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MODERN EVOLUTIONARY ECONOMICS

Economía Evolutiva Moderna

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ABSTRACT

The following paper is the result of an analysis and study of the volume *Modern Evolutionary Economics* by Richard Nelson, Giovanni Dosi, Constance Helfat, Andreas Pyka, Pier Paolo Saviotti, Keun Lee, Kurt Dopfer, Franco Malerba, and Sidney Winter.

It is aimed at describing the main aspects on which evolutionary economists have centered their analysis for over the last three decades, being these ones: technological advance, behavior and capabilities of firms, Schumpeterian competition and industrial dynamics, long run economic perspective, and the process of catching-up by latecomers.

This work has the final objective of transmitting a clear understanding of how and why the economy grows from the evolutionary perspective, and it always takes into account the fact that the economy is constantly in motion, and that innovation is the main driver towards changes.

RESUMEN

El siguiente trabajo es el resultado del análisis y el estudio del volumen *Modern Evolutionary Economics* de Richard Nelson, Giovanni Dosi, Constance Helfat, Andreas Pyka, Pier Paolo Saviotti, Keun Lee, Kurt Dopfer, Franco Malerba, y Sidney Winter.

Está dirigido a describir los principales aspectos en los que los economistas evolutivos han centrado sus análisis durante las ultimas tres décadas, como son: el avance tecnológico, el comportamiento y las capacidades de las empresas, la competencia schumpeteriana y la dinámica industrial, las perspectivas económicas a largo plazo, y el proceso de recuperación o convergencia de los rezagados.

Este trabajo tiene como objetivo final transmitir una comprensión clara de cómo y por qué crece la economía desde la perspectiva evolutiva, y siempre teniendo en cuenta que la economía está en constante movimiento y que es la innovación el principal impulsor de los cambios que ésta experimenta.

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CHAPTER I. INTRODUCTION

Neoclassical economics have considered technology to be an exogenous variable, and as a "resource" available to all firms. Furthermore, these theories have applied mechanistic assumptions based on close systems modeling the economy in order to provide better forecasts. Neoclassical economists assume both consumers and producers to act under fully rationality and subject to different variables such as the available budget, or technological constraints for instance; always trying to maximize their utility or profit.

On the other hand, evolutionary economists are focused on providing an understanding on economic growth based on empirical facts. They consider that the economy is constantly in motion, and that these is an evolutionary and cumulative process, mainly driven by innovation. From this perspective, the different economic actors' behaviors are the result of trying and failing, efforts at learning, imitation, and their ability to adapt to new scenarios, under the assumption of bounded rationality.

This report is aimed at providing a broad perspective of the economic activity shaped by the different phenomena analyzed through it in the different chapters. The first chapter "Economics from an evolutionary perspective" is addressed to lay out the general orientation followed by evolutionary economists and their key questions or points.

The second chapter "Technological advance as an evolutionary process" describes evolutionary economists' perspective on technological advance as it is considered in evolutionary economics to be one of the resources that have led to increases in living standards over the past two centuries. This chapter goes through different concepts such as "technological paradigm" or "technological trajectories", analyzing general features as well as differences among industries and how do innovation systems work.

The next chapter "The behavior and capabilities of firms" analyses the different determinants of firms capabilities and behavior, due to the fact that firms play an important role in almost every economic sector in terms of production and in the advance of technologies. This field of evolutionary economics emerged trying to solve two main problems found on neoclassical theories. The first one is the assumption by neoclassical economists regarding the behavior of different agents, as they assume cognitive and calculational capabilities that these agents do not have (perfect rationality assumption), the second one regarding the neoclassical argument that only those firms implementing profit maximizing strategies will survive in the competitive environment. To see the

evolutionary economics approach special attention is put on firms' routines and "dynamic capabilities"

The following chapter "Schumpeterian competition and industrial dynamics" is related to technological advance (discussed in chapter 3) and to firms' capabilities and behavior (discussed in chapter 4), and studies industrial dynamics in the sense of how sectors evolve due to the emergence of new technologies, and how new institutions appear as industries evolve and change.

Chapter 6 "Evolutionary perspectives on long run economic development" analyzes the different long run aspects of the processes involved in economic growth. Evolutionary economists recognize economic development to involve not only increases of productivity with the best practices and the disappearance of the less productive practices, but also the important role that continuing innovation plays on this process. Furthermore, this chapter studies the role played by institutions, and provides an understanding of economic development for countries that are at or near to the technological and economic frontiers.

The final chapter "Economic catch-up by latecomers as an evolutionary process", studies the economic development observed in countries which are significantly behind the technological and economic frontiers. Not only analyzing the different challenges that countries might face, but also paying special attention to learning and capabilities building.

When conforming the previous chapters together, which have previously been treated as independent fields, one can have a clear understanding of modern economies work and which is the nature of the economic dynamics going on. The central objective of these report is to provide a clear and uncomplicated understanding of how and why the economy evolves and grows, which are the different agents responsible for these changes and how these agents are linked, all of it from an evolutionary perspective. Therefore, it can be useful within the educational field at the university level, or for interested economists.

CHAPTER II. ECONOMICS FROM AN EVOLUTIONARY PERSPECTIVE

II.I CAPITALISM AS A DYNAMIC EVOLVING SYSTEM

The main discrepancy that can be found between neoclassical economics and evolutionary economics lies in the fact that these second ones see continuous change, largely associated to innovation, as the central characteristic of modern capitalist economies.

Economies are not a static element, in fact they are constantly changing and evolving as new elements are being introduced while old ones disappear. Although the economy evolves and changes as a whole, the different sectors and activities among it diverge in the path and nature of change, in some of them innovation is an accelerated and continuing process while in others it is limited.

Following Schumpeter's theory, evolutionary economists highlight the economic progress that the capitalist model has brought about, and thus they put forward these important economic questions: How did this economic progress occur?, what can be done so as to enable societies that have been left behind to achieve the progress? and, what type of progress can be expected in the future?

Albeit considering technological innovation as the key driving source of economic development in the long run, in the neoclassical approach it is not treated as the heart of economic description and analysis but as a special separated topic. Contrasting with the evolutionary idea of the strong linkage between what is happening in an economy at any moment and innovation.

Innovation can be briefly defined as any activity associated to something new that has not existed before and the beliefs regarding its potential value. Innovators thus, may use what is empirically known so as to predict what is likely and not likely to succeed, but luck and imagination do also play an important role.

When evolutionary economist define the process of economic change as evolutionary, they try to put special importance in the fact that the human understanding of the context is incomplete and thus, uncertainty will always besiege many important parts of the economy, especially the ones regarding new things and new ways of doing things, since how new things are actually going to end up working can only be learned by creating and trying, by taking them to actual practice.

Not only efforts on innovation are required, but the different economic actors to be able to respond to changes that may occur in the context in which they operate. Moreover, the

way in which the economic actors act is the key to understand the selection process that occurs simultaneously with economic evolution, in which actors doing well will expand and, on the other hand, actors doing poorly will decline and may even disappear.

Far from saying that economic actors "optimize" (as neoclassical economics assume), evolutionary economics state that they are able to decide what to do and how to do it depending on the specific context in which actors operate, and at the same time they (actors) learn from their own experience together with the information available in the market. Therefore evolutionary economists do not see the economy as an equilibrium configuration, but as transient phenomena being generated by an evolutionary process highly dependent on the decisions made by the different actors participating.

Given the assumption of evolutionary economists regarding the continuous changes that the economy faces, their focus of study lies on the search for patterns and relationships found in economic dynamics, which can explain the nature of the changes that are taking place.

Summarizing, evolutionary economists give special importance to the continuous change and to the role that the different actors participating have in this change. Furthermore, they do not see the economy as an equilibrium configuration but rather as the result of an evolutionary process at any time.

II.II ECONOMIC THEORIZING AND WHAT ECONOMISTS ACTUALLY BELIEVE

Evolutionary economist see, in fact, an evolutionary perspective in many neoclassical economists and theories. Being this, of course, a positive development, evolutionary economists firmly believe that getting an explicit evolutionary perspective on economic activity is an important issue.

Economic theories, whether neoclassical or evolutionary, can be developed at different levels of abstraction and generality, and some of them are very general and they are done at the highest level of abstraction.

However, many theories focus on a concrete set of phenomena or economic aspects and are normally quite formal, meaning with this they are explained mathematically. Evolutionary economists want, therefore, to highlight that in order to understand the economy, these theories should be a combination of economists knowledge and empirical studies, much more inductive in nature and not that logical and mathematical as the already mentioned formal models.

This inductive theorizing has been denominated as "appreciative theorizing", and its main advantage is that it is expressed verbally (allowing both qualitative and quantitative details). However, it is much more difficult to analyze the logical coherence and also to deduce implications.

Thus, being formal theorizing a way of trying to understand what would happen under certain idealized conditions and appreciative theorizing what economists know about how the economy is going, both ways of theorizing should be seen as complement.

Evolutionary economists consider that the evolutionary perspective should be more widely known and considered, so that economists developing appreciative theories can take into account all the actors and factors influencing the economy, even those that are left apart when following other perspectives.

II.III THE BEHAVIOR AND CAPABILITIES OF ECONOMIC ACTORS

While neoclassical economists had done the assumption that economic actors' behavior is optimal, evolutionary economists believe on the other hand, that economic actors act based on a purpose and in a not-completely known environment, that is to say: economic actors behave under bounded rationality taking into account that human failure can happen.

While behavioral economies do not put special attention to the context in which the actors are making their decisions, evolutionary economies make a distinction between actions taking place in familiar contexts and actions taking place in a new scenario. Due to this, many evolutionary economists have been attracted to the idea proposed by Herbert Simon regarding "bounded rationality", which also supported the idea of a distinction between known and unknown contexts.

Following Simon's idea, although an unknown context might be difficult to understand for the different actors, they can observe and analyze important aspects so as to get to some implications. These implications in stable contexts may lead to actors learning and being able to establish "routines" that end up being employed without explicit thinking. But inevitably, these routines will be made obsolete and irrelevant by changes occurring in the contexts. Therefore, actors will once again face and unknown scenario where to do new things. Taking this into account, search and problem solving activity which aim is to create a guidance on how to act when changes occur is another important field within evolutionary economics.

While the conventional decision theory focuses on the choice the actors makes among the different possibilities they have, evolutionary economists focus on the way this new options and possibilities are conceived and how the actors get to know them.

Formal organizations are considered to be the key economic actors, in modern economies firms are the organizations that provide most of what we need and therefore, most of the innovation is done by firms.

In a nutshell, evolutionary theories are able to explain in a much more detailed way of what economic actors do and how the behave, than the traditional presumption of actors optimizing posed by neoclassical economics.

II.IV THE NATURE AND ROLE OF MARKETS AND COMPETITION

The two key elements of capitalist economic systems are, from the evolutionary perspective, market organization of economic activity, and competition.

Although it is impossible to solve analytically a system formed by all the potential consumers, its needs, the wide variety of products and services provided by firms, different inputs, etc., market organization is somehow able to solve it and to guide economic activity towards an efficient configuration.

In contrast to the neoclassical theory regarding a static equilibrium, evolutionary economists support the idea of an equilibrium in which technologies, resources and needs are changing continuously and unpredictably.

Evolutionary economists consider price to be the key variable influencing the behavior of economic actors, reflecting shifts in demand and supply. However they do not assume economic actors to behave optimally and therefore, do not assume that markets are always close to an “equilibrium”.

Evolutionary economies see markets not only as an institution influencing prices and allocating resources but also as a key factor triggering economic actors to explore new things. Moreover, they do not consider competition to be just a tool to maintain low costs, but as a mechanism to promote innovation among firms.

What evolutionary economists highlight about markets and competition is the fact that they enable the path for economic actors to explore and to find better ways to do think, to innovate.

In order for economic actors to engage in innovation, these must be sure that they will gain profit with their efforts and innovations. Our economic system thus, provides a monopoly control over the use of any innovation by the innovator (through the patents systems). However, this monopoly control has to be temporary, as firms operating in the same industry or in the same line of business will, at the end, adopt the innovation so as to move together to the next step. Therefore, market competition becomes a tool for collective evolutionary learning.

II.V THE INSTITUTIONAL RICHNESS OF MODERN CAPITALISM

When talking about institutions, economists refer to all the structures, constraints, requirements, incentives and norms, which strongly model and influence economic behavior in capitalist economies.

Both, neoclassical and evolutionary economies, do recognize firms and market as the main institutions modelling modern capitalist economies. However, while neoclassical economists see other significant institutions as a needed tool that enables the well going of markets and that solves market failures, evolutionary economists see them as independent from markets and firms, with their own nature and operation.

Albeit considering these institutions to be independent from markets and for-profit firms, evolutionary economists do highlight their role in terms of innovation and how the enable the new paths for economies to move along.

Despite being firms and markets the ones that play the main role, in many industries, these public and non-market institutions are the ones governing and setting the "rules of the game".

Therefore, the evolution of these institutions through time is the key factor when it comes to long run economic progress; government policies, laws, programs…all of them are factors that function both as responses to changes in economic activity and as elements that foster these changes.

In a nutshell, evolutionary economists see the role of organizational and institutional innovation as important as the one of technological and industrial innovation in the economic growth process.

II.VI EVOLUTIONARY ECONOMICS AND EVOLUTIONARY BIOLOGY

Evolutionary economics and the perspective of Darwinian evolutionary biology have some similarities and differences that will now be analyzed.

The elemental analogy that can be found between these two theories is that both of them minimize the importance of long run planning in determining the prevailing scenario. Another similarity between these two approaches is the fact that both describe the dynamic process full of varieties which, by means of some selection mechanisms, can be treated with more or less importance; this process is also considered in both theories as a continuously changing process in which the introduction of new varieties is essential. A further similarity can be found within these two theories and it is the fact that both highlight that what is going on at the present has to be understood as the result of the cumulative and dynamic processes.

However, albeit seeming to be very close, these two approaches also disagree in some aspects. In the economy, the different economic actors are able to learn and change, and therefore discover new ways of doing things and new technologies. Once the shift of an industry towards a new technology starts, other firms will also established these new technologies and move towards the same path, while other will disappear and some others may arise.

Other important difference is that, unlike Darwinian evolutionary biology, evolutionary economics recognizes that social and economic processes are intentionally driven.

CHAPTER III. TECHNOLOGICAL ADVANCE AS AN EVOLUTIONARY PROCESS

III.I INTRODUCTION

Evolutionary economists contemplate the economy as a constant evolving system, and they consider that in order to understand how the economy works it is of great importance to understand how capabilities have evolved through time to be the ones that we now own.

Evolutionary economists have focused on technologies (as a wide concept that encompasses the great variety of "methods of doing things" in current economies), and their advance in order to try to understand economic growth in the long run, as technological advance is considered to be the main driving force for economic growth.

When talking about technological advance, one should take into consideration the fact that numerous actors are constantly trying to evolve and to develop new technologies which enable them to perform their activity in a better way. While actors from different sectors or industries work with different technologies and, therefore they are focused on different technologies and problems, many times actors that operate in the same sector (and therefore employ similar technologies) are trying to solve a common problem. Thus, trying to solve it becomes a competition process, which will result in some actors being winners and some others losers.

All in all, two important facts should be taken into consideration when studying technological advance: the wide variety of efforts taking place at any time (with the subsequent winners and losers) and the fact that technological advance is a cumulative learning process.

III.II TECHNOLOGICAL CAPABILITIES

Economists working on the field of technological advanced have paid great attention to the effects of technological capabilities (being these ones the supply side) on technological advance, and how they have influenced the allocation of efforts and resources.

Although at any time there are multiple unreached want and desires, that could be met with the development of new technologies (which will be rewarding for their inventors

or technologists), many times the actors in charge of developing and improving those technologies lack the capability to undertake these changes and improvements.

Economists have come to observe that there are three general variables: the strength of the scientific knowledge in which technologies are based, the cumulative knowledge achieved by experience, and the different available resources with which technologists can work so as to undertake their research and development activities.

Most of R&D activities are based on scientific knowledge from fields such as engineering and other applied sciences, which are focused on problem solving and on technologies improvement. However, these above mentioned science strongly rely on the deeper understanding and knowledge of the basic and fundamental sciences.

While engineering and other applied sciences focus on trying to solve existing problems, the most fundamental sciences try to understand the how and why and what. Thus, understanding how things work can greatly help when trying to develop them.

Although R&D is commonly considered the only way to achieve technological advance, learning by doing and by using is an important source as well. While scientific knowledge (being the base for R&D activities) is generally open and available, what is learned by doing and by using is exclusive for every inventor or firm.

Individual technologies are not independent, and therefore the development of new technologies or the improvement of already existing ones depends on the available resources, other technologies, materials, etc.

III.III THE ROLE OF DEMAND

In the same sense as in the previous section, economists have given special importance to the effects and influence of the demand side on technological advance, as most of the times, technological advances have been driven by new needs and different variables in the demand side.

Whether an inventive and innovative effort is successful or not is highly determined by what customers want, and as it is normally difficult to know whether they will accept a new product, analyzing users' needs in advance can clearly help to determine whether an invention or innovation will succeed.

These new needs and desires that trigger technological advance and innovation, together with the ability of inventors to determine them, and the roles played by user differ among

markets and sectors. Furthermore, the existence of different requirements, regulations and constraints in the industry might influence technological advance.

The interaction between people in charge of R&D and users, and the way in which this interaction or relation affects the also differ depending on the "type" of users. When final users are households or individuals this interaction is not that strong (except in some cases in which customers who have the necessary competences, do some of the needed experiments or evaluations for further improvements). However, when the final users are firms or formal organizations, this interaction and their influences on the R&D activities is stronger.

Additionally, the conditions of factor supply also have a direct influence on the different processes employed and developed in an economy. This has been called "induced innovation theory", and it proposes that changes in the prices of the different factors of production (including labor prices), are direct stimulus for inventions and innovation.

III.IV PUBLIC AND PROPRIETARY ASPECTS OF TECHNOLOGICAL KNOWLEDGE

Technological knowledge, and therefore technological advanced at some point and up to certain extend is considered as a "public good". That is to say, at a given moment, technologies become part of the public domain, and are available for every actor, without dwindling the inventor's ability to use it. Indeed, this is the main driver of technological spread and the main reason why all the technological advances have taken place during the past centuries.

However, this public spread is a double-edged weapon. The spread of an invention or innovation has clear benefits on the economy as a whole. On the other hand, business firms and independent inventors (main sources of technological advance) engage in innovation or invention primarily due to the expected profit. When this public spread begins, the inventor or innovator's returns on this new technology can drastically decline. Therefore, this public spread might be a threat that can discourage actors to engage in innovation or invention. That is to say, a balance between the public spread of a new technology and the returns for the inventor is needed.

While in many industries, and especially among large companies, patents are said to be the most used and efficient tool that enables inventions and innovations protection, in some other industries, and small firms, the way of profiting from an invention lies on the

ability to be over competitors, the increase of marketing and servicing capabilities, and continuous improvements that move down the learning curves before competitors.

The public and proprietary aspects of technological knowledge, innovations and inventions has been a controversial field of study regarding three important aspects. Firstly regarding what should be patentable and under which conditions. Secondly, whether public research findings should be patented or should be made available for the public domain. Finally, issues regarding anti-trust policies.

Regarding with what should be patented and under which conditions, economists (especially those studying technological progress) have come to observe that strong patent mechanisms led to monopolization of new technologies. Evolutionary economists consider that the patent scope is the most important variable (more important than its duration), as broad scopes can block competitors from using new technologies, making innovation and invention more difficult and costly. All in all, the patenting system should be that, it enables protection for the inventor but at the same time does not block competitors, as strong patents have clearly shown not to foster invention nor innovation.

Continuing with the patenting of public research findings, although it has been considered to be a mechanism that can facilitate the transfer and implementation of them, recent studies have come to demonstrate that this relationship has been magnified, and therefore had contributed to the rise of the analysis and study in this field.

A last issue that has taken importance in recent years concerns anti-trust policies. In industries where there is a dominant firm, this one can constraint the entrance of new firms that try to enter the market by means of inventions or innovations, as strong patents and intellectual property rights can be used to block entry.

III.V TECHNOLOGICAL PARADIGMS AND TECHNOLOGICAL TRAJECTORIES

The term "technological paradigm" put forward by Dosi (1982, 1988), which is similar to the scientific paradigm proposed by Thomas Kuhn (1962) and to the "technological regime" introduced by Nelson and Winter (1977), defines the link between three aspects, that when used in common can lead to an advance in the state of art.

These three important aspects abovementioned regarding the state of technology in an economy at any time are: the different technologies available and the way in which they are used; the knowledge and understanding that support those technologies; and the evaluation and analysis of the prevailing best practices and possible future improvements.

Within the shared technological paradigm basic designs outstand, which are the reason why there are strong similarities among different firms regarding the products they commercialize and the way in which they produce them. In some industries or sectors, there is a "dominant design", which does not mean that there is little variety (as there can be many different products) but that this variety is somehow constrained.

Additionally, the technological paradigm, also comprises a common appreciation of the weak and strong points of the prevailing practices and further approaches so as to advance technology. This has received the name of "technological trajectories", and in some such way these trajectories mark a trend and the direction of technological progress over time. These trajectories normally remain align to a direction for long periods of time and are particular to each technology.

Although technological paradigms and trajectories tend to be established in an economy for long cycles, these ones might change as changes in different variables - demand, costs, regulations, scientific and technical knowledge and understanding – change. Furthermore, technological advance based on a concrete technological paradigm generally follows a path characterized by increasing returns but at diminishing rates. These two facts lead to innovators and inventors to discard the existing paradigms and trajectories, trying to establish new ones.

III.VI GROWING UNDERSTANDING OF SECTORAL DIFFERENCES AND THE COMPLEXITY OF INNOVATION SYSTEMS

Previous studies used to consider technological progress as a common process in every sector of the economy and mainly influenced by firms and independent inventors within a competitive context. However, recent studies have come to recognize that the path and influences regarding technological advance differ among different sectors, and that not only firms and individual inventors are the ones conducting the advance, but also other non-market mechanisms and actors.

These two highlighted and recent aspects are strong related, as the differences among sectors is mainly due to the different innovation systems (most active organizations and the linkages between them) of which they are participants, thus both aspects are addressed together.

Although in the early days of this body of analysis economists used to consider technological progress to be highly related to firms' size or market power, they then came

to realize that in fact, there was not a strong relationship between them. Indeed, economists observed how among industries in which innovation was being carried out the types of firms that were fostering the process were different.

With regards to this topic Keith Pavitt (1984) proposed a classification attending to the different types of industries in which the innovative activities were being carried out. One of the different classes he proposed was the "scale intensive" in which he included industries featured by large firms operating with standardize products and by means of mass production processes (such as the automobile or the television industries), which engage in R&D activities so as to become more efficient and reliable.

Other set of industries was named "supplier dependent" (comprising industries that produce commodities or provide services) and it included smaller firms than the previous class; furthermore, the innovation in this sector is not undertaken by firms but by suppliers, which are in charge of introducing new materials, machinery…

Although it is clear that Pavitt recognized the important role of suppliers in the technological progress, he did not highlight the fact that users also play an important role. Recent studies, such as the one done by Arora, Cohen, and Walsh (2016), have started to recognized the importance of users and customers' roles in high technological industries.

An additional reason that can explain the differences among industries with regards to their technological progress is the specific scientific knowledge that supports technology in each field. While in those industries where the scientific knowledge is strong high levels of R&D can be found, in other sectors where this knowledge is weak, efforts on R&D have not been that successful nor sustainable.

Government policies and support to different industries has also been a key point when talking about the differences among industries. The electronic, aerospace, defense and medical industries have been (in many countries) the main fields to which governments have given the most public support.

Although the first studies were focused on the differences between national systems, economists came to understood that the main reason why there were differences between nations was mainly due to differences in the sectoral systems. This has helped to direct the innovation systems concept towards each particular sector of the economy, thus this new direction has helped to establish more effective policies according to each sector's needs.

III.VI TECHNOLOGICAL PROGRESS AS AN EVOLUTIONARY PROCESS

The previous analysis have come to demonstrate how technological progress differs from one sector to another (an also in a national context) and how different actors (market and non-market ones) are involved in the process.

Technological progress understood as an evolutionary process recognizes the uncertainties that the different actors face when attempting to develop new methods of doing things (technologies), furthermore this approach takes into account that at any time there are multiple actors aiming to advance technology in a competitive context, and that the technological advance, far from being the result of an individual's effort, is the result of a cumulative process of learning and advances.

CHAPTER IV. THE BEHAVIOR AND CAPABILITIES OF FIRMS

IV.I INTRODUCTION

Neoclassical theories do follow the assumption that firms' behavior can be understood as profit maximization, and therefore, that they are able to understand the complex context in which they are. However, evolutionary economists believe that firms do not and cannot always optimize.

Thus, firms are seeking for profits by adapting to the different contexts they face, taking decisions and undertaking activities that are satisfactory in every situation. Therefore, evolutionary economists believe that firms are not profit maximizing but profit seeking. This profit seeking behavior is shaped by the different routines and capabilities that firms embodied.

These for-profit firms operate in competitive environments, which are highly influenced by technological innovation. That is to say, in competitive environments, when companies want to beat other firms operating in the same sector, they engage in innovation and research, which will later remodel the environment and the competition terms.

IV.II ROUTINES AND CAPABILITIES

Following Herbert Simon's observations, evolutionary economists believe in humans' bounded rationality, and therefore in belief of that it is beyond human capabilities to understand the complexity of the context in which they are and to make optimal decisions. Instead, firms rely on routines to undertake their activities so as to do the best they can, accordingly, routines are the primary elements that shape firm behavior.

Routines can be defined as sets of rules, procedures and techniques, that is to say, the different steps needed to execute a task or an activity. These routines can have both tacit and implicit aspects.

Organizational routines do not only involve the necessary steps to execute an activity, but also division of work as well as coordination between different individuals participating. Furthermore, routines within a company encompass not only ways of doing things but also ways of making decisions, the so-called "decision rules".

Routines among the firm are established by means of repetition, bolstering a constant behavior over time. However, this does not mean that routines are rigid as the different actors may change the established routines when facing new circumstances (for instance the implementation of new technologies). Furthermore, routines have a built-in adaptive responsiveness which enables firms and organizations to adapt to the different variations.

When a firm is able to manage and undertake a cluster of routines, and not only that but also to coordinate them, it is then said that the firm possesses a capability. Capabilities have been defined as high-level routines or sets of routines and therefore, capabilities' characteristics derive from those from routines: they are based on repetition, they generate a standardized behavior among the firm and they are highly contextual dependent.

IV.III EMERGENCE, DEVELOPMENT, AND ALTERATION OF ROUTINES AND CAPABILITIES

Routines and capabilities crop up as the result of profit-seeking organizations trying to solve a problem or trying to find a new way to do things so as to outplay competitors (given that these organizations normally operate in competitive environments).

Although they are commonly associated to the Research & Development department, as this department is in charge of search and problem solving, routines and capabilities may emerge in every other area of the organization.

The emergence and the further development of routines and capabilities start as new problems arise and when firms face new scenarios or circumstances. This development occurs through time and by means of trying, failing and learning from these failures and is normally conducted through deliberate learning processes which include knowledge articulation that consists on discussing and comparing experiences and knowledge between individuals. However, once routines and capabilities are established across the organization and when the performance they enable is considered as sufficient of satisfactory, the development of the same slows down.

Commonalities within industries arise, as firms operating in the same industry, commonly, try to comprehend the already existing knowledge which is the result of historical and cumulative advances in the industry. Moreover, firms tend to imitate competitors so as not to drop behind and firms operating in the same sector or industry normally share some type of information (the one coming from suppliers, customers…)which result in commonalities among routines and capabilities.

However, differences in firms' routines and capabilities can be found between firms operating in the same industry, as their starting points, the individuals conforming them and their skills, the context and their assets are specific for each firm. And even though many times firms try to imitate competitors, they are to certain extent limited to do so.

IV.IV SEARCH, INNOVATION, AND DYNAMIC CAPABILITIES

Following once again Schumpeter's observations, evolutionary economics believe that firms (which are always profit seeking) are constantly changing and innovating so as to improve their performance. In order to survive in a competitive environment, firms need to innovate in terms of capabilities and routines so as not to lag behind.

Thus the term "dynamic capabilities" emerges (first brought by Teece, Pisano, and Shuen in 1997). This concept refers to the capability of firms to change the way in which they operate and make their profit. It includes both, the ability of firms to change internal aspects within the organization, and also the capability to transform external factors of the general environment.

Dynamic capabilities enable patterned behavior by means of experimenting, failing, and learning as any other capability. What these capabilities provide to the company is the ability to change over time the different aspects of their operating characteristics and to

adapt to whatever occurs to new scenarios. The term dynamic capabilities encompass a large variety of firm activities and are highly dependent on the firm's nature and sector.

The main difference between ordinary and dynamic capabilities is that, the first ones provide knowledge on how to undertake certain activities using mainly the same techniques and technologies, while dynamic capabilities facilitate the change towards new techniques and means of operating. Capabilities are normally hierarchized, being ordinary capabilities named as zero/lower-order capabilities, and being the dynamic considered to be first-order or higher capabilities.

Where dynamic capabilities take the most important role is in those industries or environments which are based on technological change, as they enable the company not only to move towards new techniques and processes, but also to absorb knowledge from the external environment.

At any moment in time a firms has a "position", making reference to the different resources, routines and capabilities, and their situation within the marketplace. Furthermore, firms also have "processes" through which dynamic capabilities operate internally, which at the same time can modify and open new "paths" to follow. These three concepts where used by Teece (1997) when he first introduced the approach of dynamic capabilities, so as to "frame" them.

Subsequently, Teece (2007), defined the basic functions of dynamic capabilities, being these ones: to sense new opportunities and threats arising from the external environment, to seize the already sensed opportunities and threats, and to transform business models and operating techniques so as to be able to take advantage of the opportunities and to divert threats.

Several studies have brought up that firms with more of these dynamic capabilities, do in fact have more innovative outputs and that these capabilities enable firms growth and thus, industry growth.

CHAPTER V. SCHUMPETERIAN COMPETITION AND INDUSTRIAL DYNAMICS

V.I THE NATURE AND ROLE OF ECONOMIC COMPETITION

The field in which neoclassical and evolutionary economists disagree more is in the way in which they interpret competition and specially at the industrial or sectoral level. Therefore, this chapter aims at describing competition and industry dynamics in those sectors in which innovation plays an important role.

Industrial dynamics depend on the rate and nature of the innovation going on in each sector. In those ones in which innovation is rapid, the type of competition will therefore, depend on the type of innovation. When this last one is more oriented towards new products or new designs (product innovation), the capability of firms to make profits depend on their ability to be at the leading edge, as once they reach this position firms can charge higher prices until other firms make it to that point. However, when the innovation is oriented towards improving production processes and consequently reduce costs, pricing plays an important role. That is to say, that pricing and price competition are still important economic influences even in those sectors where innovation seems to be the key element.

Initial ideas by Schumpeter suggested that large firms are the main drivers of innovation, but that their market power is constantly under threat from innovative competitors, and he considered the market power to move from one firm to another as competitors innovate.

However, in recent years evolutionary economists have come to realize that, especially in those industries which emerge due to new radical innovations, the principal source of innovation are small and new firms. Therefore, evolutionary economists have dedicated a field of study for these industrial dynamics, trying to provide a broad overview of the both the general and common characteristics of Schumpeterian competition and industrial dynamics across industries and the most important differences across them.

V.II SOME GENERAL ASPECTS OF INDUSTRIAL DYNAMICS

When evolutionary economists started analyzing industries and their dynamics, what took their attention was the fact that they could observe great variations among firms in the same industry in different dimensions.

The presence and position of firms within an industry's distribution is not static, indeed at any time there are new firms entering and other firms exiting

Initial Schumpeterian theories tended to suggest that innovative firms grow faster that those non-innovative. However further advances in the field of technological advanced helped economists to understand and recognize that a big share of innovation fails. Therefore, it might be easier for firms to be quick at responding to successful competitors' innovations and to learn by observing, rather than innovating themselves.

Differences in firms' sizes did not surprise economists, but rather huge differences in terms of productivity and profitability. Therefore the question regarding how within an industry innovators fared in relation to non-innovators started to become important for evolutionary economists. In those industries in which there are more opportunities to improve product and processes, competition forces firms to innovate or at least to stay up with new technologies. And here is where Schumpeter's concept of "creative destruction" shows clearly to be operative at the firm and industry levels.

On the other hand, when talking about differences, the variable "age" of the industry should be highlighted. Generally, new industries tend to have greater amount of entries and exits than mature industries.

V.III INDUSTRY LIFE CYCLE

Industry life cycle theory is aimed at describing the dynamic process going on within an industry and within its member firms through the industries' evolution. Although there are different approaches regarding industry's life cycle theory, there are similar patterns in those studies.

These patterns comprise in the early stages of an industry high rates of entry and exit and a wide variety of products designed and produced. When an industry starts to become important, the products attracting more customers are the ones established, and firms being not that successful will try to learn from the most successful ones.

After these first stages, firms in the industry grow, the entrance of new firms becomes more difficult, and the variety of products tends to decline. Industries start to be more concentrated and a "dominant design" is established in many of them as the result of similarities among customers' needs. (Utterback and Abernathy, 1975; Anderson and Tushman, 1990; Suarez and Utterback, 1995).

When these dominant designs come about (an even when there is not an explicit one, but the dominant firm's product), markets concentrate and monopolize. This is due to two main factors: a proprietary design or of difficult imitation, and/or the existence of economies of scale in the production of these dominant products.

However, in those industries in which there is a wide variety of consumers with different wants and needs, this monopolization does not occur. Additionally, vertical disintegration is another factor that might hinder industries' monopolization, as when a new industry emerges to become the supplier of equipment or key components for the downstream industry, new firms trying to enter the downstream industry will then find no firms superior in terms of production or key elements.

Once an industry has experienced rapid technological advances and rapid growth periods, then returns start to diminish as there are not many opportunities that foster further advances, and therefore production becomes constant and technologies stabilize. Another possible scenario for mature industries is the one in which they are out-of-date and a new industry employing new technologies might substitute the former one.

Within an industry, when a new technology is replacing an old one, there is normally a shift in the industry's leadership as the previous dominant firms typically tend not to be effective with these new technologies and new firms enter outstanding.

V.IV THE BROADER EVOLUTION OF INDUSTRY "WAYS OF DOING THINGS"

The "ways of doing things" is a wider concept that does not only include technologies (in the sense of products' design or production processes) but also the ability to adapt to new technologies, managerial and organizational activities,…, and therefore, although within an industry different firms might have the same technologies available, firms' performances might differ significantly.

As technologies and the "ways of doing things" settle down in an industry, firms operating in it tend to specialize vertically or horizontally. In modern economies, production is marked by the division of labor (different actors with different technological knowledge and expertise), as it is impossible for a firm to keep up to date in the different technological areas in which its production is based. Therefore, multiple linkages between the different actors emerge as a vehicle for knowledge and technologies transfer.

These networks evolve alongside the evolution of industries. At first, in new industries, there are multiple of them but these ones are baggy, but as the industry matures and technologies settle down, the networks become more compact and long-lasting.

Another important concept which has emerged together with the evolution of industries is the institution of "venture capital" in many countries as a source of financing new firms and new industries (due to the fact that banks and other financial institutions are generally against participating in the financing of highly speculative ventures). However, these institutions have also shown not to involve in any "new project" before there is strong evidence that it will succeed. Things change as products are produced and sales start to grow, financial institutions become interested and start developing expertise so as to be able to evaluate projects for funding.

Those new or mature industries that need skilled labor, might lead to the development of a specialized labor market, to the emergence of new programs at schools that can provide special education for the special skills or competences needed, and even to the emergence of new professions.

The evolution of industries includes implicitly the evolution of government policies and programs. As an industry emerges, firms operating in it need to adapt to the context of public policy that was established before in another era or industry. However, as the industry matures and starts to be seen as an entity on its own right, governments start to be pressured by different agents (firms within the industry, third parties affected by the new industry) that are trying to change law and regulations.

CHAPTER VI. EVOLUTIONARY PERSPECTIVES ON LONG RUN ECONOMIC DEVELOPMENT

VI.I INTRODUCTION

Since the times of Adam Smith, economic development has been a core frame of study and analysis for many (if not all) evolutionary economists. Nonetheless, as neoclassical theories emerged, the interest of economists shifted towards the analysis of economic conditions and the economic equilibrium.

The interest in this field of economic growth arose again after World War II due to the emergence of two new intellectual movements.

The first intellectual movement was the neoclassical growth theory, which placed technological advance as the main driver of economic development, where they coincide with evolutionary economics. However, neoclassical theories understand economic growth as the process of economy moving towards an equilibrium, while evolutionary ones (following Schumpeter) see economic development as a process of "creative destruction".

The second intellectual movement that fostered the interest on economic development among economists is the fact that, after World War II there were available different statistics regarding national product and income, which provided information never gathered before, that enabled economists to measure economic outputs and inputs and their changes over time. The analysis of this new data gave a lot of information about the economic development that took place.

Notwithstanding, technological advance does not refer only to advances that enable the economy to produce more outputs, but also advances that enable us to do new things, and that affect the way in which people interact and live.

All in all, evolutionary economists believe that economic development is a wider concept that cannot be explained simply by taken into consideration the proximate sources and that different perspectives need to be tuned in.

VI.II A VARIETY OF PERSPECTIVES

In pursuance of a theory that can study, explain and give us an understanding of that economic development is, different perspectives each of them focused on distinctive subgroups of aspects are taken into account so as to give a coherent overall view of what is going on in an economy.

These different perspectives can be classified in three different arrays (that might in some aspects overlap), according to the aspects of the economic development taken in consideration for the study.

The first group has to do with the fact of technological advance as the driving force towards economic development in the long run, treating economic growth as a macroeconomic phenomenon and with an explanation oriented to the "proximate" sources of growth (which were put forward by Moses Abramowitz and which make reference to labor and capital, and technological advance as a force that increases the productivity of these two sources). This work and analysis mainly involves formal modeling.

The second perspective for analysis involves the study of the emergence of new products and the disappearance of old ones, together with the associated rise and fall of different industries along the economic development. This second body of analysis does not consider economic growth as a macroeconomic phenomenon and includes both qualitative and quantitative studies. This branch focusses on structural change that takes place when growth occurs.

The last frame of analysis places the core interest on institutions and their changes related to the technologies in use and the economic structure at any time, as evolutionary economists believe that institutions are part of the factors that foster technological innovation and therefor economic development.

The different perspectives are analyzed now and, although they present different long run economic development explanations, due to the divergence of their focuses of study, the three of them are valuable. Furthermore, in order to achieve a clear understanding of economic development in the long run, the three of them should be taken into consideration.

VI.III EVOLUTIONARY GROWTH MODELS

The first evolutionary growth models were constructed on the basis of the neoclassical growth theory, which was focused on the increases over time of GNP (Gross National Product). Economists where later interested on trying to develop a model of economic growth driven by technological advance that could explain the patterns of growth experienced by GNP.

These growth models are of a one sector economy and do take into consideration the different practices undertaken by firms and also divergences among firms in terms of their performance. However these models take the assumption that all the outputs from the different firms are of the same kind, so as to later be able to sum all the outputs and treat them as like GNP.

The different models contrast in some details but they coincide in the main aspects and elements. The model taken into consideration for the following analysis is the Nelson-Winter 1974 model.

The basic assumptions taken by this model are: a market characterized by perfect competition, firms producing at full capacity (determined by the size of its capital stock), the amount of needed inputs for each firm (in the case of the Nelson-Winter model the only input is labor) determined by the technologies and output of each firm and factor prices (wage rate) sensitive to the total industry's demand.

Following this model, profit rates (rates of return on each firm's capital stock) differ among firms due to their available technologies and their unit production costs and, therefore, there are profitable and unprofitable firms. Profitable firms are the ones that own the most productive technologies and they employ their profits on expanding their capacity. On the other hand, firms that do not own the most profitable technologies learn and try to adopt the technologies from the profitable firms, an so some firms are innovating and adopting new technologies.

This process of some firms growing while others introducing new technologies results in an increase of the total output, capital, employment and factor prices. However, due to the tight linkage between profit rates to capital stocks, these rates tend to be constant over time.

This model is able to explain and to create time series of the abovementioned elements (total output, inputs, factor prices and profit rates) which coincide with the historical records. Furthermore, the model is able to distribute firms according to sizes,

productivities and profitability. Moreover the model is also able to bring about S-shaped curves of the growth of the use of technologies from when they are first introduced up to the decline they suffer when new and better technologies emerge.

In both, neoclassical and evolutionary growth models, increases in output (and output per worker) and rises in living standards are directly associated to technological advance (which increases productivity of the inputs) and to increases in capital stock. While in the neoclassical models these two sources are considered to be independent from each other, in the evolutionary models they are strongly linked in the sense that so as to be more capital intensive, firms need to develop new technologies which that are more capital intensive.

To sum up, the first evolutionary growth models paid attention to "new ways of doing things" and placed them in the center stage. However, they treated economic growth as increases in total outputs and therefore, they didn't take into consideration the appearance and disappearance of products or the rise and decline of industries. In spite of this fact, these first models have been able to provide support for an evolutionary perspective on how economic productivity has been rising.

VI.IV MULTISECTOR EVOLUTIONARY GROWTH MODELS

Although they take into account many of Schumpeter's elements, the previous models do not recognize the birth of new products and industries and the decline of others, as this would be incompatible with measuring growth as an aggregate output.

Neoclassical economist have taken into consideration increases in productivity (output per worker) associated to increases in the capital intensity of firms and industries. However, these increases in productivity do not show the development of new goods and services nor the fact that these new items have enable people to do new things. Evolutionary economists have based their theorizing with regards to the economic growth process on some other empirical facts apart from increases in productivity. Not only the emergence of new products and industries and the disappearance of old ones, but also an increase in the variety and in the quality of the products offered.

Furthermore, they state that economic growth would not have been possible without the emergence of new industries, goods and services and the decline and disappearance of others. That is to say, the increase of productivity by itself does not fully explain how economic growth changes structurally the economies.

Parallel to these increases in productivity, total outputs and in the variety of goods offered, evolutionary economists do also pay attention to increases in the resources designated to education and physical capital, as these increases in human capital have been, at the same time, the boosters of the development of new products as well as of the increase of consumption patterns.

An additional characteristic of economic growth is that it has been discontinuous rather than smooth. The emergence and implementation of new technologies have been associated to rapid growth eras, while the maturity of these technologies has slowed down economic growth. Moreover, economic growth has been strongly influenced by changes in institutions (this topic is discussed in the next section).

Recent studies, involving formal modeling, from Saviotti (1996) and Saviotti and Pyka (2004, 2008a, 2008b, 2013b) have been used so as to describe multisector economic growth. In their model, economic growth is associated to: the emergence of new economic sectors, the different advances experienced by particular sectors, and increases in productivity. In different sectors there are, at any time, multiple actors engaging in R&D, some of them oriented towards advances in the sector itself and others more generally oriented, which end up enabling the emergence of new products and, together with them, new industries. Therefore, these authors' model generates booms when a new industry appears and recessions as the industry matures, defining, that way, the appearance of long waves.

However, the study of long waves as the main drivers and markers of economic growth can be better attributed to other authors, such as Schumpeter, Freeman, Louça and Perez.

There is now a general agreement, that although the emergence of new technologies and new industries can be associated to rapid economic growth eras, long waves in the sense of being regular timed by these new technologies or industries do not exist.

Recent writings by Carlota Perez (2004) on the field of long waves strongly suggest that these long waves are highly influenced by institutions and their development. Furthermore, she put forward the concept of "technoeconomic paradigm" as being the combination of technologies and the institutions that enable their advances in a particular sector (this association is deeply analyzed in next section).

VI.V INSTITUTIONS, INSTITUTIONAL CHANGE, AND THE EVOLUTION OF ECONOMIC STRUCTURES

Being institutions defined as the "rules of the game" in a particular economic field, these ones and the way in which they evolve have become an important body of analysis for evolutionary economists.

Institutions in this sense encompass a variety of guides: organization and management of firms, structuration of markets, the creation and diffusion of new knowledge (as institutions convey and structure the different linkages and interactions among the different actors participating).

Institutions are normally characterized by being long-lasting and difficult to change and therefore, economists tend to assume that as economy changes and passes from one era to another, there are different institutions emerging and prevailing.

Institutions play a key role in economic growth, as technological advances, new knowledge and new industries emerging need different sets of institutions to be effective. In this section, different examples are analyzed in order to support the importance of institutions and their evolution.

The first example is based on Alfred Chandler's (1962,1977) analysis of the ascent of mass production in the last quarter of the 19th century. In order to adopt this economies of scale and scope (achieved by mass production), firms needed to be larger and, therefore new ways of organizing and managing were needed. New management meant new managers, what resulted in the emergence of Business Schools as an institutional mechanism that enabled professional training. Furthermore, with the increase of firms and their capacity, the existing financial institutions became insufficient to meet the market needs and at this point modern investment banks and stock markets emerged.

A second example that illustrates how institutions emerge and evolve together with technological advance is that of synthetic dyestuffs (end of the 19th century in Germany), studied and analyzed by Murmann (2003). Starting with advances on organic chemistry, firms needed to introduce the concept of industrial research laboratories where scientists could work on this field. Together with this fact, Germany supported the development of Technical Universities by means of public funding to enable professional training for the new industries emerging. Furthermore, Germany's patent and labor laws were revised, to protect firm's profits on these new industries and to be able to deal with the new labor relationships emerging.

The development of automobiles and their expansion in the early 20th century is another case that can demonstrate how technological advances foment changes in institutions. Firstly, the emergence of this new industry fostered the creation of a body of traffic law and the allocation of a big amount of government's budget on the building and maintenance of roads. Continuing with the emergence of different requirements and standards regarding safety, and more recently regulations concerning environmental issues.

In a nutshell, these three examples clearly show how the development and emergence of institutions can be driven by technological advances, but at the same time these new institutions foster further development of these new technologies, which normally result on new institutional changes, becoming this process a virtuous cycle.

Regarding institutional structures, the generation of new ones has been supported in some cases by the abovementioned institutional developments, and certainly, the emergence and development of these institutional structures can be attributed to economic development as a whole rather than to a specific technology.

CHAPTER VII. ECONOMIC CATCH-UP BY LATECOMERS AS AN EVOLUTIONARY PROCESS

VII.I INTRODUCTION

It was not until after World War II that economists started to be interested in which were the factors behind the differences among countries in terms of productivity levels, standards of living and economic development as a whole.

When these factors started to be seen as an accepted field of analysis, economists focused mainly on two variables: low levels of physical and human capital directly related to lower levels of productivity and lower levels of income in poor countries, and institutional structures of poor countries as factors hindering the development process. These first studies did not see "technology transfer" as a problem and did not give the necessary importance to the processes of learning and capabilities building .

The body of research done by the pioneers economists on this field (Martin Bell, Charles Cooper, Jorge Katz, Linsu Kim, and Sanjaya Lall), which is highly influenced by the perspective of evolutionary economics is the one going to be analyzed in this chapter.

This body of analysis is concerned with the processes of learning and capability building and catch up.

In addition to the already existing analysis, some ideas from more recent literature have been taken into consideration so as to extend their initial ideas. Firstly, the innovation systems perspective is adopted so as be able to broaden the study to sectorial and national levels and not only to the firm level. Secondly, not considering the catch up just involved with the processes of learning and capabilities building but also as a matter of the ability of latecomers to find niches and sectoral specialization. Thirdly, catch up implies also radical jumps that can be achieved by taking advantage of the opportunity windows that might open for latecomers. Finally, understanding of catch up as a cycle, in which latecomers will at one point take the industry leadership, but then they will leave this last one to new latecomers.

VII.II PERSPECTIVES ON ECONOMIC CATCH-UP

Firstly, it is important to recognize economic catch-up as a learning process and capability building rather than as a matter of copying or cloning. This is due to the fact, that every country has its own organizational, managerial, and institutional aspects, and therefore, each one of them will follow different paths and trajectories of technological advance.

An important fact to take into consideration is that learning does not automatically happen after the transfer of new foreign technologies, but as an uncertain and difficult process that countries which have not heavily invested on R&D and on the formation of skills and new capabilities have not been able to achieve.

Innovation (not only technological, but also organizational and institutional innovation) has been considered by evolutionary economists to be a main driver for successful catch-up. Thus, innovation systems are a crucial complement for firms to achieve learning and capability building.

When talking about learning, capability building and institutional and innovation systems, it is needed to analyze the different "failures" that might hinder with the catch-up process (which are different from the neoclassical "market failure").

Firstly, the so-called "capability failure" refers to the lack of opportunity for effective learning and capability building for the different economic actors, and highlights the importance of contributing to firms' rise of the above-mentioned capabilities by means of learning opportunities.

Secondly, evolutionary economists have recognized "system failures" as important as "capability failure" when talking about factors that hinder economic catch-up. This term makes reference to the different failures associated to low interaction among actors and with low learning together with it or failures in the changes of existing systems as well as in the emergence of new ones.

VII.III CATCHING UP AT THE FIRM LEVEL

When analyzing the different factors that might hinder the catch-up process for firms operating in developing countries three relevant and recent contributions need to be taken into consideration.

Firstly, capabilities, their accumulation, and their development through time. In this field of analysis, the concepts of absorptive capacity (put forward by Cohen and Levinthal, 1989) and dynamic capabilities (issue discussed in Chapter IV) play an important role. Another important concept regarding capabilities is the approach of capability life cycle, put forward by Helfat and Peteraf (2003), which explains the heterogeneity that can be found among firms' capabilities as the result of different patterns in the evolution of these capabilities through time.

Secondly, the contribution that considers entrepreneurship to be one of the main drivers of economic catch-up, as the new companies that emerge (mainly due to entrepreneurs) enter niches, they then learn, accumulate capabilities, and consequently grow. (Malerba et al. 2016)

Thirdly, business groups and their diversity as a way to apply their own exclusive and particular capabilities and resources. (Amsden and Hikono, 1994; Guillén, 2000; Kock and Guillén, 2001)

Economists have associated latecomer firms from developing countries with two aspects: resource poor and late time of entry. Regards the concept of resource poor, this one suggests that latecomers normally don't have access to the needed resources (which vary among firms, sectors and countries) for the catch-up, and therefore, they need not only to learn how to maximize the utilization of the available resources but also how to acquire these lacking resources.

The second aspect related to latecomers makes reference to their late entrance, as when these ones manage to enter the market, the value chain of production is well established by firms which belong to the advanced countries, and therefore latecomers have no other

choice rather than inheriting the segments that have been left or starting from original equipment manufacturer (OEM), to evolve later into own design manufacturing (ODM) and finally into own brand manufacturing (OBM), being this evolving process the standard upgrading one for latecomers.

Another important aspect to take into consideration when describing the catch-up process at the firm level concerns international networking and integration. Due to the fact that many times the needed resources are not available within the developing country, these foreign linkages and connection may facilitate the access to those resources. Catching-up firms might try to be export oriented, as exporting activities function as opportunity windows to learn from the worldwide scenario. Therefore, while foreign direct investment (FDI) has not been empirically proved to be positive in developing countries, when focusing this one towards production for exports rather than for local markets, these ones will work better.

In many of the developing countries, the institutions needed and which support business activities are missing and, therefore business groups emerge so as to fill this lack. For instance, business groups have a wider access to capital markets, they can create value by jointly developing professionals and can also share and coordinate the utilization of the limited resources available.

In a nutshell, the catching-up process at the firm level starts with firms focusing on building physical and human capital, it then continues with firms trying to upgrade their production process (phase which involves the upgrade of managerial and R&D capabilities and resources), and it ends by companies trying to go internationally and to operate globally.

VII.IV CATCHING UP AT THE COUNTRY LEVEL

So as to describe the catch-up process from a national perspective, evolutionary economists have focused their research on the concept of National Innovation Systems (NIS), together with the concept of "assimilation" which considers development to be an evolutionary process.

Since learning and capability building take place within specific institutional settings, evolutionary economists consider that NISs affect the different aspects with regards to new knowledge, as its production, diffusion, and use. Therefore, the several actors that compose NIS have a direct effect on the generation of knowledge, innovation and the catch-up process. Actors such as universities and public research bodies, financial

organizations, the broader institutional frameworks, the educational system, public policy the legal system, different norms,…, and as important as these actors, the linkages among them.

Regarding knowledge two topics should be discussed. Firstly, knowledge localization, which is a measure of the knowledge created domestically. While advanced countries showed to have high degrees of knowledge localization, developing countries have lower degrees. Secondly, referring to the type of knowledge needed, the technological one rather that the scientific, has been proved to be the one that matters for developing countries. This technological knowledge is related to firms' efforts on R&D.

Another notable aspect to take into consideration is local demand, and how its specificity with respect to global demand in terms of income per capita, consumer preferences, local requirements, and public procurement can help firms to survive in the global competitive environment, and consequently grow. In addition, when this local demand is large enough, it enables economies of scale that can later start off virtuous cycle of learning and capability building, and it can help local firms to grow. Two types of large local demand should be highlighted: the one concerning price sensitive and low end markets, and a second one related to specific groups of users.

A final topic to discuss regarding the catch-up process at the country level is the so-called "middle income trap". This trap is described as the failure at achieving high income status that countries which have achieved a middle income status suffer. This is due to the fact that, when countries achieve this middle income status, they are blocked between low wage manufacturers and high wage innovators, as middle income countries' wages are to high to compete with low wage exporters and their level of technological capabilities is lower than in advanced countries.

VII.V CATCHING UP AND SECTORS

To better understand the catch-up process, a final analysis from the sectorial perspective should be done, as this process takes place in specific sectors of country's economy and then drive the growth of the economy as a whole.

A first step is to define the concept of sectoral innovation system, being this one characterized by understanding the sector as a system and by focusing on the underlying knowledge for innovation and production, learning capabilities, other non-firm actors, and the different institutions.

Regards these above-mentioned sectoral innovation systems and the factors that can affect the catch-up process, some similarities and differences have been found across sectoral systems.

Three common features have been found across these systems. The first one is related to firms' learning and capability building, the second one to accessibility to foreign know-how and the third one related to the supply of skilled labor.

Continuing with the differences found, the first one can be found on the type of knowledge underlying innovation. For instance, in some sectors (as the machinery sector) the innovation is based on technological advances which do not rely heavily on advances on science, but some other sectors (as the pharmaceutical) are mainly built on science, and therefore on scientific advances. Another important aspect related to knowledge that varies from one sector to another is the role of universities and public research centers.

A second difference has to do with industries' structures, while in sectors with small firms and high entry rates new firms played an important role in the catch-up process, in sectors with large firms and high industrial concentration, the ones which have driven the catch-up process have been large firms.

Finally, institutions (broadly defined) and policies also vary across sectors according to the type and effects of the catching-up. In those sectors where the scale is relevant and where intense R&D activities are undertaken, policies are focused towards the support of these R&D activities of local firms and public research with the aim of advancing the general knowledge and capabilities of domestic firms. On the other hand, in those industries or sectors where knowledge is mainly based on skilled individuals, public policies have been oriented towards the promotion of education and formation. In sectors where empirical knowledge is crucial, governments have been focused on the development of scientific and technological infrastructures, support of experimentation… Finally, in those industries in which knowledge is strongly based on science, public policies offer support to universities and to university research.

A final mention should be done with regards to the relationship between sectoral and national systems. There is a give-and-take relationship between these two systems, as national systems can positively affect the development of those sectors which sectoral systems fit the national system's dimensions. And the other way around, successful sectoral systems or institutions might be transferred to other sectors by means of public

policies (although this only success when the latter sector's system is somehow related to the former).

VII.VI CATCHING UP, SECTORIAL SPECIALIZATION, AND LEAPFROGGING

As already mentioned in previous sections, catch-up is not only about learning and capability building but also about specializing and finding niches or new sectors, as latecomers are "late entrants" and the value chain is already established but, as they build more and new capabilities, they enter different and new sectors.

Developing countries are initially abundant in labor or resources and therefore, their best option is to enter labor or resources intensive sectors and which do not require high technological levels nor know-how and skills.

The next step for these developing countries (as history has shown) is to enter other industries or sectors that might require higher amounts of technological know-how and skills. These second step has historically been done towards mature industries or industries in which the underpinning technology is relatively constant, as these facts can ease technology transfer.

Once these developing countries have reached certain levels of capabilities, their next targets are high technological sectors which experience rapid economic growth. However, it is difficult for indigenous firms belonging to these developing countries to compete with other firms from more technological advanced countries.

When talking about high technological sectors a distinction should be done regarding whether new technologies require know-how skills similar to the old ones or completely new ones. When these technologies require periodical changes in the knowledge and competences needed, they are called "short cycle" technologies.

Industries with these kind of technologies above-mentioned offer better opportunities for latecomers, as experience does not play an important role. Indeed, new generations of technologies make incumbents and latecomers to start from the same point and therefore, open new windows of opportunity for the later entrants.

This process of firstly enter mature industries, to later enter a sector with short-cycle technology can lead developing countries to get stuck in the middle income. This is where the concept of leapfrogging (Perez and Soete, 1988) plays an important role, as

developing countries can leapfrog to a new or emerging industry where incumbents and latecomers start from the same point and, therefore have the same opportunities.

In short, developing countries have three different strategies to follow for their catch-up. The first one, the low road is the strategy that low and lower middle income countries follow when entering sectors which involve low end goods and longer technological cycles. The second strategy, the high road, consists on developing countries replicating high income countries by specializing in hard science or new technologies. The third alternative, the middle road, makes reference to those countries which are stuck in the middle income trap, due to their failure in upgrading once they enter a sector with short technological cycle.

VII.VII CATCHING UP IN THE LONG TERM EVOLUTION OF FIRMS, SECTORS, AND COUNTRIES

A final step in order to describe the catch-up is to analyze the long run aspects of the different processes involved.

Industrial leadership has shown clear changes through time, as in many industries there have been several changes of it from incumbents to a latecomers. This occurs due to the fact that sectors evolve and change, either building upon prevailing characteristics or creating a discontinuity with radical changes.

Theses discontinuities are denoted as “windows of opportunities”, and there are three kinds. The first one, the “technological window” make reference to the ones opened due to new technologies. The secondo one, the “demand window” refers to changes in the demand as a new demand or a big transformation of the local demand. And the third one, the “institutional/public policy window”, which are the result of institutional changes or public intervention in the industry.

When these windows appear, the leaders might get stuck in the “incumbent trap” and fall behind. This is due to the fact that many times, incumbents are complacent with their current situation and therefore do not pay attention to new technologies nor to new types of demand. Therefore, the type of windows, their combination and the different responses from both incumbents and latecomers determine which is the pattern of catch-ups most likely to emerge in each sector.

CHAPTER VIII. CONCLUSION

Evolutionary economists have focused their efforts on trying to provide a clear understanding of how and why the economy evolves, always from the evolutionary perspective in the sense that they consider the economy to be constantly in motion and that the main driver of these evolutionary process is innovation and technological change.

One of the main discrepancies that can be found between neoclassical and evolutionary theories lies in the different ways in which they treat the concept of technological advance or innovation, as the latter ones treat it not only as the key driving source of economic growth, but also placing it at the heart of economic development.

Evolutionary economists highlight two main aspects regarding this topic: the wide variety of efforts taking place at any time and the fact that technological advance is a cumulative learning process. They have paid attention to both, the demand and supply side and its effects on technological advance; on one hand, firms' technological capabilities (supply side) as being highly dependent on the knowledge underlying the needed technologies; and, on the other hand, the demand side to strong influence technological advances, as these late ones are the result of the different actor trying to solve new or unmet needs.

Furthermore, evolutionary economics have studied the influence that the public and proprietary aspects of an invention or innovation and have concluded that although public spread of a new technology is obviously beneficial for society and the economy as a whole, it can sometimes hinder innovative efforts, as actors engage on innovation with the expectation of profiting from the results and once these innovations go public, results might decrease.

Another divergence between these two streams lies on the way in which they consider the behavior and capabilities of the different economic actors which participate in any economy at any time. Evolutionary economists do not consider them to act optimally but boundly-rational, and following a purpose and in a known environment, without diminishing importance to human failure. From the evolutionary perspective, actors are assumed to learn by doing and by failure, and therefore to establish "routines", which are established by means of repetition, bolstering a constant behavior over time, but are, at the same time dynamic and therefore, evolve through time. When these routines reach certain levels and are not only established among the firm but there is also coordination between them, it is then said that a firm possesses a capability. These routines and

capabilities are exclusive for any firm or organization, as their starting point, their human capital, contexts, etc., varies greatly from one to another.

Regarding the concept of market, while neoclassical theories describe it as part of a static equilibrium, evolutionary theories see this equilibrium (which includes technologies, resources, and needs) to be constantly experimenting changes and thus full of uncertainty. When talking about market, competition is also an important issue to discuss. In this sense, evolutionary economics see competition not only as a mechanism to maintain low prices and to reduce divergences with costs, but also as a tool that foster innovation among firms.

Furthermore, evolutionary economists have paid great attention to industrial dynamics and to the different aspects of the economy that evolve alongside industries' evolutions. These dynamics depend, of course, on the rate and nature of the innovation going on in each industry, and although there have been different theories regarding industry life cycle, some common patterns have been found. These patterns describe how in the early stages of an industry entry and exit rates are high; then normally a "dominant design" is established and it is then when the industry tends to concentrate and monopolize (although it strongly depends on the kind of sector); after the periods of rapid technological advance and rapid growths, industries tend to stabilize, and returns start to diminish.

An important difference between these two theories that should be highlighted regarding industries (an more generally the whole economy), is the fact that neoclassical economics do not take into account the emergence of new products, firms or even industries, and the decline or disappearance of other as technological advances, or changes in demand take place.

Trying to understand economic development, evolutionary economists have developed different perspectives. The first one, is macroeconomically oriented, taking into account the economy as one sector, view and focusing on the productivity increases. The second one is based on the view of structural change as the main result of economic growth. Finally, the third one takes institutional change as the core to explain economic growth and development.

With regards to institutions, evolutionary economists consider market and non-market ones (and their evolution) to play an important role in the economic growth process. They have observed that between technological advances and institutions a virtuous cycle can

start, meaning with this that technological advances lead to changes in institutions, and these latter changes, can at the same time foster further technological advances.

Finally, with what concerns to economic catch-up, evolutionary economists have describe it as a cumulative process of learning and capability building, which occurs in the long run and for which countries normally take advantage of the different opportunity windows that open for latecomers. These theories have also recognized the importance of national and sectoral systems of innovation in the catching-up process.

Working on this report and on the volume *Modern Evolutionary Economics* by Richard Nelson, Giovanni Dosi, Constance Helfat, Andreas Pyka, Pier Paolo Saviotti, Keun Lee, Kurt Dopfer, Franco Malerba, and Sidney Winter, has helped me to understand the economy under the evolutionary perspective, not only to have a broad understanding but also to achieve a clear comprehension regarding the different topics that have been developed throughout it. I personally consider that studying this economic approach is an important addition to the educational training I have been receiving throughout the whole degree, due to the fact that these evolutionary perspectives are taking importance nowadays and also because these ones are not taught in classes. Therefore, this report can help students or other individuals interested on these new evolutionary perspective, who lack this knowledge in their formative processes.

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