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Technological Capacity Index and Innovation Index in Some Emerging Countries

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SUMMARY

In a complex and competitive world, companies of all sizes concentrate on researching strategies to build and sustain competitive advantages, improvement, preservation, discovery, and utilization of creative information.

The aim of this study is to contribute to research that demonstrates a positive relationship between innovation and technical capability. The initial aim is to provide an overview of innovation. The focus of this research was on various innovation models as well as heuristics for generating ideas and solving problems. In this analysis, innovation is a process. Of the many steps and facets of this process, only two are briefly described: creating a new concept and design. It also discussed the models deployed to represent innovation as a whole in this work. Further upstream, the role of creativity and the way to consider it at the heart of the innovation process are also reviewed.

Recent studies have shown the importance of organizational practices and knowledge management on innovation's success. Some of them emphasized the need for technological capacity, to be effective, to be accompanied by organizational changes linked to good knowledge management and so on. Significant attempts to construct aggregate indicators of technological capabilities are available. Our research aims to illustrate the methodologies followed by each of them, explore their similarities and differences, and compare the results. These recent empirical attempts result from an absolute consensus on the technology that has emerged over the past quarter of a century and is shared by different disciplines such as institutional economics, social studies in science and technology, and management studies.

The aim of this study is to compare their methodologies and outcomes. The results provide a broadly comparable ranking of countries, although a few significant differences emerge. We get empirically that Mobile cellular subscriptions (per 100 people) *LOGMOBCTS* and Domestic credit to the private sector (% of GDP) *LOGDCPS* are a key variable for technological capacity in selected emerging countries. The digital transition by moving to the smartphone can explain our findings. Furthermore, the technical capability output of countries can be determined by effective governance that supports the private sector operating in the ICT sector.

Keywords: Technological Capacity – Innovation – Emerging Countries – Panel Data.

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LIST OF ABBREVIATIONS

Abbreviation	***Meaning***
FTE	Full-time Equivalent
GDP	Gross Domestic Product
GNI	Gross National Income
HC	Headcount
HDI	Human Development Index
ICT	Information and Communications Technology
ILO	International Labour Organization
IMF	International Monetary Fund
ITU	International Telecommunication Union
IUCN	International Union for the Conservation of Nature
MDGs	Millennium Development Goals
MSCI	Morgan Stanley Capital International
OECD	Organisation for Economic Co-operation and Development
OWG	Open-ended Working Group
R&D	Research and Development
SDGs	Sustainable Development Goals
SIN	Systems Integration and Networking Model
SNI	National System of Innovation
TIS	Technological Innovation System
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCED	World Commission for Environment and Development
WIPO	World Intellectual Property Organization
WWF	Worldwide Fund for Nature

Chapter One

General Introduction and Research Objectives

Introduction

The *innovation* concept has a long history of development. Until the 1960s; the interest in innovation has increased. During the 1960 to 1990 period, the fundamental concepts of Innovation and the analysis of innovation processes have been developed; this period can be described as a *golden age* for conceptualizing Innovation in different forms. In the 2000s, Innovation became a buzzword, and a conception of Innovation became a vaguer concept (Kotsemir, M. et al., 2013).

One of the pioneers of the innovation concept, Whole, which begins with an idea and proceeds through all steps to produce a marketable product that transforms the business economy, is Joseph Schumpeter.

"Produce is to combine the things and the forces present in our field. To produce something else or otherwise is to combine these forces and things differently. As long as we can arrive at this new combination starting from the old with time, there is a modification, possibly a growth by small steps and a continuous adaptation. Still, there is either a new phenomenon [...] or evolution [...]. Insofar as, on the contrary, the new combination cannot appear, and only appears in a discontinuous manner, then the characteristic phenomena of evolution are born" (Schumpeter, J. A., 1935)

Innovation is, therefore, the execution of new combinations. For Schumpeter, this concept encompasses the following five cases: Production of a new good or unique quality of a useful, invention of a new production method, development of a new market, conquest of new access to raw materials and semi-finished goods, and the organizational change.

In addition, the scientific literature contains a plethora of meanings for innovation, as well as various typologies or degrees of innovation.

Innovation is a current topic today and recognized by all as an essential and necessary means available to individuals, companies, and states to develop their activities and make their daily lives better. It is a term widely popularized and present in most institutional discourse. The concept of innovation is considered a vital process for companies to ensure their development. Companies implement various new actions and strategies to meet market demands and increase their performance. Good knowledge of the innovation process and the company's organization are necessary to manage effectively and adapt them to their environment's challenges and changes. As a result, businesses must have resources and strategies in place to consistently measure their innovation activities by implementing the business intelligence activity, which recognizes the current developments that will impact businesses by using new technologies. They should be tasked with detecting new patents and gathering data in accordance with ethical and professional conduct guidelines.

We can define Innovation as the successful application of an invention in various fields. It comes above all from research and development (R&D), mainly carried out in companies. This integrates several stages such as fundamental research, applied research, or industrial development within the framework of projects subsidized by public authorities. Innovation can be stimulated within the company and anchored in its culture by setting up a specialized technical committee for reflection. More often than not, the pressure of more reactive existing competitors, the arrival of new entrants in the market, or the rise of innovative technologies will force the company to adopt a reactive approach.

One of the most significant determinants of a territory's economic growth is innovation, and measuring it remains a challenge. Over the last two decades, several research works (theoretical and empirical) have been established that seek to describe innovation using two key indicators: inputs (R&D expenditure, R&D workforce) (Mohnen & Röller, 2005) and innovation outputs (patent filings, S&T publications, etc.) (Crepon & Duguet, (1994); Tödtling, F. et al., (2006); Okubo, (1997)). Our research Thesis may contribute significantly to an understanding of innovation dynamics, particularly geographic dynamics based on external factors of knowledge (Autant-Bernard et al., 2010), as innovation is a process that creates forms of organization, technical objects, methods of use, skills, rules, practices, or new actors. In our study, we will discuss technological innovations and the importance of technology in these innovations, currently the subject of many measures.

Therefore, technology plays an essential role in innovation activities by developing and refining methods for the efficient use of various techniques. Even in groups or in their entirety, whether technical or mechanical, physical or intellectual, because of the assured exploitation of production mechanisms, consumption of information, communication, recreation, construction and destruction, and artistic and scientific research activities. Technology is a set of knowledge, processes, and techniques that are used to bring the latest scientific developments and applications of computing and communication into practice (Dunning, J. H., 1994).

And therefore, *technological capacity* allows incremental improvements in the use of new technologies that contribute to firms' higher economic performance (Jonker, M., Romijn, H., & Szirmai, A, 2006). It is a process of absorption or creation of technical knowledge to get challenges and opportunities to develop new products (Phaal, R., & Probert, D., 2009) and gain skills and transform knowledge into innovation (Lall, S., 1992).

This makes technological capabilities of great importance, as we find many applied and theoretical studies (Dahlman, C. & Westphal, L. (1982); Tippins, M. J. & Sohi, R. S. (2003); Zak, K., (2016); Ramos, H. A. D. C., et al., (2018)), that have been presented to use technological capabilities to enhance the ability of economic actors to use technical knowledge by trying to absorb, adapt and change existing technologies. Both Technology and innovation are critical to a country's economy, as shown by a wide body of theoretical and empirical research on innovation and technical potential.

A country's technological capabilities can be defined as the ability to use and integrate technological knowledge effectively. It takes into account human capital abilities, the size and quality of physical capital in the economy, and the technical structures in place in the state at any given time.

Countries vary in their ability to use, develop and improve innovations and modern technological methods, as well as in the capacity of states to localize modern technology within goods, products, and various productive processes within the economic sectors and the state's commercial performance in international markets, as well as the long-term economic growth equipment.

In this work, we will refer to the close relationship that exists between the Sustainable Development Goals (SDGs), which are among the most transformative projects launched by the global community for decades, and between science, technology, and innovation (STI), which play a pioneering role in economic and social change. Policymakers should prioritize to harness them to help achieve the SDGs, to help developing countries harness science, technology, innovation, and entrepreneurship through policy analysis, sharing experiences, and strengthening leadership capacities.

The 2030 Agenda is a universal action program that aims to radically change the global development trajectory to meet the aspiration of all to live in dignity as equal members of prosperous communities while minimizing the environment's degradation. One of the central elements of this program is the revitalization of the Global Partnership for Sustainable Development, which brings together governments, civil society, the private sector, and other development actors. The majority of the implementation issues that the SDGs must overcome include STI.

In the thesis, we will focus on studying these essential elements, specifically in *emerging countries* characterized by a fast-growing pace and adopting a free-market policy. However, due to the numerous classifications of these countries, no official identification of these countries has been made. On the economic level, however, the first and most influential emerging countries are BRIC; these countries have developed themselves as leaders in major sectors, such as Brazil, which is the first in agriculture and has a vast agricultural resource. Russia is extremely wealthy and heavily reliant on oil. India has a skilled workforce that allows it to compete in the service sector. China is a big emerging country in the textile and product manufacturing industry. With high industrial development and a resilient and competitive industrial fabric, South Africa is one of the world's leading economic forces. the rise of many other developing countries, such as Egypt, Greece, Hungary, Korea, Malaysia, Peru, Philippines, Poland, Qatar, Thailand, Turkey, United Arab Emirates, and so on, in order to differentiate them from emerging countries' characteristics.

Objective of the thesis

Over the past decades, increased economic development and economic instability has characterized the world economy's rapid growth in emerging countries.

Competitiveness and economic prosperity are often correlated with technological capability, according to the literature. Based on this observation, in this thesis, we analyze the impact of emerging countries' innovation and technological capacity on their performance. In the first step, we outline the various theories' conceptualizations of both the innovation index and technical capabilities.

After determining the most objectively a list of emerging countries by referring to the criteria most used in the literature, and after having measured the degree of specialization of these countries, we examine their technological capacity and their capacity to innovate over the period 2000 - 2018. We begin by evaluating the effect of emerging countries' technological capacities on economic growth and comparing the outcomes of developed and developing countries. We find that the different types of innovation and its indicators positively impact emerging countries' development and the technology index, which has a vital role in having a robust economy. Today in the literature, there is a diversity of definitions of innovation. As a result, there are many methods to measuring it (Adams et al., 2006), who reveal that there is currently no standard formula for measuring the innovation process in their study on the measurement of innovation. The various current approaches may be inconsistent at times. Several indicators, such as R&D spending, R&D staff, number of patents, scientific publications, and so on, may represent the innovation index, according to the authors. Many studies vary on what elements and metrics can be calculated in terms of technical capacities, such as R&D spending, patenting of innovations, ICT, HDI, R&D researchers, and so on.

This is the objective of our research. We bring the most theoretical and applied studies that show the most critical indicators that measure both technological capabilities and innovation, particularly those linked to emerging countries, which have been characterized by remarkable economic development in recent times.

In recent decades, emerging countries have succeeded, despite various periods of economic instability (political, financial, etc.), to integrate more and more into the world economy. This integration translates into reliable economic performance and growth compared to developed countries. As an example of the rapid development of emerging countries, these countries' economic growth rate during 1995-2014 was 4.64%, while developed countries' economic growth reached 2.15% (World Development Indicators-World Bank).

For that, we try to verify the following two hypotheses:

H1: The technological capacity variables like Patent applications for residents, Mobile cellular subscriptions (per 100 people), Domestic credit to the private sector (% of GDP) and Fixed-broadband subscriptions are determinants of innovation in the emerging countries.

H2: Emerging countries will depend on their knowledge capacity for exploring their human potential.

Organization of work

In the rest of this part, we will detail our manuscript's structure that we have built around five chapters.

In the *First Chapter*, we review a general introduction on the thesis topic and the essential elements contributing to choosing this topic with a fundamental problem that we must answer at the end of the work.

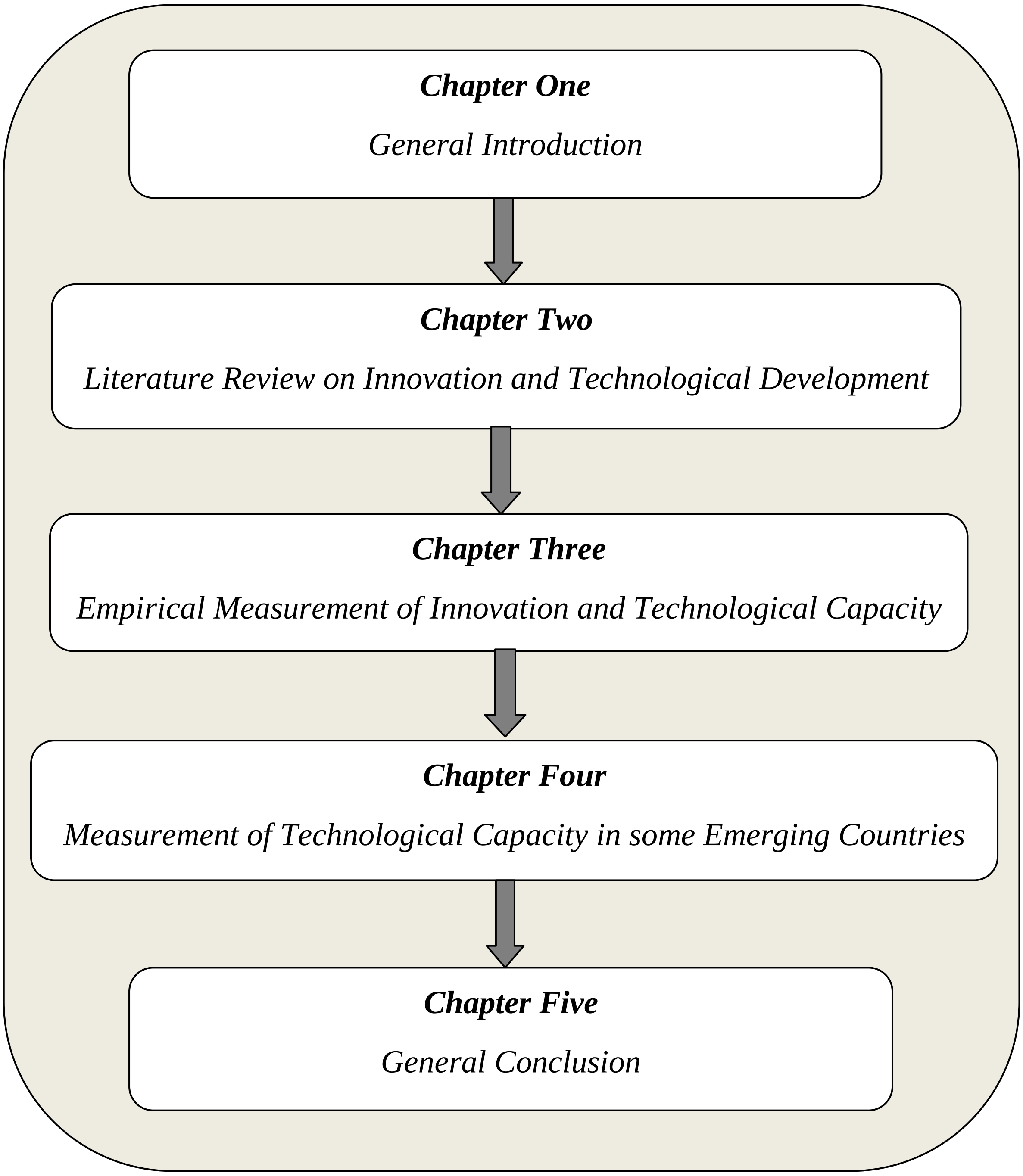
In *Chapter Two*, we will discuss the idea of innovation and, in particular, technological capacity. We will review some definitions of Innovation as well as patterns of Innovation presented in the literature. Although the term innovation is widely used, it is a tough concept to understand with many perspectives. Then, we discuss the idea of technology and the extent to which technological techniques are used, along with measures to bridge the continuous gaps between developed, emerging, and developing countries in accessing and using current technologies, as well as developing innovation, which makes them crucial to achieving the sustainable development goals and building more prosperous, sustainable, healthy and inclusive societies. This will lead to establishing the first framing of our research problem.

Chapter Three is devoted to the part of our theoretical contribution. It will allow us to complete our problem. Three major sections make up this chapter. The first will be devoted to presenting the concepts of evaluation and measurement of several important economic growth indexes such as innovation, the human development index, ICT development, etc. The second section will examine the variables and different treatment methods to identify all technological capacity indicators. In the third section, we will refer to a group of countries with specific characteristics, which are the emerging countries, which mainly depend on their economy on the elements mentioned previously.

In *Chapter Four*, we do an empirical study, and that after collecting previous studies and the most important results got to conduct proper research, by identifying the essential variables that measure technological capacity and innovation with emerging countries, with a specific period using the model of Panel data and get results and explanations.

Lastly, in the *Final Chapter*, the conclusion provides a general discussion about the result of the study that we have done about the most crucial element or elements that guarantee countries to develop economically and make them compete with developed countries in the world, and thus the answer to the problem of work.

Figure 01: The Study's Structure



Chapter Two

Literature Review on

Innovation and

Technological Development

Introduction

The 2030 Agenda for Sustainable Development sets ambitious goals at a global level that require unprecedented action and unprecedented efforts on multiple, interdependent social, economic and environmental issues. Knowledge, technology, and innovation all play a key role in achieving these objectives. The process of creative destruction brought about by technological progress can contribute to transforming economies and improving living standards by increasing productivity, reducing production costs and prices, and contributing to real wage increases.

Using advanced technologies, combined with measures to close the persistent gaps between developed, emerging, and developing countries in accessing and using existing technologies, as well as developing innovation, could be decisive for achieving the goals of sustainable development and building more prosperous, sustainable, healthy and inclusive societies. These technologies point to solutions and sustainable development opportunities that will be more responsive, cheaper and faster, scalable, and easily exploitable. The importance of technological spillovers for development has already been observed in the face of the transformations of information and communication technologies (ICTs) in many low-income countries. There are obvious opportunities to improve the environmental sustainability of development considering recent advances in technology.

However, new technologies carry the risk of imposing a pace that exceeds societies' and decision-makers' ability in the face of the changes produced, which creates a general feeling of uncertainty or hostility towards certain technological advances.

This chapter will discuss different concepts and ideas about innovation and technical capability, as well as the relationship between them and the SDGs.

Section One: Global Perspective on Innovation

"The new does not come out of the old, but appears next to the old one, competes with it until ruining it" (Theory of Economic Evolution, Schumpeter, J. A., 1935)

Since Joseph A. Schumpeter's work, innovation has played a central role in economic analysis, especially in the development of the study of economic dynamics over the last thirty years, particularly in endogenous growth theories (Howitt, P., & Aghion, P., 1998). Modern innovation research identifies various modalities of the phenomenon and categorizes it into different typologies based on its existence or economic effect. To conclude, innovation is widely acknowledged as a source of growth and productivity.

1 The Concept of Innovation

The concept of innovation has a long history of development, and it's a concept that is both polysemic and polymorphic (Loilier & Tellier, 2013). Innovations can be the different origin and scale. Innovation can be conceived as creating novelty in the services offered and in the production processes. It can also be understood as a more or less profound modification of the resources used and developed by the company. Thus, the innovation can be considered the result got by a company and the process that allowed this getting.

We begin by discussing the roots of the philosophy of innovation as well as some of its distinguishing characteristics. We'll go through the differences between innovation, creativity, invention, and exploitation. Thirdly, we see the different characteristics of Innovation.

1.1 Defining Innovation

A history of innovation shows how this concept's meaning has evolved since the Greek philosopher and historian Xenophon[1] (from the fifth century BC). He considered the concept was multifaceted and linked to political action. The word he uses for innovation is *"Kainotomia"* (Innovation), and before that, it had been used in two plays of Aristophanes[2].

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[1] ***Xenophon*** was an Athenian-born mercenary and historian. He established precedents for many logistical operations, and was among the first to use flanking maneuvers and feints.

[2] ***Aristophane***s son of Philippus, of the deme Kydathenaion, was a comic playwright or comedy-writer of ancient Athens and a poet of Old Attic Comedy.

Hence, Plato[3] and Aristotle[4] discussed the meaning of innovation in another concept. One focuses on cultural Innovation (games and music) and its effect on society, and the other focuses on changes in political constitutions. Hence, there were some positive uses for this concept in Classical Greece (Godin, B., 2017).

The word "*Kainotomia"* is derived from (*kainos: new)*. Initially, the concept of Kainotomia had nothing to do with the current meaning of innovation. It meant "cutting fresh into". It has been used in abstract thinking, "making new" and concrete thinking, "opening new mines". Innovation has gained its current meaning as a metaphorical use of this word. In ancient philosophers and writers, hands on political constitutions, Innovation "introducing change to the established order". In general, Innovation is a word with few events among the ancient writers.

Classical economists then ignore it. It is introduced to the current sense of process innovation in Joseph Schumpeter's[5] economic thought in the early 1940s and the primary purpose of Innovation produced in Peter Drucker's[6] early fifties. The latter reinvents the word and the concept, making it synonymous with completed progress.

The concept of innovation has become more complicated in other respects. Many of the researchers presented various definitions and concepts of Innovation. However, most approaches refer to the idea of "novelty" and "change" in their definition.

For Peter Drucker, innovation is a process that requires the strong participation of all the functions of the organization to benefit from it. He defined innovation as:

"Innovation is the specific c tool of entrepreneurs, how they exploit change as an opportunity for a different business or service. It is capable of being presented as a discipline, capable of being learned, capable of being practiced" (Drucker, P. F., 1985)

The definition of innovation to Smith and Ainsworth depends on the emphasis on the output from the innovation process, and they say:

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[3] ***Plato***, in Classical Attic, was an Athenian philosopher during the Classical period in Ancient Greece, founder of the Platonist school of thought and the Academy, the first institution of higher learning in the Western world.

[4] ***Aristotle*** was a Greek philosopher and polymath during the Classical period in Ancient Greece. Taught by Plato, he was the founder of the Lyceum, the Peripatetic school of philosophy, and the Aristotelian tradition.

[5] ***Joseph Aloïs Schumpeter***, an Austrian political economist, was one of the most influential economists of the 20th century, and popularized the term "creative destruction" in economics.

[6] ***Peter Ferdinand Drucker***, an Austrian-born American author, was a leader in the development of management education, he has been described as *"the founder of modern management"*.

"Innovation includes the idea of invention and discovery but goes beyond it. It is anything that provides usable, unique novel solutions to problems, opportunities, or challenges – whether small or large. Some examples might be a new use for an old product; a new product from on-the-shelf technology; a novel marketing strategy" (Smith, N., & Ainsworth, M., 1989)

The British psychologist Michael West is essentially a non-linear process that considers individuals or groups creative abilities. It is the creative process of creating ideas and procedures for developing ideas into products. Innovation can be seen as a result of creativity, but ideas cannot be controlled from the outside (Schulz, K. P., 2008).

"*Creativity is thinking about new things, innovation implementation is about doing new things*" (West, M. & T. Rickards, 1999)

"*Innovation can then be defined as encompassing both stages— the development of ideas—creativity; followed by their application—the introduction of new and improved products, services, and ways of doing things at work. Innovation, I shall argue, is, therefore, a two-component but essentially non-linear process, encompassing both creativity and innovation implementation. At the outset of the process, creativity dominates, to be superseded later by innovation implementation processes*" (West, M., 2002)

One of the leading researchers in innovation, Everett Rogers[7], believes that Innovation is an idea, practice, or theme. Therefore, it expands the traditional vision of Innovation as a new product towards a more open vision while considering processes and social change. In the late 1950s and 1960s, Rogers focused his initial empirical research on innovation on social change, particularly by adopting new technologies in developing countries (Rogers, C. R., 1962). Through his research, he brought the idea of self-novelty. For him, personality innovation is set if the object is new in the individual perception of persons or groups.

"*An Iinnovation is an idea, practice or object that is perceived as new by an individual or other unit of adoption. It matters little, so far as human behavior is concerned, whether or not an idea is "objectively" new as measured by the lapse of time since its first use or discovery. The perceived newness of the idea for the individual determines his or her reaction to it. If an idea seems new to the individual, it is an innovation*" (Rogers, E. M., 2003)

[7] ***Everett M. "Ev" Rogers***, was an eminent American communication theorist and sociologist, who originated the diffusion of innovations theory and introduced the term early adopter.

The two Irish authors, David O'Sullivan and Lawrence Dooley have defined the concept of innovation in their book *"Applying Innovation"* as:

> *"Innovation is the process of making changes, large and small, radical and incremental, to products, processes, and services that result in the introduction of something new for the organization that adds value to customers and contributes to the knowledge store of the organization"* (O'Sullivan, D., & Dooley, L., 2009)

The definitions and interpretations preceded it (see also Schumpeter, J. A., 1934; West, M. & T. Rickards, 1999; West, W., 2000; Rogers, E. M., 2003) showed a variety of characteristics, degrees, faces, etc. of innovation. On the one hand, these definitions are considered academic. On the other hand, researchers and practitioners can be more carefully considered the subject of Innovation to assess new processes, products, and resources required in the right way. This facilitates the appropriate management and decision-making process related to innovation development.

The concept of innovation is often reduced as new products and technologies, both from business management and from a scientific point of view, which reduces the importance of Innovation. While as a result of an innovative development and creativity process, the process itself starts by introducing a new idea until a new product is introduced.

Mostly, the definitions mentioned above are based on two strong agreements on innovation. As a consensus definition, Innovation is something new (new, original, or enhanced) that creates value.

Innovation may be a process, a product, or a service and can start with a few ideas and ideas in your mind. In this case, it can simply be a creative thought.

In the parallel of the note, Ken Robinson[8], the author of *"Out of our Minds: Learn to Be Creative"*, and an expert leader in innovation and human resources, defining creativity perfectly accurate when he said, *"In fact, creativity, which determines the process of obtaining original ideas that have value, most often occurs through the interaction of different disciplinary methods to see things"* (Robinson, K., 2017). Although he used the definition of creativity, he is a substantial synonym for innovation.

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[8] ***Kenneth Robinson***, a British author, an internationally speaker, engineer and education expert for his contributions to the development of creativity and innovation.

1.2 Related Concepts

Innovation has been and continues to be an essential topic of study for several disciplines, including economics, business, engineering, science, and sociology. Even though innovation has been studied in a variety of fields, the term is often poorly understood. It can sometimes be confused with related terms such as change, invention, design, and creativity.

1.2.1 Innovation and Creativity

Creativity is considered an essential element of innovation (Rosenfeld, R., & Servo, J. C., 1991) and is an inherent capacity of all human beings. Creativity is a mental process that results in innovative ideas and relevant, useful, and exploitable concepts. We can say that the process of creation has four distinct phases: preparation, incubation, enlightenment, and verification (Wallas, G., 1926).

Subsequent revisions of this process have added a last phase, elaboration, in which the idea is structured and finalized in a form that can be easily communicated to others. Creativity implies a level of originality and novelty essential to innovation. Although creativity is a fundamental element of Innovation, it is wrong to exchange terms.

Innovation promotes further processing of the creative process's output (the idea) in order to maximize its potential value through growth.

1.2.2 Innovation and Invention

The Invention is a term often used in the context of innovation. The invention is defined as follows (The New Oxford Dictionary of English, 1998, 960):

"Create something new that has never existed before"

With the invention, we move away from the world of natural sciences or formal sciences to get closer to the technical field. The terms "invention" and "innovation" are often used interchangeably. In both cases, the outcome tends to be novel, and realizing the concept behind the invention or innovation requires time and technological resources. The peculiarities of the starting events are what distinguishes the two terms. Indeed, some inventions are the result of intuitions, while others are the result of chance. In turn, innovation transforms a pre-existing Invention and is defined by its ability to respond to a need, expressed or latent.

Many authors stress the differences that may exist between innovation and invention; Ruttan, V. W. (1959) poses a temporal hierarchy between the two terms:

"The invention precedes innovation which is itself before social change"

The invention corresponds to the conception of an idea and the means and devices by which a result is obtained from this idea. By extension, it corresponds to the act of inventing or creating a genuine product. The invention is related to two factors: on the one hand, to the character of an original activity of the mind, and on the other hand to the possibility of realization, that is to say, the possibility of acting on the outside world.

For Farber, A., & Adam, M. C. (1994), the invention corresponds to the definition of a new concept by intuition, sometimes brilliant and always impossible to plan the creator. Innovation then represents the integration of Inventions available in commercially viable products and processes.

We summarize other authors who distinguished between innovation and invention in the scientific literature in Table 01.

Table 01: Concepts of innovation and invention in the scientific literature

Authors	Innovation	Invention
Freeman, 1982	*Innovation is the introduction of the change* via something new.	*The invention is the creation of a new* device or process
Senge, 1990	*The idea* becomes an *innovation* only when it can be replicated on a meaningful scale at practical costs	*The idea* has been *invented* when it is proven to work in the laboratory
Rouse, 1992	*Innovation is the introduction of the change* via something new	*The invention is the creation of a new* device or process
O'Sullivan and Dooley, 2009	Innovation *is more than the creation of something novel*. Innovation also includes the exploitation of benefit by adding value to customers. The invention is often measured as the ability to patent an idea.	The invention *need not fulfill any useful customer* need and need not include exploiting the marketplace's concept.

Source: *Kotsemir, M., et al., (2013).*

1.2.3 Innovation and Exploitation

There are many alternative definitions of innovation. A popular alternative is to present innovation as a commercially exploited invention (Sala-i-Martin, X., 1994). In this alternative definition, the term invention has the same meaning as previously mentioned: something new that had never existed before. This creation of novelty stems from the creative capacity of the organization and offers opportunities for exploitation. This alternative definition of innovation has been expressed as follows (Roberts, E. B., 1988):

Innovation = Invention + Exploitation

As a result, innovation can be described as a methodical approach to creating an environment based on creative exploration, creativity, and commercialization of unmet needs (Bacon, F. R., et al., 1998).

1.3 The Characteristics of Innovation

All innovations are not equivalent, depending on whether one uses a particular criterion to compare them. Downs Jr, G. W., and Mohr, L. B. (1976) proposed classifying innovations solely based on their primary attributes. Characteristics that are viewed in the same way by all organisations that recognize them are referred to as the latter. However, since such a criterion is arbitrary in and of itself, Jiménez, D., and Sanz-Valle, R. (2011) suggest that researchers agree on a set of characteristics to classify and compare as many developments as possible. According to E. M. Rogers (1995), most study has five characteristics in common:relative advantage, compatibility, complexity, testability, and observability. To these five characteristics are added other attributes that differ from one search to another.

- *The relative advantage*: It corresponds to the difference in value perceived by individuals between the innovation and the old one which it replaces, or between the new situation resulting from the adoption of Innovation and the old one. This advantage can be expressed in terms of profitability, social prestige. In a vast majority of research on innovation characteristics, we find definitions of the relative advantage identical to Rogers, E. M. (1995). Agarwal, J. P. (1997) provides, for example, the following definition: *"Relative advantage captures the potential adopter's perception of the degree of advantage offered by innovation over other ways of doing the same"*.

- *Compatibility:* Refers to the perceived compatibility of the innovation with the values, experiences, and needs of the prospective adopter. The more the idea is incompatible with a social system's values and norms, the more its adoption is less reproduced.
- *Complexity:* It refers to the perceived difficulty of understanding the principles, operation, and innovation use. Agarwal, J. P. (1997) uses another term to refer to this notion of complexity: ease of use. The latter corresponds to the adopter's perception of the effort required to use the innovation. Innovations perceived to be easier to use, and less complex are more likely to be accepted and used by potential adopters.
- *The possibility of testing an innovation:* It represents the ease with which Innovation can be used on a small scale or in a small area before being fully adopted.
- *Observability:* This corresponds to the possibility of potential adopters to observe the effects of innovation. The more the effects of an Innovation are visible and communicable from one individual to another, the faster the Innovation spreads.

However, Godin, B. (2008) proposed 12 concepts that divided innovation into several aspects as a single event, topic, or product: "innovation as an event," "innovation as a material body," and "innovation as something new". It can be described as follows: (Kotsemir, M. et al., 2013)

Innovation as the process of doing something new:

- innovation as imitation
- innovation as invention
- innovation as discovery

Innovation as human abilities to creative activity:

- innovation as imagination
- innovation as ingenuity
- innovation as creativity

Innovation as a change in all spheres of life:

- innovation as cultural change
- innovation as social change
- innovation as organizational change
- innovation as political change

- innovation as technological change

Innovation as commercialization of the new product.

The author Ram, J. (2010) distinguishes another detailed classification of the aspects and dimensions of innovation:

- innovation as something new
- innovation as a conduit of change
- innovation as a process
- innovation as a value driver
- innovation as an invention

Other characteristics of innovation can be found in six main areas for implementing an innovation strategy: customer, competition, technology, partnership, project, and resources. But implementing a pure strategy is unlikely to provide a sustainable competitive advantage, given the rapidly changing market and customer requirements. What will attract and grow today's capital is a strategy that blends disparate strategies while remaining adaptable to the ever-changing market (Anlló, G., 2006).

- Innovation focuses on the *customer*: in this strategy, companies concentrate their efforts according to the needs of their customers, so this type of Innovation will depend entirely on the type of customer chosen.
- Focus on the *competition:* the strategy is to monitor each leading competitor's movement and respond as quickly as possible. The goal is to be the second-fastest. Incremental innovation is the main feature of this category.
- Focus on *technology*: here, there is a substantial investment in R & D (Research and Development). The companies that belong to this group are seeking to develop radical innovations.
- Focusing on the *partnership*: this category is divided into two sections: external and internal partners. The common denominator is the sharing of responsibility in the innovation process.
- They are focusing on a *project*: companies specializing in project-focused innovation link vast and complex systems, for example, space exploration programs, satellite orbits, and fusion of companies. The innovation profile is characterized by radical innovation and is often focused on technology.

- Targeting *resources*: companies driven by this strategy put a lot of emphasis on evaluating their resources, which means the possession of know-how determines their market position.

On the other hand, when it comes to the specificities of organizations and companies, certain conditions and types favor or hinder the innovation process. It is represented in some elements described in the company's described in the company's internal field, and others related to the external field.

Where if we want to mention some factors specific to the internal field, it is often: the presence of a strong entrepreneurial spirit with an entrepreneurial mindset and a strategy aimed at renewable competitive advantages such as total quality management, introducing information and communication technology, and technology control, which makes technology an essential component in the innovation process. In the external realm, we discuss topics such as qualification and productivity at the heart of the innovation process, an effective legal framework that relates to the aspect of defending innovation through patents, a free and open market that encourages businesses to enhance their performance and thereby innovation, and other factors (Djeflat, A., 2006). These and other variables can help determine the nature of innovation in particular for businesses.

Recently, a new concept on innovation has been put in place; this concept places the customer at the heart of the innovation process with surprising results. As a result, it's possible to declare the emergence of a new category: innovation co-developed or market-centric. This category combines several strategies, and the process of innovation takes a different path. As an example, it is possible to mention the change in the design. In this alternative approach, the design activities are carried out by the customer himself, with the company's technology at their disposal. As a result, the design process is less costly and more customer-focused.

1.4 Innovation: Result or Process?

J. R. Kimberly (1981) points out two major areas of debate in the literature about the concept of innovation. The first argument is that Innovation as a processor is thought of as a separate product or program. Innovation, when viewed as a mechanism, is the act of putting an idea to use. Innovation is a concept, a process, or a product that is viewed as novel as a distinct product or program.

J. R. Cooper (1998) stresses the distinction between these two points of view. Many who view innovation as a process, according to her, are interested in the various steps that a potential adopter must take, including defining an issue, assessing solutions, making decisions, and implementing innovation. The basic responsibilities and functions of the company shift as the innovation process progresses, according to this approach.

The interplay between events and individuals at each stage of the process influences the next steps' circumstances and success. Those who regard innovation as a discrete event are not necessarily aware of the processes involved in Innovation. They're curious about the gaps between companies that embrace innovation and those that don't.

Table 02 shows some definitions of innovation considered as a result.

Table 02: Definitions of innovation considered as a result

Authors	Definitions
Dewar and Dutton (1986)	Material idea, practice or artifact perceived as new by the individual or group of individuals who considers its adoption.
Lewis and Seibold (1993)	Purpose such as a new technology, idea, product, or program introduced into an organization.
Rogers (1995)	Idea, practice, or object that is perceived as new by an individual or other adoptive community.

Source: *Authors' adaptation from Alcouffe, S. (2004)*

Definitions considering innovation. As a result, i.e., a new object or practice is always very close to one another and do not differ significantly from those adopted by Rogers, E. M. (1995). Those who see innovation as a process (see Table 03) agree that the latter is a deliberate, conscious, and directed action of an individual or organization. This somewhat deterministic view of innovation is not adopted by Akrich, M. et al. (1988), who consider Innovation a non-linear path and whose outcome is uncertain.

Table 03: Definitions of innovation as a process

Authors	Definitions
Thompson (1965)	Generation, acceptance, and implementation of new ideas, processes, products, or services.
Knight (1967)	Adoption of a change that is new to the organization.
Rowe and Boise (1974)	Successful use of processes, programs, or products that are new to the organization and are introduced due to the organization's decisions.
Barreyre (1980)	A process whose outcome is an original achievement that has value-creating attributes. Introduction in a given social environment of an invention. Initial implementation and progress of discovery, an invention, or simply a concept.
Akrich et al. (1988)	To bring an intuition, a discovery, a project at the commercial stage. A path that, from decision to decision, brings a good product to the right moment at the right time.
Damanpour (1996)	The effort to create the desired change focused on the economic or social potential of the organization.
Maunoury (1999)	Any change knowingly introduced into the economy by any agent and intended to result in more efficient or more efficient use of resources.

Source: *Authors' adaptation from Alcouffe, S., (2004)*

Some authors take a double view and believe that innovation can be seen as both a process and a result of this process. Thus, for Chanaron, J. J., and Jolly, D. (1999), the term "innovation" refers to both a process and the result it leads to. As a result, innovation is then equated by the author with an invention - hence a simple event - that has been integrated into the economic system. As a process, Innovation is confused with the different stages that lead to a technical and/or organizational change.

2 Typologies of Innovation

In organizational literature, there are several different types of innovation typologies. Downs Jr, G. W., and Mohr, L. B. (1976) distinguish two broad types of typologies in one of the first objective reviews of the literature: typologies based on an aggregate of characteristics on a single part. The three most common typologies are dichotomies opposing *"technological"* innovation to *"managerial"* innovation, *"product"* innovation to *"process"* innovation, and, finally, *"radical"* innovation to *"incremental"* innovation.

According to the innovation's nature, they are based on aggregate characteristics. The third classification is based on a specific attribute and is based on the degree of novelty.

Furthermore, they are not mutually exclusive; a single innovation can be technological, process, and radical at the same time.

2.1 Technological Innovation vs Managerial Innovation

Before clarifying what, the authors mean by the two types of innovations opposed in this typology, it should be emphasized that the vocabulary used is not always the same. There seems to be certain vagueness about what some people are trying to oppose, even if a change of meaning does not always accompany these vocabulary changes. Thus, the two most commonly opposed terms in the literature are "*technological innovation*" and *"administrative innovation"*. Some writers use the word "*technical*" innovation instead of "*technological*" without ever explaining what difference they make between the two terms. Since the definition they give of technical innovation is the same as other technological innovation, the two terms are used interchangeably. In the rest of this thesis, we will only use the term technological innovation.

Although the terminology used varies, all scholars agree that the various areas or perimeters differentiate technical innovation from managerial innovation.

For Brimm, M. (1984), technological innovation transforms an idea into an improved process or a new product for which a market exists. In contrast, organizational Innovation transforms an idea into a new organisation or a management system. This definition of managerial innovation is close to the fifth type, defined by Schumpeter (1935).

Alange, S. et al. (1998) further deepens the analysis of the differences between managerial innovation and technological innovation. According to them, the processes of development and diffusion of technological innovation have the following characteristics:

- They are cumulative and depend on more or less determined technological trajectories.
- They mobilize knowledge of an implicit nature whose transmission is ensured in particular by formal and informal networks.

- They are part of broader contexts of technological systems and national systems of innovation.
- They are difficult to distinguish one from the other.
- They are largely influenced by demand.

For their part, managerial innovations are characterized by knowledge bases of an even more tacit nature that makes them more challenging to protect against imitation. This phenomenon leads to ownership problems and reduces the incentive to develop this type of innovation. Moreover, there is no supply market for managerial Innovations similar to technological innovations, even if consulting firms can be providers of such Innovations. This is due to the almost exclusively tacit nature of the knowledge mobilized by such Innovations. Managerial innovations are often more difficult to observe and define for both writers, and determining their limits is more difficult. This makes buying and selling them in a market more difficult (Alange, S. et al., 1998).

It is impossible for an exchange market to exist and operate as efficiently as technical developments due to the nature of managerial innovations. Within each organization, the process of research and development of managerial innovations may be more important than that of technical innovations.

Another distinction noted by Alange, S. and other writers is the participation of managers and executives. For them, this involvement is even more critical and necessary in implementing managerial innovations and has consequences of a higher magnitude than technical innovations. Managerial innovations often affect more people than technological innovations. This means that more people must be convinced to embrace innovation.

Finally, the authors point out that there is a certain complementarily between managerial innovations and technological innovations. They refer to the literature on change and sociotechnical approaches that emphasize that it is sometimes preferable to balance the changes introduced in the technical field and those introduced in the organization's social area.

2.2 Product Innovation vs Process Innovation

The distinction between process innovations and product innovations is used with technological innovations to distinguish, on the one hand, Innovations within the manufacturing process that relate to the transformation of inputs, innovations in outputs, somewhere else. This distinction concerns the technical field of the organization (Daft, R. L., 1978).

According to Farber, A., and Adam, M. C. (1994), product innovation refers to creating a new product or new use of an existing product (or a new combination of product components).

Process innovation occurs after product innovation and includes the use of new instruments or equipment, modified or new control systems, and adjustments or enhancements in manufacturing technology. In addition, product innovation in one sector will lead to process innovation in a different sector.

For Broustail, J., and Frery, F. (1993), product innovations concern all the characteristics of the product and generally aim at improving the services offered to the customer. The authors distinguish three types of product innovations: those that change the product's functional concept, those that change the product's technical nature, and those that change the product's presentation characteristics. Process and product advances are concerned with the advancement of the production process, as well as its simplification and cost reduction. Production innovations affect manufacturing operations and their sequencing. Process innovations relate more specifically to the very nature of the technological manufacturing process.

F. Damanpour and S. Gopalakrishnan (2001) stress the importance of distinguishing between product and process innovation. Product innovation is a new product or service introduced to meet a customer's needs or a market. Process innovation is a new element introduced into an organization's manufacturing or service operations to manufacture a product or deliver a service. The distinction between product innovation and process innovation is essential because their adoption requires different skills. Product or service innovation requires that the organization assimilate customers' needs and develop and manufacture accordingly. Process innovation requires the organization's application of technology product development efficiency, improves product development and commercialization efficiency.

Finally, product innovation entails providing a product or service that is at least novel in comparison to other options and is well received by the target market. The transformation of manufacturing processes used to design, manufacture, and distribute goods and services is known as process innovation (Loilier, T., & Tellier, A., 1999).

2.3 Radical Innovation vs Incremental Innovation

The term "radical innovation," also known as "disruptive innovation", is often used to describe a revolutionary product that disrupts the market. It corresponds to Schumpeter's concept of "creative destruction," in which radical creativity is described as the destruction of the existing by novelty (Schumpeter, J. A., 1934). More specifically, the strong adoption of novelty has made it a radical innovation that causes the destruction of the existing by changes. From a similar point of view, Reinganum, J. F. (1989) and Rosen, R. (1991) cited by Sorescu, A. B., Chandy, R. K., and Prabhu, J. C. (2003), call radical innovation “drastic” or “revolutionary” Innovation. The authors present these innovations as the appearance of a novelty that makes the existing obsolete. Other scholars agree with this concept, describing radical innovation as "an innovation that causes macro and micro-level discontinuities in the market and technology". An innovaion that has a macro-level impact correlates to one that is new to the country, business, or sector. An innovation that affects the micro stage, on the other hand, is an innovation for the business or the consumer.

Radical innovation signifying a breakthrough in the knowledge of border and incremental innovation, meaning gradual technical change, progressive and cumulative. At the same time, both forms of innovation have propelled today's advanced countries forward (Djeflat, A., 2004).

This form of innovation entails the use of new technology to create a new market. Radical technologies don't respond to a known demand; instead, they generate previously unidentified market demand. This new demand is spawning new markets, each with its own set of rivals, businesses, distribution networks, and marketing strategies. Thus, radical innovation is a phenomenon that does not occur frequently (Rahmouni, M., & Yildizoglu, M., 2011).

As a result, radical innovation entails radically new technological applications, as well as a significant shift in habitual patterns. Product or process enhancements, as well as technology transitions from one application to another, are examples of incremental developments. Incremental innovations are more common, have a lower risk, and have a smaller effect than radical innovations. New functionality introduced or improved to a product, as well as benefits or upgrades to existing technology in the industry, are examples of incremental innovation.

This type of innovation involves adapting, improving, and refining existing products and/or production and delivery systems (Geroski, P., 1995). Incremental innovation is essential for two reasons:

- It is a strategy to increase the competitiveness of a company.
- It allows a company to maintain a watch on its business and undertake new strategies when new opportunities arise in a market.

2.3.1 The difference between Radical Innovation and Incremental Innovation

For Broustail, J., and Frery, F. (1993), radical (disruptive) innovation profoundly modifies the usual references concerning the product's benefits or their cost. For its part, incremental (progressive) innovation leads to a gradual improvement of references (services or costs) and does not require new know-how. This opposition remains relatively relative: assessing the degree of "radical" innovation depends on the chosen perspective. Thus, an incremental innovation for a given domain or sector may very well have a radical value in another field or sector.

According to Cooper, J. R. (1998), the decisive factor in the distinction between radical innovation and incremental innovation is the degree of structural and strategic change that the organization must undergo to implement the Innovation in question. Incremental changes enhance and extend the established technological order. Radical technologies, on the other hand, reflect such major advancements that revolutionary changes are needed for change to be introduced effectively.

Radical innovation is a paradigm shift that results in a technological transition in and of itself. It alludes to a distinct separation of current practices. Incremental innovation, on the other hand, refers to a slight advancement or upgrade in existing technology. The main distinction between the words "radical" and "incremental" is the amount of new invention awareness. This distinction is in line with a concept of technology based on the quality of information (Dewar, R. D., & Dutton, J. E., 1986).

In the same perspective of distinction around the rupture/continuity couple, Loilier, T., and Tellier, A. (1999) introduces the notion of know-how. For both authors, the radical innovation uses new knowledge and know-how to increase the offer's performance. The innovation effort focuses on the development and/or use of new technologies. Incremental innovation is a gradual improvement in the existing offering's performance and does not require new know-how. For its part, Sciulli, L. M. (1998) states that incremental innovations are minor improvements in current products and processes. They concentrate on mass market trends and economies of scale. Fundamental organizational changes that result in new product ideas and technical practices are referred to as radical developments.

Finally, it can be said that incremental innovation is something new for the organization considering its adoption, while radical innovation is something new for the world in general (Hoffman, R. C., 1999).

2.4 Other Types of Innovation Classifications

The classification of innovation has evolved considerably in its historical development. There are several types of classification of Innovation.

The OECD has proposed a classification of innovation types, and this classification is the most widely used in the literature. The main types of innovation in line with the OECD methodology can be summarized in Table 04.

Table 04: Typology of innovation in the OECD methodology

Type of Innovation	Field of Application	Distinctive Characteristic
Product Innovation	Innovations *related to goods and services.*	Significant improvements in the *technical specifications, components and materials* in the embedded software in the degree of friendliness to the user or other functional characteristics.
Process Innovation	Implementation of *new or significantly improved methods of production or delivery* of the product.	Significant changes *in technology, production equipment* and / or *software.*
Marketing Innovation	Implement *new marketing methods*, including significant changes in design or packaging of the product during its storage, market promotion and market based prices.	They increase consumer satisfaction, create new markets, and more favorable market positions for production companies to increase sales.

Organizational Innovation	Implementation of *new forms and methods of organization of business companies*, the organization of jobs, and external relations.	Implementation of *business practices* in the organization of *workplaces or the external relations* previously used for organizational method represents strategic decisions.

Source: *Kotsemir, M., et al., (2013).*

In the following table, Bessant, J., and Tidd, J. (2007) distinguished four types of innovation. This classification is quite similar to the OECD innovation methodology.

Table 05: Classification of innovation types (Bessant, J., & Tidd, J., 2007)

Type of innovation	Essence of innovation
Production innovation	The introduction of new products and services or changes to products and services has added benefits for the customer or meets market needs.
Process innovation	*Introduction of the new device, method, tool, or knowledge* to produce a product or render a service
Position innovation	*The positioning of a particular product* in a specific industry/business segment
Paradigm innovation	I am *shifting long-held assumptions* about *the modus operandi of some industries* or businesses.

Source: *Kotsemir, M., et al., (2013).*

In the OECD principle, production innovation is analogous to product innovation, and location innovation is analogous to marketing innovation. As a result, paradigm innovation is a wider term than organizational innovation because it incorporates all aspects of company action and policy, as well as the other three forms of innovation. Production, procedure, or positioning operations can result in changes in the operating mode of some specific sectors.

Zawislak, P. A., et al. (2012) provide another example of innovation classification, identifying two types of innovations: technology-driven and business-based. Each class is further subdivided into two groups:

Table 06: Classification of innovation types (Zawislak, P. A., et al., 2012)

Type of Innovation	Essence of innovation
	Technology-driven innovation
Technological Innovation	Development of new design, new materials, and new products. Also, they include the development of machinery, equipment, and new components.
Operations Innovation	New processes, improvements in existent processes, introduction of modern techniques, new layouts, etc. It allows the firm to produce products with quality, efficiency, flexibility at the lowest possible cost.
	Business-driven innovation
Management Innovation	Development of management skills which reduce the "internal friction" between different areas of the firm. It should create new management and new business strategy methods, improve decision-making and inter-functional coordination, etc.
Transaction Innovation	Development of ways to minimize transaction costs with suppliers and customers. It should create new commercial strategies, improve relationships with suppliers, streamline market knowledge, etc.

Source: *Kotsemir, M., et al., (2013).*

Finally, the literature extends many categories of innovations according to a wide variety of approaches, depending on the field of study and the perspective (for example, Innovation as scientific research, innovative design, the process of knowledge creation, and organizational culture). In general, innovation is seen as an interaction between technological, economic, and social development (Tan, J. et al., 2009).

3 The Different Models of the Innovation Process

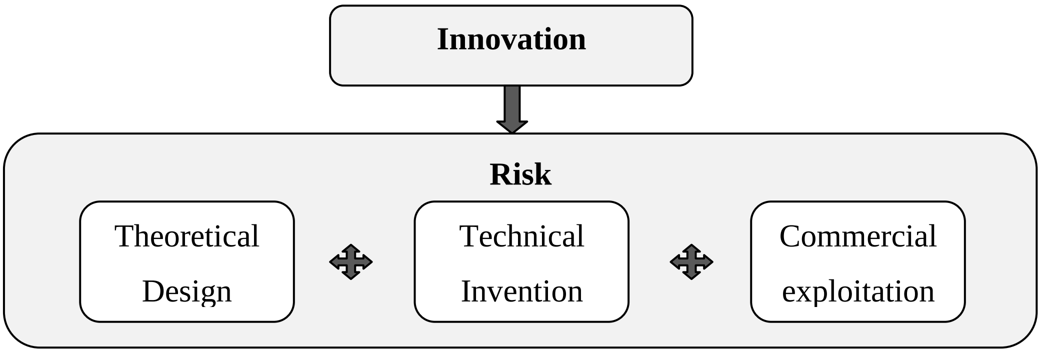
The process of innovation as a source of economic growth has been the subject of several discussions and intense research. Authors like Schumpeter, Schmookler, Kline & Rosenberg, etc., have changed how we perceive the effects of innovation on economic systems. Therefore, this part will be dedicated to presenting different models of Innovation in other contexts (Robles, G. C., 2006).

The initial step of the general innovation model is the generation of a new concept.

Even, an idea is nothing more than a collection of thoughts that have been formalized and placed in a specific context. The application of technical expertise to this set of ideas will result in an invention. The innovation serves as the foundation for the development of a variety of commercially viable goods. All of this involves the possibility of launching a new product, process, or service into a market.

Following that, the most representative innovation process models will be discussed, followed by a brief review (Brown, P. L., & Byrd, J., 2003).

Figure 02: The general model of innovation



Source: *Authors' adaptation from Christensen, C. M., et al., (2000)*

The following paragraphs address the main stages of the evolution of the innovation process models since the 1950s.

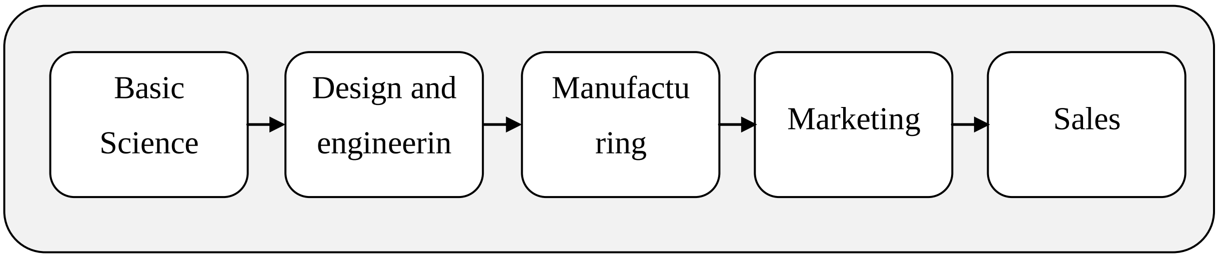
3.1 First model: Technology-Push

This model first appeared in the 1950s and 1960s, when product production was driven by technical advancements. The 1950s were a period of postwar recovery where demand exceeded production capacity. Economic growth came from new technology sectors. During this period, the predominant innovation model was the technology push model, also known as the linear model. Schumpeter's theories have strongly influenced this first approach to innovation (Schweizer, T. S., 2003). This model proposes that innovation arises from a unidirectional flow that begins in science and research and development and ends in a commercial application. Innovation was seen as primarily a linear mechanism with R&D as its primary contribution. The linear model implicitly assumes that the market is well prepared for R&D results. As a result, further R&D would result in more inventions that would benefit the business and society as a whole.

A significant weakness of the linear model is the lack of a return path in development and the market. Kline, S. J., and Rosenberg, N. (1986) note that:

"The linear model distorts the reality of innovation ... However, the improved models are not yet generalized. As a result, the linear model is still often used in ongoing discussions, especially in political discussions"

Figure 03: The first model, "Technology Push" (the 1950s - mid-1960s)



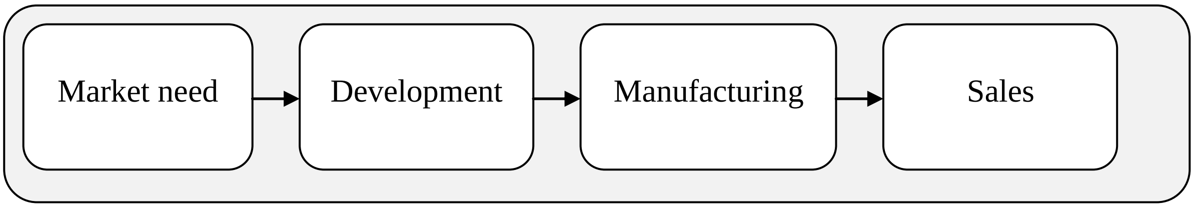
Source: *Neely, A., & Hii, J. (1998)*

However, demand in a market has a strong impact on the innovation process. This relationship is addressed by another model, that of demand-driven innovation or demand-pull.

3.2 Second model: Market-Pull/Demand Pull

The previous model focused on R&D activities (technology-push) was inadequate to explain the variations observed when diversification of demand in a market was established as a triggering factor of the innovation process. This has guided research towards a different model: the demand-pull model of innovation. This model was conceived in the late 1960s and early 1970s. The focus is on market opportunities. During this period, innovation studies conducted during this period have highlighted the market's role in the innovation process, and customer needs were seen as the innovation process's driving force. In this model, innovation is seen as derived from a perceived demand in a market that changes the development and direction of technology; innovation is driven by the department that has a direct relationship with the customer and, based on that experience, can point to existing problems during product design or suggest new directions for R&D. In other words, the market is a source of R&D direction ideas.

Figure 04: Second model: Market Pull (the late 1960s - early 1970s)



Source: *Neely, A., & Hii, J. (1998).*

3.3 Third model: Coupling Model

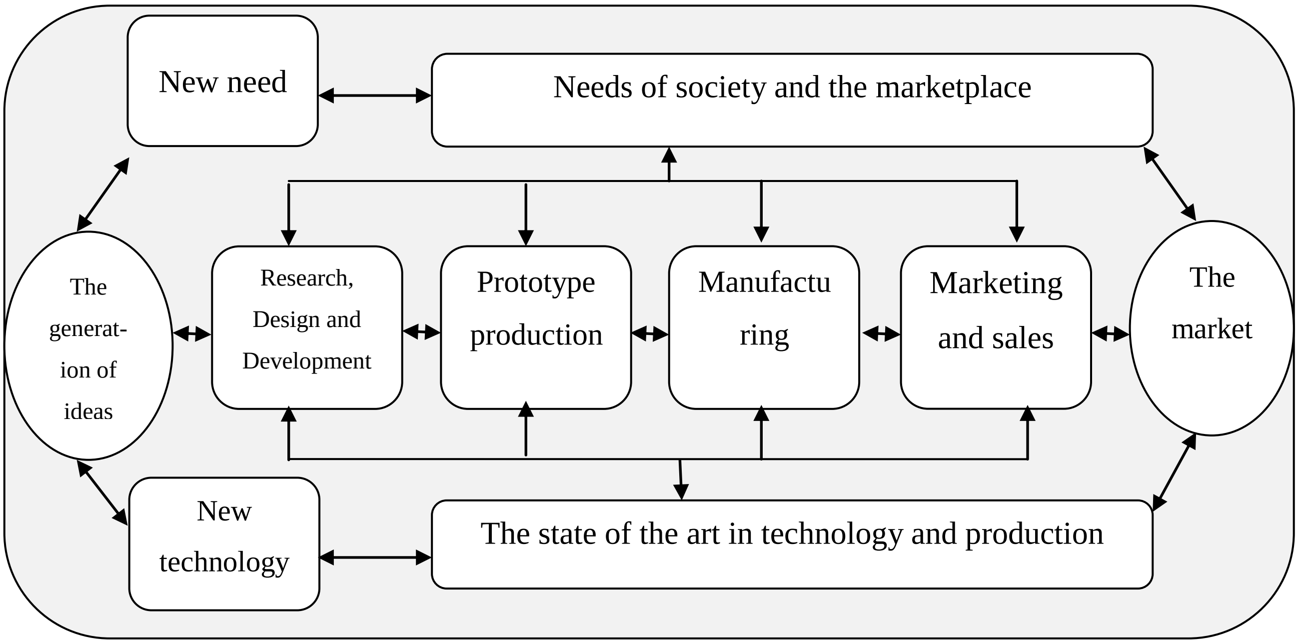
In the 1970s, the explanation of the innovation process shifted to the coupling model. Based on the coupling model, Rothwell, R[9]., and Zegveld, W. (1985) described the innovation process as:

"*A complex net of communication paths, both intra-organisational and extra-organisational, linking together the various in-house functions and linking the firm to the broader scientific and technological community and the marketplace"*

This model is a combination of the "Technology-Push" model and the "Demand-Pull" model. It describes the interaction between the market, the technology, and the organization. It is considered as a sequential, linear, logical, and discontinuous interaction process. In this model, a new trend appears as a feedback link between R&D activities and the market (Rothwell, R., 1992).

[9] ***Roy Rothwell,*** a British sociologist, an academic primarily at the University of Sussex, was widely regarded as one of the pioneers in Industrial innovation with his significant contributions to the understanding of innovation management.

Figure 05: Third model: Coupling Model



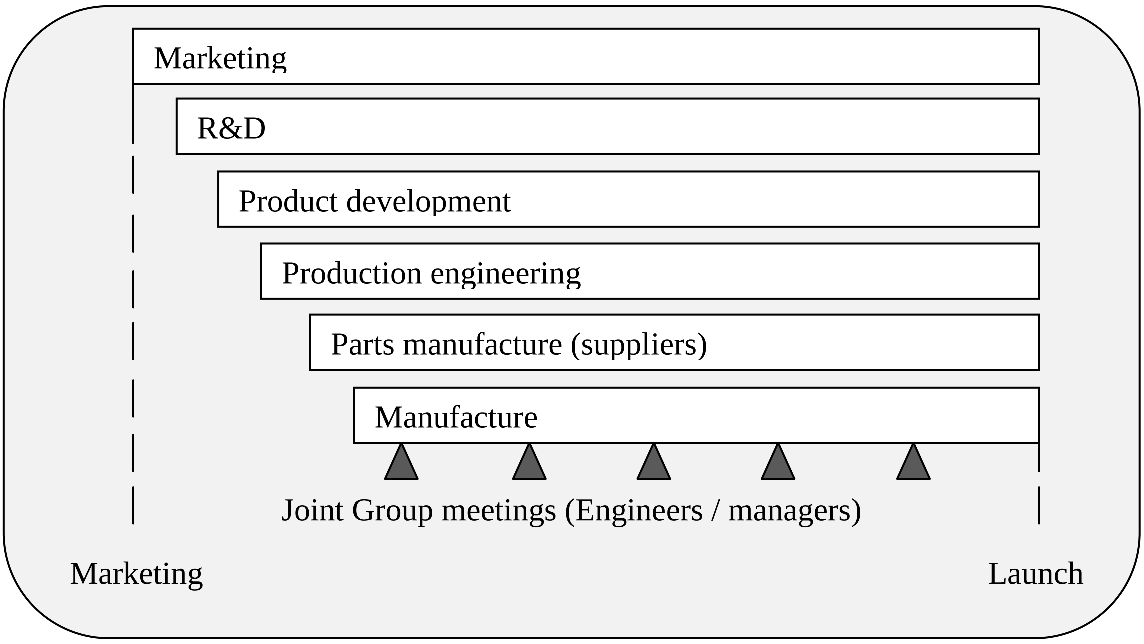
Source: *Neely, A., & Hii, J. (1998).*

The model shows the link between the internal functions of the company and the external knowledge pool in order to know the scientific and technological community and the market, where the process of innovation is influenced mainly by the interaction of technological forces and market forces.

3.4 Fourth model: Integrated Model

The fourth model became evident in the second half of the 1980s when studies of the innovation process in Japan's automotive and electronics sectors provided an integrated model. This model was found that the Japanese approach emphasizes the importance of incorporating different organization departments during the development of a new product or service. It is based on a high degree of functional integration and concurrent activities between functions (parallel development). In this light, it's critical to incorporate R&D and manufacturing into the design process (called marketing design). It also allows for better horizontal cooperation between the company, its vendors, and its customers (Rothwell, R., 1992).

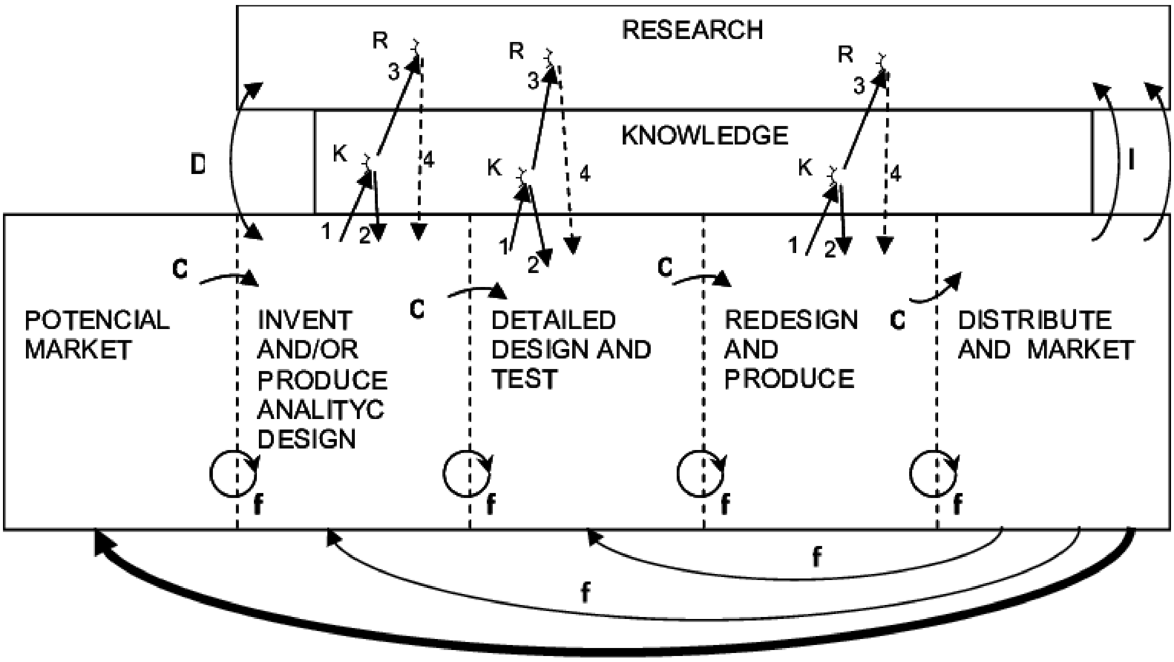
Figure 06: Integrated innovation process (mid 1980s - 1990s)



***Source**: Neely, A., & Hii, J. (1998).*

In 1986, Kline and Rosenberg presented an integrated model of the innovation process called the *"Chain - linked Model"* (Kline, S. J., & Rosenberg, N., 1986). The most significant difference between this new model and the old one is that there is no main activity path in the innovation process. The innovation process can take various paths. The central chain of innovation is the first road to innovation. This path starts with the design (C); it continues towards the development and the production until the market. The second road is a set of feedback links that combine and coordinate R&D with production and marketing. Feedback links are seen as integral parts of the cooperation system between product specification/development and marketing (Niininen, P., & Saarinen, J., 2000).

Figure 07: The Chain-linked model



***Source**: Caraça, J., et al., (2007).*

C	Central Innovation Chain
F	Short return loops
F	Long return loops
K – R	Interactions between different stages and scientific knowledge. If the problem is fixed at level K, the link is not activated
D	The relation between scientific research and difficulties encountered in the invention and design stages
I	Support for scientific research that can be provided by instruments, machines, tools, and technological procedures,
S	Influence of outside and mainly consumers on scientific research. The information obtained can be integrated throughout the chain

The model proposed by Kline, S. J., and Rosenberg, N (1986) is based on the existence of feedback loops between the various stages of the innovation process, which comprises five:

* The main course (C) is characterized by a process that starts with the design, then comes development, production, and finally marketing.

* The second path is retroactive effects (f) from one stage to another of the innovation. A retroactive effect is an act of sharing observations, queries, and suggestions with individuals at the earlier stages of the innovation process. This is how the different stages of a product's life participate in the creative process, and the emphasis is placed not only on major innovations but also on incremental innovations. We can also now model the contribution made by consumer and distributor councils using market signals (F).

* The third course is that of science (D, K, R), whose contribution is represented more realistically. Science is rarely the starting point for innovation; instead, it is used throughout the innovation process when the situation requires it. It is when existing science is no longer able to solve a problem that research is used, and at the same time, new knowledge is created that enriches existing science.

* The fourth course (D), very little used, is the direct link between discovering new science and creating a new market.

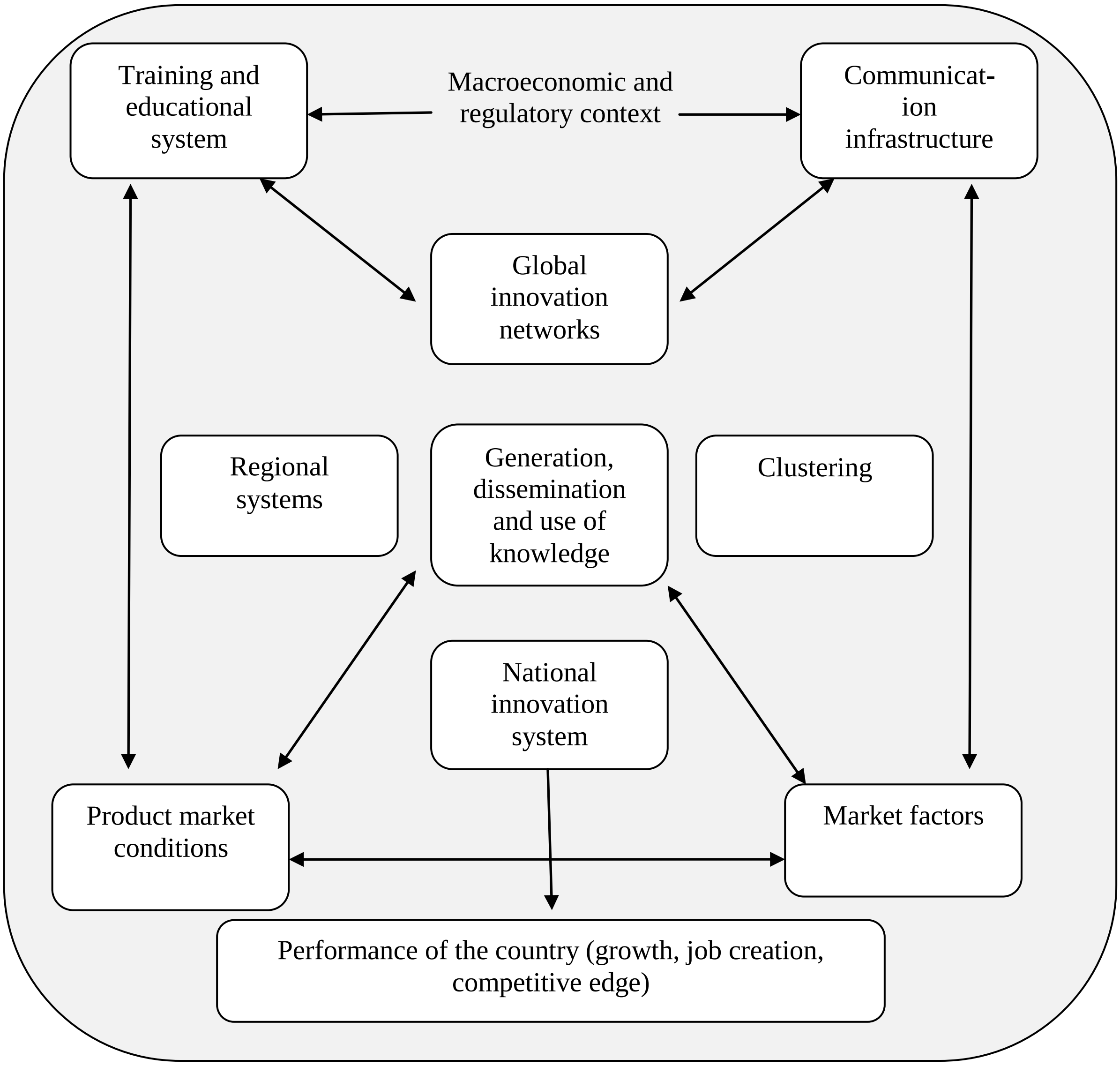
* The fifth and final course (S) is the retroactive effect of innovation on science. For example, the invention of the microscope allowed Louis Pasteur to discover the basics of modern medicine.

This model expresses the design activities that drive innovation, but more importantly, they have a central role in the success or failure of the innovation process. Kline and Rosenberg's analysis is that design is essential to initiate a technological innovation, and re-design is necessary to ensure its success. Hence, the result leads to innovation's central process *is not science but design* (Cordova Lopez, E., 2002).

3.5 Fifth model: System Integration and Networking Model (SIN)

The fifth model of innovation is characterized by a growth strategy of integration between different organizations inside and outside the company and various technological elements -electronics, informatics- and information and communication in innovation.

Figure 08: System Integration and Networking Model



Source: *Da Silva, F. M., et al. (2016).*

This model is a model of integration and parallel development that seeks to better adapt to business strategies. The latter uses expert systems and simulation. The actors involved in the innovation process focus on the customer, and there is a strong interaction between suppliers and competition. The products are based on the company, supplier, and customer relationship. This model is also characterized by a horizontal organization, which seeks to bring together groups of R&D, marketing, production, etc. (Anlló, G., 2006). It emphasizes the importance of flexibility in the enterprise, speed of development, quality, and other non-quantifiable factors. The model was created by R. Rothwell in 1992. The most important feature of this model is that it provides an objective organizational context for evaluating various aspects of the innovation process.

It should be noted that Rothwell's full description of the SIN describes more than 20 other characteristics. But we will specify the most important SIN features that are considered and measured in this study. These features are: (Niininen, P., & Saarinen, J., 2000)

- We involve leading-edge users.
- Close linkages with primary suppliers.
- We are assessing external know-how.
- Product design combining the old with the new.
- Time-based strategy.

In the Kline and Rosenberg model, these five characteristics are not all present, and the innovation process is mainly internal. In contrast, in the Rothwell model, the above information is used on a large scale. Also, in the Kline and Rosenberg model, the fifth point, the time-based strategy, did not have many places. In Rothwell's model, the feedback links were essential, and there is not much time to go back during the innovation process (Niininen, P., & Saarinen, J., 2000).

4 Innovation System

The idea of the *innovation system* emerged as a result of interactions between multiple actors who contribute differently to the development, distribution, and usage of various types of information, resulting in innovation and technological progress.

There are several definitions of innovation systems cited in the literature, all of which have the same scope and stem from one of the first definitions:

> *"…systems of innovation are networks of institutions, public or private, whose activities and interactions initiate, import, modify, and diffuse new technologies"*(Freeman, C., 1987)

According to the OECD, the innovation system is a network of public and private institutions active in their activities and interactions, creating, storing, and transferring knowledge, skills, and tools at the origin of new technologies. These institutions are companies, universities, public research organizations, professional or scientific associations, public or parapublic organizations. This will make each country play an increasingly important role in the innovation process. Each country will, therefore, have its innovation system, called the national innovation system.

Depending on Lundvall, B. (1992) distinguishes two different conceptions of innovation systems:

- The narrow conception is limited to science, research, technology, and in some cases, education.
- The broad conception extends to all the economic and institutional structures that affect the production system.

According to Smith, K. (1998), there are three conceptual sources of the innovation system approach:

- Economic decision making is based on institutional foundations. The consequence is that different institutional structures give rise to differences in these behaviors' economic behavior and performance.
- The competitive advantage (of the nations) results from the variety and specialization; it possesses properties that lead to dependence on the path followed. Technological and industrial disciplines leading to rapid growth lead to self-reinforcing phenomena, which give system effects.
- Technological knowledge is generated by interactive learning, which gives rise to different "bases of knowledge" depending on the agents. These other knowledge bases shape the possibilities for innovation.

The concept of innovation system brings together various attempts to incorporate institutional elements in the economic analysis of technical change, the architecture of scientific systems, the genesis of technological innovation, and, more important, to study the consequences of innovation on the long-term economic performance of nations. For Rickne, A. (2001), the functions of an innovation system are:

- Develop human capital
- Create and disseminate technological opportunities
- Create and distribute products (new)
- Incubate (new techniques)
- Manage (technology)
- Facilitate regulation (by setting technical standards)
- To legitimize the technology and the firm
- Create the market and disseminate market knowledge

- Lead technology, market, and partner search
- Facilitate the establishment of networks
- Facilitate financing (innovation)
- Create the job market

The list of functions also comes from the logic of progressive extension of the innovation system from science and technology. There are five functions for Bergek, A., and Jacobsson, S. (2003):

- Create new knowledge
- Guide the direction of the research process
- Provide resources (capital, etc.)
- Facilitate the creation of positive externalities
- Facilitate the formation of markets

In general, the components of an innovation system are actors, networks, and institutions contributing to the overall function of developing, disseminating, and using new products (goods and services) and new processes (Bergek, A., 2002; Carlsson, B., & Stankiewicz, R., 1995; Galli, R., & Teubal, M., 1997).

According to innovation system theory, innovation and technological development result from a complex set of relationships between the system actors, including companies, universities, and research institutes.

Moreover, innovation systems have been classified into national innovation systems (Freeman, C., 1987; Lundvall, B., 1992; Nelson, R., 1992), regional innovation systems (Asheim B. T., & Isaksen, A., 1997; Cooke, P. et al., 1997), local innovation systems, technological innovation systems (Carlsson, B., & Stankiewicz, R., 1991; Bergek, A. et al., 2015) and sectoral innovation systems (Breschi, S., & Malerba, F., 1997; Malerba, F., 2002).

4.1 National System of Innovation (NSI)

The term *"national system of innovation"* emerged when Christopher Freeman[10] and Bengt-Ake Lundvall[11] collaborated in the late 1980s. Freeman and Lundvall's research was based mainly on

[10] ***Christopher Freeman***, was a British economist, the founder and first director of Science Policy Research Unit at the University of Sussex, and one of the most eminent researchers in innovation studies, modern Kondratiev wave and business cycle theorists

[11] ***Bengt-Åke Lundvall***, is an emeritus professor in economics at the Department of Business and Management at Aalborg University. Lundvall's research is organized around a broad set of issues related to the innovation system and the learning economy.

the political economy and the historical narrative of Japan's rise as a significant economic power and essential social interactions between suppliers, customers, and their role in promoting innovation.

However, this term has no specific legal definition; we find a variety of different meanings, including as follows:

"..the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, C., 1995)

".. the elements and relationships which interact in the production, diffusion, and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state" (Lundvall, B., 1992)

"... a set of institutions whose interactions determine the innovative performance ... of national firms" (Nelson, R., 1993)

".. the national institutions, their incentive structures, and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country" (Patel, P., & Pavitt, K., 1994)

".. that set of different institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills, and artefacts which define new technologies" (Metcalfe, J. S., 1995)

".. a human social network that behaves like a sociobiological system, wherein people have developed patterns of behavior that minimize transaction costs caused by social barriers resulting from geography, lack of trust, differences in language and culture, and inefficient social networks" (Hwang, V. W., & Horowitt, G., 2012)

National systems of innovation can be inferred from national policies:

- Formal and informal coordination by the state.
- Financing of R&D and the resulting knowledge.

These policies ensure the homogeneity and linkages between national innovation agents. Thus, the national level is an appropriate analytical framework for the analysis of innovation policies.

Moreover, the national innovation system reflects the diversity of institutional systems (the role of universities, the part of large national agencies, the industry structure, the structure of financing innovation, etc.) (Lundvall, B., 2007).

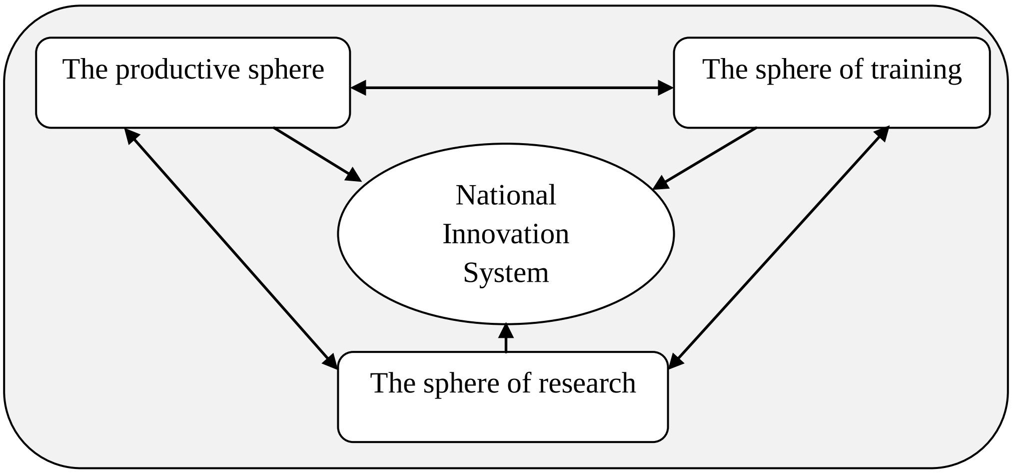
According to economists (Niosi, J., Bellon, B., Saviotti, P. P., & Crow, M., 1992), elements of the national innovation system are:

- Financial flows, with public funding of innovation but also the private financing and equity financing.
- Legal and political links, with intellectual property rules, technical standards, and public procurement policies apply to all national enterprises.
- Technological, scientific and informal flows, collaborations and interactions in technical and scientific fields.
- The social flows of innovation, of personal flows, mostly from universities to industries and companies to companies (user-producer, etc.).
- Information flows dissemination of knowledge, know-how.

The national innovation system has benefited from a sustained interest, reflected in particular through abundant literature. The role of R&D departments in businesses, the importance of scientific networks, the idea of a technical infrastructure, the role of technology, the role of the state in fostering innovation, the importance of technical alliances, and other topics were discussed (Djeflat, A., 2002).

The classic schema of the national innovation system relates three spheres: the productive sphere (the economic context and the industrial structure), the sphere of training (training and the quality of human resources), and the sphere of research (cooperation between enterprises and public research institutions). However, for the SNI designers, the national aspect is central to the extent that technological development and the flows between firms appear more frequently in the national borders than outside.

Figure 09: The classic scheme of the national innovation system



Source: *Authors' adaptation from (Djeflat, A., 2002)*

4.2 Regional Innovation System

To compete in the international competitive environment, companies must continually optimize their products, processes, and business models. This is where the *"Regional Systems of Innovation"* comes into play. The creation and strengthening of regional innovation systems to increase regional competitiveness has become a political priority in economic development strategies (Cooke, P., 2001).

The literature on the regional innovation system has overgrown since the mid-1990s (Cooke, P. et al., 1992, Doloreux, D., & Parto, S., 2004). Many studies of regional innovation systems tend to show the importance of regional actors' capacity, public and private, to interact and benefit from their interactions to improve regional competitiveness (Asheim. B, & Gertler, M., 2004).

The territorialized nature of the relationships between the actors contributing to the innovation process is reflected in the definition's regional innovation system. A synthetic definition can be proposed:

> "*a set of actors and organizations (companies, universities, research centers, etc.) that are systematically engaged in innovation and interactive learning through common institutional practices"* (Doloreux, D., 2002)

Thus, the region takes on a dynamic dimension insofar as it constitutes a space of relationship between technology, markets, productive capital, know-how, technical culture, etc. Thus, a regional system of innovation involves collaborations in innovation processes between companies and creative and disseminating knowledge such as universities, laboratories, institutes, technology transfer units, business associations, and financial agencies.

Several researchers have examined the role of the regional environment in their work. It appears that competitive advantages for industries are created and maintained through territorialized processes (Storper, M., 1997). The territory generates a potential for creating new knowledge, new technologies, and new techniques that allow industries to be more competitive and dynamic in the markets through physical, organizational, and social infrastructure (Porter, M. E., 2003).

As Courlet, C., and Soulage, B. (1995) point out, regional conditions must be seen as contributors to technological creation. Territories are set to become learning regions, innovative environments, or local systems of innovation. Innovation is stimulated when businesses are located close to each other. Cooperation and interaction between different actors are necessary conditions for the development of new products and processes. Proximity thus facilitates those collaborations that provide firms with externalities that they can exploit and use. These externalities are skilled labor, inputs to production - subcontractors, services, and support for innovation - and the benefits of regional technological spin-offs.

In summary, the regional innovation systems approach focuses on the central issues related to spatial economic dynamics, paying particular attention to the relationship between the innovative enterprise and the external inputs required in innovation processes. On the theoretical level, the regional innovation systems approach is not a definitive and formalized theory. Instead, it allows us to describe the evolution of interactions between actors and the spatial and temporal forms that these interactions take. The aim is to comprehend the new dynamics of territorial growth in order to clarify the progress of emerging regions and the shortcomings of blocked regions (Doloreux, D., & Guillaume, R., 2005).

4.3 Local Innovation System

There is no doubt that nations' role is essential in technological development (Lundvall, B., 1992). However, treating the innovation process as a national or international macro-network does not capture the full tangible dynamics of innovation, so the business networking approach at the local and regional level analyzes global innovation systems (national and international) more substantial and more intelligible. Thus, networking firms in their narrowest location becomes *"one of the factors contributing to the formation of dynamic learning processes such as virtual circles of knowledge accumulation necessary for innovation at the local, regional and* *national levels"* (OECD, 1992). And about local and regional, Pike, A. and Tomaney, J. (1999) believe that multiple theoretical and methodological impressions make it difficult to clarify the concept of spatialization. According to M. Keating (1997), the local and regional concept has a variety of meanings that translate into a variety of concepts ranging from the industrial district to the territorial system of production, to the local industrial fabric, to the industrialized system, and to the innovative environment, demonstrating both the interest and the difficulty of identifying a single concept (Maillat, D., 1996).

The literature proposes different conceptual definitions of the local innovation system. Cooke, P. et al. (1997) define the local innovation system as a system:

> *"In which firms and other organizations are systematically engaged in interactive learning through an institutional milieu characterized by embeddedness"* Asheim, B. and Isaksen, A. (1997) add that *"a local innovation system consists of a production structure (techno-economic structures) and an institutional infrastructure (political–institutional structures)"*

Most local innovation definitions agree that this concept refers to innovation processes that occur at a specific location and involve people and resources from the same location, working to solve problems or locally relevant opportunities (Abrol, D., & Gupta, A., 2014). Some authors and organizations working with local innovators point out that local innovation is created by people in a specific place, *"using their resources and on their initiative"* (Prolinnova, 2009).

Local innovation refers to creating new and improved ways of doing things in the specific local context they were developed, even though they may not be considered innovative in other parts of the world. Local innovation can be seen as a vernacular innovation, as it occurs in typical, everyday contexts of the local context. These are usually informal and community-based settings (houses, community workshops, assembly areas, outdoor spaces, etc.). Although local innovation often involves non-local inputs in the innovation process (such as inspiration, knowledge, materials, or capital from non-local sources), these are situations in which people of a specific place take the initiative to develop creative and effective ways to meet the challenges and opportunities they face in the environments they encounter in their daily lives (Hoffecker, L., 2018).

4.4 Technological Innovation System

Studies of innovation systems have focused on the impact of social structures on technological progress and economic development within nations, industries, and technological fields since the 1980s. The concept of technological innovation system has been introduced the determinants of technological change are not found just in individual companies or in research institutes but also in a vast social structure in which companies and institutes of knowledge and the goal of a technological innovation system is to analyze and evaluate the development of a given technology area in terms of structures and processes that help or hinder it (Lundvall, B., & Dosi, G., 1988).

The concept of a technological innovation system emphasizes that stimulating the flow of knowledge is insufficient to induce technological change and economic performance. It is necessary to harness this knowledge to create new business opportunities, which means that individuals are important as innovation sources (Hekkert, M. P. et al., 2007).

The technological innovation system often focuses on the system's dynamics (Suurs, R. A., 2009). The emphasis on entrepreneurial action has encouraged researchers to consider a system of technological innovation as something to build over time. This had already been advanced by Carlsson, B. and Stankiewicz, R. (1991). Technological innovation systems are defined in terms of knowledge/competence flows rather than flows of ordinary goods and services. They consist of dynamic knowledge and competence networks. In the presence of an entrepreneur and sufficient critical mass, such networks can be transformed into development blocks, i.e., synergistic clusters of firms and technologies within an industry or a group of sectors.

4.4.1 Identifying the structural components of the TIS

A technological innovation system is a technological domain by referring to systemic characteristics, including actors, institutions, technological factors, and, more importantly, all their interrelations (Carlsson, B. et al., 2002).

The **Actors:** Technological innovation system actors need to be identified. They can include organizations that contribute to technology, either as a developer or adopter, or indirectly as a regulator, financier, and even who effectively disseminate and use technologies. The potential diversity of relevant actors is enormous, ranging from companies across the value chain, universities and research institutes, public bodies, influential organizations of interest, venture capitalists, and standards organizations, from technology developers to technology adopters

(Bergek, A. et al., 2008). The development of a technological innovation system will depend on the interrelationships between all these actors.

There are many methods for identifying the actors in a particular field. Many of them can be used on a regular basis (Bergek, A. et al., 2008):

- Professional / Industry associations are a good source of information, as are exhibitions, corporate directories, and catalogues.
- A patent analysis reveals the direction of technological activity and its volume in different organizations; it is a useful tool to identify companies, research organizations, and even individuals with a specific technological profile (see, for example, Andersson, B. A., & Jacobsson, S., 2000; Holmén, M. & Jacobsson, S., 2000).
- The bibliometric analysis means the volume of publications, analysis of citations, etc., and provides a list of the most active organizations in terms of published articles. These organizations include universities, institutes, and companies.
- Interviews and discussions with experts in technology or industry, a good way used by companies, research organizations, financiers, etc. to identify other actors. Bergek, A. et al. (2008) calls this method a *"snowball"* to identify the actors; each actor can designate additional participants.

The **Institutions:** The second structural element of interest is institutional, informal, and formal structures, which are at the heart of the concept of the innovation system. According to North, D. C. (1990), it is common to view institutions as *"the rules of the game in a society, or, more formally,(...) the humanly devised constraints that shape human interaction".* Formal institutions dealing with the rules have been codified and applied by the authority. As examples, formal institutions are government laws and political decisions; informal institutions are more tacit and organically structured by actors' collective interaction, and they can be normative or cognitive. Normative rules mean values that have a moral meaning, and all social norms and cognitive rules are considered collective frameworks or social paradigms (Scott, W. R., 2013).

Technological factors: Technological structures involve the techno-economic functioning of such artifacts, including reliability, safety, costs, and technological infrastructure. These characteristics are essential for understanding the feedback mechanisms between technological change and institutional change.

Structural factors are the elements that make up the system where these factors are all related to each other. Generally, the structural analysis provides an understanding of the systemic features - complementarities and conflicts - that are factors and barriers to the diffusion of technology at a given time or period. These factors form dense configurations; they are called networks. Industry associations, research communities, policy networks, user-provider relationships, etc., are all examples of networks.

The networks are crucial for the development of technological innovation systems. As Carlsson, B., and Stankiewicz, R. (1991) point out:

"Such networks can be transformed into development blocks, i.e., synergistic clusters of firms and technologies within an industry or a group of industries"

The dynamics within a technological innovation system result from a combination of actors, institutions, technologies, and synergies constituted by the various relationships within and between the networks (Suurs, R. A., 2009).

Section Two: Global Perspective on Technological Capacity

The key drivers of economic growth in advanced and developing economies are science, technology, and innovation. In the knowledge economy, information circulates internationally through direct investment and technology flows. Technological capacity plays an important role, notably by contributing to rapid technological progress and productivity growth; moreover, information and communication technologies (ICT) have been at the heart of economic change for more than several years. In response to international competition and the increasing need for strategic interaction, businesses use ICTs to coordinate transnational networks.

1 <u>The Concept of Technology</u>

1.1 Definition of Technology Term

The concepts of technology and technique interfere, often giving rise to confusing or even divergent interpretations (Barré, R. & Papon, F., 1993). Nevertheless, Mansfield, E. (1968) provided an initial answer to this dilemma for him:

"*The technique is a method used in the production process, while technology is the way society manages knowledge about industrial art"* (Mansfield, E., 1968)

Regarding the term technology, which appeared in XVII centuries, it has a particular character, traditionally defined as a set of techniques opposed to science by its operational purpose and strategic intent. Science understands natural phenomena and body of knowledge accumulated and organized by systematic study; its purpose is the knowledge pursued its value. J.K. Galbraith confirms this idea:

"Technology is the systematic application of science, and all other organized knowledge, to practical tasks" (Galbraith, J. K., 1967)

The modern conception of the term technology reflects the complexity of the relationship between science, technology, and industry. According to Baranson, J. technology is:

"Product design, production techniques and management systems for organizing and executing production plans" (Baranson, J., 1967)

Also, another much broader definition of technology is defined by Stewart Frances (1977) as follows:

"All skills, knowledge, and procedures required for making, using, and doing useful things. Technology, therefore, includes the software of production – managerial and marketing skills and extended to services- administration, health, education and finance" (Stewart, F., 1979)

According to Jaiswal, R. K. et al. (1999) consist of two main components:

- A physical component that includes items such as products, tools, equipment, plans, techniques and processes.
- The informational component of know-how in management, marketing, production, quality control, reliability, skilled labor and functional areas.

In examining technology's definition, two fundamental components can be identified "knowledge" or technique and "do things". Technology is always linked to obtaining specific results, solving certain problems, performing certain tasks using particular skills, using knowledge, and exploiting assets (Lan, P., & Young, S., 1996).

1.2 Technology Transfer

Technology is the way society manages knowledge with industrial art. In addition to this characteristic, the transfer of technology is a compound word, made up of two terms, "transfer" which has its origins in the Greek word "trans", and which means the passage from one entity to another (Rouach, D., 1997) and technology which means science and knowledge.

For Pine, R. (1992), the definition of the term technology transfer was:

"There is a transfer of technology when a group of men, generally a part of an organism, actually becomes capable of assuming, under satisfactory conditions, one or several functions related to a specific technique" (Pine, R., 1992)

Technology transfer is the term used to describe the processes by which technology is exchanged between organizations. The technology transferred can take various forms. Concerning the international transfer of technology, it refers to how this transfer occurs between countries. As a result, Cusumano, M.A. & Elenkov, D. (1994) prefers to say that:

"Technology transfer means selling to a country the means to manufacture a material only after having provided it with the means to use it, to market it, to take advantage of it" (Cusumano, M.A. & Elenkov, D., 1994)

Broadly, technology transfer includes all international flows with technological content: patents, licenses, studies, staff training programs.

According to Chen, M., the transfer of technology:

"... is that of the transmission of knowledge between companies belonging to different countries. Technology transfer is the process by which innovations (new products, new processes) made in one country is then bought by another" (Chen, M., 1996)

In a broad sense, technology transfer is:

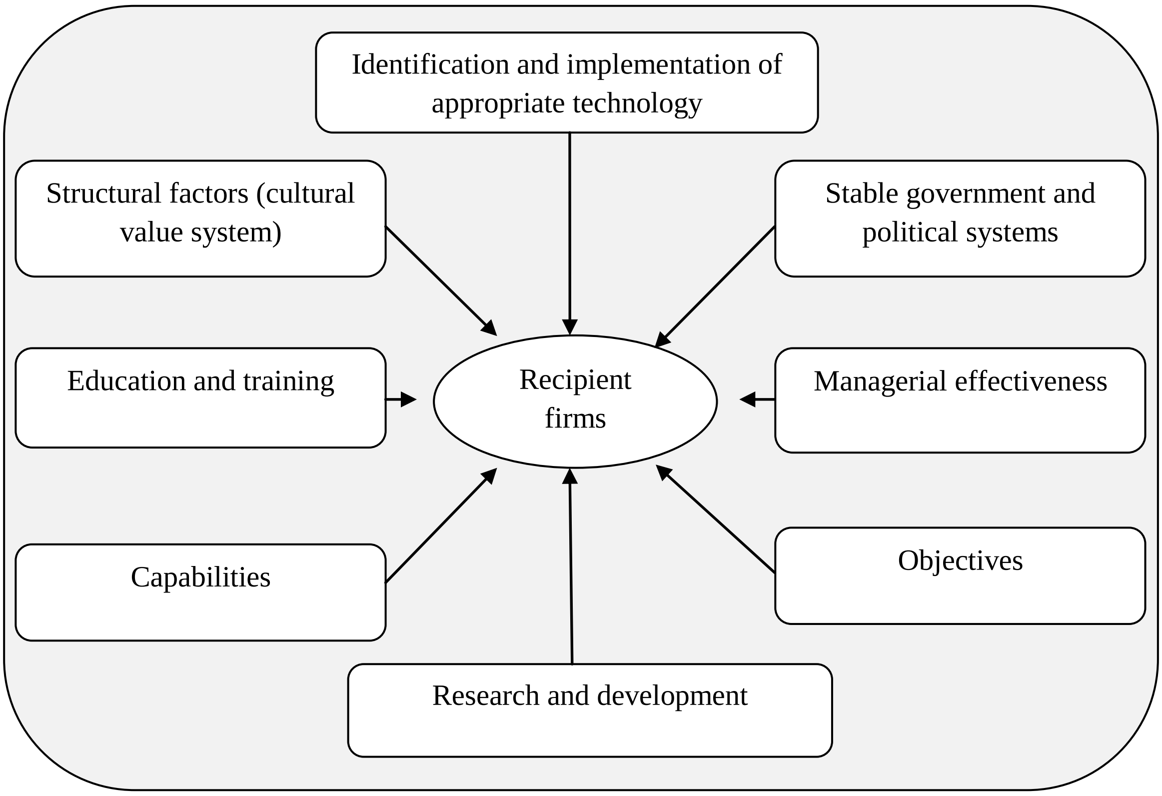
"An effective mechanism to advance the flow of technological development in a developing country's economy" (Kulviwat, S. et al., 2007)

The content of a transfer of technology is a set of material goods (machinery, teaching aids, etc.) and intangibles (knowledge, know-how) allowing technology implementation.

The following figure illustrates some of the essential elements for the success of technology transfer. This demonstrates the difficulty of the process and the wide variety of factors that influence the success of the transition.

In the model (figure 10), several factors must be in place for successful technology transfer, structural factors, education and training, and capacity to affect the block transfer's success. Another is a stable government, competent management, and clear objectives. R&D and the detection and deployment of relevant technologies are the two remaining impact factors.

Figure 10: Critical factors for successful technology transfer



Source: *Szogs, A. (2010).*

1.2.1 Different Forms of Transfer

Mansfield, E. (1975) makes a distinction between horizontal technology transfer and vertical technology transfer.

1.2.1.1 Horizontal Transfer

It manifests itself in transferring technology from one operating environment to another (from one company to another). For example, horizontal transfer refers to an established technology that has been moved from one operating environment to another. On the other hand, horizontal transfer is often associated with the situation where technology is transferred from industrialized countries to developing countries.

1.2.1.2 The Vertical Transfer

Vertical transfer refers to the transmission of new technology to its generalization during research and development (R&D) activities in the field of science and technology initiated by specialized organizations (universities, public or private research laboratories, etc.).

2 Technological Capability

Technological capability is known in several other terms. The same concept is called *Technological Effort* in Dahlman, C. and Westphal, L. (1982) and Lall, S. (1987). And it is referred to as "*Technological Capacity*" in Bell, M. (1984), Katz, J. M. (1987), and Bell, M., & Scott-Kemmis, D. (1985). It refers to be a positive predictor to prevent the product from generating innovation.

2.1 Defining Technological Capability

Dahlman, C.J., and Westphal. L.E. (1985) defined technological capability as:

"The ability to effectively use technological knowledge, it does not depend on the knowledge that is possessed, but on the use of this knowledge and control over its use in production, investment, and innovation" (Dahlman, C.J. & Westphal. L.E., 1985)

In the view of Lall (1987):

"considering technological progress only as a movement of the frontier is a highly simplified neo-classical view because 'major technological innovations' are not the only, perhaps not even the main, source of productivity improvement in the history of industrial development ... and ... minor changes to given technologies—to equipment, materials, processes, and designs—are a vital and continuous source of productivity gain in practically every industry" (Lall, S., 1987)

For Bell (1984), technological capacity should ideally be viewed as:

"Conscious use of technological information and the accumulation of technological knowledge, together with other resources, to choose, assimilate and adapt existing technology and/or to create new technology"(Bell, M., 1984)

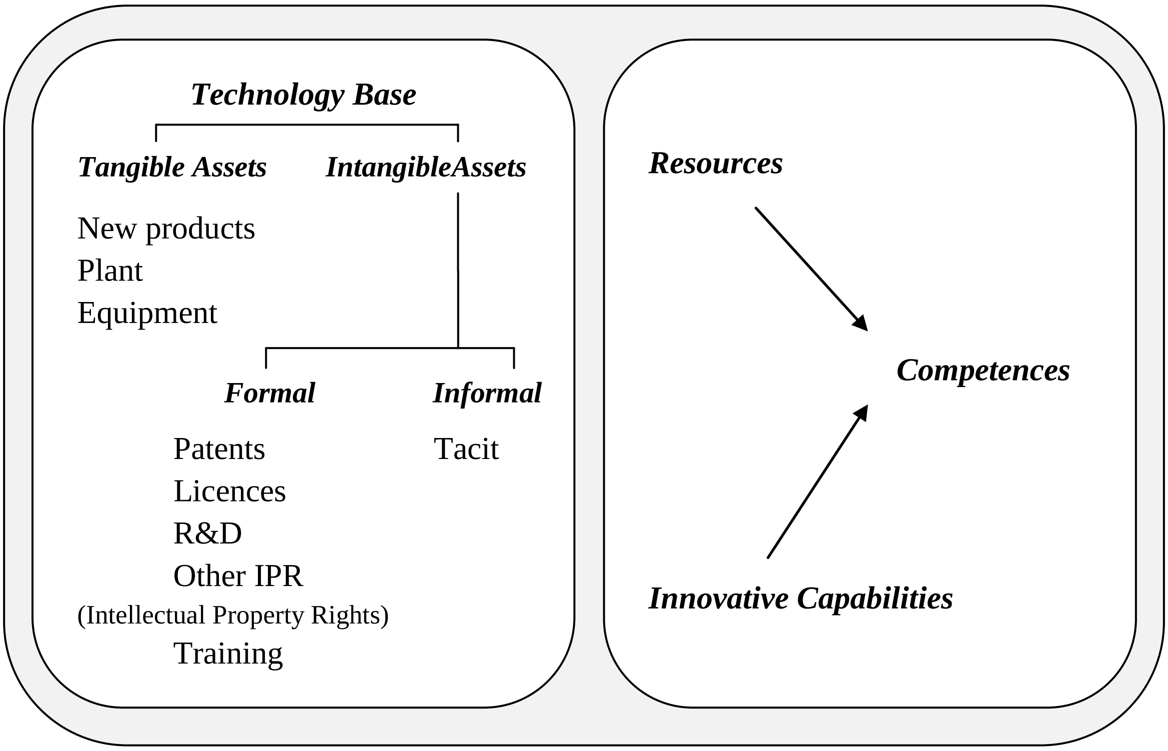
According to Tippins, M. J. and Sohi, R. S. (2003), technological capability is a good investment in technological equipment which contributes to give the organization a competitive position in the marketplace and what makes them follow all the developments of modern technology, it needs skills and highly qualified staff.

Technological capacity can perform any relevant technical function, such as developing new products, processes, and technological knowledge to achieve higher levels (Tsai, K. H., 2004).

2.2 Approaches to Technology Capability

Figure 11 shows the technological ability of how it is characterized. The authors: Howells, Dodgson, and Bessant, recognize that the ability to use and develop technologies is deeply rooted in the intangible factors surrounding the material, by the definition of *technology* that we use before.

Figure 11: Approaches to Technological Capacity



Source: *Arnold, E., & Thuriaux, B. (1997).*

Competitiveness and business performance for Howells are demonstrated by the interdependence of tangible and intangible assets. He distinguishes between its two types of assets and considers tacit knowledge an exceptional category of intangible assets.

On the other hand, we find another model of Bessant and Dodgson, it's a dynamic approach, where they define their terms as:

- *Resources:* All human and intangible business assets, skills, knowledge, organization and links to other businesses.
- *Competences (Skills):* This targeted combination of resources allows companies to differentiate themselves from their competitors**.**
- *Innovative Capabilities:* Characteristics of companies that define and develop skills to create a competitive advantage.

The ability to create and optimize routines that incorporate existing knowledge and disseminate new knowledge gained by the company and implement it into new goods, facilities, and/or production processes is referred to as technological capability (Nonaka, I., & Takeuchi, H., 1995, Grant, R. M., 1996). It is all the generic powers of a knowledge-intensive enterprise to mobilize individual resources in technoscience that promote new products and innovative production processes.

An essential source of technological capabilities is creating and exploiting knowledge within the enterprise and obtaining sustainable competitive advantages (Teece, D. J. et al., 1997).

The growth rate of knowledge creation and diffusion has increased with the rapid spread of production techniques and the likelihood of a leap forward that has become more competitive. One of the reasons is the rapid progress in information and communication technologies (ICTs), which have greatly reduced the costs of computing resources and electronic networks, allowing for faster research and development and the creation of new knowledge and technologies (Peansupap, V., & Walker, D. H., 2006).

2.3 Information and Communication Technologies (ICTs)

On the basis of competition, scientific understanding and the technological changes that follow it force individuals and groups to change their behaviors and modes of life in order to respond to the successive waves of technological novelty that the ICT brings.

Information and Communication Technologies (ICT) encompasses all information technologies that contribute to a true sociocultural revolution, as well as their economic applications.

ICTs are a set of technologies and applications used to process, store, retrieve and transfer data electronically to a wide range of users or customers.

2.3.1 The Historical Development of ICT

In the 80s and 90s, ICT development was measured mainly by increasing the number of fixed telephone lines. As of May 1844, that *Samuel MORSE*[12] , for the first time in history, sent the first public message on a telegraph line connecting the cities of Washington to Baltimore in the United States of America. He signed *"the entree of humanity in the telecommunications era"* (Aebischer, B., & Hilty, L. M., 2015).

[12] ***Samuel Finley Breese MORSE***, was an American painter and inventor. After having established his reputation as a portrait painter, in his middle age Morse contributed to the invention of a single-wire telegraph system based on European telegraphs. He was a co-developer of Morse code and helped to develop the commercial use of telegraphy.

Four phases can be distinguished in the evolution of ICT applications in information and guidance.

The first was centralized computing, from the mid-1960s to the late 1970s. Several computer-assisted guidance systems were developed and demonstrated the potential of these technologies.

The second phase has been that of the microcomputer, from the early 80s until the mid-90s. The advent of the microcomputer has made the use of interaction much more economical.

The third phase was the use of the Internet in the late 1990s. The arrival of the internet meant that instead of open access systems located in referral centers, one could create instantly accessible websites by individuals from a wide variety of locations.

The fourth step is the digital one we are entering now. The previously separate analogue technologies of computer, television, and telephone are merged into an integrated digital package.

In a nutshell, the arrival of Information and Communication Technologies (ICT) has disrupted traditional modes of information flow. ICTs bring new forms of information circulation, more comfortable sharing of information, faster information dissemination, and almost instantaneous communication. They also allow for the development of skills and team spirit through cooperative work (Duque, R. et al., 2007).

2.3.2 ICT Roles

Technology is a strategic instrument through which objectives and interests are expressed. The role of ICTs in organizational change will help differentiate between the various roles that technology can play.

Technology plays a role in facilitating change. ICTs make it possible to improve efficiency in production management and human resources management.

When it comes to providing a financial services system, technology can also play a bigger role. They also constitute the new services' necessary infrastructure: electricity, banking, insurance online, call centers, etc. In some sectors, ICTs are not just a toolbox of change tools; they are the business's very backbone (Wonglimpiyarat, J., 2014).

Technology can play a more dynamic role when it serves as an incentive for innovation, for example, the digital book, the online press, the multimedia edition. In general, the open nature of

ICTs is an incentive for product innovation, while many authors complain that ICTs have so far been used primarily as facilitators of process innovation.

2.4 Knowledge and Economic Development

The importance of knowledge as a key ingredient in technology cannot be ignored (Marwick, A. D. (2001), as it plays a crucial role in these processes of creating a technological base value (Nelson, B. H., 1991, Nonaka, I., & Takeuchi, H., 1995, Sánchez, R., & Mahoney, J. T., 1996). Moreover, in the current context of rapid environmental change, businesses and countries must return to the path of economic growth and strive to stimulate the processes of knowledge, innovation, and competitiveness.

Since the 1990s, dynamic shifts in the economy have resulted in the rise of the "new economy" or "information economy". OECD[13] and the World Bank provide a developed definition of the knowledge economy as an economy constructed, assimilated, transferred, and effectively used by businesses, organizations, individuals, and societies, a source of growth and progress for society and the economy (Kukliński, A., 2003).

The possibility of modifying the immediate and general environment, and transforming the industrial society into an information society with the use of knowledge, the need for organizations' reliance on access to skilful use and adaptability to survive, but also a global vision of the economy, markets, it is the essential characteristics of such an economy (Skrzypek, E., 2009). Increasing levels of education in societies, the internationalization of economies through global trade in services, and advances and diffusion of information and communication technologies contribute to the growth of the knowledge economy (Zak, K., 2016).

2.4.1 The Knowledge Economy Framework

When knowledge creation is at the heart of the economic growth process, the result is basically a knowledge economy. The knowledge economy is a major driver of economic development. It is a knowledge-based economy in which knowledge is gained, developed, disseminated, and effectively applied to improve economic growth. To effectively move to the economy, it requires long-term investments in education, the growth of innovation capabilities, the modernization of knowledge, and the creation of an economic environment conducive to business transactions (Powell, W. W., & Snellman, K., 2004).

[13] ***(OECD)*** The **Organisation for Economic Co-operation and Development,** is an intergovernmental economic organisation with 36 member countries, founded in 1961 to stimulate economic progress and world trade.

More specifically, the framework of the knowledge economy contains four pillars are:

- An economic incentive and institutional regime that serves to make good policies and economic institutions that allow for efficient mobilization and allocation of resources and stimulates and motivates the effective creation, dissemination and use of existing knowledge.
- Educated and skilled workers who create and use knowledge effectively by improving and adapting their skills.
- An effective innovation system consisting of companies, research centers, universities, consultants and other organizations, to keep pace with the knowledge revolution, to tap into the growing stock of global knowledge, knowledge and assimilate and adapt it to local needs.
- A modern and adequate information infrastructure facilitates effective communication, dissemination, and processing of information and knowledge.

With the spread of new information and communication technology, the global economy has become more dynamic and interdependent; economic survival has made it critical that knowledge creation and usage play a central role in long-term growth strategies.

Investments in education and training, innovation and technology adoption, information infrastructure, and an enabling economic and institutional incentive regime are needed for sustainable knowledge creation, adoption, adaptation, and use in the knowledge economy and for national economic output, increasing the likelihood of economic success, and economic development, and having a highly competitive and globalized global economy today (Powell, W. W., & Snellman, K., 2004).

Since there is so much detail about the knowledge economy in the literature, table 07 shows a list of the knowledge economy's key components.

Table 07: Knowledge economy – major components

Components	**Characteristics**
Foundations of the knowledge economy	• Increased education levels in the developed countries, • The growing internationalization of the economies through global trade in services, • Advancements in and dissemination of information and communication technologies.
Indicators of the knowledge economy	• The transition from the industrial economy to the service-based system, • An increasing number of professional and technical workers and their growing impact on the economy, • Information society organized around knowledge and information, • Scientific research and development, alongside the merger of science and technology with the economy, are the key to the information society, • Advancements in intellectual technology.
Pillars of knowledge in the knowledge economy	• ICT, • Human capital, • Social capital (trust, cooperation, and social networks), • Knowledge management in organizations

Source: *Żak, K. (2016).*

Section Three: Global Perspective on Sustainable Development Goals (SDG's)

When the major crises linked to economic activity and the environment become a new normal for humanity, it is wise to seek ways out of it by adopting an integrated approach, revealing the important essential for sustainable development by combining economic, social, and natural aspects.

The United Nations has supported sustainable development in the economic, social, and environmental fields at the local, national, and international levels since the adoption of Agenda 21 in 1992. The organization has successfully spread the idea of sustainable development worldwide, carrying out many related activities on a regular basis and defining various international political commitments, thanks to decades of previous efforts. This is, without a doubt, the start of a new age of sustainable growth.

1 Sustainable Development Goals (SDGs)

2015 was a watershed year for sustainable growth in several respects. This year was chosen as a deadline for appreciating the strides made in human development in the South at the United Nations Millennium Summit and the implementation of the Millennium Development Goals (MDGs) in the year 2000. The Sustainable Development Goals (SDGs) were developed by the UN General Assembly, the Conference on Financing for Development in Addis Ababa (Monterrey 3), the Conference on Climate Change in Paris (COP 21), and the Conference on Financing for Development in Addis Ababa (Monterrey 3) (World Health Organization, 2016).

It is a universal program applicable to all countries of the world, regardless of their development level, as a framework for overall development over the next 15 years, 2016-2030. This is the result of a broad and inclusive process of consultation and negotiations; this new plan for post-2015 aims to free humanity from poverty, hunger, violence, fear and ensure that all human beings can realize their potential with a dignity environment. It covers 17 objectives (succeeding the 8 Millennium Development Goals: MDG 2000-2015) and 169 targets structured around five key areas or the 5 Ps (People, Planet, Prosperity, Peace, and Partnerships) integrating the three dimensions of sustainable development (social, economic and environmental) and for the first time the excellent governance dimension, peace, and justice in a revitalized global partnership. In addition to the results framework (objectives and targets), the program includes an integrated vision, principles, an implementation strategy, and a review and monitoring framework (Stock, T. et al., 2017).

1.1 The Emergence of Sustainable Development

To know the emergence of the concept, it is necessary to understand its birth's historical stakes. It is a question of going back to events and the time of the events and the time of the events and ideas to identify the sources that contributed to this birth.

The term "sustainable development" was coined in the middle of the nineteenth century as a scientific definition. A large body of literature has refined this concept's conceptual meaning in relation to international environmental and development negotiations, especially the Commission Brundtland's work. The idea arose early on, but it wasn't until 1980, when the World Conservation Strategy was published, that the word "sustainable development" was coined in the modern context.

It is indeed between the World Conservation Strategy publication and the Rio Declaration, through the Brundtland "*Our Common Future"* report[14], that the concept of sustainable development has, on the one hand, considerably evolved and, on the other hand, been the most widely disseminated.

1.1.1 The First Claims

The first claims date back to the nineteenth century and relate more specifically to the protection of nature. At that time, the industrial revolution created a rupture and an inversion of the balance of power between man and Nature. The progressive ecological degradation has led to the emergence of an awareness of the problem. It can be considered the first sketch of sustainable development demands (Boutaud, A., 2005). Since the 1950s, global awareness of the dangers posed by the planet has steadily increased. The first report on the state of the world's environment, published in 1951 by the International Union for the Conservation of Nature (IUCN)[15], makes an alarming record of nature's deterioration. In the early 1970s, a new approach to man-to-nature relationships emerged centered on the quality of life and the protection of the environment called "New Environmentalism" (Bergandi, D., & Blandin, P., 2012). Growth

[14] ***Our Common Future***, also known as the ***Brundtland Report*** in recognition of former Norwegian Prime Minister Gro Harlem Brundtland's role as Chair of the World Commission on Environment and Development (WCED), was published in 1987 by the United Nations through the Oxford University Press.

[15] ***IUCN***, is one of the oldest conservation associations. It was founded in 1948 under the name *"International Union for the Protection of Nature"*. Today, it consists of 74 governments, 105 government agencies and more than 700 NGOs. In addition, IUCN also works with international networks of volunteer experts through various commissions.

models are criticized, and the concept of development suffers from a crisis of legitimacy. This turning point marks the emergence of ecological concern and the international political recognition of the environment's question (Godard, O., & Hubert, B., 2002).

1.1.2 The Concept of "Eco-development"

An awareness of the environmental crisis took on a political and institutional form with the United Nations Conference's organization on the Environment in Stockholm in 1972 (Panzaru, S., Dragomir, C., 2012). This conference is the first international meeting on man's natural environment in which the term "eco-development"[16] was born (Morvan, B., 2000).

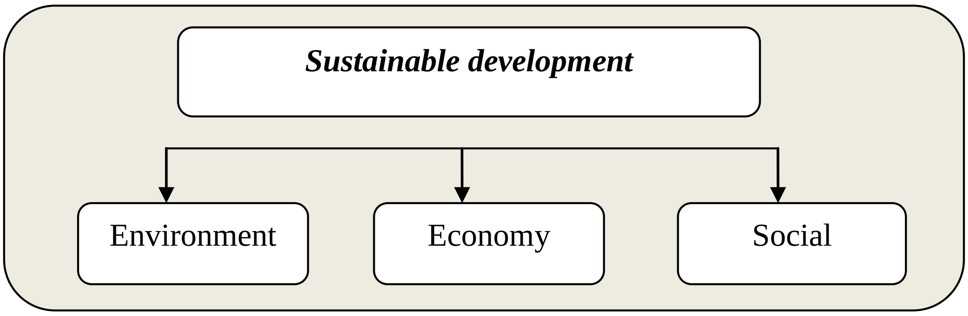
It is generally considered as the initial act of the genesis of sustainable development. In this conference, they supported the idea that the environment and development must be treated as a problem. They used as a basis the simulations of a model of "global ecosystem" composed of five parameters: the population, food production, industrialization, pollution, and the use of non-renewable natural resources (Boisvert, V., & Vivien, F. D., 2006). The simulations increased in individuals who consume and pollute more and more in a world set in motion at collapse. This new thought of development, which will ensure a dynamic balance between nature and human activities, evokes different resources to achieve harmony between economic development and ecology. In 1980, IUCN published a report on *"The World Conservation Strategy"* in collaboration with the United Nations Environment Program (UNEP) and the World-Wide Fund for Nature (WWF). This report proposes a global vision of ecosystem dynamics concerning the activities of human beings.

The term sustainable development was used for the first time by this document (Auty, R. M., & Mikesell, R. F. (1998). IUCN (1980) stated that: *"(...) the modification of biosphere and applying human, financial, 1iving and non-living resources to satisfy human needs and improve the quality of human life. For development to be sustainable, it must take account of social and ecological factors, as well as economic ones; of the living and non-living resource base; and on the long-term as well as the short term advantages and disadvantages of alternative actions"*.

Sustainable development should take into account the environment, the economy, and social. Its goal is to improve the living conditions of humans while respecting the limits of ecosystems.

[16] The term ***"eco-development"*** comes from French thought, this term was translated into the periphrasis of *"environmentally sound development"* of the United Nations language and later *"sustainable development"*.

Figure 12: The major elements of Sustainable Development



Source: *By author*

1.1.3 The Brundtland Report (1987)

More formally, the report *"Our future for all"* is the birth of sustainable development. This report was published in 1987 by the World Commission for Environment and Development (WCED)[17] 18, which was established by the UN in 1983 and chaired by Mrs. Brundtland. Essentially, the concept of sustainable development attempts to reconcile development and the respect of nature. Therefore, Mrs Brundtland's report seeks to articulate multiple actors concerns by advocating for joint actions. It supports a new kind of relatively "sustainable" and "equitable" development that integrates the environment and socio-economic development, meets human needs, and respects the natural environment.

Sustainable development is defined in this report as:

"(...) development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN Documents, 1987)

The report confirms some objects and suggests others, but it is still unable to provide strategies for how sustainable development will put together all of its objectives: economic growth, social equity, protection of the environment, responsibility towards future generations, the satisfaction of needs, limitations resources, technical innovation, quality of life, the participation of the populations, and so on.

[17] The ***UN*** *General Assembly*, adopted resolution 38/161 of 19 December 1983 creating a special commission called the World Commission on Environment and Development (WCED) or United Nations Commission for Environment and Development (UNCED).). This commission was mandated to produce a report on the global environment perspective by the year 2000. The chair of the commission was assigned to Mrs Brundtland, formerly Minister of the Environment and Prime Minister of the Norwegian Government. The report of the commission, commonly referred to as the Brundtland report, was made public in 1987.

1.1.4 The Rio Conference (1992)

The 1992 United Nations Rio Conference on Environment and Development the *"Earth Summit"* (UNCED) dedicated and globalized sustainable development (Marshall, J. D., & Toffel, M. W., 2005). It constituted a break in the perception of collective issues since, for the first time, the risks of degradation of natural resources have been the subject of discussions at the international level.

The Rio Declaration marks the beginning of international work's institutionalization related to sustainable development for a more respectful world of people and the environment. Sachs (1997) sums up the UN thinking from the Rio Summit by writing about sustainable development that *"must now meet three criteria: social justice, ecological prudence and macro-social economic efficiency"* (Atkinson, G. et al., 1997). The Declaration defines the rights and duties of states in terms of sustainable development and indicates the conditions of this development: fight against poverty, improvement of living conditions, adequate demographic policies, appropriate modes of production and consumption, involvement and participation of the population, etc. (Tsayem, D. M., 2009).

At the United Nations Rio Conference on Environment and Sustainability, the principle of sustainable development was officially recognized. The summit laid the groundwork for an action program (Agenda 21)[18] to be applied at the international, national, and local levels, consisting of 27 recommendations to promote sustainable development.

In summary, the conceptualization and dissemination of sustainable development were achieved mainly between the publication of the World Conservation Strategy (1980) and the Rio Declaration (1992).

1.2 Definition of Sustainable Development

The concept of sustainable development has been around since the 1970s. This time remains connected to the emergence of protest movements against the prevailing economic growth paradigm, constituting a significant sociopolitical and cultural turning point for humanity.

Sustainable development reconciles the ecological, economic, and social development process and establishes a virtuous circle between these three poles: development, economically efficient,

[18] ***Agenda 21***, is a structured document in 40 chapters grouped in 4 sections, 800 pages. It is a program of actions and a concrete plan for the implementation of sustainable development. It is a program of actions to be undertaken to achieve the objectives defined by the Rio Declaration.

socially equitable, and ecologically sustainable. It is respectful of the natural resources and the ecosystems, support of life on earth, which guarantees economic efficiency, without losing sight of the social ends of the development, which are the fight against poverty, against the inequalities, against the exclusion, and the seeking equity (Scheyvens, R. et al., 2016).

A sustainable development strategy must win from this triple point of view, economic, social, and ecological. Sustainable development presupposes that human decisions and behaviors reconcile what seems to be quite irreconcilable, that they broaden their vision: it imposes to open up our time horizon in the long term, that of future generations, and our spatial horizon, in taking into account the well-being of everyone, whether they live in a country in the South or the North, in a nearby region, in the neighboring city or neighborhood (Lim, S. S., et al., 2016). Sustainable development is based on the search for integration and coherence of sectoral policies. It requires joint treatment of any human policy or action's economic, social, and environmental effects. Such an integrated approach requires multi-stakeholder and interdisciplinary approaches. Its success is based on partnership and cooperation between actors from different disciplines (economy, sociology, ecology, etc.), other sectors (transport, water, waste, natural environment, social development, etc.), from different backgrounds (entrepreneurial, associative, institutional, administrative, commercial, trade union, etc.), acting at various territorial levels, and from all over the world.

A new form of governance is needed for sustainable development. The mobilization and involvement of all civil society actors in the decision-making process must take priority over mere knowledge exchange. The aim of sustainable development is to foster participatory democracy and a renewed citizen mindset. Transparency and access to information are needed.

1.3 The Road from the MDGs to the SDGs

1.3.1 Millennium Development Goals (MDGs)

The eight goals are adopted in September 2000 in New York (United States) with the United Nations Millennium Declaration by 193 UN Member States and at least 23 international organizations. They have agreed to reach them for 2015. The Declaration, which advocated a global partnership to reduce extreme poverty and child mortality, the fight against several epidemics, including access to education, gender equality, and the implementation of sustainable development, was the first-ever global strategy with quantifiable targets to be agreed upon by all UN Member States and the world's leading development institutions (Akani, E. C., 2018).

To support the Declaration, former United Nations Secretary-General Kofi Annan[19] has defined eight accompanying goals. These goals (listed below) were set with a 2015 deadline and became the Millennium Development Goals (MDGs).

Table 08: The 8 Millennium Development Goals (MDGs)

Millennium Development Goals (MDGs)	
Goal 1	Eradicate extreme poverty and hunger
Goal 2	Achieve universal primary education
Goal 3	Promote gender equality and empower women
Goal 4	Reduce child mortality
Goal 5	Improve maternal health
Goal 6	Combat HIV/AIDS, malaria, and other diseases
Goal 7	Ensure environmental sustainability
Goal 8	Develop a global partnership for development

Source: *The Sustainable Development Goals Fund http://www.sdgfund.org/mdgs-sdgs*

1.3.2 Why was the Transition to the New System?

The MDGs have brought the planet together around a common agenda to fight poverty. Although the number of people living in extreme poverty has decreased by more than half, the work remains uncompleted for millions of others. The new agenda must deepen MDG commitments, such as eradicating hunger, achieve gender equality, improve health services, and enable every child to go to school while preserving the benefits of the results already achieved (Battersby, J., 2017).

One of the main differences is that the program is universal. All countries must harmonize their strategies and identify the gaps and ways to address them in each area. The SDGs are more ambitious and complex, and they will strengthen MDG achievements when they reach the end of 2015. The program also incorporates new areas concerning the MDGs, such as climate change, sustainable consumption patterns, innovation, and the importance of peace and justice for all.

[19] ***Kofi Annan***, the seventh Secretary-General of the United Nations, was the first to step out of the ranks of the staff. He began his first term on 1 January 1997. On 29 June 2001, on the recommendation of the Security Council, the General Assembly re-elected him by acclamation for a second term, beginning on 1 January 2002 and ending on 31 December 2006.

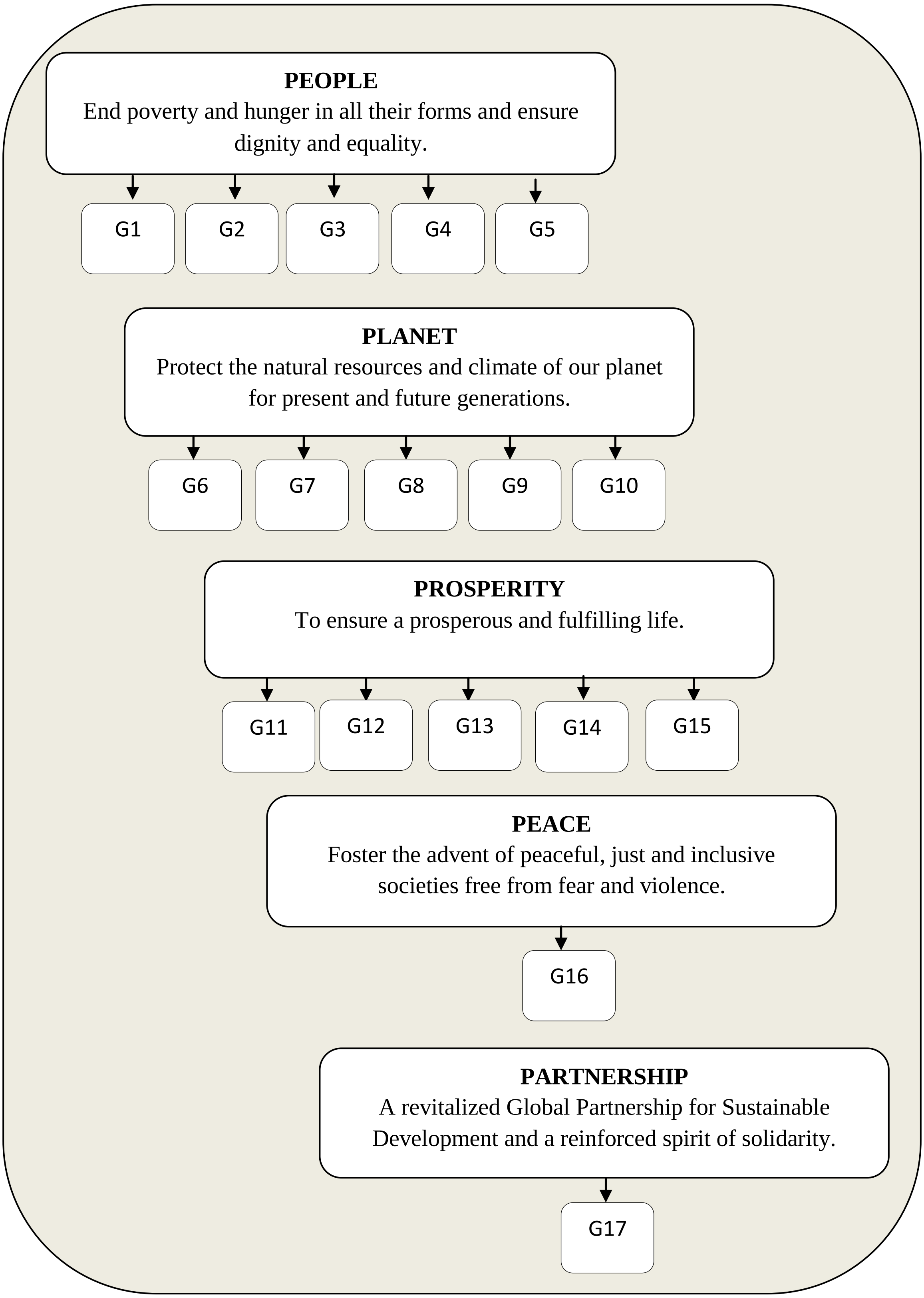
The SDGs have more objectives, but these focus on specific areas, the basis of common principles and commitments. Building on the MDGs and an equality-based and rights-based approach at all levels, the 2030 Agenda brings together sustainable development and inclusion with a commitment to leave no one behind (Servaes, J., 2017).

The 2030 Agenda for Sustainable Development includes 17 Sustainable Development Goals (SDGs) and their 169 Targets.

The 2030 Agenda for Sustainable Development is a blueprint for humanity, the earth, and prosperity that strengthens harmony and necessitates collaboration. These five aspects of long-term development are inextricably related. The SDGs concentrate on new fields such as economic disparity, innovation, climate change, sustainable consumption practices, stability, and justice, among others, taking into account both the achievements and failures of the Millennium Development Goals (MDGs) (Servaes, J., 2017).

The Sustainable Development Goals (SDGs) are basic, inclusive, and embody a bold commitment to humanity and the earth. SDGs are also referred to as global goals for sustainable growth.

Figure 13: The five elements of Sustainable Development



Source: *By author*

1.3.3 The 17 Sustainable Development Goals

In June 2012, Rio+20[20] (United Nations Conference on Sustainable Development) was held in Rio de Janeiro to develop a new set of sustainable development goals (SDGs) that will continue the momentum generated by the Millennium Development Goals and fit the framework for global development beyond 2015, where an international consultation involving civil society organizations, citizens, scientists, academics and the private sector from all over the world was actively involved in this process led by the United Nations Development Group (Biermann, F. et al., 2017).

In July 2014, the Open-ended Working Group (OWG) of the United Nations General Assembly proposed a document containing 17 objectives for the General Assembly's approval in September 2015. This document paves the way for the new sustainable development goals and global development plan stretching from 2015-2030. The following table shows the objectives for sustainable development (UN Official Document).

Table 09: The 17 Sustainable Development Goals

The 17 Sustainable Development Goals	
Goal 1	End poverty in all its forms everywhere
Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3	Ensure healthy lives and promote wellbeing for all at all ages
Goal 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5	Achieve gender equality and empower all women and girls
Goal 6	Ensure availability and sustainable management of water and sanitation for all
Goal 7	Ensure access to affordable, reliable, sustainable, and modern energy for all

[20] ***Rio+20***, was the third international conference on sustainable development aimed at reconciling the economic and environmental goals of the global community.

Goal 8	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all
Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
Goal 10	Reduce inequality within and among countries
Goal 11	Make cities and human settlements inclusive, safe, resilient, and sustainable
Goal 12	Ensure sustainable consumption and production patterns
Goal 13	Take urgent action to combat climate change and its impacts (noting agreements made by the UNFCCC forum)
Goal 14	Conserve and sustainably use the oceans, seas, and marine resources for sustainable development
Goal 15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss
Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels
Goal 17	Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Source: *The Sustainable Development Goals Fund* http://www.sdgfund.org/mdgs-sdgs

There are 169 targets for 17 goals. Each target has between 1 and 3 indicators used to measure progress toward goals. In total, there are 232 approved indicators to measure commitment. The Inter-Agency and Expert Group developed the global indicator framework on SDG Indicators (IAEG-SDGs) and agreed to, as a practical starting point at the 47th session of the UN Statistical Commission held in March 2016 (Gupta, J., & Vegelin, C., 2016). Among the 17 targets, we will focus on Goal 9 (Industry, Innovation, and Infrastructure), which concerns: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation, which has a strong relationship with technology and innovation.

2 Sustainable Development Goals and Technology

Investment in infrastructure and innovation are key drivers of economic growth and development. With more than half of the world's population living in cities, public transit and renewable energy are becoming increasingly important, and the growth of new industries and information and communication technologies.

Technological advancements are needed to find long-term solutions to economic and environmental problems. Sustainable development can be achieved by promoting sustainable manufacturing and investing in scientific research and innovation (Sciamarelli, M., 2017).

2.1 Goal 9: Industry, Innovation, and Infrastructure

This goal is to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation, including a set of targets and some indicators that measure each target. These targets and indicators are as follows: (from the 2030 Agenda for Sustainable Development)

1. Develop quality, reliable, sustainable, and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, focusing on affordable and equitable access for all.

2. Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in the least developed countries.

3. Increase the access of small-scale industrial and other enterprises, particularly in developing countries, to financial services, including affordable credit, and their integration into value chains and markets.

4. By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action by their respective capabilities.

5. Enhance scientific research and upgrade the technological capabilities of industrial sectors in all countries, particularly developing countries, including by 2030, encouraging

innovation and substantially increasing the number of research and development workers per 1 million people and public and private research development spending.

a. Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological, and technical support to African countries, least developed countries, landlocked developing countries, and small island developing States.

b. Support domestic technology development, research, and innovation in developing countries, including ensuring a conducive policy environment for, among other things, industrial diversification and value addition to commodities.

c. Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in the least developed countries by 2020.

The Sustainable Development Goals (SDGs) are one of the most transformative initiatives undertaken by the international community in decades. With science, technology, and innovation (STI) demonstrating their ability to drive economic and social change, policymakers should make it a priority to put them to work in support of the SDGs, as well as to assist developing countries in harnessing science, technology, innovation, and entrepreneurship as effective means of achieving the SDGs through policy analysis (Sinha, A. et al., 2020).

2.2 Innovation and SDGs

The link between innovation and economic and social progress is well established and is explicitly recognized in SDG (Goal 9): build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation. Successive waves of development gave rise to a virtuous circle of technological advances, successive inventions, and social progress. As a result, new technologies are generally associated with increased investment, an increase in the labor force, job creation and productivity gains, increased incomes, and improvements in public health, transportation, and education, all of which contribute to the emergence of new, more efficient economic structures and more prosperous societies (Voegtlin, C., & Scherer, A. G., 2017). The next generation of technology promises to reduce poverty further and improve billions of people's lives.

2.3 Science, Technology, and SDGs

For economic growth, science, technology, and innovation (STI) are one of the main drivers where policy and economic decision-makers have developed a set of principles that underpin the fundamental role of science for Sustainable development (Imaz, M., & Sheinbaum, C., 2017):

- Scientific advances help lay the foundations for a sustainable world, a tool for achieving the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs).
- To create a productive scientific environment, basic science is a precondition for innovation, including long-term investment, to advance fundamental knowledge worldwide.
- Achieve gender equality in science and take advantage of a wide range of societies to value sustainable development diversity.
- Strengthen scientific capacity to increase scientific knowledge while encouraging investment in science education and building scientific capacity at all levels, especially where the benefits of science and its sources are less taken into account.
- Set minimum national targets for science, technology, and innovation in the basic and applied sciences to increase science investment, thereby contributing to economic development and scientific progress. Support more scientific education and research, scientific infrastructures such as schools, colleges, universities, and centers of excellence for advanced science.
- Promote an integrated scientific approach integrating the social, economic, and environmental dimensions of sustainable development and respecting the diversity of knowledge systems. This requires expanding international cooperation among national science academies and strengthening intergovernmental research organizations, which play an important role in sustainability.

Achieving Goal 9 is about building resilient infrastructure, promoting sustainable industrialization that benefits everyone, and encouraging innovation. ICT infrastructure and services that are both efficient and affordable allow countries to engage in the digital economy and, as a result, improve their economic well-being and competitiveness (Giovannini, E. et al., 2015). Most of the least developed countries are making impressive progress towards SDG 9, which has real implications in financial inclusion, poverty reduction, and improved health.

Conclusion

We had three parts in the second chapter. The first asserts that innovation is a complex and multifaceted subject. There are many meanings of innovation that are mutually beneficial. Others are concerned with the novelty of the innovation, while others are concerned with the beneficiary of the innovation or the essence of the innovation.

Furthermore, it is undeniable that innovation is a driving force and a source of economic support for nations. We also saw in the second section how technical capability interacts with development by increasing overall factor productivity. Technology's innovative position, as realized through R&D activities, has an impact on productivity in technological development. In the last part, we discussed the Sustainable Development Goals, a global initiative aimed at making the planet a fairer and more sustainable place for all. Goal 9, in particular, is the creation of long-term infrastructure in support of innovation growth.

Economic growth has also been explained differently over time with various assumptions and determinants. These key determinants are innovation and technology or technological capacity also has its relationships with the SDG.

And this is shown by researchers and practitioners who are aware of the importance of innovation and technological capacity, as evidenced by thousands of academic documents and numerous rankings and business indices. Furthermore, we can see several studies in the next chapter that concentrate on measuring many indices that impact growth and economic awareness, with a focus on emerging countries.

Chapter Three

Empirical Measurement of Innovation and Technological Capacity

Introduction

For decades, the focus of current debates on measuring economic success and scientific advancement has been in academia and various scientific disciplines, with economists dominating and practitioners in charge of projects and programs.

Setting a benchmark for development from a historical perspective is useful for several reasons. Its growing diversity is highlighted; the new procedures correspond to old measures still in force, and their life cycle changes: some are ephemeral; others are used over a long period.

This chapter will examine a series of indexes that are the pillars of economic development and scientific development, mentioning most of the studies that have been carried out for each index and the most important elements that can measure these indicators. In the first two sections, we will mention all the studies that have been done on Innovation index, human development index, ICT index, knowledge economy index, and SDGs index. Then we'll conduct a special investigation into technological capabilities and the most relevant studies that were presented to them, in which technological capabilities are used to improve economic actors' ability to use technological expertise by attempting to absorb, adapt, and alter existing technologies. It symbolizes national efforts to turn imported innovations into active applications. As a result, several theoretical and empirical studies by a wide body of literature on innovation and technical capacity show that technology components and innovation are important for countries' economies.

At the end of the chapter, we will discuss a group of countries with distinct characteristics, known as emerging countries, whose economies are primarily based on the previously listed factors.

Section One: Empirical Study on Selected Indices

Innovation, information, development, network, education, technology... these pertain to a strong economy and are critical to the modern economy's growth and competitiveness. From this perspective, Redshaw S. (2004) stresses the importance of information and technology diffusion. This action requires an excellent understanding of "knowledge networks and national systems of innovation" (Redshaw, S., 2004). This definition reflected in key terms is innovation, networks, skills, and knowledge. Innovation research identifies organizations' knowledge as critical to effective Innovation (Cooke, P., (2007); Harris, R., & Moffat, J., (2011); Lundvall, B. A., (2010)).

1 Innovation Index

Companies must constantly develop or make improvements in their processes and/or goods, according to Peng, D. X., Schroeder, R. G., and Shah, R. (2008). The body of literature on innovation is vast and covers a wide variety of subjects. Drawing on Schumpeter's seminal contribution from 1950, theoretical advances were made in the 1990s (by Romer, Aghion, and Howitt, and Grossman and Helpman) and followed by a significant increase studies on innovation (Brach, J., 2010).

The definition of innovation has been an area of interest for researchers. Scientists have used a different approach from many perspectives to provide various purposes of Innovation, including radical or incremental, product and process changes, and the degree and nature of innovation in an organization.

Table 10: Defining innovation

Authors	Definitions
Joseph Schumpeter (1930)	• Introducing a new product or modifications brought to an existing product. • A new process of innovation in an industry. • The discovery of a new market. • Developing new sources of supply with raw materials. • Other changes in the organization.
Peter Druker (1954)	One of the two basic functions of an organization.
Stellner & Sheth (1969)	Any new element brought to the buyer, whether or not new to the organization.
Mohr (1969)	The degree to which specific new changes are implemented in an organization.
Damanpour & Evan (1984)	The broad utility concept is defined in various ways to reflect a specific study's specific requirement and characteristic.
Kenneth Simmonds (1986)	Innovations are new ideas that consist of: New products and services, new use of existing products, new markets for existing products or new marketing methods.
Damanpour (1991)	Development and adoption of new ideas by a firm.
Evans Paul (1991)	The ability to discover new relationships, of seeing things from new perspectives and to form new combinations from existing concepts.
Covin & Slevin (1991), Lumpkin & Dess (1996)	Innovation can be defined as a process that provides added value and a degree of novelty to the organization, suppliers, and customers, developing new procedures, solutions, products and services, and new ways of marketing.
Davenport (1993)	Complete a task development in a radically new way.

Business Council Australia (1993)	Adopting new or significantly improved elements to create added value to the organization directly or indirectly for its customers.
Henderson & Lentz (1995)	Implementation of innovative ideas
Nohria & Gulati (1996)	Any policy, structure, method, process, product, or market opportunity that a working business unit manager should perceive as new.
Mark Rogers (1998)	Involves both knowledge creation and diffusion of existing knowledge.
Boer & During (2001)	Creating a new association (combination) product-market-technology-organization.
Bessant et al. (2005)	The core renewal process in any organization. Unless it changes what it offers the world and how it creates and delivers those offerings, it risks its survival and growth prospects.
Plessis (2007)	Innovation as the creation of new knowledge and ideas to facilitate new business outcomes, aimed at improving internal business processes and structures and to create market driven products and services.

Source: *Popa, I. L., et al., (2010).*

The empirical studies center almost exclusively on the analysis of the indicators that measure innovation. They consider that research and development and patents and scientific articles are the main factors that measure the innovation capacity. The first approach used to evaluate innovation processes was the measure of R&D intensity (Hirsch, S., & Bijaoui, I. (1985); Greve, H. R. (2003); Bustinza, O. F., et al., (2019)).

Kleinknecht, A. et al. (2002) stressed that research and development (R&D) expenditures and R&D personnel are the indicators that represent the research efforts of companies and innovation skills that affect their performance. R&D efforts reflect the company's current inputs and the previous successes that are an integral part of its development capabilities by creating an R&D strategy with a stable set of long-term projects.

Parthasarthy, R., and Hammond, J. (2002), demonstrate in their paper the importance of research as an essential source of innovation and the means affected. In several studies, they claim that R&D intensity positively impacts technological performance and Innovation and the creation of new products and technologies. In the OECD (2005) view, R&D does not include either all the companies' efforts in innovation as other sources of technical advances such as learning by doing. In the same idea, Simonen, J. and McCann, P. (2008) argue that R&D expenditure levels and human capital are among the key factors influencing innovation the most.

Arocena, R. and Sutz, J. (2006) assume that innovation is a process of value creation; human capital is an important variable. However, economic growth is increasingly based on knowledge and driven by innovation. It is essentially a process that requires a highly skilled workforce, and the development of better human capital allows the company to expect superior performance. Similarly, Dakhli, M., and De Clercq, D. (2004) carried out a study to analyze human capital's influence on creating value and, thus, on firms' performance.

The literature also proposed another element for the evaluation of innovation and scientific and technical activities were the number of patents (Schmookler, J. (1953); Griliches, Z. (1990); Dubuisson, S., & Kabla, I. (1999); Guellec, D. (2003)).

For Dodgson, M., and Hinze, S. (2000), the number of patents is the most commonly used data for measuring innovation and inventions. It considers a patent to be an exclusive right to exploit (manufacture, use, sell, or import) over a limited period (20 years from filing) in the country where the application is made. And for OECD (2004), patents are granted for new, inventive, and industrially applied inventions, but patents do not need to be commercially used.

Valente, T. W., and Rogers, E. M. (1995) propose to join the information provided by patent measurement with other measures such as statistics on scientific publications (bibliometric), articles in professional and technical journals. In the view of Archibugi, D. and Coco, A. (2004), the scientific literature is another important source of codified knowledge used to develop innovation. It represents the public sector's knowledge, especially in universities and other publicly funded research centers. However, a large and growing share of scientific articles is published by researchers working in the business sector. Moreover, English-speaking nations are likely to be over-represented since the vast majority of the Institute for Scientific Information journals are in English. The advantage is that the data are collected homogeneously for all countries and from reliable sources. Scientific and technical journals are also used to measure innovation, knowledge production, R&D, and patents.

2 The Human Development Index

The most critical strategic factor for growth is human capital; as new innovations evolve, market demand for better goods increases. It becomes increasingly important to know how information can be accessed in today's world, how it is adopted, and how it can be assimilated. According to this, human development is about expanding wealth, the wealth of the economy in which people live. Human development is born from global discussions on the links between economic growth and development, where the human development value is an essential indicator with research and development (R&D) that is very important for human potential and efficiency of useful resource the country's R&D capacity is important for human development in this country (Özçatalbaş, O., 2017).

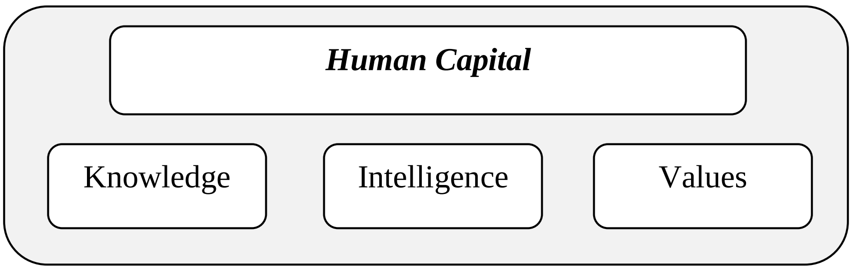
The employees' individual skills, knowledge, professionalism, and experience; all these characteristics reflect the human capital.

"It also includes individual experiences, ideas, values, attitudes, abilities (such as creativity, know-how, loyalty, etc...) and competencies of the people who work in the organization (employees and managers)" (Olmedo-Cifuentes, I., & Martínez-León, I., 2015)

Human capital refers to knowledge relevant to activity and improving and developing the knowledge acquired through lifelong learning. It is the knowledge that each employee possesses relevant to its interests and purpose and is based on the employees' talent and skills (Bejinaru, R., (2016), Schiuma, G., & Lerro, A., (2010)).

Figure 14 presents the most important components of human capital, according to Bratianu, C. (2008); knowledge, intelligence, and values.

Figure 14: Operational structure of the human capital (Bratianu, C., 2008)



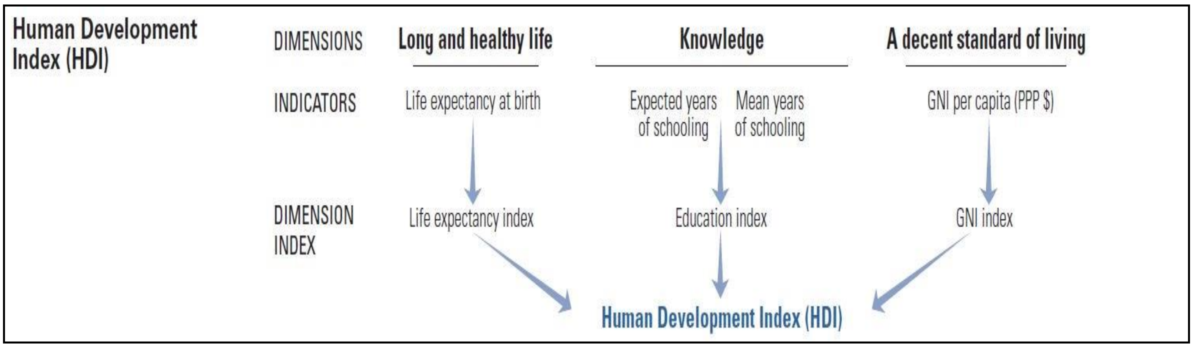
Source: *Hadad, S. (2017).*

The Human Development Index provides information on country development for the world at large and the least developed countries. There has been a significant improvement in the human development index value from over 20% to 40% for the last 25 years. The human development index has progressed in all regions of the world, while the human development index's progress has been relatively stable in all developing countries (Mihaela, M., & Țițan, E., 2014).

The components of the HDI must reflect three broad dimensions of human development: leading a long and healthy life (measured by life expectancy), being educated (measured by adult literacy and primary, secondary school enrollment, and tertiary), and have a decent level of life (measured by purchasing power parity (PPP) income). These must represent three of the essential choices *"for people to lead along and healthy life, to acquire knowledge and to have access to resources needed for a decent standard of living"* (Stanton, E. A., 2007). Another author proposes these dimensions derive from the notion of human capabilities and are considered indispensable conditions for human capacity building (Frediani, A. A., 2007) as such *"the process of economic [human] development can be seen as a process of expanding the capabilities of people"* (Alkire, S., & Deneulin, S., 2009).

The following diagram represents the three dimensions of HDI and its indicators:

Figure 15: The three HDI Dimension Indices



Source: *United Nations Development Programme (UNDP), Human Development Reports, (2019)*

In figure 15, the three dimensions demonstrate that the health dimension is assessed based on life expectancy at birth. The number of years of schooling for adults aged 25 and up, as well as the estimated years of education for school-age children entering, was used to calculate the education dimension. Gross national income per capita is used to determine the standard of living. The logarithm of income is used in the HDI to represent the decreasing value of income as GNI rises.

In addition, other dimensions exist that could also be considered essential, such as public order, peace, security, and freedom. It has been suggested that the HDI components together appear to provide a set of indicators, almost acceptable overall standard of living (Desai, M., 1991).

3 Information and Communication Technologies

Information and communication technologies (ICT) are becoming increasingly relevant and have a direct economic and social effect in many countries. They are one of the most rapidly expanding sectors. ICT refers to all technologies that process data and facilitate communication.

We may assume that the ICT sector is one of the most significant factors contributing to the country's economic development, as it plays a critical role in global economic growth, as (Avgerou, C., 2003):

- Productivity growth in the United States, which is the best example of ICT-led growth and productivity gains, has remained strong during the recent slowdown, suggesting that some of the acceleration productivity gains during the second half of the 1990s were structural. Productivity growth in Australia and Canada, both characterized by ICT-intensive growth, has also been sustained in recent years.
- ICT networks are now prevalent in most global business sectors and will be increasingly used to improve productivity and business performance. The pace of technological advances in ICT goods and services is rapid, driving down prices and creating a range of new applications. For example, business-to-business e-commerce continues to grow, broadband is rapidly expanding, and business continues to grow in the telecommunications sector.
- Although investment in ICT has declined in the recent downturn, the introduction of ever more powerful microprocessors is expected to continue into the foreseeable future, encouraging investment in ICTs and contributing to new productivity gains.
- With continued technological progress in ICT production, the ICT manufacturing sector will continue to contribute to multifactor productivity growth, especially in countries with highly developed ICT producing sectors, such as Finland, Ireland, Japan, Korea, Sweden, and the United States.

Despite the importance of ICTs, there are still marked differences between countries in ICT diffusion. New data show that the United States, Canada, New Zealand, Australia, the Nordic countries, and the Netherlands generally have the highest ICT diffusion rates. Many other countries are lagging in the diffusion of ICT, and they have room to make progress in this area. It is likely that in countries with the highest levels of ICT diffusion, the economic impact of ICTs should be the highest (Pilat, D., 2003).

The role of information and communication technologies (ICTs) for social development is becoming clearer and more widely used to meet basic human needs such as access to education, job opportunities, and public engagement in social life, where they promote immediate communication (Lee, J. W., & Brahmasrene, T., 2014).

The economic impacts of ICTs that have been measured so far differ significantly across countries. There are three types of ICT impacts on economic growth:

Table 11: **ICT Development Indicators**

Index/Dimensions	**Indicators**
Connectivity	• Internet hosts per capita • Number of PCs per capita • Telephone mainlines per capita • Cellular subscribers per capita
Access	• Internet users per capita • Literacy (population percentage) • GDP per capita • Cost of a local call
Policy	• Presence of Internet exchange • Competition in local loop telecom • Competition in domestic long-distance • Competition in Internet Service Provider (ISP) market

Source: *Authors' adaptation from Doucek, P. (2011)*

4 <u>Knowledge Economy Index</u>

The notion of the knowledge economy was born with the recognition of a growing role in knowledge production, distribution, and use in economic activities and the increase of resources devoted to it. In a recent contribution, Boyer, R. (2002) shows that there are several growth regimes, one of which he calls *"the knowledge economy"*, while Méhaut, P. (2006) describes the emergence of an economy based on knowledge.

In addition, the advancement of information and communication technology aids in the creation of intangible resources by promoting the sharing of digital data.

Economic analysis has long assimilated knowledge and information. We note that knowledge has unique links with information. These two concepts maintain a dialectic made of continuity and rupture. Machlup, F. (1962) is at the origin of the first economic conception of knowledge. The latter is represented as a specialized sector product from a production function that combines skilled labor and capital.

Machlup, F. (1984) defines information as a flow of messages and states in a 1984 book that: *“Linguistically, the difference between "knowledge" and "information" lies chiefly in the verb form: to* inform *is an activity by which knowledge is conveyed; to* know *may be the result of having been informed, "Information" as the act of informing is designed to produce a state of knowledge in someone's mind "Information" as that which is being communicated becomes identical with "knowledge" in the sense of that which is known”* (Machlup, F., 1984)

To distinguish between knowledge and information, Bouchez, J. P. (2014) puts forward that knowledge is often assimilated to information for the old authors and theoreticians of the economy. However, as early as the 1970s, it seemed evident that knowledge is not a commodity like any other reducible to a commodity. To make this distinction Bouchez, J. P. is based on three properties of knowledge that must make it possible to distinguish it: it is difficult to control, it is a non-rival good, the user does not destroy it, and finally, it is cumulative.

Finally, there is one last point that makes it possible to differentiate between knowledge and information. The latter exists independently of individuals, while knowledge is attached to individuals.

For Pesqueux, Y. (2009), knowledge would also be considered a component of the skill. For him, knowledge is most often held individually, and it is different from the skill that is a knowing act. Knowledge and competence would share the faculty of not deteriorating with use.

According to Amable, P., and Askenazy, B. (2002) and Bouchez, J. P. (2014), the knowledge economy gradually emerged from the 1970s. Since then, the development of information and communication technologies (ICT) has contributed to its exponential growth.

Based on production, management, and dissemination of knowledge, the knowledge economy has quickly become a crucial issue for developing territories. In addition, for Amable, P., and Askenazy, B. (2002), Bouchez, J. P. (2014), and Vicente, M., et al., (2015), the knowledge economy is a source of innovation and, therefore of societal competitiveness.

For Pesqueux, Y. (2009), the knowledge economy brings competition between companies into a new dimension. Knowledge is then considered a competitive advantage. For Jacob, M. C. (2014), they are at the origin of developing a unique culture that profoundly changes our ways of thinking, working, and living, which also modifies our relationship to knowledge. Amable, B. and Askenasy, P. (2005) show that structural change is underway in developed economies.

Because of technological advancements that have allowed information diffusion, the knowledge economy has grown rapidly in recent decades. However, if this development is not accompanied by significant improvements in training institutions, there is a risk of losing the benefits of ICTs and, more importantly, information and skills.

To measure the extent to which knowledge is used to stimulate economic growth and to measure it in each country/region and compare countries internationally, international institutions to develop four pillars complemented by indicators (for each pillar of indicators measure it) and which reflects the overall performance of the economy (Hadad, S., 2017).

And the following table shows these four pillars with indicators that can measure each pillar:

Table 12: The four dimensions of the Knowledge Economy

Dimensions	Indicators
Economic incentive and institutional regime	• Tariff and non-tariff barriers • Regulatory quality • The rule of law
Educated and skilled workers	• Adult literacy rate • Gross secondary enrollment rate • Gross tertiary enrollment rate
An effective innovation system	• Royalty payments and receipts, US$ per person • Technical journal articles per million people • Patents granted to nationals by the US Patent and Trademark Office per million people
Information infrastructure	• Telephones per 1000 people • Computers per 1000 people • Internet users per 1000 people

Source: *Ojanperä, S., et al., (2019).*

5 SDG Index

In line with the principles of the Rio Declaration, Agenda 21, and the Johannesburg Declaration, the outcome document of the 2012 United Nations Conference on Sustainable Development, entitled "The Future we want," highlights the three dimensions (social, economic, and environmental) of sustainable development and expressly calls for a balanced integration of these three dimensions through equitable economic growth, social development and protection of the environment (Le Blanc, D., 2015).

The international community is committed to a new plan declining the Sustainable Development Goals (SDGs) by 2030. Achieving these goals requires establishing an organizational framework and reforms at both national and international levels to promote faster growth, improve equity and equality of opportunity and determine environmental sustainability. The seventeen (17) SDGs and their one hundred and sixty-nine (169) targets or sub-targets and their two hundred and thirty (230) indicators form the core of the 2030 agenda (UNCTAD, U., 2014).

- ***Goal 9: Build resilient infrastructure, promote sustainable industrialization that benefits all, and encourages innovation.***

The three pillars of SDG 9 are infrastructure, industry, and innovation, all of which are inextricably related and share the common purpose of economic growth. Goal 9 focuses on fostering infrastructure growth, industrialization, and innovation through increased international and national financial, technological, and technical assistance, research and innovation, and improved access to ICTs.

Goal 9 calls investments in infrastructure - transport, irrigation, energy, and ICT - essential for sustainable development and community empowerment in many countries. It has long been known that productivity growth, incomes, and improvements in health and education require infrastructure investments (Klapper, L. et al., 2016).

Simultaneously, technological advances are spurring efforts to achieve environmental goals, such as the optimal use of resources and energy. Without technology and innovation, there would be no manufacturing, and without manufacturing, there would be no development. Additional investments in the high-tech products that dominate manufacturing production are needed to increase efficiency and focus on mobile cellular services that improve communication.

Goal 9 includes this, as well as a set of indicators (UNDP, 2019):

SDG9. 1: Develop quality, reliable, sustainable, and resilient infrastructure, including regional and cross-border infrastructure, to support economic development and human well-being, focusing on universal, affordable, and equitable access.

This target is operationalized through the following objectives: (i) develop road, rail, airport, and port infrastructure through the construction, rehabilitation, and maintenance of roads and engineering structures; the construction and rehabilitation of railway infrastructure; the construction and rehabilitation of airports and aerodromes and the revitalization of river and maritime transport; (ii) develop and modernize transport services through the modernization of terminal land transport infrastructure and the development of a transport system in the regions.

SDG9. 2: Promoting sustainable industrialization that benefits all and, by 2030, significantly increases the industry's contribution to employment and gross domestic product, depending on the national context, and doubles it in the least developed countries advances.

SDG9. 3: Increase, especially in developing countries, the access of enterprises, especially small industrial enterprises, to financial services, including affordable loans, and their integration into value chains and markets.

This target is through the following objectives: (i) infrastructure and financial services that facilitate access to financial and non-financial services through the implementation of the financial literacy program for SMEs and populations and the development and implementation of the national financial inclusion strategy; (ii) create the conditions for the emergence of a base of SMEs by improving the growth and competitiveness of SMEs and promoting their long-term access to appropriate financial and non-financial services in particular through the labeling process for SMEs.

SDG9. 4: By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action following their respective capabilities.

SDG9. 5: Strengthen scientific research, improve the technological capabilities of industrial sectors in all countries, especially developing countries, including by encouraging innovation and significantly increasing the number of people working in the research-development sector by 1 million and increasing public and private spending on research and development by 2030.

This target encompasses education and training. Each country should promote research results and promote access to technology by establishing incubators in all public universities and disseminating technological innovations and promotion. Research and strengthening the functioning of research institutions through the construction and operation of new research centers for technology transfer and innovation and improvement of the learning environment, higher institutes and universities, plus the contribution of ICTs to the development of scientific research.

SDG9. a: Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological, and technical support to African countries, least developed countries, landlocked developing countries, and small island developing States.

SDG9. b: Support the research, development, and innovation activities of developing countries in the technology sector, particularly by creating favorable conditions for industrial diversification and the added value of goods.

SDG9. c: Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in the least developed countries by 2020.

Table 13: Goal 9 Key Target

9.1	Quality, reliable, sustainable, and resilient infrastructure
9.2	Inclusive and sustainable industrialization
9.3	Access of small-scale industries and other enterprises to financial services
9.4	Retrofit industries to make them sustainable
9.5	Enhance scientific research, upgrade the technological capabilities of industrial sectors
9.a	Enhanced financial, technological, and technical support
9.b	Support domestic technology development, research, and innovation in developing countries
9.c	Significantly increase access to information and communications technology (ICT)

Source: *Allen, C., et al. (2018).*

Each target includes some indicators, and the following table combines the most important indicators for each target:

Table 14: Indicators of Sustainable Development Goals – Goal 9

SDG 9. 1	• Number of passengers and volume of freight transported, by mode of transport. • Share of inland navigation in the total transport of goods.
SDG 9. 2	• Value added in the manufacturing industry, as a share of GDP and per capita. • Manufacturing value added in GDP (% of GDP).
SDG 9. 3	• Proportion of small businesses in total industry value-added. • Value added excluding taxes of the manufacturing industry of enterprises with 0 to 9 employees.
SDG 9. 4	• CO2 emissions per unit of value-added. • Carbon dioxide emissions per unit of GDP (PPP).
SDG 9. 5	• Research and development expenditure as a share of GDP. • Domestic Research and Development Expenditure (GERD) as% of GDP (research effort). • Number of researchers (full-time equivalent) per million inhabitants. • R & D personnel (number of people).
SDG 9. A	• International public aid (official development assistance and other public sector contributions) allocated to. • Official Development Assistance (ODA) in Infrastructure and Economic Services.
SDG 9. B	• Proportion of value added of medium and high-tech industry in total value added.
SDG 9. C	• Proportion of population with access to a mobile network, by type of technology • Customers subscribing to mobile networks

Source: *Gupta, J., & Vegelin, C. (2016).*

The 2030 Agenda inspires us to think creatively, using innovative approaches, and critically rethinking our approach to today's development challenges. Advocacy and advocacy efforts to achieve applicable and achievable goals are essential to mobilize support for the 2030 Agenda. However, raising consciousness and advocating for reform are insufficient to bring about long-term change. To achieve the Sustainable Development Goals, it is essential to have a thorough understanding of the 2030 Agenda's scope and depth.

Section Two: Empirical Study on Technological Capacity

Technological progress improves manufacturing, marketing, and distribution of goods and services and stimulates economic growth. Technology is at the very heart of humanity's progress and development. It has been largely the engine of economic and social progress made over the past centuries. And it will help meet the environmental challenges of the 21st century.

1 What is Exactly the Technological Capability?

During the 1990s, theoretical and empirical studies have deepened research into the subject of technological capacity and its impact on economic growth (Lall, S., (1992); Bell, M., & Pavitt, K., (1995); Archibugi, D., & Pianta, M., (1996); Panda, H., & Ramanathan, K., (1996); Kim, L., (1999); Garcia-Muiña, F. E., & Navas-López, J. E., (2007), Jin, J., & Von Zedtwitz, M., (2008), Matias, C. A., et al., (2013); Reichert, F. M., & Zawislak, P. A., (2014)).

Technological capability includes skills, knowledge, and experiences that leverage existing systems and generate technical change.

According to Lall, S. (1992), technological capability is a continuous process of absorption and creation of technological knowledge that is part of the interaction with the environment and the accumulation of skills and knowledge mastered by a company (Reichert, F. M., & Zawislak, P.A., 2014).

The system of activities, the physical systems, the bases of skills and knowledge, the management systems of learning and incentive, all these expressions reflect the technological capacity. The studies revealed that TC played a significant role in gaining competitive advantages and improving business performance, and even having a strong economy for a country (Nurazwa, A., et al., 2014).

The role of technology in the new economy has become a hotly debated subject. Several authors have investigated their effect on growth, profitability, business strategies, and competitive advantage (Pepard, J., & Ward, J., 2004). The idea of technological capability has been described in a variety of ways by various writers. However, as most of them have operationalized technical capability in the same manufacturing and technology, the meanings were similar. Table 15 lists all of the main meanings for the phrase.

Table 15: Technological Capability definitions

Authors	Definitions
Lall, S. (1992)	The capability to execute all technical functions entailed in operating, improving, and modernizing firm's productive facilities.
Bell, M. & Pavitt, K. (1992)	The resources needed to generate and manage technical changes accumulated and embodied in skills, knowledge, experience, and organizational system.
Wilson, G. (1995)	The ability to select technologies appropriate for the work being undertaken, absorb and adapt technologies into local settings, and the ability to develop new technologies, processes, and products via local innovations.
Teece, D. J., et al., (1997)	The ability to perform any relevant technical function or volume activity within the firm including the ability to develop new products and processes and to operate facilities effectively.
Aw, B. Y., & Batra, G., (1998)	The ability to adapt or assimilate technology imported from abroad and to incorporate the additional and distinct resources needed to manage and put to productive use the newly acquired technology.
Kim, L. (1999)	The degree of capability of organizations in developing new products, which related to the organizations' age.
Costa, I., & de Queiroz, S. R. R. (2002)	The skills, knowledge, and experience required for a firm to achieve technological change at different levels.
Zahra, S. A., & Nielsen, A. P. (2002)	The set of skills the firm has in building and leveraging different technologies and system.
Figueiredo, P. N. (2002)	The resources needed to generate and manage improvements in processes and production organization, products, equipment and engineering projects.
Madanmohan, T. R., et al., (2004)	The knowledge and skills required for firms to choose, install, operate, maintain, adapt, improve, and develop technologies
Oyebisi, T. O., et al., (2004)	The ability of a country to choose acquires, generate and apply technologies which contribute to meeting its development objective
Tsai, K. H. (2004)	The assimilation and application of the technological knowledge from R&D activities to production.

Coombs, J. E., & Bierly III, P. E. (2006)	The firm's ability to be effective during the transformation process of turning inputs into outputs, relative to its competitor.
Wang, Y., et al., (2006)	The ability to develop and design new products and processes and upgrade knowledge about the physical world in unique ways, thus transforming this knowledge into designs and instructions to create desired outcomes.
García-Muiña, F. E., & Navas-López, J. E. (2007)	The generic knowledge-intensive ability to jointly mobilize different scientific and technical resources enables a firm to successfully develop its innovative products and/or productive processes by implementing competitive strategy and creating value in a given environment.
Sethi, A. P. S., et al. (2007)	The skills and know-how required to manage, create, and extend the existing pool of technological knowledge.
Figueiredo, P. N. (2008)	The resource needed to generate and manage technological change.
Iammarino, S., et al. (2008)	The knowledge and skills are embedded in individuals, organizations, and institutions located in a geographically-bounded area and conducive to innovative activity.
Jin, J., & Von Zedtwitz, M., (2008)	To make effective use of technical knowledge and skills, improve and develop products and processes, and to improve and develop products and processes, improve existing technology, and generate new knowledge and skills in response to the competitive business environment.

Source: *Authors' adaptation from Ahmad, N., et al. (2014)*

The different definitions can be summarized by a global definition in which technological capability can be considered a set of knowledge, skills, experience, and ability to select technologies, configure, exploit, assimilate, maintain, evolve, and extend new values to processes and products. Functional skills, which represent an organization's success through various technical activities, were also included in technological capability (Panda, H., & Ramanathan, K., 1995).

In addition to the technical aspects, the extended vision of technology encompasses the dimensions of tasks, processes, and skills. But this extended view remains a static description of the technical, functional, organizational, and social aspects of technology. The interactions between these different components and individuals' actions are not considered, obscuring major issues related to the impacts generated by technology. Some works offer a view that integrates the material vision and some extended vision dimensions (Dahlman, C. J., 1992).

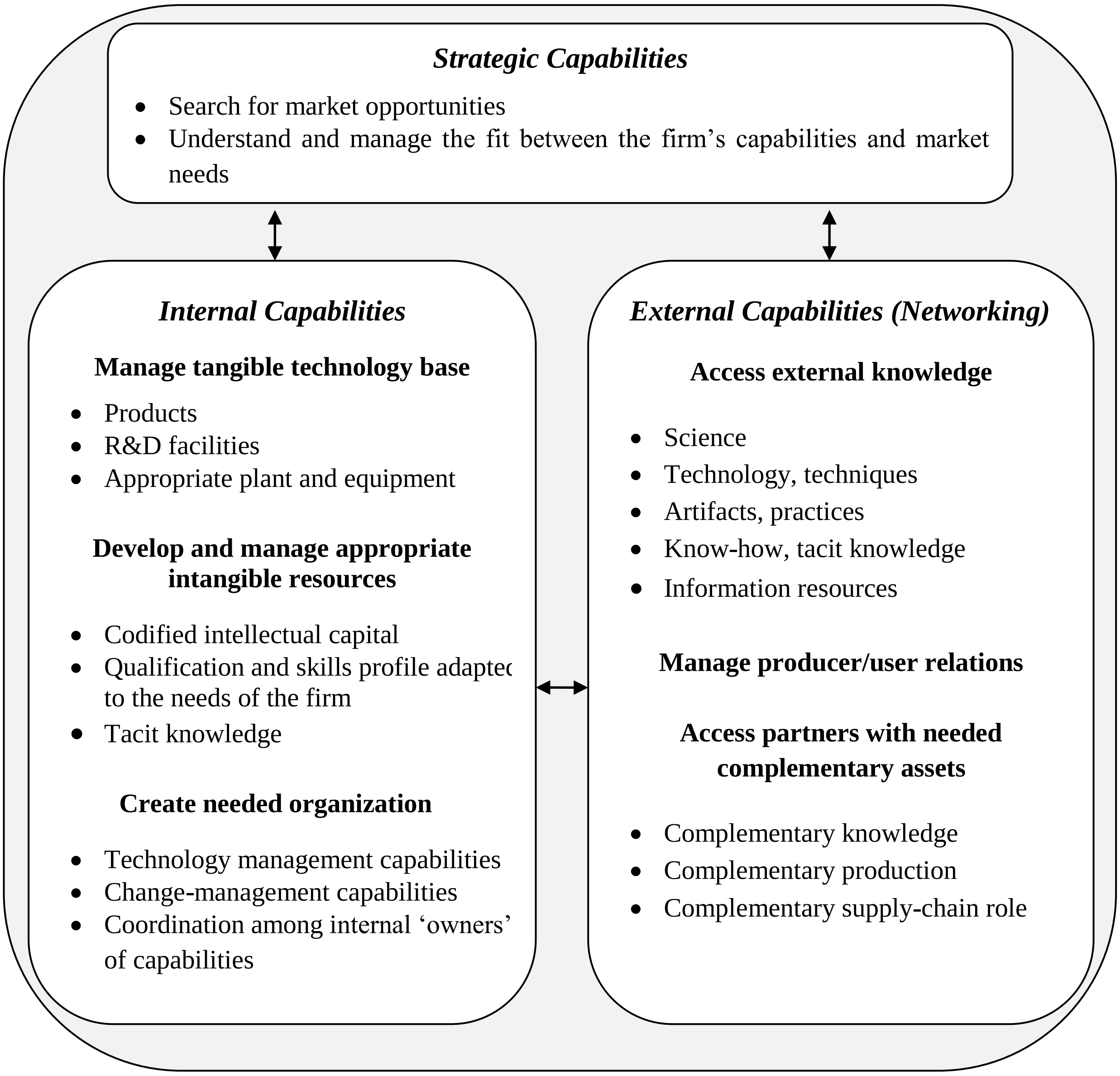
A distinction must be made between technology and the technological method, according to Weick, K. E. (1990). A technical system is a collection of devices and physical and mental processes that enable matter to be transformed. The physical system, as well as the fabric of actions and interactions between individuals and groups of individuals, that create meaning in contact with that technical system and its use, are all included in technology.

Technology, innovation, and knowledge management are at the heart of business concerns in this globalized economy. Companies must participate in a continuous learning process to ensure proper assimilation and distribution of emerging information technologies. Companies use technologies to improve their perpetual competitive position in introducing new products or exploiting new processes (Utterback, J., 1994), and this is an essential element for improving business performance (Zhou, D., et al., 2005), where companies use technologies to improve their perpetual competitive position in introducing new products or exploiting new processes (Al-Ansari, Y, et al., 2013).

Former researchers have studied different types of technological capacities and mentioned the variety of abilities in their studies as acquisition capacity (Panda, H., & Ramanathan, K., (1996); Kim, L., (1999); Takim, R. et al., (2008)), productive capacity (Lall, S., (1992); Gammeltoft, P., (2004)), learning ability (Simon, A., et al., 2011), capacity for innovation (Prajogo, D. I., & Ahmed, P. K. (2006); Takim, R., et al., (2008)), networking abilities (Äyväri, A., & Jyrämä, A. (2007); Álvarez, I., et al., (2009)), human resources (Abeysinghe, D., & Paul, H. (2005); Rasiah, R., 2009) and research and development capabilities (Krasnikov, A., & Jayachandran, S. (2008); Ren, S., et al., (2015)). The technological capacity has been classified in the technological capacity strategic, tactical, supplemental, and directional (Panda, H. & Ramanathan, K., 1996).

By reviewing the literature on the concept of technological capabilities, it is possible to design technological capabilities: there are three types of capabilities: internal, external, and strategic.

Figure 15: Key elements of Technological Capability



Source: *Arnold, E., & Thuriaux, B., (1997).*

The figure depicts how the strategic level offers an intelligence or control mechanism that enables the organization to manage its capabilities and market exploitation.

This level means that knowledge must be used to improve performance. In modern industrial practice, the strategic function monopolises learning and ensures disseminating knowledge at allwork levels. To provide a basic element of the "research intelligence" necessary for developing and managing technological capabilities, the strategic functions form the main interface with the company's commercial capabilities that determine the business's core competencies (Arnold, E., & Thuriaux, B., 1997).

The second category concerns the company's internal capabilities, enabling it to identify the appropriate physical infrastructure to meet the company's competitive needs and invest in them by analyzing the situation and applying the necessary skills (Bartmess, A., & Cerny, K., 1993). The internal capabilities contain three main elements:

- Managing the tangible technology base.
- Developing and managing intangible resources.
- Creating the organization needed to use these assets effectively.

The third level is external capabilities, managing the relationship between the company and the external resources it needs (Johnson, B. H., 1992). External or networked technological capabilities imply:

- Access external knowledge.
- Manage the producer or user relationship that is at the heart of successful innovation.
- Access other partners who have useful additional assets and capabilities.

Internal capabilities and external links - usually grouped under the term "networks" - are important.

"Cross-sector studies have found that external sources contribute around one third of all knowledge used in innovation, with more being obtained from other companies than (public sector research) institutions (..) Of the two-thirds that are obtained internally, half is knowledge which is personally held" (Rothwell, R., 1989)

2 Measuring Technological Capacity

There is a clear link between technological capability and economic growth, and it is important to better understand this link, both at the firm and at the macro level. At the national level, we need to use empirical data. Most of the indicator studies that measure business performance based on technological capability often use R&D investments and the number of patents filed by the firm (Hall, L. A., & Bagchi-Sen, S., (2002); Coombs, J. E., & Bierly III, P. E., (2006), Garcia-Muiña, F. E., & Navas-López, J. E., (2007)).

The following table includes the majority of the authors who mentioned research and development and patents in their work:

Table 16: Basis for Technological Capability Indicators

Elements	The basis for technological capability indicators
R & D	• Resources allocation to R&D (Archibugi, D., & Pianta, M., 1996; Kim, L., 1999; Tsai, K. H., 2004; Figueiredo, P. N., 2008) • Average R&D investment as % of sales (Madanmohan, T. R., et al., 2004) • R&D intensity (the ratio of R&D expenditure and sales) (Coombs, J. E., & Bierly, III, P. E., 2006; Hall, L. A., & Bagchi-Sen, S., 2002) • R&D for product specification (Bell, M., & Pavitt, K., 1995) • Cooperative R&D (Lall, S., 1992; Jin, J., & Von Zedtwitz, M., 2008) • Basic research (Lall, S., 1992) • Development of new technologies through partnerships (Bell, M., & Pavitt, K., 1995) • Projects of R&D (Panda, H., & Ramanathan, K., 1995) • Conduction of R&D activities (Archibugi, D., & Pianta, M.,1996; Jin, J., & Von Zedtwitz, M., 2008) • Existence of an R&D department (Kim, L., 1999) • R&D capability (Yam, R. C., et al., 2004) • Efforts in R&D (internal R&D, cooperative R&D, and technology import) (Tsai, K. H., 2004) • Existence of R&D centers that have a partnership with research institutes (Figueiredo, P. N., 2008)
Patent	• Number of patents (Archibugi, D., & Pianta, M., 1996; Tsai, K. H., 2004; Coombs, J. E., & Bierly, III, P. E., 2006; Figueiredo, P. N., 2008) • Patent applications (domestic and international) (Hall, L. A, & Bagchi-Sen, S., 2002) • Patent approval (domestic and international) (Hall, L. A., & Bagchi-Sen, S., 2002) • Patent impact (measured by average citations that patents received) (Coombs, J. E., & Bierly, III, P. E., 2006) • Technology cycle time (average number of years that the patent was prominently cited) (Coombs, J. E., & Bierly, III, P. E., 2006)

	• Scientific relationship (patent citation in scientific articles) (Meyer, M., 2000) • Relationship between the patent indicator and its impact (Chen, Y. S., & Chang, K. C., 2010) • Total scientific relationships of the firm's patents (Coronado, D., & Acosta, M., 2005) • Local property right of a product (Jin, J., & Von Zedtwitz, M., 2008)

Source: *Authors' adaptation from Reichert, F. M., & Zawislak, P. A. (2014).*

In addition to R&D and patents, technological capacity can be measured using a variety of other indicators, such as internal measures of an economy's performance such as the human development index, government measures such as political stability, measures of innovation such as the number of researchers, etc. Despite the fact that many authors use a variety of indicators to evaluate and quantify technological capacity, we emphasize all of the elements presented with indicators that measure technological capacity (Abdullah, M. H. R. O., et al., 2015).

It is assumed that the efficient use of resources results in positive results for the company. In this sense, investments in technological capabilities enable a company and a country to achieve positive economic performance (Reichert, F. M., & Zawislak, P. A., 2014). Then we looked for the most important measures of technical capability and economic growth. The indicators used in this search are listed in the table below:

Table 17: All indicators that measure Technological Capacity

Global Performance of the Economy	• Human Development Index (HDI) • Gross Domestic Product (GDP) Per Capita • Gross Domestic Product (GDP) (current US$ bill) • Multidimensional Poverty Index • Gender Inequality Index • Composite Risk Rating
The Economic Regime	• Trade as % of GDP • Exports of Goods and Services as % of GDP • Domestic Credit to Private Sector (% of GDP) • Cost to Register a Business (% of GNI per capita)

Governance	• Regulatory Quality • Rule of Law • Political Stability • Control of Corruption • Press Freedom
The Innovation System	• Royalty and License Fees Payments and Receipts (US$ millions) • Scientific and Technical Journal Articles • Patent Applications Granted Per Million People • Researchers in R&D • Researchers in R&D Per Million Population • Total Expenditure for R&D as % of GDP
Information and Communication Technology	• PC penetration in households • Number of internet host per 1000 inhabitants • The percentage share of ICT industries in GDP • Share of ICT in patents granted • Telephones Per 1,000 People • Computers Per 1,000 Persons • Internet Users Per 1,000 people • Mobile Phones Per 1,000 People • TV Households with Television • Availability of e-Government Services • ICT Expenditure as % of GDP
Knowledge-Based Economy	• Knowledge Investment (education, R&D, and software) as % of GDP • Education of the adult population as % of the population aged 25-64 • R&D expenditure as a percentage of GDP • Basic research expenditure as a percentage of GDP • Expenditure of Business R&D in the domestic product of industry • Expenditure of Business R&D in manufacturing

	• Share of services in R&D expenditure • Expenditure on innovation as a share of total sales • Investment in venture capital as a percentage of GDP
Education And Human Resources	• Tertiary Enrollment (% gross) • Adult Literacy Rate (% age 15 and above) • Average Years of Schooling • Internet Access in Schools • Public Spending on Education as % of GDP • No Schooling, total
SDGs (Goal.9)	• Technological Innovation and Research and Development (R&D) • Access to ICT • Internet use • Mobile broadband subscriptions • Infrastructure Investment • Logistics Performance Index • Quality of overall infrastructure

Source: *Author's adaptation from (Karahan,O., 2012), (Zak, K., 2016) and (Blakely, E. J., & Hu, R., 2019)*

Technological capacity includes all accumulated skills, knowledge, technologies, and learning experiences, both internally and through external relations with institutional actors focused on innovation (Solis-Quinteros, M. M., et al., 2017). More specifically, technological capacity includes four management perspectives: research and development (R&D), patenting of inventions, hiring of technical personnel, and introducing new products on the market (Nevado-Peña, D., et al., 2019).

Technological capacity has been considered an important element of a country's economic growth, as the development of a business depends on introducing new products over time. Little research has been done on the technological capabilities and internationalization of companies in emerging countries such as Russia, India, Brazil, Turkey, and China (Dunning, J. H. (1994); de Almeida Guerra, R. M., & Camargo, M. E. (2016); Ramos, H. A. D. C., et al., (2018)).

Section Three: Empirical Study Focusing on Emerging Countries

In emerging countries, the paternity of the term is, as a rule, attributed to Antoine van Agtmael[21], an economist at the International Finance Corporation who wanted, by this term, distinguishes within the category of developing countries between those that presented significant risks for international investors and those that, on the contrary, could be "opportunity lands". The term "emerging markets" was coined in the 1980s to differentiate between the wheat (high-growth countries with low debt levels, whose capital accounts were sufficiently open to receive capital) and the chaff (a country with low growth, collapsing under the weight of debt, and relatively closed to capital inflows) (Montiel, P. J., 2011).

1 How are Emerging Countries Classified?

What countries are considered emerging? Several large geographic areas can be distinguished. During its transformation to a market economy, Eastern Europe underwent major changes and strengthened its production apparatus. Investors were reassured by the entrance of some Eastern European countries into the European Union, as well as the convergence of these countries' financial markets. Latin America is also a member of the emerging region, with stronger macroeconomic management and a political situation that has improved the economic integration of these countries (Uribe, M., & Yue, V. Z., 2006).

It would be sufficient to refer to the lists of countries established by international institutions (World Bank, IMF), financial organizations (Goldman and Sachs), or a group of experts (Boston Consulting Group, Standards and Poor's) to determine the outline of this category of country. However, since the 1980s, the list of emerging countries has continued to multiply (each international body has its list of emerging countries), to renew itself, without it being possible to cross them - except for the indrostable Brazil, Russia, India, China, South Africa (BRICS) that appear systematically - or to find really common elaboration criteria. These lists mix large and small countries (in terms of size and population), rentier countries, oil producers, and countries more or less integrated into world trade (Nicet-Chenaf, D., 2014).

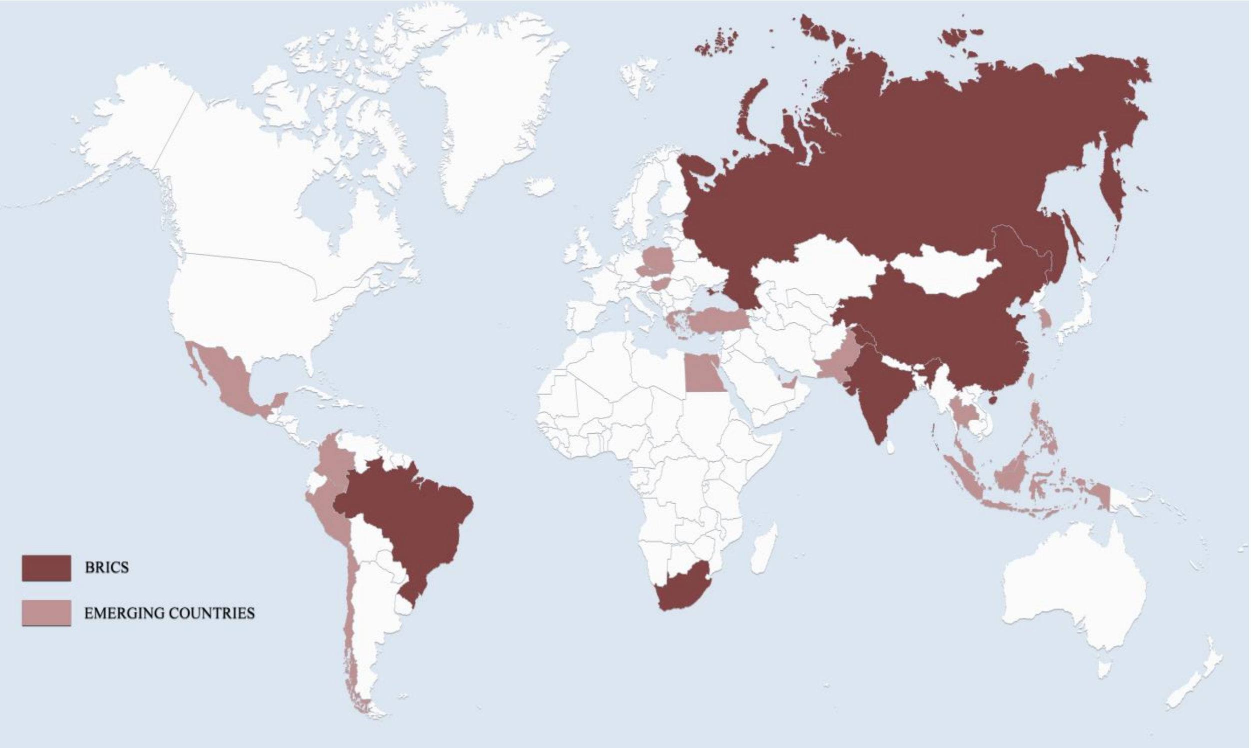
Brazil, Russia, India, and China, joined in December 2010 by South Africa in the "BRICS" group, are among the most prominent. But the notion of an emerging economy is beyond them

[21] ***Antoine van Agtmael***. As a senior advisor, Antoine brings decades of experience successfully anticipating and acting on emerging global trends. Antoine was the principal founder, CEO and CIO of Emerging Markets Management LLC, an early and leading investment management firm for emerging market equities.

and now concerns a wide variety of countries. Other countries, *"VISTA", Vietnam, Indonesia, South Africa, Turkey, and Argentina, "Next Eleven," Bangladesh, Egypt,* Indonesia, Iran, Mexico, Nigeria, Pakistan, Philippines, South Korea, Turkey and Vietnam, so many terms have been invented in recent years to designate a set of new actors whose emergence on the international scene seems indisputable and inevitable.

According to the Morgan Stanley Capital International (MSCI)[22] Emerging Market Index, 23 developing countries qualify as emerging markets - including Brazil, Chile, China, Colombia, Czech Republic, Egypt, Greece, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Qatar, Russia, South Africa, Thailand, Turkey, and United Arab Emirates. The index follows the market caps of the companies on the countries' stock markets.

Figure 17: The 24 Emerging Countries according to MSCI



Source: *Author's construction based on MSCI DATA*

[22] ***MSCI*** is a leading provider of critical decision support tools and services for the global investment community.

2 Common Characteristics of Emerging Countries

2.1 Characteristics of Emerging Countries

What does it mean to be an emerging country today? It's difficult, if not impossible, to provide a succinct answer to this question. In recent years, developing countries have seen the emergence of new economic markets that mirror developed markets, causing concern. These are emerging markets, a term that refers to countries that are not yet established. Different meanings of emerging markets, on the other hand, have been suggested. Still, we'll concentrate on the description suggested by D. J. Arnold and J. A. Quelch (1998). They looked for countries that meet two criteria: the first is rapid economic development, as well as government policies that promote economic liberalization and the adoption of a free market system (Bhagat, S., et al., 2011):

- Middle income: their per capita incomes are intermediate between those of the least developed countries and those of the rich countries, which could be expressed through GDP growth rate (it should be at least 5% per year), caused by a governmental attempt to create a market economy.
- Retrofit dynamics: their past growth has placed them on a trajectory of catching up with Western living standards without, however, reaching them. The long-term growth rate of their GDP is higher than the world average.
- Transformations and openness: in recent decades, these countries have undergone institutional and structural changes that have helped to insert them in a new way into the global economy. These economies exchange more and more with the rest of the world and benefit from Western multinational firms' industrial establishments and services. Some are now developing their investment capabilities abroad and are thus actively contributing to globalization.
- Growth potential: given the gap that still separates them from the living standards of the advanced countries and their evolution during the last decades, these economies have significant growth potential in the medium to long term.

According to Miller, R. R. (1998), each emerging country is unique, but some more common features could be summarized as follows:

- Physical characteristics, in terms of inadequate business infrastructure and inadequacy of all other aspects of the physical infrastructure (communication, transport, power generation).
- Socio-political characteristics including political instability, inadequate legal framework, weak social discipline and low technological levels, in addition to (unique) cultural characteristics.
- Economic characteristics in terms of limited personal income, centrally controlled currencies, and a role of government influence in economic life is expressed, on the other hand, in managing the transition process to the market economy.

2.2 Some Notions of Emerging Countries

An emerging country is also experiencing rapid economic growth, placing it on a convergence trajectory with developed countries. This economic growth is accompanied by a reduction in poverty and the birth of an increasingly large middle class accessing consumption. Development is gradually becoming self-sustaining and domestic markets are developing (Jaffrelot, C., 2009).

On the economic level, these countries have succeeded in establishing themselves as leaders in specific key sectors of international trade, of which we will retain, principally: Brazil is a formidable agro-exporter in agriculture, having been designated as a world farm, with abundant cultivable land and a diverse range of climates that allow for the production of a wide range of products. Russia, the world's largest nation, is rich in natural resources such as hydrocarbons, rare minerals, and vast forests. However, it is beset by economic and social problems and remains reliant on a petroleum-based rent economy. Russia is putting its confidence in its energy resources (Radulescu, I. G., et al., 2014). India holds a qualified English-speaking workforce in the services, with low wages, enabling it to impose itself in the service sectors, business services, and specializes in IT services. In manufacturing products and textiles, China is considered the most powerful of the emerging states and a rising power with which the rich and industrialized countries of the Triad[23] must now count. China is a hypercompetitive manufacturing exporter, generally has an abundant workforce (of which the countryside constitutes a colossal reservoir), unskilled, whose low wages ensure the competitiveness of Chinese industry (de Paula, L. F., 2008). South Africa joined the BRIC group at the end of 2010, which became BRICS (with an s for South Africa) until apartheid was dismantled. South Africa suffered from a set of

[23] ***Triad/Triadization,*** the concept was defined by the Japanese economist **Kenichi Ohmae** in 1985. He designated under this name the three major markets of the planet which were then *Japan*, the European Economic Community *(EEC)* (composed of ten members) and the *United States*, where all large multinational company must be present.

international sanctions. After so many years of self-sufficiency, South Africa has bet on globalization. It has reconverted its productive apparatus and took advantage of trade liberalization to integrate into the world economy. This country is positioned as one of the leading economic powers on the continent and the most robust industrial production and with a reliable and dynamic industrial fabric; it is particularly well placed in the chemical, paper, telephone, automotive, energy, drugs, armaments, and building components (Matete, N., & Trois, C., 2008). Furthermore, the democratic South Africa has been able to build on existing infrastructure. It has also been able to modernize and multiply them in order to get them up to the level of a modern world.

Figure 18: The 05 BRICS Emerging Countries

Each of these countries has exploited its competitive advantages to the fullest extent possible. The economic and demographic weight of these five nations, as well as their capacity to dominate the international political scene, set them apart from other developing countries.

Other countries Next Eleven, Colombia, Vietnam, Mexico, Nigeria, Pakistan, Philippines Indonesia, Egypt, Turkey, ect., all these countries share the following qualities: large, young and growing population; dynamic and diversified economy; relative political stability; very bright future (Valliere, D., & Peterson, R., 2009). These countries' emergence is reflected in a significant progression along two dimensions: income and foreign trade. Their rapid growth allows emerging economies to hope to emerge from underdevelopment in the long term, while their openness integrates them more deeply into world trade flows.

They are concerned with the degree of centralization of economic decisions and modes of communication between agents, the economic position of public power, the development of laws by private agents, economic ties between residents and non-residents, as well as other aspects of economic and social life (Tong, X., et al., 2018). Emerging countries are distinguished by faster and more dramatic structural change than developed countries, as well as the amount of per capita income they have now achieved, which is halfway between emerging and advanced countries (Seven, U., & Coskun, Y., 2016). Therefore, the emergence is a process of economic and institutional transformation of middle-income countries resulting in strong economic growth and increased participation in world trade flows.

3 Research and Development in Emerging Countries

3.1 Innovation and Emerging Countries/Market

Innovation is often presented in developed countries as a possible response to the challenge of emerging countries. A large volume of data on R&D and its position, as well as the transformations of education systems, indicates that these practices have now become globalized. The emerging economy is becoming more relevant. However, experience in recent years suggests that emerging countries are expected to play an increasing role in the global innovation economy under the combined effect of three prominent trends (Lanvin, B., & Miroux, A., 2016):

- Innovation from emerging economies now has a significant solvent market, stemming from the growth of a middle class whose purchasing power justifies the search for local innovations, corresponding to specific needs and often reflecting a culture of quality different from Innovation.
- The proliferation of cooperation agreements between multinationals and local companies in research and development feeds the cycle of globalization of innovation based on common information systems that allow increased and continuous innovation between partners (Nuruzzaman, N., et al., 2019).
- The majority of emerging countries still face the challenge of fully participating in global innovation, particularly concerning talent and governance; however, rapid progress in these areas in recent years indicates that these obstacles will be overcome (Frick, S. A., et al., 2019).

Emerging economies have already started to bring about fundamental changes in the very nature of the innovation process to pursue objectives; innovate in areas corresponding to the most pressing local demands (Alam, A., et al., 2020), nurturing the capacity for long-term innovation, which will, in particular, imply a policy of continuous public funding for basic research and develop new models of cooperation with companies and training and research centers in emerging countries (student and researcher exchanges, cross-investments, global career and talent management). Emerging countries are blowing the world of global innovation today must not be seen as a competition or a threat but as a collective enrichment.

3.2 Technological Capacity and Emerging Market

Emerging countries have experienced impressive growth rates on a large number of science and technology indicators. The success of these countries appears to vary based on the geographical reach of their scientific and technical capabilities; they have a high rate of opening and attract a large amount of foreign investment.Foreign affiliates have contributed significantly to these exports, especially in the ICT sector. Furthermore, international companies were instrumental in each country's recent rise in the number of patents.

Composite indicators of scientific and technological capacity have recently been developed to compare different development levels. Typically, they integrate R&D input and output indicators, data on technological infrastructures, and ICT diffusion indicators. They meet the same objectives but use different data and methodology. Numerous studies have shown that technological capacity is essential to gain a competitive advantage for emerging countries (Deeds, D. L., et al., (1997); Afuah, A., (2002), Ortega, M. J. R., (2010)), multinational companies seeking to accelerate the transfer of technology units located in developed countries to its affiliates located in developing countries (Niosi, J., (1999), Liefner, I., et al., (2013)), for example, China (Yin, J. Z., (1992); Chakrabarti, A. K. & Bhaumik, P. K., (2010); Li, D. Y., & Liu, J. (2014)), Russia (Väätänen, J., (2009); Shinkevich, A. I., et al., (2017)), Mexico, Brazil and India (James, D. D., (1991); Cassiolato, J. E., et al., (2003); Sahoo, B. K., & Tone, K., (2009)). Moreover, technological capabilities remain an effective instrument for neutralizing threats and exploiting the opportunities offered by the environment, as demonstrated by numerous empirical studies (Nicholls-Nixon, C. L., & Woo, C. Y., (2003); Teo, H. H., et al., (2006); Liao, S. H., et al., (2007); Ruiz-Jiménez, J. M., & del Mar Fuentes-Fuentes, M., (2013); Lin, C., & Chang, C. C., (2015); Morita-Lou, H., (2019)).

Conclusion

Thousands of scholarly documents and numerous rankings and business indices demonstrate that researchers and practitioners recognize the value of innovation and technical potential, as illustrated in this chapter. Many studies have looked at how to measure innovation and technical potential, and they've found that there are a variety of metrics to consider, including R&D, patents, scientific papers, and so on. Human capital is another important component that must be measured. We, on the other hand, focused on developing countries.

In 1981, as stock markets worldwide moved, the International Finance Corporation, a World Bank company, developed emerging countries' concept to distinguish developing countries that offer considerable opportunities to investors from those who provided only limited economic attractiveness. In general, in emerging countries, by liberalizing their economies, the state's role in the economy is reduced by opening these markets to foreign investors.

However, at the end of the chapter (section three), we showed no specific definition of emerging countries. Still, they can be described as incomplete countries in terms of financial infrastructure. Still, with strong growth opportunities, some countries in this category are classified according to the gross national product (GDP) or debt level.

Chapter Four

Estimation of Technological Capacity in Some Emerging Countries

Introduction

Panel data has been widely used in econometric research in many social sciences in recent years. Panel data incorporates cross-sectional and time-series data to create a more visually pleasing data analysis than either cross-sectional or time-series data alone. While more expensive to collect, the benefits of this data form include better and more accurate parameter estimation due to the larger sample size and data modeling simplification (Hsiao, 2005).

In this chapter, we use Panel data to calculate a collection of variables that we will identify on a group of countries where this study will take place over a specific time period to measure technological potential in the case of some emerging countries. The most important indicators that can measure or impact the country's technical ability and innovation due to a relationship between them will be collected in the previous chapter.

We introduce some variables to test the innovation as a dependent variable to capture the appropriate regression model for 2000-2018. This is to obtain the most important variable or variables that measure the technological capacity in some emerging countries.

Section One: Panel Data

Panel (or longitudinal) data is a form of data in which observations are collected over time on the same collection of individuals. It refers to data with a large number (N) of cross-sectional units and repeated time-series observations (T) (e.g., states, regions, countries, firms, or randomly sampled individuals or households, etc.). For individual unique variables, panel data estimation techniques may directly account for such heterogeneity.

1 Definition of Panel data model

Panel data is extracted from a (usually small) number of observations over time on a (usually large) number of cross-sectional units such as persons, families, businesses, or governments.

Panel data is a term used in econometrics and statistics to describe multi-dimensional data that typically includes measurements taken over time. As a result, panel data is made up of the researcher's observations of a variety of phenomena over time for the same group of units or entities (McManus, P., 2015).

Panel data econometrics is a continuously developing field. The increasing availability of data observed on cross-sections of units (like households, firms, countries, etc.) and over time has given rise to several estimation approaches exploiting this double dimensionality to cope with some of the typical problems associated with economic data, first of all, that of unobserved heterogeneity. Time-wise observation of data from different observational units has long been common in other statistics fields (where they are often termed as longitudinal data) (Eom, T. H., et al., 2008).

A panel data regression model (or panel data model) is an econometric model designed explicitly for panel data.

The main advantages of the panel data set and the panel data models are (Wooldridge J.M., 2001; Hsiao, C., 2003):

- The apparition of a larger number of observations
- New economic questions (identification)
- Unobservable components
- Easier estimation and inference

Panel data is data from some of the same individuals observed at a particular time. If we have T periods (t = 1, 2, ... T) and N the number of individuals (i = 1,2, ..., N), we will have total observation units of N x T with panel data.

Panel data models describe individual behavior both across time and across individuals.

There are three types of models: the pooled model, the fixed effects model, and the random-effects model.

1.1 Pooled model

The pooled regression model is one type of model that has constant coefficients, referring to both intercepts and slopes. For this model, researchers can pool all of the data and run an ordinary least squares regression model. The pooled model specifies constant coefficients, the usual assumptions for cross-sectional analysis.

$$y_{it} = \alpha + \mathbf{x}_{it}^{'}\beta + u_{it}$$

The main question is whether the individual-specific effects *αi* are correlated with the regression factors. The fixed-effects model is used when the variables are correlated. We have the random-effects model if they are not correlated.

1.2 Fixed effects model

The Fixed effects model considers individual differences, translated into different intercepts of the regression line for other individuals. This model allows the individual-specific effects αi to be correlated with the regressors x.

The term Fixed effects estimator (also known as the *within estimator*) refers to an estimator for the coefficients in the regression model, including those fixed effects (one time-invariant intercept for each subject).

We include α_i as intercepts.

Each individual has a different intercept term and the same slope parameters.

$$y_{it} = \alpha_i + \mathbf{x}_{it}^{'}\beta + u_{it}$$

We can recover the individual-specific effects after estimation as:

$$\hat{\alpha}_i = \bar{y}_i - \bar{\mathbf{x}}_i' \hat{\beta}$$

In other words, the individual-specific effects are the leftover variation in the dependent variable that the regressors cannot explain. Time dummies can be included in the regressors x.

Such models help control omitted variable bias due to unobserved heterogeneity when this heterogeneity is constant over time. This heterogeneity can be removed from the data through difference, for example, by subtracting the group-level average overtime or taking a first difference, which will remove any time-invariant components of the model.

1.3 Random effects model

When unobserved heterogeneity is constant over time and not associated with independent variables, random effect models may help account for it. This constant can be extracted from longitudinal data using differencing, as the first difference removes all time-invariant model components (Sarafidis, V., & Wansbeek, T., 2012).

Two common assumptions can be made about the individual specific effect: the random effects assumption and the fixed effects assumption. The random-effects assumption is that the individual unobserved heterogeneity is uncorrelated with the independent variables. The fixed effect assumption is that the particular specific effect is correlated with the independent variables.

The Random effect model assumes that the individual-specific effects α_i are distributed independently of the regressors.

We include α_i in the error term.

Each individual has the same slope parameters and a composite error term $\varepsilon_{it} = \alpha_i + e_{it}$

$$y_{it} = \mathbf{x}_{it}' \beta + (\alpha_i + e_{it})$$

Here $var(\varepsilon_{it}) = \sigma_\alpha^2 + \sigma_e^2$ and $cov(\varepsilon_{it}, \varepsilon_{is}) = \sigma_\alpha^2$
so $\rho_\varepsilon = cor(\varepsilon_{it}, \varepsilon_{is}) = \sigma_\alpha^2 / (\sigma_\alpha^2 + \sigma_e^2)$

To choose between the two tests, we compute the Durbin–Wu–Hausman test. It is often used to discriminate between the fixed and the random-effects models.

1.3.1 Durbin–Wu–Hausman test

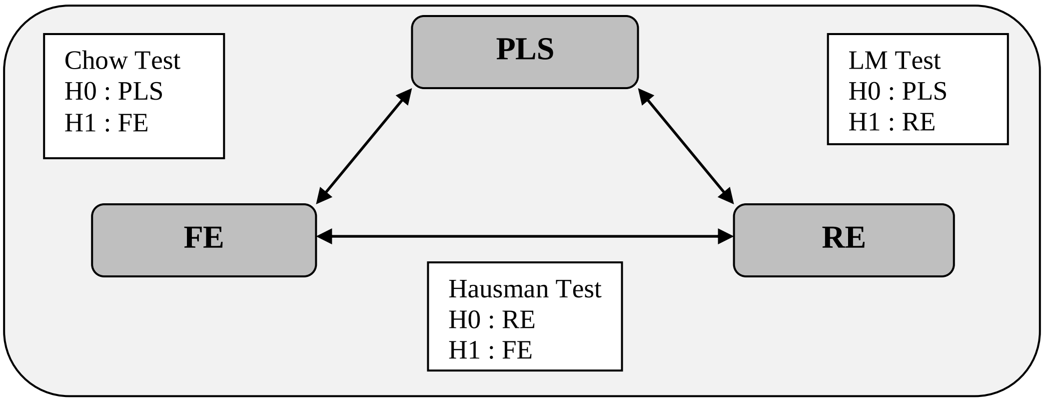
The random-effects estimator is more effictive, so we need to use it if the Hausman test supports it. If it does not help it, use the fixed effects model.

The Hausman test detects endogenous regressors (predictor variables) in a regression model. Endogenous variables have values that are determined by other variables in the system. Having endogenous regressors in a model will cause ordinary least squares estimators to fail. One of the pooled model's assumptions is that there is no correlation between a predictor variable and the error term. Instrumental variables estimators can be used as an alternative in this case. However, you must first decide if your predictor variables are endogenous before deciding on the best regression approach. The Hausman test will accomplish this.

The Durbin–Wu–Hausman test statistics is:

$$H = (\hat{\beta}_{RE} - \hat{\beta}_{FE})'(V(\hat{\beta}_{RE}) - V(\hat{\beta}_{FE}))(\hat{\beta}_{RE} - \hat{\beta}_{FE})$$

Figure 19: Choice of Regression Estimation of Panel Data



Source: *Zulfikar, R., & STp, M. M. (2019).*

Estimator/true model	Pooled model	Random effects model	Fixed effects model
Pooled OLS estimator	Consistent	Consistent	Inconsistent
Between estimator	Consistent	Consistent	Inconsistent
Within or fixed effects estimator	Consistent	Consistent	Consistent
First differences estimator	Consistent	Consistent	Consistent

Random effects estimator	Consistent	Consistent	Inconsistent

- The fixed effects estimator will always give consistent estimates, but they may not be the most efficient.
- The random-effects estimator is inconsistent if the appropriate model is the fixed effects model.
- The random-effects estimator is consistent and most efficient if the appropriate model is random-effects model.

2 Data and Model Construction

We use in our empirical chapter unbalanced panel data regression. Panel data also called longitudinal data or cross-sectional time-series data, or data where multiple cases (people, firms, countries, etc.) were observed at two or more periods.

The classical regression model is:

$$y_i = \beta_0 + x_{1i}\beta_1 + x_{2i}\beta_2 + ... + x_{ki}\beta_k + u_i \ , \ i=1,2,3,\ldots N$$

We suppose the data are on each cross-section unit over T periods for the linear Panel Data Model as:

$$\begin{aligned} y_{i,t1} &= \mathbf{x}'_{i,t1}\boldsymbol{\beta}_{t1} + u_{i,t1} \\ y_{i,t2} &= \mathbf{x}'_{i,t2}\boldsymbol{\beta}_{t2} + u_{i,t1} \\ &\vdots \\ y_{i,T} &= \mathbf{x}'_{i,T}\boldsymbol{\beta}_{T} + u_{i,T} \end{aligned} \quad , \qquad t=1,2,\ldots,T$$

We can express this concisely using **y***i* to represent the vector of individual outcomes for the person *i* across all periods:

$$\mathbf{y}_i = \mathbf{X}_i\boldsymbol{\beta} + \mathbf{u}_i, \text{ where } \mathbf{y}_i' = y_{i,t1}, y_{i,t2}, \ldots, y_{iT}$$

2.1 Data and Descriptive Statistics

Many variables have an impact and a link with technological ability and innovation as well, as the studies that we previously conducted and summarized most of the theoretical and empirical studies that talk about the most important variables that enable us to measure technological capacity; we have explained each variable separately and showed the impact or the effect of each variable has with innovation:

- *Patent applications, residents:* are patent applications filed worldwide under the Patent Cooperation Treaty procedure or with a national patent office to protect the invention to the patent owner for a limited period, usually 20 years (WIPO, 2019).

The main role of a patent is to protect an innovation by granting a temporary operating monopoly to its holder. The patent also promotes information sharing since it is one of the mechanisms for safeguarding the intellectual property of inventions. Patents not only increase incentives to invent, but they also make it easier for technological expertise to spread across the economy. Furthermore, recent research on open innovation has shown that patents promote market and non-market partnerships and interactions between businesses. Patent applications allow for the spread of new ideas.

- *The number of scientific and technical journal articles (per 1,000 populations):* are covered by the Science Citation Index (SCI) or the Social Sciences Citation Index (SSCI). Articles are counted and assigned to a country based on the institutional address (es) listed in the article. The data are reported per capita (World Bank, 2019).

A number of scientific publications are used as a measure of progress, and they are closely linked to overall research and development spending. This indicator's limitations are similar to those of patents in that the quality and sectoral distribution differ by region. Furthermore, since the vast majority of journals reviewed by the Institute for Scientific Information are in English, English-speaking countries are likely overrepresented. As a result, it is an innovation criterion and an important component in assessing a country's ability to innovate, especially in developed countries.

- *Domestic credit to the private sector (% of GDP):* refers to financial resources provided to the private sector, such as loans, purchases of equity securities, and trade, and other creditors, which establish a demand for repayment (World Bank, 2019).

Competition in the marketplace can be a catalyst for the discovery of new technologies, as a business can generate higher profits by finding a way to make its products cheaper or create products with the characteristics that consumers want. The relentless pursuit of new innovations is the basic principle of private sector and enables technology to discover a world of possibilities. Economists and scientists working in private companies compile a list of potential R&D projects and estimated rates of return. As a result, when a business invests in advanced technologies, the special benefits it receives are just a portion of the overall social benefits. The importance of any beneficial externalizes of the new invention or new product, whether enjoyed by other companies or society as a whole, as well as the specific benefits enjoyed by the business that created the new technology, are reflected in the social benefits of innovation. The creative company understands that it will almost always have a temporary advantage over its rivals, allowing it to make higher profits than average before the competition catches up.

- *Government expenditure on education, total (% of government expenditure):* is expressed as a percentage of total general public expenditure in all sectors (including health, education, social services, etc.). It includes expenditures funded by transfers from international sources to the government (UNESCO, 2019).

Governments can boost a country's performance in science, technology, and innovation by addressing external factors and the inherent complexity of the innovation process. For this reason, there has been a renewed focus on technology and innovation policies in many countries in recent decades. The role of governments that contribute large expenditures on education and rely heavily on public investment in research and development with the aim of economic development is the efficiency with which technology is transferred from public research institutions to the market. In practical terms, it includes building the capacity of governments to determine how much is spent on education in particular and on research centers, with the aim of improving the government's ability to assess the potential contribution of public spending to the country's economic development.

- *Cellular mobile subscriptions (per 100 people):* are subscriptions that provide access to the public mobile network using cellular technology (World Bank, 2019).

In several countries, cellular phones have replaced fixed lines. It contributes to economic growth, business development, and market access in general. They are a more effective alternative to remote communities' approaches and postal systems. With the progress in technology, cellular phones now enable users to access an impressive variety of creative applications in addition to making voice calls. It's a way of demonstrating the country's progress in terms of connectivity and innovation.

- *Fixed telephone subscriptions (per 100 people):* refer to the sum of Voice over Internet Protocol (VoIP) subscriptions, Fixed Wireless Local Loop (WLL) subscriptions, and ISDN voice channel equivalents (World Bank, 2019).

Telecommunications are crucial part of the information technology at large. Both technologies (hardware and software) and service providers tend to specialize in one or two of these layers, each seeking to serve all applications. Innovation and additional investments in mobile networks and fixed telephone are increasingly blurring the lines between fixed and mobile services. Specifically, the transition from voice to data-centric mobile networks and services is driving fixed-mobile convergence where more and more groups of services, devices and applications are used to access services and content. Innovation is expected to increase as seamless handoffs between fixed and mobile networks, devices and services become available.

- *Fixed broadband subscriptions:* refer to fixed subscriptions for high-speed access to the public Internet (TCP / IP connection), with downstream speeds equal to or greater than 256 Kbps (World Bank, 2019).

Fixed broadband subscriptions include the total number of subscriptions to the following broadband technologies with download speeds of 256 Kbps or more: DSL, cable modem, fiber to the home, and other fixed technologies (such as broadband over power lines and leased lines).

The number of subscriptions per 100 people and the total number of subscriptions are used to calculate this indicator. As such, it is a significant indicator of a country's technical capabilities, as well as its ability to be technologically productive and creative.

Table 18: Variables and Source of Data

Indicator	Symbol	Source
Patent applications, residents	PAR	*World Bank*
Domestic credit to the private sector (% of GDP)	DCPS (% of GDP)	*World Bank*
Fixed-broadband subscriptions	FBS	*World Bank*
Fixed telephone subscriptions (per 100 people)	FTS (per 100 people)	*World Bank*
Government expenditure on education, total (% of government expenditure)	GEET (% GE)	*World Bank*
Mobile cellular subscriptions (per 100 people)	MobCTS (per 100 people)	*ITU*
Number of scientific and technical journal articles (per 1,000 population)	STJA (per 1,000 population)	*World Bank*

Source: *By the author.*

These are the majority of the variables that have been discussed in previous research. Nonetheless, in our current research, we will examine some of these variables and extend them to emerging countries in order to obtain reliable results and significance.

2.2 Model Construction

The model used in this study is to examine some of the variables that we have identified in a specific group of emerging countries. he lack of data on other elements and achieving a meaningful result are all due to the lack of data on the variables and countries.

The Model proposed after excluding the variable *R&D (% GDP) as*:

$$LogPar_{it} = c + LogDcps_{it} + LogFbs_{it} + LogFts_{it} + LogGeet_{it} + LogMobcts_{it} + LogStja_{it} + U_{it}$$

Where:

C: is the intercept term.

U_{it}: is the error term in the statistical regression model.

We consider Patent application residents (*LogPar)* as a proxy of innovation variable. ther research, such as Pradhan et al., 2019 looks the relationships among ICT diffusion, innovation diffusion, venture capital investment, and economic growth for 25 European countries. Using a vector error correction model for 27 years in the long run and the short run, they confirm a significant impact of venture capital investment, ICT diffusion, and innovation diffusion on t economic growth in Europe. The paper (Tripathi, M., & Inani, S. K., 2020) studied the impact of teledensity (number of fixed and mobile phones per 10,000 people) as a proxy of ICT on GDP. They explain the effect of four Asian countries (Bangladesh, India, Sri Lanka, and Pakistan). In proportion to the countries in the study, ICT has a positive impact on economic development.

We also use in our model *(LogDcps)* as the variable that indicates Domestic credit to the private sector (% of GDP), and the data for this indicator was fetched from the World Bank. *(LogFbs)* the Fixed broadband subscription and *(LogFts)* indicator represents the variable of Fixed telephone subscriptions (per 100 people). Also, *(LogGeet)* as the Government expenditure on education, total (% of government expenditure) and the data of these variables collected from the World Bank. Additionally, we have *(LogMobcts)* mention the Mobile cellular subscriptions (per 100 people) and data source from the International Telecommunications Union (ITU). Besides, we have *(LogStja)* mention the Number of scientific and technical journal articles (per 1,000 populations) from the World Bank data.

A panel data estimation from the period 2000 to 2018 shows no significant impact of ICT in the Upper middle and low-income economies, weak significance in lower-middle-income economies, and high significance in the richest countries in the world, in a sample of 89 countries (Ghalayini & al., 2019).

We used a sample of 17 emerging countries due to the lack of data in some emerging countries (Brazil, China, Czech Republic, Egypt, Greece, Hungary, India, Indonesia, Korea, Rep., Malaysia, Mexico, Pakistan, Peru, Russia, South Africa, Thailand and Turkey).

In this analysis, we described and checked our sample for the years 2000 to 2018.

The results of the first stage regression are shown in Table 19. Before the Multicollinearity Test, the type of model used was Pooled Least Square (PLS).

Table 19: Pooled Least Square (PLS) before Multicollinearity Test

Dependent Variable: LOGPAR
Method: Panel Least Squares

Sample (adjusted): 2003 2016
Periods included: 14
Cross-sections included: 16
Total panel (unbalanced) observations: **153**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-13.41525	1.519752	-8.827260	0.0000
LOGDCPS	1.014094	0.144223	7.031447	0.0000
LOGFBS	0.153687	0.073380	2.094404	0.0380
LOGFTS	1.171238	0.106347	11.01336	0.0000
LOGGEET	-1.183445	0.283517	-4.174154	0.0001
LOGMOBCTS	0.653615	0.153981	4.244762	0.0000
LOGSTJA	-0.480902	0.083074	-5.788851	0.0000

R-squared	0.623122	Mean dependent var	6.684278
Adjusted R-squared	0.607634	S.D. dependent var	1.412135
S.E. of regression	0.884549	Akaike info criterion	2.637194
Sum squared resid	114.2343	Schwarz criterion	2.775842
Log likelihood	-194.7454	Hannan-Quinn criter.	2.693515
F-statistic	40.23225	Durbin-Watson stat	0.120467
Prob(F-statistic)	0.000000		

Source : Eviews 10 output

The variables Domestic credit to the private sector (per cent of GDP) *(LogDcps)*, Fixed-broadband subscriptions *(LogFbs)*, Fixed telephone subscriptions (per 100 people) *(LogFts)*, and Mobile cellular subscriptions (per 100 people) *(LogMobcts)* are statistically significant and have an effect in the pooled OLS Ordinary Least Square regression with 153 observations, as shown in Table 19.

In our sample of emerging countries, the variables Government spending on education, total (percentage of government expenditure) *(LogGeet)* and Number of scientific and technical journal articles (per 1,000 population) *(LogStja)* have a negative impact on innovation. We also note a 62 percent R-squared and a significant value of fisher statistics.

The pooled OLS, on the other hand, ignores the panel structure and individual heterogeneity in the model. We do this by estimating Fixed effects and Random-effects models, but only after ensuring that the variables are not multicollinear.

For the Colinearity test, we use the Variance Inflation Factors (VIFs) to measure the level of collinearity between the regressors in an equation. VIFs show how much of the variance of a regressor's coefficient estimate has been inflated due to collinearity with the other regressors.

They can be calculated by simply dividing the variance of a coefficient estimate by the variance of that coefficient having other regressors not included in the equation (See Eviews 10).

In the literature, there are two forms of the Variance Inflation Factor: centered and uncentered. The centered VIF is the ratio of the variance of the coefficient estimate from the original equation divided by the variance from a coefficient estimate from an equation with only that regressor and a constant. The uncentered VIF is the ratio of the variance of the coefficient estimate from the original equation divided by the variance from a coefficient estimate from an equation with only one regressor (and no constant). If the original equation did not have a constant, only the uncentered VIF will be displayed (Eviews 10 help).

In other words, VIF determines the strength of the correlation between the independent variables. It is predicted by taking a variable and regressing it against every other variable.

- VIF starts at 1 and has no upper limit.
- VIF = 1, no correlation between the independent variable and the other variables.
- VIF *exceeding 5 or 10* indicates high multicollinearity between this independent variable and the others (**https://www.analyticsvidhya.com).**

Following the various multicollinearity tests shown in the Appendix, we hold only four independent variables, as shown in Table 21 with higher observation accuracy (190 comparing with 153 observations before the multicollinearity test).

Section Two: Results and Interpretation

After determining the most important variables that have a significant role in measuring technological capacity, in theory, we will study these variables and analyze the obtained results by identifying the appropriate model based on previous studies.

Results

After passing the multicollinearity test (see Appendix), the proposed model contains innovation as a dependent variable and four indicators to assess technological capability.

$$\boldsymbol{LogPar_{it} = c + LogDcps_{it} + + LogFts_{it} + LogGeet_{it} + LogMobcts_{it} + U_{it}}$$

We use the statistical package Eviews 10 in this analysis, and we begin by computing the descriptive statistics of variables, as shown in Table 20.

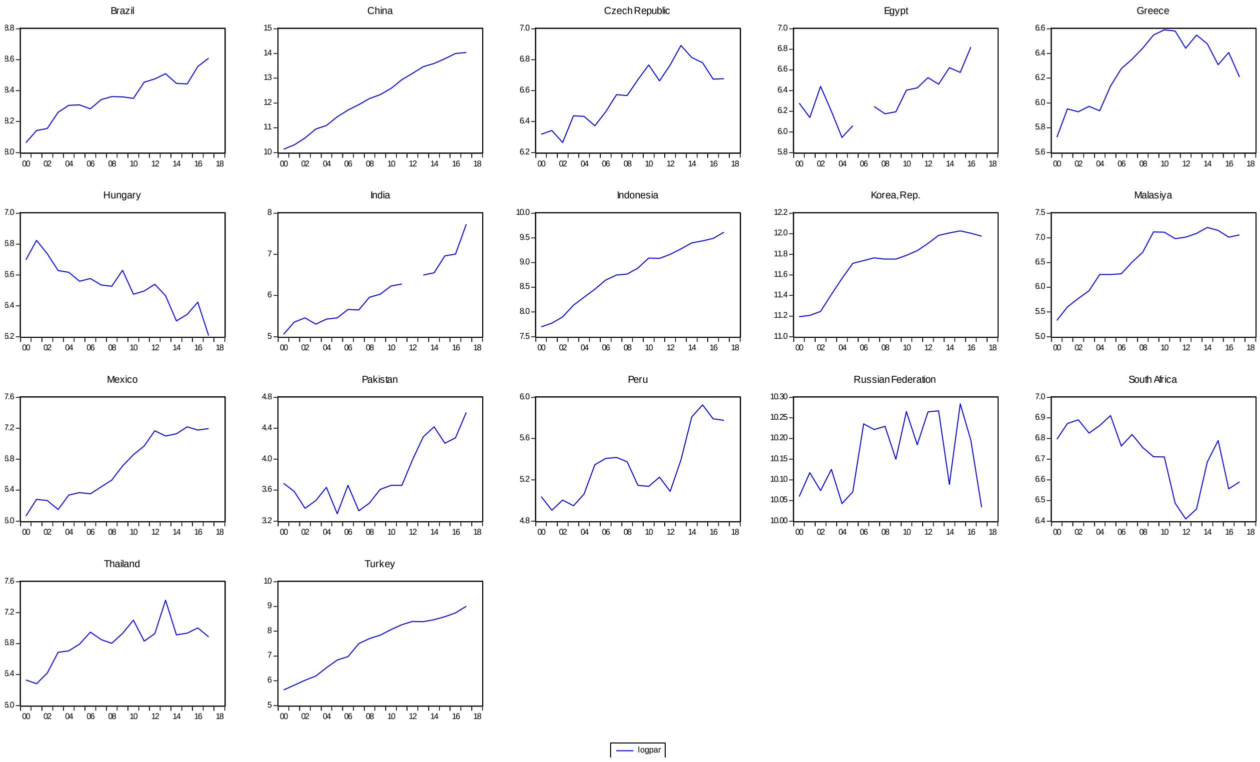
Table 20: Descriptive statistics

	LOGPAR	LOGDCPS	LOGFTS	LOGGEET	LOGMOBCTS
Mean	6.582843	3.813671	15.85072	2.643518	4.006718
Median	6.548182	3.757193	15.50426	2.687233	4.370051
Maximum	12.00410	5.075953	17.73106	3.345988	5.068168
Minimum	3.295837	2.555499	14.26719	1.524832	-1.535634
Std. Dev.	1.368128	0.696130	0.971454	0.336162	1.059816
Skewness	0.345851	0.252599	0.534711	-0.472880	-2.097270
Kurtosis	4.475561	1.968849	1.973274	2.650860	8.971935
Jarque-Bera	21.02455	10.43810	17.39948	8.046182	421.6272
Probability	0.000027	0.005412	0.000167	0.017898	0.000000
Sum	1250.740	724.5975	3011.637	502.2684	761.2765
Sum Sq. Dev.	353.7652	91.58895	178.3637	21.35787	212.2869
Observations	190	190	190	190	190

Source: *Eviews 10 output*

The descriptive findings show that the mean of Patent applications for residents is 6.58, with a standard deviation of 1.36, based on 190 observations. A minimum of 3.29 and a maximum of 12 are registered. We see a low standard deviation of 0.69 and a mean of 3.81 for domestic credit to the private sector (percentage of GDP). The average number of fixed telephone subscriptions (per 100 people) is 15.85, with a standard deviation of 0.97. The overall government education spending (percentage of total government spending) has a slight standard deviation of 0.33, with a maximum of 3.34 percent and a minimum of 1.52 percent. We find a high level of data harmonization in the Mobile cellular subscriptions (per 100 people), with a slight standard deviation of 1.05 and a median of 4.37.

Figure 20: Patent applications, residents

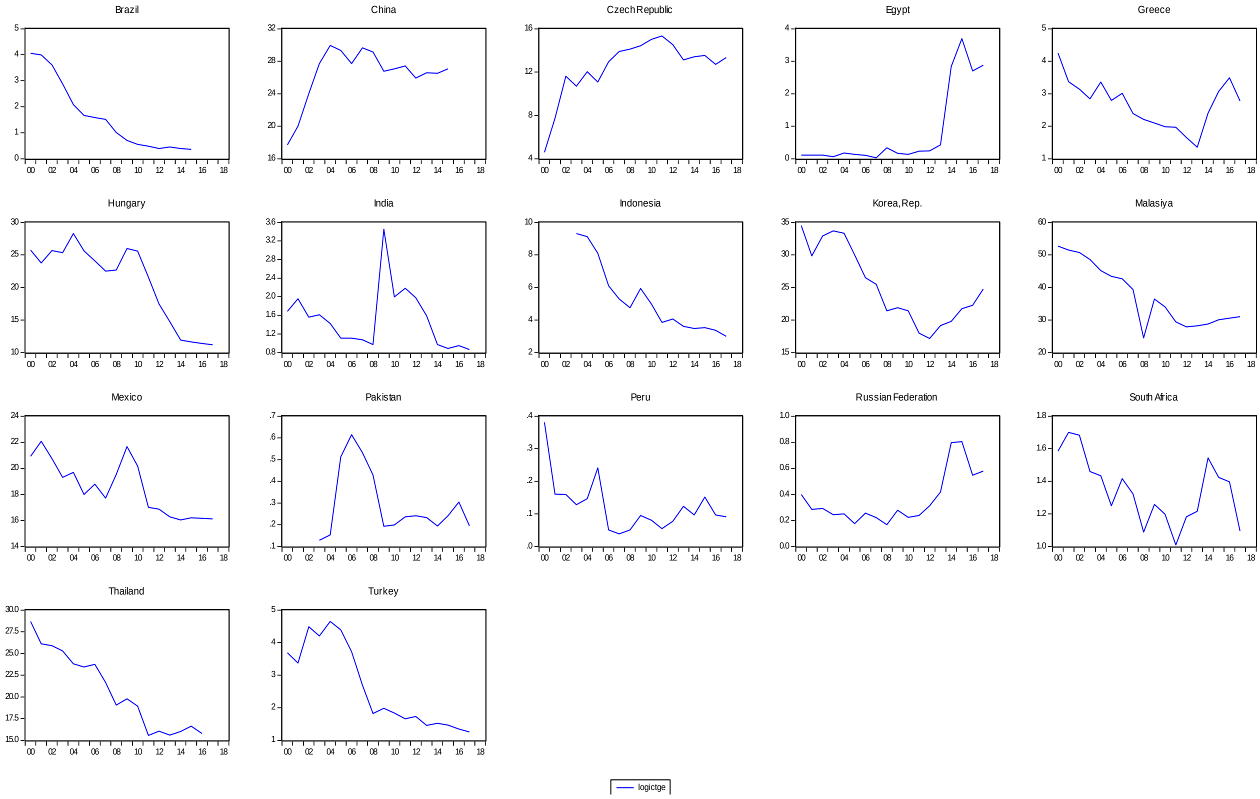


Source: *Eviews 10 output*

Figure 20 shows that, for the period 2000-2018, countries such as China, India, Indonesia, the Republic of Korea, and Malaysia saw an increase in patent applications in their countries, which we used as a proxy for innovation in our research.

The graphs for the other nations, namely Thailand, Russia, and South Africa, show a fluctuation in the number of patent applications. In the case of Turkey, we see a definite upward trend.

__Figure 21: ICT goods exports (% of total goods exports)__

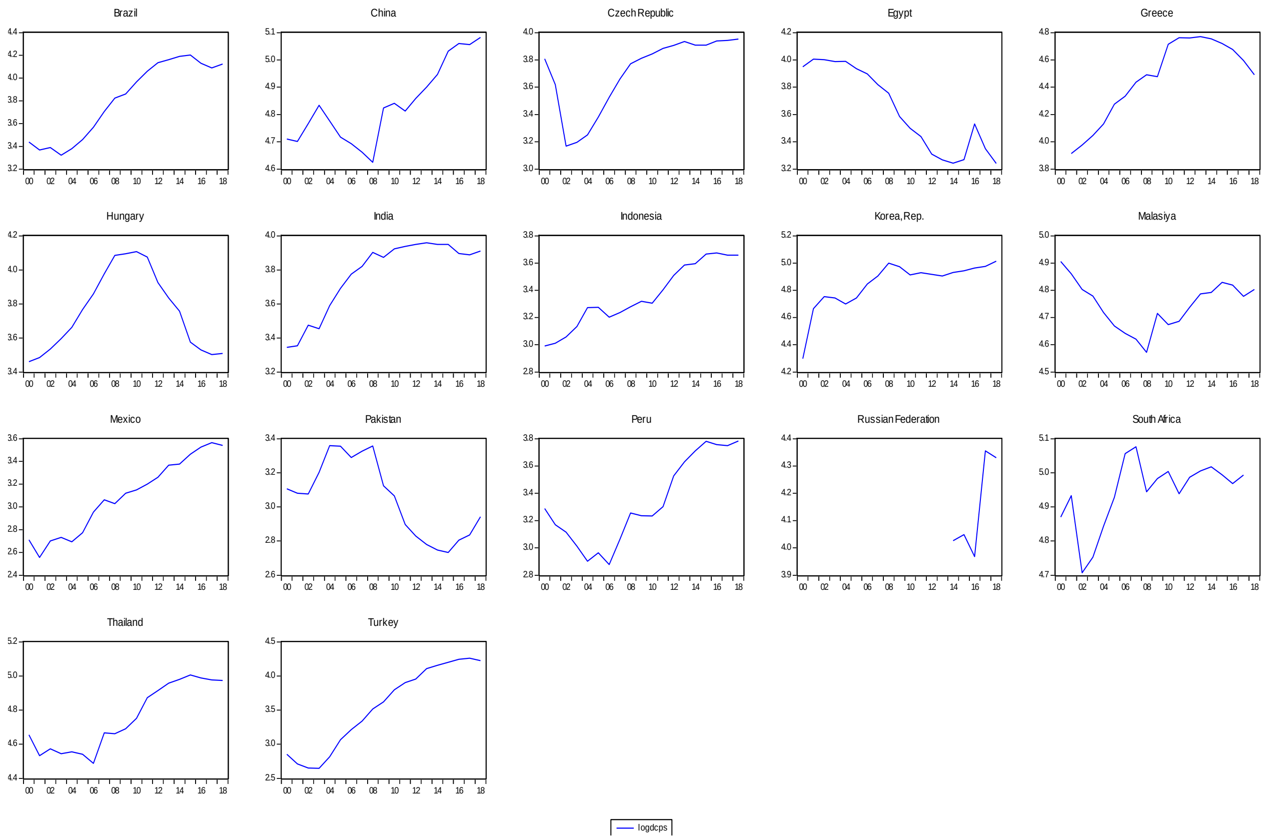


***Source:** Eviews 10 output*

To get an idea about ICT goods exports (% of total goods exports) for the countries in our research, we note that Malaysia and Korea Rep. are decreasing in terms of ICT goods exports (% of total goods exports), but still, the highest rate compared to the other emerging countries (30% and 24%). India records a pic in 2009 with 33% but shows a dramatic decrease of less than 1%.

In Figure 23, we can see that the majority of emerging countries have a fluctuation pattern. It can be explained by the rapid evolution of ICT products around the world, as well as the rapid innovation in this sector. In 2001, Malaysia had 53 percent of ICT goods exports as a percentage of total goods exports, which fell to half in 2007.

Figure 22: Domestic credit to the private sector (% of GDP)

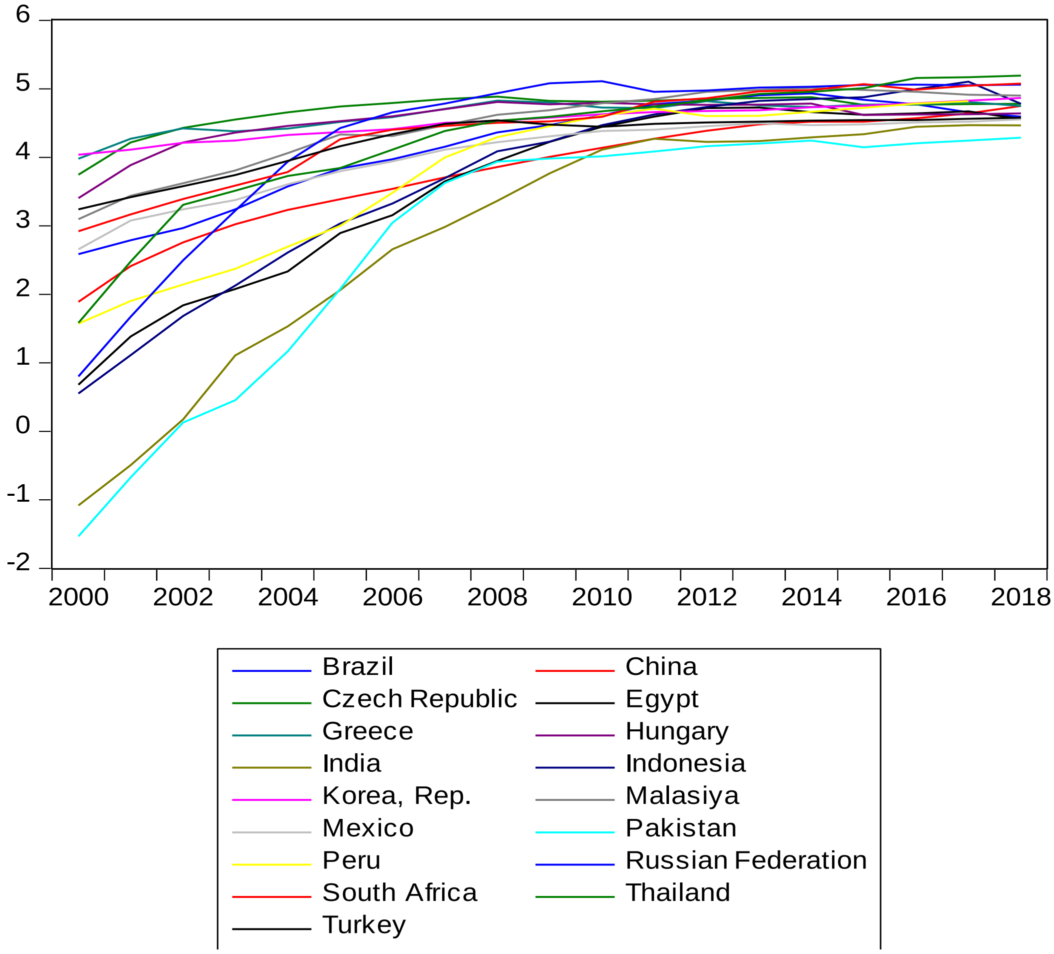


Source: *Eviews 10 output*

The majority of countries in the sample allow a lot of Domestic credit to the private sector (% of GDP), except Egypt and Pakistan who records a decrease in these credits attending less than 3%. China and South Africa are the countries with the highest rates (upper than 5%), according to the graphs.

We can also discuss the significant increase of countries like Brazil, Thailand, Turkey, and Peru in supporting the private sector by the domestic credit as a percentage of GDP.

Figure 23: Mobile cellular subscriptions (per 100 people)



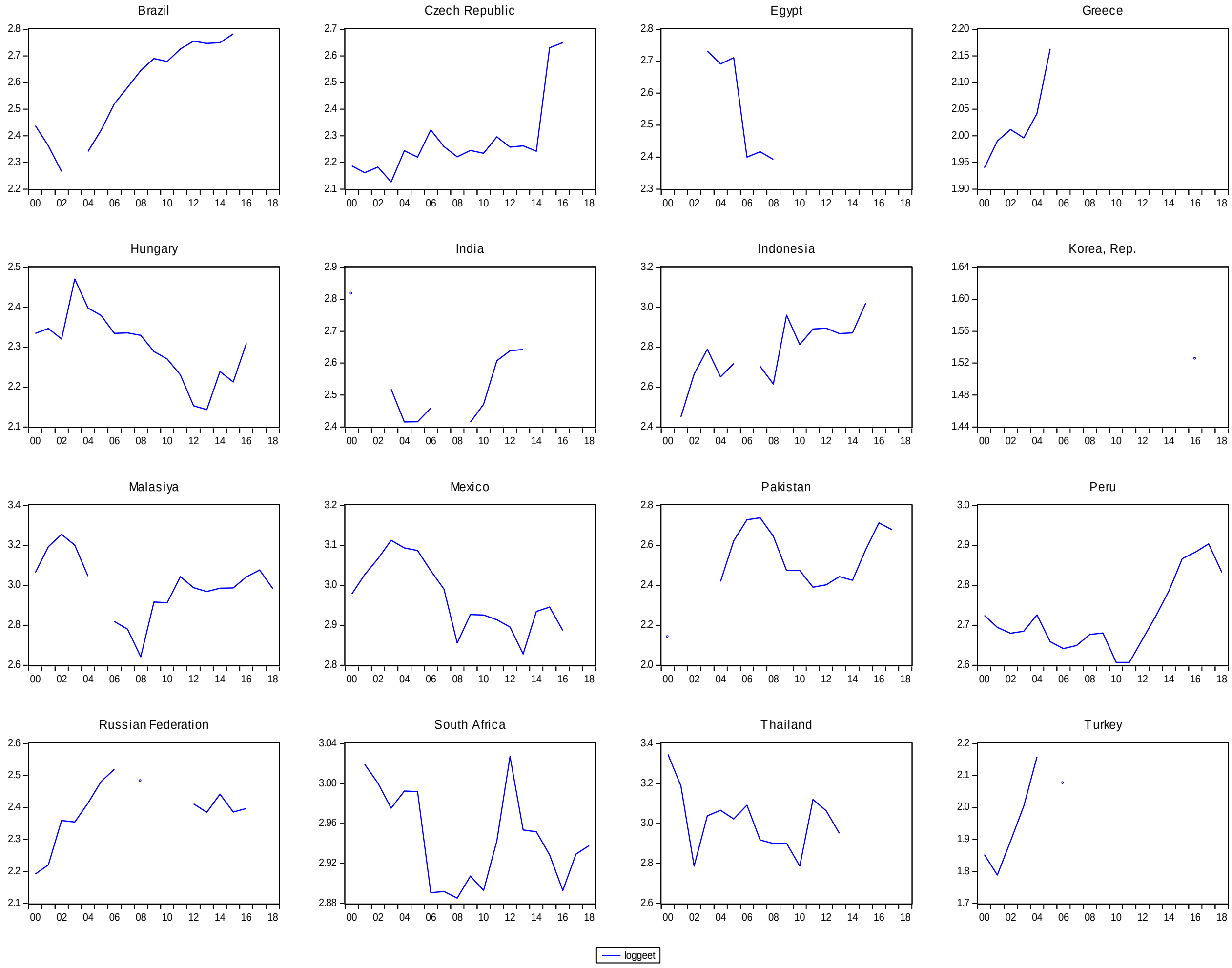
LOGMOBCTS

Source: *Eviews 10 output*

From 2000 to 2018, the gap in mobile cellular subscriptions (per 100 people) for the 17 countries in the sample has narrowed, as shown in Figure 23. Thailand and Pakistan, for example, have each earned 50 subscriptions (per 100 people). The disparity in mobile cellular subscriptions has been decreasing since 2011.

This trend toward enrollment per 100 inhabitants, which is becoming more common between countries, does not represent the quality of the mobile network and can only be used as a quantitative measure.

Figure 24: Government expenditure on education, total (% of government expenditure)

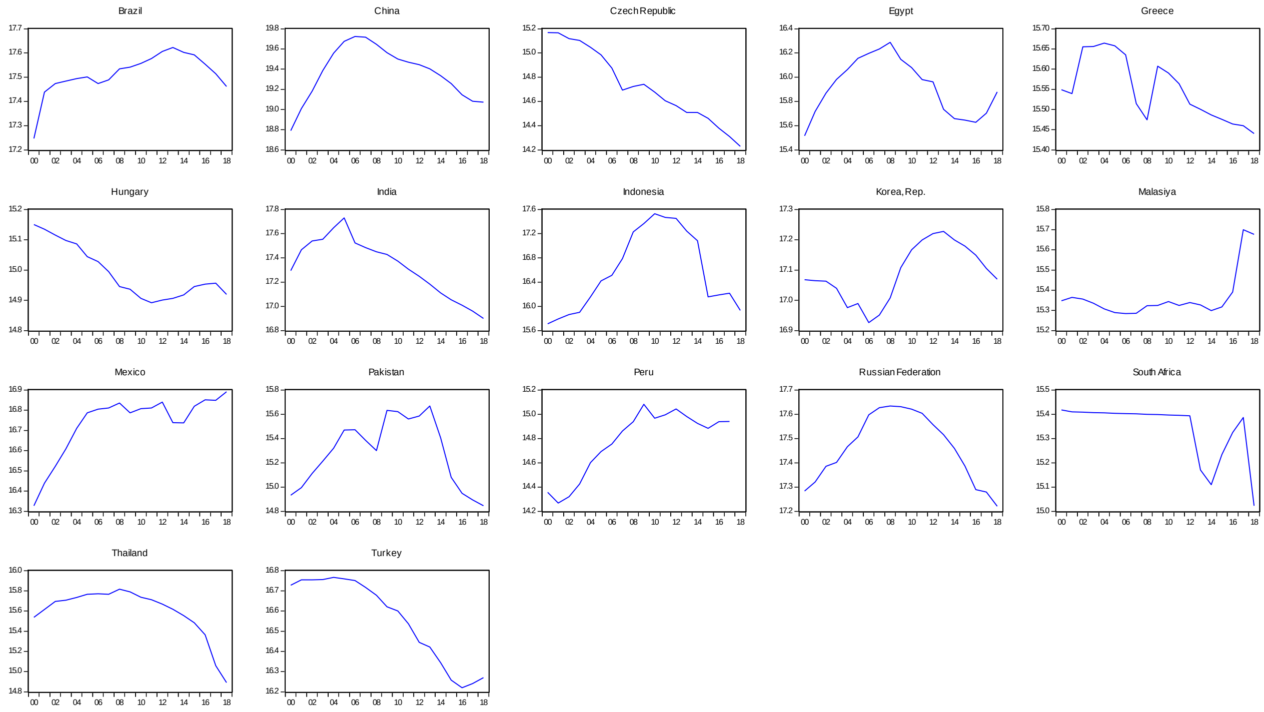


Source: *Eviews 10 output*

Figure 24 shows the Government expenditure on education as the total % of government expenditure. We may still use this variable in our model despite the lack of data in some countries. Hungary, the Czech Republic, Mexico City, South Africa, and Thailand are all experiencing significant fluctuations.

We also list some countries, such as Malaysia, South Africa, Thailand, and Indonesia, that spend more than or equal to 3% of their GDP on education.

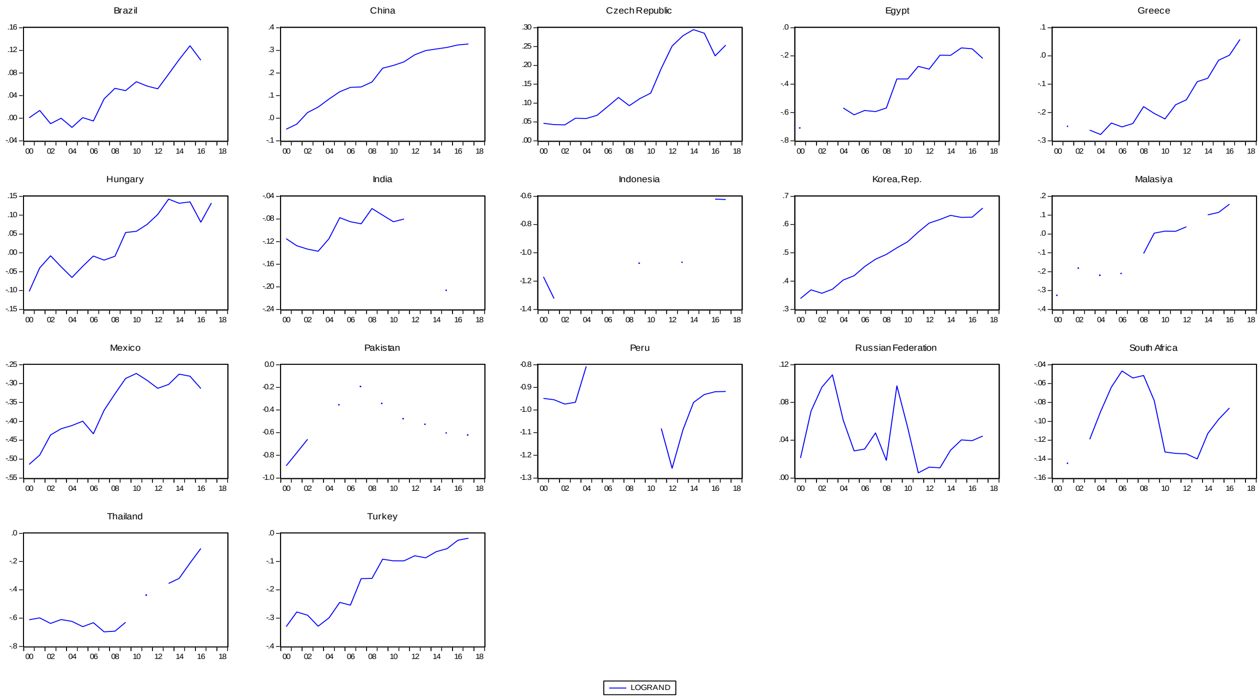
Figure 25: Fixed telephone subscriptions (per 100 people)



Source: *Eviews 10 output*

According to the curves in Figure 25, the majority of countries experienced variations between 2000 and 2018. The decline in fixed telephone subscriptions per 100 inhabitants in most emerging countries is due to the growth of mobile telephony with all modern applications in terms of connectivity. Turkey, Thailand, South Africa, the Russian Federation, and Indonesia are all examples of this pattern.

Figure 26: Research and development expenditure (% of GDP)



Source: *Eviews 10 output*

We removed this variable from the model due to collinearity issues and a lack of data for some of the countries in our study.

Nonetheless, Figure 26 shows that countries like Korea, China, and the Russian Federation invest heavily in research and development. In comparison to the leading countries, the other countries are generally below the thresholds.

Table 21: Pooled Least Square (PLS) after Multicollinearity test

Dependent Variable: LOGPAR
Method: Panel Least Squares

Sample (adjusted): 2000 2017
Periods included: 18
Cross-sections included: 16
Total panel (unbalanced) observations: **190**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.806342	1.384909	-7.080858	0.0000
LOGDCPS	0.581466	0.120658	4.819122	0.0000
LOGFTS	0.849502	0.075792	11.20835	0.0000
LOGGEET	-0.330668	0.233132	-1.418371	0.1578
LOGMOBCTS	0.394481	0.072821	5.417104	0.0000

R-squared	0.488032	Mean dependent var	6.582843
Adjusted R-squared	0.476962	S.D. dependent var	1.368128
S.E. of regression	0.989448	Akaike info criterion	2.842625
Sum squared resid	181.1165	Schwarz criterion	2.928073
Log likelihood	-265.0494	Hannan-Quinn criter.	2.877239
F-statistic	44.08767	Durbin-Watson stat	0.042259
Prob(F-statistic)	0.000000		

Source : *Eviews 10 output*

With 190 observations, we observe that the variables The Domestic credit to the private sector (% of GDP) (*LogDcps*), The Fixed telephone subscriptions (per 100 people) (*LogFts*), and the Mobile cellular subscriptions (per 100 people) (*LogMobcts*) are statistically significant and impact positively the innovation variable represented by Patent applications, residents (*LogPar*) as a proxy. The variable Government expenditure on education, total (% of government expenditure) (*LogGeet*), has a negative impact on innovation, but only to a minor extent at 5%. We also notice a significant value of fisher statistics and an R-squared of 48%.

Table 22: Fixed effects

Dependent Variable: LOGPAR
Method: Panel Least Squares
Sample (adjusted): 2000 2017
Periods included: 18
Cross-sections included: 16
Total panel (unbalanced) observations: 190

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.606563	1.565502	3.581319	0.0004
LOGDCPS	0.182108	0.105051	1.733516	**0.0848**
LOGFTS	-0.028285	0.094900	-0.298055	0.7660
LOGGEET	-0.077364	0.170606	-0.453463	0.6508
LOGMOBCTS	0.233267	0.027318	8.538987	**0.0000**

Effects Specification

Cross-section fixed (dummy variables)			
R-squared	0.962709	Mean dependent var	6.582843
Adjusted R-squared	0.958542	S.D. dependent var	1.368128
S.E. of regression	0.278569	Akaike info criterion	0.380998
Sum squared resid	13.19211	Schwarz criterion	0.722790
Log likelihood	-16.19483	Hannan-Quinn criter.	0.519453
F-statistic	230.9891	Durbin-Watson stat	0.303869
Prob(F-statistic)	0.000000		

Source : *Eviews 10 output*

Concerning the fixed effects model, only the variables Mobile cellular subscriptions (per 100 people) (*LogMobcts*) and Domestic credit to the private sector (% of GDP) (*LogDcps*) positively affect innovation at 5% and 10%, respectively. The rest of the variables are not significant. The R-squared is 96%, with a significant fisher statistics value as mentioned in table 22.

Table 23: Random effects

Dependent Variable: LOGPAR
Method: Panel EGLS (Cross-section random effects)
Sample (adjusted): 2000 2017
Periods included: 18
Cross-sections included: 16
Total panel (unbalanced) observations: 190
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.490236	1.493505	2.336944	0.0205
LOGDCPS	0.286122	0.100410	2.849548	0.0049
LOGFTS	0.133280	0.087651	1.520574	0.1301
LOGGEET	-0.237811	0.162677	-1.461861	0.1455
LOGMOBCTS	0.212584	0.026798	7.932714	0.0000

Effects Specification			S.D.	Rho
Cross-section random			0.873383	0.9077
Idiosyncratic random			0.278569	0.0923

Weighted Statistics			
R-squared	0.377586	Mean dependent var	0.589789
Adjusted R-squared	0.364128	S.D. dependent var	0.463893
S.E. of regression	0.309122	Sum squared resid	17.67790
F-statistic	28.05742	Durbin-Watson stat	0.237151
Prob(F-statistic)	0.000000		

Unweighted Statistics			
R-squared	0.157934	Mean dependent var	6.582843
Sum squared resid	297.8936	Durbin-Watson stat	0.014073

Source: *Eviews 10 output*

For the significant variables, the random-effects model yields the same results as the fixed-effects model. The coefficient of determination is around 37%. The value of Fischer statistics is 28.05, and it's significant at 5%. Compared with the fixed effects model, the Domestic variable credit to the private sector (% of GDP) (*LogDcps*) takes more importance in terms of regression coefficient than the Mobile cellular subscriptions (per 100 people) (*LogMobcts*). The results show 0.28 and 0.21.

To decide about the suitable model, either Fixed or Random effects, we calculate the Hausman test in Table 24.

Table 24: Hausman Test

Correlated Random Effects - Hausman Test
Equation: EQ01
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	44.030313	4	**0.0000**

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
LOGDCPS	0.182108	0.286122	0.000954	0.0008
LOGFTS	-0.028285	0.133280	0.001323	0.0000
LOGGEET	-0.077364	-0.237811	0.002643	0.0018
LOGMOBCTS	0.233267	0.212584	0.000028	0.0001

Cross-section random effects test equation:
Dependent Variable: LOGPAR
Method: Panel Least Squares
Sample (adjusted): 2000 2017
Periods included: 18
Cross-sections included: 16
Total panel (unbalanced) observations: 190

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.606563	1.565502	3.581319	0.0004
LOGDCPS	0.182108	0.105051	1.733516	0.0848
LOGFTS	-0.028285	0.094900	-0.298055	0.7660
LOGGEET	-0.077364	0.170606	-0.453463	0.6508
LOGMOBCTS	0.233267	0.027318	8.538987	0.0000

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.962709	Mean dependent var	6.582843
Adjusted R-squared	0.958542	S.D. dependent var	1.368128
S.E. of regression	0.278569	Akaike info criterion	0.380998

Sum squared resid	13.19211	Schwarz criterion	0.722790
Log likelihood	-16.19483	Hannan-Quinn criter.	0.519453
F-statistic	230.9891	Durbin-Watson stat	0.303869
Prob(F-statistic)	0.000000		

***Source* :** Eviews 10 output

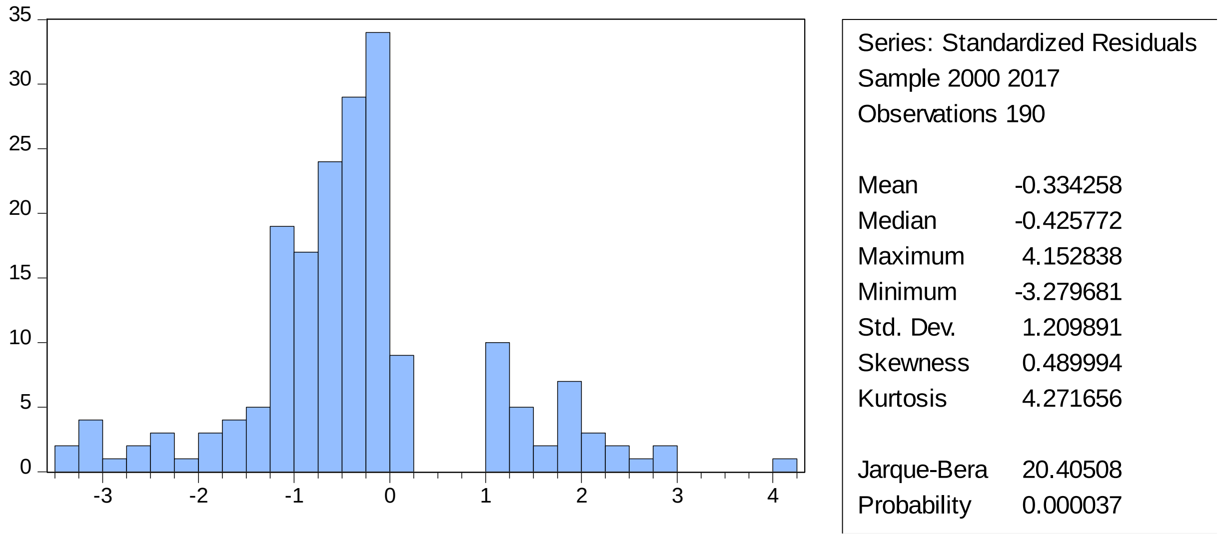
The Hausman test for the correlated Random Effects, supposing the null hypothesis as the random-effects model, shows that we reject the null hypothesis (0.0000 < 5%), so the fixed effects model is appropriate and more efficient. At this stage, the Substituted Coefficients become as :

Estimation Equation:
=========================
LogPar = C(1) + C(2)*LogDcps + C(3)*LogFts + C(4)*LogGeet + C(5)*LogMobcts + [CX=F]

Substituted Coefficients:
=========================

LogPar = 5.60656262104 + 0.182108311645*LogDcps - 0.0282853867569*LogFts - 0.0773637088929*LogGeet + 0.233267118278*LogMobcts + [CX=F]

Figure 27: Residual diagnostics for Normality test



Source: *Eviews 10 output*

From Figure 27, we can conclude that the robustness of the model is good. We accept the hypothesis of the model normality for the standardized Residuals Sample. The probability is less than 5%.

Conclusion

A panel data regression model was used in this chapter to capture variables related to Technological Capacity and Innovation. We defined the most important elements, which in turn provide adequate and precise results, after consulting the majority of studies and the most important in terms of variables and indicators that measure technical ability and innovation, and a sample of emerging countries was chosen as a measurement sample due to the lack of data for all countries.

In this study, we used the model with Panel data, which are longitudinal data or cross-sectional time-series data in some special cases, which are data derived from some observations overtime on several cross-sectional units such as in our study uses different variables and different countries over a period of time, the Panel data refers into multi-dimensional data that generally includes measurements over a given period.

However, the lack of sufficient data is a big reason for the inability to accurately conduct a study, which is the present problem in many studies. Still, we were able to do the research using the essential variables. The previously defined model was used to analyze technological capabilities and the role of some selected variables in a group of emerging countries by testing innovation as a dependent variable to capture the appropriate regression model for the period 2000 - 2018.

After doing the empirical study using the statistical package Eview10 and analyzing the results obtained, we concluded that the following variables: the variables Mobile cellular subscriptions (per 100 people) *LOGMOBCTS* and Domestic credit to the private sector (% of GDP) *LOGDCPS* are those that measure and know the strength of the technological capacity and innovation of the selected emerging countries.

<u>Chapter Five</u>

General Conclusion

General Conclusion

Our study sought to shed new light on the idea of innovation and technological capability, as well as the degree to which they have a significant impact on the economies of countries.

Many definitions of innovation have been developed over the previous years. Innovation can be defined as *"the transformation of an invention into marketable products and services, the development of new business processes and methods of organization, and the absorption, adaptation, and dissemination of novel technologies and know-how"* (Curtis, J. M., 2016). Furthermore, innovation can be described as follows; *"Innovation is the studied, practiced, and repeatable application of methods to bring something new into being in a way that's meaningful and useful"* (Moris, L., et al., 2004). According to other reports, innovation is described as the use of a new or substantially improved product, service, or process, a new marketing system, or a new organizational method in business practices, workplace organization, or external relations.

We have clearly shown that innovation is a complex process in which many elements interfere with different types and policies. However, we have defined Innovation as a process of creating knowledge and skills, as it is an essential process for the development of various fields of the economy, despite the different indicators that measure the innovation process, due to the presence of many works of literature theoretical and experimental that provides several indicators. And, it is similar to the technological capacity, which is a current topic that is frequently discussed due to its great importance in developing the country's economy and increasing economic growth, as we can say that technological capabilities include all skills, knowledge, techniques, and learning accumulated experiences, internally and through external relations with institutional actors that focus on innovation (Solis-Quinteros, MM, et al. 2017), and it is the goal of our study in this thesis.

Furthermore, researchers have applied the idea of technology in a variety of contexts. Technology, strictly speaking, refers to particular physical instruments, but it also refers to whole social structures in a wider context (namely, intangible tools). While both narrow and wide visions have analytical advantages, the various applications of the principle inevitably cause confusion both theoretically and empirically.

The future of technology and information is generated by innovation and creativity, and its construction will be possible through in-depth studies and research on competitiveness indicators. Innovation will become necessary for economic development, and the managerial approach will have to contain several processes.

The main goal of our research is to identify and extract the most important indicators for measuring innovation and technological ability in countries' economies, especially in emerging economies, in order to differentiate countries with rapid economic growth.

As explained by previously, there is no specific definition of emerging countries. Still, some common points between these countries can be identified, such as the level of gross national product (GDP) or their debt level. We can say that they are incomplete countries in financial infrastructure, but with strong growth opportunities.

In addition, the indicators of technological capabilities are increasingly needed to understand how and why countries differ. A satisfactory quantification of current technological capacity levels is required to understand why some countries innovate and have a more satisfactory performance than others. Also very broad metrics, such as those examined in this thesis, illustrate regional variations and recognize country strengths and weaknesses.

Many studies have shown the critical value of technological innovation as a catalyst of long-term development. A related stream of empirical research has shown that technology differences are a fundamental source of different growth rates across countries. One of the first attempts to tackle technological capabilities at the national level was made by Lall (1992). Lall's national technological capabilities measures include several variables grouped into three main dimensions: science, education, and performance (i.e., growth, export GDP, etc.). Archibugi and Coco (2004) developed an index of technological capacities for many developed and developing countries over two periods (1990 and 2000). Their index is divided into three main dimensions, “technology creation”, “technological infrastructure” and “human skills development”. Several international organizations, such as the World Bank, the World Economic Forum, and the European Commission, have developed their composite indicator regarding technology, competitiveness, and development. According to a study about the Arab region, investing in science and, more specifically, R&D, would increase economic growth and have a positive impact on GDP (Sour O. & Maliki S.B, 2020).

In our research study, we collected most of the indicators that were previously discussed. We select the most important ones that give a valid indicative result and then apply them to emerging countries. We chose 17 countries with the most data over the time span as a sample (2000-2018).

The Panel data models were applied using the Eviews10 program, which is a type of data collected on the same collection of entities multiple times. We arrive at the following conclusions after gathering all of the suggestions:

- Innovation is now generally acknowledged as a key driver of company and country economic growth and development.
- Technological innovation as one of the most significant innovation types on business model innovation and indirectly on business success.
- The indexes differ concerning the choice of the various technological dimensions of *technology creation, diffusion, infrastructure, human skills,* even if some common keystones are maintained: the use of R&D as an indicator of technology creation, the recurrence of ICT indicators for technological infrastructure and diffusion and tertiary education in science and engineering as an indicator of human skill.
- We accept the first research hypothesis except for the variable Fixed-broadband subscriptions who was excluded due to the collinearity for the sample of countries in the fixed-effects model.
- For the second research hypothesis, the variable Government expenditure on education, total (% of government expenditure) is not significant. We exclude also the hypothesis due to collinearity. The human resource in the emerging countries, in addition to improving the education level, the technology capacity implies a multidimensional approach including at the same time variables like Government expenditure on education, total (% of government expenditure), Number of scientific and technical journal articles (per 1,000 population), and Research and development expenditure (% of GDP).

The multidimensional components of our analysis study are concluded. According to our findings, the Technological Capability Index and the Innovation Index are multidimensional components that are influenced by the country's financial and human resources. Technological capabilities are strongly associated with technological infrastructure in general, like internet facilities, for example. Our findings highlight the positive impact of Mobile cellular subscriptions (per 100 people) and Domestic credit to the private sector (% of GDP) on Patent applications for residents as a proxy of Innovation.

We also noted from the empirical findings that the emerging countries in our sample, based on the data we used, still need to improve their technological infrastructure, especially the quality of the Internet, which is a major determinant of innovation. The private sector's contribution to a country's gross domestic product is a major determinant in the production of patents for citizens. The participation of developing countries in our study, as well as their contribution to technical and digital growth. Countries such as China, South Korea, Russia and Taiwan have proven that they can compete with developed countries in terms of technological capacity. That said, reducing the digital divide between countries will be a sustainable development factor in the future.

Another effort on the part of institutions in emerging countries is producing and developing a statistical tool to provide reliable data for future researchers and investors in the technology sector.

Finally, the competence factor is critical for developing the human resource's efficiency and ensuring high economic profitability. Emerging countries have an advantage in terms of youth availability, which could be a source of potential growth in the digital revolution and information economy.

References and Bibliography

Abdullah, M. H. R. O., Min, Y. H., Bashar, N. A. M., & Nasir, S. M. F. S. A. (Eds.). (2016). *Preface: International Conference on Advanced Science, Engineering and Technology* (ICASET 2015). In AIP Conference Proceedings (Vol. 1774, No. 1, p. 010001). AIP Publishing LLC.

Abeysinghe, D., & Paul, H. (2005). *Privatization and technological capability development in the telecommunications sector: a case study of Sri Lanka Telecom.* Technology in Society, 27(4), 487-516.

Abrol, D., & Gupta, A. (2014). *Understanding the diffusion modes of grassroots innovations in India: A study of Honey Bee Network supported innovators*. African Journal of Science, Technology, Innovation and Development, 6(6), 541-552.

Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., & Overy, P. (2016). *Sustainability oriented innovation: A systematic review*. International Journal of Management Reviews, 18(2), 180-205.

Aebischer, B., & Hilty, L. M. (2015). *The energy demand of ICT: a historical perspective and current methodological challenges.* In ICT Innovations for Sustainability (pp. 71-103). Springer, Cham.

Afuah, A. (2002). *Mapping technological capabilities into product markets and competitive advantage: the case of cholesterol drugs.* Strategic management journal, 23(2), 171-179.

Agarwal, J. P. (1997). *Effect of foreign direct investment on employment in home countries.* Transnational Corporations, 6, 1-28.

Ahmad, N., Othman, S. N., & Lazim, H. M. (2014, May). *A review of technological capability and performance relationship in manufacturing companies.* In 2014 International Symposium on Technology Management and Emerging Technologies (pp. 193-198). IEEE.

Akani, E. C. (2018). *Sustainable Development and the Millennium Development Goals (MDGs). A Comparative Analysis.* Journal of Political Science and Leadership Research, 4(2), 76-85

Akrich, M., Callon, M., & Latour, B. (1988). *A quoi tient le succès des innovations*. Gérer et comprendre, 97(12), 14-29.

Alam, A., Uddin, M., Yazdifar, H., Shafique, S., & Lartey, T. (2020). *R&D investment, firm performance and moderating role of system and safeguard: Evidence from emerging markets.* Journal of Business Research, 106, 94-105.

Alänge, S., Jacobsson, S., & Jaryehammar, A. (1998). *Some aspects of an analytical framework for studying the diffusion of organizational innovations.* Technology analysis & strategic management, 10(1), 3-22.

Al-Ansari, Y., Altalib, M., & Sardoh, M. (2013). *Technology orientation, innovation and business performance: A study of Dubai SMEs.* The International Technology Management Review, 3(1), 1-11.

Alcouffe, S. (2004). *La diffusion et l'adoption des innovations managériales en comptabilité et contrôle de gestion: le cas de l'AFC en France* (Doctoral dissertation).

Alkire, S., & Deneulin, S. (2009). *Introducing the human development and capability approach.* An introduction to the human development and capability approach. London: Earthscan.

Allen, C., Metternicht, G., & Wiedmann, T. (2019). *Prioritising SDG targets: assessing baselines, gaps and interlinkages.* Sustainability Science, 14(2), 421-438.

Álvarez, I., Marin, R., & Fonfría, A. (2009). *The role of networking in the competitiveness of firms.* Technological forecasting and social change, 76(3), 410-421.

Amable, B., & Askenazy, P. (2005). *Introduction à l'économie de la connaissance.* Contribution pour le rapport UNESCO Construction des sociétés du savoir.

Andersson, B. A., & Jacobsson, S. (2000). *Monitoring and assessing technology choice: the case of solar cells*. Energy Policy, 28(14), 1037-1049.

Anlló, G. (2006). *An overview of Latin America innovation surveys.* Measuring innovation in OECD and non-OECD countries, 141-162.

Archibugi, D., & Coco, A. (2004). *A new indicator of technological capabilities for developed and developing countries (ArCo).* World development, 32(4), 629-654.

Archibugi, D., & Pianta, M. (1996). *Innovation surveys and patents as technology indicators: the state of the art.*

Arnold, D. J., & Quelch, J. A. (1998). *New strategies in emerging markets.* MIT Sloan Management Review, 40(1), 7.

Arnold, E., & Thuriaux, B. (1997). *Developing firms' technological capabilities*. Technopolis Group Report.

Asheim, B. & Gertler. M. (2004). *Understanding regional innovation systems.* Handbook of Innovation. Oxford University Press, Oxford.

Asheim, B. T., & Isaksen, A. (1997). *Location, agglomeration and innovation: Towards regional innovation systems in Norway?.* European planning studies, 5(3), 299-330.

Askenazy, P., & Amable, B. (2002). *Introduction à l'économie de la connaissance*. Contribution pour le rapport UNESCO" Construire des sociétés de savoir", Centre Nationale de la Recherche Scientifique et Cepremap.

Atkinson, G., Dubourg, R., Hamilton, K., Munasinghe, M., Pearce, D., & Young, C. (1997). *Measuring sustainable development: macroeconomics and the environment.* Cheltenham: Edward Elgar.

Autant-Bernard, C., Chalaye, S., Manca, F., Moreno, R., & Suriñach, J. (2010). *Measuring the adoption of innovation*. A typology of EU countries based on the Innovation Survey. Innovation–The European Journal of Social Science Research, 23(3), 199-222.

Auty, R. M., & Mikesell, R. F. (1998). *Sustainable development in mineral economies*. Clarendon Press.

Avgerou, C. (2003). *The link between ICT and economic growth in the discourse of development.* In Organizational information systems in the context of globalization (pp. 373-386). Springer, Boston, MA.

Aw, B. Y., & Batra, G. (1998). *Technological capability and firm efficiency in Taiwan (China).* The World Bank Economic Review, 12(1), 59-79

Äyväri, A., & Jyrämä, A. (2007). *The networking abilities of craft entrepreneurs.* In 23rd IMP Conference. Exploiting the b2b Knowledge Network: New Perspectives and Core Concepts. Manchester Business School (pp. 30-8).

Bacon, F. R., Bacon Jr, F. R., Butler Jr, T. W., & Butler, T. W. (1998). *Achieving planned innovation: A proven system for creating successful new products and services*. Simon and Schuster.

Baranson, J. (1967). *Development as a Scientific Discipline*. American Journal of Economics and Sociology, 26(2), 127-134.

Barré, R., & Laville, F. (1994). *La bibliométrie des brevets: une mesure de l'activité technologique.*

Bartmess, A., & Cerny, K. (1993). *Building competitive advantage through a global network of capabilities.* California management review, 35(2), 78-103.

Battersby, J. (2017). *MDGs to SDGs–new goals, same gaps: the continued absence of urban food security in the post-2015 global development agenda*. African Geographical Review, 36(1), 115-129.

Bejinaru, R. (2016). *Knowledge dynamics impact on intellectual capital in organizations.* Management Dynamics in the Knowledge Economy, 4(4), 515-534.

Bell, M. (1984). *Learning'and the accumulation of industrial technological capacity in developing countries.* In Technological capability in the Third World (pp. 187-209). Palgrave Macmillan, London.

Bell, M., & Pavitt, K. (1992). *Accumulating technological capability in developing countries.* The World Bank Economic Review, 6(suppl_1), 257-281.

Bell, M., & Pavitt, K. (1995). *The development of technological capabilities*. Trade, technology and international competitiveness, 22(4831), 69-101.

Bell, M., & Scott-Kemmis, D. (1985). *Technology import policy: have the problems changed?.* Economic and Political Weekly, 1975-1990.

Bergandi, D., & Blandin, P. (2012). *De la protection de la nature au développement durable: Genèse d'un oxymore éthique et politique.* Revue d'histoire des sciences, 65(1), 103-142.

Bergek, A. (2002). *Shaping and exploiting technological opportunities: the case of renewable energy technology in Sweden*. Goteborg: Chalmers University of Technology.

Bergek, A., & Jacobsson, S. (2003). *The emergence of a growth industry: a comparative analysis of the German, Dutch and Swedish wind turbine industries*. In Change, transformation and development (pp. 197-227). Physica, Heidelberg.

Bergek, A., Hekkert, M., Jacobsson, S., Markard, J., Sandén, B., & Truffer, B. (2015). *Technological innovation systems in contexts: Conceptualizing contextual structures and interaction dynamics.* Environmental Innovation and Societal Transitions, 16, 51-64.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). *Analyzing the functional dynamics of technological innovation systems: A scheme of analysis.* Research policy, 37(3), 407-429.

Bessant, J., & Tidd, J. (2007). *Innovation and entrepreneurship*. John Wiley & Sons.

Bessant, J., Lamming, R., Noke, H. and Phillips, W. (2005). *Managing innovation beyond the steady state*. Technovation, Vol. 25 No. 12, pp. 1366-76.

Bhagat, S., Malhotra, S., & Zhu, P. (2011). *Emerging country cross-border acquisitions: Characteristics, acquirer returns and cross-sectional determinants.* Emerging markets review, 12(3), 250-271.

Biermann, F., Kanie, N., & Kim, R. E. (2017). *Global governance by goal-setting: the novel approach of the UN Sustainable Development Goals.* Current Opinion in Environmental Sustainability, 26, 26-31.

Blakely, E. J., & Hu, R. (2019). *Crafting Innovative Places for Australia's Knowledge Economy*. Springer.

Boer, H., & During, W. E. (2001). *Innovation, what innovation? A comparison between product, process and organizational innovation.* International Journal of Technology Management, 22(1-3), 83-107.

Boisvert, V., & Vivien, F. D. (2006). *Le développement durable: une histoire de controverses économiques.*

Bouchez, J. P. (2014). *The Knowledge Economy*. Savoirs, (1), 9-45.

Boutaud, A. (2005). *Le développement durable: penser le changement ou changer le pansement.* Science et génie de l'environnement. Saint-Etienne, Université Jean Monnet.

Boyer, R. (2002). *Institutional reforms for growth, employment and social cohesion: elements for a European and national agenda.* The New Knowledge Economy in Europe. Cheltenham: Edward Elgar, 146-202.

Brach, J. (2010). *Technology Adoption and Innovation in the Middle East and North Africa: Implications for Egypt*. Middle East Journal.

Bratianu, C. (2008). *A dynamic structure of the organizational intellectual capital.* Knowledge management in organizations, 233-243.

Breschi, S., & Malerba, F. (1997). *Sectoral innovation systems: technological regimes, Schumpeterian dynamics, and spatial boundaries.* Systems of innovation: Technologies, institutions and organizations, 130-156.

Brimm, M. (1986). *Sponsorship and the Diffusion of Organizational Innovation: A Preliminary View*. Insead.

Broustail, J., & Frery, F. (1993). *Filemanagement stratégique de l'innovation,* editions Dalloz.

Brown, P. L., & Byrd, J. (2003). *The innovation equation: Building creativity and risk taking in your organization*. Practicing Organization Development. San Francisco: Jossey-Bass/Pfeiffer.

Business Council Australia. (1993). *Managing the Innovation Enterprise*. Melbourne, BCA.

Bustinza, O. F., Gomes, E., Vendrell-Herrero, F., & Baines, T. (2019). *Product–service innovation and performance: the role of collaborative partnerships and R&D intensity*. R&D Management, 49(1), 33-45.

Caraça, J., Ferreira, J. L., & Mendonça, S. (2007). *A chain-interactive innovation model for the learning economy: Prelude for a proposal*

Carlsson, B., & Stankiewicz, R. (1991). *On the nature, function and composition of technological systems.* Journal of evolutionary economics, 1(2), 93-118.

Carlsson, B., & Stankiewicz, R. (1995). *On the nature, function and composition of technological systems, Technological systems and economic performance: the case of factory automation.*

Carlsson, B., Jacobsson, S., Holmén, M., & Rickne, A. (2002). *Innovation systems: analytical and methodological issues.* Research policy, 31(2), 233-245.

Cassiolato, J. E., Lastres, H. M. M., & Maciel, M. L. (Eds.). (2003). *Systems of innovation and development: evidence from Brazil.* Edward Elgar Publishing.

Chakrabarti, A. K., & Bhaumik, P. K. (2010). *Internationalization of technology development in China: an evaluation using patent data*. Journal of Technology Management in China.

Chanaron, J. J., & Jolly, D. (1999). *Technological management: expanding the perspective of management of technology*. Management Decision.

Chen, M., (1996). *Managing International Technology Transfer.* Thunderbird Series in International Management. International Thompson Press, London.

Chen, Y. S., & Chang, K. C. (2010). *The relationship between a firm's patent quality and its market value—the case of US pharmaceutical industry.* Technological Forecasting and Social Change, 77(1), 20-33.

Christensen, C. M., Bohmer, R., & Kenagy, J. (2000). *Will disruptive innovations cure health care?.* Harvard business review, 78(5), 102-112.

Cooke, P. (2001). *Regional innovation systems, clusters, and the knowledge economy.* Industrial and corporate change, 10(4), 945-974.

Cooke, P. (Ed.). (2007). *Regional knowledge economies: markets, clusters and innovation*. Edward Elgar Publishing.

Cooke, P., Uranga, M. G., & Etxebarria, G. (1997). *Regional innovation systems: Institutional and organisational dimensions.* Research policy, 26(4-5), 475-491.

Coombs, J. E., & Bierly III, P. E. (2006). *Measuring technological capability and performance.* R&D Management, 36(4), 421-438.

Cooper, J. R. (1998). *A multidimensional approach to the adoption of innovation.* Management decision.

Cordova Lopez, E. (2002). *Contribution à une approche méthodologique du processus d'innovation: application de la théorie triz aux systèmes produit-procédé-processus* (Doctoral dissertation, Toulouse, INPT).

Coronado, D., & Acosta, M. (2005). *The effects of scientific regional opportunities in science-technology flows: Evidence from scientific literature in firms patent data.* The annals of regional science, 39(3), 495-522.

Costa, I., & de Queiroz, S. R. R. (2002*). Foreign direct investment and technological capabilities in Brazilian industry.* Research Policy, 31(8-9), 1431-1443.

Courlet, C., & Soulage, B. (1995). *Industrial dynamics and territorial space.* Entrepreneurship & regional development, 7(4), 285-307.

Covin, J. G., & Slevin, D. P. (1991). *A conceptual model of entrepreneurship as firm behavior.* Entrepreneurship theory and practice, 16(1), 7-26.

Crépon, B., & Duguet, E. (1994). *Innovation: mesures, rendements et concurrence*. Economie et statistique, 275(1), 121-134.

Curtis, J. M. (2016). *Trade and Innovation: Policy Options for a New Innovation Landscape.* E15 Expert Group on Trade and Innovation – Policy Options Paper.E15Initiative. Geneva: International Centre for Trade and Sustainable Development (ICTSD) and World Economic Forum.8.

Cusumano, M.A. & Elenkov, D., (1994). *Linking international technology transfer with strategy and management: A literature commentary.* Research Policy, 23, pp. 195-215.

Da Silva, F. M., Oliveira, E. A. D. A. Q., & de Moraes, M. B. (2016). *Innovation development process in small and medium technology-based companies.* RAI Revista de Administração e Inovação, 13(3), 176-189.

Daft, R. L. (1978). *A dual-core model of organizational innovation*. *Academy of management journal*, *21*(2), 193-210.

Dahlman, C. J. (1992). *Information technology strategies: Brazil and the East Asian newly industrializing economies*. High technology and Third World industrialisation: Brazilian computer policy in comparative perspective, 38-81.

Dahlman, C., & Westphal, L. (1982). *Technological effort in industrial development. The economics of new technology in developing countries*. London: Frances Pinter.

Dahlman, C.J. & Westphal. L.E., (1981). *The managing of technological mastery in relation to transfer of technology. Annals of the American Academy of Political and Social Science, 458, pp. 12.26*

Dakhli, M., & De Clercq, D. (2004). *Human capital, social capital, and innovation: a multi-country study*. Entrepreneurship & regional development, 16(2), 107-128.

Damanpour, F. (1991). *Organizational innovation: A meta-analysis of effects of determinants and moderators.* Academy of management journal, 34(3), 555-590.

Damanpour, F., & Evan, W. M. (1984). *Organizational innovation and performance: the problem of "organizational lag".* Administrative science quarterly, 392-409.

Damanpour, F., & Gopalakrishnan, S. (2001). *The dynamics of the adoption of product and process innovations in organizations.* Journal of management studies, 38(1), 45-65.

Davenport, T. H. (1993). *Process innovation: reengineering work through information technology*. Harvard Business Press.

De Almeida Guerra, R. M., & Camargo, M. E. (2016). *The role of technological capability in the internationalization of the company and new product success: a systematic literature review.* Internext, 11(1), 49-62.

De Paula, L. F. (2008). *Financial liberalization, exchange rate regime and economic performance in BRICs countries.* In Financial liberalization and economic performance in emerging countries (pp. 52-94). Palgrave Macmillan, London.

De Prolinnova, É. I. D. A. (2009). *Innovation locale et développement participatif de l'innovation: quelques questions fréquemment posées.*

Deeds, D. L., DeCarolis, D., & Coombs, J. (2000). *Dynamic capabilities and new product development in high technology ventures: An empirical analysis of new biotechnology firms.* Journal of Business venturing, 15(3), 211-229.

Desai, M. (1991). *Human development, Concepts and measurement.* European economic Review 35

Dewar, R. D., & Dutton, J. E. (1986). *The adoption of radical and incremental innovations: An empirical analysis.* Management science, 32(11), 1422-1433

Djeflat, A. (2002). *National systems of innovation in the MENA region.* World Bank Working paper/Maghtech.

Djeflat, A. (2004). *National systems of innovation in the MENA region.* World Bank Institute Report, Washington.

Djeflat, A. (2006). *Le système de support technologique (SST) au Maghreb: cas des PME en Algérie et en Tunisie.* L'intégration de la science au développement, expériences maghrébines, ADEES, Publisud, 88-104.

Dodgson, M., & Hinze, S. (2000). *Indicators used to measure the innovation process: defects and possible remedies*. Research Evaluation, 9(2), 101-114.

Doloreux, D. (2002)a. *What we should know about regional systems of innovation?* Technology in Society: An International Journal. 24: 243-263.

Doloreux, D., & Guillaume, R. (2005). *Le système régional d'innovation: outil de développement pour les territoires.*

Doloreux, D., & Parto, S. (2004). *Regional innovation systems: a critical review*. Maastricht, MERIT, 190(01), 1-26.

Doucek, P. (2011). *Human capital in ICT–competitiveness and innovation potential in ICT*. doucek, p, gerhard chroust a václav oškrdal. idimt-2011: interdisciplinarity in complex systems. Linz: Trauner, 11-22.

Downs Jr, G. W., & Mohr, L. B. (1976). *Conceptual issues in the study of innovation*. Administrative science quarterly, 700-714.

Drucker, P. (1954). *The principles of management*. New York.

Drucker, P. F. (1985). *The changed world economy*. Foreign Aff., 64, 768.

Dubuisson, S., & Kabla, I. (1999). *Innovations et compétences. Compte rendu d'une réflexion collective.* Innovations et performances. Approches interdisciplinaires, Paris, Editions de l'école des Hautes Etudes en Sciences Sociales, Paris.

Dunning, J. H. (1994). *Globalization, economic restructuring and development*. University of Reading, Department of Economics.

Dunning, J. H. (1994). *Multinational enterprises and the globalization of innovatory capacity.* Research policy, 23(1), 67-88.

Duque, R., Collins, M., Abbate, J., Azambuja, C. C., & Snaprud, M. (2007). *History of ICT*. In Past, present and future of research in the information society (pp. 33-45). Springer, Boston, MA.

Eom, T. H., Lee, S. H., & Xu, H. (2008). *32Introduction to Panel Data Analysis: Concepts and Practices.*

Evans, P. A. (1991). *Management development as glue technology*. INSEAD.

Farber, A., & Adam, M. C. (1994). *Le financement de l'innovation technologique: théorie économique et expérience européenne*, (No. 2013/11402). ULB--Universite Libre de Bruxelles.

Figueiredo, P. N. (2002). *Learning processes features and technological capability-accumulation: explaining inter-firm differences.* Technovation, 22(11), 685-698.

Figueiredo, P. N. (2008). *Industrial policy changes and firm-level technological capability development: evidence from Northern Brazil*. World development, 36(1), 55-88.

Frediani, A. A. (2007). *Amartya Sen, the World Bank, and the redress of urban poverty: A Brazilian case study.* Journal of Human Development, 8(1), 133-152.

Freeman, C. (1987). *Technical innovation, diffusion, and long cycles of economic development.* In The long-wave debate (pp. 295-309). Springer, Berlin, Heidelberg.

Freeman, C. (1995). *The 'National System of Innovation'in historical perspective.* Cambridge Journal of economics, 19(1), 5-24.

Frick, S. A., Rodríguez-Pose, A., & Wong, M. D. (2019). *Toward economically dynamic special economic zones in emerging countries.* Economic geography, 95(1), 30-64.

Galbraith, J. K. (1967). *The new industrial state.* Boston, MA: Houghton Mifflin.

Galli, R., & Teubal, M. (1997). *Paradigmatic shifts in national innovation systems.* Systems of innovation: Technologies, institutions and organizations, 342-370.

Gammeltoft, P. (2004). *Development of firm-level technological capabilities*. Journal of the Asia Pacific Economy, 9(1), 49-69.

García-Muiña, F. E., & Navas-López, J. E. (2007). *Explaining and measuring success in new business: The effect of technological capabilities on firm results.* Technovation, 27(1-2), 30-46.

Geroski, P. (1995). *Markets for technology: knowledge, innovation and appropriability.* Handbook of the Economics Innovation and Technological Change.

Ghalayini, L., Nasser, A., & Ishker, N. (2020). *ICT Diffusion and Economic Growth: A Comparative Study Across Economies.* Journal of Economics and Business, 3(2).

Giovannini, E., Niestroy, I., Nilsson, M., Roure, F., & Spanos, M. (2015). *The role of science, technology and innovation policies to foster the implementation of the sustainable development goals.* Report of the expert group "Follow-up to Rio, 20

Godard, O., & Hubert, B. (2002). *Le développement durable et la recherche scientifique à l'INRA*. Rapport intermédiaire de mission. Paris (France): Inra éditions.

Godin, B. (2008). *Innovation: the History of a Category*. Project on the intellectual history of innovation working paper, 1, 1-67.

Godin, B. (2017). *Models of innovation: the history of an idea*. MIT Press.

Grant, R. M. (1996). *Toward a knowledge‐based theory of the firm*. Strategic management journal, 17(S2), 109-122.

Greve, H. R. (2003). *A behavioral theory of R&D expenditures and innovations: Evidence from shipbuilding.* Academy of management journal, 46(6), 685-702.

Griliches, Z. (1990). *Patent statistics as economic indicators: a survey part 2*. NBER.

Guellec, D. (2003). *Mesurer l'innovation: quelques leçons de l'expérience de l'OCDE*. 8e séminaire de la Direction des Statistiques d'Entreprises, Innovation: de l'idée à la performance, Insee Méthodes, 105.

Gupta, J., & Vegelin, C. (2016). *Sustainable development goals and inclusive development*. International environmental agreements: Politics, law and economics, 16(3), 433-448.

Hadad, S. (2017). *Knowledge economy: Characteristics and dimensions.* Management dynamics in the Knowledge economy, 5(2), 203-225.

Hall, L. A., & Bagchi-Sen, S. (2002). *A study of R&D, innovation, and business performance in the Canadian biotechnology industry.* Technovation, 22(4), 231-244.

Harris, R., & Moffat, J. (2011). *R&D, Innovation and Exporting, Spatial Economics Research Center.* SERC Discussion Paper 73.

Hekkert, M. P., Suurs, R. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. (2007). *Functions of innovation systems: A new approach for analysing technological change.* Technological forecasting and social change, 74(4), 413-432.

Henderson, J. C., & Lentz, C. M. (1995). *Learning, working, and innovation: a case study in the insurance industry*. Journal of Management Information Systems, 12(3), 43-64.

Hirsch, S., & Bijaoui, I. (1985). *R&D intensity and export performance: a micro view.* Weltwirtschaftliches archiv, 121(2), 238-251.

Hoffecker, E. (2018). *Local Innovation: what it is and why it matters for developing economies.* Massachusetts Inst. Technol. D-Lab, 21.

Hoffman, R. C. (1999). *Organizational innovation: Management influence across cultures.* Multinational Business Review, 7, 37-49.

Holmén, M., & Jacobsson, S. (2000). *A method for identifying actors in a knowledge based cluster.* Economics of innovation and new technology, 9(4), 331-352.

Howitt, P., & Aghion, P. (1998). *Capital accumulation and innovation as complementary factors in long-run growth.* Journal of Economic Growth, 3(2), 111-130.

Hsiao C (2005). *Why panel data?* Singap Econ Rev 50(2):1–12

Hsiao, C., (2003, 2nd ed), *Analysis of Panel Data, second edition*, Cambridge University Press. http://lnweb18. worldbank. org/mna/mena. nsf/Attachments/Innovation/$ File/RAPFIN. pdf.

Hwang, V. W., & Horowitt, G. (2012). *The rainforest: The secret to building the next Silicon Valley.*

Iammarino, S., Padilla-Pérez, R., & Von Tunzelmann, N. (2008). *Technological capabilities and global–local interactions: the electronics industry in two Mexican regions.* World Development, 36(10), 1980-2003.

Imaz, M., & Sheinbaum, C. (2017). *Science and technology in the framework of the sustainable development goals.* World Journal of Science, Technology and Sustainable Development.

IUCN, U. (1980). *WWF*. World Conservation Strategy. Living Resource Conservation for Sustainable Development. Gland, Switzerland, IUCN, UNEP, WWF.

Jacob, M. C. (2014). *The first knowledge economy: Human capital and the European economy*. 1750–1850. Cambridge University Press.

Jaffrelot, C. (2009). *The emerging states* (p. 320). Columbia University Press.

Jaiswal, R. K., Saxena, R., & Mukherjee, S. (1999). *Application of remote sensing technology for land use/land cover change analysis.* Journal of the Indian Society of Remote Sensing, 27(2), 123.

James, D. D. (1991). *Capital goods production and technological learning: The case of Mexico.* Journal of Economic Issues, 25(4), 977-991.

Jiménez-Jiménez, D., & Sanz-Valle, R. (2011). *Innovation, organizational learning, and performance.* Journal of business research, 64(4), 408-417.

Jin, J., & Von Zedtwitz, M. (2008). *Technological capability development in China's mobile phone industry*. Technovation, 28(6), 327-334.

Johnson, B. H. (1992). *Institutional learning. In Institutional Learning* (pp. 23-44). Pinter Publishers.

Jonker, M., Romijn, H., & Szirmai, A. (2006). *Technological effort, technological capabilities and economic performance: A case study of the paper manufacturing sector in West Java.* Technovation, 26(1), 121-134.

Karahan, Ö. (2012). *Input-output indicators of knowledge-based economy and Turkey*. Journal of Business Economics and Finance, 1(2), 21-36.

Katz, J. M. (Ed.). (1987). *Technology generation in Latin American manufacturing industries*. Springer.

Keating, M. (1997). *The invention of regions: political restructuring and territorial government in Western Europe*. Environment and Planning C: Government and Policy, 15(4), 383-398.

Kim, L. (1999). *Building technological capability for industrialization: analytical frameworks and Korea's experience.* Industrial and corporate change, 8(1), 111-136.

Kimberly, J. R. (1981). *Managerial innovation*. Handbook of organizational design, 1(84), 104.

Klapper, L., El-Zoghbi, M., & Hess, J. (2016). *Achieving the sustainable development goals*. The role of financial inclusion. Available online: http://www. ccgap. org. Accessed, 23(5), 2016.

Kleinknecht, A., Van Montfort, K., & Brouwer, E. (2002). *The non-trivial choice between innovation indicators.* Economics of Innovation and new technology, 11(2), 109-121.

Kline, S. J., & Rosenberg, N. (1986). *An overview of innovation. The positive sum strategy: Harnessing technology for economic growth*. The National Academy of Science, USA.

Kotsemir, M., Abroskin, A., & Meissner, D. (2013). *Innovation concepts and typology–an evolutionary discussion.* Higher School of Economics Research Paper No. WP BRP, 5.

Krasnikov, A., & Jayachandran, S. (2008). *The relative impact of marketing, research-and-development, and operations capabilities on firm performance*. Journal of marketing, 72(4), 1-11.

Kukliński, A. (2003). *The development of Knowledge Based Economy in Europe: The Regional Trajectory, referat przygotowany na Annual Anglo-Polish Colloquium "The Knowledge-based Economy in Central and East European Countries: Exploring the New Policy and Research Agenda"*. School of Slavonic and East European Studies University College London, 28-29.

Kulviwat, S., Bruner II, G. C., Kumar, A., Nasco, S. A., & Clark, T. (2007). *Toward a unified theory of consumer acceptance technology.* Psychology & Marketing, 24(12), 1059-1084.

Lall, S. (1987). *Learning to industrialize: the acquisition of technological capability by India*. Springer.

Lall, S. (1992). *Technological capabilities and industrialization.* World development, 20(2), 165-186.

Lan, P., & Young, S. (1996). *International technology transfer examined at technology component level: a case study in China*. Technovation, 16(6), 277-286.

Lanvin, B., & Miroux, A. (2016). *L'innovation dans les économies émergentes et en développement: politiques et enjeux*. Geoeconomie, (3), 127-144.

Le Blanc, D. (2015). *Towards integration at last? The sustainable development goals as a network of targets.* Sustainable Development, 23(3), 176-187.

Lee, J. W., & Brahmasrene, T. (2014). *ICT, CO2 emissions and economic growth: evidence from a panel of ASEAN.* Global Economic Review, 43(2), 93-109.

Li, D. Y., & Liu, J. (2014). *Dynamic capabilities, environmental dynamism, and competitive advantage: Evidence from China.* Journal of Business Research, 67(1), 2793-2799.

Liao, S. H., Fei, W. C., & Chen, C. C. (2007). *Knowledge sharing, absorptive capacity and innovation capability: an empirical study of Taiwan's knowledge-intensive industries.* Journal of information science, 33(3), 340-359.

Liefner, I., Wei, Y. D., & Zeng, G. (2013). *The Innovativeness and Heterogeneity of Foreign Invested High Tech Companies in Shanghai.* Growth and Change, 44(3), 522-549.

Lim, S. S., Allen, K., Bhutta, Z. A., Dandona, L., Forouzanfar, M. H., Fullman, N., ... & Kinfu, Y. (2016). *Measuring the health-related Sustainable Development Goals in 188 countries: a baseline analysis from the Global Burden of Disease Study 2015.* The Lancet, 388(10053), 1813-1850.

Lin, C., & Chang, C. C. (2015). *The effect of technological diversification on organizational performance: An empirical study of S&P 500 manufacturing firms*. Technological Forecasting and Social Change, 90, 575-586.

Loilier, T., & Tellier, A. (1999). *Gestion de l'innovation: décider, mettre en oeuvre, diffuser*. Ed. Management et société

Loilier, T., & Tellier, A. (2013). *Gestion de l'innovation: comprendre le processus d'innovation pour le piloter*. Éditions EMS.

Lumpkin, G. T., & Dess, G. G. (1996). *Clarifying the entrepreneurial orientation construct and linking it to performance.* Academy of management Review, 21(1), 135-172.

Lundvall, B. (1992). Å (ed)(1992) *National systems of innovation: towards a theory of innovation and interactive learning.* Pinter, London.

Lundvall, B. Å. (2007). *National innovation systems—analytical concept and development tool.* Industry and innovation, 14(1), 95-119.

Lundvall, B. A., & Dosi, G. (1988). *Innovation as an interactive process: from user-producer interaction to the national system of innovation*. 1988, 349-369.

Machlup, F. (1962). *The production and distribution of knowledge in the United States* (Vol. 278). Princeton university press.

Machlup, F. (1984). *The economics of information and human capital.* Series: Knowledge, its creation, distribution, and economic significance; v. 3./-Princeton.

Madanmohan, T. R., Kumar, U., & Kumar, V. (2004). *Import-led technological capability: a comparative analysis of Indian and Indonesian manufacturing firms*. Technovation, 24(12), 979-993.

Maillat, D. (1996). *Systèmes territoriaux de production, milieux innovateurs et politiques régionales*. Le Québec des régions: vers quel développement, 87-106

Malerba, F. (2002). *Sectoral systems of innovation and production*. Research policy, 31(2), 247-264.

Mansfield, E. (1975). *International technology transfer: forms, resource requirements, and policies.* The American Economic Review, 65(2), 372-376.

Mansfield, E. (1980). *Basic research and productivity increase in manufacturing.* The American Economic Review, 70(5), 863-873.

Marshall, J. D., & Toffel, M. W. (2005). *Framing the elusive concept of sustainability: A sustainability hierarchy.*

Marwick, A. D. (2001). *Knowledge management technology*. IBM systems journal, 40(4), 814-830.

Matete, N., & Trois, C. (2008). *Towards zero waste in emerging countries–a South African experience.* Waste management, 28(8), 1480-1492.

Matias, C. A., Souza, G., & Figueiredo, P. (2013). *Co-evolution of institutional frameworks and technological capability building across different industrial regimes: the ethanol industry in Brazil.* Journal for Global Business and Communitiy, 4(1), 65-80.

McManus, P. (2015, February). *Introduction to regression models for panel data analysis.* Indiana University Workshop in Methods.

Méhaut, P. (2006). *Knowledge economy, learning society and lifelong learning*. A review of the French literature.

Metcalfe, J. S. (1995). *Technology systems and technology policy in an evolutionary framework.* Cambridge journal of economics, 19(1), 25-46.

Meyer, M. (2000). *Does science push technology? Patents citing scientific literature*. Research policy, 29(3), 409-434.

Mihaela, M., & Ţiţan, E. (2014*). Education and innovation in the context of economies globalization*. Procedia Economics and Finance, 15, 1042-1046.

Miller, R. R. (1998). *Selling to newly emerging markets*. Greenwood Publishing Group.

Mohnen, P., & Röller, L. H. (2005). *Complementarities in innovation policy.* European economic review, 49(6), 1431-1450.

Mohr, L. B. (1969). *Determinants of innovation in organizations.* American political science review, 63(1), 111-126.

Montiel, P. J. (2011). *Macroeconomics in emerging markets*. Cambridge University Press.

Moris, L., et al. (2004). *High Performance Organizations in a Wicked Problem World*. 2004 The International Conference on Systems Thinking in Management. Innovation Labs LLC 10.

Morita-Lou, H. (2019). *Science and technology indicators for development*. Routledge.

Morvan, B. (2000). *Le développement durable: une utopie politiquement correcte.* Quaderni, 41(1), 91-107.

Neely, A., & Hii, J. (1998). *Innovation and business performance: a literature review.* The Judge Institute of Management Studies, University of Cambridge, 0-65.

Nelson, B. H. (1991). *Method of assembling stacks of integrated circuit dies*. *U.S. Patent No. 4,984,358*. Washington, DC: U.S. Patent and Trademark Office

Nelson, R. (ed.) (1993), *National Innovation Systems.* A Comparative Analysis, Oxford University Press, New York/Oxford

Nelson, R. R., Mowery, D. C., & Fagerberg, J. (Eds.). (2005). *The Oxford handbook of innovation*. Oxford University Press.

Nevado-Peña, D., López-Ruiz, V. R., & Alfaro-Navarro, J. L. (2019). *Improving quality of life perception with ICT use and technological capacity in Europe.* Technological Forecasting and Social Change, 148, 119734.

Nicet-Chenaf, D. (2014). *Les pays émergents: performance ou développement?*. La Vie des idées, 4.

Nicholls-Nixon, C. L., & Woo, C. Y. (2003). *Technology sourcing and output of established firms in a regime of encompassing technological change.* Strategic Management Journal, 24(7), 651-666.

Niininen, P., & Saarinen, J. (2000). *Innovations and the Success of Firms*. Valtion teknillinen tutkimuskeskus.

Niosi, J. (1999). *Fourth-generation R&D: From linear models to flexible innovation.* Journal of business research, 45(2), 111-117.

Niosi, J., Bellon, B., SAVIOTTI, P. P., & Crow, M. (1992). *Les systèmes nationaux d'innovation: à la recherche d'un concept utilisable.* Revue française d'économie, 7(1), 215-250.

Nohria, N., & Gulati, R. (1996). *Is slack good or bad for innovation?*. Academy of management Journal, 39(5), 1245-1264.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford university press.

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge university press.

Nuruzzaman, N., Singh, D., & Pattnaik, C. (2019). *Competing to be innovative: Foreign competition and imitative innovation of emerging economy firms.* International Business Review, 28(5), 101490.

O'Sullivan, D., & Dooley, L. (2009). *Applying Innovation*. (I. SAGE Publications, Ed.). United Kingdom.

OECD (1992), *Technology, Economy and Productivity (TEP).* Paris: OECD.

Ojanperä, S., Graham, M., & Zook, M. (2019). *The Digital Knowledge Economy Index: Mapping Content Production*. The Journal of Development Studies, 55(12), 2626-2643.

Okubo, Y. (1997). *International Collaborative Networks in Drug Innovation: A Survey of research related to recombinant DNA technique*. The Journal of Science Policy and Research Management, 10(3_4), 216-228.

Olmedo-Cifuentes, I., & Martínez-León, I. (2015). *Human capital and creation of reputation and financial performance.* Electronic Journal of Knowledge Management, 13(3), 209.

Ortega, M. J. R. (2010). *Competitive strategies and firm performance: Technological capabilities' moderating roles.* Journal of Business Research, 63(12), 1273-1281.

Oyebisi, T. O., Olamade, O. O., & Agboola, A. A. (2004). *An assessment of the level of availability of technological capabilities in the Nigerian telecommunications industry.* International journal of information management, 24(5), 423-432.

Özçatalbaş, O. (2017). *Human Development and Research-Development-Extension Relationships.* Research and Development Evolving Trends and Practices: Towards Human, Institutional and Economic Sectors Growth, 13.

Panda, H., & Ramanathan, K. (1995). *The role of technological capability in value addition: The case of the electricity sector*. Technology Management, 2(2), 84-100.

Panda, H., & Ramanathan, K. (1996). *Technological capability assessment of a firm in the electricity sector.* Technovation, 16(10), 561-588.

Pânzaru, S., & Dragomir, C. (2012). *The considerations of the sustainable development and eco-development in national and zonal context*. Revista de Management Comparat International, 13(5), 823.

Parthasarthy, R., & Hammond, J. (2002). *Product innovation input and outcome: moderating effects of the innovation process*. Journal of engineering and technology management, 19(1), 75-91.

Patel, P., & Pavitt, K. (1994). *National innovation systems: why they are important, and how they might be measured and compared*. Economics of innovation and new technology, 3(1), 77-95.

Peansupap, V., & Walker, D. H. (2006). *Information communication technology (ICT) implementation constraints*. Engineering, construction and architectural management.

Pearsall, J., & Hanks, P. (Eds.). (1998). *The new Oxford dictionary of English*. (Vol. 16). Oxford: Clarendon Press.

Peng, D. X., Schroeder, R. G., & Shah, R. (2008). *Linking routines to operations capabilities: A new perspective*. Journal of operations management, 26(6), 730-748.

Peppard, J., & Ward, J. (2004). *Beyond strategic information systems: towards an IS capability*. The Journal of Strategic Information Systems, 13(2), 167-194.

Pesqueux, Y. (2009). *Une critique du knowledge management* (No. hal-00494043).

Phaal, R., & Probert, D. (2009). *Technology roadmapping: facilitating collaborative research strategy*. University of Cambridge

Pike, A., & Tomaney, J. (1999). *The limits to localization in declining industrial regions? Trans-National corporations and economic development in Sedgefield borough.* European Planning Studies, 7(4), 407-428.

Pilat, D. (2003). *ICT and economic growth: evidence from OECD countries, industries and firms*. OECD Publishing.

Pine, R. (1992). *Technology transfer in the hotel industry*. International Journal of Hospitality Management, 11(1), 3-22.

Plessis, M.D. (2007). *The role of knowledge management in innovation.* Journal of Knowledge Management, Vol. 11 No. 4, pp. 20-9.

Popa, I. L., Preda, G., & Boldea, M. (2010). *A theoretical approach of the concept of innovation.* Managerial Challenges of the Contemporary Society. Proceedings, 151.

Porter, M.E. (2003). *The economic performance of regions.* Regional Studies, 37(6/7), 549-578.

Powell, W. W., & Snellman, K. (2004). *The knowledge economy.* Annu. Rev. Sociol., 30, 199-220.

Pradhan, R. P., Arvin, M. B., Nair, M., Bennett, S. E., & Hall, J. H. (2019). *The information revolution, innovation diffusion and economic growth: an examination of causal links in European countries*. Quality & Quantity, 53(3), 1529-1563.

Prajogo, D. I., & Ahmed, P. K. (2006). *Relationships between innovation stimulus, innovation capacity, and innovation performance.* R&D Management, 36(5), 499-515.

Radulescu, I. G., Panait, M., & Voica, C. (2014). *BRICS countries challenge to the world economy new trends.* Procedia economics and finance, 8, 605-613.

Rahmouni, M., & Yildizoglu, M. (2011). *Motivations et déterminants de l'innovation technologique: Un survol des théories modernes.*

Ram, J. (2010). *The conceptual dimensions of innovation: A literature review*.

Ramos, H. A. D. C., Ramos, P. A. D. C., & García-Peñalvo, F. J. (2018). *A system of indicators for assessing scientific and technological capacity at local universities.* In Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality (pp. 221-227).

Rasiah, R. (2009). *Technological capabilities of automotive firms in Indonesia and Malaysia.* Asian economic papers, 8(1), 151-169.

Redshaw, S. (2004). *The uses of knowledge: Collaboration, commercialization, and the driving cultures project. Innovation & Tradition: The Arts, Humanities and the Knowledge Economy.* New York: Peter Lang, 91-100.

Reichert, F. M., & Zawislak, P. A. (2014). *Technological capability and firm performance.* Journal of technology management & innovation, 9(4), 20-35.

Reinganum, J. F. (1989). *The timing of innovation: Research, development, and diffusion.* Handbook of industrial organization, 1, 849-908.

Ren, S., Eisingerich, A. B., & Tsai, H. T. (2015). *How do marketing, research and development capabilities, and degree of internationalization synergistically affect the innovation performance of small and medium-sized enterprises (SMEs)?* A panel data study of Chinese SMEs. International Business Review, 24(4), 642-651.

Rickne, A. (2001). *Assessing the functionality of an innovation system.* Goteborg, Chalmers University of Technology.

Roberts, E. B. (1988). *What we've learned: Managing invention and innovation.* Research-Technology Management, 31(1), 11-29.

Robinson, K. (2017). *Out of our minds*. London: Capstone.

Robles, G. C. (2006). *Management de l'innovation technologique et des connaissances: synergie entre la théorie TRIZ et le raisonnement à partir de cas: application en génie des procédés et systèmes industriels* (Doctoral dissertation).

Rogers, C. R. (1962). *The interpersonal relationship*. Harvard educational review, 32(4), 416-429.

Rogers, E. M. (1995). *Lessons for guidelines from the diffusion of innovations.* Joint Commission Journal on Quality and Patient Safety, 21(7), 324-328.

Rogers, E. M. (2003*). Diffusion of innovations (5th ed.)*. New York: Free Press.

Rogers, M. (1998). *The definition and measurement of innovation*. Melbourne Institute Working Paper No. 10/98

Rosen, R. (1991). *Life itself: a comprehensive inquiry into the nature, origin, and fabrication of life*. Columbia University Press.

Rosenfeld, R., & Servo, J. C. (1991). *Facilitating change in large organisation.* Managing Innovation.

Rothwell, R. (1989). *Small firms, innovation and industrial change*. Small Business Economics, 51-64.

Rothwell, R. (1992). *Successful industrial innovation: critical factors for the 1990s.* R&d Management, 22(3), 221-240.

Rothwell, R., & Zegveld, W. (1985). *Reindusdalization and technology.* Logman Group Limited, 83-104.

Rouach, D. (1997). *Management du transfert de technologie international dans le cadre de joint-ventures: application à l'Europe de l'Est-Pologne* (Doctoral dissertation, Lyon 3).

Ruiz-Jiménez, J. M., & del Mar Fuentes-Fuentes, M. (2013). *Knowledge combination, innovation, organizational performance in technology firms.* Industrial Management & Data Systems.

Ruttan, V. W. (1959). *Usher and Schumpeter on invention, innovation, and technological change.* The quarterly journal of economics, 596-606.

Sahoo, B. K., & Tone, K. (2009). *Decomposing capacity utilization in data envelopment analysis: An application to banks in India.* European Journal of Operational Research, 195(2), 575-594.

Sala-i-Martin, X. (1994). *Cross-sectional regressions and the empirics of economic growth.* European Economic Review, 38(3-4), 739-747.

Sanchez, R., & Mahoney, J. T. (1996). *Modularity, flexibility, and knowledge management in product and organization design*. Strategic management journal, 17(S2), 63-76.

Sarafidis, V., & Wansbeek, T. (2012). *Cross-sectional dependence in panel data analysis*. Econometric Reviews, 31(5), 483-531.

Scheyvens, R., Banks, G., & Hughes, E. (2016). *The private sector and the SDGs: The need to move beyond 'business as usual'.* Sustainable Development, 24(6), 371-382.

Schiuma, G., & Lerro, A. (2010). *Knowledge-based dynamics of regional development: the intellectual capital innovation capacity model*. International journal of Knowledge-based Development, 1(1-2), 39-52.

Schmookler, J. (1953). *The utility of patent statistics*. J. Pat. Off. Soc'y, 35, 407.

Schulz, K. P. (2008). *Shared knowledge and understandings in organizations: its development and impact in organizational learning processes.* Management Learning, 39(4), 457-473.

Schumpeter, J. A. (1930). *Sozialistische Möglichkeiten von heute*. [Mohr](IS).

Schumpeter, J. A. (1934). *The theory of economic development, translated by Redvers Opie.* Harvard: Economic Studies, 46, 1600-0404.

Schumpeter, J. A. (1935). *The analysis of economic change.* The review of Economics and Statistics, 17(4), 2-10.

Schweizer, T. S. (2003). *Managing interactions between technological and stylistic innovation in the media industries.* Technology Analysis & Strategic Management, 15(1), 19-41.

Sciamarelli, M. (2017). *Sustainable Development Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation.* Integrating global issues in the creative English language classroom: With reference to the United Nations Sustainable Development Goals, 91.

Sciulli, L. M. (1998). *How organizational structure influences success in various types of innovation.* Journal of Retail Banking Services, 20(1), 13-19

Scott, W. R. (2013). *Institutions and organizations: Ideas, interests, and identities*. Sage publications.

Servaes, J. (2017). *Sustainable development goals in the Asian context*. Springer Singapore

Sethi, A. P. S., Khamba, J. S., & Kiran, R. (2007). *Linkages of technology adoption and adaptation with technological capability, flexibility and success of AMT implementation in Indian manufacturing industry: An empirical study*. Global Journal of Flexible Systems Management, 8(3), 25-38.

Seven, U., & Coskun, Y. (2016). *Does financial development reduce income inequality and poverty? Evidence from emerging countries.* Emerging Markets Review, 26, 34-63.

Sheth, J. N., & Stellner, W. H. (1979). *Psychology of innovation resistance: The less developed concept (LDC) in diffusion research* (No. 622). Urbana-Champaign, IL: College of Commerce and Business Administration, University of Illinois at Urbana-Champaign.

Shinkevich, A. I., Kudryavtseva, S. S., Ivanov, G. G., Korotun, O. N., Ishmuradova, I. I., Gainullina, R. R., & Ostanina, S. S. (2017). *Research and Technological Capacity of Russia as an Indicator of Knowledge Economy Growth*. International Journal of Advanced Biotechnology and Research, 8(4), 1381-1388.

Simmonds, K. (1986). *Marketing as Innovation the eighth paradigm.* Journal of Management Studies, 23(5), 479-500.

Simon, A., Kumar, V., Schoeman, P., Moffat, P., & Power, D. (2011). *Strategic capabilities and their relationship to organisational success and its measures.* Management Decision.

Simonen, J., & McCann, P. (2008). *Firm innovation: The influence of R&D cooperation and the geography of human capital inputs.* Journal of Urban Economics, 64(1), 146-154.

Sinha, A., Sengupta, T., & Alvarado, R. (2020). *Interplay between technological innovation and environmental quality: formulating the SDG policies for next 11 economies.* Journal of Cleaner Production, 242, 118549.

Skrzypek, E. (2009). *Creativity of Knowledge Workers and Their Impact on Innovativeness of Enterprises.*

Smith, K. (1998). *Science, technology and innovation indicators: A guide for policy-makers.*

Smith, N., & Ainsworth, M. (1989). *Managing for innovation*. Mercury.

Solis-Quinteros, M. M., Avila-Lopez, L. A., Carrillo-Gutierrez, T., & Arredondo-Soto, K. C. (2017, July). *Technological Capability of the Small and Medium-Sized Enterprises Manufacturing Sector.* In International Conference on Applied Human Factors and Ergonomics (pp. 191-202). Springer, Cham.

Sorescu, A. B., Chandy, R. K., & Prabhu, J. C. (2003). *Sources and financial consequences of radical innovation: Insights from pharmaceuticals.* Journal of Marketing, 67(4), 82-102.

Sour, O., & Maliki, S.B. (2020). *Technological Capability and Growth: Evidence from selected Arab MENA Countries.* Algerian review of economic development, Volume 07 (Number 02), Algeria: Kasdi Marbah University Ouargla, 359-368.

Stanton, E. A. (2007). *The human development index: A history*. PERI Working Papers, 85.

Stewart, F. (1979). *International technology transfer: issues and policy options*. Washington, DC: World Bank.

Stock, T., Obenaus, M., Slaymaker, A., & Seliger, G. (2017). *A model for the development of sustainable innovations for the early phase of the innovation process.* Procedia Manufacturing, 8, 215-222.

Storper, M. (1997). *The Regional World*. New York: The Guilford Press

Sutz, J., & Arocena, R. (2006). *Integrating innovation policies with social policies: a strategy to embed science and technology into development processes.* Strategic Commissioned Paper, IDRC Innovation, Policy and Science Program Area, International Development Research Centre, Canada.

Suurs, R. A. (2009). *Motors of sustainable innovation: Towards a theory on the dynamics of technological innovation systems*. Utrecht University.

Szogs, A. (2010). *Technology transfer and technological capability building in informal firms in Tanzania*. Center for Innovation, Research and Competence in the Learning Economy (CIRCLE), Department of Design Sciences, Lund University.

Takim, R., Omar, R., & Nawawi, A. H. (2008). *International technology transfer (ITT) projects and development of technological capabilities in Malaysian construction industry: A conceptual framework.* Asian Social Science, 4(8), 38-46.

Tan, J., Fischer, E., Mitchell, R., & Phan, P. (2009). *At the center of the action: Innovation and technology strategy research in the small business setting.* Journal of small business management, 47(3), 233-262.

Teece, D. J., Pisano, G., & Shuen, A. (1997). *Dynamic capabilities and strategic management.* Strategic management journal, 18(7), 509-533.

Teo, H. H., Wang, X., Wei, K. K., Sia, C. L., & Lee, M. K. (2006). *Organizational learning capacity and attitude toward complex technological innovations: An empirical study*. Journal of the American Society for Information Science and Technology, 57(2), 264-279.

Tippins, M. J., & Sohi, R. S. (2003). *IT competency and firm performance: is organizational learning a missing link?.* Strategic management journal, 24(8), 745-761.

Tödtling, F., Lehner, P., & Trippl, M. (2006). *Innovation in knowledge intensive industries: The nature and geography of knowledge links.* European planning studies, 14(8), 1035-1058.

Tong, X., Lai, K. H., Zhu, Q., Zhao, S., Chen, J., & Cheng, T. C. E. (2018). *Multinational enterprise buyers' choices for extending corporate social responsibility practices to suppliers in emerging countries: A multi-method study.* Journal of Operations Management, 63, 25-43.

Tripathi, M., & Inani, S. K. (2020). *Does information and communications technology affect economic growth? Empirical evidence from SAARC countries*. Information Technology for Development, 26(4), 773-787.

Tsai, K. H. (2004). *The impact of technological capability on firm performance in Taiwan's electronics industry*. The Journal of High Technology Management Research, 15(2), 183-195

Tsayem, D. M. (2009). *Paradoxes conceptuels du développement durable et nouvelles initiatives de coopération Nord-Sud: le Mécanisme pour un Développement Propre (MDP).* Cybergeo: European Journal of Geography.

UN Documents: *Gathering a Body of Global Agreements has been compiled by the NGO Committee on Education of the Conference of NGOs from United Nations web sites with the invaluable help of information & communications technology.*

UNCTAD, U. (2014). *World investment report 2014: Investing in the SDGs: An action plan.* United Nations publication. Retrieved May, 5, 2015.

United Nation Sustainable Development Goals (UNSDGs) (2019b), *The Sustainable Development Agenda*. Available at: https://sustainabledevelopment.un.org/sdg9 (visited: 12/11/2019)

Uribe, M., & Yue, V. Z. (2006). *Country spreads and emerging countries: Who drives whom?.* Journal of international Economics, 69(1), 6-36.

Utterback, J. (1994). *Mastering the dynamics of innovation: How companies can seize opportunities in the face of technological change.* University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship.

Vaatanen, J., Podmetina, D., & Pillania, R. K. (2009). *Internationalization and company performance: A study of emerging Russian multinationals*. Multinational Business Review.

Valente, T. W., & Rogers, E. M. (1995). *The origins and development of the diffusion of innovations paradigm as an example of scientific growth*. Science communication, 16(3), 242-273.

Valliere, D., & Peterson, R. (2009*). Entrepreneurship and economic growth: Evidence from emerging and developed countries.* Entrepreneurship & Regional Development, 21(5-6), 459-480.

Vicente, M., Abrantes, J. L., & Teixeira, M. S. (2015). *Measuring innovation capability in exporting firms: the INNOVSCALE.* International Marketing Review.

Voegtlin, C., & Scherer, A. G. (2017). *Responsible innovation and the innovation of responsibility: Governing sustainable development in a globalized world*. Journal of Business Ethics, 143(2), 227-243.

Wallas, G. (1926). *The art of thought*. J. Cape: London

Wang, Y., Lo, H. P., Zhang, Q., & Xue, Y. (2006). *How technological capability influences business performance: An integrated framework based on the contingency approach.* Journal of Technology Management in China, 1(1), 27-52.

Weick, K. E. (1990). *Technology as equivoque: Sensemaking in new technologies*. Technology and organizations.

West, M. & T. Rickards (1999). *Innovation. In M.A. Runco & S.R. Pritzker (Eds.), Encyclopedia of creativity.* Vol. 2 (pp. 45–55). London: Academic Press.

West, M. (2002). *Sparkling Fountains or Stagnant Ponds: An Integrative Model of Creativity and Innovation Implementation in Work Groups*. Applied Psychology: An International Review, 2002, 51 (3), 355–424

West, W. (2000). *Psychotherapy & spirituality: Crossing the line between therapy and religion*. Sage.

Wilson, G. (1995). *Technological capability, NGOs, and small-scale development projects.* Development in Practice, 5(2), 128-142.

Wonglimpiyarat, J. (2014). I*nnovative policies to support technology and ICT development*. Government Information Quarterly, 31(3), 466-475.

Wooldridge, J. M. (2001). *Applications of generalized method of moments estimation*. Journal of Economic perspectives, 15(4), 87-100.

Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data MIT press*. Cambridge, MA, 108.

World Health Organization. (2016). *World health statistics 2016: monitoring health for the SDGs sustainable development goals*. World Health Organization.

Yam, R. C., Guan, J. C., Pun, K. F., & Tang, E. P. (2004). *An audit of technological innovation capabilities in Chinese firms: some empirical findings in Beijing, China.* Research policy, 33(8), 1123-1140.

Yin, J. Z. (1992). *Technological capabilities as determinants of the success of technology transfer projects*. Technological forecasting and social change, 42(1), 17-29.

Zahra, S. A., & Nielsen, A. P. (2002). *Sources of capabilities, integration and technology commercialization.* Strategic Management Journal, 23(5), 377-398.

Żak, K. (2016). *The knowledge economy-the diagnosis of its condition in selected countries*. Studia Ekonomiczne, 271, 176-188.

Zawislak, P. A., Cherubini Alves, A., Tello-Gamarra, J., Barbieux, D., & Reichert, F. M. (2012). *Innovation capability: from technology development to transaction capability.* Journal of technology management & innovation, 7(2), 14-27.

Zhou, D., Huang, J., & Schölkopf, B. (2005). *Learning from labeled and unlabeled data on a directed graph*. In Proceedings of the 22nd international conference on Machine learning (pp. 1036-1043).

Zulfikar, R., & STp, M. M. (2019). *Estimation model and selection method of panel data regression: an overview of common effect, fixed effect, and random effect model*. Fakultas Ekonomi. Universitas Islam Kalimantan MAB Banjarmasin

APPENDIX

Appendix 1:

Variance Inflation Factors

Sample: 2000 2018
Included observations: 153

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	2.309646	451.6407	NA
LOGDCPS	0.020800	62.20582	1.828179
LOGFBS	0.005385	212.1998	**3.063476**
LOGFTS	0.011310	560.5512	2.180793
LOGGEET	0.080382	112.1714	1.469606
LOGMOBCTS	0.023710	86.59589	2.630731
LOGSTJA	0.006901	106.5143	2.356707

Appendix 2: After Removing *LogFbs*

Dependent Variable: LOGPAR
Method: Panel Least Squares

Sample (adjusted): 2003 2016
Periods included: 14
Cross-sections included: 16
Total panel (unbalanced) observations: 154

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-14.09453	1.466135	-9.613388	0.0000
LOGDCPS	0.907223	0.135795	6.680817	0.0000
LOGFTS	1.260509	0.097682	12.90415	0.0000
LOGGEET	-1.061322	0.279316	-3.799720	0.0002
LOGMOBCTS	0.878849	0.104602	8.401867	0.0000
LOGSTJA	-0.417607	0.077951	-5.357298	0.0000

R-squared	0.623260	Mean dependent var	6.664494
Adjusted R-squared	0.610532	S.D. dependent var	1.428764
S.E. of regression	0.891654	Akaike info criterion	2.646704
Sum squared resid	117.6669	Schwarz criterion	2.765027
Log likelihood	-197.7962	Hannan-Quinn criter.	2.694767
F-statistic	48.96876	Durbin-Watson stat	0.125937
Prob(F-statistic)	0.000000		

Appendix 3: Colinearity Test

Variance Inflation Factors
Date: 03/10/21 Time: 10:57
Sample: 2000 2018
Included observations: 154

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	2.149553	416.3668	NA
LOGDCPS	0.018440	54.53469	1.600682
LOGFTS	0.009542	468.2407	1.814572
LOGGEET	0.078017	107.7174	1.409130
LOGMOBCTS	0.010941	39.34548	1.325315
LOGSTJA	0.006076	92.71609	**2.056036**

Appendix 4: After Removing *LogStja*

Dependent Variable: LOGPAR
Method: Panel Least Squares

Sample (adjusted): 2000 2017
Periods included: 18
Cross-sections included: 16
Total panel (unbalanced) observations: 190

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.806342	1.384909	-7.080858	0.0000
LOGDCPS	0.581466	0.120658	4.819122	0.0000
LOGFTS	0.849502	0.075792	11.20835	0.0000
LOGGEET	-0.330668	0.233132	-1.418371	0.1578
LOGMOBCTS	0.394481	0.072821	5.417104	0.0000

R-squared	0.488032	Mean dependent var	6.582843
Adjusted R-squared	0.476962	S.D. dependent var	1.368128
S.E. of regression	0.989448	Akaike info criterion	2.842625
Sum squared resid	181.1165	Schwarz criterion	2.928073
Log likelihood	-265.0494	Hannan-Quinn criter.	2.877239
F-statistic	44.08767	Durbin-Watson stat	0.042259
Prob(F-statistic)	0.000000		

Appendix 5: Colinearity Test

Variance Inflation Factors
Date: 03/10/21 Time: 11:05
Sample: 2000 2018
Included observations: 190

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	1.917972	372.2286	NA
LOGDCPS	0.014558	42.45485	1.361976
LOGFTS	0.005744	281.1450	1.046563
LOGGEET	0.054351	74.89732	1.185703
LOGMOBCTS	0.005303	17.67185	1.149883

Abstract

This thesis aims to analyze the technological capacity index, and innovation index, in 17 emerging countries. We apply unbalanced panel regression models for the period 2000-2018 using patent for resident as a proxy of innovation variable. The fixed-effects regression model results show that Mobile cellular subscriptions (per 100 people) and Domestic credit to the private sector (% of GDP) are drivers of the technological capacity and innovation in emerging countries.

Keywords: Technological Capacity – Emerging Countries – Innovation – Panel Data.

الملخص

تهدف هذه الأطروحة إلى تحليل مؤشر القدرات التكنولوجية ومؤشر الابتكار في 17 بلدا ناشئا. نطبق نماذج انحدار غير متوازنة للأفرقة للفترة 2000-2018 باستخدام براءة اختراع المقيمين كوكيل لمتغير الابتكار. . تظهر نتائج نموذج انحدار التأثيرات الثابتة أن الاشتراكات الخلوية المتنقلة (لكل 100 شخص) والائتمان المحلي للقطاع الخاص (% من الناتج المحلي الإجمالي) تشكل محركاً للقدرة التكنولوجية والابتكار في البلدان الناشئة

الكلمات الرئيسية: القدرة التكنولوجية – البلدان الناشئة – الإبداع – بيانات بانل.

Résumé

Cette thèse vise à analyser l’indice de capacité technologique et l’indice d’innovation dans 17 pays émergents. Nous appliquons des modèles de régression par panel déséquilibrés pour la période 2000-2018 en utilisant le brevet pour résident comme variable de substitution de l’innovation. Les résultats du modèle de régression des effets fixes montrent que les abonnements cellulaires mobiles (pour 100 personnes) et le crédit domestique au secteur privé (% du PIB) sont des moteurs de la capacité technologique et de l’innovation dans les pays émergents.

Mots clés: Capacité Technologique – Pays Emergents – Innovation – Données du Panel.