

# GEOGRAPHY AND TECHNOLOGICAL INNOVATION

*geografia e inovação tecnológica*

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## Resumo

Busca-se neste artigo debater a importância da inovação tecnológica para a Geografia, especialmente a partir da formação de uma vertente reconhecida como Geografia Econômica Evolucionária. A formação desta corrente tem raízes na Economia, sendo esta o objeto de atenção na primeira seção deste trabalho. Desta forma, aborda-se inicialmente a inovação tecnológica a partir da evolução da temática no pensamento econômico, considerando-se também algumas contribuições de Milton Santos acerca da dimensão técnica. Traçado este cenário, na seção seguinte se avança na discussão dos Sistemas Nacionais de Inovação, tema caro aos geógrafos e que se apresenta como uma das abordagens mais atuais acerca da importância do progresso tecnológico para as nações. Na última seção a Geografia Econômica Evolucionária é tratada em detalhe a partir dos fundamentos teóricos da subdisciplina em processo de consolidação. Algumas contribuições da Geografia brasileira são indicadas ao final do artigo.

**Palavras chave:** Geografia Econômica Evolucionária; Inovação tecnológica; Sistemas Nacionais de Inovação.

## Abstract

This paper discusses the importance of technological innovation to Geography, especially since the formation of an approach recognized as Evolutionary Economic Geography. The formation of this approach has roots in economics, which is the object of attention in the first section. Thus, initially discusses technological innovation from the evolution of the theme in economic thought, considering also some contributions from Milton Santos about the technical dimension. The next section is about of National Innovation Systems, a theme dear to geographers and one of the most current approaches on the importance of technological progress for nations. In the last section the Evolutionary Economic Geography is treated in detail from the theoretical foundations of the sub discipline in the consolidation process. Some contributions of the Brazilian Geography are indicated at the end of this paper.

**Key words:** Evolutionary Economic Geography; Technological innovation; National Innovation Systems.

## Resumen

En este trabajo se discuti la importancia de la innovación tecnológica en la Geografía, sobre todo después de la formación de una corriente reconocida como Geografía Económica Evolutiva. La formación de esta corriente tiene raíces en la Economía, que es el objeto de la atención en la primera sección. Por lo tanto, en principio se analiza la innovación tecnológica en el pensamiento económico, teniendo en cuenta también algunas aportaciones de Milton Santos sobre la dimensión técnica. En la siguiente sección se avanza en la discusión de los Sistemas Nacionales de Innovación, un tema de atención de los geógrafos y uno de los enfoques más actuales sobre la importancia de los avances tecnológicos para las naciones. En la última sección se trata en detalle la Geografía Económica Evolutiva, los fundamentos teóricos de la especialidad y el proceso de consolidación de la corriente. Algunas aportaciones de la Geografía brasileña se indican al final de este trabajo.

**Palabras clave:** Geografía Económica Evolutiva; innovación tecnológica; Sistemas Nacionales de Innovación.

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## INTRODUCTION

The concept of innovation was proposed by Schumpeter over one hundred years ago, however, the studies dedicated to the theme have only gained strength in the last decades. This appreciation of technological innovation emerged once a linear approach, in which innovation takes place in a sequential fashion starting with scientific research, had been surmounted in favor of the adoption of a systemic perspective of the phenomenon. In this systemic approach the perspective of the National Innovation Systems stands out, with the contribution of economists who are not only inspired by Schumpeter, but also by other fields of knowledge to construct the subdiscipline known as Evolutionary Economics. This approach inspired geographers to look for a perspective that valued the territorial dimensions of innovative processes from new categories. Evolutionary Economic Geography emerged in this scenario, approaching technological innovation with hitherto unused theoretical contributions. This is the trajectory discussed in this article, which aims to contribute to the debate in Brazilian Geography regarding the importance of carrying out studies focused on the relationship between territory and innovation.

Accordingly, this article initially highlights the importance of studies of innovation in a national context of the appreciation of the theme by academics, public officials and private agents. This appreciation can be verified, for example, in various economic studies on the subject, especially those published by the Institute of Applied Economic Research (IPEA). Within the ambit of public administration, the federal government's recent industrial plans (PITCE, PDP and Brasil Maior) make clear the government's growing concern to promote the country's autonomous development based on the incorporation of technological progress by the productive sectors. This thesis is reinforced by the incorporation of the term innovation into the title of the Ministry for Science and Technology in 2011. (One possible criticism is that the plans reflect the discursive strategy of the government of the day, more than effective action in the field of scientific, technological and innovation policy.) For the national business community, despite the insufficient innovative advances when comparing Brazil to central countries, there is a consensus that technological progress is a fundamental element to reach higher levels of competitiveness. Thus, there is a broad consensus on the importance of innovation for national development and Brazilian Geography can contribute in this field with better targeted studies on the theme.

This text is divided into three parts. The first deals with the issue of technical change and technological innovation from the perspective of economic theory, as well as considering some of Milton Santos' contributions to the theme. Next the perspective of the National Innovation System is presented, regarded herein as the most appropriate to deal with the phenomena related to innovation. The final section recognizes the theoretical bases geographers have used to study the theme more recently, notably Evolutionary Economic Geography. At the end of this section there is a succinct presentation of the work of some Brazilian geographers who value the relationship between territory and technological innovation.

## APPROACHES TO TECHNOLOGICAL INNOVATION

The theoretical perspective of the phenomenon of innovation has been a debate eminently positioned in the field of economic theory, but it can also be found in other scientific disciplines; in this study the emphasis is on the authors of Evolutionary Economic Geography. The first point to be emphasized about technological innovation is the importance of technical change for development. Above all there is agreement with the view that the difference in labor productivity largely explains the difference in incomes between nations. Technical progress is one of the most relevant factors, perhaps the greatest, for the increase in productivity rates. It should be taken into account that no economic theory is applied in full by governments in their policies; the theory reveals the



perception of the practices underway in specific territories and times and also inspires the practice of government and businesspeople.

Viotti (1997, p.9) argues that both Adam Smith and Karl Marx considered the process of technological change relevant to the study of economics. Smith pointed to technical progress, made possible by the division of labor, as a fundamental element in the growth of productivity, which is a determinant factor for economic development. This assertion is supported by the analysis that Smith made of the production in a pin factory in his main work *The Wealth of Nations* of 1776. In *The Communist Manifesto*, published in 1848 by Marx and Engels, the authors asserted the revolutionary role of the bourgeoisie in transforming science into an essential tool for the capitalist mode of production. On the other hand, the role of technical progress in economic development was not equally recognized by the authors of the Neoclassical or Marginalist School. In fact, there is a change in the actual object of the economy, which ceases to be the determinant of the conditions that enhance the growth of the wealth of nations, the concern of Classical Economics, and becomes the determination of quantities and their respective prices that balance the markets of goods and services, the object of Neoclassical Economics. In this new theoretical model, that has as precursors Jevons, Walras and Menger, technical change is an exogenous variable, as the existence of balance depends on the stability of the functions of production. In this way, the state of the art is discarded from the theoretical model and included in the set of variables to be taken as constants, a methodological resource usual explained by the expression “*coeteris paribus*”.

The Neoclassical School points to active policies as only being necessary when there are “market failures”; thus it is advisable for the State to maintain a distance from the economy. In this scenario the State should only act in the occurrence of non-competitive behavior (monopolies or oligopolies), to regulate the offer of public goods or in defense of property rights. Commercial freedom would be the best strategy for the nations, which would specialize in the production of goods and services according to conditions of perfect competition. After the crisis of the 1930s, there was a return to the central position of technical change with Keynesian theory. The Economic Commission for Latin America and the Caribbean (ECLAC), linked to the United Nations (UN), was responsible for theoretical concepts of a Keynesian nature, which strongly influenced Brazil. According to ECLAC’s diagnosis, the emergence of developed and underdeveloped nations is attributed to different appropriation processes of increased productivity arising from technical progress. The Industrial Revolution is regarded as a milestone for distinguishing between the countries of the center, where industrialization originated, and those on the periphery, with late industrialization. In the center, technical progress was disseminated rapidly and relatively homogeneously, whereas on the periphery there was a specialization in the production of food and raw materials through a heterogeneous absorption of technical progress.

From the diagnosis above, ECLAC began to challenge the assumptions of neoclassical theory, which defended the thesis that international trade would be equally beneficial to buyers and sellers, regardless of technological progress. While productivity gains in developed countries result in the higher prices of exported goods, in the peripheral countries productivity gains promote reductions in the prices of the products intended for other markets. The unequal relationship is not explained merely by productivity gains, but also by the existence of strong oligopolies and trade unions in the center, whilst in the periphery fierce competition and structural unemployment are characteristic. In addition, the demand for industrialized products grows more than proportionally to the increase in consumer income, whereas this relation is inverted in the case of food. In this way, ECLAC’s diagnosis indicates a structural perversity in the international division of labor, which contributes to the increase in the inequalities between the center and the periphery.

Raul Prebisch, the main reference in ECLAC’s thinking, defends that the break with the vicious circle diagnosed above should be the industrialization of peripheral countries. This industrialization would take place through the intervention of the State in the economy, using mechanisms like direct



State investment in strategic sectors that are not of any interest to private agents. Also, there should be exchange controls, promotion of the attraction of foreign capital and encouragement of the private sector through various mechanisms. These proposals by ECLAC coincide with other development theories in the sense of valuing industrialization as the best path when promoting development.

From the crisis of the 1980s, development strategies anchored in Keynesianism lost strength and gave way to the advance of neoliberal doctrine. In this context, discourse on modernization came into play with the defense of the free market and the reduction of the State in protectionist and regulatory measures or subsidies. Neoliberal doctrine was not endorsed by any existing development theory and did not draw any distinction between developed countries and developing ones. Nevertheless, it identified an articulated set of policies summarized in the Washington Consensus: a balanced budget, relative price corrections, deregulation of domestic markets, privatization and liberalization of trade and investment. For neoliberals, overcoming underdevelopment would be a natural consequence of free trade presented by the policies set by the Consensus. This is due to the belief that through free trade, nations could specialize in those sectors where they have the best comparative advantage. In terms of access to technology, for the neoliberal doctrine, this would be equally available to all nations regardless of the level of development in which they found themselves. (VIOTTI, 1997, p. 17)

Regarding technological change and innovation as fundamental to economic progress is a central point in Schumpeter's work. In *The Theory of Economic Development*, Schumpeter (1985[1911], p. 48) establishes five types of innovation that define the entrepreneurial act: (1) the introduction of a new good or a new quality of good; (2) the introduction of a new method of production; (3) the opening of a new market; (4) the conquest of a new source of supply of raw materials or semi-manufactured products; and (5) the promotion of a new organization of any industry. The definition of innovation proposed by Schumpeter, over one hundred years ago, is quite comprehensive, dealing with both the creation of new goods and processes and organizational changes, together with other issues. The basic distinction between the three stages of the innovative process, proposed by Schumpeter himself, assists in understanding the phenomenon. The first is invention, which results in a process of discovery and new technical principles that may not necessarily have commercial applications. Second is the innovation itself, regarded as the development process of an invention with a concrete commercial application. Finally, diffusion is the expansion of an innovation in commercial use, with new products and processes. In addition, it should be taken into account that innovation can be radical or incremental. In the former there are significant changes in products or processes, whilst in the latter the changes are only marginal. Schumpeter was more concerned with analyzing radical innovations than incremental ones, however, both should be considered according to the context of the analysis.

Schumpeter is one of the economists who consider the centrality of technical change and entrepreneurship in economic growth. The economist's focus is on the entrepreneur and the role of innovation in economic development, as well as in the regularity of the cycles presented by economic systems. On the other hand, Pérez (2010) recognizes a gap in Schumpeterian thinking, which is to regard technology as exogenous and outside the domain of economic theory. So, it was up to Schumpeter's followers, Evolutionary and neo-Schumpeterian scholars to advance this theme, taking into consideration the institutions and social organizations in the process of the evolution of technical change.

According to Hugo Cerqueira (2002) Evolutionary Economics emerged during a crisis in economic thinking. Thus, this approach would be one of the responses to the exhaustion of the mechanistic model would be exceeded by more systemic approaches. The difficulty in analyzing the processes of change by the previously established economic theories motivated researchers in the field to look for new categories to interpret, for example, the technological changes in the behavior of companies and consumers. The criticisms of the limitations of current economic theories are directed not only



at the neoclassical approach, but also the Austrian school and Marxist approaches. In the field of economic thinking the main references for the construction of an approach that incorporates the evolution of processes are: Schumpeter, as outlined above, and Veblen, followed by the American Institutionalists. Essletzbichler and Rigby (2010, p. 43) argue that evolutionary economists have progressed in fields where neoclassical economics was not capable of offering satisfactory answers, namely, economic growth, technological change, industrial evolution, the nature of competition and the role of institutions in directing individual behavior. On the other hand, even if the criticism of the complete information and perfect rationality found in the neoclassical school is a common one among evolutionists, this group is still far from formulating a research paradigm in common, agreeing on basic principles.

An important contribution to the theme in question is made by Milton Santos (2004[1996]), who highlights the relationship between the state of the techniques and the characteristics of society and geographical space. According to the geographer, knowledge of the successive technological systems is fundamental for the comprehension of the historical forms of the structuring of territories. From this discussion Santos asserts that a technique never emerges, or even works, in an isolated fashion. So, it would be more appropriate to deal with the theme by means of the perspective of technical systems, in which the constitutive techniques of the system should be taken as functionally integrated. At this point, one can recognize a convergence between the proposals of Pérez (2010) and Santos (2004): both analyze the technical dimension from an integrated, comprehensive perspective, not seeking to interpret the phenomena from isolated technical advances.

Therefore technical systems should be understood as ways to produce not only goods, services or energy, but also as ways that people can relate to each other, forms of information and discourse. Santos argues that the current technical system is characterized by the marriage of technique and science. In this context, technoscience makes up the material and ideological foundation for the discourse and practice of globalization. The author also points to the speed of the current technical system, both in its spatial diffusion and in the technological development itself. Santos also highlights the practically irreversible nature of current technology: once an innovation has been implanted, one cannot live without it. On the other hand, the geographer emphasizes that despite the technological uniqueness of current technology, it is possible to recognize that there are technical families from the past living alongside the most modern ones. This means that past has not been completely swept away and that the material inheritance remains (SANTOS, 2004, p. 193).

In a previous work, Milton Santos (2006[2000]) returns to the discussion of the uniqueness of technique, resuming the arguments about the planetary presence of the current set of techniques that has never been seen in history before. Starting from a historical perspective to analyze the relationship between technical progress and globalization, Santos states that (2006, p. 64):

It is ironic to recall that since previous centuries, technical progress appeared to be a condition to fulfill this dreamed of globalization with the most complete humanization of life on the planet. Finally, when this technical progress reaches a higher level, globalization takes place, but not at the service of humanity.

Thus, for the author, globalization takes on a perverse aspect that repels the notions of solidarity and public morality. Technoscience is not free of criticism either, as its production is selective and market-oriented. Written in the context of neoliberal advances, Santos' text also discusses the role of the State in a scenario in which information and money flow freely and fast. In this fluid world territory ceases to have rigid frontiers, which leads to both fragility and the changing nature of the State. So privatizations are an expression of this condition, with a State that reduces its role in social policies but which becomes more competent when in the service of the dominant economy. (SANTOS, 2006:66)

The discussion above sought to present some of the main issues that permeate the studies of technical change and innovation. This concern has a great tradition in the context of economics,



with Schumpeter as the main exponent, but with contributions from classical authors in the discipline to the subject. Beyond this trajectory in Economics, we sought to introduce some elements of the theme of technical change from the perspective of Milton Santos, signaling that Geography has contributions to make on the treatment of the issue. As will be seen below, this contribution is most intensive in studies developed by the approach currently known as Evolutionary Economic Geography. The next section will discuss the approach of the National Innovation System, which has received some prominence among geographic studies on the subject of technological innovation.

## NATIONAL SYSTEM OF INNOVATION

After the end of the Second World War, an understanding of technical change based on the linear model of innovation began to prevail, in which companies were considered to be external to the system. In this model companies were just users of the products and services offered by R&D institutions. In this linear perspective there is a direct relationship between R&D efforts and technological innovation, a relationship composed of successive stages initiated by basic research. After various criticisms of this model a new approach emerged in the 1990s, amid the progress of globalization and the precepts of liberalization. Other models arose to explain the relationship between science, technology and society.

Among the models that succeeded the linear approach, here the emphasis is on the National Innovation System. Fagerberg and Sapprasert (2011) recognize a growing scientific production focusing on the theme of innovation, especially in the 1990s. According to the authors, up to the end of the 1980s and the beginning of the following decade the literature about innovation was mainly concerned with the company or industry level. After this period a new harvest of work emerged guided by a more holistic approach, emphasizing the interdependencies between actors, organizations and institutions that influence innovation and, above all, much more focused on policy.

The interaction between different institutions to promote technological development in the national territory is what characterizes the category of the National Innovation System. The need to address these interactions from a new perspective motivated many authors to propose this new perspective of the innovative process in a context of the increasing importance of innovation for the development of nations. Numerous institutions focused on the theme were already active in the country; the challenge was how to articulate these actors in order to leverage the potential that a coordinated system could offer. Government and businesses adopted strategies to strengthen this system, and the more attentive researchers sought to formulate categories that could contribute to the understanding of the phenomenon.

With regard to geographers' interest in the subject, Fagerberg and Sapprasert's work (2011 p. 676) provides an insight into the importance that the theme of the National Innovation System has for researchers in this field. Only taking into account published articles from different areas with innovation as the object of study, the authors reviewed the focus given to the National Innovation System. This was an attempt to discover to what extent the theme is relevant to different areas of knowledge, including Geography and the Environment, which are grouped into a single classification. According to the methodology adopted by the authors, in terms of interest in the studies, of the ten areas selected Geography and the Environment came in second place, only behind the area classified as planning and development. Despite the recognition of the authors, the Geography of Innovation still struggles to establish itself as a subdiscipline, as will be verified in the following section.

As the outcome of the debates about the National Innovation System, two other approaches to the theme are noteworthy: (a) the regional innovation system (with various studies since the 1990s) and (b) the sectorial innovation system (captained by Franco Malerba). Among the authors who initiated the discussion about regional innovation systems, Philip Cooke stands out for his ample production since the 1990s. In a 1997 study published in partnership with Uranga and Etxebarria



he deals with the institutional and organizational dimensions of regional innovation systems. The authors address three crucial elements for the development of regional systems: finance, productive cultures and learning. Regarding finance, initially the emphasis is on the differences in access to innovation funding sources that can be connected to private or government actors. In general, government funding is carried out by national banks; it is unusual to find regional financial institutions able to focus investments on innovation.

In addition to the theme of financing, Cooke et al (1997, p. 485) also discuss the importance of learning in the configuration of Regional Systems. The authors make the following assumptions: (1) that learning is linked to certain institutional structures and (2) that learning requires resources, incentives and skills for individuals or systems to acquire this knowledge. In this context, the role of governments would be to contribute both to the allocation of these structures and the provision of resources and incentives to encourage continuous learning by companies. These measures do not only apply to regional governments, but also to national governments concerned with the dissemination of innovation. Finally, the authors address productive cultures as important elements in regional systems, highlighting the relationship between companies and the educational and research institutions present in the areas where they operate.

Like Cooke et al (1997), Viotti (1997, 2002 and 2004) makes an analytical contribution regarding the importance of learning to technological development, especially in countries with a late industrialization, such as Brazil. The author argues that a National System of Learning would be more appropriate for these countries than one of true innovation. This argument is based on the effort that a country should make in this field to advance the innovation process autonomously. To defend this thesis Viotti resorts to a comparison between the development paths taken by South Korea and Brazil. In the former, there were considerable efforts to ensure that the absorption of foreign technology was accompanied by an active learning of the production techniques. This active stance contributed to South Korea's vigorous progress in the field of innovation, as can be seen from the competitiveness achieved by Korean companies in industries such as electronics and car manufacturing. On the other hand, in Brazil the absorption of technology was more passive in nature, lacking the preoccupation of making learning a path to advance in an autochthonous manner in the field of innovation. Although the lesson appears obvious, until today Brazil has difficulties in adopting measures that promote active learning.

This section presented the category of the National Innovation System and its regional variation, the Regional System of Innovation. The latter has been the focus used the most in studies that value the relationship between territory and innovation, due to geographers' tradition of debating the theme of regional development. The importance of technological learning to the development of nations was also highlighted, presenting Viotti's argument regarding the need to study countries with tardy development using National Learning Systems. The first two sections have traced a general panorama of studies of innovation, henceforth the focus will be on the perspective specifically adopted by Geography on the theme.

## EVOLUTIONARY ECONOMIC GEOGRAPHY

This section discusses some of the ways in which innovation has been treated in the ambit of Geography. Far from exhausting the subject, since technological progress relates to the territory in several forms, being regarded by geographers in the most distinct ways, we seek to present the studies that make innovation a central dimension in geographical analyses. Thus, although the sub-discipline of Innovation Geography does not receive as much attention from geographers, there are numerous studies that value the technological dimension on territorial impacts. Considering the scarcity of authors and works that self-identify as linked to the Geography of Innovation, the subject will be treated here under another sub-discipline, Evolutionary Economic Geography.



Torsten Hägerstrand is routinely cited as one of the pioneers in the study of the relationship between technical change and territory. Hägerstrand (1962, 1967) dealt with the issue from a quantitative perspective, focusing on the analysis of spatial patterns in the dissemination of innovation. According to Paul Claval (2011, p. 201), with the research begun in the late 1940s, Hägerstrand sought to understand the process of modernization of agriculture in Småland, located in the south of Sweden. Focusing on information flows and not the flows of goods, the Swedish geographer departed from the analyses based on the transport costs that limit the opportunities for farmers, to come closer to an overview of the expenditures related to information costs. Hägerstrand also distanced himself from the classic economic models, in not assuming an isotropic environment in the theory of diffusion he proposed. More recently, *The Geography of Innovation* (1994), by Maryann Feldman, is one of the few publications found, so far, that proposes discussing the theme as a sub-discipline of Geography. The same author, in partnership with Nadine Massard, published *Institutions and Systems in the Geography of Innovation* in 2002. The economic perspective on the topic predominates in these works, as is also the case in the works addressed below.

Several authors have defended the evolutionary economic perspective, presented above, considering it fundamental for a more comprehensive understanding of themes such as: the geography of technological progress, dynamic competitive advantages, economic restructuring and economic growth. Recently, based on this approach, several geographers and economists, especially Europeans, have initiated a new approach in Evolutionary Geography. A seminar in 2006 is regarded as a milestone in establishing Evolutionary Economic Geography (EEG) as a distinct and promising paradigm. In fact, soon after the seminar a special edition of the *Journal of Economic Geography* was launched about EEG (Volume 7, Number 5, September 2007). In addition, the publication in 2010 of the manual *The Handbook of Evolutionary Economic Geography*, a collection organized by Boschma and Martin, is also a development of the debate started at the 2006 seminar, which consolidates several contributions inserted in EEG.

According to Boschma and Frenken (2007), EEG emerged as an alternative approach to Institutional Economic Geography and New Economic Geography. The first is guided by the inductive method, denying formal modeling and focusing research on case studies that value specific local conditions. The second is directed by the deductive method, making use of formal modeling based on the “neutrality of space”, in addition to seeking representative agents and analyzing phenomena based on the notion of balance. New Economic Geography, as we will discuss below, uses Complexity Theory, a source also used by authors of EEG.

The collection organized by Boschma and Martin (2010), is the principal reference used in this section to examine the theoretical bases of EEG. Brazilian geographers have paid little attention to this, as evidenced by the fact that the single review of the book in the country was written by the economist Renato Garcia (2012), in the *Revista Brasileira de Inovação* (RBI). Garcia questions the fact of EEG being a new paradigm, recognizing prior works such as Marshall’s study of English industrial districts at the end of the nineteenth century. Furthermore, Garcia also mentions studies related to industrial districts or clusters, and refers to the aforementioned Maryann Feldmann. However, the economist’s criticism disregards the formation of the Evolutionary Economic approach, referred to in the previous section. Evolutionary Economic Geography emerged from this approach with a new theoretical framework, even if the empirical objects have been the subject of previous analyzes, as recognized by Garcia. Despite the criticism, the economist recognizes the importance of the collection for studies on the territorial impacts associated with technological development. Besides Garcia (2012), another work published in the RBI shows the attention given by economists to the issue addressed herein: *The Geography of Innovation: A Methodological Regionalization of Expenses Information on R & D in Brazil* (Simões; Cunha; Cruz, 2005). Brazilian economists’ interest in the theme seems to supplant that of the geographers, who still pay little attention to the territorial impacts of the technological dynamic, especially from the methodological perspectives





of EEG.

Boschma and Martin (2010, p. 5) consider the following to be basic requisites of evolutionary economics: dynamism (in the sense of paying attention to changes), irreversible processes and innovation. In addition, the authors recognize that Evolutionary Economics receives theoretical contributions from a variety of sources, including Biology. This implies multiple possibilities for EEG, but also risks from inappropriate conceptual migrations, which may lead to the construction of analytical categories that do not contribute to the understanding of the phenomena. The low preoccupation of Evolutionary Economics with space is noteworthy, as it indicates the sizable challenges faced by EEG. It is in this context that the authors argue that as well as appropriating the concepts of Evolutionary Economics to understand phenomena, EEG should also contribute to revealing the role of space in the processes that lead to the evolution of the economy. In this way, the role of EEG would be to demonstrate how Geography matters in determining the nature and trajectory of the evolution of the economic system.

In a publication discussing Evolutionary Economics, (*Journal of Evolutionary Economics*), Dosi and Nelson (1994, p. 154) argue that evolutionary theory is marked by: (i) explaining the movement of something over time, or explaining why a certain thing is what is at any given time, emphasizing the route that led it there, that is, the analysis is expressly dynamic; (ii) the explanations involve both random elements, with which the variables in question are created or renewed, and the mechanisms that systematically expose an existing variation. The authors advance the analysis of evolutionary theory with contributions from biology; Generalized Darwinism is the clearest influence on the formulations they propose.

According to Boschma and Martin (2010, p.7), evolutionary studies have three possible approaches: Generalized Darwinism, The Theory of Path Dependence and Complexity Theory. While the first two have a greater penetration in EEG studies, the third is still little used by geographers. These three approaches are widely discussed by different authors in the work organized by the authors, including Essletzbichler and Rigby (2010, p. 43), who offer a brief analysis of the three theoretical perspectives in question:

Each of these approaches emphasizes different moments of the evolutionary process. Complexity Theory focuses on the creation of variety, path-dependence stress the retention of existing information and knowledge, and generalized Darwinism examines how a population of heterogeneous entities evolves through interaction among themselves and with the environment that they help shape.

Regarding Generalized Darwinism, the work published in 2002 by Geoffrey Hodgson, Darwinism in economics: from analogy to ontology is considered as the starting point of the influence of Darwinism on Evolutionary Economics. Like many other authors from different fields of knowledge, Hodgson was influenced by the works of the zoologist Richard Dawkins, who took up the debate about Darwinian approaches as an explanatory tool for evolutionary processes in his publication *Universal Darwinism*, in 1983. Although it is popular among evolutionists, geographers and economists, some caveats must be made in relation to the influences of Neo-Darwinism, as cautioned by Martin and Sunley (2010a, p. 93). The authors report problems in the indiscriminate use of categories developed in Biology in socioeconomic analysis. The authors then outline concern in cases of the transposition of terminologies and concepts from one field of knowledge to another, a valid precaution also for the influences of Complexity Theory on Evolutionary Geography.

Regarding Complexity Theory, Boschma and Martin (2010, p. 9) recognize that this approach receives the least attention among the three identified, although its use is growing. The approach is rooted in the principles of non-equilibrium thermodynamics, originating from Physics. Unlike Generalized Darwinism, Complexity Theory does not use analogies or metaphors, relying instead on the structuring of processes throughout all the research stages, including socioeconomic ones. Complexity Theory deals with open systems subject to constant interactions with their environments,



which are dynamic, typically far from equilibrium, although they exhibit an internal order and the emergence of structures (self-organization).

According to Martin and Sunley (2010a, p. 94), Complexity Theory has been gaining ground in various disciplines, although in Human Geography this advance is more recent and limited. In works from the 1990s, Paul Krugman sought to contribute to the formation of a “New Economic Geography” grounded in the principles of Complexity Theory. In these works, Krugman advocated the importance of mathematical modeling for understanding the behavior of the economic landscape. This approach faced resistance from many geographers, given that the evolution of socio-economic processes is not always reducible to formal modeling. A more comprehensive critique made by Martin and Sunley (2010a, p. 112) notes that Complexity Theory is not capable, at least for the present, of subsidizing the development of a general theory of evolutionary economics. The authors acknowledge that the notions of self-organization, emergence and adaptation contribute to the discussion of issues about how the spatial structure of an economy emerges and transforms itself. They also concede another point contributed by the theory, that identifies how some regional and urban economies appear more adaptable than others, over time, to technological and market changes or political measures. Or even, why certain industries and technologies develop in some specific geographical areas and not in others. Or how the diverse spatial networks of economic flows and relationships form and develop. The authors believe that it is in these issues that Complexity Theory can be of use to Evolutionary Economic Geography.

In addition to Complexity Theory, Martin and Sunley (2010b) address the fundamentals of Path Dependence, discussions started in the 1980s by Paul David and Brian Arthur. It is an approach that places great emphasis on the temporal dimension of the socio-spatial processes under review. It is argued from this perspective that the socio-spatial conditions of a given period leave seeds that influence the development of processes and relationships that will shape society. Hoff (2011, p 14) in a literature review and proposal for an analytical framework based on Path Dependence, makes the following considerations based on several authors who have dealt with the theme:

...there is convergence on the central idea about path-dependence among all the authors studied, but the way this idea is classified diverges a little from one author to another. David (1998) sometimes says that path-dependence is the property of a process and sometimes says it is a dynamic property. Goldstone (1998) classifies it as the property of a system and a model of historical research. For Mahonei (2000) path-dependence is characteristic of a historical process or even an analytic structure for studying specific historical issues. Finally, for Hansen (2002) it is the effect of a decision.

Martin and Sunley (2010b) recall that the recognition of the importance of history by geographers is not recent. For example, the authors cite Marxist Geography and its concern with explaining unequal geographical development as a historical process. However, the recent “evolutionary turn” in Economic Geography differs from the guidelines of Marxist economic policy in the analysis of phenomena. Despite Martin and Sunley’s enthusiasm for this thread, they recognize that some geographers have rushed to take on the presuppositions of Path Dependence (2010b, p.63): “In fact, economic geographers have tended to apply the concept of path dependence as if it is self-evident and wholly unproblematic”. Furthermore, the authors are emphatic in their refusal to accept that presuppositions based on the notion of equilibrium can be used to construct an evolutionary theory. In this way they are opposed to Paul David and Brian Arthur, precursors of the thread, and prefer to propose Path Dependence in other terms. Next there is a short presentation of some contributions made by Brazilian Geography regarding the relationship between territorial dimension and technological innovation.

A search conducted in June 2013 in the CNPq Research Groups Directory with the keywords Geography and Innovation only found a total of six research groups. Of these, only two can be classified as Geography, and only one is actually working fully on the theme: the Research Group



for Innovation, Technology and Territory (GRITT). Formed in 2004 by Ana Cristina Fernandes, the group is based in the Department of Geographical Sciences of the Federal University of Pernambuco (UFPE). GRITT was responsible for organizing the First International Symposium on the Geography of Knowledge and Innovation, on June 2011, in Recife. Through GRITT Fernandes has carried out analyses of scientific and technological development in the Northeast, in an initiative that contributes to the development of solutions focused on the regional devolution of resources in the sector. An example of this initiative can be found in Lima and Fernandes (2009), in which the authors emphasize the importance of state investment in the allocation of intangible infrastructure aimed at strengthening the regional innovation system.

The theme of innovation has been touched on by different fronts of Brazilian Geography. The approaches of two of the most renowned Brazilian geographers are indicated below: Milton Santos and Bertha Becker. Milton Santos has focused on the issue at least since 1977, when he wrote “Diffusion of innovations or sales strategy?” a chapter in the book *Spatial Economy: criticism and alternatives*. In this work Santos pays special attention to the work of Hägerstrand. Regarding other contributions by Santos to the debate on technical change, besides the approach to technical systems dealt with in the previous section, based on the work of Tartaruga (2011), it is worth a quick look at Santos’ reflections on the theme. Taking technique as one of his central concerns, Santos highlighted the problem of the uneven spatial distribution of techniques and how technical systems with different temporalities coexist in a given space. Thus, technical innovations install themselves in the spaces with more significant technical and informational density, forming what Santos calls luminous spaces – as opposed to opaque spaces. Nevertheless, information technologies have a flexible character that would open opportunities for less affluent groups to take advantage of innovation gains, especially through the various exchanges made possible by urban agglomerations, in Santos’ approach.

In two studies Bertha Becker discusses the possibilities of scientific and technological development policies geared for the Amazon. The first was published by the Center for Management and Strategic Studies (CGEE) in 2004 and the second in one of the texts discussed at the IV National Conference of Science, Technology and Innovation, in 2010. The latter is only mentioned to reinforce the insertion of Geography in the debates about the policies for the sector. In the first study Becker highlights that the Amazon does not require another occupation policy, but one focused on consolidating development. Among the main proposals of the study, the most noteworthy is the author’s affirmation that (CGEE, 2004, p. 4):

Only a scientific-technical revolution for the Amazon can promote the appreciation of the region’s natural heritage to the benefit of the regional and national society, attributing economic value to the forest so that it can face competition from cattle farming and the grains agribusiness and so contain deforestation. The scientific-technological revolution for the appreciation of the Amazon’s natural heritage points to the future as a milestone not just for the region, but for the country, introducing a new model of the use of territory based on ST&I.

It is clear that for Becker science and technology are fundamental to promote development for the Region. The author also proposes that techno-productive chains of biodiversity be implemented, adding ICTs and businesses around a theme. Becker was the author of several studies in partnership with the CGEE as a consultant, most of which dealt with development opportunities in the Amazon, with an emphasis on scientific and technological progress.

The theoretical bases of Evolutionary Economic Geography were presented in this section, taking up this current as representative of the state of the art studies focused on the relationship between territory and innovation. Thus, it is assumed that the sub-discipline of the Geography of Innovation has not been successful in establishing itself as a line of research to address the issue, despite the efforts undertaken by Maryann Feldman and researchers associated with him. It is



noteworthy that EEG studies have received special attention from the Geography Department of the University of Utrecht, in Holland, to which Boschma is affiliated. Writing in the field has been catalogued since 2008, with an average of twenty articles published each year, which can be found on the Department's webpage (<http://econ.geo.uu.nl/peeg/peeg.html>). Despite the low adherence of Brazilian Geography to the thread, two studies by Portuguese geographers from the EEG perspective can be found in these archives.

## FINAL CONSIDERATIONS

This paper has sought to demonstrate that there is an ancient research trajectory on technological innovation: with a stronger tradition in Economics, with classical authors dealing with the theme, and in Geography, especially from Hägerstrand. However, it is only more recently that the theme has been incorporated into the agenda of Economic research in an approach that overcomes the linear model of innovation. Among the perspectives that have overcome this model, special attention was paid to the National Innovation System, which has been well received by those geographers dedicated to studying innovation. After demonstrating the wider picture of studies on the theme, there was recognition of how Geography has approached technological progress. Next, the main theoretical influences of Evolutionary Economic Geography were debated, taking this thread as representative of the state of the art in studies dedicated to the relationship between territory and innovation. Finally, some contributions from Brazilian Geography on the theme were presented, reaching the conclusion that these studies still are not structured in such a way that could be seen as a thread dedicated to the subject in the country. On the other hand, it would not be appropriate to disregard studies on the importance of technology, as an environment, undertaken by Milton Santos. Neither would it be appropriate to discount the activities of the GRITT, a research group dedicated to the theme discussed herein. However, it is really necessary to show that, with regard to forming a sub-discipline, the reflections of the Brazilian Geography about technological innovation are scarce and poorly structured, and it was exactly this fact that this article has sought to highlight.

This paper's introduction was on the relevance of the theme of innovation to the Brazilian economic situation. Then it affirms that there is a broad consensus on the importance of the issue to promote an autochthonous development of the country. Affirming this consensus means that innovation is the subject of a political debate, that to some extent counts on the contribution of researchers to advance understanding of the phenomena, or, more actively, to formulate or review policies on the theme. In this sense, geography has much to offer to the improvement of Brazilian planning, taking advantage of precisely this moment in which efforts to integrate policy are required for the greater efficiency and effectiveness of government actions. If the connection between the regional and territorial policies is quite clear, on the other hand this relationship is not as clear in ST&I policies. Nevertheless, there are important processes of regional decentralization and devolution of these policies, about which geographers have a lot to say, especially from a perspective that values the integrating dimension of territory. Bertha Becker, among others, participated in some of these initiatives, and her absence is a significant loss for those geographers concerned about the inclusion of the subject, both in public debates and in the formulation and evaluation of public policies.

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