

Automation, New Business Models and Employment

Some prospective thinking from a Quebec-based economist

ERIC NOËL

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EXECUTIVE SUMMARY

In Quebec, a million workers will have retired between 2015 and 2024, and there will be 140,000 fewer workers and 630,000 more retirees in 2030. Without a significant effort to mitigate these demographic risks and improve productivity, the province’s potential GDP may drop by 0.7 to 1.0 %. At the same time, Quebec’s labour force will be dramatically impacted by two external phenomena: **automation and robotization, and new business models**. No sector of economic activity or organization is immune to these trends and many occupations will be affected.

In the past, new technologies have created more jobs in the long run than they eliminated. Today, while initial estimates of the number and kind of jobs under threat from technological change and how quickly new digital tools will be accessible remains speculative, they do point to some preoccupying effects. While we undoubtedly lack the imagination to make accurate predictions about the positive effects of automation, such as new occupations or more satisfying jobs, it seems likely that some 1.4 million Quebec workers will be affected, experiencing job losses, new tasks, underemployment and/or retraining.

Jobs that will be less affected by robots and smart software include non-routine, cognitive occupations such as those that require: non-standard analytical skills, creativity, and social skills, as well as the ability to improvise, solve new problems, transfer knowledge, supervise other people, and work independently. Such abilities are already common in several professions and for most Quebec workers. Simultaneously, new business models exploit automation and can lead to the elimination of long-established enterprises as well as the advent of new local and foreign economic players. The continued expansion of on-demand and custom services, remote services and sourcing, the internet-of-things, instant delivery of goods and services,

3-D printing and additive manufacturing, not to mention the sharing economy, will shape the “disruption” but also stimulate entrepreneurship and SMEs. Ricochet effects on regulations and public policies are certain to last, requiring a competent and proactive public service.

Technological revolutions have always brought change at varying speeds, created social stress, and driven a redistribution of opportunities and wealth. Socio-economic effects are to be expected, and as the number of occupations that are vulnerable to automation (and thus obsolescence) and of “gig-economy” workers increases, the gap between rich and poor could widen. The contrast between the haves and the have-nots will become one between employables and unemployables (the can and can-nots). These effects will vary based on the speed of machine/human job substitution, the rate of job improvement, and differences in organisational capacity to adopt new technologies and/or invest in people – a tough dilemma. In addition, “automatons” and new business models will generate geographic, political, and fiscal effects; and will impact both unions and the minimum wage concept.

When considering the “rise of the robots” and taking into account Quebec’s demographic challenges and its own technological momentum, the province could adopt an evolutionary rather than a defensive job strategy to profit from both digitalization and new business models. Such evolution could develop in several directions, but most will focus on improving human capital:

- Collect more data on workplace training and HR investments to better understand their dynamics and outcomes and to stimulate more of them.
- Rethink curricula, giving priority to advanced, pragmatic, and continuing education programs that meet the new criteria for employability created by advanced technologies.
- Increase university enrollments in areas that are expected to benefit from the digital economy, and cap enrollments in education programs associated with “technologically at-risk” occupations.
- Create individual permanent accounts in which workers can compile and profile their academic and training gains throughout their careers, and can save or receive funding for tuition at any age.
- Create time banks in those individual accounts or within organizations for employees to accumulate time units that they can withdraw when scheduling continuing education or training days.
- Offer shorter education and training programs and more distance learning courses through colleges, universities, and other education suppliers that target both the new skills demanded by the digital revolution and the learning capacity and behaviour of adult workers.
- Increase the formal recognition of new curricula and courses, or of their equivalences, by professional associations and the ministry of education, even when training units are earned outside the traditional academic system.

To broaden its thinking about the long-term economic prospects for Quebec, particularly the upcoming changes facing the province’s labour market, the Institut du Québec, a joint venture between the Conference Board of Canada and business school HEC Montréal, asked Mr. Eric Noël to produce two foresight essays. This first one looks at the future of automation, robotization, and new business models. The second report will focus on another long-term aspect of the Quebec economy. Mr. Eric Noël is SVP North America, Oxford Analytica; Initiator, Canada Towards 2030; and Executive Fellow, School of Public Policy, University of Calgary.

Automation, New Business Models and Employment

Eric Noël

In parallel with the acceleration of our inevitable demographic challenge and its direct effects on our workforce, economic activities and public finances, two other phenomena will speed up: automation and robotization, and new business models. The technological turmoil combined with the aging of our labour force, will demand significant adjustments and the proactive management of new risks, even as it offers new opportunities and solutions. This essay explores the sources and consequences of some aspects of the future of work and business, and suggests ten possibilities for action.

Demographic Challenges and Technological Change

It has long been assumed that Quebec is moving irreversibly towards a demographic shock. According to scenarios published by the Institut de la Statistique du Québec, the province will gradually produce more seniors than babies over the next 10 to 17 years. Between 2015 and 2024, a million workers will leave the labour market. By 2030, the number of Quebecers who are 68 years of age and over will increase by more than 630,000 while the people aged 23 to 67—the real working age population by then—will decrease by 140,000.

While today we may take satisfaction from a situation of almost full employment in Quebec,¹ the public and private sectors will both soon be confronting serious problems of labour scarcity. Some economists believe that unless productivity soars, Quebec's potential GDP could shrink by 0.7 to 1.0 %.² Is it possible to cope with the need for productivity gains and the scarcity of workers via another technological revolution and new business models? Or is it possible, on the contrary, that the 48 % of Quebecers and 58 % of Canadians who believe that robotization and automation will create huge unemployment problems may be right?³

Following the technological revolutions in the primary sector (agriculture), the secondary sector (manufacturing) and the tertiary sector (computerization), **the automation and robotization of the service sector**—including professional and specialized services—is the inevitable fourth transformation. The service sector represents 80 % of Quebec jobs.

The “cognitive” digital technologies include automated learning technologies, the recognition and processing of written and spoken natural languages and images by smart devices, and machine-driven data (re)configuration. These technologies are all evolving rapidly, and converging. With high-speed algorithms that are executed by high-performance processors, smart software is learning cognitive functions, memorizing, self-improving them, and enabling highly sophisticated, fully automated and complex decision-making applications and machines. Their applications, unimaginable a few years ago, can now be found in plants, offices, hospitals, schools, stores and on roads.

¹ In July 2017, Canada's unemployment rate was 6.3 %, and Quebec's was 5.8 %—the lowest rates since October 2008. In Quebec, the participation rates were 64.9 % and 65.4 % for those two respective years, compared to 57.8 % in 2016 for those aged 55 to 64.

² A one percentage-point variation changes the independent revenue of the Government of Quebec by about \$650 million according to 2017 information from the Ministère des Finances du Québec.

³ IPSOS-Canada, *CanadaNext survey*, (June 2017). The survey (a joint project with the author's *Canada Towards 2030* initiative and sponsored by IBM Canada) was conducted in June 2017, with 2,000 Canadians participants. The survey found that Quebecers are the most optimistic group regarding technological change.

Artificial intelligence (AI),⁴ virtual and augmented reality, advanced sensors, superpowerful microprocessors and algorithms, and big data generated by everything and everybody connected to the Internet⁵ will propel the automation and robotization of not just sectors but of several types of occupations, including:

- professionals (e.g., actuaries, accountants, engineers, healthcare workers, notaries, analysts of every sort, writers);
- technicians (e.g., legal, administrative, client service, translators, laboratory or office technicians);
- manual workers (e.g., hospitality, construction, distribution, truckers, cashiers, farmers, miners).

While 19th-century automation protected people from dangerous, manual work, and 20th-century automation spared them repetitive and monotonous work, the intelligent software of the 21st century specifically targets decision-making, and increasingly liberates men and women from work. Improving some occupations as they weaken others, these smart, automated systems will think and choose more quickly and better than humans, while freeing them from their biases and mental fatigue.⁶

No organization, regardless of size, location and area of operation, will be immune to the effects of these disruptive technologies. Millions of jobs will be eliminated or reduced, and countless workers will be reassigned to different and better jobs. In some cases mitigating the effects of retirements or prompting a struggle between those who are employable and those who are not.

Some Gains ...

Although we lack the imagination to accurately predict the positive repercussions the digital revolution will have on the world of work, we can foresee some including:

- better work quality and productivity, generating wealth and jobs;⁷
- more flexible working conditions available to older workers (reduced work time) and young people (better work/life/recreation balance);
- the creation of new occupations: thousands of jobs repairing domestic robots⁸ or home automation and telematics systems for autonomous vehicles; psychologist-programmers of artificial emotional intelligence and lawyers specializing in AI to defend them; experts in tactile cyber-simulation; sensor, drone and satellite-image technicians; automated system supervisors and correctors; experts in cyber security applied to smart systems and objects; etc.

These new jobs will not completely make up for those that are lost, particularly in terms of stability or total earnings. They will require different skills, will pay different salaries, and will even sometimes be in different cities.

⁴ According to American futurologist Ray Kurzweil, continuously gathering speed and complexity, the cognitive super-functions of artificial intelligence will exceed the capacities of the human brain by 2029.

⁵ According to Gartner, Inc., the "Internet of Things" (IoT) will consist of more than 25 billion interconnected devices representing a GDP of more than \$US1.9 billion by 2020.

⁶ A survey of AI experts conducted by the Future of Humanity Institute at the University of Oxford indicates that there is a 50 % chance that AI will exceed human capacity in almost every respect within 45 years: autonomous machines that can do everything better and cheaper.

⁷ Capgemini Consulting, *Turning AI into Concrete Value: The Successful Implementers' Toolkit*, (Capgemini Consulting, 2017).

⁸ The International Federation of Robotics expects the creation of 1 million to 2 million jobs in its sector between 2017 and 2020.

The smoothest transition will be achieved not by defending jobs against technology but through an evolutionary strategy that is synchronized with the accelerating retirement rate in Quebec. In the recent decades, we have already witnessed a gradual reduction in the number of workers in sectors where jobs are being automated, smoothly transitioning in favour of occupations that are less automated. On the other hand, considering the multiple dynamics and strengths of digitalization, there could be an increase in “technological unemployment,” an expression that dates back to the 1930s. This new or reinvented economy driven by techno-commercial leaps will not generate only winners. The initial phase of this shift could be marked by layoffs and reductions in the number of workers -- themselves often poorly equipped to achieve short-term career changes.

... and Some Losses

According to a 2013 study that made Oxford University professors Carl Benedikt Frey and Michael A. Osborne famous,⁹ some 47% of jobs in the United States may be either fully or partially automated by 2020. The McKinsey Global Institute estimates that fewer than 5 % of jobs can be entirely automated with current technology, but 60 % of occupations could be partially automated, at a level of, say, 30 % of tasks.¹⁰ According to a study conducted by Forrester Research in September 2016, 6 % of U.S. workers will have been replaced by machines by 2021.¹¹ Jobs in the customer service, retail, transportation and logistics sectors would be the most affected.

With regard to Canada, the Organisation for Economic Co-operation and Development (OECD) assesses the risk of almost complete automation at 9.2 % of jobs, while 23.5 % may experience radical change (total jobs at risk: 32.7 %).^{12,13} According to the Brookfield Institute for Innovation + Entrepreneurship (BII+E) in Toronto, 42 % of Canadian workers will be severely threatened by automation in the next 10 or 20 years, whereas 36 % are supposedly at low risk, placing employees in retail and administrative support at one extreme, and primary school teachers and educators at the other. BII+E¹⁴ suggests similar data for Quebec, which would mean that 1.73 million Quebec jobs would be affected by digitalization and robotization.

In a study published in March 2017, the C.D. Howe Institute expressed scepticism about the risk and speed of this kind of substitution in Canada. The authors state that the Canadian workforce is employed in sectors with a low risk of automation,¹⁵ and it is continuing to move towards industries, tasks, and skills that are difficult to digitize. They believe

⁹ Carl B. Frey and Michael A. Osborne, *The Future of Employment: How Susceptible Are Jobs to Computerisation?* (Oxford, U.K.: University of Oxford, September 2013).

¹⁰ Michael Chui, James Manyika and Mehdi Miremadi, “Where Machines Could Replace Humans—and Where They Can’t (Yet),” *McKinsey Quarterly*, July 2016. <https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet>; See also: <https://public.tableau.com/profile/mckinsey.analytics#!/vizhome/AutomationBySector/WhereMachinesCanReplaceHumans>

¹¹ Olivia Solon, “Robots Will Eliminate 6% of all U.S. jobs by 2021, Report Says,” *The Guardian*, September 14, 2016.

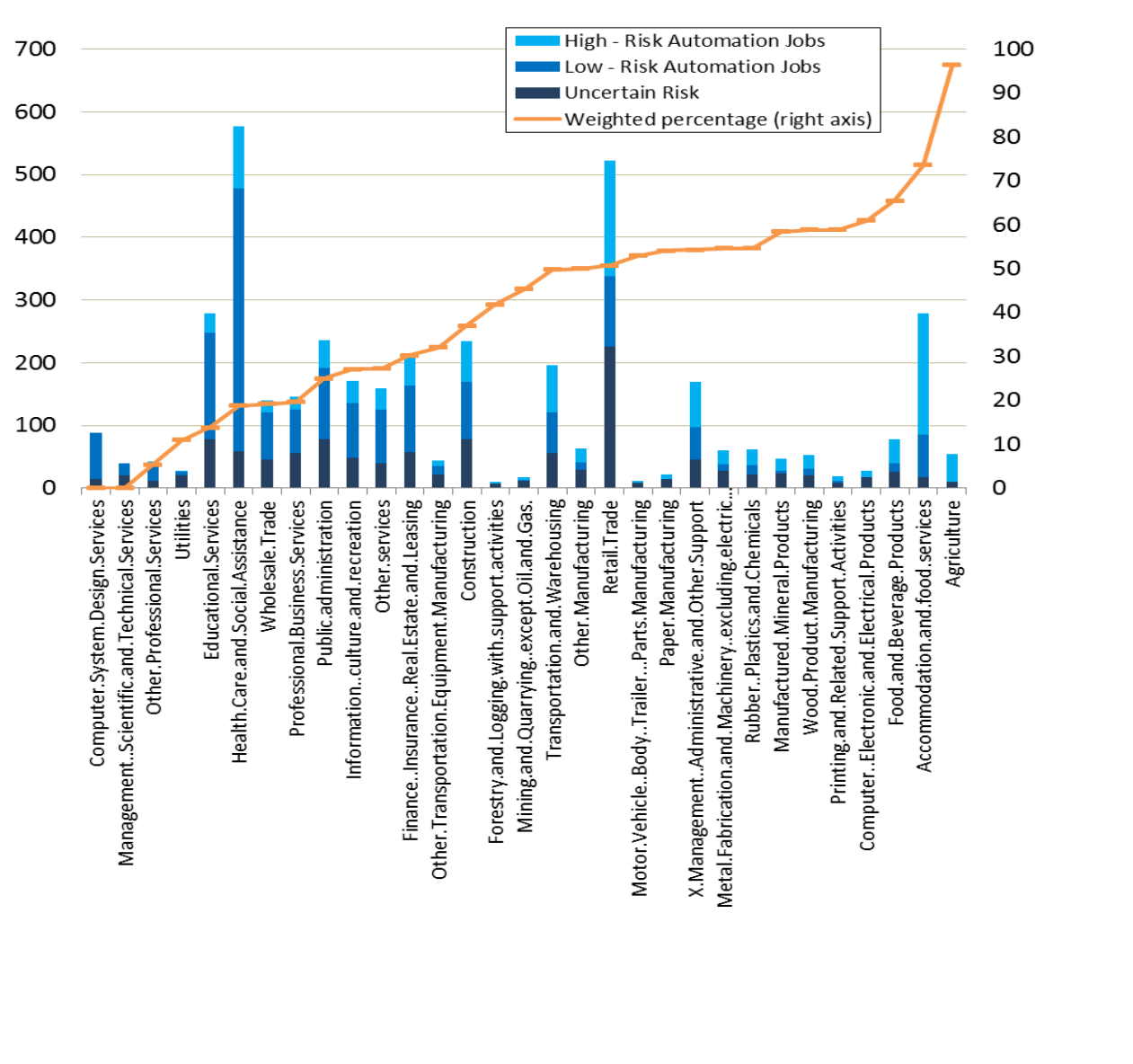
¹² Arntz, M., T. Gregory and U. Zierahn, *The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis*, OECD Social, Employment and Migration Working Papers, No. 189, (Paris: OECD Publishing, 2016). <http://dx.doi.org/10.1787/5jlz9h56dvq7-en>

¹³ OECD, *OECD Employment Outlook 2016*, (Paris: OECD Publishing, 2016). http://dx.doi.org/10.1787/empl_outlook-2017-en

¹⁴ Creig Lamb, *The Talented Mr. Robot: The Impact of Automation on Canada’s Workforce*, (Toronto: Brookfield Institute, June 2016). Using a task-based rather than an occupation-based approach, the study claims that 42 % of tasks performed by Canadian workers are at high risk to be automated with existing technology. By high risk, the authors mean a risk of 70 to 100 % automation within 10 to 20 years.

¹⁵ Matthias Oschinski and Rosalie Wyonch, *Future Shock? The Impact of Automation on Canada’s Labour Market*, Commentary No. 472 (Toronto: C.D. Howe Institute, March 2017).

Graphic 1 shows the level of automation risk by economic sector in Quebec, including the number of jobs and the probability. (Thousands of jobs -- % at risk)



Source: C.D. Howe Institute

that 34 % of Quebec jobs would be affected, or 1.4 million of the current total. Among the study’s other findings, industries in which fewer than 25 % of the jobs are at risk supposedly represent 27.5 percent of total employment (4.9 million workers), while those that are more than 75 % at risk employ only 1.7 percent of Canadians.

Worker/Machine Substitution: Not So Easy to Calculate

Many recent studies attempt to simulate the impact of automation and robotization on employment, using macroeconomic models, task inventories by occupation and digitalization’s impact on them, sectoral analysis under

current technologies, and scenarios of future technological and commercial trends.

These studies all have shortcomings in their estimation of the worker/machine substitution rate, and may overestimate or underestimate technologies, workers, and the permeability of organizations to change. Asserting that agriculture and manufacturing will accelerate their robotization is an over-extrapolation of the past (what's next after the robo-harvester and automatic milking system?). Whilst when envisioning the “end” of occupations like airline pilot, radiologist, notary, accountant, butcher, insurance claim adjuster, or an economist is speculating about the future.

Take the example of the trucking industry, which most studies classify as high risk of automation, and which employs between 65,000 and 80,000 in Quebec. It is easy to imagine that autonomous trucks will replace truck drivers, one day. Since winter conditions can reduce the performance of sensors on fully-autonomous vehicles, let us suppose that two automated trucks could follow a lead truck driven by a human driver. In this hypothetical semi-autonomous convoy, we might assume that one trucker in three will keep their job—but things are not that simple.

A variety of factors could delay the advent of autonomous commercial trucking, or reduce its impact, including: the large number of independent operators (26,000); low-volume routes on which a single truck is sufficient; and transport companies that may not have the resources to purchase autonomous trucks. Cross-border freight, petroleum products, and other hazardous materials will also likely be excluded. By comparison, mass transit, taxis, tourism, and postal and courier traffic, which account for some 107,000 jobs, would likely be easier to automate—for example, community transit corporations as they control most variables, carpooling, delivery drones, and postal routing. Warehousing, which covers 14,000 jobs (half as many as 30 years ago), could see larger warehouses that use robots for handling goods. The same applies to sorting facilities and ports, with autonomous trucks and cranes. This means that the “potential automation” offered by new technologies that use AI or robots with high levels of dexterity and vision will not necessarily translate into “actual automation”. Outcomes will depend on:

- the size of enterprises and their ability to invest in automation or people, or both;
- the cost of automation technologies compared to the cost of labour in a given sector;
- existing labour conventions and norms, and resistance from those they benefit; and
- sectoral competitive intensity.

Furthermore, some technologies will require additional workers to create, oversee, and maintain automated systems, as well as a human presence or input to complete certain tasks. All these variables are difficult to model.

In a simulation by the McKinsey Global Institute published in January 2017, 47 % of the 19.5 million Canadian jobs could potentially be automated, which would affect 7.2 million workers whose salaries total \$290 billion (US\$225.7 billion in the study).¹⁶ (See Table 1 for the automation probabilities, number of jobs, and payroll potentially affected in five economic sectors in Canada.)

¹⁶ Michael Chui, James Manyika and Mehdi Miremadi, “Where Machines Could Replace Humans—and Where They Can’t (Yet),” *McKinsey Quarterly*, July 2016. <https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet>; See also: <https://public.tableau.com/profile/mckinsey.analytics#!/vizhome/InternationalAutomation/WhereMachinesCanReplaceHumans>

Table 1. Effects of Automation and Robotization in Canada, by Sector

Sector	Probability of automation (%)	Number of jobs affected	Total payroll (\$ billions)
Accommodation and food services	69	820,000	21.4
Manufacturing	61	900,000	40.5
Retail	49	941,000	31.1
Administrative and government services	41	792,000	38.2
Health and social services	37	657,000	31.9

Source: McKinsey Global Institute, January 2017.

As suggested by economist David Autor of the Massachusetts Institute of Technology (MIT), and others, we can think in terms of two families and four categories of work that distinguish routine tasks from non-routine tasks, and the cognitive from the non-cognitive:

- **Routine manual work** is much more likely to be performed by a machine or intelligent software. This applies to, for example: the preparation of medication in a hospital or food processing in a factory or a restaurant, harvesting cereals and small fruits, operating a subway train or a heavy truck in a mine, filing objects or documents, unloading a ship or a train, and so on.
- **Routine cognitive work**—required in sectors such as administrative services, healthcare, financial services and retail—will be targeted by AI, with its speed and success in this area depending on the level of repetition and complexity of the tasks. This is not necessarily bad news if collaboration with AI and “automatons” enables a worker to focus on what he or she does best and quickest. “Routine work” as a whole represents perhaps 57.7 % of jobs, according to the C.D. Howe Institute. A third of these jobs may disappear by 2025, which will particularly affect workers without a college degree.
- **Non-routine manual work**, in which total employment in Canada reportedly rose from 7.2 % to 8.8 % between 1987 and 2015, will be more difficult to automate, particularly if the tasks include sensory motor elements (dexterity), improvisation in plans and decision-making, large workspaces (e.g., a construction site, a multi-storey building, or a convention centre), and complex communications. Professor Erik Brynjolfsson of MIT believes that jobs such as patient attendant, healthcare technician, or police officer are fairly well protected and could fare best, though advances in robotic vision and handling systems could disrupt a variety of occupations including cooks, plumbers, janitors, and foremen.
- **Non-routine cognitive work** will be better protected from robots and smart software. The category includes 30.6 % of jobs in Canada, and demands non-standardized analytical abilities, improvisation, initiative, the solving of new problems, creativity, knowledge transfer, the supervision of other people (or machines), autonomy in management

style (decision-making, timing, and approach), and social abilities such as listening skills, empathy, sense of service, and motivating teamwork. There are many examples of such work: nutritionists, professionals who work with people with disabilities, academic and teaching counsellors, psychologists, agronomists, nurses, primary and secondary school teachers, daycare workers, supervising engineers, artists, chefs, athletes and coaches, event managers, and entrepreneurs. All these very “human” occupations could even be improved with help from AI and machines.

As with the positive effects of robotization on manufacturing (e.g., lower prices, increased demand, and total sector employment, which is not the case in all sub-sectors of manufacturing), digitalization could also increase labour demand,¹⁷ and provide more leeway for creativity. This type of optimism is expressed by Thomas Davenport of Babson College in Massachusetts, David Autor, and others, who assert that the threat of automation should be seen to present an opportunity to expand human talents (“job augmentation”). Automatic devices will perform routine work, while people will excel in non-routine work. Man/machine complementarity will stimulate worker performance and productivity, leading to greater job satisfaction and even better pay. There will still be a need for employers to promote the human/machine duo rather than set one against the other -- not all bosses will have the resources to invest in both. The relationship between employer and worker will also require a reassessment of how work is compensated, based not on time spent but on value generated.

Fintech and Financial Services Jobs

The financial technology sector is a particularly interesting one to watch. As we know, more financial jobs (e.g., fund managers, bank staff, actuaries, stock and insurance brokers, accountants, financial and credit analysts, compliance and claims officers) could be replaced by automated processes. As “robo-advisers” replace investment brokers, big data and blockchain and crypto-currency technologies bring innovation to other traditional practices, such as in calculating insurance premiums or in launching web-based micro-savings and peer-to-peer credit. According to Goldman Sachs, blockchain technology alone will deny the banking sector some \$US11 to \$US12 billion worth of fees and administrative charges on securities transactions, not to mention the likely end of fees for letters of credit or daily “market-to-book” or trades reconciliation. To offset these losses, major financial institutions may eliminate hundreds of thousands of jobs in record-keeping, regulatory compliance and other back-office functions.

The fintech niche is already experiencing strong growth, with venture capital investments of US\$14.4 billion in 2015 according to KPMG, and investments of US\$20.9 billion in 2016 according to Citi. Intech is going to change the market for insurance, and regtech (compliance and regulatory record-keeping) is going to disrupt the work of many specialists, not to mention entire occupations such as notaries. The financial services sector employs some 150,000 people in

¹⁷ For example, the increase in the number of workers in the banking sector coincided with an increase in the number of ATMs.

Quebec (4.3 % of all jobs in 2015), mainly in Montreal and Quebec City. If 25 % (37,500) of these jobs were automated, some of those concerned could be redeployed to other tasks, while the financial technology sector would create new jobs. Lower financial fees or better access to financial services could also trigger an increase in demand and require more finance workers.

The New Business Models

The second phenomenon results mainly from the previous theme: **the new business models**. Like Uber and Airbnb, new enterprises will start up and offer to simplify access, accelerate performance, and reduce the cost of many goods and services.¹⁸ Whether they are in the “sharing economy” or the “new economy,” we will see two forms of impact:

- the elimination of long-established enterprises through digitally-enabled disintermediation, driven by the advent of new local and foreign economic “disruptors”;
- the emergence of new commercial activities generated by automation.¹⁹

On-demand services, customized services, remote services and sourcing, the internet-of-things, instant delivery of goods and services, 3-D printing and additive manufacturing, and the sharing economy will continue to expand. There will be notable failures and burst bubbles by 2030, but the impact of the trend on business models will be real in many industries.

We should see this as the future of the “new consumption models” and pay particular attention to what Y generations and millennials will want, and what older consumers will demand -- as this group will represent the core of the new consumer demand in Canada. After taxis and tourist accommodation, other sectors will be affected by the disintermediation of supply or the destructuring of demand, the increase in and diversification of virtual offer, and an opening up of borders that transcend legislation, customs, and other sovereign authorities. We will also see these models stimulating small and medium-sized enterprises (SMEs) and entrepreneurship through digital platforms that enable specialized and even marginal offerings to find a critical mass of buyers. Millions of people are already earning a supplementary income on eBay or Amazon, and more “micro-entrepreneurs” will likely take advantage of the digital economy and lead fulfilling careers.

The side-effects of the new business models will obviously have an impact on public finance. For example, when more assets are intangible (e.g., copyright, patents, listing or referral fees), it will be easy for SMEs and individuals to copy the “Apple model” and delocalize their tax base, avoid paying local sales tax and evade fees or social charges, particularly if they are paid in crypto-currencies. Tax experts will have more creativity in this area than IBM’s Watson computer. Things such as online commerce, improved home-delivery of food or grocery, telework, and the freelance-based

¹⁸ Progress in automation must be placed in context: the *Great Recession*—and the period of stagnation, uncertainty, and low private investment levels that followed it—accelerated cuts and cost reductions. In that trend, any technology that is inexpensive and more efficient will become more popular than one that is more expensive and does not generate as much savings.

¹⁹ This could lead in some cases to the reinvention, not to mention the privatization, of some social services.

economy will signal the death knell of large retailers, causing office buildings and restaurants to shrink, relocate or close. This will affect municipal commercial taxes and, possibly, the real estate portfolios of banks and pension funds. On-demand shared cars that continuously shift from user-to-user will reduce the scarcity and price of downtown parking spaces, as well as taxes and parking ticket revenues.

As the following section explains, there will be concerns about the losers created by the new business models, and inequalities due to the winner-take-all markets. When a few mega-corporations (we could also call them *meta-enterprises*) such as Google, Facebook, Netflix, and Amazon take world markets by storm and bring down established incumbents, we witness an overwhelming, rapid and highly lucrative consolidation. Moreover, given that artificial intelligence bases its decision-making improvements on big data flows, the sources of which belong to an oligopoly of digital titans, the winners could be “masters of their universe” for some time to come.

“Outsiders” who become “monopolists without-borders” will amass huge fortunes -- big enough to defend themselves against the next “outsider”? The way these new giants have adapted lately suggests that they are already more than a few moves ahead of their competition in locking in their kingdoms. A few examples:

- Tesla with its electric batteries, solar panels, AI software, big data and telematics, or its boss (Elon Musk) who wants to make SpaceX an Internet services enterprise from outer space, that can also offer space tourism services and, one day, colonize Mars;
- Amazon and its cloud computing services, audiovisual production, delivery drones, and health food products and stores;
- Alphabet (which owns Google) with its plans for autonomous vehicles, extension of human life, health wearables (disease detectors), virtual and augmented reality, domotics (home automation), automated real-time voice translation, solar energy, and satellites and space-based information.

These mega-enterprises monopolize the best brains in their respective fields and have enormous technical capacity (computing power, big data, algorithms) with no possible short-term rivals. They can spend hundreds of millions of dollars having fun with a start-up, an R&D project, or a potential competitor that captures their fancy.²⁰

The role of governments in overseeing and supervising these new business models will be a source of much concern. Battles with unions, professional associations, licence owners, and bosses can be expected if we fail to balance the economic disruptions in a timely and successful manner. Managing accelerated innovation in the private sector, with all its potential risks and gains, will require a competent and proactive public service. Understanding the new objectives and tactics of enterprises, and anticipating their impacts, will demand dedicated and insightful teams of bureaucrats who can ignore populist pressures and the lobbying of established enterprises. Industrial policies and public investments will sometimes be at odds in incompatible roles as co-investors, facilitators of innovation and new models, and guardians of the incumbents.

Although we should not confuse the regulation of new business models with the illusory idea that governments can create them, the very elimination of outmoded or restrictive rules will help liberate new forms of growth potential. The

²⁰ For example; Google’s acquisition of the domotics enterprise Nest for \$US3.2 billion; Boston Dynamics military robots (resold to Softbank); Titan Aerospace solar drones; WhatsApp for \$US19 billion; Oculus Virtual Reality for \$US2 billion; LiveRail (videos) acquired for \$US500 million by Facebook; and LinkedIn, acquired by Microsoft for \$US26 billion.

business world ecosystem will continue to change with or without government intervention, and the Steve Jobs of the future will not give up ambitions in favour of government (to whom they may outsource their risks!). The “creative destruction” announced by American economist Joseph Schumpeter in the 1940s will continue as a few large enterprises die away and new predators are born, temporarily reducing economic activity. Will Quebec have more “unicorns” than “zombies”? It may be at that specific point that government intervention to ease the pains of economic adjustment will be most appropriate.

Technological Disruption: Government Action or Inaction?

Only 41 % of Canadians believe that technological progress will offer more positive than negative consequences. Overall, 51 % have difficulty in staying current with the speed of technological change.²¹ Change is becoming more rapid and more complex, and the cumulative consequences are difficult to assess not only in the case of artificial intelligence and robotization, but with biotechnologies, neurotechnologies, nanotechnologies, new materials, photonics, space technology, etc. It will therefore be necessary to amend laws or pass new ones and to develop new standards, norms, protocols, and taxes. This will require skills that governments sometimes struggle to find within their own public service to resolve the following dilemma: to intervene or to not intervene.

Imposing more rules and limits can take away digitalization’s benefits and opportunities while encouraging inefficiency. Preventing the adoption of new technologies would be a serious mistake, because they drive improvements in productivity, help manufacturing and service industries, and can ease labour shortages. They can even encourage the repatriation of some economic activities and reduce prices.

Yet if we deregulate everything, passively watch Big Tech, and let technology run rampant and generate risks, we could lose economic benefits and human potential and knowledge. This may expose the public to new dangers such as autonomous defence systems that wage wars with no regard for human costs; self-programed software in genomics and biosynthetics that can create living organisms and diseases; systemic discrimination by automated recruiters or advisers; runaway autonomous trucks, etc.

While avoiding the ambivalence mentioned above, we must promote experimentation rather than ready-made “reforms” or reforms that are obsolete as soon as they are announced. Government communication will have to be clear and sustained, and critics and “Cassandras” will have to show more restraint.

The Impacts for Quebec

In 2017, 33 % of Quebecers believed that technological progress would generate more and better jobs, while 38 % thought the opposite.²² Technological revolutions have always stimulated change at varying speeds (accelerating and decelerating “adopters” and technological shocks), generating societal stress and compelling a redistribution of

²¹ IPSOS-Canada, *CanadaNext survey*, (June 2017).

²² Ibid.

opportunities and wealth. Adjustments have been required in every case.²³ The scope and speed of the coming revolution are still being contested, but people often underestimate the consequences and fallout from techno-economic upheavals, for lack of an accurate foresight of coming inventions, actions of entrepreneurs, and the deployment of their innovations. However, we can speculate about some of the results.

Socio-Economic Effects

The first effect is obviously the continuation of an economy based on capital and technologies rather than employment, affecting sectors in which either more is done with fewer workers (and done better), or sectors that are inhibited by salary inflation.²⁴ These are already dividing into “specialized and well-paid” and “unskilled and poorly paid,” which explains two movements:

- an increase in the number of job categories with strong potential for automation, and thus for obsolescence;
- a growing gap between rich and poor.

The subject of debate will shift from living standards to employability, from the haves versus have-nots to those who can work as opposed to those who cannot (can vs can-nots).

Table 2A: Sectors Most at Risk of Automation in Quebec (2015)	% Risk of automation	Total number of jobs direct & indirect labour	Number of jobs potentially automated	Average annual salary (\$)
Sectors at greatest risk of automation in manufacturing				
Food and Beverage Products	65.5	56 830	37 210	42 491
Printing and Related Support Activities	58.9	14 480	8 525	42 366
Computer Electronic and Electrical Products	60.9	13 644	8 314	62 659
Manufacture of Alcohol and Tobacco Products	65.5	9 263	6 065	58 924
Source: Statistics Canada, C.D. Howe Institute. Calculations of salaries are based on the average hourly rate, multiplied by 40 hours, then multiplied by 52 weeks.				

²³ Three different “revolutions” must be distinguished: Technological revolutions in automation (e.g., telephone operators, bank tellers, and registration and parking employees have been replaced by machines); Technological revolutions in business models (e.g., accountants, travel agency, and video rental employees have fallen victim to TurboTax, Expedia and Netflix); Replacement revolutions (e.g., photoengravers, typesetters, and fax machine or dial telephone repairers).

²⁴ If it happened, wage inflation fueled by the scarcity of labour would require a debate, particularly when major construction, infrastructure or natural resources projects would depend on increasing the number of foreign workers visas.

Table 2B: Sectors Most at Risk of Automation in Quebec (2015)	% Risk of automation	Total number of jobs, direct & indirect labour	Number of jobs potentially automated	Average annual salary (\$)
Sectors at greatest risk of automation (non-manufacturing)				
Transport truck drivers	93.8	54 300	50 911	42 120
Janitors, caretakers and building superintendents	96.1	23 000	22 110	37 502
Welders and related machine operators	95.1	19 700	18 733	43 306
General farm workers	97.7	12 300	12 017	30 701
Accounting technicians and bookkeepers	96.2	11 300	10 871	43 306
Butchers, meat cutters and fishmongers - retail and wholesale	94.1	8 100	7 620	31 304
Metalworking and forging machine operators	93.4	5 300	4 949	39 603
Dry cleaning, laundry and related occupations	92.6	4 200	3 889	34 278
Paper converting machine operators	93.0	2 900	2 697	39 333
Other metal products machine operators	93.0	2 100	1 953	38 085
Other wood processing machine operators	91.9	2 000	1 838	43 389
Glaziers	92.3	1 700	1 569	53 040
Weavers, knitters and other fabric making occupations	94.8	ND	ND	ND
Chain saw and skidder operators	93.4	ND	ND	ND
Oil and gas well drilling and related workers and services operators	92.2	ND	ND	ND
Source: Statistics Canada, C.D. Howe Institute. Calculations of salaries are based on the average hourly rate, multiplied by 40 hours, then multiplied by 52 weeks.				

As noted above, “professional” (white collar) jobs like those in healthcare, education, law, and finance—which require higher education, receive higher salaries, and are also “routine cognitive” jobs—will also be targeted by automation. Discussion will no longer focus solely on smart machines and software that can replace “routine manual” (blue collar) jobs that require low to average education. Only non-routine occupations will be more immune to technological substitution;

those requiring non-standard analytical and abstract thinking abilities, improvisation, new problem-solving ability, creativity, complex communication skills, knowledge transfer and the supervision of other people (or machines), and an entrepreneurial spirit. In the healthcare field, for example, there may be fewer radiologists but more podiatry technicians. Smart machines and expert systems will “read” medical imaging and enable “super nurses” to perform diagnostics and modest interventions, which are currently only carried out by physicians and subject to a variety of constraints such as the number of specialists, time, space, material limitations, etc.

In five to ten years, the economic impact of new technologies will depend on:

- the number of jobs created compared with the number lost (and salary gains minus losses);²⁵
- the economic activity generated (larger or smaller GDP, which may be calculated differently due to the reassessment of technological input);
- changes in taxable salaries and activities.

In the past, technology created more jobs than it eliminated over the long term. To assess if this may change in the future, estimating the types of jobs threatened and the economic sectors targeted requires more focused and distinct attention. While progress and the impact of disruptive phenomena are difficult to simulate, three vectors should be applied:

- different rates of progress in machine/job substitution for different job categories (e.g., reduction in the number of hours or disappearance of jobs);
- different rates of progress in the machine/job augmentation for different job categories (e.g., increased productivity, quality, or job creation);
- variations in organizational adaptability (e.g., ability or inability to adopt and purchase new technologies, while simultaneously investing in people).

Time will tell, the adaptation period for organizations and their employees may be too short for some, and not quick enough for enterprises that are short of workers. A curious paradox could persist: proponents of new enterprises and technologies that impact the human/machine ratio could fail to find enough specialized labour and run into unforeseen contingencies.²⁶ However, if automated apps and devices take the place of highly skilled or specialized professionals (scarce or too expensive to perform routine or non-routine cognitive tasks), there could be a period of economic stagnation in Quebec due to a decline in the numbers of the best-paid workers. The latter could coincide with an increase in the number of underemployed, inactive, retired, or technologically unemployed workers.

²⁵ In a survey of future technology experts, TechCast developed a scenario called “job failure” in which unemployment rises to 10 % and becomes the norm by about 2021, with serious social effects. In part, it is the fear of failed workers’ adaptation to the new technologies mentioned above that stimulates this pessimism.

²⁶ See next page “Robots and Smart Software: Not So Bug-Free.”

Robots and Smart Software: Not So Bug-Free

The adoption of new technologies will depend on parallel phenomena: the availability of technology, its affordability, the willingness of people and enterprises to adopt it,²⁷ and techno-risks. Since new technologies deployment is central to any examination of labour's adaptability, it is important to consider potential restrainers and obstacles, including:

- lack of reliability and human safety issues in new applications, devices and robots;
- cybersecurity issues (e.g., theft, espionage, manipulation, attacks, data corruption, etc.);
- squabbles over standardization, homologation and interface compatibility for data transmission and communication between objects and users;
- patent disputes;
- absence or inadequacy of organizational resources to invest in, and benefit from, technology, or inability to acquire the human capital and leadership to do so;
- scarcity, pricing or supply issues in strategic equipment, materials and natural resources (e.g., electronic components, functioning satellites, rare earths and minerals, energy, water, etc.);
- poorly synchronized technological progress that delays the cross-commercialization and convergence of innovations in various scientific sectors (mismatch between AI, sensors, robotics, nanotechnology, energy, materials, biotechnology, space technology, high-capacity cloud computing, etc.);
- obsolescence in commercial and civil law, including liability, privacy and intellectual property, the legal response to cybercrime, monopolies and unfair competition;
- inapplicable tax rules that render an online application illegal, either partly or entirely.

These issues, whether they are isolated, simultaneous or interconnected, could slow the trend and transform our anxieties about automation.

The second effect has to do with the nature of employment status: employable or unemployable, salaried or freelance. While the data is lacking, sharing economy and new technologies enterprises seem to favour the recruitment of part-timers or freelancers, while expanding their own worker base at the same time. The fragmentation of tasks triggered by digital business models, based on on-demand and lower-cost solutions, and modular offering (and thus fast changing production), relies on the accessibility of a flexible workforce prepared to accept this type of "gigs" (e.g., on-request and not so well paid). For many workers, this *modus vivendi* is a convenient, even perfect professional lifestyle. As quasi-entrepreneurs, many of them become self-employed with adequate revenues, and can hire other people. Others who work at home, part-time²⁸ or on a nomadic journey find in it a better work/life balance and a critical supplementary income.

The gig or freelancers' economy however comes with its fair share of financial and legal insecurities, as well as time management and skills development uncertainties. Under the impact of digitalization, some job categories will favour

²⁷ In addition to people who have little inclination to stay abreast of the latest technologies ("non-adopters"), some consumers will prefer handmade products produced locally, in some cases giving them special cachet ("Made by human, not by a machine").

²⁸ In Quebec, some 76 % of part-time work in 2015 was "voluntary." Source: *Le marché du travail au Québec* [The Quebec labour market], 2016, Emploi Québec.

freelance or self-employed workers, but it is still too early to identify in which domains. Although more people may voluntarily or inadvertently become freelancers or self-employed,²⁹ they will have to organize themselves differently to enjoy the kind of security that salaried employment provides. Governments may have to offer adapted unemployment insurance and pension savings plans, new rules for overtime (and impose them on the operators of digital platforms), or new legal protections (e.g., against client-employers who do not keep their commitments or require their workers to work overtime without adjusting their rates of pay, for example).

Geographical Effects

A high-technology economy tends to gravitate towards urban centres endowed with advanced infrastructure such as high-speed fiber and Wi-Fi networks, big data centres, high-end labs and urban technologies, geospatial data download centres, and with repositories of advanced knowledge (universities, R&D firms, incubators and accelerators of innovative enterprises). There is a skilled workforce localisation bias that attracts more digital industries, and their deployment reinforces a geography's labour attraction. Once established, the expansion of these "smart" cities or regions threatens the future of smaller towns, forcing them to rejuvenate or die. Centralized service delivery assisted by technology, particularly with the growth of governments' "e-services", can also weaken regional or rural centres. To the benefit of smaller towns, digitalization stimulates delocalization, making distance and location less essential to the operation of an innovative, global enterprise. Mid-size cities that offer good quality of life and are more affordable in terms of salaries, rents or properties, municipal and other taxes, tuitions, etc., stand a chance to succeed.

Techno-revolutions will also increase the outsourcing and off-shoring of tasks, which means more foreign call centres and "telespecialists", more remote custom manufacturing and R&D, a better access to international semi-automated data processing services, and, potentially, more distributed or delocalized assets. When they will master the use of algorithms, millions of new knowledge workers in Asia and elsewhere (perhaps one day in French-speaking Africa) will be able to serve the Quebec market and help relieve the shortage of qualified local workers, albeit to the detriment of local salaries. Protectionism could harden in the cross-border services industry.³⁰ Moreover, international competition will be difficult to fend away when mega-enterprises such as Google and Amazon achieve near-monopoly market share in Canada for marginal expansion costs.³¹ Local economic activity could suffer from the continuous rise of foreign digital and virtual competition, much like the retail or travel agency industries have experienced. The issue of taxing or not the delivery of online services in Quebec by foreign-based entities that do not have operations within our borders has already emerged: Netflix is one current example.

²⁹ According to the Quebec research organization CIRANO, 13.6 % of workers in Quebec were self-employed in 2015, compared with 15.7 % in Ontario and 15.4 % in Canada. According to the Institut de la Statistique du Québec, there were 555,000 self-employed workers in Quebec in 2016, or only 2,800 more than in 2008. According to Statistics Canada, there were 2.7 million in Canada in 2016.

³⁰ This is already apparent in the forced repatriation of call centres required by some public authorities that won't tolerate being routed to a customer support center overseas. The same can apply to data processing centres.

³¹ A similar fictional example in the "old" economy would be Canadian deregulation in air, banking, and agricultural services, allowing U.S. companies to serve the Canadian market without ever investing here.

Political Effects

Workers who are vulnerable to technological change will gradually become more militant, depending on their education-level, age, the transferability of their know-how to related occupations, and willingness to change jobs or careers. After the anti-globalization fears of some unions and the anti-development obstructions of some ecologists, the political class will be confronted by the anti-robot populism movement. When such “at risk” workers are already unionized, we could expect their unions to protest more and demand government actions. Will they suggest taxing robots, or increasing the tax burden on digital enterprises, or will they vehemently oppose the adoption of automation technologies for fear of losing union membership?

We will also see lobbying by some professional associations³² (possibly surveyors, lawyers, accountants, physicians, notaries, pharmacists, physiotherapists, or translators) who will defend their professions by contesting the legality of, or preventing the recognition of, certain acts. “Anti-techno” but inherently protectionist, technocratic arguments will keep the self-regulated professions, the politicians, and the media busy for years.

If automation accentuates the precariat and anxiety of workers in the private sector, we will also observe renewed debates regarding civil servants’ well-protected employment conditions. That discussion will depend on the political willingness to let digitalization penetrate further into the operations of public agencies and municipalities, thereby reducing costs while maintaining or even enhancing service quality, and forcing the reassignment or layoff of government and city employees.³³ Thanks to new technologies, including big data analysis, governments and municipalities will also have new opportunities to demystify the demand for and the delivery of services, and results-based management. They will be able to better invest their resources, and partially or entirely subcontract tasks and processes to a new generation of suppliers: private or social enterprises, or self-employed workers, all highly innovative and digitized, and whose data and performance will be completely accessible in real time to public authorities and citizens.

Effects on Unions

Like private enterprises, unions will also have to adapt to demographic and technological challenges. The acceleration in retirements combined with growth in the number of young, non-unionized workers and robotized or automated jobs will continue to be reflected in union membership and revenues. There are some 1.27 million unionized workers in Quebec: a million in the service sector, 748,000 in the public service, 167,000 in manufacturing, and 107,000 in retail. In the future, membership erosion may compel some unions to merge. Others will have to consider redistributing their funds in the form of retraining grants for members who are replaced by machines. However, an increase in the number of self-employed and freelance workers could provide an opportunity to regroup such workers into new unions or, perhaps, a “workers mutual” (e.g., a cooperative that would provide solidarity, defend

³² The 46 professional associations in Quebec have a total of about 385,000 members.

³³ One hypothesis: Info-santé, the SOS poison call centre, Service Québec, and Tourisme and Revenu Québec could be partly automated much more easily, so that contract employees will be able to respond only to the calls that machines have prioritized or cannot handle fully. Another example: blockchain technology will make it possible to minimize the number of civil servants required to manage licences, certificates, transcripts, forms and other government or municipal documents.

their interests on a common front, and offer shared-services and savings and insurance products). New occupations will also offer new union opportunities. The mechanization of manufacturing in response to rising wages in the 1950s, 1960s, and 1970s did not put an end to unionization in that sector. It remains to be seen how unions will oppose the automation of work, and the abolition of jobs and occupations. After their struggles against subcontracting and globalization, the battle against the robots will fire up some union leaders, particularly those representing workers in the service sector.

Table 3. The Five Most Unionized Sectors in Quebec in 2016

Sector	% of unionized workers
Public services	82.5
Education	80.4
Public administration	78.1
Healthcare and social assistance	63.2
Construction	53.7

Sources: Statistics Canada; Institut du Québec.

Effects on Tomorrow’s Minimum Wage

The protection of self-employed workers mentioned before could also come in the form of new “occupational and salary agreements”, opening the debate on a minimum wage by occupation—perhaps even a minimum wage by region, based on the local cost of living—as opposed to a universal minimum wage.

This may seem less marginal in 2030 than it does today but, under certain conditions, the end of the universal minimum wage could be considered, particularly when the difference in cost between labour and “automatons” begins to favour the latter and stimulates technological unemployment. In theory, wage inflation will have changed: scarcity of labour and talent competition between employers will mean that fewer people will need the protection of a minimum wage. The availability of willing workers will also have changed: for technological or demographic reasons, people will have more time to devote to other socio-economic pursuits. The personal right to deviate from the minimum wage standard³⁴ could facilitate the participation of some people, including seniors, people with disabilities, or “low-pay volunteers”. This group could include people who, for example, wish to work for social enterprises and non-profits, people with disabilities who cannot all be subsidized, or people excluded by small employers who can no longer pay them. Different minimum wages for different categories of seasonal migrant workers in, say, construction or elderly care, will also be up for discussion.

³⁴ The minimum wage rules already allow a few exceptions: for students employed in not-for-profit organizations, interns employed in a job entry program, and workers paid on commission.

Over the next decade, absent a crisis in technological unemployment or a fall in salaries, the freedom and the right to accept pay lower than the minimum wage will be reserved for special cases and on strict conditions. An experiment could begin by authorizing people who can prove their financial independence, or are taking part in a workplace reintegration program, to choose to exclude themselves from the minimum wage rules. A way would have to be found to prevent abuse by employers, and to validate an increase in both workforce participation and in the satisfaction of people who have made that exclusion choice.

Fiscal Effects

As disruptive technology could exert a downward effect on pay and income, a taxation system based on personal income tax could plateau or even reduce public revenues, at a time when the aging of the population also shifts the tax base (i.e., less income tax, followed by less sales tax).

Governments will also be facing various fiscal issues. For example, a growth in companies with fewer employees would reduce salary-related taxes (e.g., lower employment insurance, health tax, contributions to parental leave insurance or to the Quebec Pension Plan and workplace health and safety plan). Companies that download a plan for a part or an object and manufacture it with a 3D printer will neither pay customs duty nor a local supplier, whereas the inventor of the 3D software could delocalize his/her intellectual property revenues in a tax haven.

Freelance workers could find ways of concealing income (tax evasion) and of doing tax avoidance through virtual and non-taxable barter with their clients or associates. Self-assessment, the basic principle of taxation in Quebec, could easily be forgotten in the context of new kinds of revenues and crypto-currencies. Providing social programs for the newly “technologically unemployed” while losing tax revenue from workers and enterprises of the new economy could severely test public finances. Will we have to shift taxation from earned salaries to technology revenues, capital or even total personal assets, or apply new taxes to specific economic sectors? Can we do this without impairing the technological revolution, and Quebec’s competitiveness?

On the other hand, government receipts and expenditure could benefit from:

- a rise in the number of digital transactions and payments if they are all declared or based on traceable blockchain technology;
- the end of cash transactions;
- forcing sharing economy companies to declare their “participants” income;
- lower prices generated by new technologies that increase consumers purchasing power and their taxable spending (a net increase in sales taxes);
- a reduction in workplace accidents, diseases and illness, and even school dropouts related to better use of big data and other digital technologies;
- the opportunity of using crowdsourcing to find solutions to government management problems and innovations in public service delivery;
- The possibility of using new technologies to reduce public expenditure and optimize government and municipal resources (e.g., through predictive analytics that makes it possible to better anticipate needs and problems), and perhaps even using AI to detect fraud of every kind.

SkillsFuture: an Individual Skills Development Account in Singapore

Launched in Singapore in 2016, SkillsFuture seeks to invest in human capital through education and training. The SkillsFuture credit gives every Singaporean over the age of 25 a \$500 credit to be used for a range of government-recognized training courses. The credit never expires and is periodically increased during a person's career. The purpose of the program is for each student and worker to choose his/her own learning path. People are free to choose the type of training they need to pursue their career goals, whether by transitioning to a new industry, or acquiring new technical or non-technical skills. SkillsFuture uses a framework to help students, employees, employers, and training providers make informed decisions. It provides information on workforce profiles, occupational pathways, salary trends, the competencies associated with particular jobs, etc. SkillsFuture also includes a list of training programs that are designed to address the skill shortcomings in each sector. Launched in 2016,^{35,36} Singapore is deploying it gradually, one sector at a time. To learn more, go to: www.skillsfuture.sg

Conclusion and Ten Possibilities for Action

While there are several uncertainties about how the themes and secondary effects explored above will evolve, there should be no uncertainty about the inevitable impact that technological change will have on the employability of Quebecers and the competitiveness of their organizations: **it will be significant and will be felt everywhere. No one will be immune to the consequences of “smart” technologies, and the service sector and any routine occupations will quickly become cause for concern.**

With the upheaval of automation and digital business models, we will see the partial or total elimination, reduction or reassignment of more than a million Quebec jobs by 2030. The new business models will disrupt the traditional methods of entrepreneurs and managers, and may reshape their destiny. The adjustments will be major for many people and organizations, but the hope of finding greater prosperity—through start-ups, for example—and solutions to an aging workforce is sensible.

Apart from our courage and adaptability, the best defence against the loss of employability caused by robotization or automation is improved human capital. This is achieved through advanced, pragmatic, and continuing education. Even if our educational system and vocational training programs may sometimes seem ill-adapted to the challenges of the future,³⁷ students, parents, and workers' willingness to improve and desire to invest in advanced skills and knowledge are not lacking in Quebec. The technological revolution in education offers huge potential for improving quality and access, and these opportunities should be seized within the academic system, and/or outside it.

³⁵ Workers over age 40 are also entitled to significant training grants.

³⁶ Source: Advisory Council on Economic Growth, *Building a Highly Skilled and Resilient Canadian Workforce Through the FutureSkills Lab*, February 6, 2017.

³⁷ According to McKinsey, while 83 % of Canadian educators believe they are training well-performing graduates, only 34 % of employers and 44 % of graduates believe that they are well-prepared for the labour market. According to the *CanadaNext* survey, only 29 % of Quebecers believe that the educational system is doing well in preparing students for the jobs of the future. Such an opinion may be backed by the below average ranking for Quebec in OECD's problem-solving ability in a technology-rich environment studies (PS-TRE).

The best defence against the loss of competitiveness caused by technological revolutions and new business models is being able to anticipate and exploit them. By avoiding the status quo, promoting experimentation, and taking calculated risks (quick trial and error), leaders and their employees can work to make Quebec an avant-garde economy that can produce world-class, resilient enterprises. Public-private partnerships could also help government agencies to accelerate their digital transition—here again, pilot projects will promote the sharing of skills and experience.

The effects mentioned above will be particularly acute for employees. Demands from workers at high risk of technological unemployment will be diverse and specific, requiring suitable and focused government responses. A broad policy with generalized or universal measures would be expensive, and sometimes unfair to those most affected.

(1) For workers at risk of technological unemployment, consideration could be given to increased contributions to the Canadian Employment Insurance plan to support extended benefit periods. In addition, **(2) an increase in the basic personal amount** (the tax-free bracket) **could enable such people and others to invest in a return to school, or in continuing education**³⁸—particularly for those aged 55 or over who wish to learn a new profession.

(3) It will also be necessary to collect more data on workplace training and HR investments. As things stand, total investment and expenses per worker, the types of training and the profile of trainees, the number of days and the actual impact of training are difficult to quantify through Quebec organizations, particularly where SMEs are concerned.³⁹ A better grasp of such data would make it possible to share, stimulate and guide the efforts expended on workers training.

It will remain essential to increase the level university enrollments for Quebecers aged 18 to 25. Low tuition fees will no longer suffice. It will be very difficult to increase the number of students in periods of labour scarcity and technological revolution without a renewal of higher education (“post-automation,” and better than the training modules available online) based primarily on (a) higher employability potential and salaries, and (b) the positive association to a university “ecosystem” that favors postgraduate professional development and lifelong learning.

Pending this renewal, college and university students need to be made aware of occupations at risk of being overtaken by technology. Without discouraging people from training and graduating, **(4) candidates should be informed about progress in automation and a possible downturn in recruitment, and perhaps some programs should be subject to enrollment quotas based on the likelihood of future non-employability.** In particular, **(5) young people should be steered towards winning transversal skills in response to technology-driven changes in occupations**, which means giving priority to university and vocational training courses that help build long-term personal autonomy. Paradoxically, two opposing trends will be promoted: specialist careers related to new technologies, new occupations, and new ways of working; and generalist, lateral competencies that are essentially technology-neutral (for tasks that will never be robotized). There will no doubt be philosophical debates on education in this respect, which will likely stir opposition among incumbents of the existing system, unless regular forums of employers and educators can overcome the isolation of those two universes. If agility is lacking, then external shocks—both demographic and technological—will impose internal changes to Quebec’s educational system.

³⁸ There is a federal Lifelong Learning Plan (LLP), under which up to \$20,000 can be withdrawn from an Registered Retirement Savings Plan to fund a return to school. There are a number of eligibility conditions, including a requirement for full-time study. See the Government of Canada website for details.

³⁹ See the decrease in investment in learning and training in: Colin Hall and Simon Cotsman, *Learning and Development Outlook, 13th Edition*, (Ottawa: The Conference Board of Canada, December 2015).

Thus, there will be no lasting solutions without the active and joint participation of the educational system and employers. **(6) Continuing adult education could involve the creation of individual permanent accounts⁴⁰ in which workers can compile and profile their academic and training gains throughout their careers**—previous and new, including online certifications. **(7) Workers could save or receive funding for tuition at any age in these individual permanent accounts;** accumulating savings or transfers from a TFSA (tax-free savings account), an unused RESP amount (educational savings plan), or public or private grants. With individuals and organizations obliged to set aside time for training, an essential yet very difficult element to find, **(8) creating time banks in these individual accounts or within organizations for employees to accumulate time units that they can later withdraw would help workers plan and schedule continuing education or training periods.** To make education and training more accessible and user-friendly and to encourage participation by workers who are short on time, **(9) colleges, universities and training providers could offer shorter and more frequent programs, including online,⁴¹ targeting the new skills demanded by the digital revolution and the learning capacity and behaviour of adult workers.** In addition, **(10) the Ministère de l'Éducation et de l'Enseignement supérieur and professional associations could formally recognize the new curricula and courses, or their equivalences, even when training units are earned outside the traditional academic system.**

We will resolve our demographic, technological and economic adjustments with more long-term thinking, actions, and incentives. Short-term thinking, reactive thinking, and sheep-like thinking will not lead to better solutions. The same is true of discussions concerning automation, robotization and new business models. To keep doing better than the robots, we would be well-advised to draw on our collective intelligence rather than “artificial” intelligence to find new ideas to anticipate and adapt to a long, yet unprecedented techno-economic revolution.

ERIC NOËL



Institut du Québec
3000, chemin de la Côte-Sainte-Catherine
Montréal (Québec) H3T 2A7
institutduquebec.ca
[@InstitutduQC](https://twitter.com/InstitutduQC)



HEC MONTRÉAL

⁴⁰ Personal accounts managed by government agencies and similar to “permanent individual accounts” already exist: the annual statement from the Quebec pension plan, from the Quebec drivers bureau, or a personal health record.

⁴¹ Using eCampus Ontario as an example, which represents 45 Ontario colleges and universities, consideration should be given to grouping a wide range of online courses within TÉLUQ, a public education agency that pioneered distance learning in 1972, rather than allowing each university to invest “its” content in “its” web platform. Quebec has seven publicly funded universities.

APPENDIX A

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