



**POLITECNICO  
DI TORINO**

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Master of Science in  
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## **Industry 4.0 in developing countries: The case of Colombia**

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*“We must develop a comprehensive and globally shared view of how technology is affecting our lives and reshaping our economic, social, cultural, and human environments. There has never been a time of greater promise, or greater peril.”*

**- Klaus Schwab, Founder and Executive Chairman, World Economic Forum**



*To my family*

*“It's the possibility of having a  
dream come true that makes  
life interesting...”*

*– The alchemist, Paulo Coelho*



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\* \* \*

When you dream something, you set your goals and you work hard to achieve them. It's a checklist that you keep filling out as time goes by.

Applying at my university in Colombia for the double degree, check; being accepted, check; applying at the Politecnico, check; getting accepted, check; receiving the visa to come to Italy, check; buying a one-way plane ticket... check.

... That's when everything got real.

The doubts for not being sure if I had made the right decision, the fear of leaving my mom and dad, my siblings, my house and my friends behind, hit me like a ton of bricks.

And even though I had been far from my country before, I knew this time was going to be different. Going away by myself, to a country where I barely knew how to say anything, without a house and not really knowing when I would ever come back home, was terrifying. But it was the good kind of scared, the one where you know that there's nothing that's going to stop you from doing it, the one where you know that it's going to be extremely worth it.

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To finish up, I'll leave a quote that I read somewhere once and that I have found very useful ever since.

To whoever's reading this:

“Yes! Take the risk!

...that is always the answer”

Yours sincerely,

Luisa Alejandra Guzmán Mora.



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## i. List of abbreviations

**4IR:** Fourth industrial revolution

**ANDI:** National business association of Colombia

**CPSs:** Cyber physical systems

**CRC:** Commission of communications regulations

**DANE:** Name of the entity for the national department of statistics, abbreviation for Departamento Nacional de Estadísticas in Spanish

**DEI:** Digital economy index

**I4.0:** Industry 4.0

**ICT:** Information and communication technologies

**ICTNP:** ICT's national plan

**IoT:** Internet of things

**M2M:** Machine to machine

**MinTIC:** Ministry of Information and Communication technologies in Spanish

**MNEs:** Multinational enterprises

**MSMEs:** Micro, small and medium enterprises

**N.C.P:** Not classified previously

**NDP:** National development plan

**NRI:** Network readiness index

**OECD:** Organization for Economic Cooperation and development

# CHAPTER

# 1

## Introduction

Introductory section that presents the subject to be developed throughout the study, the objective set and the methodology carried out.



# 1. Introduction

Ever since the end of the eighteenth century the world has been witnessing an industrial transformation that has radically changed the way we live and interact with our surroundings.

It all began with the transition from muscle power to mechanical power; power that came from steam and water, leading to the creation of engines and the mechanization of processes. This first revolution was followed by two other major breakthroughs. The first one at the beginning of the twentieth century, known as the second industrial revolution, resulted in the ability of producing in large quantities (mass production) due to the use of electricity and the division of labor; and the second one, the third industrial revolution, starting in the seventies, introduced the application of electronics and information technologies to increase the level of automation in production processes.

This twenty-first century has brought with it the beginning of a new revolution, the digital revolution. There is yet a lot to be known about it and that is why it has been on the spotlight for the last couple of years, with a rising number of publications and studies on the subject, not only from scholars, but companies and governments, as well as many other entities.

This fourth industrial revolution, also known as Industry 4.0, aims to combine traditional manufacturing and industrial practices with disruptive technologies, such as the internet of things (IoT), machine-to-machine communications (M2M), cloud computing, cyber-physical systems (CPSs), to transform traditional industries into intelligent ones by introducing self-maintainability, self-optimization, self-cognition, and self-customization into the industry.

The implementation of these practices sets a number of challenges for companies from the technological, organizational and management points of view and while some processes are expected to be simplified, others are expected to become much more complex and embedded. This will result in an impact also on the labor market and the society as a whole.

At the same time, it is known that there's a large digital divide between developed, developing and the least developed countries. And since large parts of the developing world remain detached from the technological advances and the Internet, and many people lack access to high-speed broad-band connectivity there is a need to mitigate the risk that digitalization can worsen the digital divides through policymaking at national and international levels.

In Colombia, more and more people are becoming aware that industry 4.0 presents major challenges for both, the industries and the government; how to understand the new digital culture, accepting the changes, optimizing the current infrastructure, investing in new technologies and counting on human talent with the appropriate skills, are just a few of the several possible challenges. Nonetheless, there's evidence on how companies from different sectors of the industry like mining, fashion, retail, food, oil or manufacturing are beginning to see the benefits of the correct implementation of industry 4.0.

The Ministry of Information and Communication Technologies (in Spanish MinTIC) is the entity in charge of the design, adoption and fostering of the policies, plans, programs and projects of the ICT sector in Colombia. One of its main functions is to increment and facilitate the ICT access to all the citizens of the national territory.

The MinTIC, according to their website<sup>1</sup>, has a technology plan that aims to give the country a technological leap by the massification of the internet and the development of the national digital ecosystem, called the “digital future belongs to everyone” that aims to close some of the now existing digital gap. as the MinTIC states on the description of the plan “It is demonstrated that there is a direct correlation between Internet penetration, the appropriation of Information Technology and Communications (ICT), employment generation and poverty reduction” and that is why they expect the new digital agenda to evolves into significant benefits for all the Colombians”. (Mintic, s.f.)

To develop this, the MinTIC has several offices, directives, sub-directives, commissions and agencies to manage and control all the aspects related to the different projects planned.

One of the institutions related to the MinTIC, is the Commission of Communications Regulations (CRC) that provides the first measurement of the progress of the digital economy in Colombia. The results of the Digital Economy Index estimated by the CRC are provided at both country and regional levels, as well as the dimensions, subdimensions and indicators considered in the construction and estimation of the index with the data available in 2016 (CRC, 2018). Depending on availability, figures are also shared for previous years and for the regions defined in the measurement methodology - A further in-depth description and analysis of the results will be made throughout this study.

On the other hand, the National Business Association of Colombia (ANDI) is, as they state on their website<sup>2</sup>, a non-profit organization whose main purpose is to expand and promote economic, social and political principles within a free enterprise system, based upon beliefs that include human dignity, political democracy, social justice, private property and liberty. ANDI is, currently, the country’s most important non-profit organization with more than 1.200 members that represent around 40 % and 55 % of the national GDP. (ANDI, ANDI, s.f.)

ANDI was created in the city of Medellin in September 11, 1944, becoming the most important private sector association. It groups more than 1100 companies that belong to different sectors of the economy: manufacturing, financial, food, mining, health, agriculture, services, among others and therefore represents a high percentage of Colombia's GDP and total employment.

As representative of the private sector's interests, the National Business Association of Colombia assumes the representation of its members before national and international institutions, dealing with economic, legal, social, environmental, and business issues. One of the main purposes of ANDI is making Colombia and its entrepreneurs digital. For this reason, they have developed a Digital Transformation agenda that is essential for the strategies and tactics to improve the productivity of companies and the competitiveness of the country. It works under 5 main pillars: Digital Ecosystem, Digital Government, Digital Connectivity, Digital Talent and Digital Economy. (ANDI, ANDI, s.f.)

In 2016, the first Survey was launched as a special module of the Joint Industrial Opinion Survey (EOIC)<sup>3</sup> and, therefore, its responses correspond to the manufacturing industry. In 2017, a second exercise was carried out -including not only companies from the manufacturing industry, but companies from other sectors, especially services- to compare,

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<sup>1</sup> <https://www.mintic.gov.co/portal/inicio/>

<sup>2</sup> <http://www.andi.com.co>

<sup>3</sup> In spanish: Encuesta de Opinión industrial conjunta



know the progress and strengthen the information about what trends are Colombian entrepreneurs leaning towards in order to take advantage of the Digital Economy. (ANDI, Encuesta de transformación digital 2017, 2017)

For the second edition companies were measured to determine their progress in three dimensions: the necessary conditions for innovation to be adopted as organizational culture; the capabilities for it to happen in a recurring and systematic way within the company; and the results in terms of the materialization of product, process and marketing innovations. The participation of companies was 50% higher than the previous year, which shows the importance that companies are giving to their innovation processes, which are currently becoming a fundamental aspect to be more competitive in a globalized world in which changes occur more quickly. The panorama presented by this exercise showed that innovation in Colombia is contributing to boost successful businesses that leverage the growth of business organizations and pose promising scenarios for their future.

It is important to add that this Ranking is not the only project that Andi is promoting. the results of the survey and other projects will also be discussed further in the development of this study.

Another important remark of Colombia's current situation regarding the 4IR is how Medellin, the second-largest city in Colombia, has become the first Spanish-speaking affiliate centers of the fourth industrial revolution network. Both, national and international governments are sending associates to be part of project teams for 12 to 18 months. So that they can, then, become the connection to their governments, to help co-design new policy frameworks to be piloted in their home countries. (Fourtané, 2019)

The Fourth Industrial Revolution Network is headquartered in San Francisco with hubs launched in Tokyo, Beijing, and Mumbai in 2018. In addition to these Forum-led centers, the global affiliate centers selected in 2019 now include Norway, Israel, the United Arab Emirates, and the recently added Medellin, in Colombia.

The mission of this network is to maximize the benefits of science and technology for society and to achieve it, they created a global hub of expertise, knowledge-sharing and collaboration, based in San Francisco (WEF, Centre for the Fourth Industrial Revolution, 2019)

Over the last years, Medellin has become recognized internationally thanks to innovative projects with respect to sustainability, infrastructure, economic investment, infrastructure, technology, smart cities and research. Medellin has also been the host of several global innovation conferences. (Fourtané, 2019)

The predominant research-purpose of this study is to explore the industrial transformation process in a developing country, like Colombia, and to confront it with the 4IR now present in developed countries. on the basis of that, making a macro and micro economic analysis of the situation - regarding the readiness of the country as a whole and the main driving forces, opportunities and barriers for the MSMEs within the industry of the country - this purpose emerges from the needs of the companies to stay competitive in the market while also obtaining substantial improvements in terms of quality, productivity, efficiency, price of the product, waste reduction, times of production, etc. without necessarily having to incur in excessive expenses, this study aims to help as a guide to understand the current situation of Colombia for future research.

The major research question is: “what is the current situation of Colombia regarding the fourth industrial revolution, and what are the implications for the government and companies to reach the level of technology present in developed countries?”.

In order to give justified answer to the main question. Few sub-questions were answered in the process:

- What are the main challenges of the 4IR?
- What is the level of digital gap in Colombia?
- How wide is the knowledge gap of citizens, entrepreneurs, government about industry 4.0?
- What are the current policies, plans, actions of the government and other related entities regarding industry 4.0?
- How is the industry in Colombia structured and what are the main industry trends?
- What are the key drivers, opportunities and barriers to reach the fourth industrial revolution for the MSMEs in Colombia?
- Colombia’s readiness for I4.0?

To achieve the objective, the main research method used is systematic literature review. The analytical work in this article makes reference to the existing literature on industry 4.0 and draws on recent studies on the 4IR in Colombia and the world.

The rest of this study proceeds as following: the first section presents an introduction into the concepts of digitalization, digital Economy and Industry 4.0, its main components, the impact and the main challenges for governments and industries, along as the main driving forces and barriers of Industry 4.0 for multinational companies and small and medium enterprises. The second section goes further in-depth into the situation of Colombia. A description of the country, it’s industry, its current technological level and the main macroeconomic aspects regarding the digital environment of the country and the measurement of it done in the past. The third section discusses the case of Colombia regarding specifically the industry 4.0, what are the government plans and advances as well as other examples of companies using the 4IR and about the new center for the fourth industrial revolution that opened recently in the country. The fourth section makes a comparison between Colombia and other Latin American countries to have a wider perspective in the current situation of the country. And the fifth section discusses the closing points, suggestions for MSMEs, areas of future research, after which the article concludes.

# CHAPTER 2

## ┌ The state of the art

This chapter presents the main concepts related to industrialization and industry 4.0 and presents the main elements, technologies , the driving forces and barriers and the main challenges of the fourth industrial revolution.



## 2. State of the art

### 2.1 Digitalization/ digital economy concept

The three concepts of digitization, digitalization and industry 4.0 are three distinct, yet merging concepts. So, in order to expatiate on the concept of industry 4.0 we have to, first, clarify what is the meaning and differences between these other concepts closely related to it.

The traditional approach to digitization simply defines it as taking analog information and encoding it into zeroes and ones so that computers can store, process, and transmit such information i.e. the conversion of text, pictures, or sounds into a digital form that can be processed by a computer. (Bloomberg, 2018)

In the business context, digitization is important both for dealing with analog information and processes - so that the information can be processed, stored, and transmitted also through digital circuits, equipment, and networks. It is important to consider, though, that it is the information you're digitizing, not the processes – that's where digitalization comes in.

The concept of digitalization, also known as digital transformation or digital economy, can be defined as a phenomenon disturbing all sectors of the economy - where traditional products and processes are modified or at least furnished with new digital features. This phenomenon is not only affecting companies in the making of physical products, but every aspect of their business models; their nature, organizational structure, strategy, supply chains and processes are just a few of the things that can be affected. All of this resulting in significant challenges for managers, when deciding what is the best path to follow to satisfy both the needs and preferences of the customers, while still being competitive and innovative regarding their competition.

According to the OECD, the digital economy can also be defined as the result of a transformation process driven by the information technologies and communications. Its revolution has risen the power of technologies, while widely standardizing them; Improving commercial processes and boosting innovation in every sector of the economy. (OECD, 2015)

Notwithstanding, the changes that this transformation is causing in every other sector of the economy are also a reality. Hereafter, the importance of understanding how it affects productivity, growth, public politics, employment, regulation and many diverse subjects.

This new reality represents fundamental changes for the development of countries and puts digital in a leading role that had not been recognized until recent times. It is increasingly clear, that its beneficial effect is cross-cutting to all economic sectors and, consequently, it should not be treated as an isolated issue. Reinforcing always, the importance of monitoring and measuring its progress in order to determine the impact in all economic sectors and, likewise, implementing the necessary measures that would encourage the appropriation of ICTs, in order to achieve a differentiating factor in productive and commercial chains.

In the 2016-forum to discuss how to harness the economic and social benefits of the digital economy in developing countries provided by the Cancun Ministerial, all of the participant countries acknowledged that the digital transformation is a subject that has been developing for a few decades, changing along the way entire economies and societies in many countries.

It was also said that, digital infrastructures are almost fully deployed in the OECD zone, and developing countries are showing evidence of the use of digital technologies in a vast range of areas, areas that go from e-commerce to agriculture and banking. All the participants also agreed on the importance and urgency for governments to be proactive and to adopt a policy-making approach whereby all stakeholders are invited to study, develop and implement a clear way-forward to shape the digital transformation, one which builds on a fully integrated policy approach, addressing also all the challenges created for jobs, skills and trust. (OECD, 2017)

Several studies also emphasize on the importance for both MSMEs and MNEs of creating a digital strategy. But there's still not a set of defined rules to follow, or to know exactly how to approach the digital transformation.

To summarize, it becomes clear that these two concepts cannot exist without the other; any kind of digitalization requires elements to be digitized, automatically handling and displaying digital information. Therefore, research focusing on the fourth industrial revolution has to include both concepts to allow for a comprehensive analysis. The concept of the fourth industrial revolution will be further discussed in the next section of this work.

## 2.2 Industry 4.0 concept, principles, components

There have been four industrial revolutions among our history as human beings that have helped to revolutionize our systems of production as well as the way we lived and how we relate and communicate with each other. The first revolution was at the end of the 18<sup>th</sup> century, when we started to use machineries powered by water and steam - increasing the production and the productivity. The second industrial revolution began at the beginning of the 20<sup>th</sup> century, in which by using the power of electricity and labor division it was possible to reach mass production. The third industrial revolution began at the end of the 20<sup>th</sup> century and it is still in progress; it is characterized by a high level of production and automation of production and processes designed with electronics and information technologies.

“Industry 4.0” is referred as the digitalization of the entire supply chain which connect all the actors, processes and objects on real-time data exchange using internet and “smart” objects. The implementation of the Industry 4.0 allows to create what is called the cyber-physical production systems that consist of online networks of social machines that link IT with mechanical and electronic components. Allowing the companies to improve their competitiveness by increasing productivity; with faster production systems and shorter operations, delivery times and faster time to market of new products and services. (Schwab, The fourth industrial revolution, 2016)

All the new developments and technologies increase the power of digitization and information technology. All the innovations that compound the industry 4.0 have been a consequence of the development of many technologies that support each other such as gene sequencing supported by computing power and data analytics or advanced robots with artificial intelligence and computing power. As Schwab describes on his book “The fourth industrial revolution” there are three megatrends, deeply interrelated, that can summarize in a general way the main technologies of the Industry 4.0. those three big clusters are: physical, digital and biological.

### Physical

Inside this cluster Schwab identifies four physical manifestations easily to identify because of their tangibility: autonomous vehicles, 3d printing, advanced robotics, and new materials

Nowadays, there is a wide set of autonomous vehicles that can be found including cars, trucks, drones, boats and aircrafts. Artificial intelligence and sensors have been contributing to develop this kind of technologies that allow vehicles to sense and response to their environment, reaching also the capability of accomplishing dangerous task such as delivering medical supplies in war zones or checking electric power lines.

The use of advanced robotics has been increasing across all industry sectors. Quickly, the progress in robotics will make the relationship between humans and machines stronger, as they become more adaptative and flexible with structural and functional design inspired by complex biological structures. Advance in sensors is enabling robots to understand and respond better to their environment and to have access to information via the cloud and connect with a network of other robots.

On the other hand, 3D printing consists in the creation of physical objects by printing layer after layer, resulting in a 3D object from a drawing or a model. This process is the opposite of subtractive manufacturing which consist in removing layers until getting the desired shape. Unlike mass produced goods, 3D printed goods are customized, more sophisticated as they will be integrated with electronic components, human cells or even organs. This technology is used in areas such as medical implants, wind turbines, automotive and aerospace industry.

Lastly, new materials have been developed recently, they are described as lighter, stronger, recyclable and more adaptative. Smart materials such as self-healing or self-cleaning, metals with memories to go back to their original shape, ceramics and crystals that turn pressure into energy.

As there are many innovations right now, it is difficult to determine where all this revolution will end. When due to economies of scale, the cost of production of this kind of materials decreases, the impact on several industries such as manufacturing and infrastructure industries will lead into a disruption. As they will become a commodity it will also affect the economies of countries that will be able to produce these kinds of materials.

### **Digital**

In the digital megatrend, we find all about the internet of things (IoT). The internet of things is a relationship between things such as products, services, places and people connecting, in this way, to technologies and various platforms.<sup>5</sup> Nowadays, sensors are being connected to many kinds of devices that are connecting the physical world to the virtual one. The internet is being connected to smartphones, tablets, computers, and many other products such as home products, cars, and the number of this devices are expected to grow exponentially. Monitoring systems are changing the way industries manage the supply chains and, in the future, this will be applied also to the movement and tracking of people.

The digital revolution is creating new ways in which individuals and institutions engage and collaborate. Bitcoin is one clear example of this, in which technology is used to record financial transactions made in a digital currency. This technology is very useful in order to register things such as birth and death certificates, titles of ownership, marriage licenses, educational degrees, insurance claims, medical procedures and votes.

The on-demand economy helps people to consume products and services in a different way. People can interact with their providers using apps that have revolutionized their industries. “Uber, the world’s largest taxi company, owns no vehicles. Facebook, the world’s most popular media owner, creates no content. Alibaba, the most valuable retailer, has no inventory. And



Airbnb, the world's largest accommodation provider, owns no real estate". This kind of applications and digital platform have reduced the transaction and friction costs incurred for individuals when they use an asset or provide a service.

## Biological

Biological innovations have also increased dramatically and with lot of progress in the recent years. Nowadays it is possible for a genome be sequenced in a few hours and for less than a thousand dollars. With the advance on synthetic biology the humanity will be able to customize organisms by writing DNA with many impacts on medicine, agriculture and biofuels. Increasing the amount of data of DNA sequences can help to correlate them with diseases in order to develop highly targeted therapies to improve treatment outcomes. There are many applications on this subject; another example of a biological application of technology, is that since we will be able to modify animals and plants, we will also be capable of producing food in very extreme conditions.

The biological domain, according with Schwab, is the one with more challenges for the development of social norms and appropriate regulation. We are on a time in which the way we relate with each other has changed, our rights and responsibilities should be seen in new ways, our data is more accessible and therefore, the challenges and opportunities are giant.

## 2.3 Impact of industry 4.0

As we have said before, industry 4.0 is a phenomenon that is currently revolutionizing every aspect of the economy, society and life in general; but in order to be clearer and more specific, we will discuss its impact on the economy, on the society, in business, nationally or globally and lastly on the human itself based on the book "the fourth industrial revolution" (Schwab, The fourth industrial revolution, 2016)

### 2.3.1 Economy

Industry 4.0 will have an outstanding impact in all the big macro-variables of the economy that one can think of - GDP, investment, consumption, employment, trade, inflation, etc. however the most critical dimensions to be discussed are growth (in terms of productivity) and employment.

even though there is some potential deflationary impact of the 4IR in the economic growth it still has the potential positive impact of increasing the economic growth and alleviating some of the major global challenges the world is facing nowadays. the technology could increase economic growth because it enables many people to consume more at a lower price, making consumption more sustainable and therefore responsible. (Schwab, The fourth industrial revolution, 2016) however the combination of structural factors (like over indebtedness and aging societies) and systemic ones (like the introduction of the platform and on-demand economies, the increasing relevance of decreasing marginal costs, etc) that can lead to decreasing rates of growth will have to be carefully studied to prepare for both the negative and the positive outcomes of this revolution.

on the other hand, there's a common fear that the 4IR will not have such a positive impact on the dimension of employment. there are big general effects that can be considered when thinking about the effect of technology in employment. first, how the need for human labor will be decreased due to that need being satisfied by automated and disruptive technologies,

increasing unemployment, and second, how the introduction of these different types of technologies will be drivers to an increasing demand of goods and services, therefore creating new opportunities, businesses, jobs and even industries. However, as Schwab affirms on his book, employment will grow in high-income cognitive and creative jobs and low-income manual occupation, but it will greatly shrink for middle-income routine and repetitive jobs and this will actually serve to enhance human labor and cognition. meaning that leaders need to prepare workforces and develop education models to work with, and alongside, increasingly capable connected and intelligent machines.<sup>5</sup>

the 4IR will demand and place more emphasis on the ability of workers to adapt continuously and learn new skills and approaches within a variety of contexts.

In the end it can be said that even though technology can be disruptive, it always ends up improving productivity and increasing wealth, leading in turn to greater demand for goods and services and new types of jobs to satisfy it.

### 2.3.2 Business

“there is no doubt that emerging technologies, almost always powered and enabled by digital capabilities, are increasing the speed and scale of change for businesses” (Schwab, The fourth industrial revolution, 2016) from this comes the importance of speed and agility in business models. The new disruptive technologies are creating new ways of serving existing needs and significantly unsettling existing value chains. (Schwab, The fourth industrial revolution, 2016)

Another thing to take into account is that other competitors who are more agile and competitive in the way they deliver value to their customers, can also be a source of disruption to well-established incumbents.

“shifts on the demand side are also disrupting business: increasing transparency, consumer engagement and new patterns of consumer behavior (increasingly built upon access to mobile networks and data) force companies to adapt the way they design, market and deliver existing and new products and services.”

All of these reasons are forcing companies to re-examine the way they have established their businesses and re-think business models and. business leaders and senior executives need to understand that disruption affects both the demand and supply sides of their business there are four major impacts according to (Schwab, The fourth industrial revolution, 2016)

- customer expectations are shifting
- products are being enhanced by data, which improves asset productivity
- new partnerships are being formed as companies learn the importance of new forms of collaboration, and
- operating models are being transformed into new digital models (faster and with greater ability)

the challenge resides on the ability of companies in being able to combine strategies against the challenges in all the dimensions (digital, physical and biological). When a company is able to do this, it often succeeds in disrupting an entire industry and their related logistics and production systems.

One positive outlook for the MSMEs is that due to the fact that they are new incumbents they still have the advantages of being able to change and adapt fast (speed and agility). Whilst, large organizations by contrast, will survive by relying on their scale advantages and investing in their ecosystem of start-ups and SMES by acquiring and partnering with smaller and more innovative businesses.



### 2.3.3 Governments

The impact that the fourth industrial revolution will have on governments, regardless if they are on a local, regional or national level, relies on the fact that the technologies are making it possible for citizens to find different forms to express their opinions, collaborate and coordinate their efforts between each other and also challenge and evaluate governments on their abilities to govern and deliver service. This challenge is requiring governments to have the ability of agile governance which is: “shifting the manner in which policies are generated, deliberated, enacted and enforced in the Fourth Industrial Revolution. Pairing these terms sets the expectation that governance can be, and some would argue should be, more agile to keep pace with the rapid changes of society – driven significantly by the rapid development and deployment of emerging technologies. Policymakers must become more proactive in shaping these developments. The difference between plan-based methods of policy-making and the concept of agile governance relates to the shift in the value placed on time sensitivity” (WEF, Agile Governance Reimagining Policy-making in the Fourth Industrial Revolution, 2018)

There is another impact that comes from geography; the existing and widening digital divide now present in international as well as national levels is one of the main concerns for governments; the capability of bridging those digital divides depends on the speed by which cities are taking and adapting to the new technologies and the need to focus on ensuring access to the use of ICTs on which most of the new industrial revolution relies on.

The third impact of technology on governments at national and international levels, is directed to the level of international security perceived. Given that with the new emerging technologies international security is being transformed, for example, with the use of drones to spy on other territories where without the technology would have been more difficult or impossible, or with the use of autonomous weapons where the precision of the attacks significantly increases, etc. it is fundamental for countries to establish a common platform for collaboration around key international security challenges.

### 2.3.4 Society

The impact that technology will have on societies will depend on the ability of societies to adopt and use the new trends while still embracing the traditional value arrangements. According to (Schwab, The fourth industrial revolution, 2016) there will be two main drivers that will affect societies, and they are, first, how inequality is increasing the pressure put on the middle class and second how the methods for communicating from one another is changing drastically, thanks to technology.

First, inequality. There are several facts that demonstrate how the level of inequality between social classes has a direct impact on the levels of welfare, drug-use and mortality rates in the children, therefore it is critical to focus on policies and strategies that try to reduce the social gap and reduce inequality.

Second, community. Technology is reshaping the frameworks on which we recognize ourselves as a part of a community, boundaries are being blurred by the accessible and permanent exchange of information and communications. It is resulting in significant risks, like the risk of “disempowered citizens” which is the contradiction between citizens feeling empowered by the new capabilities provided by technology (gathering info, communicating and participating in social life) while feeling excluded from meaningful decision-making processes (like voting and elections).

Therefore, it is clear that the fourth industrial revolution is presenting several risks and it is critical to work on strategies that allow citizens to gather more information about how to use and adapt to the challenges that are resulting from the implementation of the technology

### 2.3.5 Individual

The impact that technologies are having in the way we live and on who we are, can be separated, most generally, in the impact on identity, morality and ethics; and in the aspect of human relationships and social connections.

On the first aspect, as we have been witnessing over the last decades, there are clear changes that have come from the use of the internet or smart phones, but there are other still to be discovered, like the impact of artificial intelligence and synthetic biology and these may bring along the biggest challenges in the ethical and spiritual aspects. With the modification of DNA, creation of “designer babies”, clones, the eradication of diseases, there are several moral questions that will have to be re-thought of.

On the second aspect, on the other hand, even though technology facilitates communication, and lets us be connected and reachable 24/7 and have basically, anyone in anywhere in the world, in the palm of the hand; there are a lot of concerns about the actual ability of humans to interact with each other losing in the way. Technology is making humans learn more and more everyday about how to interact with it, making us more dependent by “facilitating” our everyday tasks. The dependency on the technology affects our social skills and our ability to interact with other humans, but the problem is not only this. But it relies on the fact that, the more dependent we are, the more we are willing to trade our money and privacy for the convenience provided by the technological devices.

## 2.4 Challenges in implementation

Is not rare that any new phenomenon or disruptive change, like an industrial revolution, will have a lot of difficulties for its implementation. There are several challenges that all, the citizens, the companies and the government, will have to face and come up with the appropriate strategies to surpass them.

### 2.4.1 Digital divides/ Inadequate connectivity

According to the definition a digital divide is “any uneven distribution in the access to, use of, or impact of Information and Communication Technologies (ICT) between any number of distinct groups. These groups may be defined based on social, geographical, or geopolitical criteria, or otherwise. Because of ICT high cost, its adoption and utilization are highly uneven across the globe.” (Wikipedia, 2019) The term was originally intended to clarify a situation of whether who had internet access or not, but nowadays with mobile phone penetration rates of over 100% in January 2019 – the Americas and Asia-Pacific 104%, in Europe 130% and in the middle east 119% (KEMP, 2019)- the number of internet users around the world is rapidly approaching increasing and if the trend continues like this over the next years internet penetration will stop being a problem but what the digital divide will study instead, is the quality of connectivity and how much less or more broadband and fiber connections there are.

In order to take in the fourth industrial revolution and take full advantage of it, one of the fundamental aspects to be considered is, guaranteeing an affordable access to the technologies and the level of connectivity required by the revolution.

As we were briefly explain before, over the last couple of years internet connectivity has grown thanks to the mobile network penetration, this is an even stronger trend in developing countries, but the problem that still remains is that developing countries are still lagging behind on fixed-broadband subscription, computers in households, mobile-broadband subscription and households with internet access (UNCTAD, 2017)

Due to the importance of broadband connectivity in the development of industry 4.0 it is clear that developing countries and the least developed countries are at a disadvantage. This type of connectivity remains unaffordable for most of the citizens, due to high prices or availability. Apart from that, some of the developing countries are having problems to construct high-capacity networks in the cities because of the customers' preference of 'going' mobile-broadband instead of fixed-broadband connectivity. The quality of the service provided by these types of broadbands varies notably in terms of upload and download speeds and latency and these aspects affect directly some of the technologies of the industry 4.0, like cloud-based applications and internet of things.

There's also evidence of a gender gap present in developed countries, and that widens up even more in developing countries and the least developed countries, there are approximately 250 million more men using the internet than women. The gap can be explained through differences in the education levels and other reasons.

Thus, it is fundamental to make an effort into bridging these divides, guaranteeing ICTs access in developing countries, by spreading the network of broadband connectivity and improving the quality of the service, so that the activities related to the fourth industrial revolution can be done productively over the internet.

#### 2.4.2 MSMEs lagging behind

Even though it is known that ICTs can help the enterprises to become more productive, waste efficient, automated, innovative and better connected, sometimes, the micro, small and medium enterprises are not able to afford, or are little aware of the opportunities that could appear from implementing the disruptive technologies that come with the digitalization of the economy.

And taking into account the data available, there is proof that MSMEs are using in inferior levels the ICTs and are engaging less in complex tasks online. Not only is affected by the size of the company but also on the development of the country. That is, in developed countries the level of MSMEs that use ICTs is higher that the MSMEs of developing countries, due to the availability of the technologies in the market.

Governments should provide subsidies and other programs, like support centers, that focus on helping and guiding the MSMEs in enduring this new industrial revolution, where only by adapting to the technology the enterprises will be able to survive and stay competitive.

#### 2.4.3 Lack of trust

There is evidence that in developing countries the internet results more unreliable for the users; not because it actually is more insecure, but because of the people's beliefs, education and culture they are used to being more aware of the possible dangers that can occur when you trust blindly something. Internet users in developing countries and in the least developed countries, even though the participation rates in social media networks are pretty much in the same range for most of the countries as the figure 1 shows, there is a wide difference on how reluctant to online shopping and other trends, between the developed and developing countries. The lack of knowledge or limited awareness makes them go for the easy choice of doing the things they're used to and the ones they trust. While on developed countries, like Singapore (60%) or Germany (>80%) more than two thirds of the population is buying only. And since internet users are not only reluctant to online shopping but are also aware of privacy breach and impersonation risks. It is fundamental to teach and spread the benefits of the ICTs and to have the appropriate regulations to make the digital environment safe for everyone. (UNCTAD, 2017)

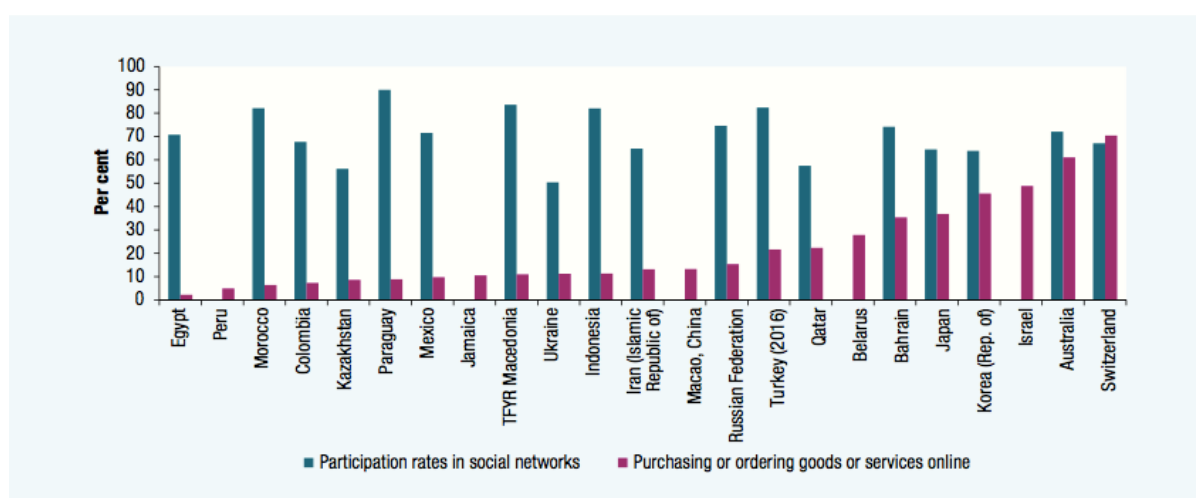


Figure 1 proportion of internet users purchasing online and participating in social networks selected countries, 2015. Taken from (UNCTAD, 2017)

#### 2.4.4 Jobs and skill gaps

There is a contradiction about the impact that the ICTs will have on the employment and skill requirements of a country. ICTs reduce the need for repetitive and simple jobs and increases the creation high skilled jobs. Nonetheless it is important first, to clarify the difference between ICT related jobs and ICT specialist jobs. ICT related jobs are the ones where the collaborator uses the technology in order to carry out a specific activity and ICT specialist occupations are the ones that require skills to produce the ICTs.

Both of these types of jobs will potentially increase with the development of the fourth industrial revolution. The more it spreads out, the more companies will need skilled workers to use correctly the ICTs implemented; and the more ICTs used by companies, the more ICT specialists will be needed in order to produce the ICTs and constantly innovate. This is why having a big number of people that are specialized in ICTs is critical when ensuring the competitive advantage of a country.

According to the (UNCTAD, 2017) there are 4 key changes that will appear in the labor market due to the digitalization of societies. First, new occupations will be created. As we were saying before, there will be an increase in the production of new products and services,

like app development, 3d printing and artificial intelligence; and there will also be an increase in the production of products that already exist but that will be responding to an increase in demand related to ICTs, like smart-phones. Second, some jobs will vanish because of technology and automation, for example retail workers are at high risk of automation. Third, there will be an increase in the risks of competition between workers, due to online labor platforms; but also, there will be more benefits for people in remote locations that had less opportunities before or people with disabilities. Last, there will be an impact of digitalization in almost every job, and the tasks will involve more and more digital skills every day.

On the other hand, the skills needed to confront the new industrial revolution will also be affected. There will be a need for stronger cognitive and creative skills. There will be the need for e-business skills (more advanced skills), digital specialist skills and digital user skills (more basic skills). Overall the level of skill requirements will be higher than before, since there will be more high-skilled jobs.

For the challenges, also according to the (UNCTAD, 2017), the most pronounced skill-gaps will pop up in Latin America because of education systems where, the high level education is private and only some can afford it, there will not be enough people with the relevant skills. Therefore, widening the income gap inside the countries, but also, putting the country at a disadvantage against the other countries.

Overall, the main effect that digitalization will have in the skill requirements and the labor market will remain uncertain and will be occurring and changing according to the context. So, it is fundamental for governments to regulate the environment on both sides of the spectrum; on the supply side, with education and skill development programs and on the demand side, regulating also the labor market conditions.

#### 2.4.5 Limited awareness

Awareness is one of the most important things of this new revolution. For governments, policymakers, managers, workers, consumers, students and every other citizen in the countries.

Being aware of the implications for each one of the roles will determine how they perform their tasks to fulfillment. For governments it is important to understand every implication and benefit of the digitalization of the economy so that they can make the national plans according to it, so they can help the entrepreneurs and how they can transform the countries not only in smart cities but smart countries. For managers they need to be aware of the trends and the benefits but also the implications of transforming a business model, so they can teach its collaborators how to respond and not to be afraid, and also so they can learn to decide how is the best form to keep what they're doing but in a digital way. For workers it is important because they need to be aware of what are the new skill requirements in the market, and if necessary, studying and improving and gaining those skills so that they also can have a competitive advantage in the labor market. For policymaker of it is important so they can understand the actual policies, arrangements and treaties on the subject, on subjects like international trade and value chains

#### 2.4.6 Trade logistics and e-commerce

According to the (UNCTAD, 2017) there are mainly 4 dimensions on which the external sectors of an economy can be disturbed by the digitalization of it.

First, we have the trade in ICT services; Second, trade in ICT-enabled services; third, in ICT goods; and last, in cross-border e-commerce.

Trade in ICT services has been reflecting how the world, thanks to connectivity, is transforming the economy, always leaning towards the digital economy and trends. It is important to highlight facts like that, computer services were responsible of more than 80% of the amount of ICT-services exports in developing countries, or that the rate of ICT services exports grew at a rate of 8% between the years of 2005 and 2016 (UNCTAD, 2017)

Trade in ICT-enabled services, on the other hand, refers to the services that can be delivered to the customer through ICT networks. This has been increasing very rapidly, and now is a great contributor of the services exports of the world and for this reason it should be of interest to developed, developing and the least developed countries.

Trade in ICT goods, which has changed over the last years due to international trade arrangements, technological innovation and the creation of new business models. In 2015, the 13% of all the global merchandise imports belonged to ICT goods (UNCTAD, 2017). Clearly the equation of imports and exports of ICT goods varies widely between developed, developing and the least developed countries. Where the first are more responsible for the exports and the latter, for the imports.

Lastly, the cross-border e-commerce practices that consist in the trade i.e. selling or buying goods through online platforms, like amazon. There is a lack of precise data on how this practice creates value but the UNCTAD estimates on its Information economy report of 2017 that B2C e-commerce in the year 2018 was equal to 189 billion, done by approximately 380 million consumers in different countries around the world.

It is fundamental for governments and companies to evaluate the benefits of these types of different trade practices, to establish regulation to make it safely and to consider every aspect related to it like postal traffics, trafficking, piracy, and intellectual property beaches.

### 2.5 Driving forces and Barriers

as Horváth and Szabó, have helped to identify with their work for the Technological Forecasting & Social Change magazine (Horváth & Szabó, 2019), there are some main driving forces and barriers of industry 4.0 that concern all companies, they also emphasize on the differences, in terms of advantages and disadvantages, for MSMEs and MNEs.

On their work they conducted an extensive literature review and a set of interviews with top executives of companies that varied between five different factors: their role in industry 4.0, the company size, their commitment, the industry sector, and if they were a domestic or a multinational company. As the role in industry 4.0 they identified the companies either as providers, or users or providers/users. The size was also categorized as small if they had less than 50 employees, medium if the number was between 50 or 250 employees, and large if the number of employees was higher than 250.



The main driving forces were identified from the literature and are exposed in the table 1 with the corresponding literature source.

The need to assure long- term competitiveness and to be able to adapt to the fierce and always-changing environment, among others, are the main reasons for companies to reach out for the technology introduction and application into their business models and processes. The higher the number of competitors and the fiercer they are, the more that companies will have to come up with ways - through technology and innovation- to strengthen their strategies either on price or differentiation; the increased innovation capacity and productivity of the competitors also motivate companies to stay updated on the latest trends ; expectations of customers also force companies to utilize and to provide the best characteristics and the most useful and required ones; efforts to save energy and improve sustainability can also be reached through the implementation of the disruptive technologies of the industry 4.0; and on the more managerial side: financial and performance factors, support for management activities and opportunities for business model innovation – are also driving forces that make companies want to pursue new structures and strategies that implement and take advantage of the evolution of the digitalized world.

*Table 1 Driving forces behind industry 4 taken from (Horváth, Szabó; 2019)*

Driving force	Sources
Growing competition	Bauer et al. (2015); Lasi et al. (2014)
Increased innovation capacity and productivity	Bauer et al. (2015); Lasi et al. (2014); Paritala et al. (2016)
Expectations of customers	Adolph et al. (2014); BMBF (2014); Karre et al. (2017); Nagy (2019); Spath et al. (2013)
Efforts to save energy and improve sustainability	de Sousa Jabbour et al. (2018); Kovács (2017a); Lins and Oliveira (2017); Nagy (2019); Paritala et al. (2016); Szalavetz (2018)
Financial and performance factors	Kiel et al. (2017b); Losonci et al. (2019)
Support for management activities	Cimini et al. (2017); Inezari and Gressel (2017); Szalavetz (2018); Uden and He (2017)
Opportunity for business model innovation	Frank et al. (2019); Kagermann et al. (2013); Müller et al. (2018); Prem (2015); Smit et al. (2016); Ustundag and Cevikcan (2017)

In spite of the increasing pressure on the companies, a number of factors can be identified that could impede manufacturers in implementing Industry 4.0. Researchers have pointed out that the lack of skilled workforce and financial resources, standardization problems and cybersecurity issues may be particular problems. In the list below take from the work from (Horváth, Szabó; 2019), the main barriers for industry 4.0 were identified from the literature.

*Table 2 Barriers to industry 4.0 taken from Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities?*

Barrier	Sources
Human resources and work circumstances	Adolph et al. (2014); Bauer et al. (2015); Erol et al. (2016); Karre et al. (2017); Kiel et al. (2017b); Müller and Voigt (2017); Shamim et al. (2016); Smit et al. (2016)
Shortage of financial resources	Erol et al. (2016); Kiel et al. (2017b); Müller and Voigt (2016); PwC (2014)
Standardization problems	Müller and Voigt (2016); Nagy (2019)
Concerns about cybersecurity and data ownership issues	Cimini et al. (2017); Kiel et al. (2017b); McKinsey and Company (2016); Weber and Studer (2016)
Risk of fragility	Kovács (2018)
Technological integration	Kiel et al. (2017b); Sung (2018); Varghese and Tandur (2014); Zhou et al. (2015)
Difficulty of coordination across organizational units	McKinsey& Company (2016)
Lack of planning skills and activities	Basl (2017); PwC (2014)
Organizational resistance	Automation Alley (2017); Kiel et al. (2017b); von Leipzig et al. (2017); Vey et al. (2017)

They identify a set of factors of the companies that have both, driving forces and barriers to industry 4.0

- **Human resources**  
in the human resources factor you can identify as driving forces: - labor shortages; reducing human work; and allocating workforce to other areas (higher added value)

and as barriers to implement it: the lack of appropriate competences and skilled workforce; and the longer learning time (training of staff)

- **Financial resources and profitability**

As driving forces classified in this factor, we can find reducing costs e.g. human resources, inventory management and operating costs.

And as barriers: the lack of financial resources; return and profitability; shortcomings in tendering systems; and long evaluation period for tenders

- **Market conditions and competitors/ management expectations/ management reality**

These three different factors are related to similar driving forces and barriers. The driving forces are market competition, follow market trends, increasing pressure from competitors, business model innovation, demand for greater control (from top management), Continuous monitoring of company performance. And the barriers: Lack of leader with appropriate skills, competencies and experience, Lack of conscious planning: defining goals, steps and needed resources

- **Product efficiency/ organizational factors/ Technological and process integration, cooperation**

The main driving forces related are: Reducing the error rate, improving lead times, improving efficiency, assuring reliable operations.

And for the barriers, from the organizational factors we have: inadequate organizational structure and process organization, Contradictory interests in different organizational units and resistance by employees and middle management; from the technological and process integration factor we have: the lack of unified communication protocol, Lack of back-end systems for integration, Lack of willingness to cooperate, Lack of standards included in technology and processes, Lack of proper common thinking, Unsafe data storage systems, The need for large amounts of storage capacity.

According to (Horváth & Szabó, 2019) there is also a remarkable difference between the level of effect that the driving forces and barriers have on the companies, depending whether they are SMEs or MNEs.

For the SMEs the driving forces that have a higher level of effect are human resources and customer satisfaction and the highest barriers come also from human resources, financial resources and profitability and management reality.

While for the MNEs the driving forces with higher level of effect are the market conditions and competitors and management expectations and the highest barriers to industry 4.0 come from organizational factors and technological and process integration, cooperation.

Therefore, it can be said that MNEs and SMEs do not have equal opportunities in the area of Industry 4.0. MNEs have higher driving forces and lower barriers than SMEs across nearly every aspect. However, SMEs have several advantages over MNEs, including their lower profitability expectations and the less technological dependencies and fewer barriers to cooperation. Customer satisfaction is also a stronger driving force for change in smaller companies. Organizational factors are also, less complex in SMES, so implementing new Industry 4.0 technologies, processes and management innovations can be easier. (Horváth & Szabó, 2019)

## 2.6 Main elements of industry 4.0



Starting from the big megatrends discussed above and taking into account also the driving forces and barriers for the companies, we can sort of classify some of the elements that belong to the fourth industrial revolution into nine factors.

The first factor, **data collection and processing**, involves the elements of data collection, big data, data processing and data analysis; all of which are interconnected;

Then for the factor of **optimizing production processes**, we have the elements of production optimization using production data, reduction of scrap percent by digital data processing, forecasting, application of production control systems and increasing designability of production;

In order to properly implement the factor of **machine-to-machine communication (M2M)** the elements of integration of systems, sensors, IO- link, application of cameras and wireless technologies should all be also utilized correctly.

The fourth factor - **traceability of production** – uses the elements of precise tracking of the production process and unique identification of products and product components in order to keep track of the data in real time, and to have better access to it.

If the goal of the company is **working without human intervention**, it has to implement the elements of working with robots and also introduce robots into R&D tasks, they have to start replacing human senses with self-learning systems and self-regulation, and to reach the automatic movement of products and conveyors without human intervention.

For the factor of **preventive maintenance**, the elements of industry 4.0 that can be applied are: monitoring the condition of systems and avoiding stoppage of production, all through technology and the application of self- monitoring systems

The seventh fact, **visualization**, has the elements of visual display of information: human-machine interface, pick-to-light systems and intelligent industrial lighting systems to support and clarify the outlook of processes to make it easier to make decisions and to react faster.

Next, for the **augmented reality** factor, elements like linking virtual-reality and reality, supporting step-by-step processes, maintenance including performance measurement, quality control and training solutions are the ones that could be executed.

Lastly, if the factor to fulfill is to have **intelligent warehousing and logistics**. A mix of the elements: training solutions, intelligent warehouse systems, radio frequency identification (RFID) and intelligent logistics; would have to be employed.

To sum up, Industry 4.0 is a phenomenon that aims to improve the competitive position of companies by making them more efficient, in terms of value creation, waste reduction, reduction of risks, shorter times of processes and operations, faster time to market, more quality and a higher level of customer satisfaction; it aims to reach this purpose by digitalizing manufacturing processes and supply chains while creating interconnected networks of humans and machines that work together and share information and data analysis along entire supply chains. Nevertheless, there's still a long way to go, to fully exploit the potential of industry 4.0. in order to do this companies will need to commit to the process and overcome the multiple challenges that will appear. There's still the need to further investigate on the areas where companies should prioritize the effort, focusing more on the managerial, organizational and human aspects, instead of focusing only on the technical matters.

## The case of Colombia

This is an introductory chapter into the country of Colombia, how it is structured, the description of the industry and previous results of studies of the country in terms of digital economy.

## 3. The case of Colombia

### 3.1 Introduction to Colombia

Colombia, officially the Republic of Colombia, is a sovereign country located in the northwestern region of South America, which constitutes a unitary, social and democratic state of law, whose form of government is presidential. It is a politically organized republic in 32 decentralized departments and the capital district of Bogotá, seat of the national government.

It has an estimated population of 49 million inhabitants, making it the twenty-eighth most populous country in the world; the country covers an area of 1,141,748 km<sup>2</sup>, making it the twenty-sixth largest country in the world and the seventh largest in the Americas. with density of 42,23 hab./km<sup>2</sup> (Wikipedia, 2019)

It has a multicultural population, which is mostly the result of miscegenation between Europeans, indigenous people and Africans, with minorities of indigenous people and Afro descendants.

Colombia's both, the purchasing power parity GDP and the nominal GDP, rank 4th in Latin America and 28th worldwide.

It is the second most biodiverse nation in the world, with 54,871 registered species; however, there are studies that place it among the eight countries responsible for half of the destruction of the world's biodiversity. Moreover, it is the country of Latin America with more ecological conflicts between the local population and multinational companies in areas of special environmental protection. To protect its environment, the country has instruments such as the National Climate Change Policy and the carbon tax. Electricity production in Colombia It comes mainly from renewable energy sources - 69.97% is obtained from hydroelectric generation. (Wikipedia, 2019)

Colombia is a democratic country in which citizens have the right to vote to empower rulers to represent them and to make decisions regarding the country. Colombians can elect their representatives when they are over eighteen and have a citizenship card. In Colombia, voting is voluntary, but the abstention percentages in the country are some of the highest in America.

The public power of Colombia and every citizen are ruled by the political institution of 1991; it determines all the rights and duties, and all the norms everyone has to follow. According to it the public power of Colombia is divided into three branches: executive, legislative and judicial. It divides it into these three categories in order to avoid the concentration of power. Each branch fulfills different functions and acts independently but harmoniously according to the constitution.

The executive branch, which is represented by the president, vice president, ministers, rulers, mayors and heads of administrative departments, is responsible enforcing the Constitution and laws; the Legislative branch, represented by the Congress of the Republic, is responsible for creating the laws and has also the power of modifying existing ones; and the judicial brand, represented by the Supreme Court of Justice, the Constitutional Court, the State Council, the Superior Council of the Judiciary, the courts and the judges, is responsible for administering justice and resolving the conflicts of the Colombian population, or between them and the State.

According, also, to the 1991 Constitution, Colombia is made up of 32 departments and a Capital District. There is a government for each department, divided into: The executive branch, exercised by the departmental governor, elected every four years. The departmental assembly, a public corporation of regional popular choice that enjoys administrative autonomy and its own budget; assemblies are made up of no less than 11 deputies or more than 50, popularly elected for a period of 4 years. Departmental assemblies issue mandatory ordinances in their territorial jurisdiction or department.

The departments are formed by the association between municipalities. There are currently 1120 municipalities among which are the Capital District, and the special districts 120 Each municipality or district is chaired by a mayor, who is elected for a period of four years, according to the electoral calendar of the National Electoral Council. On behalf of the executive branch at the local level, each municipality elects a Council composed of councilors, elected for four-year terms as well. (Asamblea Nacional Constituyente, 1991)

In Colombia, five natural regions can be evidenced by their different reliefs, ecosystems and climates.

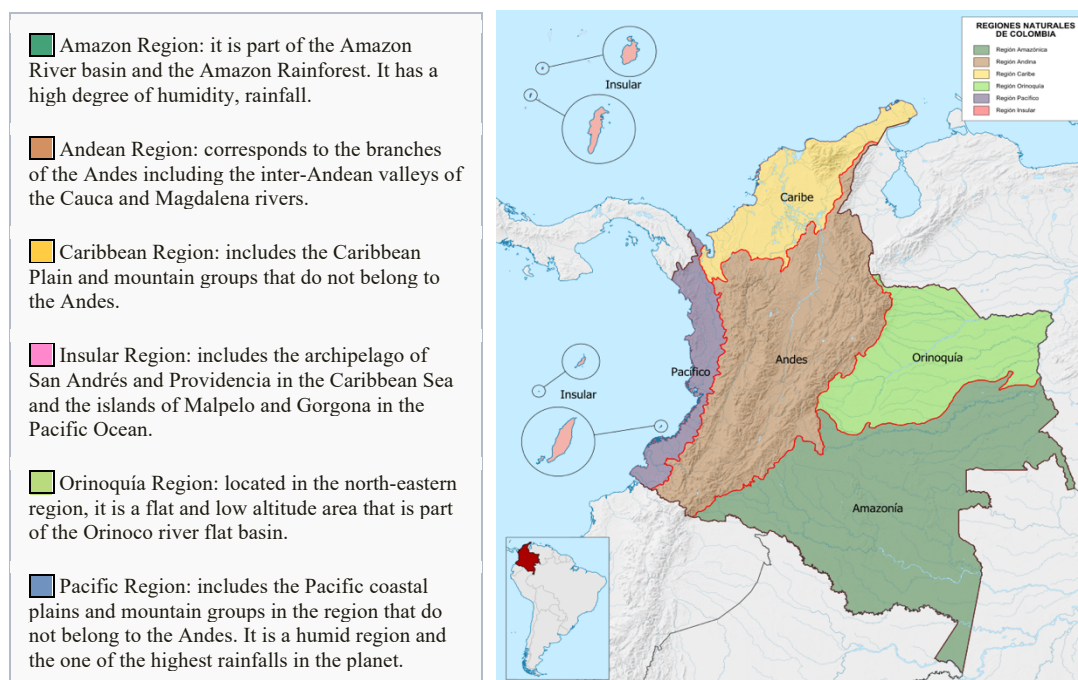


Figure 2 Map of Colombia by regions Taken from De Milenioscuro,  
<https://commons.wikimedia.org/w/index.php?curid=36272267>

The World Economic forum's expert network have stated in its Strategic Intelligence Network, that Colombia has succeeded, despite its history, in promoting a "relatively solid macroeconomic environment". An environment that despite the impact of the current low oil prices, has been able to stabilize and grow approximately 2.5% annually. However, they also recognize that notwithstanding this positive outlook, there is still a bunch of significant challenges remaining for the economy of the country – increasing the level of education, science and technology, shrinking the infrastructure gap, decreasing corruption and inequality, and building peace are just a few of the key issues to overcome to achieve an overall higher level of welfare in the country.

### **Corruption and public finance**

Corruption has traditionally been pointed out by many analysts as one of the country's main political problems.

On the Corruption Perception Index of 2018 (CPI), of the agency Transparency International, - which qualifies from 0-100 (0 being Very Corrupt and 100 being Very Transparent) according to the levels of corruption perceived by the public sector in 175 countries and territories evaluated - Colombia obtained a score of 36 points out of 100, well below the global average of 43 points; making Colombia one of the most corrupt countries in the world. Specifically, the 99<sup>th</sup> less-corrupt country out of 157. Colombia's CPI has a recorded average of 34.71 points from 1995 until 2018, reaching an all-time high of 40 Points in 2005 and a record low of 22 Points in 1998. (Trading Economics, 2019)

The annual cost of corruption in Colombia is estimated to be more than 50 billion pesos; approximately 17 billion dollars annually, represents 5% of the GDP and 21% of the national budget. (Wikipedia, 2019)

Corruption, though, is not the only problem that Colombia suffers when talking about the government and public finance. The country suffers also from lack of efficiency of public investment, tax evasion, deficient civil service and short public utilities.

Over the past few years the government has been forced to implement tax increases in order to reduce the impact of declining oil prices, which has resulted in a tax evasion rate even higher. According to the WEF's expert network one of the main things on which the Colombian government should focus on is addressing this - by introducing electronic invoicing and increasing inspections and audits of taxpayers it would be possible to progressively increase government revenues and provide fiscal sustainability and support growth.

### **Inequality**

After the 1999's crisis, poverty in Colombia has been experiencing a decreasing rate. The percentage of Colombians under the national poverty line fell from 50% in 2002 to 28% in 2013 and the percentage of extreme poverty fell from 18% to 9% in the same period. Multi-dimensional poverty fell from 30% to 18% between 2010 and 2013. (Wikipedia, 2019)

This reduction of the extreme poverty between 2002 and 2013 can be due to the recent economic growth and furthered by government loans and social programs, but also because of the recent fiscal and labor market reforms.

Despite the achievements in poverty lessening, the country continues to have one of the highest rates of economic inequality in the world. A study from the OECD noted that Colombians' severe inequality is being driven by "persistent high unemployment, a large informal /unregulated, or grey) economy, and a broad variation of wage levels within the formal economy.

According to de WEF's experts the government should boost on the government loans and social programs to have a redistributive impact of the country's tax system and by implementing more targeted social spending.

### **Education, science and technology**

The Colombian education system is regulated by the State through the Colombian Ministry of Education. The education system is divided into preschool (< six years old), basic education

(duration of nine years includes primary and secondary school), high-school education (duration of two years, includes tenth and eleventh grades), and higher education (university). Basic and high-school education is assessed through national exams called Knowledge Tests (“Pruebas Saber” or ICFES test, in Spanish) in grades 3, 5, 9, and 11.

Higher education is taught at two levels: undergraduate and postgraduate. The undergraduate level has, in turn, three levels of training: professional technical level (relative to professional technical programs), technological level (relative to technological programs), professional level (relative to university professional programs). At the postgraduate level, specializations, masters and doctorates are recognized. Higher education is assessed also through the Knowledge Tests (ICFES): The Saber TyT Tests assess the generic and common specific competencies of students of technical programs and Technologists who have passed 75% of the academic credits. The Saber Pro Tests is an exam that tests the competences of students in the last year of undergraduate academic programs at Higher Education institutions (universities).

The total adult literacy rate in 2016 was approximately 94.65%, with the rate in men being 94.4% and women in 94.89%. Colombia ranked 59th among 72 nations evaluated in the tests PISA 2015. In fact, as the WEF’s report of 2015 noted just the small 1.5% of students from poor backgrounds in Colombia placed in the top quartile on the OECD’s PISA math assessment, compared also with students from poor backgrounds of countries as the republic of Korea and Singapore who range between 12% and 15%(Wikipedia, 2019)

Science and technology in Colombia started to gain importance at the beginning of the 20th century, time at which the country began to come up with small inventions - although much earlier, great creations from other parts of the world had already been made. Colombia is recognized worldwide, for its quality in medicine, specifically aesthetic medicine, working also as a beneficial factor for tourism.

Colombia has been responsible for great contributes to medicine in the world – the first synthetic vaccine against Malaria, the pacemaker, the Lasik technique, the Hakim valve, among others – that have not only contributed to national medicine, but to the world level.

The internal war suffered by many has also resulted in military or war technology, like the robot to detect explosive devices underground or to deactivate them, such as anti-personnel mines, or like the safety cartridge, to reduce deaths and injuries due to accidental shots

Colombia is one of eight Latin American countries to have objects in orbit. On April 7, 2007, the Libertad I Picosatellite (designed by the Sergio Arboleda University of Bogotá) was put into orbit in one of the launches made from the Baikonur Cosmodrome. The Freedom I orbit around the planet and according to projections will continue to do so for 5 or 6 years. In 1955 Colombia signed a treaty with the United States for the development of nuclear energy for peaceful purposes and in 1960 it is admitted to the International Atomic Energy Agency. Colombia is one of the few Latin American countries to have a nuclear reactor in operation, the IAN-R1, manufactured in the United States, its function is the production of neutrons for research purposes.

In recent years the country has decided to implement new ways to innovate in technology being advised by countries such as the United States, Russia, South Korea, among others, as it is estimated that Colombia only uses less than 0.10% of national GDP, for the science, and technology sector, and 0.19% of GDP in research and development, precisely because of the need to invest more money in the defense and security sector. In 2006 the Law on Science,



Technology and Innovation, in order to create companies and industries based on technology, was approved

Education being a crucial factor for every aspect in a society, it should be a priority for the government to improve its quality. There are several strategies that could be implemented to achieve this goal; improving the quality of life for teachers, so that there are more and better prepared or offering guidance for schools and professors with the highest rates of poverty are just two of them.

### Peace

Even though the peace agreement with the country's most despised guerrillas, the FARC-EP is not perfect it has brought back some hope and the opportunity to focus and think about other fundamental things that were always put aside for the fear and damages caused by this war. It promises to improve security and respect for human rights in Colombia, while curbing drug trafficking, among other things. During the nineteenth and twentieth centuries, the country was characterized by its instability and a large number of civil wars; the last of these conflicts known as internal armed conflict, emerged at the beginning of the 60's. In 2012, after more than fifty years of conflict, the government of the then president Juan Manuel Santos initiated peace talks with the FARC-EP. In 2016, a final agreement was reached that, despite not being approved in the plebiscite of October 2 of the same year, was implemented with modifications in 2017. To date, the Government of Colombia has still a long way to go with the peace-building process, because, as some complain, the Colombian State has not fulfilled most of its obligations - such as establishing an integrated presence in rural regions and implementing land restitution programs and substitution of illicit crops. Also tackling the fact that Dissident factions of the FARC have refused to demobilize, or that achieving the right balance between peace and justice and integrating thousands of former combatants into society will require public faith in political processes, and efficient institutions.

Colombia tops the worldwide list of murdered social leaders, according to the latest report from the Front-Line Defenders organization, impunity in these cases is 86%. According to the United Nations Organization, 93% of the cases occurred in places where there is no state presence, which generates a great setback for the implementation of the Peace Agreement. Tourism is also one of the advantages of the peace agreements between the government of Juan Manuel Santos and the FARC; taking into account a sustained growth in the rate of foreign visitors to the country where the revenues from tourism went from 3,440M in 2010 to 5,490M in 2017, which represented an increase of 68%.

A Colombian government study predicted that reaching peace would "boost annual GDP growth by up to 0.3% over the following decade, thanks to increases in foreign and domestic investment, increased consumption, the redistribution of military resources, a tourism boost, and business expansion into more remote regions"

The Colombian government has estimated that the implementation of the peace agreement may involve spending the equivalent of 15% of GDP over the course of the coming decade. But as stated before, the country not only has to worry about the FARC-EP guerrillas, there's still a need for a truly comprehensive approach to improving domestic security in Colombia, that will also require dealing with the powerful criminal groups and the still-active National Liberation Army (ELN). Government talks with the ELN resulted in a ceasefire, though the

guerrilla group committed a series of attacks when the deal expired in January 2018, aimed at infrastructure and the military.

### Infrastructure

Colombia is the country in the region that invests most in infrastructure, only surpassed by Brazil, but due to the lack of efficiency and bad management of the infrastructure projects - it has resulted in a delay in road, oil, mining and technology infrastructure. There are deficiencies in bridges, airports, seaports, river transport and railways.

“The country has low road network density compared with others in the region and depends heavily on road transportation to move freight as the development of rail and river transportation is at an early stage. This translates into relatively high shipping costs, high commodity prices, and high prices for consumer products - all of which undermines productivity and competitiveness.” The Government, though, has tried to address this situation by investing in major projects such as the Ruta del Sol, a highway that would optimize the connection between the center of the country and the Caribbean coast; the Bogotá-Buenaventura Trunk, that includes the longest vehicular tunnel in Latin America and will allow the capital to connect with the main port on the Pacific; and the Transversal de Las Américas, on the Caribbean coast, among other major works. It can be highlighted that most of the projects still will be relying on road transportation.

Some other actions that the government has been taking are:

- Creating the Financiera de Desarrollo Nacional, a semi-public finance institution, which is designed to support infrastructure.;
- Developing a new regulatory framework for public-private partnerships;
- Facilitating capital deployment to public infrastructure, as well as to bolster efficiency and transparency in the bidding for projects;
- In 2013, the government introduced the so-called fourth generation (4G) program, which involves more than 30 concession projects, and the construction of more than 1,200 kilometers of highway. As part of the program, the government set investment targets of approximately \$25 billion for road infrastructure, and up to \$100 billion for transport infrastructure, by 2021;
- In early 2018, a number of related projects were awarded, and the government expects them to help reduce travel times by up to half while boosting Colombia's GDP growth by 1.5% per year.

In order to support the 4G program, the infrastructure sector must be increasingly professionalized, regulations must be modified to unlock additional investment capital, and solid guarantees must be provided to long-term investors.

Overall Colombia's overtaxed infrastructure must be addressed as a crucial issue, in order to sustain the country's economic growth and competitiveness.

### Economic diversification and sophistication

The Colombian human development index is 0.747 and its life expectancy at birth is 75.1 years. Colombia is part of the CIVETS group considered as six main emerging markets. She is a member of the OAS, the Pacific Alliance and other international organizations, and has been invited to join the OECD; It is also the only country in Latin America that is a global



partner of NATO. It is the second country with the highest inequality index in Latin America, after Brazil, and tied with Panama, according to the World Bank database.

Colombia has a diversified economy and has an important services component. The country's economic production is dominated by its domestic demand and household consumption expenditure is the largest component of GDP. GDP in 2018 was 330.974M.\$ and a GDP per-capita of 6.642\$ also in 2018. <sup>4</sup> (Datos Macro, 2019)

The GDP to the second trimester is 2019, is growing at a 3,0-rate respect to the same period in 2018, compared to a 2,9 rate in the same period of 2018 with respect of 2017 and a 1,3 rate in 2017-2016; as it can be seen in the table below. (DANE, 2019)

Figure 3 Gross domestic product (GDP) taken from DANE Growth rates in volumes 2012-I – 2019-II

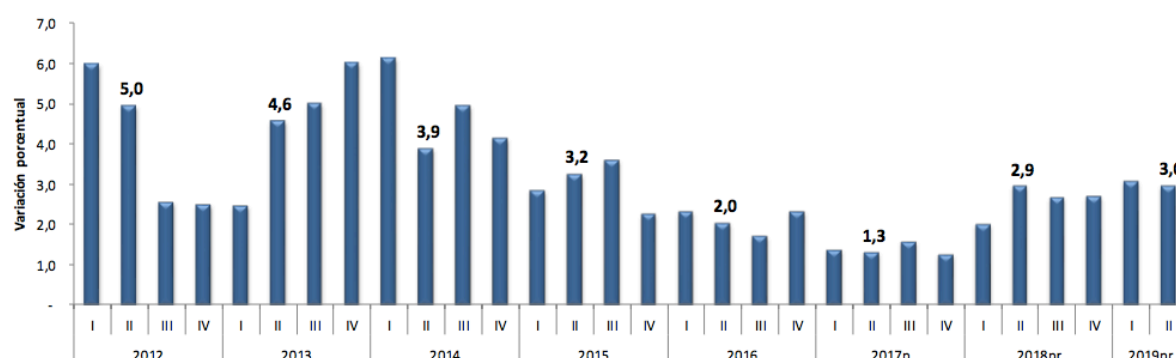


Table 3 GDP of the last three years by concept. data taken from DANE

Concept	2017 <sup>p</sup>					2018 <sup>pr</sup>					2019 <sup>pr</sup>
	I	II	III	IV	Total	I	II	III	IV	Total	I
Agriculture, livestock, hunting, forestry and fishing	12.967	12.953	13.109	13.149	52.178	13.282	13.387	13.297	13.329	53.295	13.442
Mining and quarrying	10.974	10.918	10.816	10.888	43.597	10.644	10.829	11.110	10.916	43.498	11.161
Manufacturing industries	25.466	25.146	25.282	25.246	101.140	25.490	25.547	25.863	26.017	102.917	25.753
Supply of electricity, gas, steam and air conditioning; Water distribution; sewage disposal and treatment, waste management and environmental sanitation activities	6.233	6.285	6.382	6.406	25.307	6.387	6.461	6.551	6.600	26.000	6.577
Construction	14.755	14.938	14.580	14.624	58.896	15.054	14.116	15.203	14.983	59.356	14.376
Wholesale and Retail; repair of motor vehicles and motorcycles; Transportation and storage; Accommodation and food services	34.723	35.333	35.733	35.865	141.654	36.128	36.446	36.697	37.117	146.388	37.632
Information and communications	5.930	5.921	5.879	6.028	23.758	5.918	6.137	6.151	6.267	24.473	6.161
Financial and insurance activities	9.235	9.324	9.479	9.636	37.673	9.589	9.735	9.731	9.843	38.899	10.119
Real estate activities	18.368	18.546	18.713	18.867	74.494	18.782	18.926	19.072	19.209	75.989	19.344

<sup>4</sup> <https://datosmacro.expansion.com/pib/colombia>

Professional, scientific and technical activities; Administrative and support services activities	14.191	14.158	14.245	14.147	56.741	15.172	14.976	14.719	14.703	59.570	15.536
Public administration and defense; compulsory membership social security plans; Education; Human health and social services care activities	29.222	29.790	30.371	30.829	120.212	30.566	31.088	31.524	32.085	125.263	31.802
Artistic, entertainment and recreation activities and other service activities; Activities of individual households as employers; activities not differentiated from individual households as producers of goods and services for their own use	5.080	5.114	5.139	5.142	20.475	5.151	5.210	5.194	5.269	20.823	5.266
<b>Gross value added</b>	<b>186.952</b>	<b>189.166</b>	<b>189.769</b>	<b>190.927</b>	756.814	<b>191.809</b>	<b>193.399</b>	<b>194.948</b>	<b>196.135</b>	776.291	<b>196.241</b>
Taxes less subsidies on products	18.740	18.787	19.221	19.021	75.769	19.159	19.304	19.480	19.570	77.512	19.623
<b>Gross domestic product</b>	<b>205.679</b>	<b>207.717</b>	<b>209.064</b>	<b>210.130</b>	832.590	<b>211.043</b>	<b>212.649</b>	<b>214.402</b>	<b>215.887</b>	853.981	<b>215.868</b>

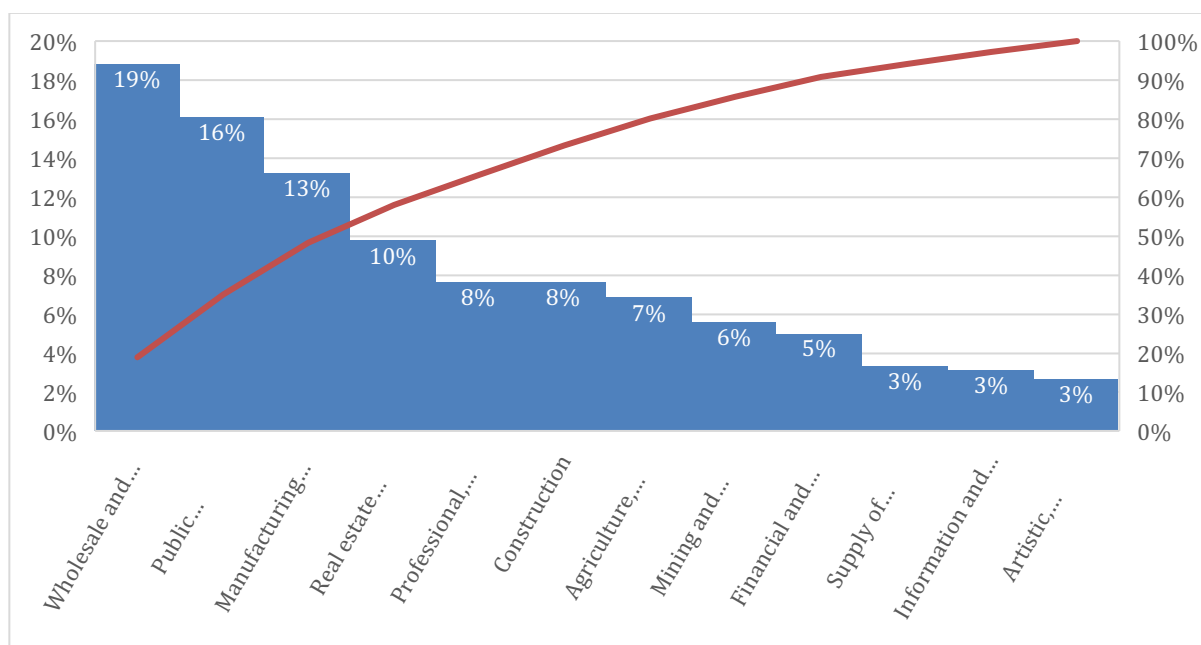


Figure 4 percentage of contribution to GDP per concept

From the GDP analysis it is clear that Colombia is a country that still relies heavily on natural resource-based industries for economic growth. Colombia is known as one of the biggest oil producers in Latin America, and one of the world's main producers of coal. The Colombian government has been able to invest in different public projects thanks to the rents and royalties produced from the mining and energy sector. The importance of this type of industry in the country is also a disadvantage because it makes the country particularly susceptible to market fluctuations, since more than half of the exports of the country are from extractive industries. The government has the challenge to shift the economy over higher value-added activities.

There's also the need to reduce inequality between cities and rural lands, the government should focus also on developing sustainable land-use practices and mechanisms to reduce the

gap by globalizing supply chains and increasing welfare for all participants through public investment on the sustainable development of these rural areas.

The service industry in Colombia, instead, embodies a great opportunity for economic diversification; it is the second most important source of foreign currency in the country and the percentage of international arrivals has been increasing progressively over the past few years, and has boosted after the peace agreement with the country's FARC-EP

Manufacturing industries, on the other hand, produced the 13% of the total GDP in the year 2018. That 12% is disaggregated into the different types of manufacturing industries showed in the table below.

Table 4 Percentage of contribution to GDP by category of the manufacturing industry. data taken from DANE

Concept	2017					2018					2019	
	I	II	III	IV	Total	I	II	III	IV	Total	I	II
<b>Manufacturing industries</b>	<b>25.466</b>	<b>25.146</b>	<b>25.282</b>	<b>25.246</b>	<b>101.140</b>	<b>25.490</b>	<b>25.547</b>	<b>25.863</b>	<b>26.017</b>	<b>102.917</b>	<b>25.753</b>	<b>25.753</b>
Manufacture of food products; beverage manufacturing; manufacture of tobacco products	6.954	6.937	7.029	7.008	27,6%	7.084	7.170	7.266	7.299	28,0%	7.203	28,0%
Manufacture of textile products; Clothing making; tanning and re-tanning of leathers; shoe manufacturing; manufacture of travel items, suitcases, handbags and similar items, and manufacture of saddlery and saddlery items; marinated and dyeing skins	2.615	2.600	2.629	2.658	10,4%	2.652	2.569	2.577	2.609	10,1%	2.638	10,2%
Transformation of wood and manufacture of wood and cork products, except furniture; manufacture of basketwork and wickerwork; manufacture of paper, cardboard and paper and cardboard products; printing activities; production of copies from original recordings	1.641	1.564	1.640	1.559	6,3%	1.601	1.641	1.638	1.663	6,4%	1.693	6,6%
Coking, manufacturing of petroleum refining products and fuel mixing activity; manufacture of chemicals and substances; manufacture of pharmaceutical products, medicinal chemicals and botanical products for pharmaceutical use; manufacture of rubber and plastic products; manufacture of other non-metallic mineral products	9.350	9.247	9.270	9.255	36,7%	9.303	9.301	9.436	9.459	36,4%	9.357	36,3%
Manufacture of basic metallurgical products; manufacture of fabricated metal products, except machinery and equipment; manufacture of electrical apparatus and equipment; manufacture of computer, electronic and optical products; manufacture of machinery and equipment n.c.p. ; manufacture of motor vehicles, trailers and semi-trailers; manufacture of other types of transport equipment; installation, maintenance and specialized repair of machinery and equipment	3.535	3.455	3.362	3.376	13,6%	3.386	3.452	3.557	3.551	13,6%	3.532	13,7%

Manufacture of furniture, mattresses and bed bases; other manufacturing industries	1.345	1.309	1.380	1.397	5,4%	1.394	1.440	1.424	1.393	5,5%	1.400	5,4%
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According to DANE In the second quarter of 2019, the value added in its original series of manufacturing industries increased 0.6%, compared to the same period of 2018pr. This dynamic is due to

The growth of:

- 0.3% in the category of Preparation of food products; beverage manufacturing; tobacco product processing
- 2.4% in Wood transformation and manufacture of wood and cork products, except furniture; manufacture of basketwork and wickerwork; manufacture of paper, cardboard and paper and cardboard products; printing activities; copy production from original recordings grew
- 0,2% in Coking, manufacturing of petroleum refining products and fuel mixing activity; manufacture of chemicals and substances; manufacture of pharmaceutical products, medicinal chemicals and botanical products for pharmaceutical use; manufacture of rubber and plastic products; manufacture of other non-metallic mineral products
- 3.2% in the category of Manufacture of basic metallurgical products; manufacture of fabricated metal products, except machinery and equipment; manufacture of electrical apparatus and equipment; manufacture of computer, electronic and optical products; manufacture of motor vehicles, trailers and semi-trailers; manufacture of other types of transport equipment; installation, maintenance and specialized repair of machinery and equipment

And the decrease of

- 0,8% in the category of Manufacturing of textile products; Clothing making; tanning and re-tanning of leathers; shoe manufacturing; manufacture of travel items, suitcases, handbags and similar items, and manufacture of saddlery and saddlery items; marinade and dyeing of skins decreases;
- 0.6%. Manufacture of furniture, mattresses and bed bases; Other manufacturing industries decreased

With respect to the immediately previous quarter, the added value of manufacturing industries grows 1.1% in its corrected series of seasonal and calendar effect. This behavior is explained by the dynamics of the following activities:

- Preparation of food products; beverage manufacturing; Processing of tobacco products grows 1.3%.
- Manufacture of textile products; Clothing making; tanning and re-tanning of leathers; shoe manufacturing; manufacture of travel items, suitcases, handbags and similar items, and manufacture of saddlery and saddlery items; marinade and dyeing of skin decreases 1.3%
- Wood transformation and manufacture of wood and cork products, except furniture; manufacture of basketwork and wickerwork; manufacture of paper, cardboard and

paper and cardboard products; printing activities; production of copies from original recordings decreases 0.9%

- Coking, manufacturing of petroleum refining products and fuel mixing activity; manufacture of chemicals and substances; manufacture of pharmaceutical products, medicinal chemicals and botanical products for pharmaceutical use; manufacture of rubber and plastic products; manufacture of other non-metallic mineral products grows 0.3%
- Manufacture of basic metallurgical products; manufacture of fabricated metal products, except machinery and equipment; manufacture of electrical apparatus and equipment; manufacture of computer, electronic and optical products; manufacture of machinery and equipment n.c.p .; manufacture of motor vehicles, trailers and semi-trailers; manufacture of other types of transport equipment; Installation, maintenance and specialized repair of machinery and equipment grows 3.2%.
- Manufacture of furniture, mattresses and bed bases; Other manufacturing industries grew 1.8%.

### Index of Industrial Production

The Industrial Production Index aims to estimate the monthly evolution of the mining, energy, manufacturing, electricity and gas supply, and water collection, treatment and distribution in the short term, through the real production variable. It is taken at the national level and for 26 industrial domains established based on the International Standard Industrial Classification of all ISIC Rev. 4 economic activities adapted for Colombia, in this way it is possible to obtain the necessary information to build reliable indicators of the total industry , which are valuable tools for economic decision making in the country.

With the index of industrial production (IPI), calculated by the National department of statistics DANE, the evolution of the industrial sector in the short term, can be evaluated. It is calculated through the real production variable across the country and it is supposed to be public information from April 2018.

The IPI complements the measurement of the industry that is done with the EMM and both serve as a basis for decision making, policy implementation and the application of sectoral evaluations by the government, private and mixed sector.

The work of compiling a real production indicator that covers the entire industry is done within the framework of the recommendations of the United Nations (UN). The results of the IPI are useful for government entities, the private sector and unions in general; the academy, businessmen, researchers and users of the DANE information.

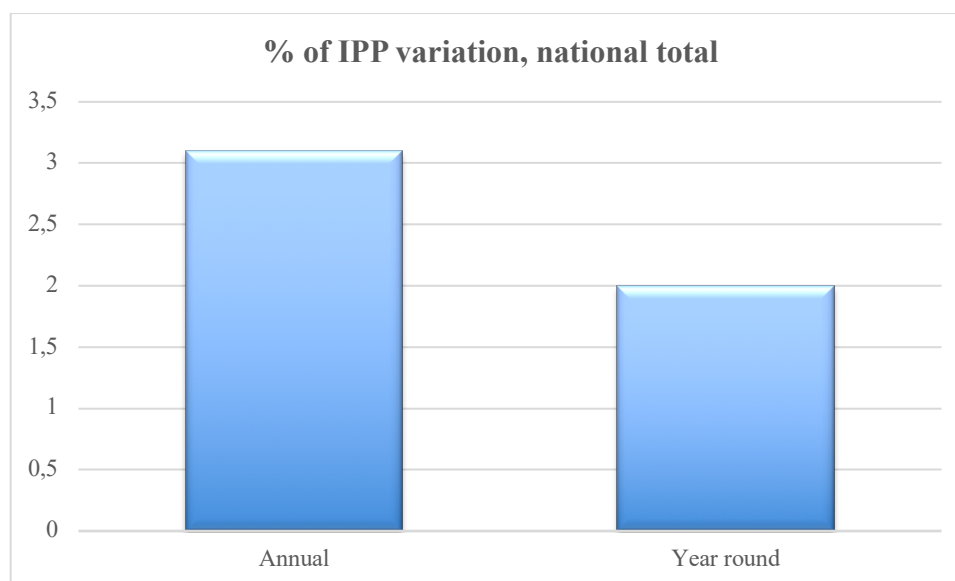


Figure 5 percentage of ipp variation at the national level data from July 2019- IPI Report 2019 taken from [https://www.dane.gov.co/files/investigaciones/boletines/ipi/bol\\_ipi\\_julio\\_19.pdf](https://www.dane.gov.co/files/investigaciones/boletines/ipi/bol_ipi_julio_19.pdf)

In July 2019 compared to July 2018, the four industrial sectors presented positive variations. Manufacturing industry presented a variation of 3.5%; Exploitation of mines and quarries of 2.1%; Electricity and gas supply of 3.4% and Collection, treatment and distribution of water of 1.3%.

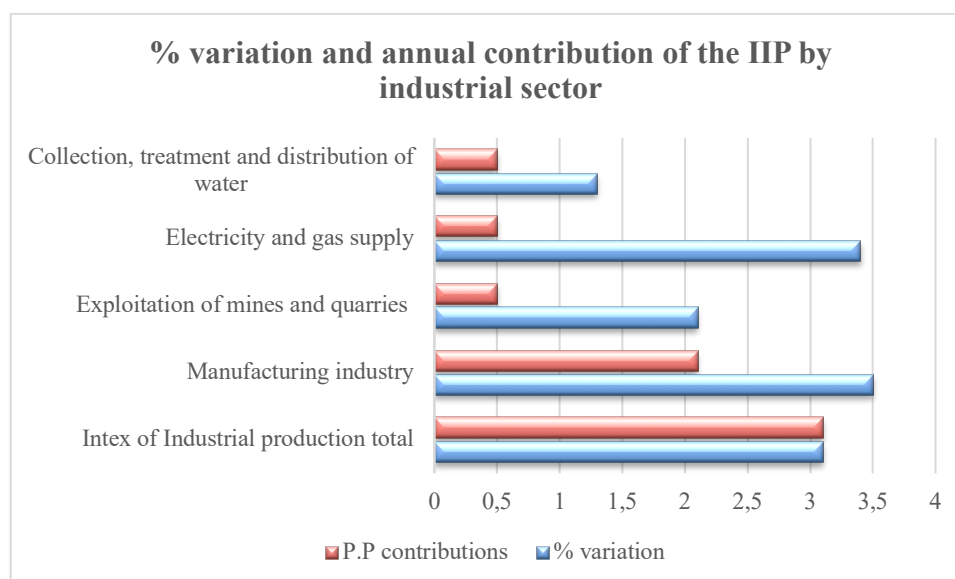


Figure 5. Variation and annual contribution of the IIP by industrial sector taken from IPI report 2019 National total July 2019 pr taken from [https://www.dane.gov.co/files/investigaciones/boletines/ipi/bol\\_ipi\\_julio\\_19.pdf](https://www.dane.gov.co/files/investigaciones/boletines/ipi/bol_ipi_julio_19.pdf)

In July 2019 compared to July 2018, of the 26 industrial activities 19 presented positive variations contributing 3.6 percentage points to the total variation. The activities that stood out for their positive contribution were the elaboration of food products with a variation of 5.5%; Preparation of beverages with 7.6% and Extraction of coal (stone coal) with 4.5%.

The remaining 7 activities presented negative variations and subtracted 0.6 percentage points from the annual variation. Among those that stood out for their negative contribution to the total variation: other manufacturing industries with a variation of -27.3%; manufacture of

machinery and equipment n.c.p. with -10.2% and coking, oil refining, and fuel blending with -1.2%.

Table 5 contribution% to the IIP by component

Description	Variation %	Contribution P.P
<b>Total IIP</b>	3,1	
Elaboration of alimentary products	5,5	0,8
Elaboration of drinks	7,6	0,5
Coal extraction	4,5	0,4
Generation, distribution and commercialization of electrical energy	3,2	0,3
Manufacture of pharmaceutical products, medicinal chemicals and botanical products for pharmaceutical use	9,6	0,3
Manufacture of motor vehicles, trailers and semi-trailers	17	0,2
Manufacture of paper, cardboard and paper and cardboard products	9,2	0,2
Manufacture of other non-metallic mineral products	4	0,2
Crude oil and natural gas extraction	0,9	0,1
Manufacture of other types of transport equipment	24,6	0,1
Distribution of gaseous fuels through pipelines	4,4	0,1
Clothing making	4,5	0,1
Printing and copy production activities	8,7	0,1
Water collection, treatment and distribution	1,3	0,1
Manufacture of textile products	5,4	0,1
Manufacture of rubber and plastic products	2,3	0,1
Manufacture of appliances and electrical equipment	1,8	0,1
Manufacture of basic metallurgical products	1	0,1
Manufacture of furniture, mattresses and bed bases	2,7	0,1
Wood processing and wood products manufacturing	-6,8	0,0
Tanning and re-tanning of leather and leather products	-6,7	0,0
Manufacture of substances and chemical products	-0,6	0,0
Manufacture of fabricated metal products, except machinery and equipment	-3,4	0,0
Coking, oil refining, and fuel blending	-1,2	-0,1
Manufacture of machinery and equipment n.c.p.	-10,2	-0,1
Other manufacturing industries	-27,3	-0,3

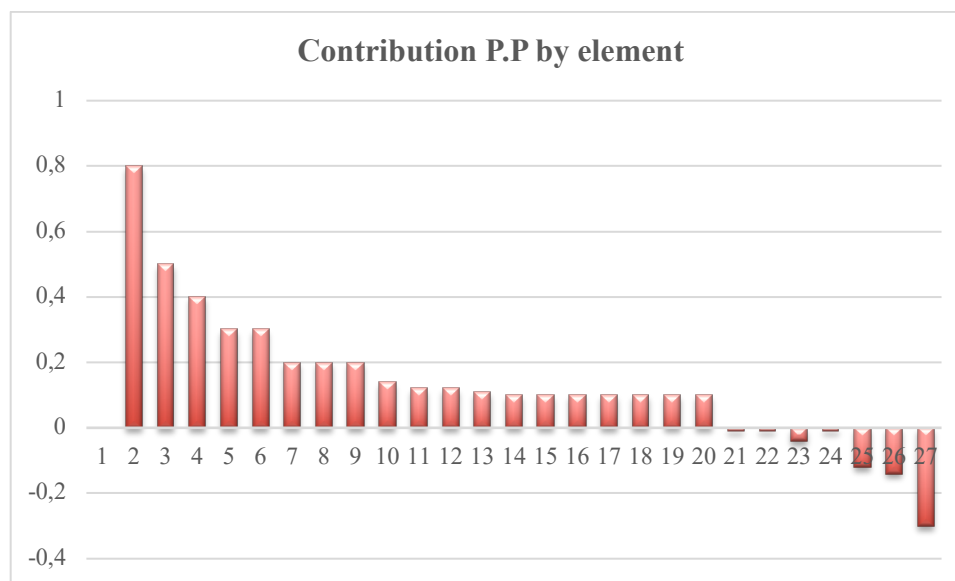


Figure 6 Variation and annual contribution of the IPI by industrial activity taken from IPI report 2019 National total July 2019 pr taken from [https://www.dane.gov.co/files/investigaciones/boletines/ipi/bol\\_ipi\\_julio\\_19.pdf](https://www.dane.gov.co/files/investigaciones/boletines/ipi/bol_ipi_julio_19.pdf)

### 3.2 Digital economy in Colombia.

According to Raúl Katz (2015), digitalization in Latin America has mobilized about 195 billion dollars to GDP in the last 10 years and has contributed to nearly 900 thousand jobs in the same period. According to the study “The Ecosystem and the digital economy in Latin America” (Services, 2015), digitalization has contributed with 6.12% of GDP growth in Colombia, between 2005 and 2013, the largest in the entire region:

Table 6 Digitalization in Latin America - translated from *Hacia una medición de la economía 2016*, MinTIC.

Country	Volume in dollars*	% of GDP**	Jobs created
<b>Colombia</b>	15.976	6,12%	153490
Peru	7.309	5,15%	32400
Brazil	88.480	4,74%	370710
Argentina	12.781	3,76%	63850
Chile	7.726	3,72%	25650
Venezuela	9.327	3,38%	41080
Mexico	33.540	3,26%	85790

\*data between 2005-2015 \*\*current dollar rate in the period

Technological progress, which goes hand in hand with the digital economy, has managed to transform people's common lives and has generated different and new trends, as well as potential advances in the development of new business models. As ECLAC puts it well, "not joining a digital revolution leads to a lag in economic growth and social development" 7.

National Development Plan, 'Pact for Colombia, Pact for Equity' (2018-2022), states that “territorial entities may define smart city strategies, and must take into account the technical guidelines in the digital transformation component that establishes The MinTIC This means



that they must incorporate technologies of the Fourth Industrial Revolution to promote intelligent territories. ” (Sierra, 2019)

### 3.3 Ministry of ICT (MinTIC)

The Ministry of Information and communications technologies, according to Law 1341 or ICT Law, is the entity responsible for designing, adopting and promoting the policies, plans, programs and projects of the Information and Communications Technology sector. (MinTIC, 2019)

Among its functions is to increase and facilitate the access of all the inhabitants of the national territory to Information Technology and Communications and its benefits.

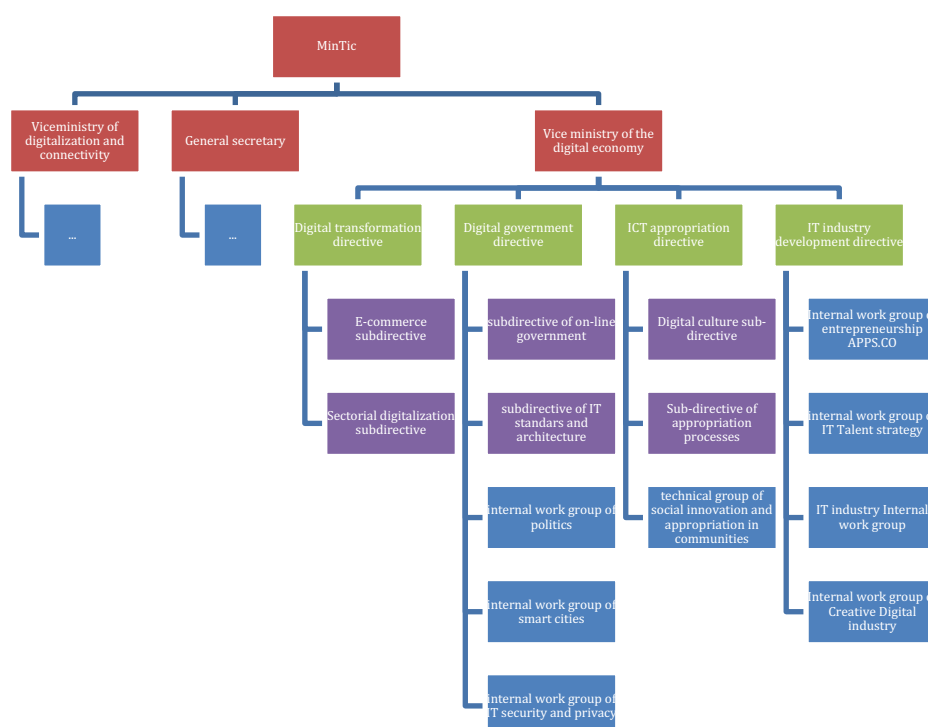


Figure 7 Organizational structure of the MinTIC Adapted from mintic.gov.co

The creation of the Vice Ministry of Digital Economy arises as a result of the importance and growth of communication processes through technology to achieve its specialization according to the advances generated by the State in matters of Information Technology and to continue with the efforts developed by the general vice ministry.

The main functions of the Vice ministry of the Digital Economy in Colombia, taken from the ministry's website are the following:

- To formulate, coordinate and monitor the implementation of public policies for the use, access and administration of the technological infrastructure that supports the information of the State, in a manner aligned with the national and sectoral government strategies, as well as granting security, privacy and Interoperability of the systems.
- To formulate policies and programs for the development of the Information Technology industry, including the digital content industry within the framework of the creative economy.

- To diagnose the degree of digitalization of the different sectors of the economy and, as a result, to formulate and articulate policies and programs aimed at encouraging the use of information and communications technologies in the productive processes of such sectors.
- To define the technological architecture of the State's information systems, including interoperability, privacy, security and construction standards or application parameterization.
- Designing and implementing financing, promotion and incentives mechanisms for the Sector in the field of information technologies in finance plans, programs and projects in accordance with the functions of the Information Technology and Communications Fund defined in Article 35 of Law 1341 of 2009 and the norms that modify, add or replace it.
- Establishing, in coordination with the National Planning Department (DNP), and the National Administrative Department of Statistics (DANE), the standards and guidelines for the application of public policies, both in terms of information in public administration entities, such as in relation to its sharing among them.
- To lead the design and adoption of policies, plans and projects to promote and to massify the Online Government by coordinating actions with the relevant bodies.
- Coordinating and granting, in each of the government sectors, the implementation of the recommendations and good practices defined by the National Digital and State Information Commission.
- Advise the Minister in the design and formulation of the Institutional Information Technology Plan and support him in the functions of management, supervision and control for its implementation.
- Defining the Information Technology information that should be incorporated into the integral information system, with the data, variables and indicators of the sector in the field of information technologies, coordinating with the Planning and Sector Studies Advisory Office the incorporation into the system.
- Defining, coordinating and executing the necessary policies to promote and facilitate that the State makes available to the general public the data sets that allow to develop processes of innovation and entrepreneurship based on technology through the use of information technologies and communications, promoting the use of state information.
- Formulating, coordinating, articulating and executing with territorial entities, policies and programs of smart cities that allow the solution of urban problems through the adoption of information and communications technologies.
- To define digital security risk management models at national level and to define the strategic agenda for cooperation, collaboration and assistance in matters related to digital security in the use of information and communications technologies.
- Generating policies to attract national and foreign direct investment in the information and communications technology sector, as well as the establishment of technology-based companies.
- Formulating policies and programs that promote digital entrepreneurship, and the consolidation of the business models involved in it.
- Coordinating and articulating the adoption of public policies that normatively reflect the new business models that are supported by the collaborative economy technology platforms.
- To formulate, articulate and promote public policies and programs aimed at the use of information and communications technologies in the development and promotion of electronic commerce of goods and services.

- To promote research, development and innovation processes in information technologies, applications, digital content and emerging digital technologies, such as Cognitive Computing, Internet of Things, Data Analytics, Artificial Intelligence, Distributed Registration, Robotics, among others.
- To promote the intensive use of Information and Communication Technologies in the production processes of micro, small and medium enterprises and their value chain.
- To attend and participate representing the Minister in meetings, councils, meetings or committees of an official nature, when convened or delegated, as well as assist him in his relations with the Congress of the Republic and in the course of the bills related to Technologies of the information.
- To provide the guidelines for the formulation, adoption and monitoring of policies, plans, programs and projects that facilitate the access, appropriation and use of all the inhabitants of the national territory to the Communication Technologies, make visible their benefits and ensure their implementation.
- To lead the formulation of administration, maintenance and development policies for the name of Internet domains under the code of the country corresponding to Colombia.
- The others assigned to it, inherent in the nature of the dependency.

### 3.4 Digital agendas

For over a decade now, the government of Colombia has been showing interest in developing different strategies to increase the technological competitiveness of the country by promoting the use of ICTs and connectivity. In parallel to this, the need to follow and measure the progress has come along. The first approach to a measurement of the internet impact on the national economy was through the National ICT Plan, “through a series of indicators that measured the progress of the Internet usage in four vertical axes: Education, Health, Justice and Business Development; and four transversal ones: Community, Online Government, Regulatory Framework, and Research, Development and Innovation (-R + D + i-). For the 2010-2014 period, the Live Digital Plan was created, which, framed in the digital ecosystem, proposed monitoring indicators for the progress of the ecosystem components, including the number of broadband accesses available and the percentage of households and MSMEs connected to the Internet currently, with the Live Digital Plan for the People (2015-2018), the national government proposed two major aspirations for the country's digital development: to make Colombia a leader in the development of applications with social impact and to consolidate an efficient and transparent government thanks to the ICTs, which brings associated indicators and measurements that allow their evolution. (CRC, 2016)

The digital agendas implemented in Colombia have not only been promoters of the digital economy, by developing different strategies to increase the connectivity and use of ICTs in the country, but they have also been one of the first approaches to their measurement. In this sense, since 2007 Colombia has been interested in knowing the impact of the Internet on the national economy

### 3.4.1 2008-2010 ICT National Plan

The first approach in the search for the impact of ICTs in other sectors of the economy was with the National ICT Plan (2008-2019), developed through a participatory process that was based on contributions made by different sectors and the opinion of a multidisciplinary group of Colombian experts, who managed to articulate the needs of the justice, commerce, education, health and science and technology sectors with the Colombia 2019 vision and with the National Plan of Development 2006-2010.

This is how the ICT National Plan 2008-2019 (ICTNP) was born, whose objective was that “By 2019, all Colombians should get informed and communicate making efficient and productive use of ICTs to improve social inclusion and increase competitiveness”

However, the follow-up to the National ICT Plan was carried out through the indicators of the National Competitiveness Policy, agreed in CONPES 3527 of 2008<sup>27</sup>, in which 11 indicators associated to the Information Technology and communications components were reported. (CRC, 2018)

The list of indicators with the calculated values to 2010 was:

*Table 7 Indicators ICT Conpes 3527 of 2008 adapted from Hacia una medicion de la economia digital, 2016*

1. Broadband users per 100 habitants	43.4
2. Number of computers per 100 habitants	17.7
3. Internet users per 100 habitants	49,4
4. Mobile telephony density per 100 habitants	92,2%
5. Percentage of municipalities with broadband internet access (rural and urban)	84,3%
6. Percentage of state entities of the national order that offer information to entrepreneurs in accordance with the established standards	68%
7. Percentage of state entities of the national order that allow online interaction with citizens according with the established standards	51%
8. Percentage of state entities of the national order that promote mechanisms of on-line participation	19%
9. Number or state entities of national order linked to the governmental internet	88%
10. Percentage of state entities of national order that exchange information with other entities to promote online procedures/services to citizens and companies, using governmental internet.	16%
11. Number of institutions of higher education and research centers connected to Renata (national academic web of advanced technology)	104

### 3.4.2 2010-2014 Live-Digital plan

With the beginning of a new period of government, the Digital Agenda of Colombia was reformulated. The President of the Republic entrusted the Ministry of ICT with the creation of a Digital Agenda that gave a technological leap to Colombia, so in 2010 the 2010-2014 Live Digital Plan was formulated.

This plan focused on reducing poverty through the use of ICTs, under the premise that the higher the usage of the Internet, the higher the employment rate. A route was drawn up to increase broadband penetration, an issue on which the country was lagging behind by having 2.2 million broadband connections in 2010. (CRC, 2018)

The Plan focused on the World Bank Digital Ecosystem and was adapted with the objective of addressing both the supply and demand of the ecosystem.

The demand side of the ecosystem consisted both in the User demand (the appropriation of the technology and the content creation) and the Applications Demand and the Supply side with the supply of infrastructure (providing digital connectivity) and the supply of services (allowing the development of digital connectivity)

Thus, the Digital Agenda was defined with the following thematic axes:

1. Infrastructure: All physical elements that provide digital connectivity.
2. Services: Those services offered by providers of telecommunications networks and services (PRST) through infrastructure and that allow the development of connectivity.
3. Applications: These are the tools that make use of the services to interact with the end user.
4. User: Users are those who make use of the applications and indirectly of the services and infrastructure to consume and produce digital information.

The Digital Ecosystem offered the possibility to evaluate the components in terms of supply and demand. In the case of the Live Digital Plan, the offer is made up of the Infrastructure and the Services that are provided by the operators, while the demand is generated by the users who use the applications.

In turn, the following objectives and their evolution were raised:

1. Multiply by four (4) times the number of internet connections (reach 8.8 million connections). At the end of 2014, there were 9.9 million broadband connections.
2. Reach 50% of homes and 50% of MSMEs connected to the Internet. At the end of 2014, the goal in households was achieved and that of MSMEs was exceeded, reaching 60.6%.
3. Triple the number of municipalities connected to the information highway (reach 700 municipalities) through fiber optic networks. Thanks to resource efficiency, 1,078 municipalities were reached.

In the global context, thanks to the advances of the ICTNP, an improvement in international indicators was achieved, but this increase was not enough for the reality of that Colombia would be entering in 2010. The main lag was presented in the infrastructure; This is why the Digital Agenda focused on guaranteeing that the digital ecosystem would work.

1. Electronic Government: by 2013 Colombia was recognized as the second-best country in the region, according to the United Nations.
2. Network Readiness Index (NRI): It went from 73rd place in 2010 to 63 in 2014.

3. Business Climate: The World Bank's Doing Business indicator categorized Colombia in the 43rd place, increasing two positions in the last year.
4. Impact of ICTs on society: The ITU ranked Colombia in 2014 in the 77th place, increasing a category with respect to the previous measurement.

Thanks to the structuring of the Digital Ecosystem, for the year 2012 the Live Digital Plan 2010-2014 was recognized as the best ICT policy in the world by the World

Association of GSMA Operators. At the end of 2014 his greatest achievements were:

1. Colombia was the first country with high-speed Internet coverage in all its municipalities.
2. Competition between mobile operators was encouraged.
3. The Internet and mobile terminals were taken to the population with less economic resources.
4. About two million terminals were delivered to complement the education of children in public schools.
5. Internet access solutions were brought in the rural area.
6. The creation of entrepreneurship was motivated through digital content.
7. Colombia was the sixth country in the world in electronic participation.

Previous achievements have allowed the digital economy to be consolidating in the country. According to the DANE figures, between 2010 and 2014 the mail and telecommunications activity had an average annual growth of 5.3%, which has represented an average participation in GDP of 3.2% in this period.

On the other hand, the development of digital content with more than 900 ventures supported by training programs is being promoted in Colombia, which generates a growing digital environment that encourages innovation and the digital economy in the country.

### 3.4.3 2015-2018 Live-Digital Plan for the people

While it is clear that the country had made great progress in the last four years in terms of technology, broadband connectivity, infrastructure and ICT services, the work had to continue with the aim of giving Colombians the necessary tools to be more productive and have better relations with the government through ICTs

Taking into account the above, the proposals were formulated to meet the objectives set, for which the national government had to promote digital talent, have more professionals in careers related to ICT and build a world-class IT industry. Importance was given to the productive sectors of the country and work together to generate impact and appropriation of ICT in i) Agriculture, ii) Education, iii) Health and iv) Tourism. Likewise, there was a great advance in the adoption of ICT in micro, small and medium enterprises (MSMEs) to achieve economic strengthening and international visibility.

The detailed control of the indicators that are generated from the Live Digital Plan for the People, allowed the adequate follow-up to the goals set, so that in the future it was evident that the approach of all these efforts and the formulation of State policies had managed to impact and they had constituted a significant advance in the economy of the Country.

As you can see from the agendas analyzed, in addition to continuing to promote the deployment of infrastructure, there is a clear impulse to elements related to digital economy such as promoting and massifying electronic payment, boosting the electronic signature, analyzing the tax system in the digital environment, promote digital public purchases,



safeguard the rights of consumers in the virtual environment, respect intellectual property and reduce the digital divide.

Likewise, it is clear the need to promote the IT and digital content industries, boost digital entrepreneurship and stimulate the digitalization of industries, which will lead to the generation of digital skills and talent in the selected productive sectors of the country (CRC, 2018)

### 3.5 A first measurement of the digital economy in Colombia

The measurement is useful to evaluate, adjust and regulate the transformation of the productive sectors in Colombia from traditional to digital models.

Taking as a framework the indicators utilized by the OECD and comparing them to the ones used previously in Colombia, the measurement of the Digital Colombia is deepened, and new indicators are presented.

It is important to mention that the base of indicators of this organization was taken as a reference, due to the fact that some of the largest economies in the world belong to it, however, it does not mean that the data set of other international organizations, to which Colombia already reports information, such as the International Telecommunications Union (ITU) will be set aside.

Finally, a query is presented that seeks the open participation of individuals or organizations from multiple economic sectors, both private and public, to generate constructive contributions in structuring a methodology for measuring the digital economy in Colombia, through which, private and public organizations, have relevant information to analyze and develop initiatives that promote the digitalization of their respective sectors. In the consultation process, discussion and linking activities of the different relevant actors in these sectors are planned.

In this way, in compliance with its legal functions, especially what is established in numeral 3 of article 22 of Law 1341 of 2009, regarding the issuance of regulation of a general and particular nature in relation to the criteria of efficiency of the sector and The measurement of the sector indicators, and what is defined in the Bases of the National Development Plan 2014-2018<sup>11</sup>, the CRC has considered it necessary to continuously review and analyze the behavior of the digital economy in Colombia and the relevant experiences to achieve better regulation, if necessary.

The design of a measurement methodology requires having basic inputs that serve to define the elements to be included and their scope. In this particular case, the conceptual framework proposed by the OECD was used as the main input, from which a dissemination, participation and discussion strategy was established that allowed adapting that conceptual framework to the Colombian reality and proposing a methodology that is consistent with the characteristics and needs of the country. (CRC, 2018)

#### 3.5.1 Description of the methodology

The challenge for the MinTIC was knowing what to measure and how to measure it, so it was necessary to analyze how this economy impacts productivity, employment, industries and people. This measurement was planned by the CRC (regulation of communications commission) to advantage of the elements already developed and the joint work with MINTIC, the National Administrative Department of Statistics (DANE) and the National Planning Department (DNP), among others.

Specifically, it began with the publication of the document “Towards a Measurement of the Digital Economy in Colombia” which presented a diagnosis of the advances in the measurement of the digital economy in Colombia and included a public consultation of the initial battery of indicators. With this document, public and private organizations, academia and civil society were invited to participate in the construction of a measurement methodology.

In this sense, the dissemination and participation strategy began with a stage of online participation, where all the actors of the society could send their comments and proposals. This stage was followed by the realization of working groups with other State entities and with representatives from different economic sectors, including some that were not directly linked to the ICT sector. Subsequently, the review of similar measurement exercises continued, carried out at national and international level, which together with the different participation mechanisms provided the inputs for the definition of the themes, indicators and other elements to be considered in the measurement of the economy Digital in Colombia. A summary of the activities developed for the definition of the methodological proposal is given in Figure 6. (CRC, 2018)

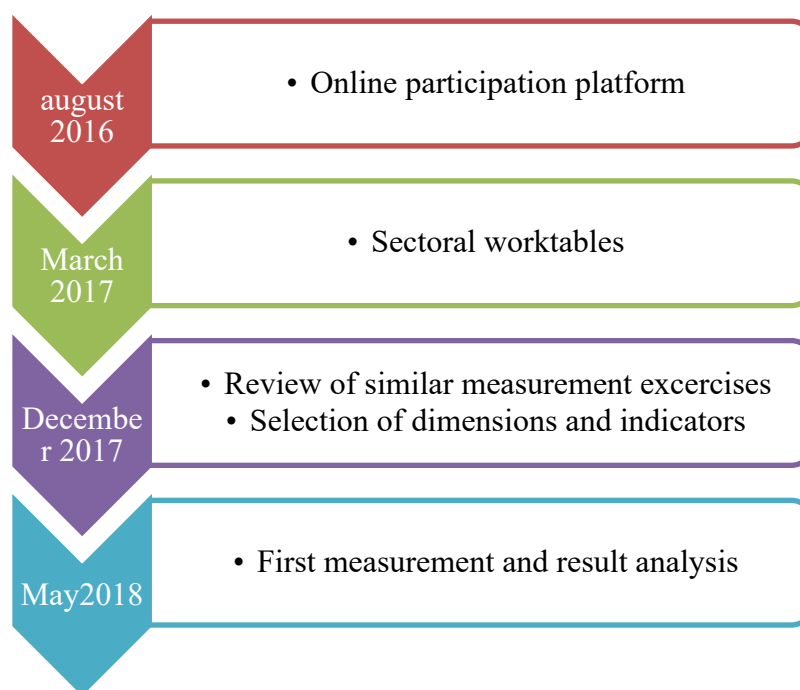


Figure 8 Timeline of the activities developed in the methodology for the measurement

adapted from methodology for the Measurement of the digital economy in Colombia 2017

The proposed measurement methodology is the result of a participatory exercise that matches the reality of the country in terms of measurement and development of factors such as the digitalization of society and the economic sectors.

To measure the progress of the digital economy in Colombia, a conceptualized methodology was defined in terms of dimensions and subdimensions, which are measured through two statistical instruments and / or techniques: individual indicators for each subdimension and composite indicator.

Specifically, 4 dimensions are defined, 33 subdimensions and 128 indicators that will allow monitoring the progress of the digital economy in relation to access and use of ICTs (mainly,



the Internet) by society and the productive sector. As well as the impact of ICT on economic growth, investment, labor productivity and the creation and promotion of new jobs, and the creation of the human capital necessary to fill them, among other aspects.

### 3.5.2 Aspects

The digital economy, understood as the transformation process triggered by ICT and its impacts at the economic and social level, is not only dynamic and involves several actors (people, companies, and government), but also invades different areas (infrastructure, networks of access, devices, etc.), socioeconomic sectors (telecommunications, contents and applications, manufacturing industry, etc.) and social activities (communication, study, purchase of goods and services, completion of procedures, etc.). It is for this reason that the measurement for Colombia is based on four large dimensions, with which it seeks to address this multiplicity of elements. Specifically, the defined dimensions by the CRC (CRC, 2018) were:

- Investing in smart infrastructure
- Empowering society
- Unchained creativity and innovation
- Creating growth and employment

### 3.5.3 Indicators

A series of individual indicators were defined that would not only facilitate the quantification and interpretation of some specific fact, but also allow evidence of specific phenomena or realities that need to be addressed to have a better performance in terms of the digital economy in Colombia. Likewise, the definition of indicators will allow to evaluate the fulfillment of the goals that are proposed against them. Specifically, a battery of 128 indicators is proposed from which the measurement of the 33 subdimensions and four dimensions will be carried out. The dimensions were the same as those used by the OECD and indicated above.

*Table 8 Dimensions and subdimensions of the measurement adapted from Metodología para la medición de la economía digital*

Dimension	Subdimension	N° of Indicators
Investing in smart infrastructure	Broadband internet penetration	2
	Internet of Things (IoT)	1
	Internet growth	3
	internet quality	2
	Broad-band internet coverage	3
	connectivity prices	4
	ICT devices and apps	2
	security and privacy	7
	Total	24
Empowering society	Internet users	4

	Online activities	1
	Internet-user sophistication	1
	Social network use	2
	OTT video service adoption	2
	Local content consumption	1
	online children care	2
	ICT in education	8
	ICT skills	1
	ICT work use	3
	E-consumers	5
	Digital government use	10
	ICT and health	5
	Total	45
Unleashing creativity and innovation	innovation in ICT industries	6
	E-business	10
	technologically based entrepreneurship	6
	Intellectual property	9
	Total	31
Creating growth and employment	ICT investment	2
	ICT business dynamics	6
	ICT added value	1
	Work productivity in IT industries	2
	E-Commerce	5
	ICT human capital	6
	ICT jobs and ICT-sector jobs	2
	Commerce competitiveness	4
	Total	28

Dimension	N° of indicators
Investing in smart infrastructure	24
Empowering society	45
Unleashing creativity and innovation	31
Creating growth and jobs	28

Therefore, for a better measurement of Colombia's performance in relation to the digital economy, the construction of two composite indicators is also proposed as a second measurement stage. This type of indicators can be understood as the mathematical combination of a set of individual indicators that, when aggregated taking into account an underlying model, provide a measure of a phenomenon or concept to be measured. A relevant feature of this multivariate analysis technique is that it manages to reduce a certain number of indicators, which generally have different units of measure and importance, to only one index without eliminating the information considered relevant for the measurement, as well as including more information without exceed the existing size limit (CRC, 2018)

Composite indicators are ideal for measuring multidimensional concepts, which cannot be captured by a single indicator (OECD, 2008). offering a summary and holistic view of a given reality that facilitates decision making. Concepts such as competitiveness, industrialization, sustainability, and innovation, as well as the development of ICTs and the development of the digital ecosystem have been widely addressed based on composite indicators<sup>26</sup>.

Another reason why it is proposed to use this type of indicators is because they are a good tool for comparative analysis of the performance of countries (or other type of territorial unit such as departments, states, provinces or municipalities) in relation to a multidimensional or complex concept, as well as assess its progress over time, providing important elements for public policy.

Likewise, following the OECD (2008), one of the advantages of using a composite indicator against a battery of indicators is that it facilitates the communication of the results with the general public and promotes measurement, since it is easier to analyze and interpret A composite indicator than an extensive list of individual indicators.

Thus, taking into account the conceptual basis developed in previous sections, it is considered that the construction of two composite indicators to measure the progress of the digital economy in Colombia will allow to address in a simplified way all the aspects considered relevant under this concept. An initial approach to each of the composite indicators is presented in chapter four of this document.

A first measurement of the digital economy in Colombia is proposed from the construction of two composite indicators, one at the country level and the other in regional terms. The first called “Digital Economy Index - Country Level (DEI)” and the other called “Digital Economy Index - Regional Level (DEI)”; Both exploratory exercises, which, beyond establishing a definitive approach, intend to be a proposal from which to work and improve to demonstrate the situation of Colombia in terms of the digital transformation of its economy and society motivated by ICT.

## COMPOSED NATIONAL INDICATOR

The first composite indicator built, called the Digital Economy Index - Country level (DEI), aims to measure the country's performance in terms of the digital economy and thus have a global measurement that, to the extent that can be implemented, will allow for a follow-up in Colombia's progress in this concept at the national level. In this sense, the structure and construction are based on the conceptual framework outlined above<sup>28</sup>. The index consists of four dimensions and each of them has the certain number of subdimensions and indicators, mentioned before.

The selection of the subdimensions and indicators to be used in the construction of the index was the result of an additional selection process, which was mainly guided by the availability of the information, discarding those subdimensions for which there was no information or if there was it was old data.

Thus, the Digital Economy Index - Country level (DEI) is defined by the following formula:

$$DEI = w1D1 + w2D2 + w3D3 + w4D4 \text{ (CRC, 2018)}$$

Where  $w = 0.25$  and  $Dx$  corresponds to the four dimensions.

By its construction the results of the index are between zero and one hundred, with zero being a low (or no) performance in terms of digital economy and a hundred a high performance or a great low advance in this concept. The estimate was made for 2016.

## REGIONAL COMPOUND

It seeks to determine whether the performance observed at the country level is the result of a uniform behavior of the regions or on the contrary there are gaps between them that need to be addressed so that Colombia as a whole can take advantage of the economic and social transformation generated by ICT.

The definition of the regions considered in the development of this index was carried out taking into account the regional distribution used by entities such as DANE and MinTIC to apply their surveys and collect information related to the possession, use and appropriation of ICTs by the people and companies. Specifically, there are eight regions: Antioquia, Bogotá D.C., Caribbean, Oriental, Orinoquía-Amazonia, Pacifica and Valle del Cauca.

Like the country-level index, the structure and construction of this composite index is based on the conceptual framework of digital economy outlined above. Again, the index is made up of four dimensions and each of them has a certain number of subdimensions and indicators. However, for the aggregation of the dimensions a different weighting was used, giving greater weight to the first two dimensions (Investing in intelligent infrastructure and Empowering society, respectively), considering that they are the dimensions that have the largest number of subdimensions and indicators. Additionally, under the geometric measure, the marginal effect of the improvement in the score of an indicator is greater for those who have a poor performance than for those indicators with high scores. Both desirable and necessary characteristics for the regional index considered.

Thus, the Digital Economy Index - Regional level (IEDR) is defined by the following formula:

$$IEDR = Dw1 * Dw2 * Dw3 * Dw4 \quad (4) \quad 1234 \text{ (CRC, 2018)}$$

Where  $w1$  and  $w2$  is equal to 0.40, and  $w3$  and  $w4$  is equal to 0.10.  $D$  are the four dimensions.

And its results are between zero and one hundred, zero being a low (or no) performance in terms of digital economy and one hundred a high performance or a great advance under this concept. The estimate was made for the year 2016. In this case it is also valid to mention that, an upper limit of one hundred is quite demanding considering the feasibility of reaching that value and may be leading to an underestimation of the results obtained.

### 3.5.4 Lack of sources of information

In the design of the methodology, once the battery of indicators was defined, the availability of information for them was reviewed. This exercise included the review of national and international sources, including public and private entities, and showed as the main result that, of the 128 indicators proposed for this first measurement, Colombia has information for 96 indicators, that is, 75% of the total contemplated, of which 81.6% (78 indicators) are produced by state entities such as DANE, MinTIC, and the Superintendence of Industry and Commerce (SIC); the remainder was obtained from multilateral organizations such as the Development Bank of Latin America (CAF), the World Bank (WB) and the International Telecommunications Union (ITU).

In this sense, the sources of information for the defined indicators are State entities and international organizations, which are characterized by continuity and quality standards in their production processes and publication of statistics.

With the availability review it was also possible to show that 25% of indicators not available for this initial measurement are due to the fact that in Colombia there is an important battery of indicators related to Internet coverage, penetration and speed, as well as those related to possession and use of ICT by the people, households and productive sectors of the country; However, there is still progress in collecting more specialized indicators regarding this use and carrying out a greater number of ICT measurements in sectors such as health. Similarly, work must be done to have indicators that allow measuring the impact of ICTs on economic growth, labor productivity and employment.

The non-availability of this information has a significant impact on the accuracy of the results of the measurement of the digital economy and demonstrates the importance of continuing to make progress in the construction and collection of indicators related to this concept.

The sources of information for the indicators defined are State entities and international organizations, which are characterized by continuity and quality standards in their production processes and publication of statistics.

There are limitations related to the availability of figures for a significant number of indicators, which made it difficult to have a battery of indicators with completeness of information and to apply more robust techniques in the different steps considered in the construction of composite indicators. This can generate underestimations in the country's performance; therefore, these results must be interpreted in the framework of the methodological development presented in this document and considering that they must be completed in time to achieve greater precision.

The information availability review exercises show that Colombia has an important battery of indicators related to Internet coverage, penetration and speed, as well as those related to the possession and use of ICT by people, households and productive sectors of the country, which were defined in the dimensions “Investing in intelligent infrastructure” and “Empowering society”; However, in order to have a better measurement of this last dimension, it is necessary to make progress in collecting more specialized indicators regarding this use and to carry out a greater number of ICT measurements in sectors such as health.

Similarly, work must be done to have indicators that allow measuring the impact of ICTs on economic growth, labor productivity and employment. Of the four dimensions contemplated, “Creating growth and employment” was the dimension that produced the highest proportion of indicators not available (35.7%).

Most of the leading indicators are available for Colombia at the country level. Of the 96 indicators for which information is available, only 43.8% are available at the regional level. This situation makes it difficult to monitor the performance of the digital economy in terms of regions and can hide important gaps within the country. Therefore, it is considered important to increase institutional efforts to maintain and increase the number of indicators at the regional level, mainly in relation to the use of ICTs in the productive sector.

### 3.5.5 Results

#### 3.5.5.1 national 1

Table 9 Results at the national level- Adapted from Metodología para la medición de la economía en Colombia

Dimension	IED
Investing in smart infrastructure	48,1
Empowering society	33,5
Unleashing creativity and innovation	28,7
Creating growth and jobs	29,5
<b>Country</b>	<b>34,9</b>

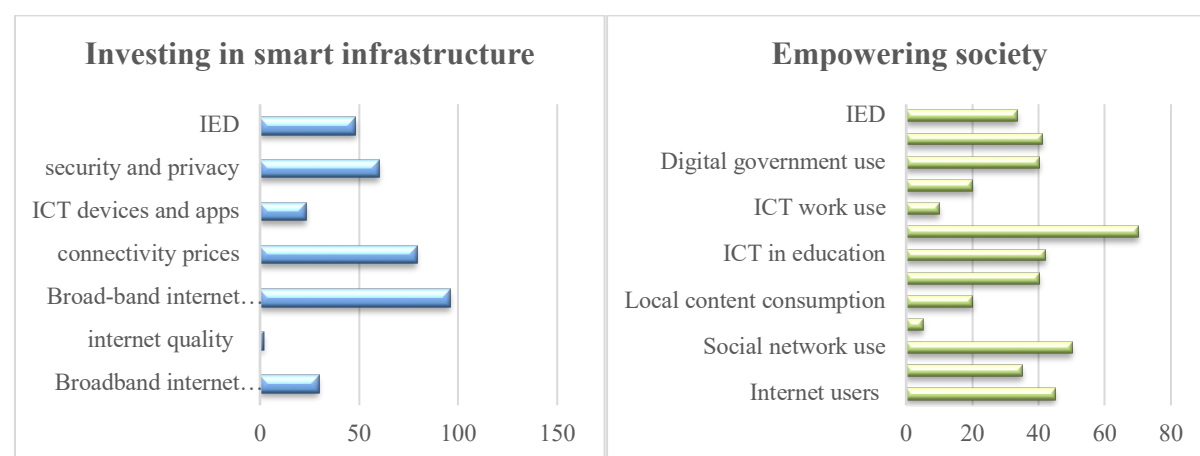


Figure 9 Results dimension 1 and 2. (CRC,2018)

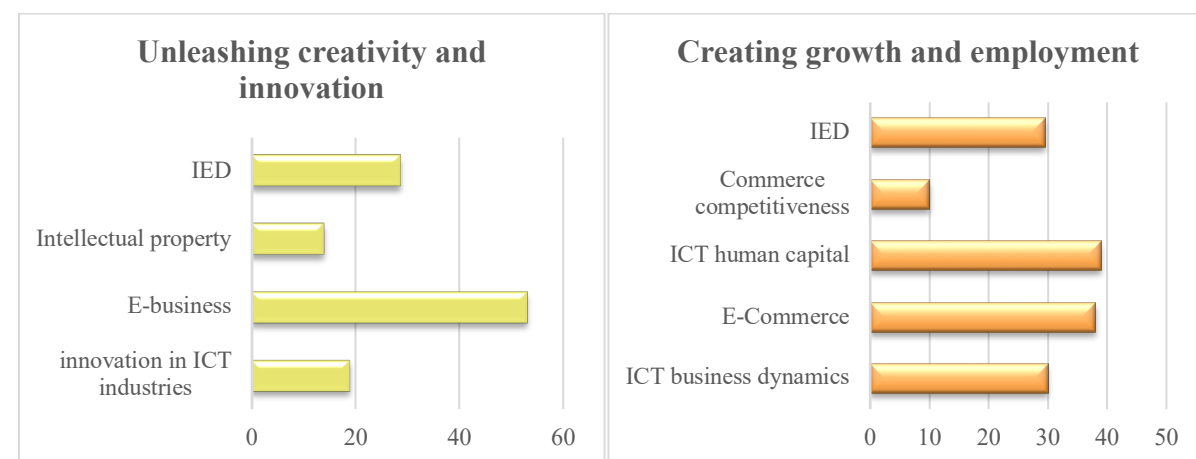
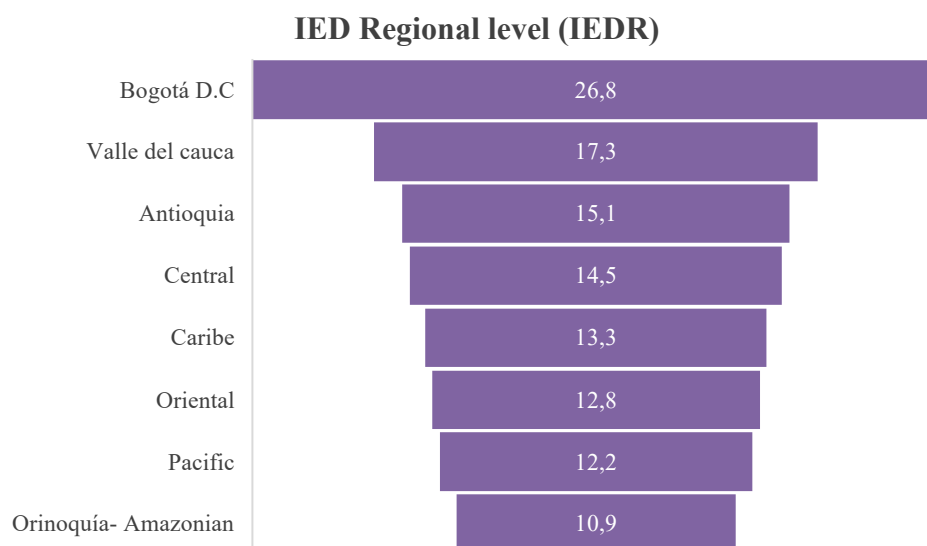


Figure 10 Results dimension 3 and 4. (CRC,2018)

The results obtained for Colombia in 2016 of the Digital Economy Index - Country Level (DEI), measured between 0 and 100, was 34.9. This score indicates that, although Colombia has made progress in terms of the digital economy, it still has a great room for improvement, which should be directed by the public and private sector to improve the country's performance in relation to digital transformation in the coming years. Specifically, it is obtained that the country has important advances in key aspects to have a good performance in terms of the digital economy such as **the infrastructure and use of**

**ICT by people and the productive sector;** nevertheless, to have a significant growth in the index, important efforts are required in aspects such as Internet connections with speeds greater than 10 Mbps, which is an important element for an improvement in the performance of all dimensions.

### 3.5.5.2 regional level



*Figure 11 Regional level results*

*adapted from CRC, 2018*

The results of the regional indicator indicate that Bogotá D.C. is the region with the best performance, followed by Valle del Cauca and Antioquia, with scores of 26.8, 17.3 and 15.1, respectively; while the Pacific and Orinoquía - Amazon regions are those that exhibit the least development in terms of digital economy, with scores lower than and equal to 12.2. Results that show the existence of an important gap between Bogotá D.C. and the rest of the country

## 3.6 Other project-results to 2018

- **Hacker Girls’**: it is a program that consists in the promotion of female digital talent and skills, aiming to educate and generate opportunities and jobs for women on this field. It offers a training program on hacking tools, which are methodologies and techniques that extend the IT knowledge and cybersecurity related (MinTIC, 2019)
- **Apps.co**: it’s a program by the ICT Ministry that aims to promote and strengthen the creation and consolidation of businesses from the use of ICT, with special emphasis on the development of mobile applications, software and content. Since its creation in 2012, Apps.co has accompanied 2,175 teams and companies and benefited more than 137,000 people throughout the offer and it has consolidated as the largest digital entrepreneurship community in Colombia and a reference in Latin America (AppsCo, 2019) (MinTIC, 2019)



- Subsidies for education: Students who are studying an academic program related to the IT area, can finance or subsidize their studies between second and fourth semester. To apply, they must present the Saber 11 test certificate following a set of conditions stipulated or the certificate of grades of the educational institution where the studies are conducted, with a GPA higher than 3.6 over 5.0. The MinTIC will finance 90% of the value of the tuition as a forgivable credit and Icetex<sup>5</sup> will handle the remaining percentage as a refundable credit. (MinTIC, 2019)
- Workshops “More security, better region”: this academic training, organized by the Directive of Digital Government of the MinTIC, was aimed at promoting the understanding of the Digital Government Policy as a tool to support the management of each entity; identify the accompaniment route for this year, and favor the transfer of knowledge in information security and privacy, specifically in digital risks that organizations may face. the participants, who trained in topics such as digital transformation; Digital Government Index 2018; information security and privacy; Digital Government policy and self-diagnosis, and the strategy of ‘Maximum speed’, rated the workshop received with 4.79 out of 5. (MinTIC, 2019)

### 3.7 2019-2022 – NDP: Pact for Colombia, pact for equity

The 2019-2022 national development plan, called “Pact for Colombia, Pact for equity” has the objective of turning the country into one that seeks for legality, entrepreneurship and equity throughout all the citizens. (DNP, 2018)

As the government says, the goal is to face the challenges derived from the story of the country and the other challenges that have resulted from the context of disruptive changes on a global scale, by applying a set of strategies that will result in a future with equity for all Colombians. The formula “*LEGALITY + ENTREPRENEURSHIP = EQUITY*” is the basis for the definition of the plan.

The National plan of development is structured through 3 main pacts, which correspond to Legality, Entrepreneurship and Equity and 13 transversal pacts, that relate in different ways to the three pacts mentioned before.

There is one pact and several transversal pacts that relate directly with the digitalization of the economy and we are going to be focusing on them.

The pacts related to the digitalization of the economy are the following: <sup>6</sup>

#### PACT FOR ENTREPRENEURSHIP

- **Environment to grow: formalization, entrepreneurship and business revitalization** it focuses on the end of the fear of formality to boost Colombian entrepreneurship; spreading the benefits and decreasing the costs of being formal
- **Business transformation: productive development, innovation and technological adoption for productivity** the objective is to encourage sectoral public goods and technological adoption to drive a diversified and productive economy

<sup>5</sup> Colombian institute of educational credit and technical studies abroad - ICETEX

<sup>6</sup> Adapted from “Plan nacional de Desarrollo 2018-2022 pacto por Colombia, pacto por la equidad. Todo lo que no le han contado”



- **A world of possibilities: taking advantage of international markets and attracting productive investments** to boost foreign trade with agile processes, promoting high impact investment, and new health and commercial strategies to take advantage of the international market.
- **Simple state: less paperwork, clear regulation and more competition** with the objective of diminishing the ranks and paperwork. A simple regulation that drives economic development and competitiveness

### TRANSVERSAL PACTS

- **Pact for Science, Technology and Innovation:** a system to build Colombia's knowledge of the future Scientific knowledge and development of technology and innovations to transform Colombian society and its productive sector
- **Pact for the Digital Transformation of Colombia:** Government, companies, universities and homes connected with the Age of Knowledge Information technologies and Internet enhanced to improve the quality of life of citizens
- **Pact for the protection and promotion of our culture and development of the orange economy:** More artistic and cultural activities and development of new productive ventures for the consolidation of creative and cultural industries
- **Equity Pact for Women:** Economic, political and social empowerment of women to promote the full guarantee of their rights
- **Pact for effective public management:** An agile, modern and close to the Colombian State; with efficient use of public resources, doing more with less
- **Decentralization Pact:** connecting territories, governments and populations Empowered regions and connected rural areas for development with territorial equity

As the director of the national planning directive, Gloria Alonso said “The seventh chapter of the PND is dedicated, in its entirety, to the Government's strategy to ensure that ICTs become the new engines that drive the national economy towards new business models aligned with industry 4.0. “The line on the digital transformation of the PND is a transcendental axis for the efficiency of the State with the citizen and the entrepreneur,” and that Assuring that 70% of households are connected to the internet when today the number goes only to have half; going from 87,000 to 290,000 digital transactions, and achieving 3,500,000 unique users of the Digital Services Model is what will make Colombia a much more competitive country with a better economy (MinTIC, 2019)

The main objectives set by the government in the NDP were to:

- Bring Internet to lower income households.
- Improve the interaction between public entities and citizens.

The Goals were to:

- Increase to 70% Colombian households connected to the Internet goal 11.8 million
- Increase from 87 to 290 million digital transactions made
- 34 procedures of high citizen impact, digitally transformed

The challenges, on the other hand, were to:

- Increase the Internet connection of strata 1, 2 and 3.
- Improve the quality of Internet connections with speeds greater than 10Mbps.
- Promote the use of the Internet by the entire population.
- Promote the digital transformation of public administration, the private sector and territories.

- Promote digital government strategies by public entities.
- Increase the number of digital transactions.

The strategies defined to reach the objectives and goals planned, were: (DNP, 2018)

- The creation a single fund and regulator to meet the challenges of technological convergence in the ICT sector.
- To accelerate digital social inclusion through incentives to deploy networks to reach the neediest homes.
- To generate a sustainable model for public Internet access solutions in rural areas.
- To promote a State policy for digital transformation and the exploitation of the fourth industrial revolution, through the interoperability of platforms, contact through the Single State Portal, use of emerging technologies, digital security, training in digital talent, and promotion of the entrepreneurial ecosystem.
- To improve the quality of Internet in the country.
- Promoting the digital transformation of public administration through the digitalization and mass automation of procedures.
- To design and execute a technological modernization plan of the DIAN.
- Using Big Data in the fight against corruption.

The NPD also defines, what they call “Route to 2030” which is:

“The Colombian society will be a digital society connected to the Internet of quality. We will transform digitally through the use of data and new technologies in public administration, the productive sector and in the territories. DIAN will be a modern and more efficient entity in its processes, using cutting-edge technologies and Big Data will be an important ally in the fight against corruption.” (DNP, 2018)

### 3.7.1 NDP budget for Industry 4.0

The seventh chapter of the NPD “VII. Pact for the digital transformation of Colombia: Government, companies and homes connected with the era of knowledge” has a total budget of 17,874 billion COP, which is equivalent to approximately 5,2 billion \$US. The budget is divided into the components of:

1. Colombia connects: mass broadband and digital inclusion of all Colombians: 3,344 billion \$COP
2. Towards a digital society and industry 4.0: for a more efficient, effective and transparent relationship between markets, citizens and the State 14,530 billion \$COP (DNP, 2018)

Table 10 NDP budget of the pacts related to the digital transformation. Values in billions of COP

	Annual Budget	As a Percentage of total budget
VII. Pact for Colombia’s digital transformation: Government, Enterprises and homes connected to the era of knowledge.	17.874	1,63%
1. Colombia gets connected: massification of broad band	3.344	0,3%

connection e digital inclusion of every Colombian.		
2. Towards a digital society and industry 4.0: for a more efficient, effective and transparent relationship between markets, citizens and the State	14.530	1,32%

General total 1,096,122

\* values in billions of Colombian pesos

# CHAPTER 4

## Industry 4.0 in Colombia

This chapter presents the plan of action of the ministry of ICT for the next 4 years, followed by the current situation and strategies that are being deployed regarding each of the challenges of I4.0. The sectors of the economy that are investing in going digital are discussed and the case of the city of Medellín, becoming a hub for the 4IR, is exposed.

## 4. Industry 4.0 in Colombia

### 4.1 2019 MinTic Action Plan: The Digital Future belongs to everyone

The MinTic action plan is created starting from the objectives and goals set in the plan "The Digital Future belongs to everyone". The MinTIC action plan is framed within a group of strategic components and transversal components, the following are defined: (MinTIC, 2019)

#### 1. Strategic components

- 1.1. ICT Environment for Digital Development
- 1.2. Digital Social Inclusion
- 1.3. Empowered Citizens and Homes of the Digital Environment
- 1.4. Sectorial and Territorial Digital Transformation

#### 2. Transversal component

- 2.1. Culture.
- 2.2. Institutional Architecture
- 2.3. Relationship with Interest Groups
- 2.4. Monitoring Analysis and Improvement
- 2.5 Leadership, Innovation and Knowledge Management

Each one of the strategic components or axes is associated with a strategy related to the National Development Plan; and further connected to an initiative, that is defined as the basic component or articulating module of the strategic planning scheme adopted by the MinTIC

The table 11 shows the initiatives that are directly related to the NDP action line of "Towards a digital society and industry 4.0: For a more efficient, effective and transparent relationship between markets, citizens and the State". Therefore, we can see that from the axis belonging to the MinTIC action plan only the sub-numbers 1.1 ICT Environment for Digital Development; 1.3: Citizens and Empowered Homes of the Digital Environment; and 1.4: Sectorial and Territorial Digital Transformation, with a higher number of initiatives on the last one.

Table 11 Initiatives of the MinTIC action plan related to the digital economy. Adapted from (MinTIC, 2019)

NDP BASES	NDP ACTION LINES	AXIS	STRATEGY	INITIATIVE	INITIATIVE OBJECTIVE	INSTITUTIONAL MANAGEMENT AND PERFORMANCE POLICY	RELATED SUSTAINABLE-DEVELOPMENT OBJECTIVE	RESPONSIBLE	RESPONSIBLE DEPENDENCE
Pact for the digital transformation of Colombia	Towards a digital society and industry 4.0: For a more efficient, effective and transparent relationship between markets,	1.1: ICT Environment for Digital Development	Increase the institutional efficiency of the ICT sector	C1-E1-4000-E - Strengthening of the Official Postal Operator	Develop strategies that strengthen the Postal Operator as a service provider that contributes to the	01. Institutional Planning	Not related	Carlos Rebellón	6. ES SPN National Postal Services

	citizens and the State.				development of the sector.				
Pact for the digital transformation of Colombia	Colombia connects: mass bandwidth and inclusion of all Colombians. Towards a digital society and industry 4.0: For a more efficient, effective and transparent relationship between markets, citizens and the State.	1.3: Citizens and Empowered Homes of the Digital Environment	Safe and responsible use of ICT	C1-E3-1000-E - Use and Appropriation of ICTs	Promote the use and appropriation of ICT in citizens, homes, seeking to be done safely and responsibly in the country.	01. Institutional Planning	9.c. Significantly increase access to information and communications technology and strive to provide universal and affordable Internet access in least developed countries by 2020	Claudia Stela Nuñez Duarte	3.1 Directorate of Appropriation of Information and Communication Technologies
Pact for the digital transformation of Colombia	Towards a digital society and industry 4.0: For a more efficient, effective and transparent relationship between markets, citizens and the State.	1.3: Citizens and Empowered Homes of the Digital Environment	Measurement and dissemination of the benefits of using digital goods and services	C1-E3-4000-E - Radioelectric Spectrum Knowledge Management	Manage knowledge and innovation on the radio spectrum	01. Institutional Planning	17.8. Put into full operation, at the latest in 2017, the technology bank and the support mechanism for science, technology and innovation for the least developed countries and increase the use of instrumental technology, in particular information technology and communications	Martha Suarez	6 ES ANE - NATIONAL SPECTRUM AGENCY
Pact for the digital transformation of Colombia	Towards a digital society and industry 4.0: For a more efficient, effective and transparent relationship between markets, citizens and the State.	1.4: Sectorial and Territorial Digital Transformation	Standards and massification of Digital Government (PUBLIC SECTOR)	C1-E4-1000-E - Government PRO	Obtain a proactive and reliable State, which delivers its services in an integrated way for the permanent improvement of people's quality of life	01. Institutional Planning	Not related	Carlos Roza	3.2 Digital Government Directorate
Pact for the digital transformation of Colombia	Towards a digital society and industry 4.0: For a more efficient, effective and transparent relationship between markets, citizens and the State.	1.4: Sectorial and Territorial Digital Transformation	Digital Transformation of Industries	C1-E4-2000-E - Boosting the digital transformation of Colombian companies	Increase the degree of adoption of technologies in Colombian companies	01. Institutional Planning	9.c. Significantly increase access to information and communications technology and strive to provide universal and affordable Internet access in least developed countries by 2020. 17.17. Encourage and promote the establishment of effective alliances in the public,	Ximena Castrillon Ayerbe	3.3 Digital Transformation Directorate

							public-private and civil society spheres, taking advantage of the experience and strategies to obtain resources from the associations		
Pact for the digital transformation of Colombia	Towards a digital society and industry 4.0: For a more efficient, effective and transparent relationship between markets, citizens and the State.	1.4: Sectorial and Territorial Digital Transformation	Elimination of barriers that prevent the development of digital businesses (INDUSTRIES)	C1-E4-3000-E - Development of the Digital Industry Development	Increase participation in the Gross Domestic Product of Digital Industries	01. Institutional Planning	9.c. Significantly increase access to information and communication technology and strive to facilitate universal and affordable access to the Internet in least developed countries by 2020. 17.8. Put into full operation, at the latest in 2017, the technology bank and the support mechanism for science, technology and innovation for the least developed countries and increase the use of instrumental technology, in particular information technology and communications	Dario Castaño Perez	3.4 Directorate of Development of the Information Technology Industry
Pact for the digital transformation of Colombia	Towards a digital society and industry 4.0: For a more efficient, effective and transparent relationship between markets, citizens and the State.	1.4: Sectorial and Territorial Digital Transformation	Elimination of barriers that prevent the development of digital businesses (INDUSTRIES)	C1-E4-4000-E - Promotion of the development of skills in Human Talent required by the Digital Industry	Increase the number of people with knowledge and employability in Information Technology	01. Institutional Planning	9.c. Significantly increase access to information and communication technology and strive to facilitate universal and affordable access to the Internet in least developed countries by 2020. 17.8. Put into full operation, at the latest in 2017, the technology bank and the support mechanism for science, technology and innovation for the least developed countries and increase the use of instrumental technology, in particular information technology and communications	van Dario Castaño Perez	3.4 Directorate of Development of the Information Technology Industry

Pact for the digital transformation of Colombia	Towards a digital society and industry 4.0: For a more efficient, effective and transparent relationship between markets, citizens and the State.	1.4: Sectorial and Territorial Digital Transformation	Standards and mass of Governance of digital transformation (PUBLIC SECTOR)	C1-E4-5000-E - Development, use and application of science, technology and research, associated with the creation of a public information ecosystem	Implement the activities required for the commissioning of the Digital Citizen Services Model as well as Position the DNA as a Research and Development Center Applied for the public sector	01. Institutional Planning	Not related	Mayerly Diaz Rojas	6 ES AND - National Digital Agency
Pact for the digital transformation of Colombia	Towards a digital society and industry 4.0: For a more efficient, effective and transparent relationship between markets, citizens and the State.	1.4: Sectorial and Territorial Digital Transformation	Standards and mass of Governance of digital transformation (PUBLIC SECTOR)	C1-E4-6000-T - Organizational Transformation - ANE	Strengthen institutional management, climate and organizational culture, communications and implement different initiatives to strengthen collaborative relationships with citizens within the framework of ICT management and innovation.	01. Institutional Planning	Not related	Martha Suarez	6 ES ANE - NATIONAL SPECTRUM AGENCY

For each one of the Axis there is a number of projects planned that will be carried out in order to fulfill the objectives and the main goals of the NDP. The Axis 1.1; 1,3 and 1,4 will be discussed further in depth.

#### 4.1.1 ICT Environment for Digital Development

This axis creates a modern regulatory and institutional environment that provides security and legal stability, encourages the sustainable investment necessary to close the digital divide and accelerates digital transformation, promoting equity, legality and entrepreneurship. Additionally, it seeks to generate enabling conditions that boost investment as a vehicle to connect Colombians and bring the benefits of technologies to the entire population. The structural objectives of this axis are to increase institutional efficiency, focus investments for the effective closing of the digital divide, link the private sector, harmonize the consideration and economic burdens to the present and future challenges of the ICT sector and guarantee the Television and public radio. For the development of this axis, the initiatives presented in the following subsections are being implemented



Table 12 Increase the institutional efficiency of the sector projects of the MinTIC action plan

Strategy	Projects	Indicator Description	Unit of measurement	Responsible
Increase the institutional efficiency of the ICT sector	Postal Sector Regulatory Environment.	Percentage of progress in the execution of the regulatory agenda	100	6 EN SPN - NATIONAL POSTAL SERVICES
	Rebranding	Elaborate Brand Book	1	
	E-commerce Strengthening	E-commerce mobilized parts	300000	
	Collaborative Economy Platform	Collaborative Economy Platforms in Operation	1	
	Extension of Points of Sale Coverage Official Postal Operator	Number of points of sale and commercial allies of the Official Postal Operator	1337	

#### 4.1.2 Citizens and Empowered Homes of the Digital Environment

This axis aims to empower people to take advantage of the social and productive opportunities of digital goods and services, with the safe and responsible use of ICT, and thus improve their quality of life.

Additionally, it includes mechanisms for citizens and households to make use of digital goods and services from all sectors of the economy and territories.

Its structural objectives are the generation of digital skills that are transversal to the entire population, the appropriation of ICTs in homes, the empowerment of digital services with a social approach associated with zero-rating applications with a private public cooperation approach, the reduction of barriers to gain digital goods and services, the development of productive skills with a regional focus that recognize cultural diversity and that promote the development of entrepreneurial ecosystems, the measurement and dissemination of the benefits of using digital goods and services, and the generation of trust through digital security.

For the development of this axis, the initiatives presented in the following subsections are being executed.

Table 13 Safe and responsible use of ICT strategy projects of the MinTIC action plan

Strategy	Projects	Indicator Description	Unit of measurement	Responsible
Safe and responsible use of ICT	Responsible use of ICT	Number of reports created against the sustainability of the digital action	8	3.1 Directorate of Appropriation of Information and Communication Technologies
		reports channel that violates the rights of minors		
		Number of contents produced in safe and responsible use	500	
		Number of formations in safe and responsible use	800000	
	Digital Inspiration	Number of interactions made in the digital contents of responsible use of ICT	2300000	
		Number of organizations empowered in the use and appropriation of ICT	22	
		Women inspired by the use and appropriation of ICTs belonging to women's organizations.	1500	
		Number of teenagers trained in digital activism	2000	
		Number of contents produced	300	
		People sensitized by the redvolution program	50000	
	Digital Citizenship	Number of Formations in digital competitions	90000	
		People in the community with disabilities trained	3000	

		in ICT for inclusion in the use of ICT		
	Teleworking	Number of studies developed in teleworking	2	
		Number of interns trained and certified in teleworking	400	
		Number of people impacted by the diffusion and promotion of Teleworking	15000	
		Number of workers of public and private entities advised	7500	
	Promotion of the Use and Appropriation of ICT	Number of studies carried out to analyze and diagnose the current state of the use and appropriation of ICT, by the Colombian population.	1	
		Number of appropriation projects advised	15	
		Number of projects developed for innovation and technological appropriation.	1	
		Number of inspections of the initiatives for the use and appropriation of ICTs	2	
Measurement and dissemination of the benefits of using digital goods and services	Promote knowledge in spectrum	Compliance % with the schedule of activities	100	6 ES ANE - NATIONAL SPECTRUM AGENCY
	Promote innovation in spectrum issues	No. of investigations carried out	3	

### 4.1.3 Sectorial and Territorial Digital Transformation

The purpose of this initiative is to raise the level of productivity and competitiveness of the public and private sectors, in order to reach high international standards.

In the digital transformation of the public administration there will be standards of digital government, interoperability, citizen folder, electronic authentication, electronic invoice, big data for the fight against corruption, 100% new digital procedures, governance of digital transformation and massification of Data exploitation

In turn, in the digital transformation of industries barriers to adoption will be removed of technologies, there will be transversal credit lines for the adoption of technologies and management skills will be developed with a focus on MSMEs. For entrepreneurs, barriers that prevent the development of digital businesses will be removed and public-private ICT partnerships will be regulated.

Below, in table 14, is the information of the projects associated with this initiative

*Table 14 Standards and massification of digital government strategy projects of the MinTIC action plan*

Strategy	Projects	Indicator description	Units of measurement	Responsible
Standards and massification of Digital Government (PUBLIC SECTOR)	Measurement and monitoring Digital Government Policy	Number of follow-up reports on the implementation of the Digital Government Policy (Furag)	1	3.2 Digital Government Directorate
	Generation and updating of guidelines and tools related to the Digital Government Policy	Number of guidelines documents created or updated	4	
	Strengthening of components of the Digital Government Policy	Percentage of public entities that develop their digital transformation through the Architecture enabler of the Digital Government policy	21	
	Technological solutions and support	Technological solutions created, updated or improved	1	
	Empowerment CIOs	Number of CIOs participating in the empowerment project	300	
	Accompaniment for Digital Transformation	Percentage of entities of the national order that implement elements of the Digital Government Policy	25	

	Development of solutions and new business models of Digital Government	Number of projects accompanied by the Digital Government Technology Development Center	2	
	Transversal Enablers of the Digital Government Policy	Users of the Digital Citizen Services Model	500000	
	Unique Portal of the Colombian State	CN 3920 Number of progress reports on the National Data Exploitation Policy (Big Data)	2	
		Availability percentage of the single Portal of the Colombian state	85	
	Digital Security	CN 3854 Number of progress reports on the National Digital Security Policy	2	
		Percentage of national and territorial entities that identify and assess digital security risks	25	
Digital Transformation Industries	Digital skills project for electronic commerce	Number of Reports of the implementation of the appropriation plan	1	3.3 Digital Transformation Directorate
		Number of campaigns executed	1	
	Business Digital Transformation Centers.	Updated platform	1	
		Updates of the Maturity Model for Digital Transformation	1	
		Number of Reports on Strengthening Activities of the Digital Business Transformation Centers.	2	
		New Business Digital Transformation Centers	5	
	Digital Payments	No. of calls made to run the pilot focused on implementing advanced technologies	1	

		No. of reports of results of programs implemented	2		
		No. of frequently used services that implement digital payments.	2		
		Articulation and Advanced Technology Development Centers	No. of calls for institutional or business challenges to be served through advanced technologies		3
			Number of new centers for the attention of institutional or business challenges with advanced technologies		1
		Digital Laboratories for Productive Sectors	No. of calls for advanced technology solutions		3
			No. of open sector laboratories for Digital Transformation		1
			Productive sectors impacted with the development of technological solutions of the Sectorial Laboratories		3
		Digital Farming	Departments with implemented methodology		2
Elimination of barriers that prevent the development of digital businesses (INDUSTRIES)	Develop promotion and dissemination events of the Digital Industries	Number of events held	4	3.4 Directorate of Development of the Information Technology Industry	
	Develop the Crea Digital and New Media calls	Number of Companies in the Digital Creative Sector benefited	20		
	Internationalization	Number of Internationalization Promotion Activities	18		
	Creative services for traditional companies in the region	Number of Companies benefited in creative services	100		
	Productive Chain Program (Scale Ups)	Number of Companies benefited in the productive chain program	20		
	Accompaniment to digital	Accompanied digital companies	80		

	entrepreneurship-Strengthening companies sector T.I.	Enterprising teams with digital business initiative accompanied	450	
	Strengthening service provision processes for the audiovisual sector	Companies that have benefitted in sectors for the audiovisual sector	30	
Standards and mass of Governance of digital transformation (PUBLIC SECTOR)	Management of solutions to problems of the public sector through projects of science, technology and applied innovation.	Number of entities that recognize AND as Manager of applied science, technology and innovation solutions	19	6 ES AND - National Digital Agency
Standards and mass of Governance of digital transformation (PUBLIC SECTOR)	Optimize the entity's Integrated Management System	Progress percentage of the implementation plan	100	6 ES ANE - NATIONAL SPECTRUM AGENCY
	Potentialize the capabilities of human talent and communications of the entity	Progress percentage of the implementation plan to enhance the capabilities of human talent and communications of the entity	100	
	Implement the IT Strategic Plan (PETIC)	PETIC progress percentage	100	

## 4.2 Challenges of industry 4.0: Colombia.

As it was exposed in chapter 2 of this work, there are a number of existing challenges in each country regarding the implementation of industry 4.0; in this section, we will be discussing how Colombia is facing them- either by itself, with plans of actions and public investment into the accomplishments of the ICT goals; or with the help of foreign investment, like the US \$ 550 million Siemens investment in the development of projects in Colombia and the training center inaugurated also by them. Siemens signed a memorandum of understanding with ProColombia and SENA to work on issues related to strategic areas for the country's development, such as digital manufacturing, smart infrastructure, energy transition, cybersecurity, health and mass transportation. (Zambrano, 2019)

The main challenges of industry 4.0 concern **the digital gap**, an existing gap that separates us even further not only on an international level but also on a national level, with the divide existent between rural and urban areas, where the access to internet costs less and has a much better quality; the **inadequate connectivity**, due to the fact that, for the correct implementation of most of the technologies of industry 4.0, specially IoT, is necessary a 5G connection that allows faster speeds it is fundamental to see how the country is acting to reach a better connectivity; **Enabling the micro, small and medium enterprises** so that they are able to transform into digital enterprises to stay competitive and survive in the harsh competitive market; **Lack of trust** because societies now tend to be absolutely insecure with

respect to technology, being vulnerable to privacy breaches, identity theft and data mis manipulation and the government and the companies have to be aware of this challenge and act accordingly to guarantee the protection of the rights of the citizens; and not only with respect to legal regulation, but also about self-regulation; **jobs and skills** it is clear that one of the main concerns when talking about the fourth industrial revolution is the impact that it will have on the labor force, since some jobs will be replaced by the technology and some new jobs will be created in order to carry out the new tasks that come with the implementation of the technologies, it is certain that a whole set of new skills will be required; preparing the workforce to be ready to offer the skills needed in the market is a must; **limited awareness** of entrepreneurs and citizens in general, with respect to the concept of industry 4.0, as well as the benefits, barriers, technologies and all the implications of this revolution, which leads to a higher reluctancy rate, being informed and trained is also fundamental ; and **Trade logistics and e-commerce**, there will be the need of a regulatory environment that takes into consideration each of the types of trade that will appear in the market. (Zambrano, 2019)

### 4.2.1 Digital divide / Inadequate connectivity

Colombia has becoming through the years into a digital country; however, it is evident that a digital divide still separates cities from the countryside. Internet usage has increased its accessibility rate for many Colombians but there's still the need to close the digital gap, on which the government is focusing and promising to work on, the access in rural areas of the country is still difficult or too expensive compared to the level of service provided, i.e. it costs more and the service level is the same or, sometimes, worse. (Erb, 2019)

"Three times a year, the Colombian Ministry of Telecommunications (MinTIC) publishes a bulletin with the latest numbers on Internet usage in the country. Those numbers are invariably announced as a success, as they are rising steadily. According to the latest bulletin, published in November 2018, Internet penetration has reached 60 percent, with more than half the total population accessing the Internet through their mobile phones. Five years ago, only 15 percent of the population had access to broadband Internet." (Speak up barometer) Just by looking at these numbers, it can be said that Colombia is on the right path towards the digital transformation of the country

This picture is supported up by bodies like the GSMA, which represents the interests of mobile network operators worldwide. According to the GSMA's 2017 report, mobile operators invested more than \$9 billion (€7.9 billion) in networks and spectrum since the start of the decade. "As a result, mobile broadband coverage in Colombia exceeds 90 percent for 3G, with 4G coverage expanding rapidly and now reaching nearly two-thirds of the population," the report states. And although the transition from 2G to mobile broadband occurred more slowly in Colombia than in other Latin American countries, "the gap will substantially close by the end of the decade except in comparison with the regional leaders – Brazil in particular."

Nevertheless, the above-mentioned numbers are a bit misleading. There are huge differences in how people are able to access the Internet, and a divide continues to exist, especially between the urban side and the rural side

Today, most people in Colombia use the Internet on mobile devices, usually with prepaid contracts. 1 GB of data, for example, costs around \$6.50. In comparison, the minimum wage in Colombia is about \$260 per month. Most network operators allow people to use WhatsApp and Facebook for free. This does, however, undermine net neutrality somewhat, as not all



services are treated the same. Officially, net neutrality is guaranteed in Colombia, but there have been no known sanctions against the companies. "There is not much competition, that's part of the problem," says Camila Perez, an economist and author of the report "Digital Colombia: Maximizing the Global Internet and Data for Sustainable and Inclusive Growth" (Erb, 2019)

### 4.2.2 Enabling MSMEs

The MSME sector also participates. MinTIC has invested 138,000 million Colombian pesos (approximately 44,5 million US dollars) since 2012 in 70 digital transformation programs for medium and small businesses.

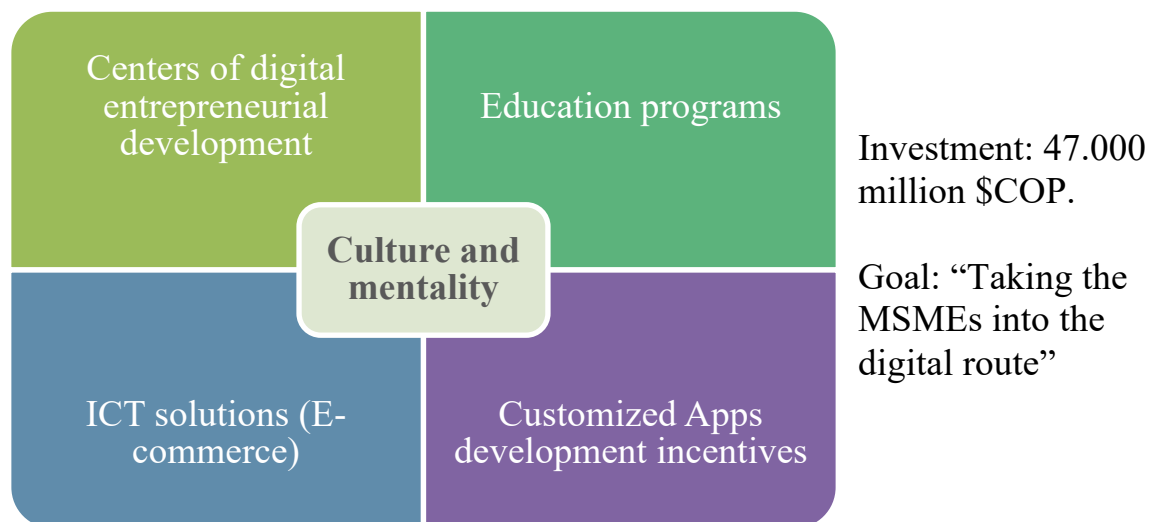


Figure 12 line of action of the project MiPyme taken from <https://mintic.gov.co/portal/vivedigital/612/w3-channel.html>

From 2016 to 2018 the government presented a strategy with 5 interconnected components that aim to lead the MSMEs, known as Mipyme in Spanish, into the digital route through the transformation of their business models. This strategy involves 5 lines of action which are:

- Training programs
- Centers of digital entrepreneurial development
- ICT solutions (e-commerce)
- Initiatives of customized-APPs development
- Culture and mentality

The results were positive; to 2018 and since its creation in 2012, Apps.co had accompanied 2,175 teams and companies and benefited more than 137,000 people throughout the offer. It was consolidated as the largest digital entrepreneurship community in Colombia and a reference in Latin America

In the new Plan of Action of the minTIC as it was shown in the previous section 4.1 , the strategies on which the government is focusing now, while still working on the projects implemented before, are **Boosting the digital transformation of Colombian companies** and **The promotion of the development of the digital industry.**

With the first strategy, the government aims to increase the degree of adoption of information and communications technologies in Colombian companies and in strategic economic sectors

- through the design, development, generation and execution of programs to promote the transformation of business models of micro, small and medium enterprises based on the strategic use of technology, in order to increase their productivity and competitiveness. It aims to accomplish this strategy through six specific projects: Digital skills project for electronic commerce, Business' Digital Transformation Centers, Digital Payments, Articulation and Advanced Technology Development Centers, Digital Laboratories for Productive Sectors and Digital Farming

In 2019, by executing the **digital skills project**, 10,000 companies and enterprises are digitally transforming a process or action, through the generation of confidence in the use of ICT. With the **Business' Digital Transformation Centers (CTDE)**, 3,000 companies will be accompanied and served to take them along the digital transformation route.

Likewise, through the **digital sectorial laboratory** three productive sectors will be impacted with the development of technological solutions, while with the **Centers of Excellence and Appropriation** four projects will be carried out to address institutional or business challenges with advanced technologies; finally, the digital agricultural methodology will be implemented in two departments of the country, such as strategy to promote the adoption of technology in the agricultural sector of Colombia.

During the first months of 2019, programs and strategies that allow the use and appropriation of ICTs in companies and productive sectors have been structured. In that sense, the design phase of the projects to be developed has been carried out, with the aim of guaranteeing the achievement of the goals set. The design phase includes the identification of national government entities with which it is efficient to combine efforts to ensure the effective development of the proposed instruments, and thus avoid duplication of efforts

With the second strategy, Promotion of the development of the digital industry the government is aiming to increase participation in the gross domestic product of the digital industries, promoting the strengthening of the industry so that it is able to offer services to the market based on technological solutions.

Additionally, through **Apps.co**, , it continues to seek the closure of gaps for digital entrepreneurship, through advice and support that enhance the generation, creation and consolidation of businesses from the use of ICT, especially the development of web applications, mobile, software, software-hardware integration, digital content, among others. The support phases of the Apps.co program, aimed at entrepreneurial teams and digital companies according to their degree of maturity - early stage or advanced stage - are under construction in the period January-May 2019. In that sense, it is expected to make the calls and the accompaniment of at least 203 teams in the early stage and 70 companies in the advanced stage, which will be beneficiaries of the calls mentioned during the term 2019.

Between January and May 2019, Apps.co has made progress in the construction of terms of reference for the call to allied operators, which will support the entrepreneurial teams and the digital companies that result from the respective calls per phase

### 4.2.3 Lack of trust

According to the panelist that reunited in the university EAFIT in Colombia (Valencia, 2019), one of Colombia's challenges in the administration of justice also involves legal and

technological innovation, in the way of developing tools that allow citizens to bring justice and perform complex tasks such as systematization of court records or conduct virtual court hearings, which can improve institutional capacity in these scenarios.

“The regulation will have to be flexible enough so that it does not hinder the development processes we have in our economy. If we are going to talk about regulating the fourth industrial revolution, know what it is. If we are going to be in a world that is being transformed by each of the technologies that come, let's know what they are. Once we have this clear, how do we manage to protect citizens without bothering the development of the economy of the country and the world by regulating technologies?” Asked lawyer Catalina Rengifo, manager of Government Relations in South America for the company IBM. For his part, Ricardo Posada, lawyer and director of the Criminal Law Area at the Universidad de los Andes, said that the current technological convergence has led societies to be absolutely insecure, where people are ‘hyper vulnerable’ victims in computer science. There legal innovation can give a great help. “There is a mistaken belief in terms of information security. Two distinctions must be made. The first is in the protection of the community, in general terms, and that has to be done by the State based on regulation. The second is to encourage self-regulation, and in that we are in an obvious contradiction. On the one hand, we protect the population regardless of their will, and on the other, we are promoting self-regulation, for example, in financial matters” said the expert.

About this, in the Plan of action of the MinTic (MinTIC, 2019) we can see that the Colombia’s government is focusing in the implementation of the strategy of **Use and appropriation of ICT** where the purpose is to promote the use and appropriation of ICT in citizens and households, seeking to be done in a **safe and responsible way** in the country; This is also intended to reduce the digital divide, reduce poverty and contribute to the development of the country. Additionally, digital coexistence among citizens will be promoted, the appropriation of ICTs by minorities will be facilitated, the use of the internet will be inspired and teleworking in the national territory will be massified as an instrument to increase the levels of productivity of public entities and private organizations. The projects are currently in the contracting process and their development and impact will be reflected in the second half of 2019.

The “**I trust ICT**” and “**Telecommuting**” projects were contracted, and the contractual process of the “**Redvolution**” strategy began, with its projects “**Digital citizenship**”, “**Digital coexistence**” and “**ICT for women**”

- The “I trust ICT” project seeks to train the target population in good cybersecurity practices and identification of false news.
- Within the framework of the “Digital Citizenship” project, it seeks to provide 90,000 certifications and build accessible content.
- The “Redvolution” seeks to inspire the use of the Internet in 50,000 Colombians: 20,000 of them through the voluntary strategic line and 30,000 through the strategic educational line, prioritizing 91 municipalities in remote regions of the country.
- The “Digital coexistence” project seeks to train children and adolescents in the use of ICT for solidarity purposes, to encourage coexistence in virtual environments, citizen participation and the strengthening of youth digital communities - those that promote good treatment. The stated goal is to form at least 4,000 children and teenagers between 13 and 18 years in 12 intermediate cities of the country.

- As part of the development of the “ICT for women” initiative, it is hoped to empower women in the use and appropriation of ICTs, promoting ventures and digital prevention environments, so that they can take advantage of the potential they offer them to access development, face poverty and promote the defense, promotion and exercise of their rights. With the development of this initiative, at least 1,500 women and approximately 22 women's organizations or networks from different areas of Colombia will benefit.

### 4.2.4 Jobs and skills

On July of 2019, an alliance between Siemens, Colombia’s SENA and Procolombia that seeks to strengthen the competences of its apprentices in new technologies, Industry 4.0 and the Internet of things, was firmed. As the president of Colombia Iván Duque said “Siemens has decided to partner with SENA to bring to this headquarters a training program for the fourth industrial revolution where thousands of students will pass three modules that will certify them in Siemens technologies that are applied in the rest of the industries and will give them the possibility of having an added value in the search for a job” (Perea, 2019)

This Memorandum of Understanding will also allow the alignment of curricula focused on the needs of the Colombian industry for the adoption of a new model of organization and control of the value chain through the life cycle of products and manufacturing systems, made possible for information technologies and 4.0 industries such as IoT, simulation, data analytics, advanced automation, communication networks, advanced design and control industry.

The alliance, framed in the strengthening of cooperative relations with Germany, includes the joint work in research projects, innovation, technological update of equipment and knowledge transfer in Industry 4.0, as well as the adoption of new technological platforms in the 117 centers SENA training that will benefit more than 700,000 young people nationwide, who can be trained in software development and programming.

In the same way, the Entity's instructors and apprentices will be trained and certified in new technologies such as PLM Software (Product Lifecycle Management), advanced automation and communications.

"The signing of this memorandum of understanding will allow many young Colombians to acquire the skills, knowledge and knowledge with the necessary added values so that they can successfully insert themselves into the world of the fourth industrial and labor revolution," said Carlos Mario Estrada, general director of SENA.

This alliance also includes Mindsphere, a cloud-based operating system for the Internet of things from Siemens that will allow you to connect the systems and machines in the SENA training centers with advanced data analytics applications and that, thanks to the development of new APPs, it will be possible to have specific applications to promote increased productivity in industries. (Perea, 2019)

The Didactic Factory 4.0, located in the Design and Metrology Center in Bogotá, has become the most important training environment in Colombia, the only one of its kind outside Germany and one of the most modern in Latin America.

On the other hand, the doctorate in Engineering of the **Pontificia Universidad Javeriana**, is also focusing on reaching through education the highest level of human talent in each of these topics of industry 4.0, so that with technical and ethical criteria, the graduates can make the

best decisions in the development of initiatives that allow their industries to compete in the current global environment from research and innovation units.

Also to understand everything that involves the development of industry 4.0, the Faculty of Engineering is constructing a laboratory building, within which it will have a space that will contain an industrial plant with all the technological tools that will facilitate the appropriation of these new technologies in the country and in the region. (Parra, 2018)

The MinTic's approach to the challenge of jobs and skills is through the strategy of the **Development of skills in human talent required by the digital industry**, this initiative aims to increase the number of people with knowledge and employability in information technology. Additionally, it seeks to strengthen the human talent of the digital industry in the country, focusing on the generation of spaces so that Colombians can strengthen their digital skills and abilities, to boost competitiveness, research, innovation and the international projection of the sector through technology-based solutions and thus enhance the different sectors of the economy.

In quantitative matters, in the period January-May 2019, 13,605 people benefited in **virtual digital entrepreneurship workshops** of Apps.co and 129 people in a **face-to-face digital entrepreneurship workshops**, thus generating skills inspiration for the creation and development of digital businesses.

Between January and May of 2019, Apps.co has increased the number of beneficiaries nationwide in **free virtual digital entrepreneurship workshops** offered through its platform, generating skills for the creation and development of digital businesses.

On the other hand, the project called “**Programing for girls and boys**” (Coding for kids) is aimed at teachers and students of public schools in the country, in order to facilitate access to best practices in the integration of innovative and cutting-edge coding education, so that teachers' ICT competencies are promoted and strengthened as multipliers in education.

However, the “**Capabilities and productivity models**” project promotes a dual capacity generation model aimed at the productive sector, with the purpose of strengthening the competences and skills in subjects related to digital technologies, in an articulated way with the productive sectors of the country and the academy. (MinTIC, 2019)

The objective of all the actors that work for the economic and social development of the country should be to support these developments as an initiative that allows consolidating knowledge in Colombian engineering in such a way that the commitment made by the National Government is translated into a real transformation of the industrial sector

For Colombia this great outlook because the digital training, in the cloud and all the technological advances that are being implemented and developed are needed with urgency for the young people allowing them to move forward in this digital labor market.

It is important for Colombia to continue to adapt its educational system to strengthen digital technical skills, knowledge in programming and software development, with initiatives that help to increase the number of certified software developers, as well as technical and technological certifications in Mechatronics, Industry 4.0, and the other technologic trends

### 4.2.5 Limited awareness

Regarding the awareness of entrepreneurs about the fourth industrial revolution, the results of the 2017 survey carried out by ANDI showed that the percentage of entrepreneurs who know what the Fourth Industrial Revolution is, improved from the year 2016 to 2017, significantly.



In 2017, 65.2% of the total entrepreneurs responded affirmatively, with very similar percentages between the industrial sector (65.1%) and those of services (65.3%). It is important to highlight, the very significant increase in the manufacturing industry, taking into account that in 2016 43.7% replied that they knew about the benefits, challenges and the opportunity cost of adapting to the digital economy and by 2017, the percentage increased to 65.1 %. (ANDI, Encuesta de transformación digital 2017, 2017)

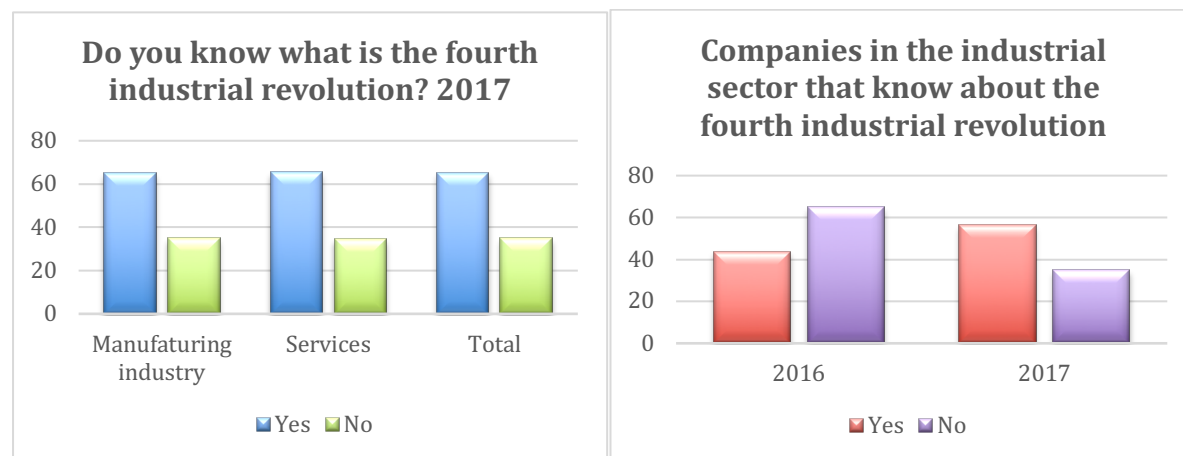


Figure 13 adapted from ANDI's Digital transformation survey 2016-2017

When asked about having a digital transformation strategy, Colombian businessmen were leaning also towards a positive answer. In total, almost 60% of the companies said that they had a digital transformation strategy versus a 40% that responded negatively. However, there was a significant difference between the service sector and the manufacturing industry sector. Which can lead us to say that this transformation process is much faster in the service companies, with a 71.4% of affirmative answers, versus a 48.4% of affirmative answers in the industry sector. Nevertheless, the industrial sector showed a noteworthy enlargement of 23,3 percentual points, comparing the results from 2017 and 2016.

In the same direction, the percentage of entrepreneurs who believe that their business will be digital by more than 50% in the near future, practically tripled in the manufacturing industry from 21.9% in 2016 to 60.9% in 2017. In the sector of services, in 2017 it is 85.7%.

In the manufacturing industry, 26.5% of companies have transformed their business in a short term of 2 years while 58.8% consider that it will be transformed in 5 years. In the services sector, it is expected that this transformation will be much faster, 43.2% in 2 years and 45.9% in 5 years. "The society was transformed digitally, and the successful organizations are those that understand it and also transform"

Another very positive element, from the results of the survey, was that in 2017 more than 98% of entrepreneurs considered important to promote the use of emerging and digital technologies in the company.

Employers belonging to the manufacturing industry and who answered affirmatively, the technology they use most is Cloud Computing 74.5%, increasing significantly compared to the previous year, where the percentage was 54.7%. They are followed in order of importance in 2017, Data Analytics (58.2%), e-commerce (58.2%), digital marketing (45.5%), provision of goods through mobile devices (43.6%), internet of things (41.8%) and the use of robots (34.5%).

In the services sector, the technology they use most is Cloud Computing (78.0%), followed by the provision of services through mobile devices (68.3%), Data Analytics (65.9%), digital marketing (53.7%) and e-commerce (51.2%).

This reflects that, in modern economic activity, where the needs and expectations of consumers have been sophisticated, demanding and not very patient, the transfer and transmission of data is presented as a fundamental tool for companies. Thanks to the widespread access to the Internet, there is practically no business model that does not use and benefits from moving large amounts of data in the country and beyond the physical borders of the country.

With respect to the implementation of technologies in the processes of the companies, while in 2016 the BI (Business Intelligence) was the most used practice, in 2017 the Cloud Computing (80.2%) had the prominence, followed by the Business Intelligence (74.5 %) and mobile productivity tools (69.8%).

With respect to the implementation of technologies in the manufacturing industry sector, 78% of entrepreneurs use Cloud computing services, 76.3% Business Intelligence, 72.9% mobile productivity tools, 44.1% now have e-commerce services, 27.1 % incorporated in their processes internet of things, 23.7% Bigdata and 22% of entrepreneurs say they have automated processes through robots.

With respect to the implementation of technologies in the services sector, 83% of entrepreneurs use Cloud Computing, 72.3% Business Intelligence and 66% mobile productivity tools.

On the other hand, 3D printers and omnichannel have shown low use in both years. This attracts attention, because there are great benefits for production in different industries, such as the automotive, health, electronic products and education, among others. Designers and engineers can, through 3D printers, pass their ideas to physical models with the same materials, but without having to go through the traditional process of producing the different parts and in this way save time and money significantly in the production processes. Similarly, digital consumers demand and use different channels of interaction with their brands, products and services, and therefore companies are forced to make available an integrated network of different solutions (omnichannel) to serve them. The good, efficient and prompt experience is what influences the consumer's decision in the 21st century.

It is important to highlight that; entrepreneurs are becoming more aware of the importance of new business models to generate new opportunities by removing the barriers between the physical world and the digital world with the use of emerging technologies. On the other hand, being aware that the expectations of the clients are always increasing and that they are expecting same service level when visiting a physical point or a digital point, the client today will always seek to improve the experience.

In the opinion of the entrepreneurs, the main motivations to start a Digital Transformation are the new business models (77.5%), the expectations of the clients (66.7%) and the new technologies (58.6%). When dividing by sectors, very similar results are observed as seen in the following graph.

The main areas, with the greatest impact digitally transformed in the next two years, according to businessmen, are innovation in products and services (77.3%), the area of

customer relations (74.5%), the area of internal processes and the organization (73.6%) and the area of new business models and revenue streams (60%).

The main barriers and challenges that companies face today to achieve a successful digital transformation are in their order, lack of culture (74.1%), ignorance (61.6%) and budget (56.3%). In industry, currently the main concern is the lack of culture (76.2%), when in 2016, the main concern was financial resources. In the services sector, the greatest barriers are ignorance and lack of culture (71.4%).

To achieve a successful digital transformation, different elements are needed, where the main one is the change of mentality. Similarly, have the relevant technology and also the ideal digital talent to lead change and make decisions. In this sense, companies are timidly advancing in raising the power and leadership of their management team.

In 2017, 50% of the total companies surveyed have a CIO (Chief Information Officer) and / or a CDO (Chief Digital Officer), a percentage that is the same in both the manufacturing industry and the service sector. In the manufacturing industry, although an increase is identified with respect to 2016 (31.1%), half of them do not yet have an Information Systems Director.

This confirms the importance of changing the mentality, exercising leadership from the highest level of companies, including the CEO, the Vice Presidencies, the Board of Directors and not only the CIO or the CDO who are already clearly interested in advancing in adoption. Digital in the company.

### 4.2.6 Trade logistics, digitalization and e-commerce

Industry 4.0 is revolutionizing some of the dynamics that have been developing over the last few decades in industrial production. for example, the search for cheaper human labor and reduction of costs in developing countries could migrate into more technologic countries or even in the same country by investing in the technology and replacing the need of human labor by robots. However, it is important to highlight that even if feasible, it is imperative to consider and evaluate if the transformation is economically valuable. All the aspects related to the management of supply chain and logistics, like transportation, replenishment and production have to be considered and act upon the best solution to make the value chains the most efficient chains possible, saving in costs and time. (GONZALEZ-PEREZ, 2019)

This is why both digital transformation and trade wars (and their collateral effects) involve a reconfiguration of global value chains; countries can be certain that great challenges are coming for the design and implementation of a new generation of Industrial policies.

The Government of Colombia through the ministry of ICT is focusing on the transformation of the postal sector as a first approach to the logistics, it has two big strategies which are the transformation and the strengthening of the postal sector.

With the **transformation of the postal sector** the objective is to support the modernization of the postal sector based on the use of ICTs and the diversification of the service, as well as to benefit the entire postal sector, including the services of courier couriers and payment postcards. , that is, 192 postal operators. (MinTIC, 2019)

Until 2019 the diagnosis of the postal sector was made by means of the elaboration of a problem tree, in which four situations that obstruct the adequate development of the sector could be identified:



- a. the current regulations do not have a sanctioning capacity that guarantees the provision of effective, efficient, safe, continuous and quality postal services;
- b. lack of incentives to develop new innovative schemes that allow traditional postal services to be modernized;
- c. insufficient strategies for the insertion of the postal sector as a logistically in electronic commerce (although the courier companies are responsible for distributing and delivering products and packages from electronic commerce, the long times of delivery make users opt for complementary or substitute models to receive these packages);
- d. the absence of an information registration system that allows the control and monitoring of postal objects that are part of the universal postal service.

With the second strategy **Strengthening of the official postal operator** the intention is to develop strategies that strengthen the postal operator as a service provider that contributes to the development of the sector.

With respect to the **regulatory environment of the postal sector**, progress has been made in preliminary documentation and in meetings on different topics of the regulatory agenda, with the most relevant aspects being the inclusion in the Financing Law of the VAT exemption privilege for shipments of less than USD 200 that are sent by postal traffic.

Regarding **negotiation issues**, a bilateral agreement was reached with the official postal operator of Curaçao to have a virtual ETOE (extraterritorial office) that allows us to generate a Cn 38 that gives the privilege of tariff exemption to locker shipments virtual weighing less than 2 kg and less than USD 200

In terms of **rebranding**, after making the comparative analysis between the current positioning and the positioning by income in the category, it was identified that there is a disparity in remembering the brand regarding the position of the brand in revenue.

With regard to **e-Commerce**, progress has been made in presenting a proposal with private clients and requesting a proposal for operation in China. Additionally, approaches have been made with international airlines to receive proposals as allies. And finally, a marketing proposal is being developed to promote the new service, including digital and physical parts.

With respect to the **extension of coverage at points of sale of the official postal operator**, those points that require strategic relocations are being evaluated, according to their income. Apart from this, meetings are being organized with companies that can become commercial collaborators (allies) and progress is being made in the definition of technological solutions that allow automating services. Currently, there are 1,320 points of sale and commercial allies of the official postal operator. (MinTIC, 2019)

#### 4.2.7 Government Involvement

There are three strategies related directly to the transformation of public entities to improve the organizational structures and efficiency resulting in a better level of service provided to the citizens and that the MinTIC discusses in its (MinTIC, 2019).

The first strategy is **Government PRO** which aims to achieve a proactive and reliable state to deliver services in an integrated manner for the improvement of permanent quality of life of people.

During the first quarter of 2019 responses were given to signatory entities on 134 observations of subrogation decree 1413-2017; Likewise, the adjustments requested by the Vice Ministry of Digital Economy were made to the analysis of the three technological

options of interoperability tools to select the most favorable one in the Digital Citizen Services model.

Currently, MinTIC and Colombia Compra Eficiente (Colombia efficient purchase) are structuring the **new generations of the IT framework agreements** for 2019, among which the following stand out: technological and peripheral equipment, public cloud, Private cloud and software.

The ICT Ministry launched the “**National Strategy for Digital Integration of the Colombian State**”, which will allow the country to advance in the digital transformation and positively impact the people's quality of life, generating public value in each of the digital interactions between citizen and state. This initiative was born in 2019 and to date it already has the first integration tool, the Single Portal of the Colombian State (GOV.CO), which in its beta version constitutes the citizen's digital access point to the procedures, services, public information, participation exercises, among others, offered by public entities.

The design of the **shared solutions model** and the identification of those needs that can be met by means of technological tools shared by public entities began. In addition, progress was made in the definition of the **resource library** section, aimed exclusively at those entities that will be available on the GOV.CO portal, which will allow housing, promoting the use of open and free technologies, and generally open source or in accordance with the principles of free software, as well as some technologies that public entities can use.

The **work route and the main elements of the smart cities and territories model** were defined, in which maturity levels are established that allow identifying the capacities and needs of a public entities to advance in each of the enabling axes: leadership and management, institutionalism and financing, human capital, technology and interoperability, and infrastructure.

The installation of the **self-diagnosis tool of digital government** was completed as an instrument to support follow-up and the definition of permanent improvement actions to advance in the implementation of the Digital Government Policy.

The second strategy of the government is the **Development, use and application of science, technology and research, associated with the creation of a public information ecosystem**. Within the framework of the fulfillment of the institutional objectives, the National Digital Agency (NDA) defines its execution in the policy axis for the sectorial and territorial digital transformation sector, which aims to raise the level of productivity and competitiveness of the public and private sectors, reaching high international standards, through the digital transformation of the public administration. To this end, the NDA proposes as an initiative the creation of an ecosystem of public information, whose objective is to implement the activities required for the operation of the Digital Citizen Services Model, as well as to position the NDA as a center of research and development applied to the public sector.

To accomplish this objective, two projects are carried out: the articulation and implementation of the Digital Citizen Services Model and the management of solutions to public sector problems through applied science, technology and innovation projects.

The National Digital Agency, in compliance with its missionary purpose, has contributed to the digital strengthening of four entities in 2019, through the **development of solutions** to various problems, thereby introducing significant improvements in the processes of public administration through the use and development of software solutions and data analytics, among others.

Apart from this, NDA has developed several projects together with other public sector entities, such as:

- Mining and Energy Planning Unit: UPME Integrator project and UPME Auctions project.
- Ministry of Agriculture: project for granting and monitoring the housing subsidy of rural social interest.
- Ministry of Labor: data collection project for pension administrators.
- Ministry of Interior: LegisAPP project.
- Presidency of the Republic: project pact for Colombia, project certifications of contractors and project implementation of austerity directive.
- Ministry of Labor: Integrative Risk System project.
- Ministry of Foreign Affairs: My Virtual Consulate app project.
- MinTIC: ELAC project, eCenso project, GOV.CO, and update, application and appropriation of ConverTIC.

Additionally, the NDA has been developing actions with the MinTIC aimed at defining the national interoperability standard, within the framework of which the evaluation and definition of the applicable technologies was met.

And lastly, the third strategy the **Organizational transformation of the ANE (National spectrum agency)**. This initiative aims to strengthen institutional management, organizational culture and communications, and implement within the framework of ICT management different initiatives to strengthen the collaborative relationship with the citizen. The progress made so far on these projects is:

- Structuring and planning of the activities of climate and organizational culture for the validity 2019, which was built in conjunction with the directors of the entity.
- Preparation of the previous study and analysis of the sector to contract activities in the field of climate, culture and strengthening of the competency model, which include actions to improve the work environment index and closing development gaps to improve institutional performance.
- Development of the work plan to comply with the monitoring and improvement of the Occupational Health and Safety Management System (SG-SST).

This are some of the fundamental advances of ICT in the construction of a country with greater equity and aimed at making the great leap to the digital era, where technology is a fundamental instrument for the transformation, not only of the national economy, but of the way in which we relate as a society within what we know as the Fourth Industrial Revolution.

### 4.3 Sectors of the economy investing in Industry 4.0

There are several examples of companies that have been successfully going digital in the country and globally.

It shows how new technologies can have a positive impact on everything, as with the smart clinic project that Siemens will be carrying out in Colombia. The smart clinic is a mobile health unit that Siemens will donate to Colombia and that they hope to put into operation in February 2020. The objective is to meet the most pressing needs of the migrant population in a state of pregnancy and with minors in the northern part of the country.

The Smart Clinic will have basic clinical laboratory equipment, as well as diagnostic imaging devices such as X-rays and ultrasound to attend initial consultations. It will have an office and a procedure room to attend pediatrics and gynecobstetrics services.

The Smart Clinic had been offered in donation by Kaeser to the Colombian government, at a meeting in Berlin last May, where among other issues the complex situation of migrant health care was raised. Official data indicate that in the northern part of the country, where a high percentage of this population comes in, children are born without having any prenatal care and control. In addition, there is a spread of viral diseases that have been growing in this population.

Another example is the case of Kaeser compressors Kaeser Compresores, is a pioneer firm in Colombia in implementing a strategy focused on Industry 4.0 and it is found in the ranking of the 20 most innovative companies in the world in Industry 4.0 according to the Internet of Things Institute. the company understood that the future of productivity is closer to reaching the country, and with innovative options in technologies such as analytics, Big data, social networks, IoT, which together with compressed air solutions will allow real-time analysis of information. (Kaeser, 2019)

From what they affirm in their website page, they are aware that Industry 4.0 still has important challenges for the industry, such as understanding the new digital culture, accepting changes, optimizing current infrastructure, investing in technologies and having adequate staff. However, they see how companies from sectors such as mining, oil, water treatment plants or manufacturing, are beginning to see the benefits of the correct implementation of industry 4.0 and this is what they plan to do in their industry (intelligent compressed air solutions). (Kaeser, 2019)

Since the real benefits for the company can only be achieved if there are developments that allow them to understand the needs of the customer, this added to the integration of compressed air stations into computer systems. This permanent dialogue between machines and the interaction with the human resources in charge of controls thanks to the Internet, allows them to become the only ally in Colombia to improve customer efficiency, thanks to the use of energy savings and early detection of possible failures in the machines.

In fact, Kaeser has already made a great investment, potentiating the power of Big Data in search of implementing a real-time business solution, which is based on the ability to analyze an immense amount of data from IoT (internet of things) at compressed air stations.

The approaching industrial revolution is unprecedented. The machines are generating their own social networks to communicate with each other, and thus being able to communicate with people, in an integration that will lower costs for companies and allow greater operational efficiency. This is a path that brings competitiveness and they are already preparing to see Industry 4.0, at its best in Colombia. (Lopez, 2018)

Like these cases we will be discussing how the technology is impacting sectors like the fashion, food, retail, banking and mining sectors in Colombia and in the world.

Previous to this, it is important to clarify if Colombian companies are actually investing in technology and then what is the main focus of the companies when investing in the digital transformation. According to the results reported by the ANDI in the survey of 2017, the 58.9% of companies had already made advances or planned to make investments in technology or digital transformation in 2017. By sectors, the percentage is higher within service companies (67.3%) than in manufacturing ones (52.4%).

However, it is important to keep in mind that the percentage of manufacturing companies that are investing in technology increased slightly from 50% in 2016 to 52.4% in 2017.

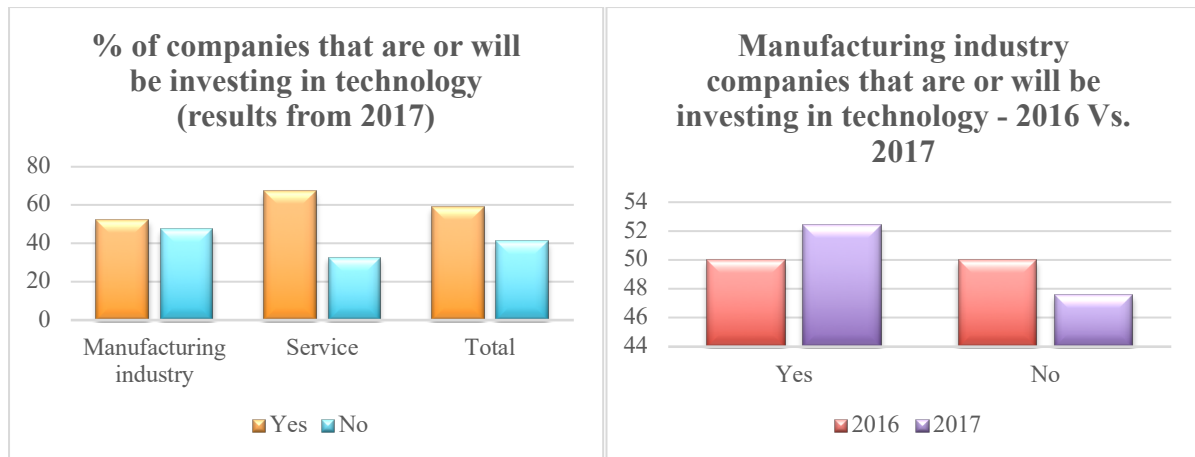


Figure 14 Adapted from the results of the Digital transformation survey - ANDI 2016-2017

With respect to the total number of entrepreneurs, 49.2% expect to invest between 50,000 to 100,000 USD and 30.2% between 100,000 and 500,000 USD. The main objectives that companies seek with these investments in digital transformation are in the first instance, process automation (82.8%) where it is sought to accelerate the execution time of activities and replace manual processes with software applications. Reducing costs (57.8%) and generating new income (48.4%) were also some of the reasons to invest in the digital era. In the manufacturing industry, 87.9% of entrepreneurs invested between 50,000 to 500,000 USD in 2017 and the sector's investment was mainly used to automate processes (81.8%), reduce costs (54.5%) and achieve disruption in their own industry or other industries (45.5%). In the services sector, 70% of entrepreneurs invested between 50,000 to 500,000 USD in 2017 and the sector's investment was mainly used to automate processes (83.9%), reduce costs (61.3%) and generate new income (54.8%).

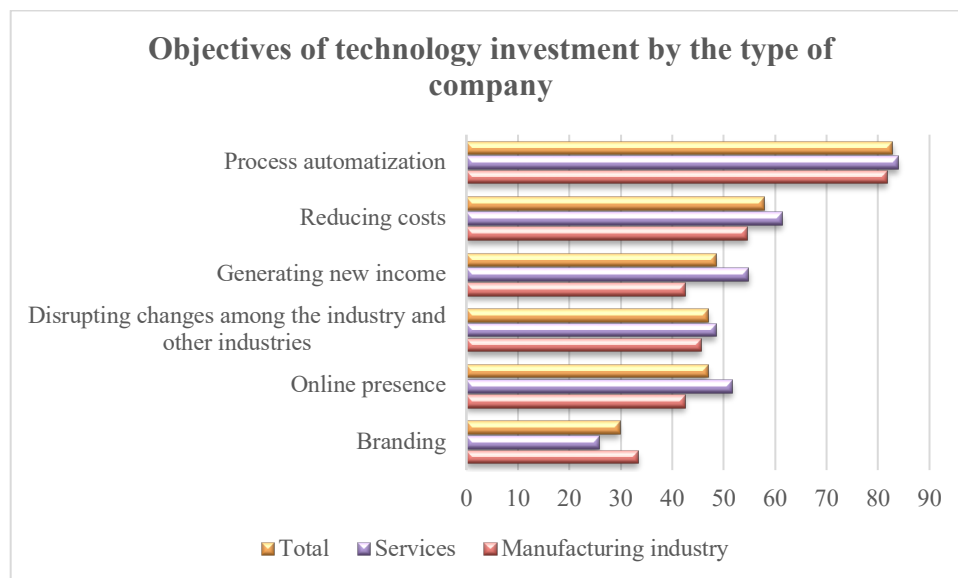


Figure 15 Adapted from the results of the Digital transformation survey - ANDI 2016-2017

In the food sector, and in the manufacturing sector in general, companies usually have problems in the terms of customers complaints or compliance with standards of quality and errors in the making; because of this companies are now trying to implement intelligent



identification systems that allow a better traceability of all the processes involved in the production lines. like sensors, RFID tags, other systems that analyze entire supply chains to keep a better track of the products from the moment its production starts till it is delivered to the customer. There are cases like Beard Naked's granola packages where they allow customers to define what they want in the mix and have it delivered directly to their houses (Furore, 2019) or beer factories like Corona group where they are implementing entire production lines with robots that allow for more precise and standardized processes.

In the banking sector, on the other hand, there's the proposal of stopping requesting physical documents at the time of making a financial process, instead it is intended to strengthen the adoption of biometric technologies that allow to verify the identity of a user through your fingerprint, or with the recognition of the iris of your eye and other methods that allow the transmission of the information from the bank to the customer and vice versa to be easier and more fluid , as the president of Asobancaria, Juan Carlos Mora, said. (Economía, 2019)

The mining sector, on the contrary, in turn has common challenges with other sectors of the Colombian economy, for example the increase in production and the reduction of costs, which in the end means that companies must be more efficient every day. In this age of industry 4.0 or what some call the fourth industrial revolution, the most relevant leverage of this efficiency has been the use of technology. Through the use of 3d printing the mining sector could contribute to the achievement of efficiencies and also to the reduction of waste and contribute in a relevant way to the sustainability objectives. Efficiency is achieved using only the raw material required to "print" the final product on site (such as a spare part, a custom tool, a 3D model or plot of the land, among others) without incurring costs and time of transport, generating a reduction of the carbon footprint of the product. In the mining sector, technology like the one of drones is used to support perimeter security, providing air support to security departments (areas) and avoiding travel on foot or in vehicles to large areas of land. Automatically scheduled flights on the routes that the user wants, help increase the level of surveillance coverage without increasing costs. The drones in the mining sector have been supporting the topographic operation with planimetry and level curves for years, and recently HSE teams in aspects such as fire control, reducing the risk of accidents in these operations. There are billions of equipment connected to the network, the interesting thing is the role they can have to increase the efficiency of the companies' operations. For some years now, mining and non-mining vehicles have computers that report service needs or failures. In the beginning, it was required that who was interacting with the team report the failure or the need for service in order to schedule maintenance. IoT allows to have all the information of the equipment in the cloud and through a remote-control tower, to support preventive maintenance programs. In the mining sector this has been extrapolated to the operating equipment: drillers, scoop trams, concrete launchers, compressors and power plants, among others, thus allowing operation control towers that together with maintenance can schedule mine stops. Efficient way and optimize corrective maintenance costs for proper preventive maintenance execution (Almeida, 2018)

Like these examples we can find several and several different ones about the success and the positive outlook that this new industrial revolution is bringing into companies and societies in general.

## 4.4 Medellín: The new center for the Fourth industrial revolution network

In April of the present year, the first center in Latin America dedicated to shaping the way in which countries and companies govern emerging technology opened in Medellín. The Center for the Fourth Industrial Revolution of Colombia will maximize the benefits and minimize the risks of emerging technologies by creating new policy frameworks and governance protocols so that the whole society, not just a few, can benefit from its advances. The opening of the Center took place through a plenary with President Duque and Mayor Gutiérrez.

We need to start first by defining what is a center for the fourth industrial revolution; It is a space of trust and knowledge exchange for global cooperation. Also, it will be the perfect place for the discussion about the latest trends and its technological applications, and the regulatory frameworks for different industries and countries in terms of: artificial intelligence, blockchain, the Internet of things, machine learning, Big Data, nanotechnology, and the impacts of this revolution on the lives of people and governments. The speed of these developments taking place in this field and the blurred borders between the sectors due to the use of information technologies are the main reasons for the creation of the Centers for the Fourth Industrial Revolution, whose mission is to ensure that the benefits of the current era impact all of humanity. (ACI Medellín, 2019)

The cities chosen to host the Centers for the Fourth Industrial Revolution have important characteristics in common: investment in science, technology and innovation; a significant and effective relation between the public, private sector and academia; the ability to provide qualified human talent on technological issues and bets from their governments to leverage the industry with the technological advances of the fourth revolution. These installed capacities plus those generated around the establishment of the Centers for the Fourth Industrial Revolution will bring a series of benefits and development processes that impact the quality of life of the host cities' inhabitants. The industry benefits directly from the incorporation of technological advances, the stimulation of formal employment, the systematization of its innovations and the generation of synergies among the entities that participate in this Center. In addition, action frameworks will be created to attract and create high added-value businesses for cities which impact on its competitiveness and positioning. Thus, attracting capital and human talent.

The Center will bring together governments, business organizations, dynamic new companies, civil society, academic institutions and international organizations to achieve an impact and drive change. The Center will be affiliated with the network of Centers for the Fourth Industrial Revolution of the World Economic Forum. Colombia's projects could be implemented in the Forum's global network of centers and be implemented by any of the 100 governments and business partners. Ruta N, the public-private agency for innovation in Medellín, will host the center and its project teams. (Russo, 2019)

Artificial Intelligence, Machine Learning, Blockchain, distributed accounting registration technology, the Internet of Things, Robotics and Smart Cities will be the first areas of work of the new Center. The local teams will focus on the projects that will be carried out in Colombia. The Forum's global network will help projects developed in Colombia accelerate and share with partners around the world.

The network of Centers for the Fourth Industrial Revolution brings together governments, leading companies, civil society and experts from around the world to co-design and test innovative approaches in technology policy and governance. His vision is to shape the development and use of technology so that benefits are maximized and risks are minimized. The network develops, implements and expands agile and human-centered pilot projects that can be adopted by policy makers, legislators and regulators, and companies around the world. However, for everything to operate synergistically, there are a number of challenges that the Center for the Fourth Industrial Revolution must overcome so that it is not only success in the newspapers. (Mercado, 2019)

Among those challenges we have first, creating a **regulatory framework** that helps as a guide for the articulation of institutes, and in the work with local governments and international allies as well as to allocate resources in the most efficient way; second, **training programs for teachers and students**, it is important to tackle the problem of easiness to find skilled workers before it even appears by training teachers and students in the fields of science and ICTs; third, **improving the infrastructure**, even though the infrastructure of the center for the 4IR is not really a big deal, the goal of it is to facilitate the adoption of the new technologies, therefore for any city to be a leader in this industrial revolution should focus on having a powerful ICT infrastructure and by modernizing the conditions of connectivity it will benefit all the industry already inserted in the industry 4.0; and last, **appropriating technologies**, it is important to understand this revolution, what are the technologies involved as well as the benefits and impact so that governments and citizens can take full advantage of them.



# CHAPTER 5

## Colombia Vs. Latin America

This chapter focuses on confronting the current situation of Colombia versus the other Latin American countries in terms of productivity. Then goes further in-depth into the environment for I4.0 in some of the main countries of the region

## 5. Colombia Vs Latin America

According to The global competitiveness Index 4.0 2019 ranking published by the WEF (Schwab, The Global Competitiveness Report , 2019), Colombia ranks 57 out of 141 countries evaluated, with a competitiveness score of 62.7 points. This score measures the competitiveness of a country through the institutions, policies and factors implemented that help to define the productivity level.

Colombia is the fourth Latin-American country in the ranking, after Chile (70.5), Mexico (64.9), and Uruguay(63.5); and before Costa Rica (62.0), Peru (61.7), Panama(61.6) and Brazil (60.9). however, regarding the neighbor countries of Venezuela (second-to-last place), Peru, Ecuador, Panama and Brazil, they are all located a few places down in the rank.

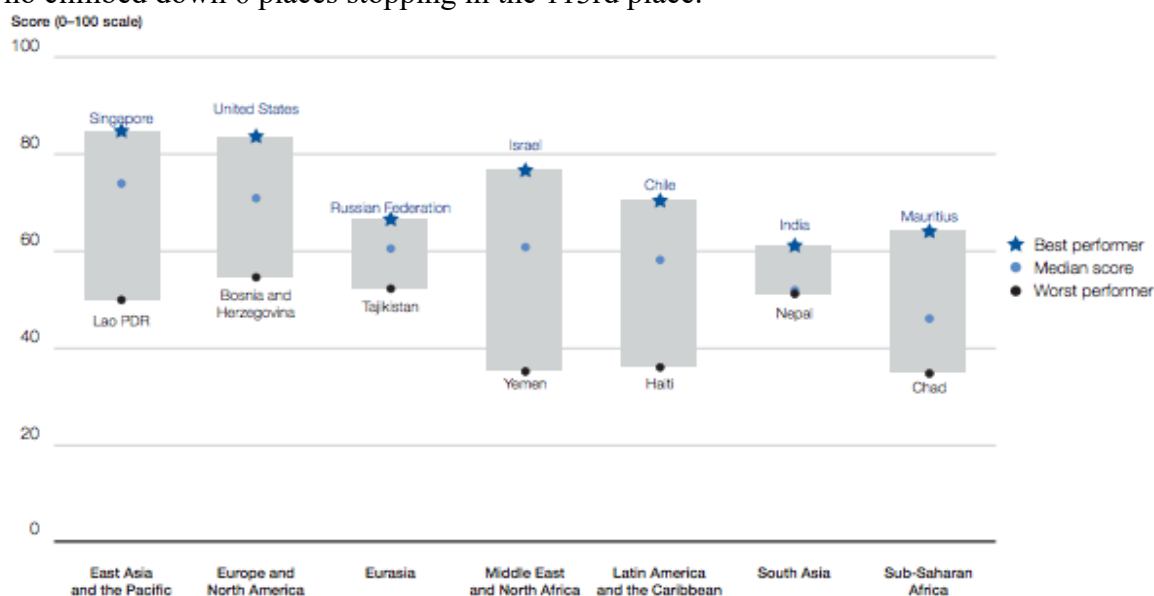
*Table 15 Latin-American countries' productivity index. Data taken from (Schwab, The Global Competitiveness Report , 2019)*

L-A Rank	WORLD Rank	Country	Score
1	33	Chile	70,50
2	48	Mexico	64,90
3	54	Uruguay	63,50
<b>4</b>	<b>57</b>	<b>Colombia</b>	<b>62,7</b>
5	62	Costa Rica	62,00
6	65	Peru	61,70
7	66	Panama	61,60
8	71	Brazil	60,90
9	77	Barbados	58,90
10	78	Dominican Republic	58,30
11	79	Trinidad and Tobago	58,30
12	80	Jamaica	58,30
13	83	Argentina	57,20
14	90	Ecuador	55,70
15	97	Paraguay	53,60
16	98	Guatemala	53,50
17	101	Honduras	52,70
18	103	El Salvador	52,60
19	107	Bolivia	51,80
20	109	Nicaragua	51,50
21	133	Venezuela	41,80
22	138	Haiti	36,30

The 10 first places in the world ranking are occupied by Singapore (84.4), USA (83.7), Hong Kong SAR (83.1), Netherlands (82.4), Switzerland (82.3), Japan (82.3), Germany (81.8), Sweden (81.2), UK (81.2), and Denmark (81.2). And the last places are occupied by the Sub-Saharan African countries of Congo (36.1), Yemen (35.5) and Chad (35.1)

From the 2018-ranking Colombia showed an increase of +1.1 points and climbed up from the 60<sup>th</sup> to the 57<sup>th</sup> place, which shows the positive evolution of the country.

Regarding the other Latin-American and the Caribbean countries, it is important to highlight the performance of Chile - on top of the list, being in the 33<sup>rd</sup> place in the world thanks to its stable macroeconomic context and open markets; and the poor performance of Venezuela, who climbed down 6 places stopping in the 113<sup>rd</sup> place.



Source: World Economic Forum analysis.

Note: See the At a Glance section on page xiii for regional classifications. Regions are arranged according to median scores.

Figure 16 Competitiveness gap within regions. Best, median and worst GCI 4.0 2019 scores by region. Taken from (Schwab, *The Global Competitiveness Report*, 2019)

However, Latin America is still behind in the world compared to the other regions, as it is showed by the WEF in the figure of competitiveness gap within regions; Latin America has been performing worse than the regions of the East Asia and the Pacific, Europe and north America, Eurasia and the Middle east and North Africa. Only followed by south Asia and the sub-Saharan African countries.

## Chile

Chile is a country located in the southwestern part of South America, it has a population of 18.5 million, a GDP per capita of 16078.7 US\$ that represents the 0,36% of the world's GDP. It has presented a 3,2% annual GDP growth in average over the las 10-years. In the social and environmental aspects, the country has an unemployment rate of 7,2%, a 46,6 score in the Gini index<sup>7</sup>, a 24,9% share of renewable energy consumption, an environmental footprint of 2,7 gha/capita and a global gender gap index of 0,7<sup>8</sup>

As it can be seen from the figure 16 taken from the (WEF, 2019), Chile, currently with a competitiveness score of 70,5 points and reaching the 33<sup>rd</sup> place in the world rank and 1<sup>st</sup> in Latin America (for two consecutive years), has been showing how, due to its macro-economic stability that comes from the low 2,3% inflation rate and the debt dynamics, where it has a score of 100 points out of 100, and other contributors to the good performance of the country like, its product markets that characterize for their trade openness, and the stable

<sup>7</sup> The Income Gini index evaluates the equivalent of equality in a society where 0 = perfect equality and 100= perfect inequality

<sup>8</sup> The scale of the global gender gap index is 0-1(gender parity)

financial system, being 1<sup>st</sup> in the world with their (-3.3%) credit gap %, the soundness of banks (6,4) and a market capitalization of 89,8% of GDP.

Global Competitiveness Index 4.0 2019 edition

Rank in 2018 edition: 33rd/140

## Performance Overview 2019

Key ◇ Previous edition △ High-income group average □ Latin America and the Caribbean average

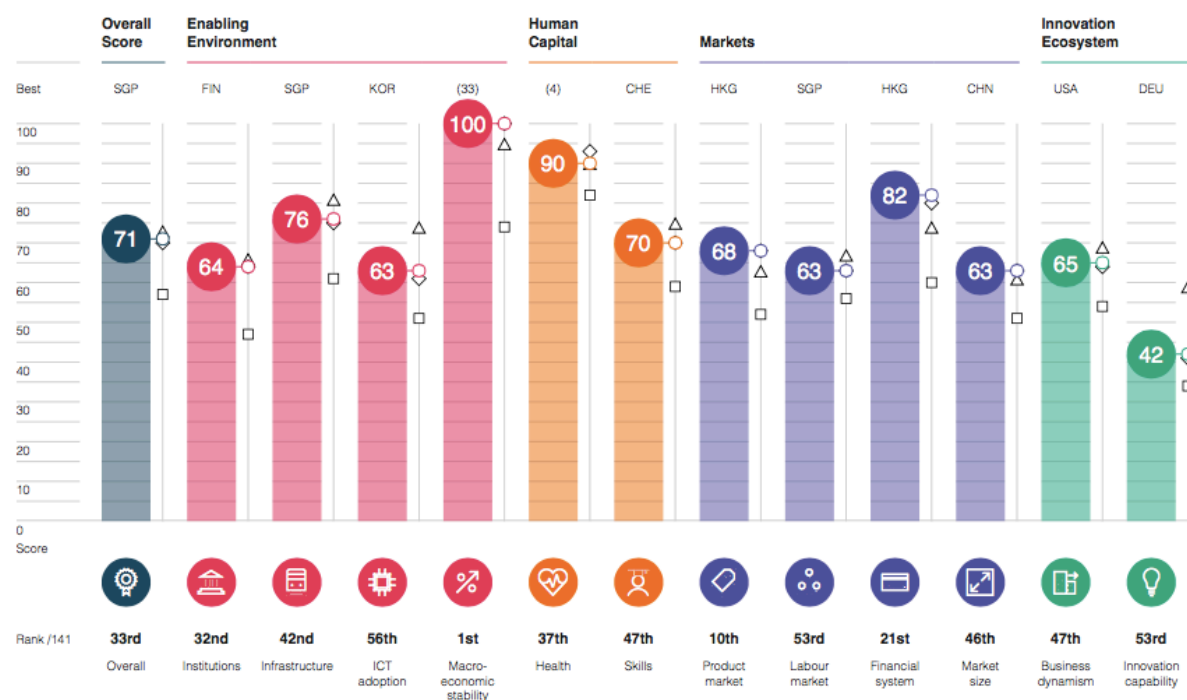


Figure 17 Chile's performance overview 2019 taken from (WEF, 2019)

Nonetheless the country is the best performing country in Latin-America, it still has opportunity to grow and work towards being a more competitive country in the world. According to its current performance, the components on which the country could focus in the near future are its security, innovation capacity, ICT adoption and human skills.

Chile has a homicide rate of 4,3 per 100000 pop, ranking 89 out of 141 countries, and has a terrorism incidence of 99,1<sup>9</sup> (90<sup>th</sup> place in the world rank). Facts like the ones mentioned before, lower the total security score. On the skills component, the goal is to enhance the skill base of the current work force – by extending the staff training and promoting digital skills among active population, and encouraging critical thinking in teaching to enhance the skills of the future work force in order to match the future requirements of the economy. The country should focus, also, on its innovation capability (42,5 points and 53<sup>rd</sup> place) by investing in R&D (0,4% of GDP) and making the environment more diverse and interactive with inventions. And lastly, it should promote the ICT adoption, where it scores 63,1 points and ranks 56/141 due to its low fixed-broadband internet subscriptions (91,6 per 100 inhabitants) and also low mobile-broadband and fiber internet subscriptions.

<sup>9</sup> 0 very high – 100 no incident

## Colombia

Colombia on the other hand, with a population of 49,8 million (more than double than Chile's 18,5), has a GDP per capita of 6684,4 - 59% less than Chile. Colombia produces the 0,55% of the World GDP and has been maintaining an average growth rate of the annual GDP of 3,3%. In the social and environmental aspects, the country has an unemployment rate of 9,1%, a Gini score of 49,9, a global gender gap index of 0,7, a 23,6% share of renewable energy consumption and an environmental footprint of 2,2 gha/capita.

Global Competitiveness Index 4.0 2019 edition

Rank in 2018 edition: 60th/140

**Performance Overview 2019** Key ◇ Previous edition ▲ Upper-middle-income group average □ Latin America and the Caribbean average

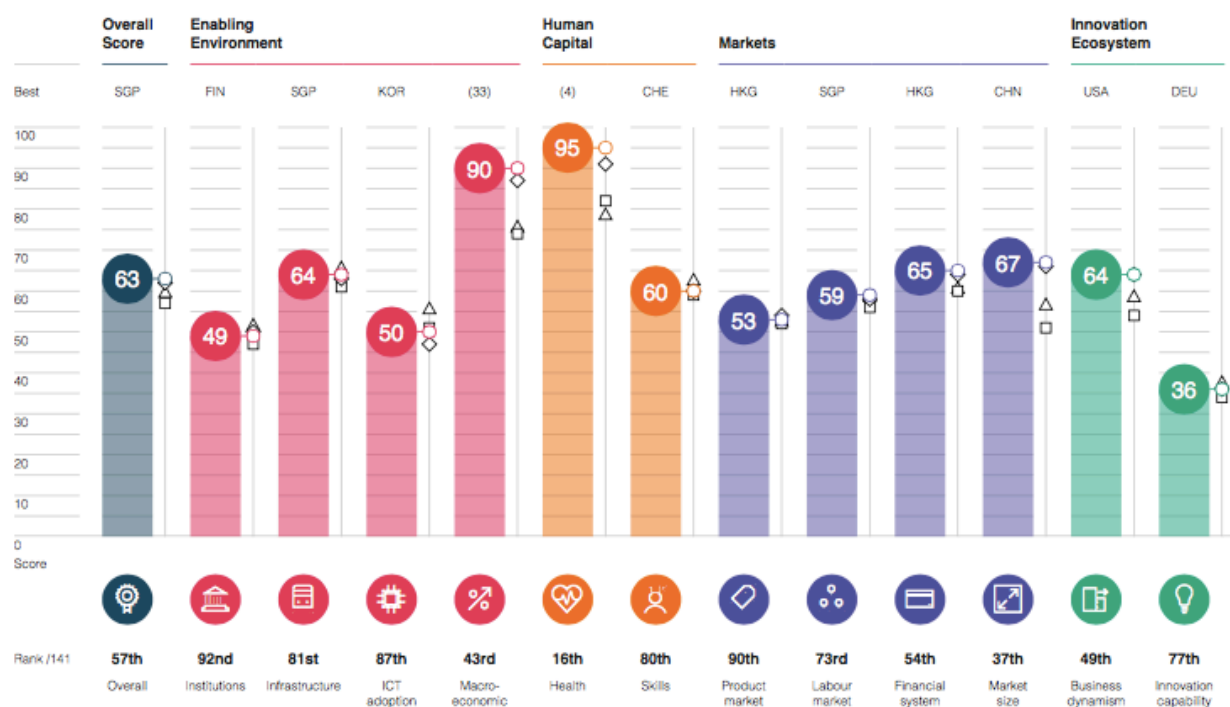


Figure 18 Colombia's performance overview 2019 taken from (WEF, 2019)

According to the components' score, it can be appreciated that Colombia still has a long way to go in terms of productivity. The poor institution management (92nd place), being in the 127th place regarding security, the high corruption (36/100) and poor regulation, are some of the aspects that lower the productivity index. The government should follow the example of the first world countries and focus on improving its innovation capability, making the environment for innovative business friendlier and should destine more of the country's GDP in R&D expenses.

## Venezuela

Venezuela, located also in the northern region of south America, has a population of 29,2 million and a GDP per capita of only 3373.7 US\$. The GDP of the country is equivalent to the 0,23% of the world GDP and only in the last year has climbed down 6 places in the competitiveness rank, due to its unstable macroeconomy and its poor political administration. On the social and environmental aspects, it has an unemployment rate of 8,4%, a Gini score

of 46,9, a global gender gap index of 0,7, an environmental footprint of 2,2 gha/capita and a 12,8% share of renewable energy consumption.

Global Competitiveness Index 4.0 2019 edition

Rank in 2018 edition: 127th/140

**Performance Overview 2019** Key ◇ Previous edition ▲ Upper-middle-income group average □ Latin America and the Caribbean average

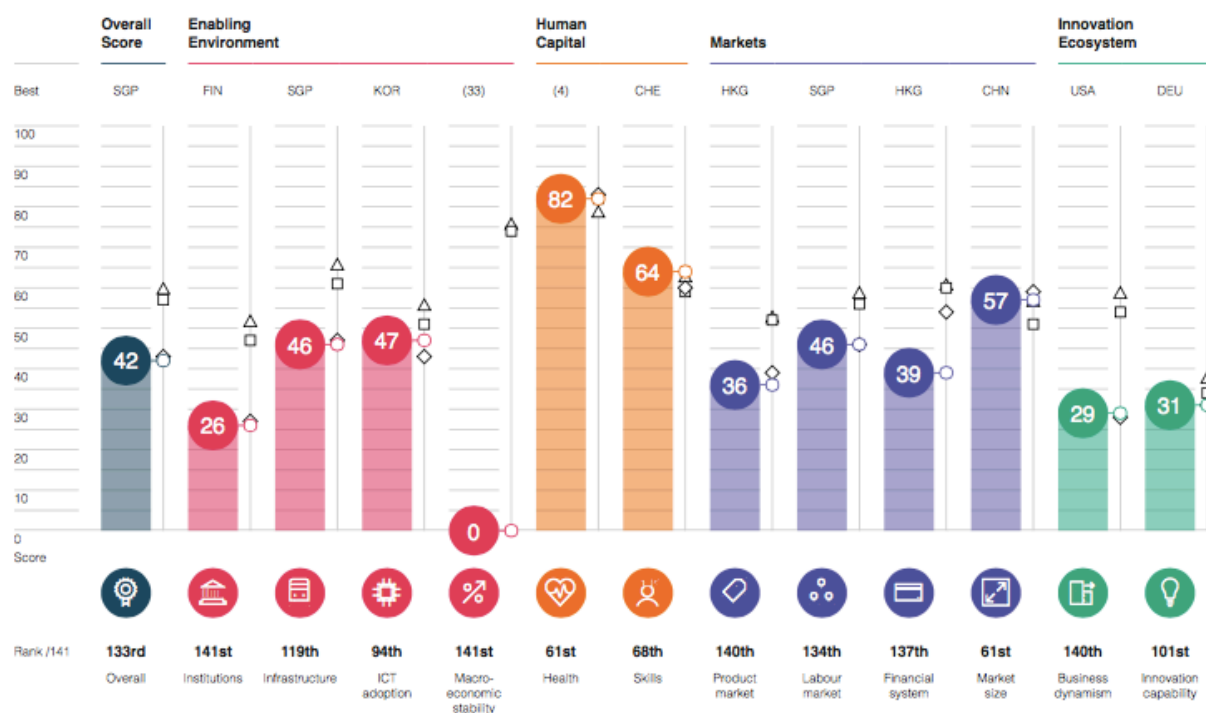


Figure 19 Venezuela's performance overview 2019 taken from (WEF, 2019)

The country is performing terribly in most of the index's components. Due to the country's colossal inflation rate (465141,6%) and its poor debt dynamics with a score of 0 (in a scale of 0 to 100), the country has no macroeconomic stability and its currently on the worst position in the ranking (141 out of 141 countries considered).

The country occupies the last place in the rank (141st) in the components of

- Macroeconomic stability; Institutions; Checks and balances in the sub-indexes of judicial independence, efficiency of legal framework in challenging regulations; Public sector performance; transparency; property rights; corporate governance, future orientation of government, competitive markets, labor markets, business dynamisms and financial systems.
- On the component of ICT adoption, it scores 46,7 and is in the 94th place and in the innovation capability one, the country scores 30.9 and is in the 101st place.

Showing that it is urgent for the country to stop the current internal war and to have a new president who can take the wheel and work, along with international support, towards recovering the economy of the country.

## Comparison of the Industry 4.0-related Components of the productivity index in Latin-American countries.

Table 16 Country scores in Industry 4.0-related components

Pillars	Components related to 14.0	Singapore	Chile	Mexico	Uruguay	Colombia	Brazil	Argentina	Venezuela
Institutions	E- Participation (public-sector performance) [0-1 best]	<b>0,97 (13)</b>	0,82 (45)	0,94 (17)	0,92 (26)	<b>0,92 (23)</b>	0,97 (12)	0,62 (84)	0,4 (113)
	Property rights [0-7 best]	<b>6,4 (3)</b>	5,3 (32)	4,1 (86)	5,1 (36)	<b>4,1 (91)</b>	3,9 (103)	3,8 (112)	1,6 (141)
	Intellectual property protection [0-7 best]	<b>6,4 (2)</b>	4,7 (42)	4,1 (67)	4,7 (39)	<b>3,8 (92)</b>	3,8 (95)	3,9 (85)	1,9 (141)
Infrastructure	Electricity access [% of population]	<b>100 (2)</b>	100 (2)	100 (2)	99,7 (74)	<b>97 (91)</b>	99,7 (73)	98,8 (84)	98,9 (83)
	Electricity supply quality [% of output]	<b>6,8 (2)</b>	3,6 (9)	12,5 (81)	12,9 (85)	<b>9,1 (51)</b>	16,1 (102)	13,0 (88)	33,2 (123)
ICT adoption	Mobile-cellular telephone subscriptions [per 100 pop.]	<b>145,7 (16)</b>	134,4 (32)	93,0 (112)	149,9 (13)	<b>129,9 (43)</b>	98,8 (101)	132,1 (40)	71,8 (127)
	Mobile-broadband subscriptions [per 100 pop.]	<b>145,7 (6)</b>	91,6 (43)	70,0 (78)	123,8 (17)	<b>52,3 (101)</b>	88,1 (46)	80,7 (60)	54,5 (99)
	Fixed-broadband Internet subscriptions [per 100 pop.]	<b>25,9 (43)</b>	17,4 (56)	14,6 (62)	28,3 (34)	<b>13,4 (64)</b>	14,9 (61)	19,1 (53)	8,7 (80)
	Fiber internet subscriptions [per 100 pop.]	<b>22,3 (8)</b>	2,2 (52)	2,5 (50)	18,8 (10)	<b>1,4 (65)</b>	1,6 (61)	0,5 (78)	0,0 (120)
	Internet users [% of adult population]	<b>88,2 (24)</b>	82,3 (33)	65,8 (72)	68,3 (69)	<b>62,3 (80)</b>	67,5 (70)	74,3 (56)	72,0 (61)
Skills	Digital skills among active population [1-7 best]	<b>5,6 (5)</b>	4,3 (64)	3,8 (99)	4,3 (65)	<b>3,8 (94)</b>	3,1 (133)	4,0 (80)	3,6 (113)
	Ease of finding skilled employees [1-7 best]	<b>5,1 (9)</b>	4,9 (23)	4,2 (69)	4,1 (77)	<b>4,3 (59)</b>	3,4 (129)	4,2 (68)	3,4 (128)
Market size	GDP [PPP \$ billions]	<b>503 (36)</b>	428 (42)	2,284 (11)	77 (88)	<b>662 (32)</b>	2991 (8)	813 (29)	277 (56)
	Imports of goods and services [% of GDP]	<b>154,3 (3)</b>	29,5 (111)	42 (74)	20,9 (130)	<b>19,3 (132)</b>	13,6 (140)	17,2 (136)	7,2 (141)
Business dynamism	Growth of innovative companies	<b>5,0 (14)</b>	4,2 (56)	4,0 (81)	3,7 (97)	<b>3,9 (87)</b>	4,2 (60)	3,9 (86)	3,4 (121)
	Companies embracing disruptive ideas [1-7 best]	<b>4,6 (13)</b>	3,6 (74)	3,6 (77)	3,1 (124)	<b>3,6 (72)</b>	3,8 (56)	3,7 (69)	4,0 (45)
Innovation Capability	R&D expenditures [% of GDP]	<b>2,2 (14)</b>	0,4 (74)	0,5 (64)	0,4 (71)	<b>0,2 (88)</b>	1,3 (27)	0,5 (60)	0,1 (107)

GDP per capita US\$	<b>64041,4</b>	16078,7	9807,4	17164,9	<b>6684,4</b>	8967,7	11626,9	3373,7
Population (millions)	<b>5,6</b>	18,5	124,7	3,5	<b>49,8</b>	208,3	44,6	29,2
Unemployment	<b>3,8</b>	7,2	3,3	8	<b>9,1</b>	2,5	9,5	8,5
Inflation	<b>0,5 (1)</b>	2,3	5,5	6,9	<b>3,8</b>	3,6	30	464141,6

In the table 20, we can find the scores published by the (WEF, 2019) in a list of components related to the enablement of the environment for the fourth industrial revolution, in each one of the countries. We can find the scores of Singapore that serve as a reference point from developed countries.

By comparing Chile, the best performing country in Latin-America, with Singapore, it can be seen how wide the digital gap is between developed countries and developing countries. Starting from the most prominent difference in R&D expenditure, with an investment of the 2,2% in Singapore and 0,4% in Chile and an even lower rate in Colombia, only 0,2% of the

GDP. In all of the components studied, there is a big difference between Singapore and all the Latin American countries allowing us to notice how behind the productivity of the countries are and the reason of it.

Between the other Latin-American countries and Colombia, the results are not favorable for the gateway to South America. Colombia has only performed relatively better than the other countries in the categories of E-participation of the government, with a score of 0,92 (23<sup>rd</sup>) only behind of Mexico (0,94; 17<sup>th</sup>) and Brazil (0,97; 12<sup>th</sup>) and the Ease of finding skilled employees (4,3; 59<sup>th</sup>) only behind of Chile (4,9; 23). In the rest of the components Colombia has till a long way to go, and many efforts are required in order to improve the country's productivity. It is fundamental that the government focuses on guaranteeing an adequate ICT environment that is accessible for all the citizens. Starting from the infrastructure we have the electricity access supply share; the government should work on making that percentage share equal to 100%. And moving forward from that, the next objective should be working on the internet connectivity, the skills, the innovation capability and the business dynamism so that the country can increase step-by-step the overall level of productivity.



# CHAPTER 6

## Conclusions

Conclusive chapter that presents a summary of the main aspects discussed in the study



## 6. Conclusions

Over the last years, different advances in the use of disruptive solutions and emerging technologies to boost the transformation of business models and the strengthening of the Digital Economy have been developing. The development of the Fourth Industrial Revolution in the world and in Colombia has deepened, with which challenges and opportunities arise in the way we work, interact and live. The main challenge remains a change of mentality in citizens, academia, businessmen and the government before the digital reality impacts economic growth, employment, education, health and in general the quality of life.

The digital revolution is already changing companies and even entire industries. In this new world, we have seen how large, medium, small and micro companies have begun to use, among other technologies, social networks, data analytics and the advantages offered by smart devices, in their businesses. Others have gone further and have gone from being analog, that is, organizations that use some digital and technological solutions of the 21st century but that maintain the culture, philosophy, operation, processes, products and services of the 90's, to become referents of a digital company, by having a disruptive DNA and using some digital and technological solutions of the 21st century.

Digital transformation is not just a technological issue. Technology is a tool and not an end; What this permits us is connecting to live better lives. Therefore, digital transformation also implies business leadership to challenge the traditional way of doing things, identifying and investing in technology and driving change in organizations to put digital innovation into practice.

The government, the ministry of ICT and several public and private entities have been working to make Colombia and its entrepreneurs digital. For this reason, they have been promoting a Digital Transformation agenda as an essential strategy and tactic to improve the productivity of companies and the country's competitiveness.

Notwithstanding this positive outlook, there is still a bunch of significant challenges remaining for the economy of the country – increasing the level of education, science and technology, shrinking the infrastructure gap, decreasing corruption and inequality, and building peace are just a few of the key issues to overcome to achieve an overall higher level of welfare and productivity in the country.

Specifically, from the results taken from the measurement of the digital economy we have that the country has important advances in key aspects to have a good performance in terms of the digital economy such as the infrastructure and use of ICT by people and the productive sector; nevertheless, to have a significant growth in the index, important efforts are required in aspects such as Internet connections with speeds greater than 10 Mbps, which is an important element for an improvement in the performance of all dimensions.

The results of the regional indicator indicate that Bogotá D.C. it is the region with the best performance, followed by Valle del Cauca and Antioquia, with scores of 26.8, 17.3 and 15.1, respectively; while the Pacific and Orinoquía - Amazon regions are those that exhibit the least development in terms of digital economy, with scores lower than and equal to 12.2.

Results that show the existence of an important gap between Bogotá D.C. and the rest of the country.

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