



Part of the **CREATING DIGITAL OPPORTUNITY FOR CANADA** Partnership Project

THE TRANSFORMATIVE IMPACT OF DIGITAL TECHNOLOGY ON TRADITIONAL INDUSTRIES

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Creating Digital Opportunity is a national research partnership funded by the Social Sciences and Humanities Research Council and based at the Innovation Policy Lab in the Munk School of Global Affairs. The mission of the project is to identify strengths in current and emerging digital sectors, by examining the place of Canadian corporations, products and services in the global economy. The project is also investigating the extent to which digital technologies are being adopted and diffused across a wide range of other sectors— from advanced manufacturing to natural resources and business services – which are crucial for the future competitiveness of the Canadian economy. The project addresses the question whether we are taking full advantage of the opportunities on offer.

The Innovation Policy Lab (IPL) at the Munk School of Global Affairs is committed to applying novel methods and disciplines to the study and teaching of innovation and its impact on economic opportunity and society. The IPL focuses on core questions in a number of areas including innovation and growth, innovation and inequality, globalization and innovation, social innovation, new technologies and their impact on society, innovation in traditional industries, and arts and innovation. Since our aim is also to effect change, we pay particular attention to the role of public policy in nurturing innovation, while at the same time enhancing its positive impacts on society and limiting its negative consequences.

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OVERVIEW

UNDERSTANDING THE FULL IMPLICATIONS of digital technologies for Canada's economic prospects requires an analysis of the resource, manufacturing and service industries that are being transformed through the application of information technologies and digital media. The key research questions for this theme were:

1. How effectively are a wider range of manufacturing and service sectors in Canada adopting and deploying new digital technologies and media applications?
2. What policy initiatives are needed to ensure that Canadian industry remains at the forefront of digital adoption and diffusion?

The key finding of this work was that there is more than one pathway whereby digital innovations are causing value to migrate. Understanding environments that encourage innovation are just as important as understanding the flows of value migration themselves.

In some sectors, digital technologies are not only being adopted and deployed within the sector but are transforming the nature of the sector by challenging the traditional boundaries of firms and the production network. Technology allows activities that previously were inside the firm to be performed externally and, in other cases, enables previously external processes to be performed internally. The impact of digital technologies in traditional manufacturing, for example, has changed the production model from macro-structural to micro-structural manufacturing and extended supply chains in ways that challenge the established models of value creation and the boundaries of the traditional firms in this sector.

Digitization of existing assets is a common theme across all the industries we examined. What in the past was tacit knowledge either embodied in machinery, processes or human capital is now becoming codified in data generated by sensors and organized by algorithms. Previously, the factor of production most linked to the tacit knowledge—be it land, labour or capital—generated the lion's share of any value attributable to that knowledge. Now that this knowledge is codified and differentiated from the other factors of production, whoever owns or controls access to that knowledge has the opportunity to carve out value from the global value chain.

In this context, who owns and controls the data and algorithms matters a lot. In most of the sectors we examined, control of the majority of the ICT technologies and algorithms lie with international firms, some of whom have cultures that are open to local partnerships and technology transfer but others that are far less so. We identified and studied many Canadian SMEs contributing to the digitization of the economy and society and learned that specific local conditions with procurement and financial assistance are often key factors in their success. But almost everywhere we found that scaling up within global supply chains is limited.

Capital-intensive resource and manufacturing sectors

The “primary” and traditional heavy industries in the “secondary” sector are at the vanguard of testing and adapting to digital opportunities, and of particular importance to Canada as they underpin a disproportionately large portion of our economy and labour market. Furthermore, these sectors are highly distributed across Canada, often offering the only real market-based opportunity for employment and income (particularly when flow-on effects are considered). In contrast to many other sectors, this part of the economy is highly capital intensive and mostly export oriented. Made-in-Canada solutions, while important, may be harder to control or exploit.

There is substantial effort globally to adapt and adopt digital technologies to agriculture, which encompasses a diverse set of production systems, has large and complicated supply chains and is globally competitive. Some of the technological applications are purpose-built by and for actors in these sectors but many of the applications are being repurposed from other uses, often sourced from other countries (e.g. geomatics, GPS-coordinated mobility, sensors and distributed loggers). The level of venture capital investment, especially in agriculture, has accelerated; Canada ranks about third in the world in terms of activity. The Canadian agri-food sector is differentially adapting and adopting these technologies. In western Canada, most commercial farmers now use at least one and most use many digital applications. Almost all farmers surveyed recently used GPS guidance systems for their operations (98 per cent), more than 85 per cent of the combine harvesters used some form of real-time monitoring and 70 per cent of chemical, 37 per cent of fertilizer and 26 per cent of seed applications used automatic section control (with variable rate applications in response to land and soil conditions). About two-thirds of farmers report using temperature and moisture sensors to monitor grain stores and 40 per cent use remote imagery in-season to monitor crops. The challenge is that except for a few entrepreneurial plug-ins and apps, most of the big investments are directed by foreign enterprises and directed to exploiting global markets.

In extractive industries, such as mining, oil and gas, the technical and scientific challenges of digging deeper, extracting lower grade minerals and drilling in more remote or challenging areas are driving the technology. This is compounded by the complexity of the underlying economics of extractive industries, which face protracted commodity price cycles, interspersed with occasional and surprising price shocks. While there is widespread belief that digitalization—including advanced robotics, big data and analytics, artificial intelligence, mobile computing, wearable technology, internet of things (IoT), and autonomous and near-autonomous vehicles—will transform extractive industries, the timelines and consequences for such a transformation are less clear. For both mining and oil and gas companies, the future could include heavily digitalized assets (i.e., oil rigs, mining equipment) capable of high levels of autonomy and inter-asset cooperation, operating within challenging natural environments (e.g., a deep or remote mine or far offshore oil field) monitored using advanced embedded and remote intelligent sensor technology. New digital enterprises are predicted to be deployed to improve supply chain management and resource management, to balance supply and demand for product, to manage contracting among project partners, and to help secure and maintain public confidence.

Because employment in extractive activities is no longer concurrent with residential location of the employees (fly-in fly-out), the ripple effects of employment changes will be difficult to predict. One thing that appears likely is that there will be a rise of city-based remote-control digital coordination centres. We already have seen this in Australia, where autonomous and semi-autonomous machinery in mines in the outback are monitored and managed from large urban centres (e.g. Perth and Adelaide)

We also investigated the application of a range of digital processes in advanced manufacturing – best defined as the combination of advanced materials and software, especially the application of 3D printing to automotive manufacturing—and discovered a nuanced story of change. One aspect of our research focused on 3D printing at the entry and intermediate levels, where we saw a range of different practices that could be categorized as adoption, informal learning and learning-by-doing. 3D printing skills are highly transferable between sectors, tending to enable entrepreneurs to pursue opportunities across numerous sectors and markets. 3D printing works well in industries that demand high product customization but less well for large-scale production. Because 3D printing (or additive manufacturing) has significant limits related to the materials involved, the most common applications in manufacturing are related to prototyping and product development. This means the nature of the emerging firms are often in the form of service bureaus rather than stand-alone manufacturers, and they tend to have a much more porous boundary between their service and the pre-existing client companies.

While 3D printing is widely endorsed for diffusion across many industries, Canada has made its innovation policy bet in a specific way. We have sought to promote advanced manufacturing in small enterprises by using community colleges as partners for private firms and anchors for regional industrial commons. By providing both information and working capital to private sector partners, programs are designed to mitigate the so-called “valley of death” in local ecosystems. While there are many successful individual cases of partnership, doubts remain about the ability of the decentralized local community colleges to provide aid that is both sufficient and appropriate to support optimal uptake and scale-up of advanced manufacturing in Canada.

The automotive industry, in particular, is being disrupted by digitalization through the de-coupling of value creation from traditional sites of production. Whereas in the past value came from fabrication and processing, now more value comes from design, engineering, embedded software, research and innovation. The automotive industry can no longer rely exclusively on investments in plant, machinery and business processes. This has broader policy implications arising from the general shift from tangible to intangible assets. The growth of these new digitally rich supply chains has stretched out into a networked industrial and innovation framework. It is not unusual for up to 80 per cent of a final product to be produced somewhere in the supply chain but not in any single enterprise. These networks are mostly comprised of SME firms which do most of the actual manufacturing, value creation and innovation. Therefore, the technical and cognitive capacities of these SME firms is a critical factor for policy.

The advanced manufacturing approach appears to be emerging as a dominant model across a range of industrial organizations involved in production and innovation. At the frontier of production in all goods-producing sectors of the economy, both in the primary and secondary industries and related services, we observe a new model of production that is inherently collaborative, integrating both contract production with innovation. New forms of contracts and engagement are being used to facilitate joint innovation among rapidly changing groups of partners.

A key question in manufacturing and other goods-producing sectors is whether value is migrating away from traditional manufacturers toward digital-economy firms? And if so, what are the implications? The digital architecture is the foundation of the value proposition. One challenge is that data owners and controllers could appropriate the lion’s share of the value being created by OEMs and the related supply chain partners, by exploiting control of the digital architecture and production and market data. If the cyber sector was simply ‘down the road’ from the traditional manufacturing plants, the regional impacts could be modest. But much of cyber technology space, especially the automotive software business, is traditionally foreign owned and

delivered. A few foreign firms are acquiring Canadian start-ups in this space but leaving operations in Canada and expanding R&D efforts here but, for most, more value added is distributed in locations far from the site of physical production. To some extent this is both an opportunity and a threat. It is still an open question whether this value migration will be significant, whether there is a tipping point at which agglomeration economics will consolidate the mobile value in one or a few centres far from the plant floor, and what capacities, if any, regions or cities can use to attract these kinds of higher order operations.

Lower-capital intensive sectors

CANADA HAS A WIDE ARRAY of regionally-important light manufacturing and service sectors, which both serve local markets and selectively export. Compared with the massively capital-intensive resource and heavy manufacturing sectors, many of these industries, on paper at least, have shorter capital cycles and therefore may have more capacity to respond to new production and market opportunities.

The textile and apparel industry is one example. Technology is impacting the design process, the role of the designer and changes in the production system—in particular, new automated production requires complete frontloading of design decision-making. One view is that these new technologies could drive a shift toward mass-customization of apparel through online selection and input of production variables. We investigated cases where companies are using online data collection and digital fabrication in China to produce customized garments with two to three week turnaround times. However, limited access to higher-end 3D printing and 3D knitting equipment is currently impeding adoption, use and diffusion of this production model. One outstanding question is whether high production costs for prototyping will become more scalable—if they don't they may be more feasible for the manufacture of products with long life-cycles rather than for the production of non-durable and semi-durable consumer products which offer less opportunity for amortizing these high fixed costs.

The knowledge-intensive business services (KIBS) sector is responding differently to digital technologies than many of the more traditional industrial sectors. Innovation in KIBS are not directly driven by ICTs and digital apps. KIBS enterprises frequently purchase or acquire technologies that are most useful in optimizing existing business processes, rather than creating new forms of technological or non-technical innovation. Innovation in KIBS is less dependent on technology and more driven by external sourcing and external partnering strategies. Marketing innovation entails sourcing significantly more external knowledge than any other type of innovation. It remains unclear how KIBS will use these new and different technologies to drive their internal processes, as other determinants have proven to have more impact. KIBS providers have been emerging as innovators themselves as they develop and introduce new technologically driven services. Indeed, a large majority of firms that were surveyed reported having introduced both non-technological and technological innovations in the recent past. Our sense is that KIBS will contribute to the digital shift of the overall Canadian economy not because of what they do in and for their own sector, but rather as they develop and distribute advanced solutions to their clients in an array of other sectors. The results of this research suggest a large and important role for specialized services in the development of Canadian industrial strategy.

There are opportunities for governments to assist here. The primary step in encouraging the development of KIBS is to raise awareness of their role and contribution at the sectoral and firm levels. This is especially relevant for smaller firms that seek to improve their processes but lack the internal skills and expertise to do so. A clearer understanding of the long-term benefits of acquiring external specialized services could lead to net efficiency and profitability gains. However, firms often lack the financial resources to acquire these services. Two forms of policy

intervention might assist. First, a supply-driven approach focuses on supporting the provider through funding, tax incentives, or consultancy. Increasing the supply of specialized services would benefit consumers by lowering their prices. Secondly, a demand-driven approach could involve providing financial support to firms acquiring knowledge-intensive services for various applications, including commercialization, expansion and profitability. Indeed, these types of policy interventions could further the development of the digital economy in Canada by encouraging the creation and diffusion of specialized knowledge within and across ecosystems, representing commercial opportunities for KIBS themselves as well as for a wide range of other economic sectors.

One important finding from our work is that although the architecture of KIBS' innovation activities varies across regions, the propensity to introduce new services to the market is similar in both metropolitan and peripheral regions. KIBS are key structural elements for the development of strong ecosystems both in and outside metropolitan areas. Many of the policies directed at regional economic development tend to target urban growth, especially where KIBS are involved. This is a real opportunity for policy makers to work on solutions relevant to the development of peripheral regions.

Banking and finance are large, internationally competitive sectors in Canada that are profoundly influenced by new digital approaches. The speed and scope of change in the financial services sector in the past decade is unprecedented. Since the start of our research on the possibilities of fintech, the sector has grown rapidly both in Canada and around the world. Our research has shown that we need to better understand many issues in this sector, including the future of cash, digitized payment methods, digital currencies, data privacy, and the best ways to support Canadian innovation in this rapidly growing economic sector.

During the period of the project digital finance has become less extraordinary, more commonplace, and better understood. Regulation and governance of fintech development and viability are key issues today for policy in Canada, but also for the world at large. It is important to bear in mind that Canada's policy framework for fintech innovation and for development of the fintech sector takes place in the G20 context. The key question that has emerged is how to regulate fintech applications in ways that encourage innovation to enhance the international competitiveness of Canada's financial industry. Critically important questions have emerged with regard to how we ensure consumer data is not jeopardized and that our central bank is comfortable with how the technologies integrate into our financial industries. We face the ongoing challenge of keeping fintech firms in Canada rather than moving to the US in search of more and larger investment opportunities.

Digital innovation in the fintech landscape has made great advances in a relatively short time but we still have a long way to go to remain competitive with our G20 peers. Our research revealed that innovation happens at a slower pace in Canada because multi-layered regulation hinders fintech innovation. Canadian innovation in the financial services industry appears to be lagging due to a 'wait and see' regulatory approach by the big banks, according to industry players. However, history suggests a strong regulatory environment for finance and banking is a national economic strength and not a weakness.

In June 2018 the Canadian government started working on regulation of "virtual currencies." The initial draft regulation, scheduled to be released in late 2019, is expected to require blockchain and crypto exchange companies to keep detailed records of users and information, require them to inform the authorities of any suspicious activity as well as to provide written policies and procedures and to undergo regular risk assessments and audits. Everything involved with fintech development requires a high degree of technical expertise,

making access to and the capacity to produce our own specialized talent pool in Canada important issues for consideration. The fintech sector remains a work-in-progress in Canada, and around the world. National jurisdictions seek to protect consumers without stifling innovation. Regulatory sandboxes seem to manage to do just that and we suggest that it would be prudent for open banking to go through a similar process once the Ministry of Finance releases the results of its open banking consultation process.

Finally, the communications media sector, the third or fourth largest spender on IT systems after financial services, manufacturing, and natural resources, is full of lessons about what to expect as other industries become digitized, disintermediated, automated, and platformed. The digital shift affecting Canadian creative industries is creating a challenging entanglement of opportunities and threats in a volatile, uncertain, complex and ambiguous environment. The key question is how Canada can successfully navigate the digital shift in the creative/cultural industries. We need to focus on adoption and diffusion of digital techniques and practices, especially market-facing capabilities among creative/cultural firms. In Canada, the domestic broadcasting system's suitability as the main vehicle for cultural policy is declining. Content distribution, not production, is the economic and political high ground. Competition is mainly among transnational "platform ecosystems", while the (relatively small) domestic media and telecommunications firms are marginalized through loss of advertising revenue. Transnational digital platforms have emerged and have grown very quickly. They frequently offer value propositions that domestic incumbents cannot match, gaining the loyalty of consumers. They represent an opportunity to some domestic cultural producers but a threat to territorial and cultural sovereignty. Effective micro-targeting and identification of highly specialized market niches require access to vast amounts of market and consumer information (which is not always accessible to smaller producers) as well as advanced analytics capabilities. These are sometimes provided by platform complementors (for example, YouTube) and sometimes withheld (for example, Netflix) as different platforms exploit their strategic resources.

Transnational platform firms profit from regulatory fragmentation and net neutrality. Canada's 'partnership' approach with Netflix is made less credible by highly visible policy asymmetry. There is urgent need to bring domestic tech strengths to bear on the domestic cultural sector and find ways to grow domestic platform firms. Among SMEs in the cultural industries, adoption involves exploiting 'repertoires' or consistent bundles of channels, preferences in content, and communication practices of target markets. Key dimensions that affect the speed and scope of change include: competitive pressures; business growth aspirations; willingness and ability to experiment; expectations of customers/clients; and ingrained habit.

Much of the work in the cultural/creative sector is contingent and 'gig-like'. In Ontario, more than 50 per cent of the jobs in the cultural/creative sector are structured as short-term contracts. Contingent work is not just about income insecurity and economic precariousness. Many social insurance benefits (e.g. health, employment, collective bargaining, retirement, occupational safety, caregiving, non-discrimination) are tied to the standard employment relationship. New forms of work which define the worker as a self-employed independent contractor do not provide these benefits. Many in the industry call for review and updating of the employment security protections to mitigate the insecurity occasioned by the increasing numbers of workers who do not have access to stable employment. There is an emerging typology of risks to which contingent workers are exposed that includes: misclassification, underemployment, income fluctuation, knowledge obsolescence, IP loss, risk of illness/accident/injury, reputation, and discrimination related to age, gender, ethnicity, and social class. Given the importance of this across the entire national economy, this issue needs much further research on its own.

Policy challenges

SEVERAL POLICY QUESTIONS EMERGE from our work. Who owns, controls and exploits the data that is generated in Canada will determine who gains from this wave of transformative innovations. Data will be the raw resource that drives investment, jobs, income and growth. But unlike earlier staples that provided the impetus for economic development, data is not fixed in Canada. Our diverse research studies suggest the fundamental issue surrounding the adoption and diffusion of digital technology will have to do with data. Who owns it? Where is it stored? How is it valued? Who can or should have access to it? Data ownership has become a monumental issue that governance experts around the world are only just beginning to tackle. *Progress on all the digital transformations is likely to be held back until some general precepts regarding data ownership, control, usage and access are established.*

In addition to data related issues, policy will need to tackle the the growing market power of platform-based firms over critical sectors of the economy, such as the creative and cultural industries. Canadian researchers, as far back as the 1980s, have identified the competitive challenges that high technology firms in a small, open, trading economy such as Canada's face in industries with a strong tendency towards oligopolistic concentration. The consolidation of market power in the platform economy over the past decade provides overwhelming confirmation of the challenge. Public policy in Canada to date has lagged behind the pace of digital innovation. Governments at all levels need to craft effective policies around standards, IP and regulation to help Canadian firms compete in the intangible global economy that is being driven by digital technologies.

The diffusion of digital technologies through every sector of the economy remains a critical policy objective. The federal government should build on the best elements of current and previous programs delivered by agencies such as NRC/IRAP and Business Development Canada to promote the increased application of software and digital technology across all sectors of the economy and all facets of the innovation spectrum, from product and process innovation to the development of new organizational, sales and marketing innovations. A critical focus should be on digital customer acquisition — the ability to gain new customers through purely digital processes as opposed to through traditional sales channels — which is key to rapid growth in the digital era. Such policy challenges can only be tackled through the adoption of a whole-of-government approach that puts the promotion of Canada's digital opportunity at the centre of national and regional policy agendas.

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