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History of Economic Thought
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Space in Economics
– a Historical Perspective

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Contents

1. Science, Models and Economic Space

Being simplified images of reality, scientific theories intend to broaden or deepen our understanding of the world, and to improve our capabilities to predict future phenomena.[1] A healthy requisite for these simplified images is the possibility of their objective transmission. We restrict ourselves from designating as scientific the knowledge that is not liable to be codified and transmitted objectively.

When a theoretic economist or a wise person expresses its knowledge, the decision of classifying the message as scientific or unscientific depends upon the observation of socially accepted norms, which may surely evolve with time. The scientific community imposes a certain degree of codification and objectivity in the expression of knowledge that prevents, for better or worse, a great number of ideas from being examined. The reader is asked to either accept this or retain his criticisms for other instances, as we abbreviate this discussion by jumping to the conclusion that the ideas that can only be codified with recourse to models of great complexity are frequently abandoned and forgotten.

These considerations apply to the history of the study of space in economics. There was an increase in the degree of rigour and logic demanded by the scientific community in the roughly measured period ranging from 1930 to 1960. This mathematization of economics shadowed many ideas and conceptions about the influence of space in the economy, many of which had been formulated in the eighteenth and nineteenth centuries by brilliant economists such as Richard Cantillon, Sir James Steuart, Adam Smith and Alfred Marshall.

The economist has an image of the economy, which she combines at each stage with her observations. These new facts, as Edgar Morin puts it, clash against her conceptions until new ideas carry out a reorganisation of experience that allows their accommodation.[2] The

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[1] This assertion is not meant to bring about any kind of disagreement, but simply to introduce a context for the discussion in mind. Nevertheless, the way is opened for quoting Nicholas Georgescu-Roegen (1971, p. 37):

"[…] *the purpose of science in general is not prediction, but knowledge for its own sake.*"

[2] This idea was best expressed by Edgar Morin (1977, p.21):

evolution requires, then, both acute observation and creative conceptual flexibility. But these new ideas need "*solid ground*" to propagate, that is, abstract formulation, usually in the form of some sort of model.[3]

A good analogy, presented by Krugman (1999), is about the evolution of the maps of Africa. In the fifteenth century, these were drawn on the basis of explorers' reports, and included rivers, cities, resources, and maybe even some imaginary creatures. Now, if we compare these maps with ones made in the eighteenth century, we can appreciate the technical evolution of the cartography, since the line of coast is so precisely reproduced that it is difficult to distinguish it from that of the modern maps. Yet, the interior of the continent was left blank! The requirements of rigour in the production of maps led to the loss of a lot of accumulated imperfect knowledge.

The neoclassical economic theory is based on a set of simplifying assumptions that prevent the consideration of space in the analysis. Suppose that there are no economies of scale and that the world is a homogenous plane. In these conditions, the efficient mode of producing would be to spread production in order to render transportation unnecessary. This is an absurd result, as we observe concentration of production, regional specialization and increasing transportation of goods. At this point it is needful to remind a remote complaint of Walter Isard (1949, p. 477) on the economic treatment of spatial dimensions:

"[…]*space is repudiated, everything in the economy is in effect compressed to a point, and all spatial resistance disappears.*"[4]

"*En science et surtout en politique, les idées, souvent plus têtues que les faits, résistent au déferlement des données et des prouves. Les faits effectivement se brisent contre les idées tant qu'il n'existe rien qui puisse autrement réorganiser l'expérience.*"

And our amateur translation:

"*In science and above all in politics, the ideas, frequently tougher than facts, resist to the attacks of data and proofs. The facts actually break against the ideas while there isn't any that can otherwise reorganise experience.*"

[3] To wrap up, we recur to Einstein's sensible, but nevertheless wishful, address to the Physical Society on Max Planck's 60th birthday ("*Principles of Research*", Berlin, 1918):

"*The supreme task of the physicist is to arrive at those universal elementary laws from which the cosmos can be built up by pure deduction. There is no logical path to these laws; only intuition, resting on sympathetic understanding of experience, can reach them.*."

[4] In the same lines, Walter Isard accused economics of taking place in a "*wonderland of no dimensions*" (1949, p. 477).

Hopefully the reader will accept the conclusion that some of the neoclassical assumptions must be relaxed, if we want to analyse the influence of space in a meaningful manner.

For space to be relevant in economic analysis, it is forceful to account for some factor that prevents the economic activity from spreading homogeneously. One possibility is the consideration of fixed costs, or initially increasing returns, that imply the need for some scale to make production economically viable. The problem is that these conditions may induce a complex market structure, difficult to model. Certain analysis, simple under perfect competition and constant returns, may turn out to be extremely complicated in a more realistic setting. This has delayed the development and acceptance of the spatial economic theories.[5]

The introduction of space in economic analysis leads, sometimes, to results that oppose the conventional views. For example, August Lösch (1940) showed how profit-maximizing producers raise prices in the local market and lower them in the distant markets, due to differences in the elasticity of demand. Such results demonstrate the pertinence of accounting for the influence of space in economic analysis.

The trade-off between rigor and reach in the transmission of ideas has already been made evident. There are many different, complementary, approaches:[6] (1) the application of the standard tools, ignoring the questions that these cannot grasp; (2) the development of new tools that allow the treatment of more questions; (3) the literary treatment of the questions, favouring the transmission of ideas relatively to the logical rigour; and (4), the most eclectic approach, the use of current techniques as a base for the analysis, and the carrying on in a literary mode of the exploration of problems that the rigorous tools fail to reach.

There are factors that influence the preferences for location that are not usually designated as economic.[7] Social relationships constitute a restraint to the mobility of the population, as was recognized by

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[5] In 1977, the seminal article by Dixit and Stiglitz provided a practical way to model imperfect competition of a special but illustrative kind.

[6] What is presented in this instance is no more that the inspiring view of Stephen Meardon (2000, p. 325).

[7] This reminds the acute warning that hanged in Albert Einstein's office at Princeton:

"*Not everything that counts can be counted, and not everything that can be counted counts.*"

Melvin Greenhut (1952)[8], who always attached great importance to personal factors, and called for attention to case-studies of plant location in Japan in which employment and social welfare proved decisive, ahead of short-term profit considerations.

Some of the current breakthroughs in this area concern the concept of economic space itself. It is increasingly recognized that a broader concept of economic proximity would be useful, one that could grasp the diffusion of information and knowledge, and the coordination and trust among economic agents. In our so-called "*Information Society*", the interaction between economic agents has an increasing importance, being perhaps on the core of a future integration of the theories of innovation, knowledge and information with the conventional conceptual schemes of economic theory.[9]

[8] Upon asked why he moved to the South, Greenhut answered that his mother-in-law loved the South (Ohta & Thisse (Eds.), 1993).

[9] This integration is not mentioned in the context of a search for a unified theory and a single encompassing logic. What is meant is that the interaction between agents is crucial for the understanding of the relationship between these different theories and the conventional economic analysis.

2. The *Hall of Fame*

The economic activity takes place in a geographically concentrated fashion, being the existence of cities the most evident example. The current demographic trends are towards a further increase of the urban population, which represents already half of the world population.[10] Another kind of agglomeration is of industrial activity. There are small regions in which a great share of a country's productive activity takes place,[11] like the famous *Silicon Valley* and *Blue Banana*.[12] Spatial heterogeneity is a patent fact, and, in what concerns the deprived areas, sometimes a dramatic one. Why is it that some places are so prosperous while others are so depressed?[13] This question is one of the ingredients of the background set for the spatial theories in economics. These theories (this is stated for the sake of concreteness, not to place an '*a priori*' restriction to this study) deal with the processes of location selection by economic agents, and, in general, with the spatial organization of the economic activity. Unfortunately, the dedication of the economists to this subject hasn't always been in accordance to the importance that it may be regarded with.

The interest for the spatial questions in economics has been, historically, cyclical.[14] Pioneer economists like Sir James Steuart (1767), Adam Smith (1776) and the Abbot of Condillac (1776), taken into account the influence of geography and distance in their studies. However, these contributions were followed by more than one century of hibernation of the field we now may call geographical economics.[15]

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[10] In Europe, USA and Japan, this percentage is over 75% (Fujita & Thisse, 2002).

[11] A small group of Japanese industrial zones with an area that is 5% of Japan and 0.2% of East Asia, represents 40% of Japan and 29% of East Asia's GDP (Fujita & Thisse, 2002).

[12] The "*Blue Banana*" ranges from London to the north of Italy, through the Netherlands, Belgium and western Germany.

[13] The importance of the theories of economic development was stressed the most by the Nobel laureate Robert Lucas (1988, p. 5):

"*Once one starts to think about them, it is hard to think about anything else.*"

[14] Ekelund & Hébert (1993).

[15] Stephen Meardon (2000, p. 326) claims to have introduced this designation, which, unlike "*spatial economics*", avoids any confusion with astronauts and inter-stellar adventures (it is not unlikely that the terms "*spatial economics*" and

The exception was the work of Johann von Thünen (1826), the founder of spatial economics, whose importance was not fully appreciated in his time. It is puzzling that while there were times in which space was seen as central, in others the spatial dimensions were simply ignored. We have to wait until the closing stages of the nineteenth century to see the interest for space emerge again, with the studies of Launhardt (1882), Marshall (1890) and Weber (1909). The history of spatial economic analysis is, therefore, a recent one. Mark Blaug (1996, p. 612) attributes this neglect for space to the lack of clarity of von Thünen and to the excessive formalism of Launhardt.[16] Nevertheless, the importance of the linguistic barrier should not be underestimated, as it contributed both to the supremacy of the German school in the field and to the reduced diffusion and recognition of these authors in the rest of the world.

The pioneer theories of location intended to explain location and spatial organization in the different sectors of the economy. Broadly speaking, von Thünen focused the agriculture, Weber the industry and Christäller the services, while Lösch has attempted a synthesis. In the model of von Thünen, the market for the agricultural produce is a point, representing the city. In equilibrium, the spatial organization of agriculture takes the form of concentric rings around the city, being located in the interior rings the activities with higher transportation costs and lower intensity of land use. He also noted that in the case where factors of production are substitutable, there exists a tendency for the adoption of less land intensive production processes in the interior rings. That is to say, in the activities with high transportation costs and with already low intensity of land use. More than fifty years passed before Launhardt reversed some of von Thünen's assumptions to arrive at an innovative model. Production takes place in a point, the plant, and it is the market that spreads across the land. The problem is to find the optimal location for the plant, that is, the location that minimizes transportation costs of delivery.[17] The solution is analogous to finding the centre of gravity of a plate whose distribution of mass represents the spatial distribution of the market size. In a similar

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"*economics of space*" will come to designate economic analysis of space colonization prospects.

[16] Mark Blaug (1996, p. 612) suggests that the solution of the puzzle may lie in the absence of classical locational theory from Marshall's *Principles*:

"*If Ricardo had based his rent theory on locational advantages instead of fertility differences, if Thünen had been a lucid instead of an obscure writer, and if Launhardt had expressed himself in words instead of equations, is there any reason to doubt that the whole of classical locational theory would have found a place in Marshall's* Principles *and, thereby, in the corpus of received economic doctrine?*"

[17] Launhardt (1882) explains how, even with important fixed costs, a small firm may coexist with a gigantic one when the economic space that separates them is significant.

work, Alfred Weber assumed a set of market points and perfect competition to find the location that minimizes the transportation costs.

In the modern location theory, it is common to assume a homogeneous market area, as in the model of Launhardt, instead of market points. It is also usual to follow the lines of the model of Hotelling (1929), in which firms first choose their location, to engage in price competition only in a second stage.[18] The contribution of August Lösch (1940) must forcefully be referred, as it was important as well as comprehensive. Besides formalising a model of general spatial equilibrium in which an architecture of central places is determined, he criticised the theory of the comparative advantage in a spatial economy with more than two countries, initiated the theory of intra-industry trade, and gave the first steps towards the theory of foreign direct investment.[19]

In spite of the importance of these contributions, space has remained, to say the least, only a secondary figure in economic analysis. In the fifties, under the leadership of Walter Isard (1956), there was an attempt to unify location theory and neoclassical economics. His work of synthesis puts together von Thünen, Weber, Christäller and Lösch in an intelligible whole. The result, quite opposite to the original intentions, was the foundation of an eclectic applied field: regional science.[20] His contemporaneous Melvin Greenhut (1956) also tried to build a general spatial economic theory. But while Isard focused on the generalization and mathematical formulation, Greenhut reformulated the theory by changing the assumption about the behaviour of firms from cost-minimization to profit-maximization, and by analysing the spatial distribution of firms and its relation to the pricing policies.

In location theory, many assumptions of firm behaviour are common, each having certain advantages, disadvantages and complexity. Three objectives of the firms are usual: (1) cost-minimization, based on production and transportation cost;[21] (2) revenue-maximization,

[18] Hotelling's spatial competition can be modelled as a two-stage game. The second stage is a duopoly with spatial differentiation. The first stage, in which the firms select their locations, this spatial differentiation is determined.

[19] Norman (1993).

[20] Some would refer that ubiquitous '*law of unintended consequences*', which simply maintains the implausibility of coincidence between the results and intentions of an act. This law is frequently invoked to pseudo-explain the failure of a direct action.

[21] Whose most distinguished contributors were Weber (1909), Predöhl (1925), Dechesnes (1945) and Isard (1956).

focused on the control of market areas;[22] or (3) profit-maximization, that integrates the two previous assumptions.[23] On the other hand, it is also necessary to assume the existence (or absence) of certain strategic behaviour on the part of the firms, that can, for example, take the location choices of other agents as given, or be aware of the impact of their location on other firms decisions. Obviously, a great deal of complexity is introduced if strategic behaviour by the firms is allowed.

Geographical economics is much broader than location theory. In the end of the sixties and the beginning of the seventies, there was a renewal of the interest in the questions related to space. The new field of urban economics emerged, consisting essentially in the application of von Thünen's model to the study of the internal structure of cities. Other areas where space is patently relevant will be discussed throughout this study, but for now this eclecticism is only suggested to interest the reader. Who should already be aware of this field's importance, given the process of global economic integration we are witnessing.[24] In fact, many economists are becoming interested on the influence of space in economic analysis[25] and the perception that a global economic theory cannot leave space aside is generalising.

[22] Developed from the works of Fetter (1924), Hotelling (1929), Lerner & Singer (1937) and Smithies (1941).

[23] Appears with Lösch (1944), including also Greenhut (1956).

[24] An example is the constitution of enlarged spaces of commerce, like the EU and the NAFTA.

[25] Like Lucas (1988), Krugman (1991a, 1991b) and Becker & Murphy (1992).

2.1. Early Spatial Economic Thought

Dating the beginning of spatial economic thought would be an arbitrary exercise.[26] Early economic thought can be found in many sources, some of them invaluable writings of the most brilliant and wise individuals of ancient times. These are many interesting and inspiring issues related to spatial economic analysis, having forcefully led some of these thinkers to dwell on them. To name a few: the location and size of cities; the spatial organization of agriculture, the importance of the means of communication; the spatial patterns of trade; and the geographical distribution of wealth and population. It is under these considerations that the reader is asked to be taken to early eighteenth century France.

In the year 1730, Paris witnessed the '*debút*' of Voltaire's *Brutus*, a tragedy developed around a conflict between love and patriotism. This is a time when the idea of the priority of the interest of the state over those of the individuals is increasingly questioned. Absolutism, as well as its economic counterpart, mercantilism[27], are under challenge by liberal ideas that defend the need for free markets and that confine the role of the state to the maintenance of security and justice. Mercantilism and liberalism had opposed views regarding the spatial distribution of the economic activity. In spite of the consequent

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[26] The number of relevant manuscripts that have been destroyed is probably enormous. The libraries of ancient civilizations were frequently sacked or burned, either accidentally or with the purpose of weakening the cultural identity of the conquered nations. And we do not have to remember the Great Library of Alexandria, as examples abound in the 20th century. For two examples of double deprivation, remember: the library of Louvain, partially reconstituted after the destruction of its 300 000 titles following the German invasion in WWI, was destroyed again in the WWII's German invasion; and the double devastation suffered by the Chinese libraries with the Sino-Japanese war and the Communist Revolution. It is worth mentioning the less spectacular but equally devastating effects of Nature: in 1923, an earthquake destroyed the Imperial University Library in Tokyo; in 1966, the river Arno flooded the library basements in Florence, damaging 2 million books; and in 1988, a fire in Leningrad burned 3,6 millions of books.

[27] Roger Backhouse (2002, p. 57) stresses that mercantilism is not a doctrine:

"*This term has been used to describe the economic thought of the entire period from the end of the Middle Ages to the Age of Enlightenment*".

And provides an illustrative synthesis (2002, p. 58):

"*Mercantilist economics, unlike ancient or medieval economics, was centred on the nation state, which was viewed as being in a competitive struggle with other nations*".

aggravation of inequality, the mercantilist doctrines encouraged the concentration of production, generally seen as favouring the interests of the state. In opposition, liberalism argued for self-organization, and thought of dispersion as a result of both the natural and the rational order of the society.

It was probably in the same year of 1730[28] that an Irish merchant banker living in France, Richard Cantillon (1680/90-?1734), wrote "*An Essay on the Nature of Commerce in* General". In this book, which may be said to mark the birth of economics, the influence of space is treated in a rigorous and integrated form. City formation is explained by economies of transportation, and the interdependence between urban and rural areas is systematically analysed. In simplified lines, Cantillon's spatial theories are based on transportation economies and the land is seen as the source of all wealth. The agricultural workers need to locate near the fertile lands, so the considerable transportation costs render the formation of villages an economic imperative. The same transportation costs explain the transformation of some of these villages into cities, whose sizes depend upon the produce of the land, after deducing taxes and transportation costs. On the location of capital cities, Cantillon noted the attraction of the sea and rivers, motivated by the advantages of sea and river transportation.

It is a fact that the liberalists that followed Cantillon argued for the equitable distribution of wealth and for the dispersion of economic activity. However, in practice, the influence of space remained at the margin of economic analysis, as it was ignored by those who dominated economic thought in France in the second half of the eighteenth century, the fisiocrats.[29]

Meanwhile, in a backward part of Europe, there was an intense intellectual activity in a quest for the discovery of the principles of human nature and explanation of social history and progress. This movement, designated as the Scottish Enlightenment, included the thinkers that would make the subsequent contributions to spatial economics. Contrasting with the French fisiocrats, for whom agriculture was the only productive activity, David Hume (1711-76), one of the main exponents of this movement, considered that the strength of the state depended upon labour and commerce. And whereas in England the industrial revolution was germinating, in Scotland, a controversial political thinker started to use such terms as *supply* and *demand* to explain price formation. Having spent 18 years in exile, mostly in France and Germany, for supporting the 1745

[28] Most sources place Cantillon's *magnum opus* in this date, but Claude Ponsard (1983) refers an earlier date: 1725.

[29] In spite of claiming that agriculture was the only productive activity.

uprising of the jacobites, Sir James Steuart (1712-1780) returned to Scotland in 1763, publishing his "*Inquiry into the Principles of Political Economy*" four years later. In this work, that some describe as the first systematic treatise on economics in English, he takes on questions such as the location of population and industry, the evolution of cities, the construction of railways, and the division of labour between urban and rural areas.

Steuart observed that, in general, people locate where they can find jobs. Agricultural workers need to locate near the fields, while proprietors have freedom to choose the residence that provides them the highest quality of life. Artisans seek to locate near their customers, normally in the cities, but also take into account the location of the sources of energy and raw materials, the existence of cheap and abundant labour, and, of course, the routes of communication that determine the accessibility to these factors of attraction. Agglomeration is also induced by the government, which concentrates administration in the capital. A predecessor of von Thünen, Steuart described the use of land as taking the shape of five concentric rings. In the central ring, land was used to cultivate vegetables; in the second, to produce milk and meat; in the third came the ploughed fields; the pastures for cattle in the fourth; and, finally, a fifth ring of forest. In spite of its importance and quality, this work was ignored for a long time, maybe overshadowed by that of Adam Smith (1723-1790).[30]

Meanwhile, in France, the philosopher and clergyman, Étienne Bonnot de Condillac (1715-1780), was again bringing space to the centre of economic theory. Observing that the value of goods depends on both utility and scarcity, he considered that it was trade that carried goods to where they were more valued. This was a founding idea. However, one that would be later detached from geographical economics due to the overlook of transportation costs and subsequent results of spatially homogeneous prices, instead of understanding price differentials between locations as determined by transportation costs.

But lets return to Scotland, since the founding father of political economy was a truly enlightened Scotchman. There are some references to the influence of space in Adam Smith's *magnum opus*, "*The Wealth of Nations*" (1776). He considered that the division of labour is determined by the size of the market, which in turn depends upon the communication routes and the transportability of the product. Adam Smith made other considerations related to space, for instance when he held that: spatial variations of the production costs influence the value of the goods; domestic trade is explained by the emergence of cities and by the relationship between cities and rural

[30] As suggested by A. S. Lopes (1985).

areas; and that protectionism may arise from the concentration of production.

The interest for geography shown by Adam Smith was followed by oblivion, as David Ricardo (1772-1823), like most nineteenth century economists will neglect geography in their analysis. The coming classical theory of location will be a German tradition. This field remained lowly recognized, despite some important and original contributions, especially that of von Thünen.

2.2. Von Thünen's *Isolated State*

The late eighteenth century saw two major revolutions: the Americans gained independence in 1775, and the French overthrown absolutism in 1789. Meanwhile, in Germany, a different tone was set, as liberalism was reprobated, and the Historical school dominated economic thought. It is in this context, and against all odds, that we find the undisputed '*father*' of spatial economics to be a pure theorist as well as a liberal and defender of free trade. This may explain why Johann-Heinrich von Thünen (1783-1850) was a neglected genius. In spite of being a farmer without a university degree, he erected an intricate mathematic work that puts him among the greatest all-time economists: "*The Isolated State*" (1826). The discussions of Cantillon and Adam Smith on the influence of space may have been more comprehensive, but von Thünen provided the first formalization of economic space.

Von Thünen wanted to study the sale prices of the agricultural output, the rents earned by each piece of land, and the patterns of land use, that is, which crops were cultivated and where. His model assumes homogeneous land, without roads and rivers, having a city in the centre. The farmers cultivate different crops in this uniformly fertile terrain, and transport the produce to the city, supporting transportation costs that are proportional to distance and weight.

In these conditions, von Thünen shows that concentric rings are formed around the city. In the interior rings the rents are higher, being used to cultivate the crops that have higher transportation costs and that are more labour-intensive. A spatial equilibrium prevails, and a general and innovative relation between prices and marginal rent. Having provided a modern exposition of the marginal theory of distribution, von Thünen was 60 years ahead of his time.[31]

This model explains the use and structuring of land in agriculture. Some of the economic problems are formulated clearly and in spatial terms: the influence of the cities and firms on rents; the prices of agricultural produce, and the laws of price-formation in general; the effect of the growth of cities over cultivated land; the communication between city and country; the relationship between use of land and the distance to the markets; and the rental value of location.

[31] Blaug (1986, p. 248).

Johann von Thünen even relaxed some of the assumptions of the model, having considered heterogeneous fertility, privileged routes of transportation and the existence of a second city. The essential ring structure result remains, now with distortions.

Besides being the founder of spatial analysis and, it might be said, of *marginalism*,[32] von Thünen was also a pioneer econometrician, since he followed a meticulous empirical method, based on observations in his agricultural state, in the iterative adaptation of theoretical results to observation, and in the use of statistics and construction of time-series.

[32] Nerlove & Sadka (1991, p. 97).

2.3. A Quiet but Fertile Interlude

Two separate lines of research in old geographical economics can be perceived, corresponding to the Anglo-Saxon and German traditions. In general, the Anglo-Saxon authors focused the influence of geography on the economic activities and identified relevant factors for the selection of location. The German tradition followed a more theoretical approach, developing the deductive analysis of spatial problems, particularly the problem of firm location. It may be said that the German school dominated spatial economic theory from von Thünen until the 1960s, but a unique contribution would come from the great classical economist, Alfred Marshall (1842-1924), the first to systematically relate location and innovation in his analysis of the *industrial districts*. But let's continue our narrative without jumping stages.

One of the few Anglo-Saxon contributions in the nineteenth century came from the Scottish Andrew Ure (1778-1857). A defender of free international trade and of unregulated internal industry, he had many interests and competences, having also worked as a doctor, a chemist, and an inventor. In "*The Philosophy of Manufactures*" (1835), Ure enumerated the factors that determine location: cheap energy; adequate population; the existence of a port, warehouse or market; and the introduction of innovations by local entrepreneurs. This last factor shows that Andrew Ure understood the existence of spatial diffusion of innovations. Remember that this was a period of industrial revolution: a lot of new inventions came to light every year, some of them allowing significant productivity jumps. Being close to the sources of innovation meant a significant raise in profits. The work of Andrew Ure was perhaps the only important Anglo-Saxon contribution to spatial economics from Adam Smith to Alfred Marshall.

In Germany, one of the founders of the historical school, Wilhelm Roscher (1817-1894),[33] took on a different approach: to find the natural laws that govern the spatial evolution of economic structures. His conclusion was that the birth of an industry presupposes certain

[33] The other founders of the movement headed by Roscher were Bruno Hildebrand (1818-1878) and Karl Knies (1821-1898). This movement should not be confused with the 'younger' historical school (this one much more of a school), led by Gustav Schmöller (1838-1917) (Backhouse, 2002, p.173).

conditions: a developed agriculture; high consumption standards; enough population density to allow division of labour; an abundant source of capital; and advanced means of communications.

Some decades later, it was the German statesman Albert Schaffle (1831-1903) that systematized the ideas of Roscher, in a model in the line of von Thünen's. The concentric rings emerge again,[34] now determined by two opposing forces: a dominant tendency towards centralisation, and a decentralising reaction due to congestion. One can see how this equilibrium with centrifugal and centripetal forces is a predecessor of the *core-periphery* mechanisms and the field designated as *new economic geography*.

A major figure in the history of location theory, despite having been neglected in his time, was the German engineer Wilhelm Launhardt (1832-1918). He was a specialist in transports, with contributions on the location and pricing of roads and railways. Quite ahead of its time, Launhardt was a pioneer in several fields: mathematical economics, pure welfare theory, and, of course, location theory. He showed how to determine the optimal location in a system with transport costs (1882), known as the three points problem.[35] His approach to the problem of the market areas anticipated many of the intuitions of Fetter and Palender, having even arrived at the hyperbolic shape of the frontier between the market areas of two competing firms.[36]

[34] For the third time, after Sir James Steuart and Johann von Thünen.

[35] A solution that was independently rediscovered by Alfred Weber (1909).

[36] His reasoning contains also the crux of the notion of hexagonal market areas, commonly traced to Christäller and Lösch.

2.4. Marshall's *Industrial Districts*

A bright mathematician, who moved into economics to improve society, dominated Anglo-Saxon economics from the 1880s to the 1930s. Raised in a modest Londoner middle-class family, Alfred Marshall (1842-1924) saw his "*Principles of Economics*" (1890) become the most influential treatise on economics until Samuelson published his book. Besides his expertise on the wisdom of the past, Marshall offered several important contributions, and gave inspirational suggestions for future research. One of these was his claim that the economists should search for analogies not in mechanics, but in biology, a much richer source.[37] His impact on spatial economics derived mostly from his discussion of the *industrial districts*, but also from evolutionary concepts like path-dependence, from his thorough analysis of increasing returns, and from the idea that monetary estimation of the advantages of locations is possible.[38]

Marshall's analysis of internal and external economies ended up inspiring modern theories of local development. While internal economies give rise to big companies, external economies originate the agglomeration of firms. The *industrial district* is an agglomeration of small and medium-sized firms in the same industry that become more competitive because of local specialization and that benefit from the proximity of a myriad of suppliers and customers. It arises when the dominant economies are external to the firm but internal to the industry. That is, when the activity of a firm benefits the neighbour firms in the same industry. Marshall's wonderful writing compels to quote him extensively:

"*When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously. Good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organization of the business have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it*

[37] "*The Mecca of the economist lies in economic biology rather than in economic dynamics.*" – Alfred Marshall (1890, preface).

[38] "*Industry and Trade*" (1919).

becomes the source of further new ideas. And presently subsidiary trades grow up in the neighbourhood, supplying it with implements and materials, organizing its traffic, and in many ways conducing to the economy of its material."[39]

In abstract terms, the neighbourhood of firms in the same trade brings advantages and disadvantages. These external impacts, designated as *local external economies*, determine, ultimately, the agglomeration or dispersion of industry. Marshall describes economies that are industry-specific and predominantly positive (economies rather than diseconomies), thus explaining the agglomeration of firms in the same trade.

The local external economies in the industrial districts are of essentially two kinds: local specialization, reflected in the abundance of specialized labour; and transportation economies that arise from the proximity of customers and suppliers. Transportation economies were present in all the historical contributions, but previous authors, with the exception of Andrew Ure, had neglected issues related to innovation and to the quality of the labour force. In short, an original relation between location and innovation emerges in the *industrial districts*.

And to explain the formation of the *industrial districts*, Marshall brings into play a piece of evolutionary thought:

"*This accident or that may have determined whether any particular industry flourished in any one town; the industrial character of a whole country even may have been largely influenced by the richness of her soil and her mines, and her facilities for commerce.*"[40]

Industry thus casts anchor in an initially privileged location, for example, in the neighbourhood of sources of raw materials. Afterwards, the local external economies determine that each firm prefers to stay near the others, granting great geographical inertia to the industry.

Influenced by Marshall's economic biology, Austin Robinson (1897-1994), the husband of Joan Robinson, would study the dimension of the firms. Positing that the market size depends on the density of demand and on the area that can be served at some transport cost, Robinson (1931) derived the optimal size of the firm, distinguishing five criteria of optimality, which he tried to conciliate afterwards: technical, organizational, financial, commercial, and flexibility.

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[39] Marshall (1890, IV, X, p. 271).

[40] Marshall (1890, IV, X, p. 270).

The empirical work of the Stanley Dennison (1912-1992) sought to explain interregional migrations and the relationship between local and national unemployment. In his work, Marshall's idea of *industrial atmosphere* is recovered to become a factor of attraction for firm location. Writing after the Great Depression, he relates depression with location and with irreversible processes that alter the patterns of economic activity.

Many recent developments in regional and development economics rest on Marshall's conceptual scheme: the analysis of *clusters* and of the '*milieux innovateur*'; and, indirectly, the development models of cumulative causation or endogenous growth, which are supported by the reasoning elaborated by Marshall in his theory of the *industrial districts*.

2.5. Weber's *Location Theory*

Having neglected the results obtained by Launhardt, economic theory entered the 20th century without any formalized explanation for the agglomeration of economic activity. To fill this vacuum was the ambition of Alfred Weber (1868-1958) when writing his "*Theory of the Location of Industries*" (1909). The elderly brother of the famous sociologist Max Weber committed his life to both scholarship and politics. After fighting communism previously, he abdicated of his professorship to join the resistance to Hitler's National Socialism in 1933. This act of courage makes him stand today as a fierce defender of democracy.

Weber's great contribution to economics is in the domains of the pure deductive theory: the mechanical location theory, already developed by Launhardt, and sometimes designated as the Launhardt-Weber model. Having been anticipated by Launhardt, Weber significantly generalises his analysis, with the introduction of differential labour costs and of agglomeration economies.

The economy of the basic model is made up of several predetermined urban (consumption) centres, which are perfectly competitive markets, and of different sources of energy, raw materials and labour. All these relevant elements have negligible areas, being modelled as points in a homogeneous terrain. The basic problem of the firm is the minimization of the transportation costs, proportional to distance. In this partial equilibrium model, each firm selects its location in a certain moment, taking into account the current spatial organization of the economy, but ignoring future developments.

After the determination of the optimal location in this setting, Weber introduces distortions caused by spatial variations in labour costs and other agglomerative forces. In this more general setting, the firms consider three characteristics of the locations: transportation costs, labour costs, and agglomeration economies. Location factors are divided in two groups: the general, applying to all economic activities; and the specific, which apply only to certain industries. There is a further distinction between technical-natural factors, susceptible of incorporation in the models, and socio-cultural factors, which are not.

Weber's model also suggests that when the transportation of raw material implies loss of weight[41], the optimal location is close to the source of raw material; and that when the weight of the products is higher than the weight of the materials used in its production, the firm chooses to locate near the markets.[42] Unfortunately, Weber overlooked the problem of the market areas, and it would only be Palender (1935) to bring together the analysis of plant location and the theory of market areas.

In 1931, William Reilly offered an original approach,[43] inspired, as was fashionable at the time, in the laws of physics. He suggested that the spatial organization of the economy is based on attraction forces that resemble the law of gravitation. Spatial interaction and attraction between urban centres varies proportionally to the population and inversely with the square of the distance.[44] Accordingly, firms should choose the location of points of sale that maximized the market potential, that is, the commercial attraction exerted by the different cities.

[41] A common simplification in location theory is to consider transportation costs as a percentage of product loss instead of a pecuniary payment.

[42] Developed initially by Launhardt, this theory was ignored, until Weber developed it independently. This theory is usually designated as the Launhardt-Weber model.

[43] In "*The New Palgrave*", William Alonso mentions E. G. Ravenstein's laws of migration (1885 and 1889) as the first use of a kind of gravity model.

[44] The actual parameters in the gravitation law of retail can be taken as given (extrapolated from observations in other areas), or estimated empirically for the area under study.

2.6. Marginalism and Spatial Oligopoly

The introduction of the concept of marginal utility and of the principle of substitution originated a deep change in economic theory. And it is a fact that the rigorous formalisation presented by the *marginalist* authors[45] would be the starting point for many advances in spatial economic theory.

In 1925, the German Andreas Predöhl (1893-1974) viewed location as part of the production process and as based on the principle of substitution, in a highly influential work. In later years, he developed a comprehensive *core-periphery* framework, focusing the close connection between development analysis and spatial theory. With this original contribution germinated the modern development theory of the *core-periphery*. The principle of substitution had been used in 1924 by Frank A. Fetter (1863-1949) to sustain that the frontier between market areas depends upon the price differentials and the transport costs, and to derive some specific shapes of the market areas.

In this period, two trends dominated the evolution of economic theory: the wave of mathematization, still in its awake; and the rise of American economics. The authors that we present next, Hotelling and Chamberlin, account for both tendencies.

Harold Hotelling (1895-1973) developed another line of research in spatial economics, searching for the relation between price formation, market areas and the location of the producers. Strategic behaviour could occur in several variables: prices, quantities, location, product variety, product quality, etc.

Hotelling (1929) suggested that the firms compete in two stages: in the first they select locations; afterwards, they set prices. In his single-product model, the market demand is homogeneously distributed along a line. In addition to the price of the product, the consumers support transportation costs from the selling point to their location. In these conditions, both firms decide to locate in the centre, each one capturing half of the market, a result that is known as Hotelling's

[45] Stanley Jevons (1871), León Walras (1873) and Karl Menger (1871) presented these notions in England, France and Austria.

principle of agglomeration.[46] The formalization of the question of product differentiation begins in this study, as the distribution of demand may be interpreted not only as spatial distribution but also as distribution along any parameter of consumer preferences. Also important, even contemporaneously, was his insight of coexistence of different prices in equilibrium, due to the existence of transportation costs.

Meanwhile, Edward Chamberlin (1899-1967) was studying monopolistic competition, a decisive topic for the advance of spatial economics. In the process, he showed that Hotelling's principle of agglomeration was not robust. With more than two producers, the optimal location consists in the dispersion of producers along the market line. In a later work, he introduced advantages of proximity (agglomeration economies), deducing the existence of urban rents.

Lerner and Singer (1937) would return to Hotelling's model in search for generalization. Introducing demand elasticity, in an analysis that would be completed by Smithies (1941), they obtained several equilibrium configurations. Agglomeration was only a particular case, showing that Hotelling's principle of agglomeration held only with inelastic demand and in the absence of fixed transportation costs.

In the same year of 1937, it was Hoover that started the analysis of monopolistic competition and price discrimination,[47] relating spatial distribution of demand with marginal gain. Based on the assumption that demand elasticity raises with price, he showed that *f.o.b. pricing* policy leads to subsidization of transport to distant customers at the cost of the neighbouring ones. Hoover suggested three types of agglomeration economies: economies of scale associated with technical and organizational efficiency, location economies, and urbanization economies that arise from accessibility to infra-structures, to provision of support services, to qualified labour, and to customers and suppliers in general.

In this area of research, dedicated to spatial oligopolies, Melvin Greenhut would offer a spatial version of the Cournot oligopoly, contributing to the explanation of the growing importance of trade between different industries. He synthesized the classical trails of location theory, namely Weber's cost minimization approach, and Hotelling's theory of interdependent locations. It is worth noting that Greenhut often highlighted the importance of the non-economic factors of location.[48]

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[46] In fact, Hotelling's original study in game theory had a subtle error, shown by D'Aspremont, Gabszewicz & Thisse (1979).

[47] In an analysis that culminated with the work of Lösch (1939).

[48] Mai & Hwang (1993) review and generalize Greenhut's ideas.

2.7. Heckscher-Ohlin Trade Theory

Classical international trade theory, from Ricardo to Taussig, had been built upon the labour theory of value, which assumed constant factor proportions. This implied the failure to appreciate the influence of space because this setting prevented the explanation of migrations. The rationale is pretty straightforward. Constant factor proportions imply constant factor productivities, which in turn imply constant factor remunerations. As a consequence, there should be total migration (to the country which gave the higher returns), or no migration at all (in case of equal returns). With migration left out of the theory, a satisfactory treatment of agglomeration was not possible.

The way out of this dead end would come from the emerging Swedish tradition. Heckscher and Cassel, two predecessors of the Stockholm School (a tradition concerned especially with temporary and intertemporal equilibrium), would lay the ground for the seminal contribution of their student Bertil Ohlin (1899-1979).

Eli Heckscher (1879-1952) allowed factor proportions to vary in the production of different commodities and across countries. The different relative factor scarcities were responsible for different factor returns, and trade constituted an implicit exchange of factors. In general, each country would produce less of the commodities that required the use of the relatively more scarce factors, seeking to obtain these through international trade. Heckscher considered that the assumptions of factor immobility and factor price equalization were contradicted by the empirical observation. And turned to the exploration of the idea that differences in factor returns explained migrations, and that migrations altered factor proportions, thus equilibrating the returns of a factor in different places. This marks a paradigm shift from international factor immobility with factor price equalization to international factor mobility induced by differences in factor prices.

Sweden would be again in the spotlights, in 1918, when Gustav Cassel (1866-1945), one of the founders of modern economics in Sweden, published "*The Theory of Social Economy*". In this work, Cassel presents a general equilibrium model of price determination that is a simplification of the Walrasian system.

The Nobel Prize (1977) laureate, Bertil Ohlin (1899-1979), would put together Heckscher's trade theory and Cassel's model of general equilibrium. Seeking to conciliate the theories of international trade and of price interdependence, he would use the intermediate concept of the region to explain patterns of trade, factor migrations and the agglomeration of industry. In Ohlin's theory, trade results from the differences in natural resources and productivities. Given factor prices and demand, deduces the trade patterns between the different regions. And finally, with the introduction of a monetary system, a theory of international trade is obtained, with exchange rates as a determining factor and trade balance equilibrium as a new equation. The distinctive characteristic is that transportation costs took a central role, placing a spread between the price in the country that exports the good and the country that imports it. The variation in the prices of goods led to variations in factor prices, which, in turn, constituted an incentive for migrations.

Another important insight was that the geographical units could be regions as well as countries. His theory would apply either to international and interregional trade. Ohlin then envisioned the need to introduce friction to obtain partial and gradual migration, in the fashion of a process. But Cassel's tools would not allow this, so he resorted to eclectic literary analysis of the process of agglomeration.

2.8. Lösch's *General Equilibrium*

In the inter-war period, several authors tried to use neoclassical price theory to depart from Weber's location model. While Predöhl (1925) used the Marshallian partial equilibrium version, Hans Weigmann and Tord Palender (1902-1972) started from Cassel's general equilibrium framework.

Weigmann (1933) studied a spatial economy considering the spatial structure of the economic process and relating the spatial theory to the monopolist competition. He considered that the principle of perfect competition, generally accepted in his time, as inadequate, given the existence of physical space. Space implied limited competition, shaped by areas of influence; and some rigidity in the labour market, with gradual structural change, essentially a migration from the rural to the urban areas.

The Swedish Tord Palender (1935) developed a theory of spatial equilibrium based on a spatial duopoly that stands closer to Launhardt, Fetter and Hotelling than to Walras. He extended the analysis of the spatial duopoly to pricing policies other than the *f.o.b. pricing*[49], that imposes to the customer the payment of the transportation costs. Alternatively, he considered uniform delivery pricing, a policy in which it is the producer that supports the costs of transport. Being also an engineer, Palender compared roads with railways, concluding that the latter are a monopoly while the former are characterized by competition.

Weigmann and Palender agreed that an examination of spatial economics required the consideration of imperfectly competitive markets in opposition to the perfect competition in the Casselian general equilibrium model. They also agreed as to the need for dynamic modelling instead of the static analysis of Cassel, since factors should be allowed to move, and with some friction. Facing the inadequacy of the tools at their disposal, they decided to keep their general equilibrium theories in a verbal mode.

The German August Lösch (1906-1945) would pursue and deliver what Weigmann and Palender had pursued but withdrawn: the

[49] The *f.o.b.* pricing policy consists in pricing at the point where marginal revenue equals marginal cost and then adding the transportation costs.

formalization of a general equilibrium model applied to space, with imperfect competition. A declared anti-Nazi, he could keep his integrity only at a great personal cost. His premature death probably prevented further achievements, but Lösch's magnum opus, "*The Economics of Location*" (1940), suffices to grant him the status of an innovative genius.

Seeking to integrate the results of his predecessors and to give a formal expression to the remarks of Weigmann and Palender. His main critic of the model of Heckscher-Ohlin was that the regions were assumed '*a priori*', rather than endogenously determined. In view of that, Lösch formulated a complete system of equations expressing the spatial relationships of economic equilibrium with imperfect competition, which also allowed for multiple production locations and general interdependence of location selections. This was a decisive progress towards the development of a general model of spatial interdependence.[50] Lösch supposed homogeneity of the spatial distribution of population, raw materials and labour.[51] Making no assumptions about the geographical units, he left to the model to show where and how the economic boundaries arose. Furthermore, in Lösch's model, economic agents seek profit maximization, a more realistic objective than the Weberian cost minimization.

In 1933, the geographer Walter Christäller (1894-1975) had made an original contribution to the explanation of the spatial distribution of population. Never having held an academic post, Christäller showed immense insight in his theory of *central places*. In his model, population and demand are homogeneously distributed, while supply is concentrated in cities. The result is a hierarchy of central places drawn around the city, which is the centre of a regional community. Each place of a higher level, existing in a smaller number (because of higher fixed costs or lower transportation costs), performs all the functions of the inferior levels and also some additional ones. In this setting, Christäller also had the intuition that the zones of influence of the central places are hexagonal.

In the model of Lösch, the demand for a commodity is maximal at the point of production and decreases with distance, taking the shape of a distorted cone. But, as Christäller had foreseen, for the whole space to be covered, the spatial organization of the economy should acquire the form of a network of hexagonal market areas. All that remained to be determined was the sizes of the hexagons, the location of the centres and the prices paid for goods at the centres.

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[50] Lösch (1940).

[51] Lösch keeps the classical assumption of proportionality between distance and transportation costs.

Considering the elasticity of demand as a function of the distance to the selling points, Lösch solves the general equilibrium model for three different pricing policies: fixed *f.o.b.* prices; different prices for each customer; and *uniform delivery* prices. Equilibrium emerges as a consequence of two opposing forces: the maximization of individual advantages; and the maximization of the number of independent economic units, with entries until profit is suppressed. The model can be seen as a composition of five fundamental conditions: (1) the location of each industrial unit must be profit maximizing; (2) all the economic space must be served; (3) profits must disappear as a consequence of free-entry; (4) areas of supply, production and sales must be as small as possible; (5) in the frontiers, it is indifferent for a consumer to belong to one or other region. General equilibrium is obtained in both open and closed economies.

August Lösch made several contributions that go beyond this model: showed how differentiation arises as a way to decrease the intensity of competition; distinguished punctual from area concentrations, like rings, and also homogeneous from heterogeneous agglomeration of industry (a distinction that resembles that between industrial districts and urban centres); developed Christäller's central place theory and used the superposition of hexagonal networks to explain agglomeration; and considered an heterogeneous model with more general conditions - patterns of transportation cost, natural elements, and political questions -, distorting the hexagonal shapes that result from the simplified model by successive approximations.

Finally, in his trade theory, the spatial organization of labour is explained in with recourse to three factors: (1) people, (2) occupations and (3) location. Each pair of factors gives rise to one of the following problems, which he discusses in detail: (1-2) selection of an occupation by the economic agents; (2-1) the population in each sector; (1-3) selection of residence by economic agents; (3-1) the population in each locality; (2-3) the location of the industrial sectors; (3-2) and the activity of a locality.

In 1956, Walter Isard would follow up the work of Lösch, deducting the implications of his model of spatial general equilibrium. Isard made several other contributions: presented the set of equations describing the conditions for an optimal spatial equilibrium; applied *input-output* tables to interregional flows; and shown that the profit maximization and cost minimization are equivalent only with Leontief production functions. His work culminates with the reformulation of spatial economic theory, which originated the applied field of Regional Science.[52]

[52] With the work of Isard. Regional Science, as we know it, emerged (Costa, 2002).

2.9. Myrdal's *Cumulative Causation*

The idea of cumulative causation is so elementary that its overlook in economics is somewhat puzzling. A process of agglomeration can be regarded as result of cumulative causation, if local external economies (positive, of course) are postulated. But actually, agglomeration itself has also been systematically neglected in economic theory. The old mercantilist doctrines advocated the concentration of production, but ever since, the geographical concentration of the economic activity was generally omitted from the theory.

Nevertheless, agglomerative mechanisms are inherent to numerous theories and analysis. The Weberian theory of location clearly leads to agglomeration, as firms chose to locate in the vicinity of their customers and suppliers. Adam Smith's (1776) consideration that the division of labour is limited by the size of the market can be stretched to explain agglomeration: an increase in the size of the market leads to more division of labour, which increases productivity and factor prices, which, in turn, represents an increase in the size of the market.[53] The market potential analysis that will be treated in the next chapter also suggests a cumulative process. To satisfy possible curiosity, the crux of the reasoning is advanced here: the location of a firm in a given region raises the market potential of the same region, thus raising the probability that another firm chooses to locate there.

A challenger of these puzzling overlooks would grow from the farming fields of Sweden and the teachings of Wicksell, Heckscher and, above all, Cassel. This atmosphere produced a puritan and egalitarian economist and politician, Gunnar Myrdal (1898-1987), who received the Nobel Prize in 1973[54]. He started as a pure theorist, clarifying concepts of *ex-ante* and *ex-post*[55] and explaining unexpected gains and losses as well as price fluctuations as deriving from the adjustment of expectations. But then turned to politics and, describing himself as an institutionalist, built his fame on a critique of

[53] Justman (1994) uses *input-output* tables to show that local demand influences decisions of location.

[54] Together with Friedrich von Hayek.

[55] Savings and investment must be equal *ex-post*, but not necessarily *ex-ante*.

economic theory, especially of its application to underdeveloped countries.[56]

Centring his inquiry in the relationships between unequally developed places, Myrdal (1957) concluded that the disparities have a tendency to aggravate. The core of his reasoning is that investments generate internal and external economies. So, a place where investment takes place reinforces its attraction of investment relatively to the neighbourhood, and attracts further resources from the periphery. This idea of *Circular* or *Cumulative Causation*[57] was much cherished by Myrdal, who used it widely. Leading to increasing returns and to the magnification of small advantages, the principle of cumulative causation explained underdevelopment as a self-reinforced process.

In a refutation of the neoclassical postulate of the mobility of factors towards convergence, Myrdal held that mobility occurs in the opposite direction, through selective migration of the young, dynamic and productive human resources.[58]

The nature of cumulative growth is related to the concepts of *backward linkages* and *forward linkages*.[59] Consider the existence of certain fixed costs, which imply some minimum scale for an industry to be profitable. It is said that an industry creates a *backward linkage* when its demand reaches a minimum scale that enables the creation of an intermediate upstream industry. The *forward linkage* is the downstream image of the *backward linkage*. From another angle, a *backward linkage* takes place when an industry reduces the costs of the potential customers beyond some critical value, so they actually become customers. This creation of *backward* and *forward linkages* may lead to the development of a local industry, to regional specialisation, and to a reinforced process of development.

In 1954, Fleming presented an analysis of the nature of external economies in development that clearly focused the interaction between factor supply and economies of scale. The model of the *Big-Push* is based on this idea that scale economies at plant-level translate into

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[56] Myrdal's *Critique* is a ferocious attack on the technocrat, which runs along five lines (Palgrave (Dic.), 1987): appeal for realism, accusing mainstream of '*opportunistic ignorance*'; search for a broader definition of development that acknowledges the actual needs of the people; attack on the narrow definitions and limits of disciplines; critic of spurious objectivity, which conceals political valuations and interests; accusation of biases and twisted terminology.

[57] Myrdal inherited this idea of Cumulative Causation from Wicksell, who used it to explain divergences between natural and market rates of interest.

[58] Migration of worldwide young talents to the American universities supports this view.

[59] Hirschman (1958).

increasing returns in the aggregate via external economies. In this model, economies of scale at plant-level and the elastic supply of production factors interact, leading to external economies and welfare improvements.[60]

Notice that the elasticity of labour supply in a region may be high, despite the low elasticity in the country as a whole, due to the high regional mobility of workers, in comparison with international mobility. So, while a *Big Push* for the country economy may be implausible, a *Big Snowball* for a particular region can make perfect sense.

Other authors engaged in the analysis of increasing returns and self-reinforced processes. In 1964, Lowry produced a pioneer model for the use of urban land, and calibrated it for the city of Pittsburgh. In this model, many location decisions were endogenous, and increasing returns implicitly caused multiple equilibria.

Assuming economies of scale, Alan Pred (1966) discussed the critical points over which it becomes profitable to substitute imports of some good by local production. This substitution, on the lines of the *backward* and *forward linkages*, increases employment and the local market, and may induce a growth cascade process, reflecting the circular relationship between market size and the region's portfolio of industries.

[60] Murphy, Schleifer & Vishny (1989).

3. A Taxonomy of Spatial Economics

After the elaboration of a *hall of fame* of geographical economics it is useful to provide an overview of the *state of the art*. In such a far-reaching field of study, it is fundamental to organize and interrelate the competing and complementary models and theories. Each theory will be presented in a forcefully superficial fashion, as our search is for an organizing synthesis of all this body of knowledge associated with the connection between space and economics[61].

As in every exercise of classification, there are many ways to organize the subject of geographical economics. Some arbitrariness is evident in the definition of the different paradigms, and perhaps also in the labelling of each theory. It is possible that a theory cannot be adequately put under one of the previously defined headings, but this damages the elegance of the taxonomy. It is up to our analytical knife to cut through and make sharp distinctions between different theories that may actually have much in common, and to arrive at an elegant and enlightening organization. This may be starting to sound a bit like a *groovy* intrusion in a scientific work, but all we can do is prevent the more suspicious readers that there is some art in science, and that it is surely preferable to state it than to keep the skeleton in the closet.

Fortunately, artists like Claude Ponsard, Paul Krugman and Stephen Meardon have suggested organizations for this field. The inadequacies of their classifications will be pointed, and a proposal will be made in order to clarify the different dimensions of spatial or geographical economics. It is useful to start with the description of the established works.

Ponsard (1983) considered that were four classical models of spatial analysis in economics:

- Von Thünen's model of the rings (1826);
- Weber's optimal location (1909);
- Hotelling's agglomeration principle (1929);
- The central-places of Christäller-Lösch (1940);

[61] Which has been designated as geographical economics by Stephen Meardon (2000), although we are perhaps more comprehensive, as we include other traditions, such as the Marshallian *industrial districts*, and give more emphasis to the relation between space and innovation.

His organization of the field is based on the main models and on the different problems that each of them intends to solve. Von Thünen's model explains the price of land around a central market for agricultural use, or, more generally, the rents of land around an attractive location.

Weber's model approaches the problem of the location of the firm that wishes to be near the markets and the factors of production. While for von Thünen the optimal location was given (as close to the city as possible), for Weber, rents are unimportant (the use of land by the manufacturing plant is considered not significant) and the problem is to find the optimal location.

Hotelling introduced a new dimension in the problem of location: interdependence in the firm's choices. Furthermore, in his model (like in Launhardt's analysis), the demand is not considered as given, being determined by the market areas that are a consequence of the firm's locations. The problem that Hotelling approaches is actually in the lines of modern game theory.

Finally, the theory of central-places of Christäller and Lösch is a sort of architectural paradigm, since it derives a whole optimal spatial organization from scratch, with hierarchies for service provision in cities and villages. The problem considered could be that of finding the optimal spatial configurations of the economic system, or instead of optimal, the ones that result from given assumptions.

It is also worth mentioning that Ponsard also analysed the trends of the contemporaneous research (in 1983), concluding that it consisted of five main areas: modelling of spatial interaction; spatial equilibrium theory; spatial public economics; spatial econometrics; and inquiry on the concept of economic space.

In a recent work, Paul Krugman (1999) considered the existence of five traditions in Economic Geography:

- *Germanic Geometry*, which comprises the model of Weber and the theory of central-places;
- *Social Physics*, which includes the empirical Zipf laws and Reilly's gravity laws;
- *Cumulative Causation*, which explains development spirals with models like the Big Push;
- *Local External Economies*, that comes from the ideas of Marshall about the industrial districts;
- *Rents and Land Use*, based on the model of von Thünen, also applied to urban economics.

Paul Krugman uses a different "*knife*", acknowledging not only the type of problem to be solved, but mainly the crux of the idea that originated the model. Krugman characterizes the tradition designated as *Germanic Geometry* as being more about geometry than about economics. In fact, Weber's model is build around a theorem of Fermat[62], and the theory of central places is based on the brilliant geometrical insight of the hexagonal market areas.

The second tradition that Krugman isolates, that of *Social Physics* (which will be mentioned ahead in this text), is founded on the application of empirical laws similar to those used in physics. These laws can describe interaction between distant places (for example international trade) or the distribution of city sizes. The models in this tradition are descriptive, not providing economic explanations for what is observed.

Then there's the tradition based on the idea of *Cumulative Causation*, which Krugman traces to Harris (1954), comprising the theories of Myrdal, the model of the *Big Push*, *backward* and *forward linkages*, and other self-reinforcing processes of agglomeration.

The fourth tradition (*Local External Economies*) is rooted on the Marshallian concept of industrial districts, and on the idea that proximity to other producers yields advantages like local specialization. In this tradition Krugman includes also the local external economies that are external to the industry, usually designated as urbanization economies.

Finally, Krugman presents, as a fifth tradition, the model of von Thünen and its applications both to agriculture and to urban economics. This model is praised for the idea of general equilibrium, the emergence of value as a consequence of the market process, the simultaneous determination of prices of products and factors and of the use of land.

Finally, Stephen Meardon (2000), who coined the term '*geographical economics'*, divided his article distinguishing, with care for the chronological order, perhaps three main modern areas:[63]

- *Growth Poles* or core-periphery models;
- *Regional Science*, which includes Location Theory and Urban Systems;
- *New Economic Geography*, which arose out of trade theory.

[62] Fermat was the first to solve the three-points problem – finding the point that minimizes the sum of the distances to other three given points.

[63] Stephen Meardon (2000) didn't present it as an organization, but we infer this from the structure of its article.

This has some relation to the way Krugman organized the field. The area of *Growth Poles*, linked to Development Economics, essentially coincides with the tradition of *Cumulative Causation*. The area of Regional Science seems to be overcrowded. It joins von Thünen with the central places of Christäller and Lösch, and also with Weber's Location Theory. But Meardon helpfully identifies the sub-fields of Location Theory and Neoclassical Urban Systems. With the consideration of this subdivision, we can relate his taxonomy directly to Krugman's: *Location Theory* corresponds to *Germanic Geometry*; and *Neoclassical Urban Systems* to *Rents and Land Use*.

So, comparing the ways in which Krugman and Meardon organize geographical economics, we find that Meardon overlooks the Marshallian tradition of the *Local External Economies* and the less important tradition of *Social Physics*. On the other hand, Meardon regards the *New Economic Geography*, of which Krugman is a major contributor, as an independent tradition, while Krugman himself thinks of it as overcoming the previous traditions.

The taxonomy of Claude Ponsard is the least comprehensive of the three, comprising only the two traditions that Krugman identifies as *Germanic Geometry* and as *Rents and Land Use* (which in turn are related with Meardon's area of *Regional Science*). But although his scope is narrower, Ponsard regards Hotelling's work on interdependence and agglomeration as very relevant, and is very thorough in the appreciation of the contributions to location theory. Perhaps because of its privileged relation with microeconomics, location theory was under-represented by Krugman and Meardon.

Here a different taxonomy is designed, intending to address the limitations that were pointed. The general, and fundamental, principles of simplicity and elegance were sought. In what concerns the justification for this particular taxonomy, it will be clear that it is based on different points of view from which it is possible to approach the economic problem. The base is the division of Geographical economics into three main areas of inquiry:

- *Location Theory*;
- *Spatial Organization*;
- *Spatial Development*.

The first area is bounded, in general, by microeconomics, particularly by industrial economics. The essential problem is that of a firm that wishes to find the location that maximizes some objective (profit) function. It is evident that this area of inquiry is based on the point of view of the economic agent that seeks to choose a location for its economic activities. Besides providing the perspective, these economic

agents are the elemental audience for these theories. In *Location Theory* we include, recalling our *Hall of Fame*, the works of Launhardt (1882) and Weber (1909) on the location of the firm, and also the tradition of spatial interdependence that begins with the seminal paper of Hotelling (1929).

As its name suggests, the area designated as *Spatial Organization* is concerned with the spatial configurations that characterize the economic system. The perspective is one from the outside. Some spatial structure of the economy is likely to emerge out of given assumptions. This may be an optimal spatial organization, or simply the organization that arises out of the assumed behaviour of the agents. The concentric rings of the von Thünen's model are placed here, as well as the hierarchies of hexagons of the theory of central places, and also some empirical laws as the rank-size rule, that describe the relations between the sizes of different cities.[64]

The category designated as *Spatial Development* is centred on the problem of local development. It comprises, on the one hand, the theories of cumulative causation, growth poles, core-periphery and the new economic geography, and, on the other hand, the Marshallian tradition of the industrial districts and its offshoots. The essential common ground is the idea of agglomeration – economic activity attracts more economic activity – and its different justifications. The perspective may well be the government or a development agency, seeking local development and growth, possibly in competition with other places.

This is our taxonomy, that is, the way in which it is held that the field of geographical economics should be organized. Notice how the structure resembles the intersections of geographical economics with three main fields in economics: location theory is included in microeconomics; spatial organization arises from a macro-level perspective, although being somewhat excluded from mainstream macroeconomics; and spatial development is intimately linked to the areas of development, growth and regional economics. The next chapter follows this structure, and illustrates its usefulness.

[64] These three areas have some unavoidable overlap. On this problem one should recur to Umberto Eco's "*Kant and the Platypus*" (the platypus defies the reigning taxonomy of the animal kingdom). An example of this overlap is related to Hotelling's principle of agglomeration and its generalizations. It falls in the area of *spatial organization* to the extent that it describes the resulting spatial configuration of the economic structure. But, given the relevance of spatial differentiation and of Hotelling's model in general, to the problem of firm location, it also falls on the category of *location theory*.

4. Modern Theories

The structure of the chapter that follows, on the modern theories, is based on the proposed organization of spatial economics into three sub-fields: *location theory*, *spatial organization* and *spatial development*.

In the first section, on *location theory*, are presented the developments on the firm location problem, covering the static Launhardt-Weber problem and the dynamic (interdependent) framework set by Hotelling. In this sub-field, at the intersection of geographical economics and microeconomics, the influence of space is seen from the perspective of the individual firm (or other single economic agent).

The second section, on *spatial organization*, comprises the questions of general equilibrium in space, and the emergence of spatial organization – including the developments of von Thünen's model, the theory of central places, and the so-called laws of social physics. The influence of geography is on the macro level of the economy, on its spatial organization and structure.

The third and final section is about local external economies, cumulative causation, and consequent development spirals. It comprises the literature on growth poles and core-periphery, as well as the Marshallian *industrial districts*, the *clusters* and the "*milieux innovateurs*". Here the fields of development economics, growth theory, and regional economics meet the influence of space, especially in what regards the spatial economic structure.

4.1. Location Theory

4.1.1. The Static Problem of Firm Location

In the chapter that covered the fundamental contributions (*Hall of Fame*), we saw that Launhardt (1882) and Weber (1909) analysed the problem of location of a firm that intends, simultaneously, to minimize its transportation costs, take advantage of agglomeration economies, and to have cheap and abundant labour at its disposal.[65] The crucial problem is geometric, and its solution was firstly discovered by Pierre de Fermat (1601-1665). The basic problem assumes a homogeneous space,[66] and firms choose to locale in the point that minimizes the sum of the weighted Euclidean distances to a finite number of points (attractors), which represent markets and sources of production factors.

In this basic version of the model, the impact of space on the economic activity was only due to the existence of transportation costs. In fact, the minimization of the transportation costs dominated the theory of firm location for a long time, with the model of Launhardt-Weber serving as the reference for a lot of developments.[67] We should highlight the contribution of Alonso (1967), who introduced scale economies, factor substitution and demand elasticity.[68]

Weber's optimisation problem hasn't got, in general, analytical solution.[69] The beauty of this theory attracted the attention of genius mathematicians like Fermat (as already mentioned) and Steiner, and

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[65] Remember that the two latter objectives were accomplished by successive distortions of the solution to the transportation cost minimization.

[66] Von Thünen, Weber and Lösch informally approached the role of natural irregularities. Using modern tools, Goldman & Witzgall (1970) showed the distortion effects caused by geography.

[67] The introduction of additional variables allowed a better understanding of the geographical determinants of location. Eswaran, Kanemoto & Ryan (1981) used duality theory to unify existing theories and to derive new results.

[68] An analysis deepened and generalized by Thisse & Perreur (1977).

[69] Kuhn & Kuenne (1962) proposed an efficient algorithm for its resolution, generalizing Weiszfeld's (1936), which was valid for the non-weighted case.

led to various investigations of its geometric and mathematic structure.[70]

The possibility of building several plants is, of course, common. This is a sort of union of Launhardt-Weber's model with the theory of central-places. Many contributions to this area came from Operational Research, being frequently neglected by mainstream economists.[71]

Modelling space as a linear segment, Sakashita (1967) has shown that the firm locates either in the market point or in the source of production factors.[72] An alternative line of research models transportation networks as a topological graph.[73] This representation of space allows the study of the interaction between location selection by the firms and the transportation policies designed by governments. Hakimi (1964) showed that a firm that minimizes transportation costs prefers to locate in a network node or in a market point.[74] The process of location selection has, thus, a discrete nature.

But perhaps the greatest development in location theory consisted in the consideration of a more realistic objective for the firms: profit maximization instead of cost minimization.[75] This development is said to mark the transition from classical to neoclassical location theory. Isard (1952) showed that the two objectives were equivalent in the case of Leontief production function, and Greenhut (1952) tried to reconcile the two approaches. But it was Moses (1958) that arrived at a synthesis of the classical and the neoclassical theories, showing also

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[70] Some authors dealt with alternative definitions of distance: Francis (1963) worked with *rectangular norms* (movement is allowed only along two axis, in a grid); Love & Morris (1979) with *lp-norms*; and Ward & Wendell (1985) used *block norms*. General theorems for orthonormed spaces have been established by Wendell & Hurter (1973) and by Duriez & Michelot (1985).

[71] Wesolowsky (1993) reviews the literature. Models in the Operational Research tradition and their main extensions are reviewed by Love, Morris & Wesolowsky (1988).

[72] This property attracted a lot of attention and was object of several extensions (Mathur (1979), Mai (1981) and Eswaran, Kanemoto & Ryan (1981).

[73] Labbé, Peeters & Thisse (1995) provide a review.

[74] Gülicher (1965) independently obtained this result, which was generalized it for profit maximizing firms by Louveaux, Thisse & Beguin (1982). Continuous and network models are developed and discussed by Hurter & Martinich (1988).

[75] According to Mai & Hwang (1993), the modern firms are characterized by a separation between ownership and management, which leads to behavioural deviations from profit maximization. The authors show that, in the absence of increasing returns, the bias is towards locating closer to the markets than the optimal solution.

that the two objectives are equivalent only for fixed proportions production functions - the Leontief kind.[76]

4.1.2. Interdependence and Spatial Competition

The models of competition in space remount to Hotelling (1919), having been developed by Lerner & Singer (1937), and by Smithies (1941). It is assumed that the firm's locations interact, and that's why Greenhut called it theory of *spatial interdependence*. Firms, instead of profit maximization, search to guarantee a small but stable market, and to maximize the satisfaction of the owners, which includes psychological profits. In this setting, space means more than transportation costs. Firms may actually take advantage of space to as a differentiating factor, in order to engage in monopolistic competition, instead of perfect profitless competition.

Assuming inelastic demand and no fixed costs, Hotelling (1929) concluded that firms agglomerate in the centre of a linear segment market – a result known, as already mentioned, as Hotelling's Agglomeration Principle. In 1941, Smithies showed that with linear demand and purely variable transportation costs, the result was a compromise between agglomeration in the centre and dispersion.[77] His seminal contribution originated two groups of spatial competition models: in one the market is a line segment; in the other it is a circular line.[78]

Hotelling understood that in order to study this kind of competition, a framework of interactive decision-making was needed, but his message was ignored until the advent of game theory. Together with linear programming, game theory came to renew the interest in the spatial duopoly, and in the study of spatial oligopolies.[79]

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[76] Based on the work of Predöhl (1925), Nijkamp & Paelink (1973) reconciled the classical and neoclassical approaches with a supplementary difficulty: the firm faces uncertain demand when solving the problem of location. Anderson & Fisher (1993) abdicated of the simultaneous production and sale, showing that the relationship between demand and production is altered.

[77] Hurter & Lederer (1985) generalized Hotelling's model, showing how different, pricing policies lead to different spatial configuration of competing firms.

[78] Takahashi & de Palma (1993) brigde the two types of models.

[79] Gabszewicz & Thisse (1986) present a review of the literature on spatial competition.

D'Aspremont, Gabszewicz & Thisse (1979) showed that spatial competition does not lead to agglomeration because firms wish to differentiate in order to reduce the intensity of price competition. Agglomeration may result, however, if firms sell differentiated products.[80] The problem of differentiation in space is more complex than in other variables, because both consumers and firms are mobile, and interdependently select their locations.[81] Nevertheless, the general conclusion is that firms tend to disperse in order to differentiate.

Another important insight about the specific character of spatial competition was offered in 1935 by the Hungarian Nicholas Kaldor (1908-1986). He explained that, given the existence of significant transportation costs, each firm competes only with its neighbours, independently of the total number of firms in the industry.[82]

The *trade-off* between fixed production costs and transportation costs is central to the theories of geographical organization.[83] Increasing the number of plants or warehouses reduces transportation costs but increases fixed costs.[84] One of the reasons for the agglomeration of stores is the fact that people go shopping with multiple intentions. This generates non-convexities that render analysis much more difficult.[85]

It is worth mentioning that the classical assumption regarding the pricing policy was *f.o.b.* pricing plus transportation costs. Kats & Thisse (1993) proposed *uniform delivery* pricing, and showed that f.o.b. plus transports pricing emerges only when the *reservation price* is high enough.[86]

Stigler (1961) considered the sale of differentiated products with imperfect information, and existence of search behaviour on the part of consumers. The *cost of information* is, in his model, minimized by the agglomeration of *specialized stores*.

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[80] De Palma et al. (1985).

[81] A first attempt at integrating both kinds of differentiation is made by Fujita & Thisse (1986), in a model in which firms anticipate the residential choices of the families when selecting their locations.

[82] The implications of space in competition are reviewed by Eaton & Lipsey (1977).

[83] It is in fact the base for the whole field of economic geography.

[84] Beckmann (1972a) finds the optimal solution as a Nash equilibrium.

[85] Preliminary solutions have been proposed by Eaton & Lipsey (1982) and Stahl (1983). Stahl (1987) suggests future developments.

[86] Eaton & Schmitt (1993) present a model where the results depend on who supports transportation costs: the producers or the consumers.

The differentiation in space and the resulting monopolistic competition has connections with public economics,[87] since it justifies regulation of these industries.[88] Recall that *public goods* may serve an unlimited quantity of consumers without seeing their quality degraded. If their supply is local, their consumption gives rise to problems of congestion, and to the consequent lost of purity of their public nature.[89] In general, space[90] has a fundamental role in models with public goods: capitalization. The value of land reflects public services, taxes and the transportation costs that affect the resident.[91] The land prices and the population adjust to compensate the variations in the attraction of different places.[92] In this context, Henry George's Theorem shows how differential rents may finance the supply of public services in a city.[93]

4.1.3. Spatial Equilibrium

Lets now turn to the problem of price equilibrium in space. Suppose that buyers and sellers of a certain commodity locate in nodes of a transportation network, and consider the problem of the simultaneous determination of supply and demand in each node, as the respective prices. Equilibrium is attained when bid price equals the demanded price plus transportation cost. If it is inferior, there is no exchange.[94]

Existence of equilibrium as shown by Arrow e Debreu (1954) presupposes convexity of the consumer preferences and of the firm's production possibility sets. In a spatial context, these assumptions are

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[87] Myers & Papageorgiou (1993) estudam as condições nas quais o espaço é relevante para a economia pública.

[88] Benson, Marquis & Sauer (1993) maintain that geographic delineation of markets is a crucial issue in regulation policies.

[89] Samuelson (1993) analyses the problem of congestion due to rivalry in the consumption of a non-exclusive good.

[90] Ohta (1993) sees space as a public good frequently supplied to individuals, but that can be used by many without congestion.

[91] Tideman (1993) shows how the local supply of a good or service increases the value of land in the neighbourhood.

[92] Wildasin (1979).

[93] This is shown by Flatters, Henderson & Mieszkowski (1974), and by Arnott & Stiglitz (1979).

[94] Cournot (1838) studied this problem in a model of interregional trade. Samuelson (1952) formulated it in a linear programming framework.

untenable.[95] Equilibrium was sought by recourse to the combination of spatial economics with transportation analysis, which originated a range of contributions.[96]

The hypothesis of increasing returns to scale has more dramatic implications. In the limit, each consumer produces for herself. General equilibrium models contour this problem assuming an exogenous number of firms. Even so, each firm would prefer to have many small plants in different places. Therefore, increasing returns are essential to the explanation of the geographical distribution of economic activity.[97] And if indivisibilities are introduced, non-existence of equilibrium is common.[98]

[95] Schweizer, Varaiya & Hartwick (1976) relax the assumption of convex preferences, in a model with many consumers. They establish existence of competitive equilibrium in an economy in which consumers decide to live in a single place.

[96] Florian & Los (1982) study this problem and Friesz (1985) offers a review.

[97] With increasing returns, Starrett (1974) shows that the differential land rent equals the corresponding cost for the firms (that set prices equal to their marginal cost), confirming a suggestion of Hotelling (1938).

[98] As was shown by Koopmans & Beckman (1957) and by Starrett (1978). Heffley (1972) suggests that indivisibilities in production doesn't necessarily prevent existence of equilibrium. Mills (1970) guarantees existence with perfect divisibility in production (constant returns to scale).

4.2. Spatial Organization

The theories of spatial organization seek to describe optimal spatial configurations, or, instead of optimal, the actual configurations derived from simplified behaviour of the economic agents. The spatial organization of economic activity may be more or less agglomerated, and it may be possible to define specific shapes – like von Thünen's concentric rings, the hyperbolic market areas of Launhardt (developed by Fetter and Palender), and the hierarchies of hexagons in the theory of central places. The major paradigms of spatial organization are:

- The concentric rings of von Thünen;
- The theory of central-places of Christäller and Lösch;
- Empirical laws of social physics, like Zipf's rank-size rule;

These three paradigms have different origins. The model of Von Thünen is one of classical general equilibrium, with simultaneous determination of prices, quantities and use of land. The theory of central-places is based on induction and hindsight (even though Lösch built a general equilibrium model with imperfect competition), and tries to find optimal patterns of economic organization. The laws of social physics are derived from observation, being simply descriptive.

4.2.1. Urban Rents and Land Use

The studies on the rental values and uses of land derive directly from von Thünen's "*Isolated State*" (1826), in which different products are cultivated around a market point. As we have seen, he explained the use of land for different productive uses as a function of transport costs to a centre, having concluded that the central terrains should be reserved for the activities that are more intensive in transportation costs and less intensive in land use.[99] Since Thünen's time, almost two centuries have passed, and the economics of agriculture changed

[99] Beckmann (1972b) designated von Thünen's model as neoclassical theory of land use.

profoundly. The introduction of techniques of food conservation led to the decrease in importance of the transportation costs relatively to land fertility. Another characteristic that cannot be bypassed is the existence of economies of scale in production, which he ignored. Therefore, his model of rings is inadequate as a modern theory of land use for agriculture.[100]

The contemporaneous relevance of von Thünen's model lies in its adaptation to urban economics, allowing the study of urban and suburban rents and of the location of families and economic activities in the cities.[101] Following a suggestion of Isard (1956), Alonso (1960) generalized the model of von Thünen, explaining the demand for locations near commercial centres like shopping malls, employment centres such as skyscraper headquarters, and to stadiums and other leisure centres. The fundamental characteristic of the urban economy reflected in the model is the need for families to go to the centre to work using a radial transportation system.

This structure thus became the typical model of urban economics. Solow (1973) fitted it into the neoclassical model of consumer theory, while Mills (1967) endogenized the dimension of the cities.[102] From this point, the contributions multiplied. A fault in this approach is that it assumes something we want to explain: the existence of an urban central market.[103]

Avoiding the problem of the generation of the city centre is not so important, as models cannot be wished to explain all. But another fault of the Thünen-Mills model leads us to use it with some reserves. The problem is that there are a lot of cities without a perfectly defined centre, like the one perpetuated by Chicago's rail hub. Los Angeles has 16 edge cities that overshadow its two downtowns. As Krugman (1996) creatively acknowledges, cities are not so much as a slice from an onion than as a plum pudding, with each local centre corresponding to a plum.[104]

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[100] Dunn (1955) studied the theory of land, viewing it as a production factor. Stevens (1968) and Fujita (1976) also approached the problem of the optimal use of the land.

[101] The pioneer applications of von Thünen's model of the rings to the real estate market were made by Alonso (1960) and Muth (1961).

[102] The endogenous determination of urban centres was approached by Ogawa & Fujita (1980), Imai (1982) and Fujita & Ogawa (1982).

[103] Krugman (1999).

[104] Papageorgiou & Casetti (1971) generalized the model of Alonso-Muth to polycentric cities.

4.2.2. Christaller-Lösch's *Central-Places*

The theory of central-places arose from the huge intuition of Christäller and Lösch, who imagined a hierarchy of centres and realized that these had hexagonal areas of influence. In their model there are several levels of centres: the main, of the highest order, that provide all the services to the homogeneous market area; passing through centres of intermediate orders, which provide only some services; to the centres of the lowest order, which provide the least number of services, according to economic laws that dictate that these specific services be supplied in the close proximity of the citizens.

A relevant generalization was offered by Isard (1956), who showed that the hexagons in the periphery should be bigger than the central ones. The fundamental idea of the central-places is very simple: each industry faces a trade-off between economies of scale and transportation costs.[105] But for this paradigm to achieve a dominant status in spatial economic analysis, it must deal with the problem of market structure.

4.2.3. Empirical Laws of Social Physics

The tradition of the laws of social physics includes several studies of the spatial organization of economic activity in which are used empirical laws similar to the laws of physics.[106]

One of the most famous is *Zipf's law*, or the *rank-size rule*. This law is sort of a discrete counterpart of Pareto's distribution, named so because the insights of Vilfredo Pareto (1848-1923) on the

[105] Baumol (1993) incorporates location theory into the theory of international trade, which increasingly recognizes the importance of the economies of scale to explain the division of labour and the location of industry. The Ricardian principle of marginal competitive advantage depends on decreasing or constant returns to scale. Baumol highlights the theoretical and empirical relevance of increasing returns and of the notion of average competitive advantage. Under increasing returns, the principle of competitive advantage may not collapse. Even in case it does, the equilibrium may be *locally stable* and *efficient*.

[106] Krugman (1999).

concentration of influence.[107] G. K. Zipf was an imaginative linguistics lecturer at Harvard, with broad interests. A somewhat eccentric intellectual with a passion for numerical regularities, Zipf supported Hitler's annexation of Austria and the *Sudetenland* on the grounds that Germany's urban system did not conform to the rank-size rule, while the resulting pan-German system did (Palgrave (Dic.), 1987). This empirical law relates the population of the biggest city with that of the second largest, and with the population of the third largest, the fourth, etc. It asserts, approximately, that the population a city is inversely proportional to its rank. So, the population of the largest city should double that of the second, triple that of the third, etc. The exact parameters of the relation are derived econometrically through observation. A variation of this law may be applied to some oligopolistic market structures (the leader has the double of the market share of the second bigger company in the industry, the triple of the market share of the third bigger, etc.[108]

Reilly's law of retail gravitation (1931) relates the interaction between cities, that is, the intercity trade, with their sizes and the distance that separates them. It may be used to predict flows of international and interregional trade, demand for transportation of persons and goods, migrations, etc. The interaction is approximately proportional to the sizes of the economic units and inversely proportional to the square of the distances between them. The exact parameters of the relation are also derived empirically.[109]

The idea of a theory of location is that firms choose to locate in the places with highest market potential, that is, near the most important economic centres. Given a certain spatial structure of the economy, the market potential consists in the sum of the interactions predicted by the gravity law. This approach actually has some power to explain the decisions of location both in the USA and in the EU. But, having no *a priori* assumptions about market structure, it doesn't explain what is it that firms maximize.

Huff (1964) modelled commercial attraction probabilistically, generalizing Reilly's gravitational model. He considers that a consumer chooses a certain consumption centre with a probability that is proportional to the commercial area and inversely proportional to the square of the distance. Nakanishi & Cooper (1974) tried to generalize

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[107] Vilfredo Pareto observed that 80% of the Italian income was concentrated on 20% of the population.

[108] Prediction of earthquakes and meteorites also follows a similar power law (Krugman, 1996, p. 44)

[109] Anselin & Florax (1995) edited a volume about the new trends in spatial econometrics.

Huff's model to heterogeneous supply, in what became known as the model of multiplicative competitive interaction.[110]

[110] The book by Sen & Smith (1995) resumes the '*state of the art*' of gravity interaction models.

4.3. Spatial Development

The theories derived from cumulative causation had their fifteen minutes of fame in the seventies, as a doctrine of development. In sum, this line of inquiry is based on the observation that external economies give rise to a circular process: investment decisions for production in large scale depend upon the size of the market,[111] which depends of the investment decisions. This may explain virtuous cycles of industrialization and agglomeration, or vicious cycles of divestment and desertification.[112]

The idea that agglomeration of producers brings advantages, and that these advantages explain the agglomeration itself is an old one. It was provided by Marshall, who highlighted: the ability of a local market to absorb an efficient scale of production of intermediate goods; the advantages of a deep labour market; and the exchange of information that occurs when firms in the same industry agglomerate. Marshall's analysis was progressively refined. Since the 1940s or 50s, economists started to distinguish between external economies that are mediated be the market from those that are technological. Since the 1980s, the Marshallian paradigm has received increasing attention, following the works of Becattini on the Italian industrial districts and of Michael Porter on *clusters*.

The theories related to cumulative causation and to the Marshallian industrial districts constitute the area of *Spatial Development*, whish is presented below.

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[111] Hymer (1960) explains internationalisation as exploration of patents that allow market power in the form of monopoly or oligopoly in the destination markets. In these conditions, the size of the market is the crucial variable for the investment decision.

[112] Duning (1981) refers three conditions for internationalisation: property of some advantages; internal appropriation of these advantages preferable to sale or licensing; opportunity for combination of these advantages with resources in the country of destiny. A country experiencing decreasing demand and resources may not be attractive for foreign investment.

4.3.1. *Core-periphery* Theories

The model of cumulative causation, developed from the critique of Gunnar Myrdal to the neoclassical analysis. As was mentioned in the previous chapter, the kernel of Myrdal's reasoning is that investments generate internal and external economies. Being so, a place where investment takes place reinforces its attraction of investment relatively to the neighbourhood, and captivates the resources of the periphery. This was his explanation of underdevelopment.

But the first formalization of a core-periphery model was made by Jay Forrester (1969). In his model, the city expanded continuously in a self-reinforced process, until it lost its power of attraction for having reached a very large size. Then, the surrounding rings became attractive, and growth focused on the periphery. Friedmann, Richardson and Von Böventer would follow his original analysis, in what we call *core-periphery* analysis and models.

Friedmann (1972), considered undisputable the fact that regional convergence was not automatic. Studying the interaction between centre and periphery, he held that development resulted from discrete and dynamic processes of structural transformation associated to innovation. In his model, the innovations are generated in the centre, and this implies its dominance of the periphery. Friedmann acutely questioned the basis of the neoclassical model. His theoretical formulation implies that, once the core-periphery structure is established, the invisible hand of the marketplace acts towards divergence.

The main elements of his theoretical basis are the following:

- Advanced activities concentrate in the centre;
- Cultural environment is more beneficial in the centre;
- The decreasing returns that should delay development in the centre take long to arrive;
- The periphery has difficulty in identifying and taking advantage of business opportunities;
- There is a growing demand in the periphery for the exports from the centre;
- It is hard for the periphery, drained of capital and human resources, to make structural adjustments.

Richardson would give a crucial contribution to the development of *core-periphery* theory,[113] based on the consideration of two

[113] Another contribution made by Richardson (1973) was the introduction of uncertainty in the analysis of location, together with Webber (1972).

antagonistic forces, one of agglomeration and other of dispersion, whose resultant varied in space and time. Following the good practices of scientific inquiry, Richardson (1973) started from two questions:

- What are the fundamental spatial aspects of growth that the theory must explain?
- What are the essential elements that explain these aspects, and that the theory should integrate?

He concluded that the theory should explain the existence of three stages of development:

- 1. Initial Concentration – polarized growth, in a small number of regions;
- 2. Concentrated dispersion – diffusion of the economic expansion to other regions, concentrated in the urban centres of these regions;
- 3. Decentralized concentration – migration of the population and the economic activities from the centre to the periphery.

Richardson considered that the urban dimension was fundamental to regional growth. Essentially, a poor region had more to gain from a strong and dynamic urban centre than from the same level of economic activity dispersed homogeneously. Consequently, Richardson wanted to integrate the urban dimension as well as the intra-regional and the interregional determinants of growth. The spatial variables in his model are: distances, transportation costs, parameters of location, agglomeration economies and preferences for location. The parameters of location describe the initial conditions of the terrain, including the existence of cities, natural resources and means of communication.

Agglomeration economies, in this model, are actually economies of urbanization, with positive effects in terms of innovation and technical progress, reflecting the advantages of organization in cities. The preferences for location eliminate volatility in the location of agents, which acquire some inertia.

In 1975, von Böventer made a critical review of Richardson's model, incorporating some extensions. He criticizes essentially the lack of operationality of the model: many of the independent variables have small variability, leading to weak econometric estimation. Von Böventer built upon the three stages of development defined by Richardson, presenting two requisites for development: a minimum level of local (urban) agglomeration economies; and improvements in the infrastructures for transports and communications (interurban agglomeration economies).

After reaching a critical size, a process of cumulative development is launched that creates the main agglomeration of the country.

Subsequently, centres of medium dimension benefit from the proximity of this big centre, and the better the communications, the more they will benefit. As a consequence, these medium sized centres may also surpass a critical agglomeration and benefit of the same process of cumulative development.

But, at some point, strangulations (diseconomies of agglomeration) put a limit to the growth of the big centres, so the process of development is transferred to the periphery. This is the third and last stage of development.[114]

Both Richardson and von Böventer considered fundamental the elaboration of a theory of regional growth. A theory that explained the trends for convergence and divergence, interconnected the analysis of urban and regional growth, and illustrated the role of cities as the engines of growth. They intended to design a basis for future developments, but their studies remained at the margin of economic analysis.[115] Probably because of their kind of research, which was based on "*joining mental or visual images with semantic taxonomy, anecdotal evidence, and empirical study*" (Meardon, 2000, p. 345).

4.3.2. The *New Economic Geography*

Historically, the economists have ignored the influence of space, studying, as Isard (1949) complained, a "*wonderland of no* [*spatial*] *dimensions*". The geographical concentration of economic activity is an evidence for the existence of increasing returns, which give rise to markets with imperfect competition. But the difficulty of modelling these conditions withheld economic geography and urban economics in the margin of research in economic theory. Meanwhile, the economic globalisation came to renew the interest in the study of the intersection between geography and economics, given the lost of importance of frontiers and the need to attract foreign investment and economic activity in general. The study of the emergence of a *core-periphery* system has attracted a lot of attention. Economists seek to identify the forces that tend to agglomerate the economic activity, and the forces that tend to disperse it. With knowledge of these forces (microeconomic foundations), the second step is to explain the

[114] More recently, Sakashita (1993) presented a model with positive and negative effects of aglomeration.

[115] Cheschire & Evans (1995).

formation of the geographical structure from the equilibrium between them.

Suppose that the local external economies, which promote the concentration of production, are subject to congestion effects that increase with agglomeration. This would lead us to a theory of the size and number of cities. Vernon Henderson (1974) proposed an elegant model along these lines. An equilibrium with free-entry is obtained, with entry meaning the creation of a new city. He also showed that if the cities have incentives for specialization in different industries, with industry-specific scale economies, then the cities would have different sizes, producing at optimum scale and exporting the excess production.[116]

The central problem, the same that interested Christäller and Lösch, is to explain the concentration of economic activity. The evolution from the classical theory of international trade to the Heckscher-Ohlin model was already mentioned. But, unable to model what he thought as evident, the factor mobility, Ohlin claimed that there still wasn't any theory that could explain both trade and agglomeration. In spite of the subsequent generalisations and thorough formalisation, some criticisms to the Heckscher-Ohlin model could not be shaken up. In 1953, Wassily Leontief noted that the U.S. imports were capital intensive relatively to its imports. This was in direct contradiction to the Heckscher-Ohlin model, which predicted that highly industrialised countries would export more capital-intensive products than those imported. The model also could not explain the findings of Grubel & Lloyd (1975) on the importance of intra-industry trade, nor why there was more commerce between countries with similar factor proportions. The *new trade theory* would introduce imperfect competition and depart from the assumption of constant returns to scale, considering the existence of some fixed costs, setting the stage for the emergence of a new field: the *new economic geography*.

Maybe the first reason for agglomeration is the existence of economies of scale in production, at the level of the plant and at a higher level of a complex of interrelated activities. Combined with costs of transport, this would lead to the agglomeration of industry.[117] This is the central hypothesis of the field known as *new economic geography*.[118] Being based on views and concepts that are liable to modelling, it differs from the *neoclassical urban systems* field, deriving from Vernon

[116] Henderson (1987).

[117] Many mechanisms of agglomeration have been proposed (Fujita, 1990). The important work of Fujita and Ogawa (1982) stands up, electing the intensities of externalities between producers as the determinant factor.

[118] The book by Fujita and Thisse (2002) reviews the recent contributions.

Henderson, which kept the agglomeration economies in an external "*black box*".

Relatively to the kind of imperfect competition that is considered, two approaches are possible to introduce these assumptions in a formal model. The first is grounded on the idea of self-organization, involving many small agents. Along the lines of Dixit-Stiglitz, these models assume increasing returns, differentiation and monopolistic competition,[119] trying to discover microeconomic foundations and to identify strategic interactions previously included in "*black boxes*".[120] The second approach assumes the opposite: that the economic landscape is determined by a small number of important agents that behave strategically,[121] like in the simple Cournot oligopoly. This is more in the spirit of spatial competition, but both approaches have their merits and limitations, discussed in Fujita & Thisse (2002).

A crucial assumption is about the existence (or absence) of labour mobility. Krugman's (1991b) model supposes that migrations are possible, a phenomenon that Venables (1996) excluded. If the object of study is the relationship between regions in the same country, it is forceful to consider the possibility of migrations, which reinforce and accelerate the agglomeration of economic activity.

Krugman's (1999) economy has two sectors: agriculture, which is immobile, and industry, that has some mobility. Industry produces differentiated goods, with each plant producing a single good. The existence of increasing returns ensures that not all the potential products are actually produced. The problem of strategic behaviour is simplified by recourse to the model of monopolistic competition of Dixit & Stiglitz (1977). All that firms decide is their optimal location, accounting for the distribution of demand and the transportation costs. After the definition of the initial conditions, the model simulates the decisions of the economic agents in time. It is computationally verified that the regular distribution of central-places imagined by Christäller and Lösch may emerge from Pred's cumulative processes.[122]

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[119] Like in Krugman (1991b), Fujita & Krugman (1995) and Englmann & Walz (1995). This approach develops ideas that remount to the work of Allen & Sanglier (1979, 1981).

[120] Abdel-Rahman & Fujita (1990) suggest a mechanism of agglomeration based on the common use of intermediate goods.

[121] Among the main contributions are Hesley & Strange (1990), Henderson & Slade (1993), and Henderson & Mitra (1996).

[122] Matsuyama (1995) offers a review of the theory of cumulative processes in a monopolistic competition framework.

4.3.3. *Industrial Districts* and Local Development

The fundamentals of the theories of local development based on technological specialization were already in Marshall's *Principles*. As we have seen, Marshall discussed the *local external economies* that prevailed in and gave rise to the *industrial districts*. The essential idea is that proximity between firms in the same trade brings them benefits (or losses), designated as local external economies, which in turn lead to the agglomeration (or dispersal) of the industry. In the industrial districts, local external economies are predominantly positive, which explains the agglomeration of competing firms, and the permanent character of this spatial distribution.

An industrial district is essentially an agglomerate of small and medium firms in the same trade, whose competitiveness resides on the local specialization and on the proximity to a myriad of specialized suppliers. In the Marshallian industrial districts, two kinds of local external economies prevail: abundant supply of specialized labour and transportation economies due to the proximity of customers and suppliers. Notice that these are internal to the industry, favouring agglomeration of firms of the same trade, but not of those of unrelated trades.

In the last decades of the 20th century, Italian scholars have recovered the conceptual scheme of the industrial districts. Given the fact that the Italian economy is organized around specialized small and medium sized firms, it was natural that those studying it understood the resemblance to Marshall's ideas. And it was in a study on the development of Tuscany that Becattini (1979) first used the term *industrial district ("distretto industriale").* Other developments of the Marshallian analysis followed, as the "*milieux innovateur*" of the GREMI group and Michael Porter's "*clusters*".

Location, historically viewed as determinant of transportation costs, now appears as a determinant of innovation and development.[123] External economies of agglomeration, of scale and variety, and organizational and technological proximity became more important than physical proximity. The importance of transportation costs is now, in many industries, a minor issue, when compared to the local technological specialization and diffusion of innovation. The last chapter of this work is reserved for an approach to the also intimate relation between space and innovation

[123] Benko & Lipietz (1994).

It is a fact that the Marshallian paradigm came to shed a new light on the relationship between the local and the global, appearing as a meeting point between the global logic and the local social dynamics. As a result, the small and medium scale of production was positively revaluated, and attention moved towards the endogenous face of development. The industrial districts constitute the competing paradigm of that of the gigantic firm.[124] Their endogenous technological and innovative capacity turns into international competitiveness of local SMEs, at the level of the big vertical integrated firms. In Italy, this alternative is patent.[125] The two paths towards industrialization are based on the demand for territorial economies that include (increasingly) the involvement of society in the productive process, the incentives to the generation of new firms, and the interaction between existing ones.[126]

It is a characteristic of the industrial districts that trust and managerial attitudes reproduce locally. And not simply in the direction of homogenisation, since complementary specialized capabilities are also developed. This is healthy, because the competitiveness of the industrial district requires openness to external change.[127]

Joseph Schumpeter (1942) insisted that the first thing to understand about capitalism is that it is an '*evolutionary process*'. And it was Alfred Marshall who first defended an evolutionary approach to economic analysis. He held that the industry established itself in an initially privileged place, like one that is in the neighbourhood of a source of raw materials (there is actually an economic imperative that induces firms to locate there). Now suppose that this activity entailed intense local external economies internal to the industry. For the sake of concreteness, consider that the firms' innovative capacity is decisive, and that the diffusion of innovation is strongly associated with spatial proximity. An enterprise that chose to locate outside the industrial district would have a severe handicap in its innovative capability. Thus, the industry remains cohesively agglomerated.

The suppliers and customers of the characteristic industry of the district also tend to locate in the neighbourhood to save some transportation costs. This proximity of the related firms constitutes

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[124] Maryann Feldmann (1999) mentions two studies that support the view that the engines of modern economies are technological districts characterized by great interaction (Storper, 1995; Scott, 1993).

[125] Becattini (2003, 4), underlines the advantages of flexible organization and social management. Based on the idea of transaction costs, he describes the mix of cooperation and competition based on local conventions.

[126] Becattini (2003).

[127] Becattini (2003, 10).

another source of the inertia of the local industry, and strengthens the attraction of the industrial district.

In this setting, the endogenous growth theory makes sense, as well as evolutionary theory. The location of the economic activities is clearly path-dependent. Furthermore, technical progress has a cumulative nature. This path-dependence is confirmed in several studies. Arthur (1986) and Krugman (1991b) state that, with increasing returns, the location of industry may result of historical accidents in the distant past. The historian William Cronon (1991) distinguishes two landscapes for urban emergence: the *natural* and the *created*. The *natural* includes rivers, mountains and some given factors of production. The *created* landscape is formed by railroads, highways, cities and other consequences of human activity. He further argues that the second landscape is now more determinant than the first, stressing the path-dependence of development.[128]

The view associated with Marshall, Arrow and Romer (MAR model), highlights the importance of increasing returns to scale, and of the process of *learning by doing*, and suggests that firms benefit from locating in the industrial centres. A second perspective, associated to Jacobs, argues that the best locations for new factories are areas with a diversified set of industries.[129]

Two important studies that cross the evolutionary theories and the geographical economics are worth mentioning. Becattini (2003, 8) studied the evolution of the Italian industrial districts in several dimensions: relationship between the productive structure and the socio-economical environment; relationship between firms; the importance of social and human capital; and the socio-economic processes that originated the industrial districts. And Boschma & Lambooy (1999) explored the interconnection between evolutionism and geographical economics, focusing the concepts of *natural selection*, *path-dependence*, *increasing returns*, and *chance*.[130]

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[128] Dumais, Ellison and Glaeser (2002) used data from the U.S. census to describe the dynamics of agglomeration of American industry. The agglomeration indexes deceased slightly in the last 25 years, but many geographically concentrated industries present great mobility. They split agglomeration in terms of its causes: entry, expansion, contraction, and exit. It is shown that location choices tend to disperse productive activity, while plant closures tend to reinforce agglomeration. The stability of agglomeration, in spite of the mobility of industry, is a strong evidence that the levels of geographic agglomeration are determined by fundamental characteristics of industry. Historical accidents may have important long-run effects in some industries, like the textile, but not quite in technological ones.

[129] Empirical studies of MAR and Jacobs' models can be found in Glaeser et al. (1992) and in Henderson, Kuncoro & Turner (1995).

[130] Krugman (1996) is a creative and intensive text on self-organization, time and space in economics.

5. Space and Innovation

The spotlights now turn to the relationship between location and innovation. This is a relatively recent concern. It was only in the second half of the twentieth century that the economists' attention turned to the questions of technical progress. Some of them have tried to explain the interdependence between the spatial organization of the industry and its capacity to innovate.[131]

The pioneer and fundamental contributor was Alfred Marshall, who introduced the concept of *industrial atmosphere*. The Marshallian vision of an environment in which the secrets of the trade are in the air, with children learning the local trades unconsciously, is still the essence of some of the modern theories on the relationship between location and innovation. This chapter reviews the multidimensional modern developments of Marshall's theories of the industrial districts, and the many empirical results that support the linkage of location and innovative activity.

Marshall's ideas on location and innovation were ignored for a long time, until the Italian Giacomo Beccatini (1979) saw the resemblance between Marshall's description of the *industrial districts* and the structure of the Italian economy. The ideas of Alfred Marshall regained life, to be developed and applied to the modern economy. Still, the modern economy is radically different than the one that Marshall observed in his time. During the twentieth century, mankind benefited of enormous technological progress, reaching all the economy. Many discoveries had an instrumental and fundamental impact. Can you imagine how the economy (and life!) would be without electricity, cars and television? Remember that we had to wait for the 80s to have personal computers, and for the 90s to have the ubiquitous mobile phones and Internet.

For geographical economics, the most important progresses were the ones related to transportations and communications. With e-mail and mobile phones, we are essentially in permanent contact. And the

[131] The convergence between the theories of innovation and economic geography is treated by Morgan (1997), who presents an interactive model of innovation and regional development applied to Wales. Gregersen & Johnson (1997) also discuss the meeting of innovation and geography so central to "*learning economy*", in the context of the interaction between the national dynamics and the European integration.

physical mobility of people and goods increases continuously. These developments had important impacts in what concerns the relationship between space and economic activity.[132].

A good example concerns the distance between Europe and America. The physical distance remained, of course, constant. But what matters most are the possibilities of communication and transportation. In 1858, with the installation of the telegraphic cable across the Atlantic, the time needed to transmit a simple message from Europe to America shortened from around a month to one second. Now, people have the possibility to be permanently *in touch* through their e-mails and mobile phones, and the development of transports by air and sea increased the global mobility of both persons and goods.

In the twentieth century, the concepts of technical progress and innovation themselves also evolved radically. Joseph Schumpeter (1934) attributed to innovation the central role in the process of economic development, a vision that became common in the second half of the century. Innovation thus took a leading role in economic analysis.

In the 80s, a wave of studies comes to question the *fordist* conception of innovation. The mechanical idea of a process of linear transformation of research effort into technical progress was gradually abandoned, and replaced by a completely different view. Modern theories of innovation conceive it essentially as the result of interchange of ideas and information between the innovative agents. The basic preconception is that permanent technical evolution demands continuous and cumulative learning, specialization of knowledge, and a cooperative environment.

An important empirical result for the study of the relationship between location and innovation was obtained by Audretsch and Feldman (1996), who, following Krugman (1991a), showed the existence of a positive relationship between the geographical concentration of an industry and the importance of innovation for competitiveness in that area of activity.

Since Marshall's pioneer contribution, the economic concepts of distance and innovation have changed dramatically. Studying the evolution of theories on the relationship between location and innovation, we find that this is an evolving relationship between two evolving concepts. From the Marshallian *industrial districts* to the modern *clusters* and "*milieux innovateurs*", multiple mutations took

[132] In a global perspective, Feldman & Kutay (1997) discuss how the effects of the new technologies may be incorporated in a new theory of location.

place. And in modern theories, proximity becomes much more than geographical distance. What matters most is the relational proximity, the trust and the interaction between the agents. This new conceptual views lie at the intersection between economic theory and the emerging paradigm of the *network society*.

5.1. Innovation

5.1.1. Innovation and Development

There are three lines of analysis on the importance of regions in economic development. One is centred in institutions, another in industrial organization and transaction costs, and a third in learning and technical progress.[133] It is consensual that innovation is intimately related with economic growth and development.[134] In theoretical terms, the expansion of the technological frontier allows for productivity gains, so innovation and growth are related *a priori*. This is valid at the global as well as the local level.

This third line of research is supported by Maskell and Malmberg (1999), who argue that local competitiveness founds itself on the capability for creating knowledge and on the establishment of local basis for promoting collective learning. In an empirical work, Suarez-Villa (1997) confirmed the crucial relevance of innovative capacity for the endogenous regional growth.

The agglomeration of industry is seen as promoting technical progress. A justification is offered by the new growth theories, which suggest the existence of increasing returns in the production of innovation.[135] For easing the search and selection of information and the coordination of tasks, agglomeration may give rise to increasing returns, leading to increased production of innovations and to economic growth.[136]

As early as 1912, Joseph Schumpeter placed innovation at the centre of his "*Theory of Economic Development*". For some decades, he remained alone in this consideration, but now his vision is generally accepted. The rebirth of Schumpeter's vision on innovation and

[133] Storper & Scott (1995).

[134] Scientific activity lies at the heart of the new theories of economic development, technical progress, and industrial evolution (Romer, 1986, 1990; Lucas, 1993; Krugman, 1991a, 1991b).

[135] Romer (1986) and Lucas (1988, 1993).

[136] Krugman (1991a, 1991b) and David & Rosenbloom (1990).

economic development constituted an important stimulus for the study of the processes of production and diffusion of innovation. With innovation in the centre of the process of economic development, it becomes more interesting to study its determinants, so that adequate development policies may be formulated and applied, both at local, national and global level.[137]

5.1.2. Modern Theories of Innovation

The *fordist* legacy transmitted us an idea of innovation as a linear process of transformation of R&D effort into technical progress. This vision prevailed until the wave of contemporaneous research, which rendered it obsolete. Innovation is now conceived as the result of network interaction of strategic knowledge.[138] This interaction is, in its essence, socially constructed – based on the accumulation, diffusion and utilization of knowledge (tacit or codified) obtained by continuous and interactive learning.[139]

The attention moved from R&D effort towards informal contacts, network exchange of tacit knowledge, relational capital, social capital, and to the accepted rules and conventions.[140] The innovative ideal is synthesized in the Japanese concept of "*kaizen*": continuous improvement through collective interaction and problem solving, in the spirit of the motto "*learn to learn*".

To sum up, in the *black box* of innovation, opened by Rosenberg (1982, 1994) we now distinguish diverse actors, institutions and relationships. And it is recognized that location is one of the factors that conditions innovation and technical progress.[141]

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[137] Funck & Kowalski (1997) study the diffusion of innovation and the R&D activity in Eastern and Central Europe, and make policy recommendations for the countries in transition to the EU.

[138] Asheim (1996) presents a view of *learning-by-interacting* , holding that learning and innovation result of wide access to intangible strategic resources like information and knowledge.

[139] Innovative capability depends strongly on the processes that allow learning and accumulation of knowledge (Kirat & Lung, 1999).

[140] Storper & Scott (1995).

[141] Azzini et al. (1997) review the literature and compare four different modelling approaches.

Knowledge has certain features that influence the effects of location on innovation.[142] In what follows we consider what the empirical work suggests about three relevant concepts: *tacit knowledge*, *technological opportunity*, and *appropriability of knowledge*.

Knowledge can be more tacit or more capable of being articulated.[143] Articulated knowledge can be easily classified, codified, and transmitted by tangible means. Geographic proximity offers more advantages when we consider the transmission of tacit knowledge.[144] Being somewhat uncertain, that is, requiring some interpretation, this diffusion is helped by interpersonal contacts. Distance is, then, an important obstacle.

More than a continuous flow, technical progress is determined by discoveries and breaks that offer opportunities for innovation. Caballero & Jaffe (1993) argue that the knowledge *spillovers* depend on the rate of obsolescence of ideas,[145] and on the rate of knowledge diffusion. They conclude that the location in the neighbourhood of the sources of new knowledge is increasingly important.[146]

The effects of the appropriation of the surplus of innovation on the innovative effort are ambiguous.[147] According to Liebeskind (1995), innovation in biotechnology is stimulated by the rigorous regimes of intellectual property, that give rise to *patent races*. The analysis of these patent races is very complex. Firms cooperate and share technological knowledge to compete with third parties. As a result, social networks based on trust are formed.[148] Vicinity may provide the social contacts that are needed for the development of these networks.

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[142] According to Henderson (1983), both location and urbanization effects are more important in high technology industries.

[143] Feldman & Lichtenberg (1997) constructed several indicators of "*tacitability*" of knowledge.

[144] Von Hipple (1994) holds that the least codified is the knowledge, the greater the agglomeration.

[145] Jaffe & Trajtenberg (1996) concluded that the duration of patents is highly dependent on the field of study.

[146] Based on patent quotes, they also conclude that the relevant knowledge for the generation of new ideas has diminished.

[147] Cohen (1995). Zucker & Darby (1996) say that firms choose to locate near their competitors when appropriation is low. Audretsch & Stephan (1996) hold that after registering their patents, firms make their discoveries public to attract financing.

[148] Liebeskind et al., 1995

5.1.3. Production and Diffusion of Innovation

According to the endogenous conception of innovation, it is not surprising that the innovative firm is seen as a product of the local environment, which is perceived as the true innovative agent.[149] But notice that the milieu or local environment cannot be perceived in a strict sense of physical distance. It refers to all that surrounds the firm, including infrastructures, communications, labour market, capital markets, markets for energy and raw materials, and local institutions.[150]

To integrate innovation in economic analysis, the innovative process is generally split in two stages:[151]

1. Incubation and generation of new ideas and technologies, and respective introduction of commercially successful products;
2. Geographical diffusion of products and technologies and market adoption.

The determinants of innovation are analysed by Campisi et al. (1997), who discusses the innovative behaviour of firms, relating it to R&D effort and market share.[152] The degree of market acceptance of the new products is decisive, and a recurrent issue whenever new technologies are made available.[153] In other instances, the problem relates to the absence of incentives to production and to the introduction of new products, in particular when the provision of public goods is concerned.[154]

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[149] Genosko (1997).

[150] Davelaar & Nijkamp (1997) review the literature on the spatial distribution of innovation, and its determinants. Focusing on innovation at a regional scale, Nijkamp & Poot (1997) study how spatial interdependence in a system of regions may influence technological change, presenting a model in which technical progress in endogenous.

[151] Bertuglia, Fisher & Preto (1995) focus the first stage; Bertuglia, Lombardo & Nijkamp (1997) the second.

[152] Haynes et al. (1997) made an empirical study on investment, product development, and marketing of innovations.

[153] Nijkamp, Pepping et al. (1997) investigate the new information technologies through the user's perspective, exploring the relationship between human behaviour and *telematics* in transports in a study of bus passengers in Southampton and highway users in Holland.

[154] Geerlings et al. (1997) analyse innovative behaviour in the context of environmental technologies, and the problems caused by transports (State of California's "*Clean Air Act*").

The complexity of the scenario favours the use of simulation. Lombardo & Occelli (1997) simulated municipal policies and business strategies in an interactive model of:

1- Adoption of new technologies;
2- Location choice;
3- Historical movements of firms in the urban area.

The growth models with human capital, in the lines of Lucas (1988), also suggest that the capacity of developing and implementing new technologies depends on the medium level of human capital in the local economy.[155]

Local development may be promoted indirectly through incentives to the modernization of the firms. Some studies on innovation focus this issue. It is crucial to discover the determinants of this modernization.[156] But it also matters to find out to what extent there are network externalities in modernization, that is, if the modernization of a given firm leads others to modernize themselves, creating a sort of a chain reaction.[157]

In the study of the diffusion of innovation, the relevant concepts of distance and proximity are not purely physical. Keeble & Wilkinson (1999) show that proximity (cultural, institutional or geographic) is reflected on the transmission of knowledge and in collective learning processes.[158] By definition, a process of diffusion progresses according to proximity, but what matters is to find out what kind of proximity mediates the diffusion of technical progress.

There are many possible approaches for the modelling of diffusion.[159] Martellato (1997) presents a model in which the spatial aspects of innovation are connected to agglomeration economies. Hewings et al. (1997) discuss diffusion and structural change, using an econometric *input-output* model of the economy of Chicago.

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[155] Bartel & Lichtenberg (1987) confirm the positive relation between the average level of competencies and the production of innovations. Glaeser et al. (1992) show that a superior average human capital is associated with higher city growth rates.

[156] Heli Koski (1997) investigates the determinants of the adoption by firms of advanced communication systems, with an empirical application to the Finnish industries of metal and mechanics.

[157] Capello & Nijkamp (1997) develop the concept of network externality in the context of regional adoption of new technologies, with special emphasis given to the innovation in the information and communication technologies. They also make an empirical comparative analysis between the north and south of Italy.

[158] Lucertini & Telmon (1997) theorize on the adoption of innovations.

[159] Karmeshu & Jain (1997) clarify and describe several approaches to the diffusion of innovations, with particular attention given to the temporal dimension. Frenkel & Shefer (1997) describe the structure of several spatial diffusion models of innovation.

From a perspective of adaptation, Vangeenhuizen e Njkamp (1997) explore the strategies that allow firms to adopt new products and production processes in an empirical study of the Dutch textile industry.

The hypothesis that technological diffusion is geographically mediated is quite credible. In fact, Audretsch & Feldman (1996) found a positive relationship between the agglomeration of an industry and the importance of innovation for competitiveness in its activity. In the literature, we find four different approaches to the study of local knowledge *spillovers*:[160]

- Study of the spatial production functions of innovation;
- Observation of patent quotations to infer technological proximity between industries;
- Study workers as vehicles of knowledge transmission, relating their mobility with the production of innovations;
- Study of the transmission of knowledge incorporated in the products, relating international trade with growth and technical progress.

The first approach gives robust results, suggesting that distance is an obstacle to the diffusion of knowledge.[161] *Spillovers* tend to be limited to the regions in which the new technology was produced.[162] Therefore, we should expect innovative activity to be regionally concentrated.

Patent documents include references, which are indicative of the knowledge *spillovers*.[163] By connecting each patent to the ones it references, a measure of the spatial *spillovers* can be obtained.[164] This approach shows the geographically concentrated character of knowledge *spillovers*. Concentration becomes diffuse with the time, suggesting a speed of knowledge diffusion. It is expected that the new communication technologies come to diminish the spatial obstacle to

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[160] According to Feldman (1999), whose organization we adopt.

[161] In the first study of spatial diffusion of knowledge, Jaffe (1989) used the knowledge production function introduced by Griliches (1979), with spatial and product dimensions. Feldman (1994b) adapted the production function to data relative to the introduction of new products (instead of new patents).

[162] Using less aggregated data, the basic results hold (Anselin et al., 1996).

[163] Krugman (1991b) advises us to abandon the search for technological spillovers, holding that these fluxes are invisible.

[164] Jaffe, Trajtenberg & Henderson (1993) (like Jaffe et al. (1993)) did this, following the approach of Trajtenberg (1990). They observed that the patents from the same city are quoted ten times more than would be expected if there were no spatial effects. Almeida e Kogut (1997) reached similar conclusions in a study of the semiconductor industry.

the transmission of knowledge,[165] but this Internet effect is yet to be shown empirically.

One thing is to show the actual existence of spatially mediated knowledge *spillovers*. Another is to find the mechanisms for the diffusion. Zucker & Darby (1996) assume that the ideas are incorporated in people, and that these have the capacity and the knowledge required for the promotion of technical knowledge.[166] In sum, it is showed that local intellectual capital is a key to the development of new industries, and that there are local knowledge *spillovers*.[167]

Knowledge can also be transmitted for being incorporated in the products. By launching a new product, some new knowledge becomes public, and the producer may be prevented from appropriating all the surplus allowed by the innovation. Romer's (1990) growth model can also be seen as representing the incorporation of ideas in products. The innovation becomes immediately public, but the competitors cannot use this new design. Yet, they use it in their research for new designs. In the area of international trade, there are a lot of empirical studies that view trade as mediator of the international knowledge *spillovers*.[168].

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[165] Sokoloff (1988) showed that the local concentration of patents has diminished with industrialization.

[166] The authors review the articles on the role of top scientists on the commercialisation of new technologies, and show that there are knowledge *spillovers* in the places of residence of these top scientists. Notice that they highlight the role of a few individuals of exception, not the average human capital in the region.

[167] Almeida & Kogut (1997) studied the mobility of top scientists to follow the transmission of ideas in the area of semiconductors. Their results suggest that mobility increases the diffusion of ideas, and that this process is mediated by physical distance

[168] Branstetter (1997) reviews the studies of international diffusion of knowledge. Coe & Helpman (1995) showed that the international knowledge spillovers are mediated by trade and significantly correlated to the national productivity. Park (1995) measured technological proximity between R&D institutions in different countries, and found evidence of international diffusion. Yet, the conclusions of Keller (1997), who studied the elasticity of national productivity relatively to external R&D, raise doubts about the validity of the previous studies. Branstetter (2001) uses firm-level data to conclude that *spillovers* are essentially intranational.

5.1.4. Innovation in the *Industrial Districts*

The *industrial districts* are very competitive in the production and acquisition of specialized knowledge. Marshall tells us that the mysteries of the trade are "*in the air*", that is, that the diffusion of knowledge is (locally) fast and effective. He also tells us that the children learn many of the industry specific knowledge unconsciously, just by growing in that environment. This explains the abundant supply of specialized labour in the *industrial districts*.

The characteristic activity of the industrial district becomes part of the social life of the region.[169] People chat about the news and trends of the industry, appreciate good work and the progresses in the machinery and organization. Each one's ideas may be discussed with others, who may develop them or offer sensible advice.[170]

Innovation in industrial districts departs from social processes that condition the technological trajectory of the region. A local production system presupposes an historical process of technical accumulation and consolidation, and a characteristic tacit know-how (de Bernardy, 1999) that gives rise to a superior collective productivity.

Becattini (2003, 5) considers that the innovation in the industrial districts is based on the orientation of the small firm towards innovation. To compete with the big firm that has the possibility to spend heavily in innovation, the small firms present flexibility, tacit knowledge, and collective invention.

As we have seen, the collective dimension is central to the functioning of the industrial districts.[171] The cooperative relations and the local networks give rise to external economies of agglomeration:

- Specialization due to the deepening of the division of labour;
- Labour economies, due to learning and accumulation of specific *know-how*;
- Economies of information and communication, arising from the high level of social interaction and common context;

Innovation is based, thus, in the complex social networks that characterize the district. The proximity between firms and the

[169] Becattini (2003, 3) shows how the economic activity moulded the institutions and the character of the people of Prato (Italy).

[170] An analysis of the benefits of the inclusion of economic activity in social life may be found in Granovetter (1985).

[171] Lawson & Lorenz (1999).

common culture raise the probabilities of diffusion of information, leading to increased learning and incremental innovation. The problems of incentives associated with the exchange of productive knowledge between competitors are analysed by Becattini (2003, 5).

It is natural that technical progress in the industrial districts is of the incremental type. The radical technological jumps usually involve the combination with other fields of knowledge, and may render obsolete much of the know-how of the region. In this case, the competitiveness of the industrial district may be at risk.

The importance of the interaction with the international knowledge networks should not be underestimated. It is from the combination of tacit cumulative knowledge with the codified knowledge spread by globalisation that territorial competitive advantages arise (Lawson & Lorenz, 1999).

The Marshallian paradigm came to enrich the debate. The industrial activity of the region becomes part of the local culture, as if there were a fusion between the social system and the economic system.[172] The symbiosis between the business structures and the society brings to the forefront of the discussion the importance of institutions and policies, the role of collective representations and communal solidarities, and the territorial specificities.[173]

Regions turned into more than a passive support of investment. They became leading actors, specialized, and gifted with competitive advantages founded on the historically accumulated tacit knowledge. This highlighted the importance of constructing coherent local productive systems.

After being recognized that the dynamics of innovation come from specific local resources, the focus moved to the study and design of *regional complexes of innovation.*[174] This concept was followed by that of *regional innovation systems*, defended by many as an orientating notion for regional development. The primary objective considered in the project phase of these structures is the production, attraction and application of knowledge. Central to the architecture of the system is the interaction (networking), since the innovation is seen as

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[172] The socio-economic transformations constrain the evolution of the industrial districts. Becattini (2003, 2) studies different industrial districts in Tuscany and their transition from industry to services.

[173] The vicinity of complementary external resources may offer economies of scale and variety to small firms. Feldman (1994a) uses the knowledge production function to establish that third parties (like universities and the scientific system in general) may provide knowledge at a local level, benefiting small firms.

[174] Stöhr (1986).

determined by good management and efficient use of the strategic flows of information and knowledge.

5.1.5. Agglomeration Economies of Innovation

The agglomeration economies can be Marshallian external economies or urbanization economies.[175] The former are external to the firm, but internal to an industry in a particular region,[176] while urbanization economies are scale effects associated with the dimension and density of cities, or to particular attributes of some place.[177]

The geographical concentration of industry may increase the level of innovative activity for reducing the cost of specialised labour,[178] for inducing upstream and downstream specialization, or by favouring the diffusion of knowledge.[179] From these knowledge *spillovers* between neighbours in the same industry arise the Marshallian external economies.[180]

Geographical concentration may also be due to the existence of region-specific production factors. Urbanization economies are external to the industries, but internal to geographical units like cities.[181] According to Lucas (1993), the only reason for the existence of cities is the presence of increasing returns deriving from concentration of productive factors, which make these places more competitive.

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[175] This is stated already in Lösch (1940), although he designates by economies of localization what we call Marshallian external economies.

[176] Neither Glaeser et al. (1992) neither Feldman & Audretsch (1996) observe increases in growth and technical progress deriving from geographical concentration.

[177] This is the hypothesis advanced by Head, Ries & Swenson (1995), who depart from the literature on international trade. Henderson (1986) finds congestion effects (negative urbanization economies) in measuring productivity growth.

[178] Henderson (1986) shows that agglomeration raises factor productivity in the USA and Brazil.

[179] Adams & Jaffe (1996) suggest that knowledge *spillovers* in the pharmaceutical industry are strongly dependent of physical distance.

[180] Glaeser, Kallal, Scheinkman & Shleifer (1992) define economies of localization as Marshall-Arrow-Romer externalities.

[181] Nakamura (1985) and Moomaw (1988) find evidence that urbanization economies are more important in specific industries, and less in heavy industries or in those related with durable goods.

Jane Jacobs (1969) held that urbanization economies are characterized by the exchange of complementary knowledge between firms and economic agents that are geographically close.[182] Related activities then tend to agglomerate to favour innovation. Industries that are based on the same technology also tend to agglomerate, leading to an increased production of innovations.[183] But knowledge *spillovers* don't resume to similar technologies.[184] An important inquiry is about the kinds of complementary knowledge that creates economically relevant externalities.[185]

The role of universities should not be underestimated. They are important suppliers of knowledge,[186] raising the average competencies of the surrounding area, with positive effects on wages and employment.[187]

In specific industries, it may be possible to define a set of relevant suppliers. Smith and Florida (1994), in a study of investment in the Japanese automotive industry (in a wide sense), show that specialised suppliers tend to locate around the plants that use their products, originating an industrial district as is described by Marshall.

In general, the effects of location depend upon the characteristics of the firms, such as phase of development and competitive strategy.[188] The fundamental question resides in knowing what kinds of firms are capable to absorb and benefit of location, being generally supported that new firms in an industry have grater capacity for commercialisation of radical innovations.

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[182] Glaeser et al. (1992) present an empirical test for Jacobs' externalities.

[183] Feldman & Audretsch (1996).

[184] In the study of Jaffe et al. (1993), 40% of quotations are associated with patents of a different class.

[185] Feldman & Audretsch (1996) use data from Levin et al. (1987) to study the interdisciplinary relations of inter-industry increasing returns.

[186] Beeson & Montgomery (1992) examine the relationship between universities and the labour market.

[187] Mansfield, 1995.

[188] According to Cohen & Levinthal (1989), the costs associated to innovation, like learning and application of research results, are lower when the new knowledge is relevant for the future activity of the enterprise.

5.2. Innovation Networks

5.2.1. The "*Milieu Innovateur*"

The role of space constitutes one of the main challenges for the field of development economics. In regional economics and urban studies, the influence of proximity is clearly felt. Modern theories accept that the territorial structure and the technical progress are interdependent.[189] This interaction between the trajectories of spatial development and of technical progress implies that the spatial structure has an active role in development, being much more than a mere scenario.

The traditional approaches to the study of the role of space were eminently static, centred of the efficiency of location. This efficiency accounted for transportation and transaction costs, and for the presence of external economies, which may reduce, through various mechanisms, the costs of production. Among these mechanisms we may refer the education and training of labour, the information gathering, the sharing of infrastructure, and the existence of shared service provision.

The GREMI[190] centres its studies on the relationship between innovation and territory, using an eminently dynamic approach. It starts from this idea that the development and restructuring of industry may be seen as an interactive process of technical progress and shaping of economic space. The basic hypothesis is a tautology: "innovative '*milieux*' generate innovations".[191] The successful technological trajectories of certain regions are attributed to their intrinsic capabilities to fabricate new products, to improve their productive processes, and to adopt innovative organizational and institutional configurations.

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[189] According to Crevoisier & Maillat (1991), the interactions between the structure of the 'milieu' and the needs of the industry give rise to different territorial structures and to different degrees of capability and orientation towards innovation.

[190] The GREMI ("*Groupe de Recherche Européen sur les Milieux Innovateurs*") was created in 1985, with the objective of developing a methodology and theoretical approach for the study of innovative behaviour, and for carrying comparable empirical studies.

[191] Crevoisier (1993).

The focus moves to the generation of innovative behaviour. Collective learning is considered crucial, for allowing or accelerating the creative adaptation of high technologies to the local industry. We may speak of a paradigmatic change from '*location theory*' to '*spatial development*'.

The framework of the GREMI is centred on the concept of *innovative 'milieu'*, interpreting the economic dynamics in terms of territorial relationships. The '*milieu*' consists of the economic environment that surrounds the agents, referring to all the envelope of the enterprise and industry in general. It includes the set of infrastructures, the local market conditions, the socio-cultural environment, and the institutional environment. Economic space is seen as a relational space of social interaction, interpersonal synergies, and of social collective action.[192] It is determinant for the innovative capability and economic success of specific areas.

Camagni (1991) defines the innovative '*milieu*'[193] as the complex network of essentially informal social relationships in a limited geographical area, which determines an external image and an internal representation, as well as a feeling of belonging, which enhance the local innovative capacity through synergic processes and collective learning.

For Perrin (1991), the territorial environment becomes an innovative '*milieu*' through a self-organizing process based on economic integration, on interaction and synergies between forms, and in formal and informal networks oriented towards the innovation. According to Matteaccioli (1998), a '*milieu*' (local environment) becomes an innovative '*milieu*' when it develops the capacity to apprehend the transformations of its economic, technologic and market environment, as well as the evolution of other territorial production systems, by connecting to the most significant international dynamics, yet preserving its global coherence and identity.

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[192] According to Ratti (1991), the firm interacts with three strategic or functional spaces: the production space, the market space and the supporting space. The supporting space is the set of selective qualified relationships with sources of information, privileged partners, and strategic institutions. These interactions and synergies define the identity of the firm, its capacity for innovation, and its capacity of adaptation to a turbulent environment.

[193] Other definitions of the concept of '*milieu*':

- Relational capital, including a productive system, a technical culture, and a collective of actors, which is not a closed system, being, on the contrary, in constant interaction with the surrounding environment, leading to collective learning (Maillat, Quévit & Senn, 1993);

- Socio-territorial network of material and immaterial resources, dominated by a historically sedimented culture, vector of knowledge and know-how, based on a relational system of cooperation and competition between local actors (Lecoq, 1991).

The '*milieu*' may also be described through the enumeration of its components (Maillat, Quévit & Senn, 1993):

- A specific envelope – homogeneity of behaviour and technical culture;
- A set of autonomous agents (firms and institutions of education and R&D) anchored in the local socio-economic reality;
- Several elements: material (firms, equipments and infrastructures), immaterial (norms and values, information flows and *know-how*) and institutional (organization of public government and of civil society);
- A logic of interaction (relational capital) regulating behaviours and promoting local dynamics towards development and good use of existing resources;
- A logic of learning, leading actors to redefine and reconfigure their behaviour, adjusting to the external transformations, in particular of markets and technology.

The '*milieu*' corresponds to the brain of the local production systems, aggregating the capacities for action and the cognitive capabilities of the different actors.[194] It is a multi-dimensional reality, subordinated to a rationality that is guided by innovation and involving, on the basis of collective learning dynamics, the relationships between actors whose knowledge is close or complementary.

It is clear that proximity matters not so much because of savings in transportation costs, but also in relational terms. It favours information exchange, leads to similarities in cultural and psychological attitudes, increases the frequency of interpersonal contacts and cooperation, and the density of productive factors in the region. Proximity is redefined in terms of the medium of interaction. It is crucial, not only because of its effect on the efficiency of the local productive system, but in particular for determining the response to a mutating external environment, the capacity for innovation, and the productive flexibility.

Survival demands adaptation and reaction to the changes in the technological and market environments. According to the entropy law,[195] we expect growing disorder and homogeneity. The system needs negative entropy: new technological opportunities, new organizational models and new marketing ideas. Therefore, one of the central objectives of the innovative '*milieu*' is the attraction of external energies and *know-how*.

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[194] Maillat, 1996).

[195] This approach found some inspiration in the modern scientific theories, particularly in thermodynamics, which it applies metaphorically, without concern for rigour.

In case of threat to its survival, the local '*milieu*' may transform itself,[196] reducing dramatically its internal complexity. Sometimes this happens through fusion and rationalization of the myriads of small firms in a big one.[197]

This approach came to complement three pre-existing ones: the Swedish and Anglo-Saxon tradition of Johannisson and Sweaney; the territorial production system tradition initiated by Allen Scott; and the Marshallian concept of the industrial district, reviewed by Becattini. All of them highlight the role of the socio-cultural conditions on the development patterns of the local productive systems.

The competitiveness of the '*milieu*' resides in the creativity and permanent innovation, which in turn are based on collective learning. These processes are nourished by intergenerational transference of *know-how*, imitation of technical innovations and successful management practices, interpersonal contacts, formal and informal cooperation between firms, and by tacit circulation of commercial, financial and technological information.

A common disadvantage of the small firms is its greater vulnerability to risk and consequent difficulty of finding credit. The proximity derived from the agglomeration of industry, and the close social ties, allows the establishment of trust relations, which favour the access to credit.[198]

A factor introduced by the GREMI is the reduction of uncertainty. The cooperation and sharing of information allow better understanding '*a priori*' of the consequences of the decisions, better interpretation of technological information, and greater control and interdependence between the decisions of the different firms.

The approach of the *innovative 'milieux'* recovers Adam Smith's deep conviction of the social foundations of the market. Concrete and genuine social relations determine the decisions of the firms about products, quality, prices, technology and location.[199]

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[196] Social integration as a competitive advantage: extraordinary collective action adapts the system to external changes (Becattini, 2003, 9).

[197] Camagni (1991).

[198] Lerner (1999) evidences the benefits of a small firm for locating in an area that attracts venture capital. Becattini (2003, 6) studies the role of financing in the germination and growth of industrial districts, and the importance of trust for access to credit..

[199] Gordon (1991) criticizes the neoclassical equilibrium theory and the transaction costs theory for their incapacity to 'grab' the social foundations of the firm and to consider interaction outside the markets.

Quévit & Van Doren (1996) argue that the innovative '*milieu*' is itself an innovative concept, embodying and articulating three paradigms:

1- Cognitive – existence of a collective rationality oriented towards learning and innovation;
2- Organizational – culture of contact and interaction, regulative of the behaviour of actors, generating a dense cooperative network, subordinated to a logic of innovation;[200]
3- Territorial – the territory becomes a privileged vector of integration of historical, cultural, social and technological factors, which are at the heart of the distinctness of the '*milieu*'.

The dynamics of innovation in the '*innovative milieux*' distinguishes from that of the industrial districts, which derives of *ex-ante* institutional coordination and design. In the '*innovative milieux*', it is the fruit of informal relationships, of unplanned aspects, which derive from the intimate relationship between the actors. It is not surprising, thus, that in the *industrial districts* the incremental innovations prevail, while in the '*innovative milieu*' the radical innovations are the ones that prevail.

5.2.2. Innovation Networks

The idea of the *innovative 'milieux'* arrives in a context of affirmation of a new social paradigm: the network.[201] Naturally, the conceptual schemes of the network society were imported by the theory of the *innovative 'milieux*'.

To the two traditional archetypes of organization we must add a third:

1- Hierarchical, focused on the internal development;
2- Reactive, which adapts, conforming the best reaction to the external environment, but has a bad performance in terms of dynamic efficiency, innovation and structural change;
3- Relational, based on cooperation agreements and strategic alliances, reacting to the exterior and building the interior.

[200] Bramanti & Senn (1991) highlight the importance of technological creation from the bottom, instead of innovation diffusion from the top.

[201] Kamann & Strijken (1991) examine the concept of 'network', the types of networks and the possible behaviours in the network, namely power relations and power strategies.

This third organizational form has pros and cons. It increases the network surplus, as cooperative behaviour translates into scale economies (in R&D, production and marketing), collective learning (taking advantage of complementary *know-how*), and strategic synergies between firms.

On the other hand, the network structure is costly. It requires the construction of an own language and of structures for interaction.[202] And more fundamental is its intrinsic vulnerability to opportunistic behaviour (*free-riders*), which turns it into a riskier model. In fact, integration is not always beneficial, since sometimes partners absorb the entire surplus.[203]

Inter-firm networks provide opportunities for information exchange, transmission of tacit or explicit knowledge, and increase the mobility of qualified workers. In case they include public as well as private elements, the benefits may be even greater.[204]

The competitiveness of the innovation networks depends critically of their external relations. To be competitive at an international level, the SMEs cannot rely solely on local economies, they must also relate with external firms in cooperative international networks.[205] In fact, to be innovative at a global level, the 'milieu' must be integrated in the international networks: financial, technological, and market.[206] Cappellin (1991) elects as policy strategy for the local development the infrastructure provision and the establishment of cooperation agreements that strengthen the international connections such as financial networks between stock markets, scientific networks among universities, or information networks between headquarters.[207]

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[202] The genesis of an innovative 'milieu' is, according to Camagni (1995), a radical innovation.

[203] Gillespie (1991) questions the positive effect of advanced telecommunication networks in the peripheral areas. These gain access to information and production flexibility. But incur in losses caused by the control and absorption of local surplus by central headquarters.

[204] Jaffe (1989) found an important relation: research in the universities increases the R&D of firms, which, in turn, increases patent registries.

[205] Solé & Valls (1991).

[206] Amin & Robins (1991) examine this in the context of globalisation.

[207] The traditional dichotomy between local and international attitudes doesn't hold. In a logic of network cooperation, local relationships as well as international become sources of competitiveness by supplying strategic *inputs* and innovation factors (Quévit, 1991).

5.2.3. Intelligent Regions and Innovation Systems

The role of local governments[208] is treated by Becattini (2003, 9), who stresses the importance of collective action for the local development. He opposes the vision of the spontaneous development of the *industrial districts*. Like Becattini, Krugman (1999) also defends the planned incubation of local productive systems. Krugman observes that the three big agglomerations that he studied: the Silicon Valley[209], the Route 128, and the Carolina triangle; resulted from the action of visionary bureaucrats, not from private enterprise.[210] The germination of agglomeration processes is not necessarily spontaneous, so governments should pursue policies that promote local growth spirals.

The concept of intelligent region is centred on the relationship between innovation and territory, and in the interactive learning dynamics. It enlarges the analysis of the GREMI to the emerging productive paradigm, based on information, communication and computation technologies, as well as to the challenges of the "*knowledge economy*". It was Florida (1995) that suggested this concept, to characterize regions with the ability to attract and store ideas and knowledge, and that offer environment and infrastructures that favour learning and the diffusion of ideas and knowledge.

In parallel, from systems theory and the economics of innovation comes the idea of *innovation system*, which recognizes that technology and innovation depend upon a socio-economic complex of interactions, frequently structured at country scale – '*national system of innovation*' (Lundvall, 1992; Nelson, 1993). In this model, the productive system and the institutional universe are intimately linked and evolve together.

The possibility of existence of a system of innovation depends on spatial and technological proximity. The transformation of these two proximities into a system of innovation presupposes an institutional

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[208] Becattini (2003, 11) explores the question of the reorganization of the state oriented by the new approaches to the problem of development.

[209] The historians Leslie & Kargon (1997) conclude that there are too many unique factors in Silicon Valley for its success to be replicated.

[210] It was from the connection between the University of Stanford and Hewlett-Packard that germinated the Silicon Valley. Route 128 was born from the incentives of the MIT for the incubation of the projects of their researchers. The triangle of Carolina is based on three pre-existing universities, who benefited from the creation of a technological park.

organization. A system of innovation involves, therefore, a productive system and its political and institutional envelope.[211]

Autio (1998) divides the '*regional system of innovation*' in two subsystems:

- A system of generation and diffusion of knowledge, eminently public, including institutions of education and R&D, technological centres and institutions for technological transfer;
- A system of application and exploration of knowledge, eminently private, constituted essentially by firms, horizontally and vertically related, who assume the commercialisation of innovations.

Although they are used to describe similar entities, the designations of '*intelligent region*' and of '*system of innovation*' have quite distinct natures. The '*system of innovation*' has more geographical freedom, and may even be an international system, but the designation of '*system*' does not grant it the self-consciousness implied by the term '*intelligent*'.

5.2.4. Cities and Innovation

The diffusion of innovation follows organized structures of propagation based on networks of communication and interaction, themselves a defining characteristic of modern economies.[212] The new information and communication technologies are instrumental for the processes by which the technical progress propagates throughout the economy, having a dominant role as a vehicle for the communication and interaction that we mentioned, and for the formation of the so called '*innovation networks*'.

Modern analyses of network behaviour stress the value of the nodal points. Cities are, frequently, the nodal points in transportation networks, and have usually a strategic role on the creation and diffusion of innovation. The '*urban milieu*' is favourable to the innovative behaviour, given that is provides socio-cultural and educative infrastructures, and it eases the access to venture capital.

[211] Asheim & Isaksen (1997) suggest the existence of two models for the creation of 'regional systems of innovation': the regionalisation of the 'national system of innovation', and the promotion of regional innovation from an endogenous and territorial approach.

[212] Kamann & Strijker (1991).

Besides, cities also act like catalysers for the transmission of discoveries to other places.

The innovations may have substantial effects in all the economy, especially if there exists a high degree of interdependence between the different activities, which can grant a cumulative and circular nature to the effects of innovations. In a city, these relations of circular interdependence are quite plausible.

The '*urban breeding place*' hypothesis starts from the idea that cities, and urban areas in general, are agents or incubators of economic, technological, social and cultural change. The cultural opportunities it provides, and the geographical connections it offers turn them into sources of socio-cultural mutations. As a result, the city offers advantages at various levels: human capital; capital availability; infrastructures; socio-cultural environment; and other economies of urbanization.

Davelaar (1989) mentions several conditions why big cities favour the emergence of new firms and the innovation in the established firms:

- The agglomeration economies caused by the proximity between firms gives rise to significant scale economies. The production of innovation requires flexibility, which is favoured by the diversity of the metropolitan environment.
- The availability of human capital is crucial, especially in the initial phases of innovative projects.
- Specialised information flows are more intense in the cities, as communication patterns in general. These allow better decisions, innovation, and risk reduction.
- Socio-cultural capital also acts favourably to the diffusion of innovation in metropolitan and central areas.

As to the evolution of cities, it is accepted that, in general, there are critical values for the launch of city growth, which is then limited by problems of congestion.[213]

5.2.5. Uncertainty and Cooperation

The proximity between competitors confers them an increased control over the markets, and a reduction in the uncertainty of the business

[213] Glaeser et al. (1992) show that higher average human capital is associated with higher city growth rates.

activity. Uncertainty may be caused by several kinds of gaps: of information, diagnostic, or competence. Information gaps refer to failures in the access to specific information, for matters of cost, time and distance. When the effects don't allow the discerning of the causes, we speak of a diagnostic gap. Competence gaps result from the limited cognitive abilities of the agents to process and evaluate the available information. Dynamic uncertainty may be caused by control gaps, that is, by the incapacity to precisely estimate the consequences of the different alternative options.

The local environment of a firm is an important factor for the reduction of uncertainty. It may be defined as a set of territorial relations, including in a coherent fashion the productive system, different economic and social actors, and a specific system of culture and representation; generating a dynamic process of collective behaviour. As to the reduction of uncertainty, the local environment has different functions:

1. Collective gathering and selection of information;
2. Signalling of market tendencies;
3. Collective learning, enhanced by the local mobility of specialised workers, by the technical and organisational exchange between clients and suppliers, by processes of imitation, and by the exhibiting of successful technologies;
4. Collective definition of management styles and of decision-making processes.

All these functions contribute for a greater efficacy and innovative capacity of the firms. Camagni (1991) particularly connects the concepts of '*innovative milieu*' and '*innovation network*' to decision under uncertainty. The local milieu and the business networks are uncertainty reducers, as they gather, filter and interpret information; they select adequate reactions; and they control the behaviour of the competitors). Informal relations of proximity ('*milieu relationships*') and formal trans-territorial relations with selected partners ('*network relationships*') become fundamental characteristics of a new dynamic theory of technical progress that takes uncertainty into account.

6. Conclusion

A profound transformation is taking place in the modern economy, known as globalisation. Consisting essentially in the worldwide integration of economic activity, it is leading to a renewed interest in the spatial dimension of economics. Production of some kind of goods now tends to take place on a very specialized region, and then to be transported worldwide. The process of globalisation is bringing an increased interest to inquiries on location choice for production, on the evolution of the spatial configurations of economic structure and activity, and on local specialization and technological trajectories.

Spatial economics was left out of mainstream economics after the movement towards orthodoxy that occurred in the twentieth century. But, in contrast to the neglect that followed, the influence of space had been taken into account in economics since ancient times. In the work that marks the beginning of economics, Richard Cantillon (1730) attributed the formation of villages and cities to economies of transportation. Transportation costs were also the origin of Von Thünen's (1826) concentric rings, and the variable that governed the choice of plant location in Weber's (1909) theory.

Space would soon transcend the role of determinant of transportation costs. Andrew Ure (1835) understood that the diffusion of innovation was mediated by physical distance, and that firms sought to locate in places where local entrepreneurs introduced innovative products and processes. Alfred Marshall (1890, 1919) developed these ideas in his analysis of the *industrial districts*, based on the concepts of *external economies*, *industrial atmosphere* and *local specialization*. Location became also a determinant of innovative activity.

Marshall was so eclectic that his impact on geographical economics cannot be condensed in the theory of *industrial districts*. It is forceful to refer his discussions on increasing returns and external economies, and, last but not least, the evolutionary ideas of path-dependence and technological trajectory. These happen to be the essentials of the theories of cumulative causation, which became popular after Myrdal's *Critique*.

With the exception of the theories of the *industrial districts* and of *cumulative causation*, spatial economics is considered a German tradition. The main responsible is Von Thünen, who provided an

innovative model of general equilibrium in space. The other main icons in spatial economics also came from German authors: the theory of firm location of Launhardt and Weber, and the theories of central-places of Christaller and Lösch.

The complexity of these models, in a time when economic reasoning was predominantly literary, in addition to the use of the German language, rendered difficult their diffusion to the dominant Anglo-Saxon economists. Moreover, the wave of mathematization in economics, which left out the spatial dimension constituted a double blow to spatial economics: first, the literary ideas and theories that constituted the bulk of geographical economics became outdated and disregarded; second, the few models that existed were ignored and left out of the mainstream economic theory.

Especially in the last two decades of the 20th century, a revival in geographical economics has been witnessed. Gradually, economists learned to model imperfect competition and increasing returns. The development of game theory improved the analysis of interdependent decision-making. And the computer now allows us to analyse complex systems through simulation. With the complexity associated with the modelling of spatial economic systems becoming less and less dramatic, there is a trend – the so-called *New Economic Geography* – towards the mathematization of geographical economics.

Some obstacles stand in the development path of spatial (or geographical) economics. It is recognized that this is an eclectic field. We have seen how it can be divided into *location theory*, *spatial organization* and *spatial development*, and how this division has a lot to do with the prevailing split of economics into micro, macro and development. The three subfields that have been proposed correspond to different perspectives on economics and on the influence of space. *Location theory* corresponds to the perspective of the economic agent who must choose a location for its activity (usually a firm that seeks the optimal location for its plant). In *spatial organization*, an economic system is designed for which optimal spatial configurations emerge. The perspective may be that of an outside observer that seeks insights about the general laws of the evolution of the spatial economic structure. *Spatial development* is centred on the role of institutions that seek the economic development of some territory. Governments and development agencies should find useful the investigations under this label: what makes some places prosper and develop, what are the mechanisms of cumulative causation, on the sociological dimension of productivity, etc.

Although reasonable, the existing split between microeconomics, macroeconomics and development economics is detrimental to the development of geographical economics. The establishment of this

eclectic field could bring some overlap in the organization of economic science - usually negatively designated as redundancy and subject to criticism. But right now this field is sliced by the higher level split, and could use some eclecticism on the part of economists – which would more than offset its cons for the study of the influence of space in economics. Further development will demand either intense communication and teamwork between specialists or the dedication of authors with a fairly general training in economics.

In the 20th century, the role of innovation was consensually recognized as crucial for economic development and profitability. As we have seen, location has an intimate relation with technology and innovation. Naturally, we are observing a progressive shift of the perceived influence of space from determinant of transportation costs to determinant of innovation and technology. But in the existing spatial economic models, the questions relative to transportation costs and increasing returns are not merged with the questions of innovation and local specialization. As a result, the views on the influence of space are still partial. To make integration more difficult, the spatial diffusion of innovation is mediated by different processes and infrastructures than those that mediate transportation of people and goods. The diffusion of innovation occurs by interpersonal contacts, worker mobility and trade, being boosted by infrastructures of communication like the Internet, and by social capital related to trust and cooperation.

As we enter the 21st century, the struggle to overcome the poverty and famine that impinge on thousands of millions of people must be in the first line of concern of the economic profession. Understanding the laws that govern the spatial structure of the global economy may bring valuable insights for addressing this problem. Space has many impacts on economic activity, and thus some eclecticism is demanded to approach the matter in an integrated form. This constitutes a challenge to the economists of our time. May them succeed sooner than later, and both our science and our world will be enriched.

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