manufacturing Canada (TMMC) in 2015.[3] It is supported through the Canada Foundation for Innovation and the Ontario Research Infrastructure Program. The Chrysler Group also partnered with the Canadian Government and McMaster University in a 2013 and $18.2 million project to develop advanced electric and hybrid Powertrains (Morris 2013). Work is to be performed primarily at McMaster University by research engineers, faculty members, engineering students and engineers from Chrysler Group's Global Electrified Powertrain Group, while students are also expected to benefit from training and potential recruitment by the OEM. Another noteworthy investment is by the Tier 1 supplier Siemens, which partnered with Seneca College in 2015 to establish Ontario's first Mechatronics Simulation and Demonstration Center (MSDC) meant to address technical skills gaps with the financial support of the province (Dalton 2015). Siemens has also partnered with the University of Waterloo to establish a green technology and advanced manufacturing training and skills initiative.

Finally, R&D project funding can be allotted through newly established consortia of both industry and non-industry actors, including community colleges, universities, non-profits and industry. Government committed $10 million in 2016 to the Canadian Urban Transit Research and Innovation Consortium, a centre to fund partnerships in support of R&D and the commercialization of technologies – such as light weighting and autonomous software – in partnership with the federal and Quebec

[3] https://uwaterloo.ca/systems-design-engineering/news/world-yours-gaia-auto-research-facility-opens

governments (Shum 2016). The five identified research pillars within which CUTRIC-funded projects are classified are: 1) Low & Zero Emissions Vehicular and Infrastructure Innovation, 2) Lightweight Materials & Processes, 3) Autonomous Connected Vehicles, 4) Cyber- & Critical System Security, 5) Big Data & Analytics.

In addition to supporting strategic R&D partnerships on a case by case basis, government support has also been provided through special competitive programs such as the Automotive Innovation Fund[4] established in 2008 and geared toward OEMs and first tier suppliers and set to last until 2021. Funds have been allocated not just to build increased R&D capacity, but also to transfer these new technologies into new production capacity. For example, the fund has supported energy efficiency research by Toyota, as well as the implementation of new technologies in their existing production facilities, including new laser-welding robots to produce faster high-quality welds that enhance vehicle rigidity and, by extension, handling. Ford Motor Company of Canada is also set to establish a flexible engine assembly plant and create an advanced powertrain research center in Windsor, Ontario. Finally, government has supported the establishment of assembly capacity for the Toyota's Lexus RX450h hybrid. At the provincial level, significant funds are being allocated through the Jobs and Prosperity Fund established in 2015.[5] The funds are going to improving and establishing new production capacity (FCA minivan, Honda teaching plant, Mitsui high tech first facility for motor cores for EV and hybrids), establishing R&D capacity by FCA and Linamar (energy efficiency).[6]

The degree to which growing linkages between local foreign R&D facilities and Ontario's knowledge infrastructure will impact the absorptive capabilities and strategies of local firms is unclear, but efforts by GM indicate that they are interested in tapping into the Canadian supply chain. The section below outlines the initiatives to support suppliers and examines the degree to which they can help firms overcome institutional obstacles in the Canadian context.

[4] Support for private sector investment in excess of $75 million.
[5] Private investment has to exceed $5 million for the project to be funded.
[6] https://news.ontario.ca/medg/en/2016/03/ontario-invests-in-new-electric-and-hybrid-vehicle-parts-manufacturing.html

Changes in the supply base

The Canadian automotive supplier industry has also been undergoing changes in the past decades, including a movement toward the production of more electrical/electronic components. Globally, traditional electronics hardware component suppliers have gradually expanded their value chain coverage into ADAS/AD (Advanced Driver Assistance Systems and Automated Driving Features) component development, and begun to present a competitive threat to incumbent automotive suppliers from their own supply base. The use of ICT in the supply chain has led to emergence of companies supplying EV producers.[7] A report by the Automotive Policy Research Centre, however, argues that a number of ICT-adopting automotive companies are yet to utilize the aforementioned growth opportunities (Yates 2015).

The Canadian context is perceived to lack the kind of innovation networks and inter-company forms of collaboration that are characteristic of innovative regions in Continental Europe (Smardon 2014). A number of studies, however, refine this characterization, and highlight different degrees of collaboration depending on the industry sector (and/or sub-sector). The presence of innovation networks might suggest a greater ability to diffuse and uptake new knowledge. Rutherford and Holmes (2007) distinguish between the core automotive parts sector and the tool, die, and mold (TDM) sector. For example, there is little formal cooperation or information sharing among highly competitive TDM firms that have succeeded in adopting CAD/CAM technologies as part of their operations. However, there is a significant amount of informal knowledge that flows between firms through the movement of skilled workers and through social and family networks.

Among a number of obstacles, even well connected firms are experiencing difficulties with going beyond incremental innovation. Rutherford and Holmes (2007) point to OEM poaching of SME intellectual property (IP) as part of the reason for this. However, a survey conducted by AUTO21

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[7] Companies that do manufacturing in Canada include: Etratech in Burlington, Vecture in Concord, which just got bought by Eberspacher (a big German Tier I). However, there are cases where companies produce and are moving R&D elsewhere, which might be due to difficulties they are facing with the supply chain (e.g. Electrovaya is getting government funds, but is manufacturing in Taiwan and planning to move R&D to Germany).

suggest that a direct investment program supporting R&D would address problems associated with levels of R&D in Canada's auto industry (CAR 2010). In line with this, there is evidence to suggest that despite these threats to IP, SMEs remain willing to collaborate with external partners such as universities and community colleges. A recent survey conducted by Holmes, Rutherford and Carrey (2017) concludes that SMEs find relationships with universities and community colleges relevant to the same degree as large companies do. In addition to building new competence in emerging technologies, there is some evidence that ICT companies in Waterloo region might also be developing networks that would help them enter the automotive application segment. An example of this is the Communitech AUTO Peer2Peer Network. The presence of informal networks as a way to diffuse information might contribute to the capability of these firms to partake in the restructuring of the automotive sector in Ontario.

Government policies have targeted the different types of suppliers that can be relevant to the future of the automotive industry, including established automotive suppliers and new or potential entrants and attempted to strengthen their linkages to regional organizations. Companies relevant to Canada's future in integrating ICT and automotive technologies, range from 1) battery manufacturers, to 2) providers of connected vehicle technologies and 3) existing plastics molding firms, foundries, machine shops, tool and die manufacturers, and electronic- components producers. Many of these initiatives have the goal to help 1) new companies integrate into the automotive supply chain and 2) existing companies upgrade their technologies.

Public policy and the supply chain

Competitive research grants, like the Connected Vehicle Automated Vehicle Program (CVAV, launched in 2014), the Vouchers for Innovation and Productivity and the Automotive Supplier Competitiveness Program (ASCIP, launched in 2016) have been the main policy instruments and administered and coordinated by existing regional organizations such as OCE and APMA. Furthermore, government also administers separate funds, such as the Automotive Supplier Innovation Program (ASIP, launched in 2015) and regional development funds to support automotive related projects. The programs are available both to 1) to individual firms for new technologies and to integrate existing ones, 2) collaboration of firms with external partners.

The ASIP is geared toward helping both new entrants integrate into the supply chain, and existing suppliers to upgrade their technology. One of the most significant investments in connected vehicle SMEs has come through ASIP to Pravala Car, in the amount of $9.7 million (CBC News 2016). Funds have also been awarded to companies for the development of electric battery technology as well as for lightweight materials used in production processes. A significant amount of ASIP funding has gone to the development of new production technologies (hot stamping, reducing measurement and inspection time), products (plastic muffler) in Ontario based automotive suppliers.

The OCE is more heavily geared toward the provision of SME R&D support, even though OEMs are funded as well. OCE, on behalf of the Ontario Ministry of Economic Development and Growth, will invest $1 million supporting driverless and connected vehicles. As such, the OCE has a significant degree of influence over the type of technologies that have the potential to develop in Ontario. In terms of provincial level investment in new connected vehicle technologies, OCE has funneled monies through CVAV (500,000) and programs such as the Innovation and Commercialization Voucher. Generally, the funds funneled through OCE are targeted at facilitating collaboration between universities and SMEs.

Another program funneled through the OCE is the ASCIP ($5 million), which is designed to facilitate the diffusion of ICT technology among existing automotive suppliers.[8] The program is a partnership between the APMA, OCE and the Province of Ontario's Ministry of Economic Development and Growth and part of the Business Growth Initiative (5 year, 400 million initiative). The goal is to help companies increase their productivity, adapt quickly to market changes and take advantage of new opportunities with larger manufacturers. Funding can be allocated to SME auto suppliers or to larger companies partnering with SMEs and will be up to $100,000. The program has two streams, including: 1) technology adoption of advanced hardware, software and training to enhance product life cycle management and improve competitiveness. The second segment of the program is the mentorship pilot

[8] http://www.oce-ontario.org/programs/commercialization-programs/automotive-supplier-competitiveness-improvement-program-ascip

program, which would provide grants to Ontario SMEs that conduct projects to improve operational efficiency. Furthermore, another stream or second segment aims to pair automotive industry experts with background and expertise in manufacturing process efficiency with suppliers to assist them with their business development needs. A relevant actor in this program is the APMA, which will help market the ASCIP to existing companies in the automotive supply chain. Another relevant source of funding for established automotive parts suppliers are the regional development funds, which are mainly geared toward upgrading equipment as well as for purposes of worker training. For example, in 2016 seven automotive companies in Windsor-Essex were awarded combined funding share of $7.8 million

The aforementioned programs, with the exception of a segment of the ASCIP, mainly provide funding support to both existing and new entrants for technology adoption, but firms might face a number of other issues surrounding technology commercialization related to: 1) marketing (failure to obtain sufficient market information or its proper use as well as insufficient knowledge about the international market and business growth, including an inability establish local and international sales); 2) resources (inability to acquire and assign resources, including inadequate managerial and business skills, funds to market product); 3) the business environment (problems in the business infrastructure and absence of business partners), and the planning and management of the commercialization process (Natsheh et al. 2015). Furthermore, they don't address many of the difficulties SMEs have in gaining access to OEMs such as Ford and GM – especially in the absence of a working prototype of how different technologies would interrelate, with the exception of the Connected Vehicle Program discussed below. This critique has been put forward by a variety of constituents, including OEM executives, the Canadian Automotive Partnership Council as well as beneficiaries of existing NCE projects (interview).

The Connected Car Program is among the rare initiatives that go beyond R&D and demonstrate the various challenges associated with integrating new technologies in end product vehicles. In particular, it points to the difficulties associated with attempts to mediate the relationship between OEMs and SMEs and the high levels of industry knowledge required to do so. The committee of the Connected Car program didn't just facilitate collaboration between a company and a university, but drew on a variety of funding sources, including the OCE, other government agencies as well as OEMs in efforts to integrate existing vehicle technologies into functional prototypes.

OEMs were initially hesitant in terms of their role in the project, as was the University of Waterloo, which was initially supposed to be the technology integrator and which role was subsequently taken up by the Ottawa-based firm QNX.[9] In any case, the presence of a university in these projects is relevant because it opens access to funds from various resources including the OCE, NSERC, and other programs geared toward academic institutions. The concerted effort necessary to obtain the required funds demonstrates challenges with the commercialization and eventual integration of these technologies into vehicles, but also the possibilities for success within the proper organizational structures.

Despite the language of collaboration in government documents, a program like the Connected Vehicle where collaboration had to be facilitated between multiple companies experienced significant challenges in obtaining funding for all the partners (Munim and Yates 2015). This was both because of existing regulations, but also because a number of government stakeholders didn't fully understand the nature of the project and saw it as just a prototype and marketing project. This was even in spite of the concerted leadership of powerful organizations like the APMA and participation of companies like QNX and Toyota. Furthermore, there were also issues with defining the obligations of the partners, communicating and learning about each other's strengths and weaknesses and equitably distributing resources through diligent budget documentation. This was partly because uncertainty related to government funding made the budget unpredictable. There are some other examples where OCE funding helps join customers with suppliers, like in the case where Peytec and Ryerson are trying to bring the Internet of things to the factory floors of automotive OEMs (the total funds leveraged so far amount to $140,000 with $20,000 coming from OCE).

The Ottawa region, home of the former telecom company, Nortel, has not traditionally been

[9] BlackBerry Ltd.'s QNX is a Canadian technology leader in developing operating systems for integrating infotainment systems in vehicles. QNX also makes the entertainment, navigation and connected-device system used by Volkswagen AG, Daimler AG, Ford Motor Co. and others.

viewed as a central part of the province’s automotive sector. However, the presence of QNX, a Blackberry subsidiary, has been drawing greater attention to the region. In December, 2016, Blackberry announced the establishment of its BlackBerry QNX Autonomous Vehicle Innovation Centre (AVIC) in the Ottawa region to develop technology for connected and autonomous vehicles, both on its own and in collaboration with private and public sector organizations and research institutes. The new AVIC builds on QNX’s 20-years of experience in developing and marketing the kernel that provides the platform for the infotainment systems found in a large number of vehicles on the market. The mandate of the centre is to foster new ideas and implement them through advanced engineering projects and vehicles demonstrations (Owram 2016).

Another notable new entrant into Ottawa’s burgeoning automotive ecosystem is Apple, which has clearly been drawn to the region because of the presence of QNX and is seeking to draw on existing regional strength in the ICT sector. It’s opening of a significant research centre in the region has clearly put Ottawa on the map of locations relevant to connected vehicle development. Apple has dozens of software engineers in the Ottawa suburb of Kanata building a car operating system, many of which came from QNX (Gurman & De Vynck 2016). One of the most notable hires from QNX was its chief executive officer, Dan Doge, who oversees the car operating system, which is the software core of a future Apple automotive platform. While Apple has still provided limited information about the precise role that its Ottawa R&D centre is to play in its connected car and autonomous vehicle strategy, its growing presence in the region provides a further indication that Ontario’s traditional strengths in the ICT sector constitute a strong inducement to shift the region’s automotive sector onto a new developmental trajectory.

Conclusion

Ontario’s automotive industry is been undergoing a significant restructuring in terms of the orientation of both OEM and supplier operations, with increased research activities and the introduction of new product lines by OEMs and a move by suppliers into higher value added segments of the industry. There have also been changes on the institutional front. In light of this restructuring, the paper argues that the

Ontario automotive cluster is in a phase of transition toward being a regionally embedded cluster with both global and local linkages. The evolutionary geography literature suggests that within the scope of this transition, both path modernization and path upgrading lie open as potential trajectories for Ontario to take. Further policy interventions might be necessary for influencing which trajectory the automotive sector develops along, considering that OEM research initiatives are still in their early stages, while the existing suppliers struggle to adopt the newest technologies and it remains unclear whether new companies can achieve critical mass.

Within this context, the paper has examined how recent policy initiatives aim to support these emerging trends and whether these efforts by government and industry might place the automotive industry on either a path of modernization or upgrading. Current policies aspire to accelerate the institutional changes underway, by enhancing the degree of collaboration between Ontario's regional innovation organizations and both the automotive and ICT sectors. Government policy has been consistent with stakeholder claims, which argue that Canada should play a greater role in innovating technologies used in manufacturing by drawing on existing regional resources, including its vast research infrastructure and diversified industrial landscape. The main policy instruments utilized have been financial incentives to individual firms or partnerships and competition bids, from which only the best projects are selected. Financial incentives to individual firms have supported OEMs attempts to expand their Canadian R&D and production lines by utilizing the expertise present at Canadian universities. Competitive research funding on the other hand, has encouraged both OEMs and SMEs to partner with knowledge organizations, including universities and community colleges.

Despite these advances, there are further challenges to both path upgrading and path modernization as potential trajectories for the Ontario automotive cluster. It is not clear how dedicated the OEMs are to build on current initiatives and further expand their R&D operations in Ontario. Furthermore, there is uncertainty surrounding the degree to which knowledge will flow to local firms or whether many of the new technologies funded can be commercialized in the Ontario context or translate into enhanced strengths in the supply chain. This is due to the many obstacles SMEs face in adopting new technologies, ranging from IP to marketing, which policy initiatives do not address. Overall, although the interactions between firms and the regional knowledge landscape have intensified, SMEs might not be able to overcome many of the institutional obstacles to scale up ranging from access to capital, trained labor and customers. Despite the fact that policies do not directly address the challenges facing many SMEs, the efforts by OEMs to tap into the start-up landscape, coupled with the resilience demonstrated by the automotive supply chain suggest that there is strong potential for the emergence of a new ecosystem of more innovative automotive companies in Ontario, capable of transforming the sector into a competitive jurisdiction in the 21st century automotive industry.

References

Asheim, Bjorn T., and Meric S. Gertler. 2005. "Regional Innovation Systems." In *The Oxford Handbook of Innovation*, eds Jan Fagerberg, David C. Mowery, and Richard R. Nelson. Oxford: Oxford University Press, 291–317.

Bathelt, Harald., Anders Malmberg, and Peter Maskell. 2004. "Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation." *Progress in Human Geography* 28 (1): 31-56. Web.

Bjerregaard, T. 2010. "Industry and academia in convergence: Micro-institutional dimensions of R&D collaboration." *Technovation, 30*: 100–108.

Boschma, Ron. 2014. "Towards an Evolutionary Perspective on Regional Resilience." *Regional Studies* 49(5): 733–51.

Boschma, R. A., and K. Frenken. 2005."Why Is Economic Geography Not an Evolutionary Science? Towards an Evolutionary Economic Geography." *Journal of Economic Geography* 6 (3): 273-302.

Bunnell, Timothy G., and N. M. Coe. 2001. "Spaces and Scales of Innovation." *Progress in Human Geography* 24(4): 569–89.

Canadian Automotive Partnership Council. 2016. *CAPC Submission on a Canada Innovation Strategy*. Ottawa, Http://capcinfo.ca/en/CAPC-Innovation-en.html.

Cantwell, John A. 2013. "Blurred Boundaries between Firms, and New Boundaries within (Large Multinational) Firms: The Impact of Decentralized Networks for Innovation." *Seoul Journal of Economics* 26 (1): 1-32.

Cantwell, John. 2009. "Location and the Multinational Enterprise." *Journal of International Business Studies* 40:5-19

Cantwell, John. 2017. "Innovation and international business," *Industry and Innovation* 24 (1): 41-60.

Cooke, P. 1998. “Introduction: Origins of the Concept,” in *Regional Innovation Systems,* eds H. Braczyk, P. Cooke, and M. Heidenreich. London: UCL Press, 2-25.

Council of Canadian Academies. 2009. *Innovation and Business Strategy: Why Canada Falls Short*. Ottawa: Government of Canada. Web.

Center for Automotive Research. 2010. *AUTO21 Network of Centers of Excellence Impact Assessment of the Research and HQP Programs in the period 2001-2009.*

Dalton, Alyssa. 2015. "Siemens partners with Seneca, Sheridan College for Mechatronics training." Retrieved February 28, 2017 (http://www.automationmag.com/education/news/5031-siemens-partners-with-seneca-sheridan-college-for-mechatronics-training).

Dunning J.H. 1996. The Changing Geography of Foreign Direct Investment, paper presented at UNU/INTECH international workshop on foreign direct investment, technology transfer and export orientation in developing countries, Maastricht, Netherlands.

Eickelpasch, Alexander., and M. Fritsch. 2005. "Contests for Cooperation: A New Approach in German Innovation Policy." *Research Policy* 34 (8): 1269-282.

Freeman, Christopher, and Carlota Perez. 1988. “Structural Crises of Adjustment, Business Cycles and Investment Behaviour.” in *Technical Change and Economic Theory*. eds ounci

Galvin, Patrick, Elena Goracinova, and DavidA. Wolfe. 2015. ‘‘Recent Trends in Manufacturing Innovation Policy for the Automotive Sector: A Survey of the US, Mexico, EU, Germany and Spain.’’ In *The Global Automotive Industry*, ed. P. Nieuwenhuis and P. Wells, 53–66. New York: Wiley. http://dx.doi.org/10.1002/9781118802366.ch6.

Gertler, Meric S. and David A. Wolfe. 2004. “Ontario’s Regional Innovation System: The Evolution of Knowledge-Based Institutional Assets,” in *Regional Innovation Systems*, 2nd. Ed., Ed.s Philip Cooke, Martin Heidenreich and Hans-Joachim Braczyk (London: Taylor and Francis), pp. 91-124.

Guimon, Jose.2008. "Government Strategies to Attract R&D-intensive FDI." *The Journal of Technology Transfer* 34 (4): 364-79.

Gurman, Mark, and Gerrit De Vynck. 2016. "Apple said to develop car operating system in BlackBerry country." *Bloomberg*, October 25.

Holmes, John. 2016. "Regional Resilience and the Recalibration of Automotive Industry Labour Relations in the Great Lakes Region." Proc. of Resurrection or Reinvention: Industrial Resilience in Traditional Manufacturing Regions, Collegio Carlo Alberto, Torino, Italy.

Holmes, John, Tod Rutherford., and Jeffrey Carey. 2017. "Challenges Confronting the Canadian Automotive Parts Industry: What Role for Public Policy?" *Canadian Public Policy* 43 (S1): 75-89.

Isaksen, Arne, and Michaela Trippl. 2016. "Path Development in Different Regional Innovation Systems: A Conceptual Analysis." In *Innovation Drivers and Regional Innovation Strategies*. ed. Mario Davide Parrilli, Rune Dahl Fitjar, and Andres Rodriguez-Pose. New York, NY: Routledge, 66-85.

Kitchener’s Pravala networks to receive $9.7M from feds to build online platforms in vehicles (2016) Available at: http://www.cbc.ca/news/canada/kitchener-waterloo/kitchener-pravala-9-7-million-dollar-funding-internet-vehicles-1.3533387 (Accessed: 28 February 2017).

Lampinen, Megan. 2016. "Wages slip to the wayside in Canadian labour talks." Retrieved February 28, 2017 (http://www.automotiveworld.com/analysis/wages-slip-wayside-canadian-labour-talks/).

Lundvall, Bengt-Åke. 2006. "One Knowledge Base or Many Knowledge Pools?" DRUID Working Paper No. 06–08. Aalborg and Copenhagen, Www.druid.dk.

Martin, Ron., and James Simmie. 2008. "Path Dependence and Local Innovation Systems in City-Regions." *Innovation: Management, Policy & Practice* 10(2–3, December): 183–96.

Martin, Ron., and Peter Sunley. 2011. "Conceptualizing Cluster Evolution: Beyond the Life Cycle Model?" *Regional Studies* 45 (10): 1299-318.

Maskell, Peter., and Anders Malmberg. 1999. "Localised Learning and Industrial Competitiveness." *Cambridge Jounal of Economics* 23:167–85.

Menzel, M.-P., and D. Fornahl. 2009. "Cluster Life Cycles--dimensions and Rationales of Cluster Evolution." *Industrial and Corporate Change* 19 (1): 205-38.

Morris, Charles. 2013. "Chrysler partners with McMaster university to develop advanced electric powertrains." Retrieved February 28, 2017 (https://chargedevs.com/newswire/chrysler-partners-with-canadian-government-and-mcmaster-university-to-develop-advanced-electric-and-hybrid-powertrains/).

Munim, A., and C. Yates. 2015. The APMA's Connected Car Project: Innovation through Collaboration in the Canadian Automotive Parts Industry. Research Report. Hamilton, ON: Automotive Policy Research Center, McMaster University.

Natesheh Al A., Gbadegeshin S.A., Rimpilainen A. 2015. "Identifying the challenges in commercializing high technology: a case study of quantum key distribution technology," *Technology Innovation Management Review*, vol. 5 (1).

Owram, Kristine. 2016. "BlackBerry opens self-driving research centre in Ottawa," *The National Post*. December 16. http://business.financialpost.com/news/transportation/blackberry-opens-self-driving-research-centre-in-ottawa-aims-to-build-software-foundation-for-autonomous-cars.

Pike, Andy, Stuart Dawley, and John Tomaney. 2010. "Resilience, Adaptation and Adaptability." *Cambridge Journal of Regions, Economy and Society* 3(1): 59–70.

Rutherford T., and John Holmes. 2007. "Entrepreneurship, knowledge and learning in cluster innovation: the Windsor Ontario tool, die and mould cluster." *International Journal of Entrepreneurship and Innovation Management* 7(2):320-344.

Shum, David. 2016. "Ontario to invest $10 million over 4 years for transit innovation." *Global News*, April 25.

Simmie, James, and Ron Martin. 2010. "The Economic Resilience of Regions: Towards and Evolutionary Approach." *Cambridge Journal of Regions, Economy and Society* 3(1): 27–43.

Smardon, Bruce. 2014. *Asleep at the Switch: The Political Economy of Federal Research and Development Policy since 1960*. Montreal & Kingston: McGill-Queen's UP.

Spithoven, A, Vanhaverbeke, W, & Roijakkers, N. 2013. "Open innovation practices in SMEs and large enterprises." *Small Business Economics 41*(3): 537–562.

Storper, Michael, and Richard L. Walker. 1989. *The Capitalist Imperative: Territory, Technology, and Industrial Growth*. New York: Basil Blackwell.

Strambach, Simone, and Benjamin Klement. 2013. "Exploring Plasticity in the Development Path of the Automotive Industry in Baden-Württemberg: The Role of Combinatorial Knowledge Dynamics." *Zeitschrift Für Wirtschaftsgeographie* 57(1–2).

Timothy Sturgeon. 2003. "What Really Goes on in Silicon Valley," *Journal of Economic Geography* 3(2): 199-225.

Trippl, Michaela, Bjorn Asheim, and Johan Miorner. 2015. "Identification of Regions with Less Developed Research and Innovation Systems." Circle Working Paper No. 2015/1 Lund, Sweden.

Wolfe, David A. 2010. "The Strategic Management of Core Cities: Path Dependence and Economic Adjustment in Resilient Regions." *Cambridge Journal of Regions, Economy and Society* 3(1): 139–52.

Yates, C. 2015. *How Can Public Policy Help Sustain a Globally Competitive Canadian Automotive Industry?* Research Report. Hamilton, ON: Automotive Policy Research Center, McMaster University. At https://aprc.mcmaster.ca/sites/ default/files/pubs/aprc-public-policy-paper-yates.pdf.