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The digital transformation ecosystem in the age of disruptive innovation

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Abstract
Digital Transformation affects individuals, companies and societies as a whole. In particular, a rapid spread of digital technologies establishes a huge change of movement. It is essential that economies continually invest in developing digital infrastructures to meet existing and future demand. They use the foundation for many new services, applications, and business models. They are also crucial to supporting and enabling digital innovations that are transforming production, including in the context of Digital Transformation, Industry 4.0 and Disruptive Innovation. Ideally, these plans should address the main barriers to deploying high-speed networks and services and include measurable goals to meet the challenges associated with ensuring competition and investment. It is also important that these plans include goals related to key technical facilitators such as access to Internet exchange points and spectrum, among others. This article promotes a reflection on social, economic, and intergenerational management development, and a vision for developing, disseminating, and governing technologies in ways that foster a more collaborative, collaborative, and sustainable foundation in all of these transformations.

Keywords: digital transformation; fourth industrial revolution; disruptive innovation

Introduction

In business theory, a disruptive innovation is an innovation that creates a new market and value network, and eventually disrupts an existing market and value network, replacing established companies, products, and strategic alliances (Berman, 2012) [1]. Not all innovations are disturbing, even if they are revolutionary. For example, early cars in the late 19th century were not a disruptive innovation, because old cars were expensive luxury items that did not disturb the horse-drawn car market. The haulage market remained virtually intact until the debut of the lower-priced Ford Model T in 1908. The mass-produced car was a disruptive innovation because it changed the haulage market, while the first thirty years of caring did not change (Maynard, 2015) [9]. Disruptive innovations tend to be produced by outsiders and startup entrepreneurs rather than existing market leaders. Market leaders' business environment does not allow them to pursue disruptive innovations when they first come out, because they are not profitable enough at the outset and because their development can divert scarce resources from sustaining innovations (needed to compete against today's competition), (Peters, 2017) [11].

A disruptive process may take longer to develop than by the conventional approach and the risk associated with it is greater than other more incremental or evolutionary forms of innovation, but once deployed in the market, it achieves much faster penetration and a greater degree of impact on established markets. In addition to business and economics, disruptive innovations can also be considered disruptive to complex systems, including economic and business-related aspects (Schwab, 2017) [13]. In relation to this evolving process of technology, West (2018) [17] portrays what is and is not (a) disruptive innovation:

- Outage is a process, not a product or service, that occurs from the periphery to the mainstream.
- They originate in low cost bases (less demanding customers) or in new markets (where they did not exist).
- New companies do not serve traditional customers until quality meets their standards.
- Success is not a requirement and some businesses may be disruptive, but fail.
- The business model of the new company differs significantly from the current one.

Technological changes that hurt established businesses are usually not radically new or technologically difficult. However, they have two important characteristics: First, they often have a different set of performance attributes - which, at least initially, are not valued by existing customers. Second, the performance attributes that existing customers value improve at such a rapid rate that new technology can later invade established markets (Schwab & Davis, 2018) [14]. In 1979, futurist Alvin Toffler

popularized the concept of a new information age, underpinned by several key ideas, including media de-massification, the end of mass production and mass consumption, personalized service, decentralization, interactivity and total products, but hyper-flexible employment. Information and communication technologies (ICTs) have now comprehensively represented images and expectations of the future. Hopes of continued progress, economic growth, skills enhancement and possibly also democratization are linked to new ICTs as well as fears of totalitarian control, alienation, job loss and insecurity (Matt, Hess & Benlian, 2015) [8].

Currently under the terms Industry 4.0. and Fourth Industrial Revolution (QRI), refer to the incipient transformation of the production of goods and services resulting from the application of a new wave of technological innovations (Hirschi, 2018) [6].

The essential element of this transformation is considered the cross between online production, processing processes and information flows such as Internet of Things (IoT), Cloud, Big Data and devices (sensors, chips) that communicate independently between each other. themselves along the entire value chain. Companies would establish global networks incorporating their machines, storage systems and production facilities in the form of cyber-physical systems (SCF), (Chung & Kim, 2016) [4].

The World Economic Forum Report on the Future of Labor (2018) portrays the changing nature of work and examines how technology shapes the relative demand for certain skills in the labor markets and expands the reach of business, robotics and digital technologies, for example. enable companies to automate, replacing work with machines to become more efficient and innovate, expanding the number of tasks and products.

Ransome (2019) [12] explains the process of how disruptive technology, through its necessary support network, dramatically transforms a particular industry. When technology that has the potential to revolutionize an industry comes up, established companies often see it as unattractive: it is not something their top customers want, and their projected profit margins are not enough to cover the cost structure of large companies.

As a result, new technology tends to be ignored in favor of what is currently popular with the best customers. But then another company comes in to bring innovation to a new market. Once disruptive technology is established there, smaller-scale innovation rapidly increases technology performance in customer-value attributes (Westerman, Bonnet & McAfee, 2014) [18].

The implementation of high technology is often resisted. This resistance is well understood by active participants. The electric car will be weathered by gas station operators just as ATMs were weathered by bank tellers and automobiles by horse manufacturers (Willcocks & Lacity, 2016) [19].

According to industry leading representations 4.0. Private and public institutions, their effects are expected to be mainly positive, as regards productivity, economic opportunities and the future of work (Ustundag & Cevikcan, 2017) [16].

According to Schwab & Davis (2018) [14] in Open Round Table Annals on the Future of Labor (2018), the "Fourth Industrial Revolution" has the potential to raise global income levels and improve the quality of life of populations across the world. the world. Ransome (2019, p. 77) [12], today we are at the beginning of a fourth industrial revolution. It began at the turn of the century and is based on the digital revolution. It is characterized by a more ubiquitous and mobile internet, smaller and more powerful sensors that have become cheaper and artificial intelligence and machine learning.

According to Colombo *et al*. (2017) [5], The word 'revolution' denotes abrupt and radical change. In our history, revolutions have occurred when new technologies and new ways of perceiving the world trigger a profound change in social structures and economic systems. Technology has the role of reducing company costs and increasing the production of goods, whether they are consumer goods or capital goods.

The inventions of the eighteenth century to the present day are influencing the direction of the economy. New technologies have generated many advances in the quality of life of humanity. Technology is the fruit of human knowledge accumulated over time and advances have been faster and faster as humans uncover the mysteries surrounding the functioning of their brain (Bloem *et al*., 2014) [2].

In short the article brings a look of Brazilian economists aware of the speed with which Industry 4.0 has been producing changes and digital transformations in the economy. The expressions Fourth Industrial Revolution, Fourth Technology Revolution, Revolution 4.0 and Industry 4.0 will be used with the same meaning in this article, trying to explain how these three expressions have been disseminated in the media, at conferences and lectures held in various institutions in Brazil and around the world.

The steam engine revolution

The mechanization of industry and agriculture occurred with the use of the steam engine invented by the Scottish engineer James Watt in 1765. The application of the driving force in industry enabled the development of the factory system. Spectacular access to transport has taken place using trains and steamships. The first steam locomotive in the world was the invention of the English engineer George Stephenson in 1825.

The first technological revolution, which is recognized as the Industrial Revolution or First Industrial Revolution, took place in the second half of the 18th century (approximately 1760-1840). England as a pioneer nation. Its greatest symbol is the use of steam energy, extracted from charcoal, as a basic energy source, replacing the traditional forms of energy previously used, namely, traction-powered energy and hydraulic energy. In addition to the transition to steam energy, the introduction of machines and equipment is often emphasized, turning mechanical processes that were previously handcrafted or manual, which depended on muscle strength. We observe the emergence of the first mechanical loom in 1784.

Not so cited, but of as great or even greater importance than these two, for the first technological revolution is the spread of the division of labor, an aspect that has not escaped the keen vision of the Scottish economist. Adam Smith, who dedicated to her the opening chapters of his famous work, The Wealth of Nations, published in 1776. Smith held that a nation's wealth depends on labor productivity and the proportion of workers who are employed productively.

This large increase in the amount of work that, as a result of the division of labor, the same number of people is capable of doing, is due to three distinct circumstances: first, because of the greater dexterity that exists in each worker; secondly, the savings of that time which would usually be customary to lose when moving from one type of work to another; finally, the invention of a large number of machines that make it easier to shorten work, enabling a single person to do work that would otherwise have to be ugly for many (Cherry, 2015) [3].

The electricity revolution

Iron is replaced by steel as the raw material of the base industry. And steam is replaced by electricity as a source of energy for industry. Electricity was essential in the Second Industrial Revolution (Kane *et al*., 2015) [7] and, in this regard, we highlight the 1879 incandescent light bulb of the American inventor, scientist and businessman Thomas Edison, author of a very reproduced statement: "My inventions are one percent inspiration and ninety-nine percent perspiration. "

The second technological revolution (or Second Industrial Revolution) occurred about a century after the first - in the latter half of the nineteenth century, therefore - and is symbolized by the substitution of steam energy for electricity and oil as basic energy sources and the advent of assembly line, which favored mass production (Morrar, Arman & Mousa, 2017) [10].

These new sources of energy provided companies, as they adapted, with far greater potential than that afforded by steam energy, considerably expanding the productive capacity of the countries that most rapidly integrated into this paradigm, in accordance with the meaning given to the term by Thomas Khun4. It was the ready ability to integrate with change that allowed the United States of America to assume world economic (as well as geopolitical) hegemony. We note that the first industrial production line appeared in the slaughterhouses of Cincinnati, USA, in 1870 (West, 2018) [17].

The computer revolution

The Third Industrial Revolution, which spread in the second half of the twentieth century, is, according to professor and economist Eduardo Giannetti, constituted by technologies aimed at the search, generation, processing and transmission of information and genetic engineering (Schwab & Davis, 2018) [14].

Peters (2017) [11] states that it is often referred to as the digital or computer revolution because it was driven by the development of semiconductors, mainframe computing (the 1960s), personal computing (the 1970s, and 1980s), and the internet (1990s). We note the first programmable logic controller (PLC) in 1969.

This Third Industrial Revolution, characterized by the emergence of the first computer (1943) and the first robot (1948) to automate production, therefore, by the increasing use of computers whose size It has been rapidly declining, is often associated with the phenomenon of economic globalization and, according to West (2018) [17], has been accompanied by the creation of free trade areas and integrated economic blocs (European Union, NAFTA, MERCOSUR, etc.) and interconnection. and interdependence of physical and financial markets on a planetary scale (Willcocks & Lacity, 2016) [19].

During this period, we witnessed the increasing use of electronic chips and the relative importance of Asian countries in the world economy, starting with Japan, which became the world's second largest economic power from 1992 to 2009, and the so-called Asian Tigers in the 1980s. 1980 (South Korea, Singapore, Taiwan, and Hong Kong), currently reaching China, the world's second largest economy since 2010, and most recently India (Hirschi, 2018) [6].

The Autonomous Integrated Robot Revolution

Finally, the Fourth Industrial Revolution, also called Industry 4.0, a term coined in 2011 at the Hannover Fair to describe how this will revolutionize the organization of global value chains (Schwab, 2017) [13] and spread in the early decades of the century. XXI Although we are in its infancy and still needing to understand it to its full extent, we are no doubt left with the speed and breadth of this new paradigm (Ransome, 2019) [12].

In this regard, it is worth reproducing the vision of Kane *et al*., (2015) [7], in the introduction of their work: Imagine the unlimited possibilities of billions of people connected by mobile devices, giving rise to processing power, storage resources and access. to unprecedented knowledge. Or imagine the astonishing profusion of technological news that spans numerous areas: artificial intelligence (AI), robotics, the internet of things (IoT), autonomous vehicles, 3D printing, nanotechnology, biotechnology, material science, computer storage. energy and quantum computing, to name just a few. Many of these innovations are just beginning, but they are already reaching a turning point in their development, as they build and amplify each other, merging the technologies of the physical, digital and biological worlds (Morrar, Arman & Mousa, 2017) [10].

As is natural when a technological change of this magnitude occurs, there is some resistance from some skeptical people, who seek to minimize the importance of ongoing change by saying that it is no exaggeration to compare them with previous technological revolutions or past industrial revolutions. (Chung & Kim, 2016) [4]. Schwab & Davis (2018) [14], however, is convinced of the Fourth Industrial Revolution and has three reasons to justify his point of view: speed; the amplitude and depth; and the systemic impact.

According to Ransome (2019) [12], the rapidity of the advances that are taking place is unprecedented in history and interferes in almost all sectors of all countries. In terms of breadth and depth, it has the digital revolution as its foundation and integrates diverse technologies, leading to profound paradigm shifts and ultimately systemic impact as it involves the transformation of entire systems between countries and within them into companies, sectors and throughout society.

Already Ustundag & Cevikcan (2017) [16], say that digital technologies, based on the computer, software and networks, are not new, but are causing disruptions to the third industrial revolution; they are becoming more sophisticated and integrated and, consequently, transforming society and the global economy.

In the Fourth Industrial Revolution there is the convergence of the biological (digital technology applied to genetics), digital (internet of things or digital platforms) and physical (3D printing or advanced robotics) worlds, for example, a cook robot. In Silicon Valley, California, Zume Pizza offers delicious robot-made pizza (Hirschi, 2018) [6].

According to Chung & Kim (2016) [4], Industry 4.0 is the comprehensive transformation of the entire industrial production

sphere through the fusion of digital and Internet technology with the agreed industry.

In developed countries as well as emerging countries, among the ten professions least prone to automation in the Fourth Industrial Revolution, highlighted by decreasing order of probability by Schwab & Davis (2018) [14] are: 1) Substance abuse and mental health social workers; 2) Choreographers; 3) Physicians and surgeons; 4) Psychologists; 5) Human resource managers; 6) computer systems analysts; 7) Anthropologists and archaeologists; 8) Marine engineers and naval architects; 9) Sales Managers; and 10) Directors.

Many industries in developed and emerging countries invest billions of dollars a year in information technology (IT), the Internet, robots, e-commerce, and digital marketing to attract more national and international consumers to their products or services (Willcocks & Lacity, 2016) [19].

The following is a summary of the four major industrial revolutions. From the late eighteenth century to the present day there have been four major industrial revolutions: the steam revolution, the electric revolution, the computer revolution, and Industry 4.0 (Peters, 2017) [11]. Table 1 provides a synthesized view of the main features of technological revolutions or industrial revolutions from the 18th to the 21st century.

Table 1: Technological characteristics of industrial revolutions

Industrial Revolution	Período	Características tecnológicas
First Industrial Revolution	It began in the second half of the eighteenth century and advanced until the mid-nineteenth century. It occurred between the 1760s and 1840s.	• Steam machine • Replacement of artisanal production by factory production; • Mechanical loom.
Second Industrial Revolution	It began in the nineteenth century and advanced the first half of the twentieth century. It occurred between the 1860s and 1900s.	• Electricity; • Petroleum; • Taylorist-Fordist production system division of manual and intellectual work; • Automation and mass production; • Mobile assembly line.
Third Industrial Revolution	It began in the second half of the twentieth century and advanced until the end of this century. It occurred between the 1960s and 1990s.	• Emergence of informatics and advancement of communications; • The knowledge society emerges; • Flexible production system; • Information Technology (IT); • Computing.
Fourth Industrial Revolution	It began in the first decade of the 21st century, in the 2000s.	• More ubiquitous and mobile Internet, smaller and more powerful sensors; • Fusion of technologies and interaction between physical, digital and biological domains; • Connected intelligent systems and machines enabling a mass customization production model; • Advanced robotics.

Source: Schwab & Davis (2018) [14]

Technological innovations in the Fourth Industrial Revolution

With the beginning of the Fourth Industrial Revolution, several technological innovations emerged, among which we highlight:

1. Artificial intelligence (AI);
2. Robotics;
3. Internet of things (IoT);
4. Autonomous vehicles (cars, trucks, airplanes and boats without drivers);
5. Drones (they are essentially flying robots);
6. 3D printing (Third Dimension);
7. Nanotechnology;
8. Biotechnology;
9. Neurotechnology;
10. Energy storage;
11. Cloud Computing;
12. Quantum Computation;
13. Big Data;
14. Synthetic Biology;
15. CPS (Cyber Physical Systems);
16. Blockchain;
17. Information and Communication Technology (ICT);
18. Machine Learning;
19. Biomedicine;
20. Shared Economy Apps (Uber, Airnb, Alibaba, Cabify, etc.).

In Collaborative Economics, new ways of organizing collective work in society such as coworking occur daily. The factors that distinguish the Fourth Industrial Revolution from the previous three industrial revolutions are the speed, breadth, and depth of technological innovations; besides the fusion of technologies and the interaction between the physical, digital and biological domains in the industrial sector. For example, a refrigerator connected to the IoT sends daily health information such as temperature and power consumption on your door's digital screen, the food supply, stating that the cheese, ham, curd, eggs, in addition to fruits and vegetables (Bloem *et al*., 2014) [2].

At the last annual meetings of the World Economic Forum in Davos, Switzerland, the role of the Fourth Industrial Revolution in addressing the grave problems of humanity such as misery, social inequality, global warming, terrorism and international conflicts has been emphasized (Colombo *et al*., 2017) [5]. It is worth mentioning the advanced robotics today. The word robot is of Czech origin. We can find robots for operational and industrial application as well as robots with artificial intelligence. Recently, Japanese scientists launched the world's first real-life humanoid robot from a newscaster (Kane *et al*., 2015) [7].

Robots are already part of the lives of many humans and factories in developed countries like Japan and emerging countries like

China. According to the International Robot Federation (IFR), China is the country with the most robots in the world, with 87,000 robots in 2019. Japan is in third place with 38,586 robots in 2019. Brazil It has 1,207 industrial robots (Ustundag & Cevikcan, 2017) [16].

Today it is almost unanimous that robots represent a lot to humanity because they can protect it and help it in its quest for a better quality of life. For Klaus Schwab, we are now in the next phase of the new technology, the Fourth Industrial Revolution (Ransome, 2019) [12]. We need to be aware of their impacts on the economy and the labor market. Business automation, robotization and 3D printing could end up with 9 million formal jobs worldwide by 2021 (Schwab & Davis, 2018) [14].

The Fourth Industrial Revolution is already underway, humanoid robots are already working in smart factories and smart answering services, so get ready for this revolution, as it's your turn to be able and willing to create your new opportunity, your new business (Matt, Hess & Benlian, 2015) [8].

In this world, where change occurs at breakneck pace, it is impossible to predict what will happen in a few years, hence the title of this article. Industry 4.0 has begun and the gold of the 21st century is knowledge (West 2018) [17].

Conclusions

The current wave of technological innovation and its relationships with work and production are composed of expressions such as Industry 4.0 and digital capitalism. The rhetorical narratives and expectations that accompany these definitions of current changes in capitalism are not new.

They confirm and broaden the rhetoric and expectations that in recent decades have been linked to concepts such as post-Fordism and the knowledge-based economy. In this article, the choice was to focus primarily on the implications that current transformations may have on the job, given what has happened in recent years and the current scenario. In particular, the rhetoric about digital and knowledge work was confronted with the literature and evidence on this subject.

What emerged is that all the transformations often called the "digital revolution" so far have failed to deliver on any of the promises it has made. Work organization does not have to become more horizontal, if not partial and formal. Workers did not increase their decision-making power or autonomy. Work has become more creative only for a fraction of highly skilled workers.

On the other hand, work has become more precarious and less paid, and the distinction between working time and life time has narrowed. Contrary to what is stated by Industry 4.0. Institutional readings, so far technological innovation has not replaced predominantly less skilled jobs.

The creation of new jobs mainly refers to the backlog of services. So far, digital innovation has produced predominantly results that companies have always pursued in the history of capitalism: reducing the workforce, wages, guarantees, and work-related rights and bargaining power of workers; an increased ability to monitor and evaluate work performance; labor force dispersion and capital concentration (monopolies, "the Winner takes all the economy"), ownership and management functions; Increased production process efficiency and value chain management due to increased production and dissemination of data.

Nowadays, companies are managing to make the second pole of these dichotomies (digital Taylorism, verticalization, commodification, individualization) dominating the first (autonomy, participation, peer cooperation and socialization of production). As has always been the case in the history of the relationship between capital and labor, the possibility that the process of production will change in favor of labor depends mainly on the capacity for coalition and conflict and on the negotiating power of the latter.

These elements develop within the work also thanks to the support of dynamics (political, cultural, organizational) and actors that are external to the production process, as the history of workers' movements demonstrates. Therefore, positive "Industry 4.0" results for workers will depend on social and political conflicts.

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