

# **Disruptive Technologies and Implications for Business Sustainability**

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## **Abstract**

The objective of this research is to analyze the disruptive technologies that support business sustainability within the framework of digital transformation and industry 4.0. In this context, qualitative research is carried out through a systematic literature review of industrial revolutions, disruptive technologies, and business sustainability. The results show that some disruptive technologies such as: Blockchain, Big Data, Internet of Things and Artificial Intelligence are relevant in supporting some business sustainability programs. This suggests a strong practical impact on the way we use some technologies for our daily activities, as well as, the way we work, live, and buy/consume products and services. It is expected that some disruptive technologies gain more access to society and economy soon, and become affordable, and therefore have a stronger impact allowing companies and industries to support their business sustainability program and goals.

**Keywords:** disruptive technologies, business sustainability, and industrial revolutions.

## **Introduction**

In the framework of the fourth industrial revolution a new disruption is taking place, which is defined as “the action of completely changing the traditional way that an industry or market operates by using new methods or technology” (Cambridge, 2021). Its challenges must be met by mobilizing decision-makers, producers, consumers, and global society to foster and adopt new technologies that allow society, economy, business, and all stakeholders to work towards the international and local commitments regarding sustainability in the long term.

In this context, the structure of the research is divided in four stages. First, it begins with a literature review and analysis of the development of the industrial revolutions, as stated in (Klaus Schwab, 2017).

The second stage is carried out through a literature review on disruptive technologies to identify which are the most cited in relation to the fourth industrial revolution and business sustainability. To achieve this, several key author and their contributions are reviewed in the areas and topics such as blockchain, big data, internet of things and artificial intelligence.

The third stage is a review of sustainable development and business sustainability, considered the United Nations Sustainability Goals, which provides a general view of the main challenges that all stakeholders have for the 2030 and 2050 agendas.

In the fourth stage, a literature review was carried out in Scopus about the four selected technologies. Also, a graph was developed that shows the identified relationship between these technologies, the industries that have adopted them and the business models that emerged from the acceptance of these main technologies.

The final part of the article is entitled "Towards a better use/implementation of disruptive technologies for business sustainability" to match the theoretical framework and give way to the conclusion, which states that indeed, the 4 disruptive technologies studied in the article can support the transition to business sustainability if they are complemented by innovation and an effective business model.

## **Industrial Revolutions**

Karl Marx and Friedrich Engels<sup>1</sup> proposed the modes of production by observing that humans are different from animals because they can produce his own means of life. These livelihoods arise because of the search for satisfaction of needs and desires, coupled with the pleasure that human beings evoke to go further, go faster, mass produce and innovate. When man begins to create instruments that facilitate his day to day, industrial revolutions emerge.

An industrial revolution originates "when new technologies and novel ways of perceiving the world unleash a profound change in economic systems and social structures." (Schwab, 2017, pág. 12) The first took place in 1760 and this represented a great step in the evolution of the human being because the creation of James Watt's steam engine triggered the development of the industry in a world that was leaving the feudalism, that period of great subjugation that at the end concentrated capital on those who were merchants. While the serfs became workers in the large industries that originated the first industrial revolution. It is worth mentioning that the main industries that developed were textiles and steel. The second industrial revolution is driven by the development of electricity and the use of fossil fuels due to a total ignorance of what they cause in the environment. This age was characterized by mass production as a result of the increased demand for goods and services. It was necessary to transform the machines to provide better results in less time. In the third industrial revolution, information technologies emerged, which managed to connect the world in a more effective way. As there are more demanding industries that work with electricity, it was sought to generate electricity through nuclear energy, but in the face of dangerous use and imminent climate change, efforts were directed to the development of renewable energies that integrate technology with the force of nature to meet the needs of today and tomorrow. For that reason, the fourth industrial revolution arises trying to provide technological solutions to a growing and unsustainable industry.

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<sup>1</sup> Karl Heinrich Marx (1818-1883) was a revolutionary, sociologist, historian, and economist known for creating the Communist Manifesto in 1848 alongside Friedrich Engels (1820-1895), who was a philosopher, journalist, and communist theorist.

**Chart 1** Industrial Revolución.

NAME.	TIME.	CONTEXT.	TECHNOLOGICAL DEVELOPMENTS.	ENERGY SOURCE.	IMPACT ON ENVIRONMENTAL AND SOCIAL RESPONSIBILITY.
First Industrial Revolution.	1760	Transformation from a feudal world to a capitalist one. Merchants became the owners of capital by starting industries.  In 1830 socialism and communism slowed down the advance of industries, but models failed, and capitalism returned.	The steam engine and railroads.	Carbon.	Concern for the environment increases due to the new industries and Rachel Carson's voice in the book "Silent Spring" where she invites us to reflect on the use of pesticides.
Second Industrial Revolution.	1870	Capitalism causes mass production, and it is main engine of countries. People invest in science and technology.	Electricity and the assembly line.	Electricity through fossil fuels such as oil.	Institutions such as the World Labor Organization emerge to regulate industry and control labor exploitation.
Third Industrial Revolution.	1960	Capitalism is stronger than ever, and internationalization is being promoted.	Semiconductors, mainframe computing, personal computing, and the internet.	Nuclear energy.	Greenpeace arises as a movement against nuclear practices.
Fourth Industrial Revolution.	2001	The effectiveness of capitalism is called into question by its high negative impact on the environment.	More ubiquitous and mobile internet, smaller and more powerful sensors, artificial intelligence and machine learning, more sophisticated software, and networks at their core.	Renewable energies such as solar, wind, hydro, geothermal, tidal and biomass.	Millennium Goals and Sustainable Development Goals 2030. The Kyoto Protocol enters into force.
Fifth Industrial Revolution.	2005 (is in development).	It is developed in a neoliberal, digital and responsible context. In this model, people are at the center of technology.	Robots, cognitive computing, IoT, blockchain, collaboration between humans and systems.	Renewable energies.	It seeks to establish a link of cooperation and not dependency between machines and humans to make life possible in 2050.

The table on Industrial Revolutions shows the history moments where disruptions have occurred, the technologies that have driven them and the evolution of energy to meet the demand of the industry and the social and environmental needs. Currently, we live under the ideas of the fourth industrial revolution, but in the face of its deficiencies and new challenges, the proposal of a fifth industrial revolution is being developed that seeks to put the human being at the center of technology.

## **Research Method**

Once the context in which the research is carried out is understood, it is important to carry out a systematic literature review through specialized databases such as Elsevier, Science Direct and Google Scholar with the keywords disruptive technologies, sustainability, and industrial revolutions to define the study topic and its implications for business sustainability.

With the information collected, a literature organization diagram was made to define the structure of the research and identify the most important authors of each one. Also, tools such as Mendeley were used for document storage and analysis, as well as to manage references during development. This study identifies and qualitatively analyzes 51 research papers related to the implications of disruptive technologies on sustainability.

## **Fourth Industrial Revolution and its Disruptive Technologies**

Today's technology has a high potential for disruption, which means that technology can transform some aspects of daily life and business. This kind of transformation has been witnessed by humanity in the industrial revolutions, however, in this fourth industrial revolution it is observed that the changes are happening faster than before.

One of the main challenges facing humanity is that the knowledge acquired throughout life will not always be the best because the world is changing and people change with it, as well as their needs and desires. Therefore, industries must begin to accept and seek ways in which they can access new knowledge that will enable them to adapt and survive the wave of technological disruption. According to Christensen, (1995) Technology is the key to transformations and causes innovation.

Therefore, it is important to understand the disruptive technologies that have the potential to transform the production and service industry towards business sustainability. According to Kostof, (2004) "disruptive technologies can be regarded as scientific discoveries that transcend ordinary product / technology capabilities, form the basis of a new competitive paradigm".

Among the strongest disruptive technologies in the fourth industrial revolution are Blockchain, Big Data, Cloud, Cybersecurity, Virtual and Augmented Reality, Smart Cities, Service Robotics, Autonomous Vehicles, Artificial Intelligence, 3D Printing and Nanotechnology. All of them have unique characteristics, but they coincide in their transformative capacity, speed of evolution and adaptability to different industries or business models. Therefore, this research studied the use and behavior of Blockchain, Big Data, Internet of Things and Artificial Intelligence, the technologies that promise to support the transition of business to sustainability.

- **Blockchain:** "to a fully distributed system for cryptographically capturing and storing a consistent, immutable, linear event, log of transactions between networked actors". (Risius & Spohrer, 2017) One of the most important benefits of the blockchain is the confidence that its system provides when working independently. "Blockchain can benefit circular economy practices across industries, but an important issue to consider is that blockchain is not a one-size-fits-all solution. Industrial implications for the blockchain-CE linkages will tend to vary; some industries due to product, process, and supply chain characteristics may benefit more than other industries. We observe that core benefits across industries include developing a digital data management ecosystem for supply chain network integration and collaboration. Industrial supply chain network digitalization has implications for resource and materials regeneration, waste reduction, operational visualization DFG and knowledge (data) excellence for strategic decision making." (Kouhizadeh, Zhu, & Sarkis, 2019)
- **Big Data:** "Big Data processing, especially with the increasing proliferation of Internet of Things (IoT) technologies and convergence of IoT, edge and cloud computing technologies, involves handling massive and complex data sets on heterogeneous resources and incorporating different tools, frameworks, and processes to help organizations make sense of their data collected from various sources." (Nikolov, y otros, 2021) "Simply put, because of big data, managers can measure, and hence know, radically more about their businesses, and directly translate that knowledge into improved decision making and performance." (McAfee & Brynjolfsson, 2012)

- Internet of things: “The term Internet of Things generally refers to scenarios where network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention. There is, however, no single, universal definition.” (Singhania, 2015)
- Artificial Intelligence: “It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.” (McCarthy, 2007)

Currently, sustainable development supports business survival, and the economic, social, and environmental axes give rise to business sustainability. It is important that each organization knows and adapts the different sustainable strategies for optimal business development.

### **Sustainable Development and Business Sustainability**

The first antecedents of sustainable development date back to the 18th century, mainly during the Industrial Revolution between 1760 and 1840. It began in England, but soon expanded around the globe and this constituted the beginning of the linear economy, which was characterized by the transition from a life based on agriculture, fishing, livestock, and traditionally artisanal processes to industrial production that, little by little brought great technological and mechanical advances with which production increased, managing to meet the needs evoked by that time. Since then and until now, human beings have dedicated themselves to overexploiting resources, with the sole aim of uncontrolled production without any responsibility. The ease with which products were generated began by giving birth to societies, but over time led them to darken by catering to more whims than needs. This sudden and growing transformation led to crises around the world, due to the overexploitation of resources. This concern gave rise to the beginning of the process of human awareness about the environment, which was strengthened with the use of the term “sustainability”, which was used by German loggers to refer to the balance between cutting down trees and the responsibility to replace them with new to avoid exhaustion.

The next step in the evolution of sustainable development took place in 1962 because of the pesticide effects. Which was exposed to the world thanks to "The Silent Spring", a book by Rachel Carson. She warns that the irresponsible and excessive use of pesticides caused deaths because, in addition to being toxic, they remained in the body and caused problems in sexual reproduction. The title alludes to a spring without birds, where there would only be silence.

Finally, in 1972 the United Nations Environment Program was founded in Nairobi, Kenya by the UN. The program sought to be a spokesperson for the environment, so it was defined that its main purpose would be to promote sustainable development, assess environmental conditions and trends, and contribute to environmental law. The founding of this program had an important impact on the use of new concepts such as “eco-development”, which was used by the first executive director of The United Nations Environment Program (UNEP). Currently, the program is led by Inger Andersen, a Danish economist and environmentalist. The concept of Sustainable Development was made known worldwide in 1987 through the Brundtland Report. The report addressed issues of global concern such as the threats of the future, the need to generate sustainable development, the role of the international economy, as well as common tasks and efforts to be followed. Within this, sustainable development was defined as: “Meeting the needs of the present without compromising the ability of future generations to meet their own needs.” (United Nations Brundtland Commission, 1987) However, it is important to clarify that concern for the environment had already attracted people’s attention since the beginning of the first industrial revolution.

Interest in sustainability increased as the negative impacts of industry on the environment grew. This led to the concept gaining strength, consolidating, and becoming more important. This is how the concept now involves that humans can meet their needs by reinventing ways to do so in a responsible way and by fostering prosperity for nations and individuals, different economic opportunities, greater social benefit by ensuring that citizens participate in decisions that involve the future of the planet and the development of technologies capable of transforming the context. This is concentrated in 3 main axes, which are environmental, social, and economic. Business sustainability seeks to create long-term shareholder value by embracing the opportunities and managing the risks that result from an organization's economic, environmental, and social responsibilities. Business sustainability must meet the needs of the organization and its stakeholders today while also protecting,

sustaining, and enhancing the environmental, social, and economic resources needed for the future. ( Pojasek, 2007) Currently, companies pronounce themselves capable of positively impacting the economy, society and the environment through strategies aimed at sustainable competitiveness.

Achieving the SDGs by 2030 and 2050 requires collaboration and commitment from a range of stakeholders, including governments, businesses and individuals. Some of the main challenges than stakeholders face in achieving sustainability by 2030 and 2050 include: understand the importance and urgency of sustainability, limited resources, limited will and leadership, climate change and environmental degradation, global economic systems, inequity and social justice.

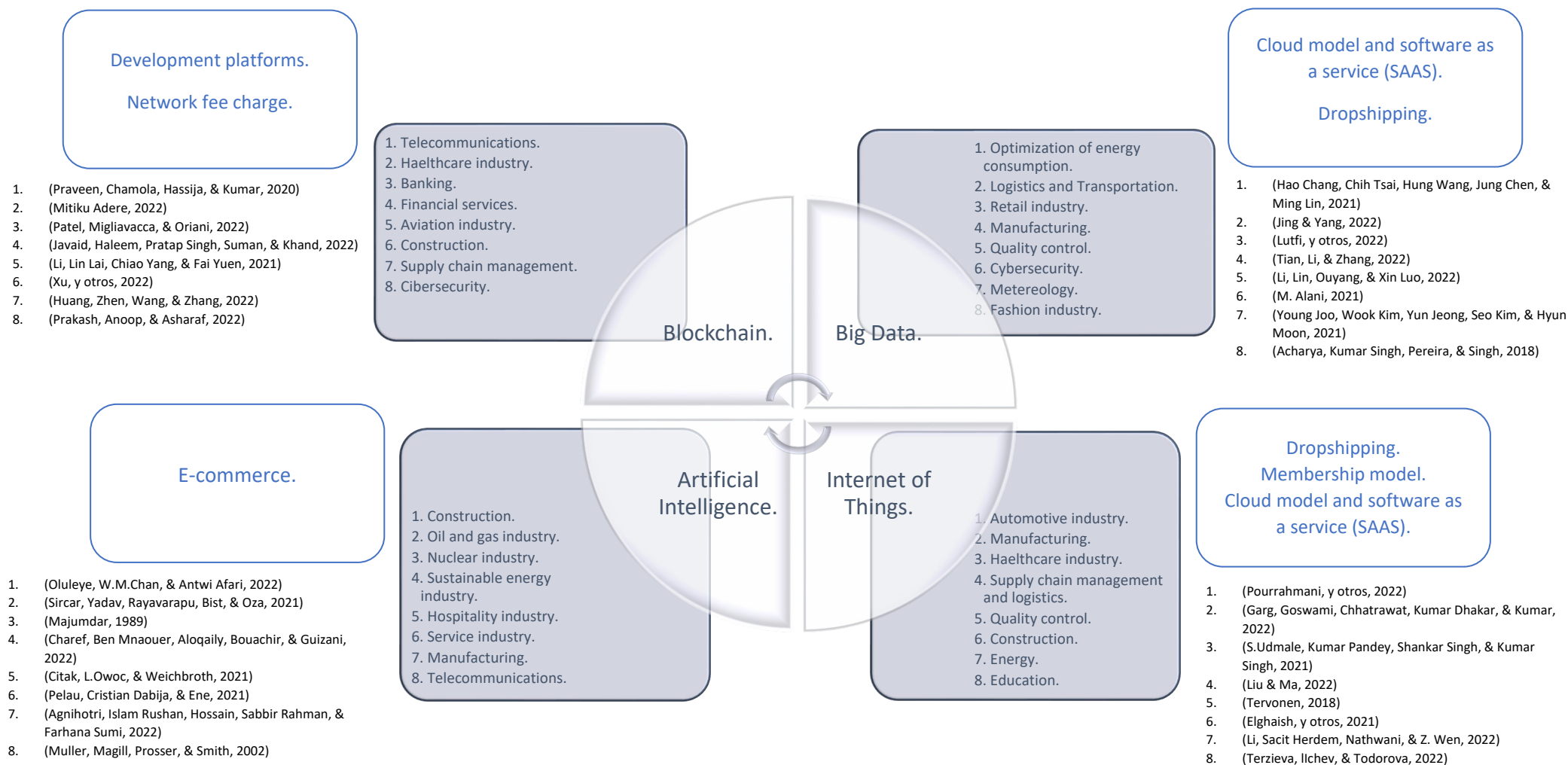
### **Analysis and Discussion of Disruptive Technologies in Business Sustainability**

Despite the popularity of disruptive technologies as a research topic, there is still scant research related to the role of disruptive technologies in business sustainability. However, the analysis of their use and implications can lead us to identify how they contribute to business sustainability.

On the following page a figure was developed that shows the relationship between disruptive technologies, industries and resulting business models, supported by a systematic literature review of the four disruptive technologies that were chosen as the most mentioned in scientific articles in specialized databases such as Elsevier, Scopus, and Google Scholar.

After, there is a section on the implications of each selected disruptive technology to look at how they may support the transition to enterprise sustainability in the industries discussed above.

**Chart 2** Relationship between disruptive technologies, industries and business models.



It is interpreted that disruptive blockchain technology, big data, internet of things and artificial intelligence have a wide range of acceptance in different industries, from healthcare to construction and cybersecurity. In other words, a significant number of important industries can contribute to business sustainability using disruptive technologies, but they must update their business models to achieve a better positive impact on society, the environment, and the economy.

Chart 3 Implications for business sustainability.

IMPLICATIONS FOR BUSINESS SUSTAINABILITY.	Blockchain.	Big Data.	Internet of Things.	Artificial Intelligence.
<b>Economic.</b>	“Blockchain capabilities lead to digital product tracking, authentication, digital rights management, fraud prevention, and the creation of autonomous organizations”. (Goel, 2015)	It optimizes costs to become efficient and can be linked to the waste design of the circular economy posed by Ellen MacArthur.	“IoT can be applied to almost any setting for which appropriate sensors can be developed. For instance, IoT can be applied to industry, by monitoring manufacturing and logistics processes”. (de Villiers, Kuruppu, & Dissanayake, 2021)	Artificial intelligence can provide faster and more efficient responses, it also can drive the circular economy by reducing waste and optimizing production through efficient data designs.
<b>Social.</b>	Blockchain technology is important for business ethics because the transparency and security it provides results in the strengthening of the company's values and its human talent.	It improves decision-making and can guide them towards social responsibility. In addition, it provides security and accessibility to data, but this requires the development of a business culture aimed at sustainability and coupled with effective leadership, technology, and talent management.	According to the World Economic Forum, in 2018 it was determined that the best way to maximize the benefits of sustainable development it is through the analysis and assurance of development metrics in the design phase of IoT projects that show companies in their different sizes. It is worth mentioning that the study was carried out through the mixed investigation of 640 implementations of the IoT.	One of the biggest challenges about AI is getting the population to advance alongside technology so that they are not left behind in their pursuit of sustainability.
<b>Environmental.</b>	“Blockchain technology as a powerful distributed ledger tool of secure interconnectivity has the prowess to facilitate cleaner production of goods and services and address the ethical agenda of business development.” (Upadhyay, Mukhuty, Kumar, & Kazancoglu, 2021)	The truth is that the use of big data has not had priority in the environmental aspect, but it could be the technology that enables the development of new forms of analysis on environmental problems for better decision-making and optimal development of strategies. “As the problem of environmental degradation begins to rise, we must work towards conserving the environment. The rise in big data technologies has made much progress in fields like healthcare, politics, social media as well as weather forecasting. However environmental sector has yet to take benefits from big data.” (Sharma & Bajracharya, 2017)	Through the IoT it is possible to promote sustainability by providing effective monitoring of recycling, promoting sustainable development on digital platforms, and carrying out better energy management.	“AI may be useful in helping us take better care of the planet in terms of supporting waste and/or pollution management, but also, predictive systems can be used for earthquakes and weather forecasting to better recognize the likelihood of extreme event occurrences such as hurricanes and tsunamis.” (Khakurel, Penzenstadler, Porras, Knutas, & Zhang, 2018)



The business sustainability implications chart shows how disruptive technologies support each pillar of business sustainability through their use. The challenge is to integrate the economic, social, and environmental aspects, which can be achieved through the redesign of the business model of the industry in which the technology operates.

### **Towards A Better Use/Implementation of Disruptive Technologies for Business Sustainability**

In the framework of digital transformation, disruptive technology is sometimes interchanged with disruptive innovation technology, without a business model, does not have an intrinsic capacity to be disruptive. A disruptive technology or disruptive innovation is a type of innovation that creates a new market and value network and, in the process, disrupts existing ones through displacement of incumbents. One distinguishing characteristic is that this innovation improves products or services that exceed customer immediate needs, create new market niche, and then lower price to disrupt the existing market over time. Interestingly, the most important component in disruptive innovation is not the technology, but the business model. (Ekekwe & Islam, 2012)

Disruptive technology, understood as that which has the ability to transform things in its environment can be used in different industries such as: Telecommunications, Healthcare industry, Banking, Financial services, Aviation industry, Construction, Supply chain management, Cybersecurity, Optimization of energy consumption, Logistics and Transportation, Retail industry, Manufacturing, Quality control, Meteorology, Automotive industry, Construction, Oil and gas industry, Nuclear industry or Sustainable energy industry can produce changes in society, environment and economy to support business sustainability, but it needs innovation and updating within the organization to adopt a business model that is in line with the current technological context derived from the fourth industrial revolution and the commitment of the human being, the environment and themselves.

### **Conclusions and Further Research**

One of the most important challenges of society and especially of industries is to adopt disruptive technologies before others to obtain a competitive advantage. However, through the qualitative research carried out in this article, it is observed that this competitive advantage is not only economic but is also a social and environmental advantage. Which means that disruptive technologies can support the transition to business sustainability if they are complemented with innovation and an efficient business model.

The results show that the main industries in which this disruption towards Business Sustainability can happen are in twenty-one industries, because they already use these technologies, but they must modify their models and innovate to positively impact Business Sustainability. In addition, there is great potential for adoption in other industries that remain in a technological lag but knowing what technologies can be implemented in their businesses through this article, it is possible to expand the benefits to more areas and industries.

The challenges within the implementation of disruptive technologies to support business sustainability are to bring or promote technologies with the world population to create trust for users, create instruments capable of regulating the movement of data and use of technologies, as well as revolutionize traditional industries.

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