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UNIVERSITY OF TORONTO

A POLICY AGENDA FOR THE DIGITAL ECONOMY

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The Challenge

For the past four decades, the relentless wave of innovation in information and communications technologies (ICTs) has driven a sweeping set of changes across the globalizing knowledge-based economy. The embedding of microprocessors and sensors in a growing range of products has become a ubiquitous feature of the global economy, controlling the rhythm at which it operates. At each stage of this ongoing revolution, commentators have predicted that it has reached the limits of what is technologically feasible. However, the current wave of innovation embodied in mobile devices, cloud computing and the Internet of Things is once again putting the lie to this prediction. The all pervasiveness of this technology is leading informed commentators like Brian Arthur to label this 'the second economy' which comprises a revolution as sweeping in its scope as the first industrial revolution from 1760 to 1850, which created a muscular system that drew upon machine power as the motive force driving the economy. He suggests that the current revolution is developing a neural system based on digital technologies that communicate and interact with each other. It is this neural system based on digital technology that underpins the second economy and is driving the most fundamental technological change. Virtually no sector of the economy is immune to its disruptive effects and the full impact of its contribution to future growth is still not readily apparent. This emerging digital economy is the focus of our current research project on *Creating Digital Opportunity*. The development of digital technology has now reached the stage where it has become a foundational technology that is as all pervasive and essential to our daily lives as electricity. The information and communications technology sector lies at the heart of the emerging digital economy, but its significance extends far beyond this single sector. Because no other industry or technology sector is more central to the development of a globally competitive economy, few countries can afford to ignore this trend and many are positioning their ICT industries as the drivers of future growth.

> This second economy that is silently forming – vast, interconnected, and extraordinarily productive – is creating for us a new economic world. How we will fare in this world, how we will adapt to it, how we will profit from it and share its benefits, is very much up to us (Arthur 2011).

While the current era of information technology began in the 1970s with the invention and rapid diffusion of the microprocessor, the development of optical fiber, and the simultaneous digitization of telecommunications with the introduction of the first digital switches, the full effects of the digital economy was not felt until the mid-1990s when the introduction and rapid adoption of the Internet and the set of widely used standards that comprise the World Wide Web began to transform what had previously been discrete

individual computers and corporate networks into a network of globally interconnected digital networks, or what we colloquially refer to as 'cyberspace'. The integration of microprocessors, increasingly embedded in mobile rather than fixed devices, digital telecommunications and the Internet is creating a new architecture for the delivery of products and services based on cloud computing. Cloud computing refers to the ability to easily use remotely located shared computing resources in a flexible and scalable manner. The progressive dispersion of cloud computing is creating a new economic reality that lies at the heart of the digital economy – an increasing abundance of computing resources that is fundamentally altering the economic calculus of production, distribution and sales in virtually every sector of the economy – from agriculture and mining to automotive manufacturing and entertainment. Several critical consequences follow from this transition from scarcity to abundance in computing resources. Cloud computing is delivering computation-intensive resources to a wider range of firms at ever lower cost. It is turning traditional high-value added economic activities into commodified activities, making it possible to disaggregate and disintermediate both production activities and service activities that have been embedded in the structure of large corporate organizations. This disintermediation extends from the production of physical products, such as electronics and automobiles to the delivery of services from hotel accommodation to screen-based entertainment content. As cloud computing becomes more widely accessible at ever lower costs, value is moving up the architecture, away from infrastructure providers towards those delivering software as a service (Kushida, et al. 2014).

The result is the emergence of what Kenney and Zysman refer to as the platform economy. They define platforms as "frameworks that permit collaborators . . . to undertake a range of activities often creating de facto standards, forming entire ecosystems for value creation and capture." A diverse range of platforms provide the infrastructure and tools upon which other firms across a wide range of manufacturing and service sectors can deliver their products and services. The emergence of platforms represents a new business model that is making digital services more widely accessible and leading to a profound reconfiguration of markets, forms of work organization and the very basis of value creation in the second economy. They are profoundly unsettling of existing patterns of economic activity in the manner depicted by Schumpeter, as many prevailing models of business organization, production and service delivery are affected by their disruptive potential (Kenney and Zysman 2015). No sector of the economy and indeed, no national economy, can be protected from the effects of this transformation.

An important corollary of the forces that are driving the cost of hardware toward zero and making immense levels of computing power more widely accessible is that the software

component of the information technology sector is increasing dramatically in significance. This point has been underlined in Mark Andreessen's widely cited WSJ article entitled "software is eating the world", but it has also been stressed by a number of others, including MIT's Willy Shih. Shih argues that the current technological revolution involves a fundamental shift in the functionality of information technology from the hardware side to software. A key consequence of this shift is that functionality that previously had to be built into the hardware of a product can now be programmed through its software and modified or updated much more easily. One consequence of this shift is that it is lowering the entry barriers to many industries, making it easier for companies to introduce innovative new products that can disintermediate and disrupt existing industries, from automobiles and taxis to hotels and financial services. Increasingly, the competitive advantage of products will be embedded in their software, as well as in the management of the brands that employ the latest software tools. "The software revolution will be a powerful complement to the cheap-computing revolution, and the opportunities for unique and innovative products are boundless -- it's just a matter of programming" (Shih 2015). Even Intel has recently announced that its venture financing arm is significantly increasing investments in software companies (NYT).

Previous generations of federal innovation policy, from the failed experiment with Microsystems International in the 1960s to the more successful example of the Microelectronics and Systems Development Program of the 1980s (among other initiatives of that period) contributed directly and indirectly to stimulating the growth of some of Canada's most successful information technology firms that, in turn, fueled the boom in Canada's high technology sector in the 1990s and early 2000s. Canadian success was strongly concentrated on the hardware side of the telecom and mobile sector in the last phase of the boom (with some notable exceptions like Cognos, CGI and Open Text) and it is this part of the sector that has been impacted most severely by the increasing commoditization of hardware. Canada has become less competitive in hardware than it was in the 1980's and 1990's. The demise of Nortel, the absorption of Newbridge into Alcatel, the decline of RIM/Blackberry and the effective integration of JDS into the California base of Uniphase all symbolize this decline. On a more positive note, Mitel, one of Canada's long standing telecom firms has successfully made the transition from a hardware company specializing in PBX business systems on premise to a software company based on virtualized software systems operating in a cloud environment. In a similar vein, Blackberry is shifting its business focus from the production of hardware to the enterprise security side of its product offerings.

Policy Directions for Canada

As the CDO research proposal set out, the critical research and policy challenge is to determine what parts of the production process can competitively be retained in Canada and what are the added value activities that can most profitably be carried out domestically. Designing policy with this increasing global division of activity in mind is critical to framing a successful digital strategy for Canada. Policy needs to focus on how to take advantage of this transition by building on and supporting Canadian strengths in software and then how to scale them more effectively.

This trend of shifting functionality from hardware into systems through the application of software code may hold an important key to the future of Canada's place in the emerging digital economy. Leading economists have noted that there is a traditional bias in small, open economies, such as Canada, against technology-based industries. The entry barriers associated with technological innovation, especially in hardware, affect smaller firms to a greater extent than large ones. To the degree that smaller economies are characterized by a larger number of smaller, indigenous firms, this places the entire economy at a competitive disadvantage. As a consequence, there is a greater social incentive or justification for providing business support to technologically-intensive industries in a small open economy, than is the case with larger, more self-contained economies (Harris 2015, 89). The relative size of firms in the smaller economy leads to a sub-optimal industrial structure with respect to competing in innovation-based industries. Subsidizing small firms to engage in greater levels of R&D spending alone does not automatically ensure that the firm will grow to sufficient size to overcome the barriers to entry into world markets. This suggests that government policies to support the digital sector of the economy must include ones that are targeted at supporting firms as they grow beyond the start-up phase and face more intense competition in continental and global markets. The market failure in the industrial R&D process within technologically intensive industries disadvantages firms in a small open economy, resulting in the need to design technology (and business support) policy with this fact in mind.

Theories that link international trade with technological innovation argue that shifts in leadership are not randomly distributed across industrial sectors or between countries. Technological competition tends to be cumulative and the nature of that competition contains a large degree of irreversibility. Countries and regions gain substantial advantages from being first in new and emerging technologies. The initial advantages that accrue to the technological leader in an area allow it to retain that lead for a period of time and to undermine the efforts of its competitors. The benefits of technological leadership allow a firm to recover its research and development costs, as well as realize a higher than average return on its investment. In effect,

'success breeds success' or "being successful today raises the probability of success in the future" (Harris 2015, 89; Dosi, Tyson, and Zysman 1989). This success, in turn provides capital for firms to recycle into greater research and development investment to support future innovations.

The critical question is how government should respond to these changes. While the CDO project is still in its early stages, our research thus far provides a perspective on the policy changes needed to respond to this challenge. The analysis below presents some preliminary insights from our CDO research and some policy implications for consideration. As CDO researcher Dan Breznitz recently argued in the G&M, the uncertainty associated with investments in research and development and the inability to appropriate the research results are among the biggest obstacles to innovation in most economies. Numerous studies and policy reports have documented the fact that despite Canada's excessive reliance on the delivery of its innovation support through the tax-based SR&ED program, levels of business spending on research and development have been falling. While the SR&ED program itself is in need of reform to more effectively meet the needs of the technology community, it is evident that continuing to rely primarily on the tax system to move Canada off its "low innovation equilibrium" (Council of Canadian Academies 2013) is insufficient. What is required is the introduction and expansion of a range of direct spending programs to support innovation in the high technology and digital sectors of the economy.

The Role of a Technology Development Agency

Researchers in the CDO network have documented the different types of policy instruments that have proved effective in those countries that have moved from a relatively low level of technological intensity to a much higher level of performance. A key feature in many of the success stories has been the use of a relatively low profile technology development agency, such as DARPA in the U.S., Sitra in Finland, the Office of the Chief Scientist in Israel or the Enterprise Development Program and International Service Program in Ireland. Key to the success of these agencies is the fact that they were effectively insulated from short-term political pressures to produce results and were staffed with technology experts from academia and industry who could target the agency's investments to build innovative capacity in indigenous firms through their ability to experiment with new and emerging technologies and make long-term investments. These agencies were relatively inexpensive for the public purse, with budgets often in the range of $300-400 million a year; what was crucial for their success was the institutionalization of the agencies and the ability to pursue a long-term strategy. While not every investment has proven successful and some agencies have been more effective in

sustaining their strategies over the long term, the evidence suggests that the model can be highly effective in shifting the technological trajectory of an indigenous high-tech sector to a path that will enable it to exploit new and emerging technologies with greater elasticities of demand in the international market place (Breznitz 2013; Breznitz and Ornston 2013).

Indeed a recent article in the Harvard Business Review by a former director of DARPA currently implementing the agency's innovation model at Google's Advanced Technology and Projects group, which is charged with the task of bringing to fruition a host of next generation mobile technologies, argues that the key lessons learned at DARPA over many decades can effectively be transferred to the private sector and help to accelerate the pace of innovation in private firms. They argue that the key to DARPA's success consists of three elements: setting ambitious goals, using temporary project teams to carry them out and maintaining the complete autonomy of the agency in selecting and running its project. Also central to DARPA's success has been its unwavering commitment to building a research agency dedicated to solving technological problems located in Pasteur's Quadrant (Stokes 1997) which "entails pushing the frontiers of basic science to solve a well-defined, use-inspired need" (Dugan and Gabriel 2013; Bonvillian 2015).

It is important to differentiate between the role that this type of technology development agency plays in many of our leading competitors and the current model of research funding that dominates the Canadian innovation system. The existing federal model for R&D is focused on the funding of basic research through the federal granting councils, NCE's and CRC's at one end of the continuum and support for private sector R&D primarily delivered through the tax system with a number of minor programs devoted to commercializing university based research. There is a significant body of research which documents the importance of fundamental research in generating many of the scientific breakthroughs that have been critical for the development of today's digital technologies (National Research Council 1999; Mazzucato 2013); but what is lacking in the Canadian system is a focused and autonomous agency charged with the mission of stimulating radical innovations that are close to the technological frontier. One example of a successful model along these lines within Canada is Sustainable Development Technologies Canada (SDTC), a not for profit foundation created by the federal government, with significant funding that operates with an independent board, outside of the federal departmental structures.[1] We believe that a similarly well funded entity would be highly successful for supporting ICT companies, from applied research through commercialization. This is not to say that we can afford to ignore the financing of basic

[1] (https://www.sdtc.ca/en)

research. Canada needs to expand the range of direct spending programs to support innovation in digital technologies, while maintaining our strength in the basic research that can be the source of the next generation of technologies, as well as train the highly qualified personnel to work on those innovations.

Along with the establishment of a strategic technology agency we require a more focused and strategic approach to innovation in the ICT sector, building on proven strategies that have worked both in Canada and other countries. A key starting point is to develop a sector strategy in consultation with key industry associations and representatives. There is no shortage of policy documents and recommendations currently available from these organizations, so this process could be launched and undertaken with some sense of urgency. Some of the provinces, particularly Ontario, have undertaken such sector strategy exercises, which should be built upon and integrated into any federal initiative in this area. The process itself needs to be an iterative one: there is not a beginning and an end point. Given the pace at which digital innovation continues to sweep through the economy, the strategy and the consultation needs to be revisited on a periodic basis. A key component of such an exercise is the launching of an ICT/digital road map exercise to explore existing strengths and make strategic decisions about the areas where we could achieve maximum leverage in the shortest time frame with the minimum amount of additional federal spending. The results of such an exercise could also provide an important resource for the work of the strategic technology agency. The federal government has an established track record in convening industry and sectoral roundtables to draw up technology road maps that can be used to inform industry sectors about where the technological frontier is moving. Given that experience, this is something that could be initiated fairly quickly.

The Availability of Risk Capital

We also need to expand the range of policy instruments available to support market driven innovation in the digital sector. Fortunately, there are a number of highly successful examples of programs that have worked well in other countries and that could be adapted to Canada. One of the most effective of these is the Small Business Innovation Research (SBIR) program in the U.S. A number of commentators have suggested that it should be applied in this country. Introduced in 1982, the Small Business Incentive Research Program was designed to simulate technological innovation particularly by small business and increase private sector commercialization of innovations derived from federal research and development. The SBIR program required federal agencies with R&D budgets over $100 million to set aside 2 per cent of their funds for the program. In the early 1990s, the program criteria were revised by

Congress to increase the set aside to 2.5 per cent and to increase the emphasis placed on commercial potential for successful applications. By 2010 more than $16 billion had been awarded under the program with current expenditures of $2.5 billion a year. Numerous evaluations that have been conducted of the program have documented its positive effective on the growth and success of innovative start-up firms, including the increased likelihood of recipient firms attracting venture capital investments (Lerner 1999, 56; Branscomb and Auerswald 2001). It is unlikely that the program could be financed and delivered exactly as the U.S. program is; care would need to be taken in selecting a program design and delivery mechanism to ensure its maximum effectiveness in Canada. The Canadian Advanced Technology Alliance (CATA), has recently put forward a proposal to introduce an SBIR-type program in Canada by replacing the refundable portion of the SR&ED tax credit targeted at small business to a Canadian SBIR to be administered by a dedicated agency established for that purpose.[2] The proposal merits serious examination by the federal government, as well as examine how the existing Build in Canada Innovation Program (BCIP) could be integrated into this new program.

Another existing federal program with a proven track of stimulating innovation in small and medium-sized enterprises is the Industrial Research Assistance Program (IRAP). Numerous studies of federal innovation policy (Lipsey and Carlaw 1998; Lipsey, Carlaw, and Bekar 2005) and a number of reports by leading industry associations have called for a significant expansion of the funding available for IRAP. Measures are needed to strengthen and expand the staff of IRAP and significantly increase its budget. One problem that has plagued IRAP in recent years is the constant expansion and contraction of its budgets in response to changing macroeconomic conditions and shifts in the policy mandates assigned to the program. IRAP requires stable and assured long term funding to ensure that it plays the critical innovation support role for which it is intended. While its mandate to stimulate innovation in Canadian SME's extends well beyond the information technology sector and digital technologies, a significant expansion of its budget to the range proposed by CATA, among others, should be a significant component of an expanded federal strategy to create digital opportunity for firms in Canada. Due attention needs to be paid in the design of the CSBIR to ensure that it complements and does not overlap or compete with the current mandate of IRAP.

[2]The CATA proposal for a Canadian SBIR can viewed online at:
https://docs.google.com/document/d/1fDKTBJDTWN0nTm_QujgixGvcnaZWvkUCjX6rmHAeIMQ/edit

Growing Start-up Firms to Global Scale

A key challenge for Canada in dealing with the competitive issues of how to both start and grow indigenous firms in digital technology involves dealing with the dual problems of scaling up and the evaluation of technology firms by the capital markets. The recent demise of Nortel, the buyout of key telecom firms like JDS Uniphase and Newbridge Networks and the substantial downsizing of RIM/Blackberry all point to the challenges of growing and sustaining indigenous Canadian firms in the digital economy. Governments at both the federal and provincial levels have introduced a number of important initiatives in recent years to expand support for incubators and accelerators (part of which are being studied in the CDO project), as well as expand funding for the venture capital market. These policies have helped to expand the support available for start-up firms and the degree of funding available to finance them; starting new firms is just one part of the problem. The other part is the fact that we do not grow enough of our start-up firms to the global scale, so that when one disappears, the dynamism of the whole system is jeopardized. We need additional policies to support the scaling up of digital firms once they have been launched.

The challenge is to create a new program, federal and/or provincial, that can effectively designate a number of the most promising start-ups in the digital sector for additional support to help them scale up. In doing so, it is important to recognize that age of firms should be a more important criterion for direct or tax-based public support than the size of firm. Such a program can designate a specific number of promising high-growth start-ups across the country and provide them with resources in strategy, revenue generation, talent management and growth capital to help them scale up. The program should focus on the most critical challenges facing scale-ups -- such as growing their revenue base, particularly by accessing global, not just continental markets, helping them recruit, retain and develop the managerial and technology talent need to grow a competitive company to global scale and ensuring that they have access to sources of capital that are adequate, not just to launch the company, but to grow it. The program could be designed and implemented as a supplement to existing federal and provincial programs that support start-ups, such as the existing Canadian Accelerator and Incubator Program (CAIP), the Ontario Network of Entrepreneurs (ONE) or Alberta's Regional Innovation Networks. There exist a number of scale-up programs in the U.S. that merit close attention. Care should to be taken to ensure that the program is effectively targeted at a selective group of start-ups, the ones with the most promising chances of success on the global stage, and that it is delivered through existing agencies with a strong and proven track of providing effective support for start-up firms. Diluting the program to the level where it was applied too broadly or indiscriminately, would ensure its failure before it even got off the ground.

In a far ranging presentation, CDO partner Wesley Clover has also documented a number of initiatives that can help Canadian companies scale up to attain greater success in global markets. One suggestion calls for the establishment of sales & marketing consortia to help give Canadian technology firms the breadth & critical mass needed to penetrate the BRIC markets, where size matters. They also suggest that the federal and provincial governments should increase direct support for SMEs, such as FX risk insurance, more aggressive and targeted foreign intelligence on sales opportunities, & direct support for industry export consortia (Wesley Clover 2011). This call is reinforced in the recent policy document from the Information Technology Association of Canada (ITAC). The ITAC report calls for a range of initiatives to help Canadian firms penetrate global markets, including that industry organizations should develop, identify and bring together sets of SMEs from specific sectors (for example, health informatics, cyber security, digital media and enterprise solutions), that can be exposed to key foreign markets in a very targeted way -- increasing the chances for success for subsequent trade missions (Information Technology Association of Canada 2015).

A related issue that requires serious policy attention to help Canadian digital firms grow to a sufficient scale is dealing with the challenge of stock evaluations provided by the capital markets. In a penetrating presentation to the Re$earch Money Conference in 2013, the late Adam Chowaniec argued that public companies in Canada realize stock market valuations that are much lower than their peers south of the border; that this applies both to TSX listed companies and dual listed Canadian companies. He referred to a recent analysis which suggested that ICT companies are valued at a 23 per cent discount in the software sector and a 34 per cent discount in the hardware sector (Chowaniec 2012). Statistics from the BDC, cited in the Wesley Clover policy document referred to above, indicate that a VC backed Canadian tech firm exit in Canada will raise only 61 per cent of what it would get in the U.S. and a Canadian firm VC exit in U.S. achieves just 74 per cent of what a comparable U.S. firm realizes there. Similarly a Canadian tech firm exit in Canada achieves less than 50 per cent of what the same U.S. firm would raise in the U.S (Wesley Clover 2011).

The consequence of this systematic undervaluation of Canadian technology firms has been well documented in the annual reports of the Branham Group on the leading information technology firms in Canada, which list 164 leading Canadian IT firms that have been lost to acquisition over the past decade and a half. The capital markets' challenge for Canadian information technology firms is one of creating pools of capital that are not only targeted at funding angels and start-ups or early stage VC's, but can also contribute to growing mid-stage companies that are already well established in Canada. This problem is also the focus of a report by the President of ITAC, a CDO partner, on the challenge of building stronger tech

companies in Canada. The report calls for changes to the regulatory framework to support the growth of indigenous Canadian ICT firms, as well as a program for infrastructure to support Canadian companies in achieving greater success in the global marketplace at an earlier stage of their corporate development (Gupta 2012).

The Impact of Digital Technology across the Economy

While the information technology sector underpins the emerging second industrial revolution and the platform economy, its revolutionary significance lies in its potential to impact and disrupt virtually every sector of the economy as an enabling and transformative technology. A large share of the economic impact of the digital opportunity will play out well beyond the ICT and manufacturing sectors of the economy, in the primary and secondary industries that are using digital technologies to change the way they do business (by raising productivity, increasing product diversity, reducing risk) and to restructure global production networks. This suggests that a key concern for the federal government, working jointly with their provincial counterparts, might be to chart effective strategies to ensure that Canadian firms are provided the support needed to take full advantage of this potential, no matter what sector of the economy they operate in. There is an opportunity to work with industry associations, who have already done a considerable amount of work on the technological changes impacting their industries, to develop sectoral strategies that can identify and target specific initiatives (which can often be funded through existing federal and provincial programs) to promote the adoption and diffusion of digital technologies across their sectors.

One area where Canadian firms continue to lag across the board is in terms of investments in software. A recent report from the Centre for the Study of Living Standards suggests that under investment in software accounts for 85 per cent of the broader Canada-U.S. ICT investment gap and is consequently a significant contributor to Canada's lagging productivity performance. It is evident that Canada requires a national strategy to support the adoption and use of the latest software available across a broad range of economic sectors. Given the critical link between investments in ICTs and productivity growth, as well as the pervasive effects of digital technology across the economy, the CDO Research Partnership views this as a critical political issue urgently in need of attention. The short-lived Digital Technology Adoption Program, administered by the National Research Council was intended to achieve this goal but suffered from a number of design limitations. We still require a national digital technology adoption strategy to assist SMEs in identifying what technologies are most appropriate for them and boost software investment and productivity. The Business Development Bank of Canada (BDC) offers support to SMEs looking to adopt and exploit digital

technologies through the Smart Tech service; businesses may also apply for an available $200 million in loans for investment in hardware, software and consulting services (Centre for the Study of Living Standards 2014, 82). The federal government could examine the possibility of expanding this program and ensuring its coverage across a broad range of sectors in the Canadian economy.

As part of the current CDO project, research team members and partners are undertaking an extensive set of sectoral studies that chart the current and potential impact of digital technologies across a wide range of industry sectors. Although still in their early stages, many of these studies highlight the need for policy changes across a range of areas, including regulatory issues. Disruptive innovation across many different sectors is challenging current regulatory regimes at the federal, provincial and municipal level. Uber, which is being studied in the CDO project, provides an excellent illustration of the kind of challenges this technology creates for the prevailing regulatory regime at the municipal level, but it is just a forewarning of even bigger changes that lie ahead. Numerous other challenges are just beginning to emerge in related fields. Research conducted in association with the CDO project suggests that the coming introduction of autonomous vehicles (made possible by the spreading use of digital sensors and controllers) is going to herald even greater changes in urban planning, urban design and the implementation of urban transportation systems. Working with the City of Toronto, a CDO partner is helping the municipality to understand how the transition from transportation as a single owner product to transportation as a service will require a major rethinking of a number of municipal planning and regulatory areas.

Fintech

Other sectors being studied in the CDO project range from agriculture and mining to advanced manufacturing, digital media and financial services. These studies afford important insights into the growing impact of digital technologies on established sectors of the economy. Working in conjunction with industry representatives, members of the CDO research team have recently completed an analysis of the evolving Fintech ecosystem in the Greater Toronto-Kitchener-Waterloo region, benchmarking Canada's strengths against other emerging Fintech ecosystems and suggesting a strategic direction to help stimulate and support the growth of the ecosystem. The report highlights both the potential opportunities being created by Fintech firms, but also the significant challenges they pose for established industry players. The research team has suggested a number of critical policy initiatives to help grow the emerging Fintech ecosystem. Many of these can be implemented at the provincial and municipal level, which have targeted financial services as a key area for policy support, but some will require federal action. One of

the critical elements of the Fintech ecosystem currently missing is the presence of large, inexpensive incubator centres, offering basic services with high connectivity at highly discounted rates. While a number of incubators exist, the inexpensive ones are far below the scale currently available in London and New York, and the more expensive ones demand rents far above what start-ups can afford. The result is that efforts to build a dynamic Fintech ecosystem in key Canadian centres are lagging behind developments in leading global centres, such as New York and London. There is also evidence that despite recent efforts by the federal and provincial governments to increase the supply of seed and very early venture capital available to start-ups in Canada, there may still be a shortage. This suggests a more direct approach, for examples, grants or conditionally repayable loans as a policy area for increased government participation. Research has been conducted by members of the CDO Research Partnership on "best in kind" international cases, such as Israel and Finland (Breznitz, Breznitz, and Wolfe 2015), which can provide instructive lessons for Canada.

However, some of the most significant initiatives to support the growth of the Fintech sector may require regulatory changes at the federal level. Canada has one of the world's most respected financial regulatory frameworks, and this framework is one of the bases for the continuous stability of its financial system. Nonetheless, this regulatory system and specific regulatory bodies now act (and are perceived to act) in a way that limits or restricts innovations emerging from new companies, thus preserving the status-quo for established Canadian financial institutions. This leads, first, to many Fintech firms either relocating their operations to the U.S., or not developing products in these niches, thereby allowing foreign companies to gain global prominence and control greater market share. At the same time, the presence of an excellent regulatory system and the high degree of respect for the regulators is widely seen as a potential asset for the Fintech ecosystem. Hence, finding ways in which the Canadian regulators, perhaps by taking a page from their U.K. counterparts, can develop procedures to stay abreast of new technology developments and their predicted impact on the market, while allowing for rapid small-scale experimentation (leading to scale-up in cases of success), is a source of great potential. Such actions, would not only make Canada a more attractive global hub for Fintech development attracting high quality entrepreneurs and investors, but would also create institutionalized pathways for information diffusion, collaboration, and the development of a vibrant ecosystem (Breznitz, et al. 2015).

Advanced Manufacturing

Within the context of this sectoral approach to support the adoption and diffusion of digital technologies across the economy, we draw particular attention to the strategic importance of

the manufacturing sector. The spread of the digital economy and new global production systems have fundamentally altered the landscape of the industrial economy. The emergence of new materials has changed the manufacturing process by introducing new software layers into traditional machining processes. Instead of classical `metal bashing', metal manufacturing now is based on the manipulation of the microstructures of the materials. Industrial companies, including about 10 per cent of SMEs, have developed specialized software tools for optimizing production tools and processes. However there are still important gaps in the modelling and visualization of microstructures and their related production processes. Further there is the opportunity to expand markets by integrating them into global supply chain platforms developed by leading multinational corporations. Research suggests that the major opportunities for growth will lie within existing industrial companies who have more stable income streams, established customer bases and the production capabilities and staff. Because of the critical importance of SMEs for economic and job growth, it is important to focus on increasing the innovative capacities of SME firms, particularly for new technologies like 3D printing and additive manufacturing.

The growing shift from the embedding of control mechanisms in hardware systems to their design in software is creating broad opportunities for Canadian firms in both the ICT and the advanced manufacturing sectors, given Canada's long standing expertise in software. There are SMEs that have developed their own software applications, sometimes in standard code and sometimes as vertical applications running on top of mainstream platforms provided by leading international database vendors. There is an opportunity to deploy these as modules for running on larger digital manufacturing platforms from global multinationals. This offers the potential for them to be added as value-added modules for other manufacturing environments and export markets. It is also possible for individual dedicated applications to be optimized through integration with other software modules and data sources across the supply chain.

The spread of the digital economy and new global production systems have qualitatively changed the nature of the industrial economy. This now applies to manufacturing, resource industries and agriculture. It also means that most of the value-added is created away from the original location of production be it the farm, mine or factory. Concomitantly, the revised version of industrial policy is networked industrial policy, which focuses on enhancing the regional industrial commons in key locations across the country in order to utilize the existing research, education and training infrastructure to support Canadian SMEs at the leading edge of the digital revolution in their respective sectors.

A recent policy report from the Connect Innovation Institute at the University of California San Diego drew attention to the central role played by the manufacturing sector in

process and incremental innovation and the long-term implications of a decline in the sector's ability to innovate. As the production of a wide range of manufactured goods has become increasingly globalized, production has become more fragmented and organized in global production networks. As a consequence, companies involved in these networks have become more specialized from the R&D they undertake to the design, manufacturing and assembly of their components or final products. Production is an increasingly networked activity, as companies share responsibilities with other partners in their global production and innovation networks. As a consequence, the key to supporting domestic manufacturing capability is the adoption of policies designed to solve what the report refers to as "semi-public good supply problems" (Breznitz and Cowhey 2011).

Recent policy initiatives in both the U.S. to establish a National Network for Manufacturing Innovation (NNMI), which is being set up as a private-public partnership program and the U.K. to establish Catapult Centres, are both aimed at improving the manufacturing capabilities for technologies developed in their respective countries by emulating some of the key features of the Fraunhofer Institutes in Germany U.S (Hepburn and Wolfe 2014). The NNMI model, in particular and the new institutes it is establishing have significant bearing for the competitive standing in a range of technologies and industries in the manufacturing sector of the Canadian economy. Many of the new institutes are located in physically proximate regions to Canada and they are being established in industrial sectors in which the U.S. competes directly with Canadian firms for investment and product mandates. The model being adopted in the U.S. may not be wholly transferable to Canada, but the rationale behind its adoption applies equally to the domestic manufacturing sector.

Focusing on a sectoral strategy for manufacturing is based on the recognition of the significant role that manufacturing plays in private spending on research and development, as well as the need to build regional and provincial capacity to support new technology platforms in emerging areas such as "the connected car" in the automotive sector or the adoption and integration of ICT's in the delivery of medical services and the management of the health care system more broadly. The trends in government policy to support manufacturing discussed above is based on recognition of the strategic significance of technology platforms as opposed to the R&D spending at the levels of individual firms. This recognition has two critical implications for existing and proposed policies at both the federal and provincial levels:

- It requires a broader and deeper integration of the links between programs designed to support the research and development capabilities of research institutions, especially in the public sector and the integration of those research capabilities with the absorptive capacity of domestic (provincial) firms;

- It also requires that the effectiveness of existing R,D&I programs be assessed within the context of the competitive status of Canadian firms in the global economy, their strategic position in evolving global production and innovation networks and policy interventions to enhance the export performance of indigenous producers and suppliers.

A recent report prepared by researchers at the Innovation Policy Lab (part of the CDO Partnership) identifies some of the common design, funding, governance and operational characteristics of the German, British and American technology transfers (Hepburn and Wolfe 2014). It is evident that we need a Canadian made technology transfer centre or "innovation hub" focused on the application of digital technologies to manufacturing processes. As part of the policy development process for the development of such a centre we need to look closely at the strategic areas where both the Catapult Centres in the U.K. and the NNMI's in the U.S. are focusing. In the course of research being conducted on one of the four themes for the CDO project, we have come across three or four initiatives currently being developed by private sector firms, university consortia or some combination of the two. The federal government might consider designing a process that will allow it to build upon these initiatives to develop a "made in Canada" solution to the manufacturing challenge that many of our domestic firms are facing. CDO researchers working in this area have proposed a number of related initiatives which include: support for an accelerated introduction of metallics advanced manufacturing machines in Community Colleges and Regional Innovation Centres; funding for demonstration projects on the integration of advanced manufacturing with next generation digital manufacturing process planning and quality control systems; support for increased Community College training of Cadcam capacity for Canadian SMEs; and the introduction of a five year effort to develop a new Canadian manufacturing software platform equivalent to the European Industry 4.0 standard.

Security Issues

In the 'old economy' governments have long taken responsibility for policing, justice and national defence. In the second economy, nothing short of the same is required of the State. Data hacking and other crimes facilitated by digital technologies are now a common occurrence facilitated by the lack of secure systems and the lack of enforcement across borders. Cybersecurity for government, business and households is a fundamental policy domain of 21st century government. In its 2013 Survey of Digital Technology and Internet Use Statistics Canada found that approximately 30 per cent of all *large firms* in Canada saw Security and/or privacy concerns as a barrier to further integrating ICTs into their business. Some of the CDO partners

are involved with the leading U.S. consortia of firms that are grappling with these security issues. Leading industry associations, such as CATA, are also focusing some of their efforts on the issue of cybersecurity. Other governments, such as Germany, are coordinating national efforts to respond to this challenge through the creation of the Federal Office for Information Security (BSI), which has a mandate that crosses all three sectors.[3] The Agency's *The State of IT Security in Germany* reports provide valuable insights on the current challenges for cybersecurity. The federal government needs a coordinated response to the issue of information security that involves both leading firms and industry associations in the field.

Local and Regional Strategies for Digital Innovation

The final policy area that deserves mention is the importance of including a "local context" perspective to maximize the impact of federal policies at the local level. The advantage of adopting this approach is to use existing policy instruments in a more focused and coordinated way to facilitate coordination, dialogue and interaction among the constituent elements, especially firms, at the local and regional level. Clusters are one approach that have proven effective as a policy instrument in fostering linkages between firms, universities and research institutes and providing a basis for firms to take better advantage of market opportunities. They also afford the opportunity for small and medium-sized firms to establish connections with larger partners and multinational firms. This focus on the local and regional dimension of digital innovation is based on the recognition that Canada is large and diverse economy that requires policy responses that are tailored to this diversity and able to take full advantage of successful local initiatives. The effective implementation of this approach at the local and regional level requires a greater degree of coordination between all three levels of government and their respective economic development agencies.

The adoption of a local and regional perspective does not require the introduction of new spending programs by the government, but rather the implementation of an additional lens through which to review and evaluate a wide range of existing programs, both within the Department and beyond it. The Competitiveness Institute's *Cluster Policies Whitebook* notes that cluster policies, for example, can cut across a wide range of existing policy areas: industry policy, science and technology policy, competition policy, education and labour market policy and social policy (Andersson, et al. 2004, 52–53; OECD 2007). Policy initiatives focused on providing support for local and regional concentrations of firms in interrelated sectors do not

[3]See https://www.bsi.bund.de/EN/Home/home_node.html.

constitute a new policy area, but represent a new approach to synthesizing an existing range of policy instruments that cut across the three fields.

The Action Plan for Prosperity developed by the Coalition for Action on Innovation in Canada presented a very concise and focused set of recommendations for a series of actions the federal government could adopt to support clusters at the local and regional level. The Plan argued that the federal and provincial governments should align their existing policies and spending to support the development of regional and local clusters. This should include efforts by universities, colleges, polytechnics and research institutions to align research and training efforts to meet the needs of existing and potential local clusters. Support for cluster organizations can help ensure that experienced actors in the private sector can assist cluster development by offering advice and guidance to new start-ups, supporting the entry and growth of related firms into an area and consistently communicating their needs to local post-secondary institutions and research centres. The Plan also recommended the creation of a national network to share know-how and best practices on how to improve cluster competitiveness and reinforce cluster development (Coalition for Action on Innovation in Canada 2010). This network can build on the considerable experience already located in a number of key cluster organizations across the country, as well as existing national organizations, such as the Canadian Digital Media Network, also a CDO partner.

Labour Market Issues

One of the most challenging issues to address concerns the question of whether there is a sufficient supply of graduates being trained to work with digital technologies across the economy. Human capital, which is a common factor in both the hardware and software sectors is an increasingly critical input for the sector as a whole as well as key geographic concentrations of firms. Canadian post-secondary institutions are well regarded for producing a significant number of well trained and highly qualified graduates with many of the skills required for growing the digital economy, but there is also a need to introduce students to career opportunities in this sector at a much earlier stage of their education. A number of recent studies have suggested that there may be critical skills shortages in some specific ICT categories and the overall number of graduates may be insufficient to meet growing demands across the digital sector of the economy. CDO partners working in the ICT sector of the economy are experiencing shortages of people with ICT skills in specific areas, such as software development. Another finding from the Nordicity study of ICT skills is the lack of senior technology, business and marketing managers with global skills, precisely because so few

Canadian companies are reaching global scale before they are bought out (Nordicity in association with David Ticoll 2012). Working with provincial counterparts, it is imperative that federal departments ensure that the future skill needs of the sector and its key local and regional concentrations of industry are met.

The Urban/Rural Dimension of the Digital Economy

Digital technologies are being adopted and used on the ground in cities and communities across the country. Most of our economic activity is based in our cities and their overall ecosystem, including support for knowledge job creation, start-ups and new "smart solutions" in healthcare is of paramount importance to the overall growth of the ICT sector. The CDO project is studying how the diffusion of these technologies at the municipal level and in rural communities can support their adoption and use across the economy as a whole. One policy proposal in this area is to design and implement an initiative like the U.K. Smarter Cities Fund and its companion funding of the Future Cities Catapult Centre, one of the technology transfer centres discussed above. Establishing a Smarter Cities Fund can help position Canadian firms to take fuller advantage of the world smart cities market, a trillion dollar business that will continue to grow rapidly for a long time. It would also create an ecosystem that supports start-up clusters and creates a local market for a wide range of ICT companies. Fostering a local Smart City market supports the development of skills and solutions for companies to then go abroad and compete in the trillion dollar global Smart City market.

However, as Canada works to ensure that its major cities are globally competitive and can match the most innovation metropolitan centres in the world, we must also recognize the growing "innovation divide" emerging with the smaller cities and towns. Taking innovation to smaller communities, particularly northern, Aboriginal and rural settlements, is a formidable challenge, although there are successful centres that have capitalized on improvements in technological infrastructure, the ubiquitous nature of the Internet, and the opportunities for individuals and small companies to compete internationally in targeted markets. The search for models of non-metropolitan innovation development is much less developed than for major cities, but Canada's widely distributed population and unique regional cultures underscore the importance of identifying means of engaging all Canadians in the 21st century technology-driven economy.

Among the policy initiatives that merit closer attention are the creation of virtual incubators and innovation centres on a regional basis (i.e. northern innovation) or on a thematic basis (cold weather innovation), with an anchor institution leading the national effort.

Governments can support a national "lone eagles" strategy based on the idea that highly skilled individuals are no longer place-bound and can work and live anywhere. Their economic impact in smaller communities can be dramatic. Government should also work to raise the profile of small town/rural/northern and Aboriginal innovation business developments in recognition of the fact that digital innovation can also occur outside of the major metropolitan centres. Finally, we also need to undertake a major quality of life and work study that examines the short and long-term impact of digital technologies on small towns, rural areas and remote communities, recognizing the fact that the distribution of costs and benefits of digital technology differ significantly between larger urban centres and smaller communities.

Conclusion

This is clearly an ambitious agenda to lay out for any government, let alone a new one that faces a wide range of pressing policy issues. Despite this fact, we would argue that the policy agenda for the digital economy must be a priority area for any government in Canada for the reasons described at the outset. Not since the first onset of the industrial revolution have we seen an interconnected set of technologies with a similar potential to both disrupt our established industrial sectors and economic patterns, but also to generate new economic opportunities for ourselves and future generations. While some of the initiatives set out above require new program spending, many can be achieved through a reallocation of existing program spending or a refocusing of the priorities of existing programs on the digital dimension of the economy. Collaborating more closely with provincial and municipal governments can also leverage existing program spending at those levels. The effectiveness with which all three levels of government grasp the digital opportunity and succeed in laying the foundations for future growth will determine their economic and fiscal capacity to deal with the numerous other issues pressing in upon them.

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