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Toward a systems framework for technology and the future of work

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Key Findings

- Discussions of the impact of technology on jobs tend to focus on labour substitution: the replacement of human work by intelligent systems and robots.
- Labour substitution analysis is necessary but insufficient. It underestimates changes that render jobs and tasks unnecessary and therefore redundant to labour substitution. Nor is labour substitution analysis very good at predicting future job growth or the skills needed for tomorrow's jobs.
- This paper proposes elements of a comprehensive systems framework for modelling the future of work. In addition to labour substitution, the model includes changes to products and services, business models, and industry ecosystems.

Research and foresight on the prospects for jobs in the context of the future of work (FoW) typically zones in on the role of digital technologies such as computers, software, telecommunications, and robots. And for good reason. Investments in physical capital — from the wheel, to the powered motor, to the shipping container — have progressively reduced the volume of labour required to get things done. But these physical technologies typically require humans to manage or operate them.

The current wave of digital technologies — machine learning and robots in particular — augur a historic shift from human to material capital for many cognitive work functions. Technology now increasingly takes the helm in jobs and tasks previously piloted or supported by humans. This difference has defining implications for the future of work. Non-digital process technologies intrinsically require human labour where AI-based process technologies require less or none of it.

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Labour substitution thinking: Necessary but insufficient

The rise of machine learning and robotics has led to widespread focus on the issues of digital labour substitution. Predictions on the amount of human labour susceptible to AI-driven automation include both cumulative task time and entire jobs. Global forecasts of how many jobs will be affected range from 25–50%.[2,3]

This *labour substitution FoW model*, which emphasizes productivity, is illuminating and important. But it produces two kinds of problems.

1. Substitution thinking ignores other factors that render jobs and tasks unnecessary. These activities become obsolete, so they are not candidates for automation. For example, digital photography shut down the film manufacturing industry, rendering nearly all the work performed in film-related warehousing, manufacturing, and processing redundant. This example suggests that labour substitution forecasts for sectors that are candidates for future obsolescence are intrinsically flawed.
2. By definition, the labour substitution approach addresses the negative impacts of technology on employment. As a modelling tool, it has limited ability to predict future job growth or the skills needed for these jobs. As this model only describes the productivity drivers of job displacement, answers about job creation must be found elsewhere. They typically depend on economic theories or unverifiable extrapolations of history such as these:
   - "Market clearing" will take up the cheap labour of displaced workers.
   - Lower cost of goods (due to productivity) will increase demand and therefore jobs.
   - Demand for functions that require uniquely human skills will offset job losses.
   - History will repeat itself: job creation exceeded job losses in previous industrial revolutions, so it will happen this time too.[4]

Valid or not, these approaches do not answer the core question: What, if any, will be the stable, decent jobs that employ hundreds of millions — indeed billions — of people around the world?

Dimensions of a systems framework: a 21st century toolkit for a 21st century challenge

The labour substitution lens is one-dimensional. It doesn't tell the whole story and often leads to wrong conclusions. It understates innovation-driven job losses and can't credibly project job gains. Instead, what if we were to look at these issues with a systems approach? A proposed systems framework combines labour substitution analysis with three other dimensions of the future of work: 1) products and services, 2) business models, and 3) ecosystems. These three dimensions are explored in the following sections.

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2 See, for example, the following: Carl Benedikt Frey and Michael A. Osborne, ***The Future of Employment: How Susceptible are Jobs to Computerisation?*** (University of Oxford, 2013); McKinsey Global Institute, **A Future that Works: Automation, Employment, and Productivity** (January 2017); L. Nedelkoska and G. Quintini, "**Automation, Skills Use and Training**," *OECD Social, Employment and Migration Working Papers*, No. 202 (OECD Publishing, 2018). These and others are summarized in Creig Lamb, Daniel Munro, and Viet Vu, ***Better, Faster Stronger: Maximizing the Benefits of Automation for Ontario's Firms and People*** (Brookfield Institute, 2018), 22.

3 Note that all predictions are subject to error. For example, the literature doesn't address unforeseen technologies and business methods that could accelerate task replacement. There is also uncertainty regarding employer and societal choices that affect the pace and breadth of technology-based labour substitution.

4 Labour Market Information Council, ***Annotated Bibliography: Future of Work*** (February 2019).

(1) Product and service innovation

Substitution models implicitly treat product and service offerings as established, unchanging, and almost incidental to production processes. This at a time when a host of factors drive dramatic changes in core products and services of many sectors and subsectors. In addition to machine learning and robotics, other emerging digital and information technologies — such as energy storage, blockchain and DNA sequencing — are facilitating disruptive product and service changes. The technology drivers are complemented by shifts in demand, skills and competencies, competition from market entrants and established players, regulations and trade regimes, government policies and programs, and other factors. Digitization typically enables, and often defines, product and service changes that ripple and spread across the world's economies.

Consider a now ubiquitous digital product — the camera. In 1837, Louis Daguerre launched the photography industry with the daguerreotype, a silver-based chemical technology for capturing and saving an image inside a camera. The industry's fundamentals remained unchanged for nearly 150 years. The leading beneficiary of what became silver halide film was the Eastman Kodak Company headquartered in Rochester, New York. Kodak's peak worldwide employment of 145,300 was in 1988, seven years after Sony unveiled the first camera to employ a digital image sensor. Over the next twenty years, Kodak shed over 125,000 jobs, filing for bankruptcy in 2012.[5] More broadly in the United States, four out of five jobs in leading film manufacturing and processing subsectors vanished between 1998 and 2014 (Table 1).

Table 1. Photography sector job losses

US Photography subsector	Employed 1998	Employed 2016	Job Losses	% decline
Photofinishing laboratories, except one-hour	57,140	5,809	51,331	90%
Photographic film, paper, plate & chemical manufacturing	36,942	10,242	26,700	72%
One-hour photofinishing	15,102	812	14,290	95%
Total	**109,184**	**18,863**	**92,321**	**83%**

Source: US Census Bureau, Statistics of U.S. Businesses: 2001 & 2016

5 RochesterFirst.com, "Timeline of Kodak History" (Nexstar Broadcasting, 2019). Kodak emerged from bankruptcy in 2013 after selling its photographic film, commercial scanners, and kiosk operations. Its main business segments today are Digital Printing & Enterprise and Graphics, Entertainment & Commercial Films.

These job losses were due to product — not process — digitization. Once product digitization had taken hold, productivity investments in film photography were money down the drain. On the other hand, digital photography generated some jobs, albeit fewer than those lost. Cheap digital image sensors, when embedded in smartphones, contributed to job growth in that product sector (including electronics, packaging, and software).

(2) Business model innovation

A second issue is that productivity-centric FoW models ignore the relevance of business models. The term "business model" has various definitions, both abstract and tangible.[6] A 2005 definition by Risto Rajala and Mika Westerlund refers to "the ways of creating value for customers, and to the ways a business turns market opportunities into profit through sets of actors, activities and collaboration."[7]

The business models of leading digital firms are very different from those of traditional firms. They mobilize digital information goods, the internet, low transaction costs, data assets, social media, analytics, advanced software systems, and highly qualified talent.[8] Digital goods are simultaneously "non-rival" (as they can be infinitely reproduced at near zero marginal cost) and "excludable" (rendered proprietary thanks to patent regimes).[9] Top companies like Google and Amazon harness so-called "platform" business models to control the context of business and social interactions on a large scale. Taken together, these capabilities enable dominant firms to capture markets quickly, enjoy near monopolies in various spheres of activity, diversify into non-adjacent sectors, and generate highly profitable rent-like revenue streams.

"DIGITAL BUSINESS MODELS MOBILIZE INFORMATION, LOW TRANSACTION COSTS, SOCIAL MEDIA, ANALYTICS, AND HIGHLY QUALIFIED TALENT."

For a Canadian example, consider the newspaper business. In 1986, Canada's 110 daily newspapers derived 80% of their revenue from selling 50–60% of their space to advertisers.[10] Twenty years later, Google and Facebook, quintessential exemplars of digital business models, radically shifted advertising away from print media. Based on tracking the online pursuits of individual consumers and targeting ads to them accordingly, the advertiser typically pays a higher fee if the consumer follows through on the ad.

6 Mutaz M. Al-Debi, Ramzi El-Haddadeh, and David Avison, "Defining the Business Model in the New World of Digital Business" (Proceedings of the 14th Americas Conference on Information Systems [AMCIS], Toronto, ON, 14–17 August 2008), 300.

7 Risto Rajala and Mika Westerlund, "Business Models: A New Perspective on Knowledge-Intensive Services in the Software Industry" (Helsinki School of Economics), 3.

8 David Ticoll, Alex Lowy, and Ravi Kalakota, "Joined at the Bit: The Emergence of the E-Business Community," in *Blueprint to the Digital Economy*, eds. Don Tapscott, Alex Lowy, and David Ticoll (New York: McGraw-Hill, 1998). This thinking was further developed in Don Tapscott, David Ticoll, and Alex Lowy, Digital Capital: Harnessing the *Power of Business Webs* (Boston, MA: Harvard Business School Press, 2000).

9 Hal R. Varian, "Markets for Information Goods" (University of California, Berkeley, 1998). Google hired Dr. Varian in 2002, where he became Chief Economist.

10 *The Canadian Encyclopedia*, "Newspapers in Canada."

The impact on print media jobs has been significant:

- Between 2000 and 2018, Canadian employment at newspaper, periodical, book and directory publishers declined by 58%, from 84,028 to 35,585.
- Jobs at pulp, paper and paperboard mills dropped from 76,711 to 40,163 from 2000 to 2017.
- Canada, the world's largest producer of newsprint, experienced a drop in annual production from 9.2 to 3 million tonnes during the same period.
- The drop in newsprint production (70%) greatly exceeded pulp, paper and paperboard job losses (47%), which suggests that automation was not a major factor.[11]

Jobs in other sectors disrupted by digital business models include music, retail, and travel. Next, potentially, are banking, insurance, real estate, supply chain and transportation, among others. In addition, firms across the economy harness features of digital business models to increase the volume and contingency of temporary and part-time employment.

(3) Ecosystems impacts

A third overlooked FoW dimension is the impact of product and/or business model changes on supply chains, value networks, and business ecosystems. Ecosystem impacts can range far afield from the item or business model that has been innovated. In this sense, they can be interpreted as second- or third-order effects.

Consider, for example, the standardized shipping container and multimodal transportation — supported by supply chain computer software — that proliferated during the 1970s. These productivity-oriented innovations facilitated the shift of manufacturing to China and other emerging economies.[12] Then followed low-cost retailers that mobilized supply chain efficiency. Walmart deployed these tools to achieve a significant share of US productivity growth during the 1990s.[13] Ecosystem impacts in Canada and the United States included job losses and declining incomes in manufacturing and less cost-competitive parts of the retail sector. For example, Eaton's, founded in 1869, was Canada's largest department store until it closed its doors in 1999.

Looking forward, some have suggested that the shift to on-demand mobility, especially that provided by autonomous electric vehicles, will have a severe impact on professional driving jobs — as well as jobs in insurance, vehicle sales and service, and other subsectors across the mobility ecosystem.[14]

When manufacturers replace the car's core technology — the internal combustion engine — with a battery, they remove hundreds of components that go into the engine, reducing demand for labour, whether by humans or machines. Volkswagen has said that a shift to electric vehicle production will mean a 30% decline in the labour component of its

11 Statistics Canada and Natural Resources Canada data

12 Marc Levinson, *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*, 2nd ed. (Princeton, NJ: Princeton University Press, 2016).

13 McKinsey Global Institute, ***How IT Enables Productivity Growth: The US Experience Across Three Sectors in the 1990s*** (San Francisco, CA: November 2002).

14 David Ticoll, ***Driving Changes: Automated Vehicles in Toronto*** (University of Toronto Transportation Research Institute, 2015).

vehicle manufacturing activities.[15] And across the automotive ecosystem, electrification will render obsolete the tool and die and mold makers who manufacture machines that make engine parts, as well as gasoline, oil, and oil change providers (among others).

Implications for further research

To summarize, in the context of technology and business innovation, these four dimensions frame risks and opportunities for labour markets and skills development:

1. Labour substitution
2. Products and services
3. Business models
4. Ecosystems

Current models of prediction suggest that globally, labour substitution will displace 25–50% of task time. However, the labour substitution foresight model is intrinsically flawed in light of the dimensions of disruption we have described. A broader approach is needed if we are to better understand and plan for the future of work.

The proposed systems model is not intended to be comprehensive. Indeed, it invites the addition of other dynamic dimensions such as demographic changes, policy interventions, and discrete market forces.

It is beyond the scope of this paper to quantify or qualify the specific implications of this preliminary systems framework for Canada or beyond. But here are some observations and ideas for further research, foresight, and policy development:

- Digital computing is not the sole basis of product and service innovation. Robots, for example, combine computing, electronics, and mechanical engineering. Today's advanced product innovations also draw on biotechnology, engineered materials, and non-computing electronics like solar panels, batteries, displays, and lighting.
- Each of the four dimensions can impact demand for jobs and skills in any combination.
- Job creation/job destruction feedback loops occur in various directions across the model. Depending on one's lens, an element of the model may be foreground or background. For example, in the interaction of shipping containers and retail, one or the other could be primary.
- Ecosystem models should reflect changing roles of customers, complementors, infrastructure providers, platform players, regulators, and other non-traditional actors. These models should also pay attention to digital market dynamics such as network effects; data accumulation, analytics, and machine learning; information asymmetries; potential rapid innovation and scaling; and winner-take-most.
- Macroeconomic methods will not be sufficient to research the past or develop foresight for the future in the context of this framework. Sector and firm-focused case studies and scenarios are required. This may necessitate methodological innovation.

15 William Boston, "Volkswagen Supercharges Electric Car Push as Profits Weaken," *Wall Street Journal*, March 12, 2019.

- Scenarios for and implications of the market forces listed (as well as others not mentioned) are needed as a basis for developing models of possible and desired futures. These forces include technology innovations, shifts in demand, available skills and competencies, competition from market entrants and established players, changing regulations and trade regimes, other market shocks, and government policies and programs.
- Systems modelling derived from this framework would benefit from today's computer processing power and AI/machine learning toolkits.

To be clear, this paper proposes a foresight toolkit, not the solution to a future of good, stable, well-paying jobs. Scenario-based systems modelling (e.g., for 2030–2035) should address best case, worst case, and desirable futures. They should encompass the specifics of Canada's (or any other country's) advantages, downsides, and unique place in the world and identify the proactive steps that governments, employers, educators, and citizens can take to achieve the country that we want.