

PERSPECTIVE



Disruptive Technologies: Questions That Go beyond the Economy

As consumers, workers, entrepreneurs or members of a government, we all have the impression that we are living in the midst of technological upheaval due to the speed and sheer number of developments. We don't know where to look, how to act or where to start to benefit from these advances. Then there are the challenges involved in assessing what these new technologies contribute to the economy and understanding how they change it. Although discoveries and applications are proliferating almost exponentially, we have to take the time to better understand what's coming. The outlook is primarily favourable in terms of their impacts on the economy and the well-being of populations. Analysis quickly reveals that the economic aspects of these technologies link back to human beings and to questions surrounding the redistribution of wealth, of privacy, security and intellectual property.

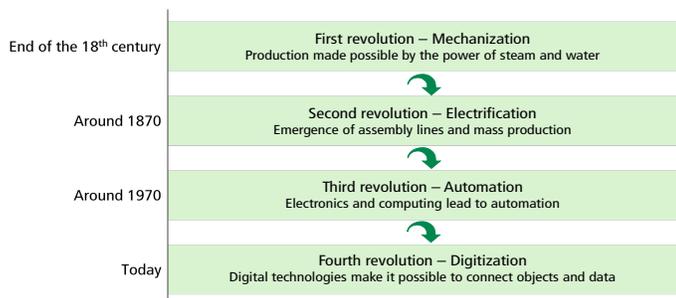
Naming the Phenomenon Is a Challenge in Itself

The current proliferation of discoveries and technological developments brings with it plenty of attempts to characterize the movement, or to name the technologies themselves. Many observers describe the period we're in as the fourth industrial revolution. The first industrial revolution was brought on by the mechanization made possible by the power of steam and water at the end of the 18th century (box 1). Electrification led to the second industrial revolution, toward the end of the 19th century, while the third, automation, involved the pairing of electronics and computers. Digitization appears to be the fourth industrial revolution, with the connectivity of objects and data that digital

technology makes possible. This vision is mainly focused on the production of goods.

Others do not necessarily associate the current developments with history; they propose a vision that goes beyond manufacturing, one that encompasses all aspects of human life, in which physical, digital and biological boundaries are wiped out. They characterize these technologies as "disruptive," in that they create rupture and upheaval. These words essentially describe the same situation: technologies that extensively disrupt the established order... The word "disruptive" is not new. It is attributed to Clayton Christensen, a management professor in the United States who published *The Innovator's Dilemma* in the 1990s. Broadly, what Clayton Christensen says can be boiled down as follows: existing businesses with solid foundations are "disrupted" by new businesses that do not face the same constraints (such as past investments, managing existing employees, budget commitments, physical assets and so on) and can use the new technologies to their utmost to conquer markets.

BOX 1 The industrial revolutions



Source: Business Development Bank of Canada

A Plethora of Technologies

We may well feel dizzy given the colossal number of technologies that can be applied in every aspect of life. The swarm of new developments is so intense that it is difficult to get a clear picture. Many research, analysis and consulting firms are even turning to panels of experts to establish rankings to identify which technologies are likely to trigger the most upheaval. Each

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group assembles a ranking of technologies that are deemed to be more striking than others. However, a look at the various lists shows that the choices differ depending on the concerns of the people establishing the rankings.

Opinions are divided, depending on whether the experts involved are concerned with health issues, industrial production, energy issues or data processing (data, sounds, images). Looking at a few lists reveals that a plethora of technologies have been selected and considered “disruptive.” In other words, there’s no consensus. However, within the array of possibilities, there are still a few points of convergence among the choices of the groups that have made public statements on the matter. Here, a majority mentions artificial intelligence (box 2), connected objects (box 3), advanced robotics and virtual and augmented reality (box 4 on page 3). Other technologies that have been identified as likely to completely alter how we do things include mobility (autonomous vehicles, among other things), genomics¹, 3D printing, drones, advanced diagnostics, personalized medicine, algorithms for quantum calculators (or quantum computers), to name just a few.

¹ Genomics is the science that aims to decipher and understand the entire genetic information of an organism (i.e., human, animal, plant or microorganism) encoded in its DNA and related molecules (i.e., RNA and proteins) – Genome Canada.

BOX 2 Artificial Intelligence

Data is what fuels artificial intelligence (AI). With data, AI makes it possible to build analytical and predictive models in order to develop applications that can adapt and learn from experience. They have two features: velocity and transversality. Developments are moving at a breakneck pace and the applications are impacting all facets of life.

Among other things, we expect AI to help make better decisions in business and government settings (municipal, regional, national and international), in healthcare, research... In short, the areas of application are endless. This is the topic of the day in terms of disruptive technology, given the enormous developments and gigantic promises. Artificial intelligence is currently creating a lot of fear, because it is not well understood. Its proponents do not see it as eliminating jobs, but rather as a tool that helps improve business and organizational performance.

Note that Montreal is a very important research hub. One of its key researchers is Yoshua Bengio, a pioneer in deep learning. Along with two colleagues, he is the recipient of the 2018 Turing Award (considered the Nobel Prize in computing), to be presented in June.

What researchers, analysts and consultants do agree on is the need for action. They point to the importance of not remaining stuck in existing technologies, and of initiating change. In their opinion, we all have to respond: businesses, workers, governments and institutions. However, before making any decisions, it would be useful to consider the following questions: Why make changes? Who benefits?

The Expected Repercussions

In terms of the expected and potential impacts, we have already gotten a glimpse of the coming changes. Regarding the labour market, we already know that automation will change the nature of the tasks that will henceforth be done by humans, as happened when the first robots arrived in factories. Given this, some workers already expect their jobs to vanish (in retail sales, for example, as the Brookfield Institute has noted in its work). What percentage? That remains to be seen. We discussed this matter in a previous [Perspective](#) published in September 2016. Since then, studies on the issue have popped up sporadically, and increasingly they focus on tasks rather than jobs. In return, new functions are being created. For example, there are designers in the fields of virtual and augmented reality, platform managers and even “data cleaners,” whose job it is to eliminate duplicates and correct information in databases. That is just a small sketch of the new jobs that have emerged more recently.

Moreover, as with market globalization, there will be winners and losers. We can’t expect that all the monetary repercussions will be distributed equally. We will need to anticipate how to

BOX 3 Connected Objects

“The Internet of Things describes connected, physical objects that have their own digital identity and can communicate with each other”, [Futura Tech](#) (website in French only). There are many examples, such as sensors that make it possible to track a stock item or merchandise in transit. In terms of building management, this may involve smart meters, security systems that are connected to devices to detect water or gas leaks remotely. In healthcare, there are connected watches and remote monitoring of vital signs, to name just two. In terms of the environment, among other things, sensors can monitor air quality. In industry, some people believe that using the Internet of Things preventively would help cut machine down time (due to breakdowns, among other things) by up to 50%. In manufacturing, we can easily imagine quality control being done before an item leaves the assembly line using sensors built into the various inputs. This would substantially reduce merchandise returns due to manufacturing defects. Closer to home, devices such as Google Assistant and Alexa are becoming part of our domestic lives, making it possible to control thermostats, start appliances or initiate purchases.

BOX 4
Virtual Reality and Augmented Reality

“Virtual reality puts users in a virtual, three-dimensional world in which they can move around and interact”.² It requires a helmet and motion sensors. Certain video games provide a nice example of this. Similarly, to attract visitors, some vacation spots have developed virtual reality experiences that allow travellers to visit dream locations or historic sites without actually going anywhere.

Augmented reality is a technology that superimposes information such as images or texts or even 3D elements on reality. Modelling systems that make it possible to design a room in a house by adding furniture are an example, trying on clothes without having to go into a changing room in another.

Putting it simply, if not simplistically, if we had to boil each reality down to a single word to differentiate them, we could speak of immersion in the case of virtual reality and superimposition in the case of augmented reality.

² Jérémy PIROTTE, *Quelles différences entre réalité augmentée, virtuelle et mixte?*, Realite-virtuelle.com, Ecosystème, April 15, 2016.

redistribute the positive effects of these technological changes and mitigate the negative impacts. Therefore, it’s important to know where the gains are being made.

The impacts will go well beyond the fields in which the changes will be implemented. Take for example the creation sector (visual, musical content, etc.), where the arts community and those running the new distribution platforms are in the process of defining their respective roles. The relationships between creators, content editors and technology companies are being redefined, which raises major questions about property, royalties and the means of distribution, to name just a few.

The arrival of these disruptive technologies makes us contemplate the following issues: protection of privacy, the security of premises as well as people and data, intellectual property, as the work is increasingly collaborative, the potential exploitation of production chains (hacking), genomics and ethics.

Other challenges arise, including measuring what new technologies contribute to the economy and well-being. Do they bring prices down, or increase them? Are we underestimating growth? These are some of the questions for which there are no specific answers at this time.

Assessing the Phenomena

We are well aware that GDP is not a metric that captures all of an economy’s growth and progress; we tackled this issue in an [Economic Viewpoint](#) published in the fall of 2018. This is true for human development, as well as for assessing a population’s well-being. Similarly, it is currently very difficult to capture the positive or negative impact of disruptive technologies. Despite the pitfalls, organizations like the Bank of Canada (BoC) and Statistics Canada are looking at the digitization of the economy and the effects it can create.

We know that digital technology disrupts how we shop (online vs. in brick and mortar stores), consume music (purchasing songs on iTunes and using subscription-based music streaming services vs. buying physical albums and concert tickets from a box office), perform financial transactions, deliver healthcare (telemedicine) or even produce goods (3D printers, connected objects, remote quality control, maximization of commodity use, minimization of waste, etc.), to provide just a few examples.

In a [speech](#) delivered in September 2018, the Governor of the BoC, Stephen Poloz, described the BoC’s concerns about digital technology, and revealed that the BoC had been taking a close look at them for several years. He presented several observations, which included the fact that digital technology is disrupting how we take stock of the economy and we have to adapt. Although many are following the movement, the pace of adaptation differs among people, businesses, governments and organizations. The BoC believes that the digital revolution is creating real value, notably through five different channels. One channel is higher profits (Stephen Poloz gave the almost exponential growth by market capitalization in the area of computer system design and related services as an example); another is the increase in real wages (once inflation has been factored in), the creation of new types of jobs, the jobs generated by expenses related to the new jobs created (the multiplying effect: in retail sales, construction, maintenance, food services, etc.) and the growth triggered by this movement, as well as the benefits to the entire economy.

However, the spinoffs are hard to measure. In terms of price variation, we are increasingly talking about the “Amazon effect.” This refers to the showcasing of goods and services on digital platforms, which enables more price comparison and heightened competition. How much of an impact does the Amazon effect have on inflation? It’s hard to say. Moreover, the way businesses invest is changing: once upon a time, investing necessarily meant purchasing equipment and building plants or offices. These days, investing in IT can mean purchasing cloud services, acquiring digital applications or hiring computer specialists rather than buying equipment. In fact, we can no longer use the same metrics: we have to develop new ones but, for that to happen, we need to know how investments and transactions are occurring.

Statistics Canada has also issued findings³ similar to those of the BoC: the economy's dematerialization is making things particularly complicated when it comes to taking the economy's pulse. For example, even though e-commerce has, in practice, been around for many years now, it is still hard to grasp all of its contours and include purchases Canadians make on certain online shopping sites abroad.

And this is only one aspect of the economy's dematerialization. We can well ask ourselves how to measure the impact of free web-based courses, rentals (apartments, houses, cottages, etc.) transacted between individuals, the second-hand market, telework, and online consultations, to name just a few of the new realities. We must respond to modern phenomena with modern measurement tools: satellite images for crop production, website extractions to get a better view of prices, optical reading, artificial intelligence for processing and compiling the masses of data, etc. The development of measurement tools is not keeping pace with these realities. Despite that, efforts are being made to catch up. This observation could suggest that the growth that has been described as "anaemic" since the start of this millennium may not be as anaemic as we thought, and that productivity gains may have been underestimated. Several factors can contribute to enhancing living standards and improving GDP; these contributions are real, but poorly captured at this time. Some examples include production costs that are decreased by automating some operations, and greater visibility in prices posted across the web, which helps rein in increases and stabilize inflation. Little is known about the cumulative nature of the different technologies, but the sense is that they will have a positive impact. Moreover, we need a better assessment of the expected benefits of scientific breakthroughs that could improve human health and decision making (in fields as different as farming and emergency situations), strengthen monitoring of natural environments, or even improve management of water resources. These examples attest to the diversity of the expected advances that could create economic value and greater well-being for populations.

However, this is not the first time that we've run into difficulties related to metrics. Problems also arose when it came to measure the contribution of information and communication technologies (ICT) that were meddling with the entire economy. We also had to show some creativity in assessing Canada's tourism industry, as well as the culture industry, or to estimate the underground economy. We succeeded.

Looking Ahead

We know that the employment market is changing, and the current scarcity of labour could precipitate certain actions, such as advanced robotics. Yes, some jobs will be lost, and others will

be created. In terms of losses, repetitive and dangerous jobs have been flagged as being most at risk. However, most analysts stress that we must, starting now, pursue frequent training to stay in a labour market that is already changing constantly. This task is not exclusive to workers, the analysts point out. Businesses and governments are also responsible for facilitating such upgrading.

Consulting firms agree on a vision of disruptive technologies, emphasizing that societal and business leaders looking to adopt them must first prepare to do so. Although the race to embrace the new tools has already started, and everyone wants to be in the lead, it is essential to invest in acquiring knowledge of these technologies.

First, we need to know and understand what they can do, so that they serve our objectives, rather than the opposite. Some reflection is required: we have to decide whether adopting such tools will impede or propel the comparative advantages that some businesses and societies already have. We cannot avoid questions about the impacts the changes will have on the relationship with customers or citizens, with employees, and on the values of the company (or society, organization, government authority, etc.).

Other questions are arising, including the issue of the lead already enjoyed by the web giants (Google, Apple, Facebook, Amazon and Microsoft: GAFAM) and the power they have to consolidate their position as a result of their colossal financial resources. What kind of room remains for start-ups? More importantly, what kind of future do they have? Is getting bought out by a GAFAM corporation the only outcome of their success?

How can we manage the new risks? How do we establish a balance between the progress that is looming, data security and privacy? What rules will prevail in terms of intellectual property? How will plant workers cope with collaborative robots (named "cobots") that could take an initiative? This question links back to the health and safety as well as training needs of the people working with these new "colleagues."

Lastly, although disruptive technologies have their fans, they also have detractors. Unanimity does not exist, particularly when it comes to artificial intelligence. At a time when the topic is being discussed from every angle and in every forum, some think we've already said too much, and that the current developments are more akin to a "misshapen version of innovation"⁴ than a true revolution.

Some are also looking at the social costs and the nature of work triggered by the disruptive technologies, and already seeing new problems. Here, it is a question of digital work (rather than

³ André LORANGER, *La mesure des technologies perturbatrices*, Statistics Canada, May 2017, 19 p.

⁴ Chloé BONNET, *Pour en finir avec la religion de l'innovation disruptive*, Five by Five, March 12.

computer work), which does not call for extensive expertise and therefore does not receive big compensation, on the contrary.⁵ We are referring to the splitting of work into small operations, like data collection, content identification and classification, or putting words on images. This work can be done autonomously from the worker's home. Then there are "click farms," where such workers are assembled in decommissioned plants in parts of the southern hemisphere. These situations do not wipe out the benefits that we can derive from artificial intelligence and other disruptive technologies, but they make us aware that not everyone comes out a winner.

Beyond the Economy: People

Disruptive technologies have huge development potential. What we decide to do with them will make all the difference. It's hard to imagine what that will be. We are already struggling to measure their early manifestations. Some people are already exhausted by the speed at which the economy is changing. However, we must take time to think about our goals in adopting these technologies as well as their impact on people.

Most of those who analyze and comment on the current movement believe the coming changes will deliver gains. Furthermore, the outlook is primarily favourable in terms of their impacts on the economy and the well-being of populations. This immediately raises the question of how the benefits will be shared, as we can well imagine that not everyone will profit in the same way. A word of warning to those who are tired of hearing about disruptive technologies: the debate is just getting started.

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⁵ Diane BÉRARD, [IA : les fermes à clics remplacent les Sweatshops](#), *Les Affaires*, March 21st, 2019.