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Digital Policy Hub

Digital Policy Hub – Working Paper

Locating Canada in Industry 4.0: Barriers and Opportunities

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Key Points

- The Fourth Industrial Revolution, or Industry 4.0, is introducing rapid technological advancements that will fundamentally alter wealth distribution, labour automation and the creation or reinforcement of monopolies.
- Canada's manufacturing industry is not as internationally prominent as those of other Industry 4.0 leaders such as China, Germany, Japan and the United States. Yet Canada is making significant advancements to improve and develop its advanced manufacturing industry, which has the potential to actively participate in developing critical Industry 4.0 technologies and processes.
- As it integrates Industry 4.0 technologies into its manufacturing sector, Canada must balance sustainable resource management with technological advancement.
- Canada has a unique opportunity to join the call for international collaboration made by Germany and Japan's Industry 4.0 movements. This would not only provide Canada with access to critical data for training Industry 4.0 technologies, but also ensure that the development of these technologies is not monopolized by big tech corporations. It emphasizes the importance of global cooperation in the development of Industry 4.0 technologies.
- Canada has the responsibility to protect workers during the transition to Industry 4.0. Efforts to reskill and upskill workers should be enacted through corporate responsibility. Additionally, Canada must provide financial safeguards for workers who may be displaced by this transition and fund initiatives aimed at creating new employment opportunities.
- Further innovations to foster partnerships across Canadian industries would ensure the strength of Canada's economy.

Introduction

Emerging technologies are developing at a rate far more significant than previous technological evolutions, as seen in the first and second industrial revolutions. Technological development is coupled with political and economic motivations, bringing myriad consequences such as the increased automation of labour, changes to wealth distribution, the reorganization of global supply chains, the reinforcement/creation of monopolies and resource extraction. The Fourth Industrial Revolution, also known as Industry 4.0, is ushering in disruptive technologies and modes of production.

Entering into a new industrial revolution begs the questions of how Industry 4.0's critical technologies affect the current international economic system, whether Canada is prepared for such transformations and how the country can effectively participate in Industry 4.0 in a sustainable manner. This working paper explores what Industry 4.0 is and how it may operate, as well as global Industry 4.0 leaders and their impacts on Canada, Canada's positionality in relation to Industry 4.0 adoption and concerns in adopting these technologies. The paper ends with four recommendations for Canada moving forward.

What Is Industry 4.0 and What Opportunities Does It Present?

The term Industry 4.0 originates from a 2011 German government initiative to increase industrial production within the nation (Oláh et al. 2020). Technologies such as artificial intelligence (AI), robotics automation, sensors, big data, cloud computing, additive manufacturing and mixed reality systems will be used in a technological ecosystem to create smart machinery that controls production processes independently (Rainnie and Dean 2019). In this technological ecosystem comprised of smart machinery, the technologies are capable of communicating with each other and can, therefore, adjust in real time to production commands (ibid.). This is possible through the use of the Internet of Things (IoT) and the Internet of Services to electronically connect internal and external supply chain networks, thereby making industries "smart" (Oláh et al. 2020). Further, this transformation of technological organization is supported by cyber-physical systems, which integrate hardware and software to achieve results beyond the binary perceptions of the cyber and physical realms, allowing it to achieve large-scale results (ibid.). Some believe Industry 4.0 to be a complete digitization of a corporation's physical assets and integration into digital ecosystems alongside value chain partners (PwC 2016).

Studying Industry 4.0 provides insights into how emerging technologies will be utilized in an ecosystem rather than analyzed individually. This is what makes Industry 4.0 unique; it operates in the physical and digital realms and creates a system in which technologies communicate with each other autonomously, reducing the need for labour and human input. The interconnected network of Industry 4.0 allows for real-time data exchange, decision making and optimization of manufacturing processes, with the goal of enhancing productivity and efficiency. This includes the reorganization and improvement of global value chains. Some scholars have gone as far as to say that Industry 4.0 presents a paradigm shift due to the disruptive nature of these technologies (Bongomin et al. 2020). Such a significant shift is due to its aspirations to evolve a coordinated structure by sequentially advancing technologies, promising significant changes across production and impacting politics, social relations, culture and scientific progress (Kurt 2019).

It is also important to acknowledge the relationship between Industry 4.0 and other emerging technological paradigms such as Web3 and the metaverse. Kudzai Manditereza (2018), the founder of Industry40.tv, describes the aim of Industry 4.0 as transforming factories into computers composed of modular processes through Cyber Physical Systems. Web3 concepts could facilitate decentralized peer-to-peer networking of these factories via Industrial IoT, similar to Bitcoin's operational model (ibid.).

Although the technologies underpinning Web3 are, in some cases, similar to those driving Industry 4.0, Industry 4.0 is being implemented in manufacturing to serve state and corporate interests. This represents a more realistic application of emerging technologies than Web3's decentralized aspirations to render corporate dependence and big tech monopolies obsolete. However, the current monopolies held by big tech on the infrastructure underpinning emerging and disruptive technologies protect them from obsolescence.

On the other hand, the metaverse can serve as the operational space for Industry 4.0, enabling remote monitoring and control of physical devices worldwide via smart devices due to the capabilities of the IoT.[1] Unlike Web3, the metaverse does not require the decentralization of technology or a shift of power and value from platform corporations to users (Ball 2022). Metaversal technologies are being applied to Industry 4.0 development in the form of digital twins, where physical objects are represented in a virtual reality environment, and some corporations have already begun utilizing this tech as a tool for Industry 4.0 development.[2]

Leading Global Industry 4.0 Projects

However, the goals motivating Industry 4.0 vary between countries. For instance, while the German government popularized the term, other initiatives, such as China's Made in China 2025, the United States Industrial Internet Consortium and Smart Manufacturing Leadership, and Japan's Robot Revolution Initiative and Industrial Value China Initiative, are based on similar principles (Luthra et al. 2020; Bongomin et al. 2020). Yet, at least in the North American case, big tech corporations are developing and distributing Industry 4.0 technologies.

China, a global manufacturing superpower, has taken a more nationalistic approach to its Industry 4.0 project, Made in China 2025. Its primary aim is to lessen China's dependence on foreign technology imports by heavily investing in domestic innovations, thereby fostering Chinese companies capable of competing both locally and internationally (Institute for Security and Development Policy 2018). To achieve these goals, Beijing is implementing regulatory changes and standards to encourage innovation and restrict foreign competition, while government entities and state-run banks are supporting manufacturing development through policies, subsidies and financial aid, including offering substantial funds for technological upgrades (ibid.).

Germany and Japan are taking a collaborative approach to Industry 4.0 development. At Hannover Messe 2016, Japan's Robot Revolution and Industrial IoT initiative and Germany's Plattform Industrie 4.0 formed a partnership and action plan (Working Group on Manufacturing Data Spaces 2024). This initiative recognizes that global manufacturing industries face similar challenges, including climate change, geopolitical tensions and interrupted supply chains, which transcend national borders. Digitization and data use provide solutions, such as reducing carbon footprints, increasing supply chain resilience and enabling new business models, driven by advances in AI. They recognize that barriers to achieving advanced digitization stem from an unwillingness to share valuable data, as well as an overwhelming array of competing solutions and the necessity of investing significant financial and human resources to launch Industry 4.0 manufacturing projects. Germany and Japan have formed a collaboration to minimize these barriers but are also calling on further international collaboration in order to share resources to tackle these barriers, while also creating international standardization.

1 See www.multiverse.ai/stories/transiting-the-metaverse-how-web3-is-shaping-the-fourth-industrial-revolution.

2 Ibid.

The United States relies heavily on its corporations to advance Industry 4.0. In 2013, General Electric proposed the US concept of Industry 4.0 by suggesting the convergence of information technology and industrial equipment (Qin, Chen and Peng 2020). To implement this concept, five leading US industrial companies — AT&T, GE, Cisco, Intel and IMB — formed the Industrial Internet Consortium (IIC). The goal of the IIC is to promote the inevitable integration of the physical and digital worlds in order to produce innovative industrial projects and smart manufacturing (ibid.). Since then, US big tech corporations have dominated Industry 4.0 infrastructure development.

Amazon is currently advertising its Industry 4.0 technologies to small and medium-sized enterprises (SMEs) by selling cloud computing services in a pay-as-you-go model through services such as Amazon Monitron and AWS IoT SiteWise (Biswas, Can and Sol 2023). The company claims that cloud computing democratizes Industry 4.0 technologies, which allows SMEs to provide their customers with cloud services without having to spend the time and resources in order to develop them. Amazon further claims that SMEs can also benefit from scalable resources and ensure data security and compliance (ibid.). Offering these services to SMEs amounts to a form of rent extraction, ensuring that these smaller businesses rely on big tech corporations for critical Industry 4.0 infrastructure. The SMEs' reliance on larger businesses such as Amazon also gives these corporations access to data, which is stored on the Amazon Web Services cloud.

Google Cloud is also an industry leader in manufacturing solutions and its advertising to businesses promises the optimizing of manufacturing and supply chain operations through data and AI with the help of Google Cloud Cortex Framework.[3] Google also claims to "deliver next-generation digital customer experience and products," which includes predictive marketing and replacing customer service agents with AI tools.[4] Currently, Google works in the automotive, energy, electronics and semiconductor industries. Businesses can also register to visit Google Cloud's residency at the MxD (Manufacturing x Digital innovation centre), a 22,000-square-foot research factory where digital manufacturing technologies are tested and applied in real-world situations to demonstrate how Google Cloud and AI solutions can improve production, supply chain and front-line workforce processes.[5] This reliance on big tech monopolies for the global implementation of Industry 4.0 is concerning for Canada, as 93 percent of Canadian manufacturing is comprised of SMEs.[6]

Where Is Canada Today?

Canadian industries garnering the largest amount of GDP are real estate and rental and leasing, manufacturing and health care and social assistance.[7] Canada is also a global leader in advanced manufacturing, agribusiness, life sciences, finance and insurance, digital industries, and natural resources.[8] Currently, Canadian manufacturing firms are

3 See https://cloud.google.com/solutions/manufacturing.

4 Ibid.

5 See https://inthecloud.withgoogle.com/fy23-mxd-booth/register.html?_gl=1*990mw5*_.

6 See www.cmts.ca/event/news/future-of-canadian-manufacturing/.

7 See www.statista.com/statistics/594293/gross-domestic-product-of-canada-by-industry-monthly/.

8 See https://businessevents.destinationcanada.com/en-ca/economic-sectors.

at a disadvantage because they are not far along enough in their digital transformation processes, as Canadian companies and the country as a whole have been slow to adopt AI technologies.[9] Canadian Manufacturers & Exporters have located three issues that are limiting Canadian manufacturers' adoption of Industry 4.0: high purchase costs and uncertain return on investment, lack of information and testing opportunities and labour and skills shortages.[10] However, PwC suggests that Canadian manufacturers, specifically those in southwestern Ontario, are well positioned to be leaders in Industry 4.0 manufacturing, given that it is already home to various industries such as automotive manufacturing (PwC 2016). Adoption of Industry 4.0 technologies in Canadian factories could lower maintenance expenses by 10–40 percent, while smart factories could also tailor to customers' expectations, driving the market for Canadian businesses (Salesforce Canada 2024).

Although Canada is not internationally recognized for its manufacturing capabilities compared to manufacturing leaders such as China, it has recently invested heavily in advanced manufacturing. Innovation, Science and Economic Development Canada created Canada's Advanced Manufacturing Cluster, which aims to enhance Canada's manufacturing and growth while addressing global challenges such as supply chain security, health-care improvement, environmental protection and technology adoption, hoping to position Canada as a green supplier.[11] It focuses on technologies such as machine learning, automation, cybersecurity and additive manufacturing (3D printing) (ibid.). This cluster is Canada's version of Industry 4.0, as it focuses on creating technological ecosystem initiatives across national borders to enhance Canada's advanced manufacturing, emphasizing strengthening the capacity and scalability of Canadian SMEs.

The cluster boasts 12 success stories, yet only one is located in Alberta, four reside in Ontario, one operates between Ontario and Quebec, and the remaining half are described as pan-Canada. Pan-Canadian development represents the creation of borderless digital products or projects, including intellectual property rights. This disproportion among project locations is indicative of Canada's historic economic disparities; it is unsurprising that Industry 4.0 development occurs in areas with pre-existing infrastructure. For example, leading Industry 4.0 research and development is occurring at major Canadian universities, including the University of Waterloo's Multi-Scale Additive Manufacturing Lab, the University of Toronto Robotics Institute, the Southern Alberta Institute of Technology's School of Manufacturing and Automation and the Centre de recherche industrielle du Québec's Réseau Québec — 3D Initiative (Destination Canada 2021).

Ontario will most likely benefit from Industry 4.0 development in manufacturing due to the prevalence of auto manufacturing, computer systems design and data services industries in the province.[12] Similarly, Quebec may also see significant benefits from Industry 4.0 adoption due to Quebec City's manufacturing, information technology, IoT and applied technologies industries.[13] The Prairies are much more dependent on natural resource commodities — particularly Alberta, but also Saskatchewan and Manitoba — while the Atlantic provinces rely more on offshore energy supplies and natural resource

9 Ibid.

10 See https://cme-mec.ca/initiatives/industry-4-0-canadas-digital-future-in-manufacturing/.

11 See https://ised-isde.canada.ca/site/global-innovation-clusters/en/canadas-advanced-manufacturing-cluster.

12 See www.bankofcanada.ca/2023/06/canadas-regional-economies/.

13 See www.quebecinternational.ca/en/choose-quebec/quebec-industries.

processing (ibid.). British Columbia, Saskatchewan, Manitoba and the Territories also rely on their mining industries. There is the potential to integrate Industry 4.0 technologies in Canada's mining and oil and gas industries nationwide. This integration could enhance worker safety by shifting direct production jobs to remote operation centres, reducing the need for on-site presence (Gosine and Warrian 2017). The digitization of mining and oil and gas operations would foster a transition from manual processes with large crews to automated systems managed by a few highly trained specialists working remotely (Destination Canada 2021).

Concerns for Canadian Industry 4.0 Development

Reliance on American Big Tech Infrastructure

Canada's manufacturing industry does not match the strength of these industries in countries leading Industry 4.0. Given the rapid technological advancements and scalability of American big tech corporations, the development of Industry 4.0 in Canada will likely rely significantly on their existing tech infrastructure. Big tech corporations create user-friendly and accessible Industry 4.0 infrastructure, such as cloud services, and sell it to SMEs that lack the capital to create such infrastructure individually.[14] Even large banks such as ING claim that they expect to rely on big tech's AI infrastructure due to the machine power that is needed to operate these technologies, as well as the unfeasibility for banks to create their own infrastructure (Howcroft 2024).

Relying on these platforms allows SMEs to conserve resources and develop more quickly. There is pressure for Canada to adopt Industry 4.0 technologies, as studies, including one from BDC, indicate that the productivity gains from Industry 4.0 will eventually create such an advantage that businesses failing to adopt them will struggle to compete.[15] But this comes with various consequences, including monopoly entrenchment for American big tech corporations. Instead of creating Canadian technological infrastructure that would contribute to the Canadian economy, Canadian corporations would pay big tech corporations rent to use these services. This is why advanced Industry 4.0 tech development by American big tech corporations such as Amazon and Google are concerning for Canadian Industry 4.0 development.

Future of Work and Skills Inequality

What makes Industry 4.0 different is the speed at which those in control of its essential technologies will achieve enormous scale with decreased employment rates (Rainnie and Dean 2019). Over time, those working in manufacturing in the Global North will require upskilling, while most labour is transferred to robotics (Salesforce Canada 2024). This push to reskilling, or upskilling, is often heralded as a positive transition by corporations that claim it allows workers to obtain more knowledge and education in their trades. Yet the social inequalities of obtaining higher education are often ignored in these conversations.

14 See www.hpe.com/ca/en/what-is/cloud-services.html.

15 See www.bdc.ca/en/articles-tools/technology/invest-technology/what-is-industry-4.

The specific new skills required for workers are also not advertised by corporations pushing for Industry 4.0 transformations in manufacturing: for instance, it is unknown if coding will be an essential technical skill that workers must adopt. If so, these potentially complex and time-consuming skills will present various barriers to workers attempting to adapt. In the case of the mining or oil and gas industry, the goal of integrating Industry 4.0 technologies is to reduce the need for physical labour while hiring highly specialized workers, such as computer or software engineers.

A critical concern regarding this shift in labour needs is that workers will feel that they are being left behind in a manner similar to the uptick of offshoring labour from the Global North to the Global South due to globalization. This process has not only exploited workers in the Global South but has also led to a sense of abandonment among workers in the Global North, fuelling right-wing populism. Dani Rodrik (2021) highlights the role of technological change and reindustrialization on labour markets, as well as workers placing blame on elites — whether domestic or foreign — who are perceived as neglecting workers' interests, thereby causing severe political tensions and mistrust in government institutions. Since the election of Donald Trump in 2016 and the Brexit movement in the United Kingdom, populism in Canada has increased, with 34 per cent of Canadians exhibiting populist beliefs, most common in less educated, working-class Canadians (Graves and Smith 2020). To prevent further populist ideology caused by wealth inequality and job loss, Canada must work to protect those who may be displaced by the transition to Industry 4.0 and create jobs for less-skilled workers entering this era.

Environmental Impact

Industry 4.0 is often touted as a significant step in more sustainable manufacturing because it fosters sustainable automation through data cultivated in a smart factory environment to increase performance and optimize demand, prioritizing efficiency (Javaid et al. 2022). Yet critical technologies of Industry 4.0, the most recent example being AI, have recently been criticized for their carbon footprint and significant water demand. The data centres necessary to train and operate AI technologies require significant amounts of water resources, causing Microsoft to increase its water consumption by 34 percent and Google by 22 percent in 2022 (Criddle and Bryan 2024). Such demands for water have already been causing significant issues for the hardware development of critical technologies needed to develop Industry 4.0; for example, chip manufacturing in Taiwan has caused the government to redirect water usage from rice farmers to semiconductor factories (Feng 2023). Canada must consider these significant environmental impacts as it incrementally integrates Industry 4.0 technologies into its manufacturing sector, with a focus on ensuring a balance between sustainable resource management and technological advancement. Industry 4.0 technologies being utilized in the mining and oil and gas industries in Canada's Prairie and Atlantic provinces raises concern regarding the shift away from fossil fuel dependency toward sustainable and renewable energy sources. Further developing these industries may increase Canada's reliance on these extractive practices. Economic regional fairness is also a significant concern with respect to lowering Canada's dependence on fossil fuels.

Recommendations

- **Recommendation 1:** Participating in Germany and Japan's call for international collaboration on Industry 4.0 could be crucial for Canada's development in this area. Such collaboration would enhance data availability, allowing Canada to effectively train and advance its Industry 4.0 technologies, including AI. Further, Canada could suggest creating a team of experts and industry leaders from each country to produce a standardized Industry 4.0 tech infrastructure, thereby avoiding a reliance on big tech corporate infrastructure.

- **Recommendation 2:** As part of Innovation, Science and Economic Development Canada's Advanced Manufacturing Cluster, an additional program stream should be introduced to focus on upskilling, reskilling and addressing job displacement resulting from the transition to Industry 4.0. This initiative should emphasize corporate responsibility, encouraging companies to retain their current employees while providing education and training to enhance and diversify their skill sets. There should also be a focus on projects aimed at protecting workers who would be displaced by Industry 4.0 automation. These initiatives should seek solutions and opportunities within Industry 4.0 for those skilled in manufacturing or physical labour, preventing mass layoffs and mitigating the risk of displaced workers turning to populist ideologies driven by job and wealth displacement.

- **Recommendation 3:** Foster cross-industry partnerships by encouraging collaboration between Canadian financial entities, real estate, manufacturing, technology development and energy industries to invest in and develop Canadian Industry 4.0 infrastructure.

- **Recommendation 4:** The federal government's adoption of the Sustainable Finance Action Council's proposed Climate Investment Taxonomy could aid Canadian financial investment in Industry 4.0 by providing a standardized framework that would allow financial markets to determine if projects align with Canada's climate goals(Arnold et al. 2023).

Conclusion

Industry 4.0 technologies are advancing rapidly, and Canada must participate in the development of such technology in order to compete with other international Industry 4.0 leaders. Industry 4.0 has also introduced various opportunities to further enhance Canada's advanced manufacturing sector. By joining international collaborations and fostering partnerships across industries, Canada can strengthen its economy while actively participating in Industry 4.0 developments. To enhance the effectiveness of this transition, Canada must also balance sustainable resource management with technological progress and protect workers through reskilling and financial safeguards.

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