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Economic theories and spatial transformations clarifying the space-time premises and outcomes of economic theories

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Abstract

This article examines the approaches adopted by various schools of economic thought towards dealing with space and time. Each school has its own approach, though their treatment of time and space has generally been implicit. These spatial and temporal factors determine, right from the start, the way both reality and the explanatory frameworks which are supposed to take account of that very reality are looked at. The purpose of examining these various economic approaches is to clarify the view of space and time that is reflected in their premises. These ultimately determine the sometimes radical differences that emerge when looking at various theoretical traditions.

In the first section, a number of contributors to equilibrium theory (from Walras to Krugman) are brought together. The approaches they use are characterised by their historical relationships with physics and mathematics. In short, their view is that space is exogenous, unchangeable, objective and abstract. The second section concentrates on schools of thought rather than specific contributors. Institutional and territorial economics have developed different conceptions of space and time, drawing their inspiration from social science and complexity theory. Space and time are always concrete. Space is marked by contrasts: it is both specific and generic, given and constructed, endogenous and exogenous. Finally, in the context of territorial economics and complexity theory, the part played by those engaged in research and modelling is addressed in terms of the way space is constructed.

Keywords: Space, time, transformations, innovations, economic theories
JEL classifications: B0, O0, R0

1. Introduction

This article examines the approaches adopted by various schools of economic thought towards dealing with space and time. Each school has its own approach, though their treatment of time and space has generally been implicit. These spatial and temporal factors determine, right from the start, the way both reality and the explanatory frameworks which are supposed to take account of that very reality are looked at. The purpose of examining these various economic approaches is to clarify the view of space and time that is reflected in their premises. These ultimately determine the

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sometimes radical differences that emerge when looking at various theoretical traditions.

This is not a completely new issue. Many writers have investigated time and uncertainty in economics, providing comparative surveys of how these issues are viewed (for example O'Driscoll and Rizzo, 1985; Davidson, 1995; Facchini, 1999; Sapir, 2000; Moureau and Rivaud-Danset, 2004). Others have examined the treatment of space (Crevoisier, 1996; Martin and Sunley, 1996; Chanteau, 2001; Perrin, 2001). Few, however, have looked at time and space together. The novelty of this article lies in providing an overview of the different ways in which economic theories views space and time.

Specifically, it looks at several of the contrasting ways in which various spatial and temporal issues are dealt with (see the criteria in Table 1).

- In the models and theories examined are space and time *exogenous* or *endogenous* (or both at the same time)? This issue is important because it determines our way of thinking about how space and time have impacted on economics and the way it has developed. Does the economic model have its own, distinct procedures, where space and time play no part or does time and space play, right from the start, a role in the explanatory framework?
- Should space be considered as something which is *unchangeable and naturally endowed* or *is it a social construct which can be handed down and altered*? This is an important distinction. However, as we will see, it is not always obvious that most economic theories use definitions which make this distinction. The first way is to adopt an *atemporal* view of space as something which is fixed and intangible and which cannot be changed by human action. Secondly, we can take on board the transforming influence of economic agents in the past, present or the future. While space may be something that is initially given, it is nonetheless something which can be constructed over time through human actions.
- Are space and time understood in an *abstract* sense in the same way as mathematical space (such as Euclidean space)? Or can it be seen concretely; in other words as an explanatory framework which cannot be dissociated from real historical and geographical circumstances? This is a crucial issue in terms of the explanatory scope of various theories. Using an *abstract* concept of space offers the prospect of universality through being able to construct theories which claim to be valid at all times and in all places. Looking at space in *concrete* terms means that given spatial and temporal situations can explained, and it opens the way for comparisons with other situations.
- Are space and time *neutral* and *objective* entities? In other words, do they exist independently of observers and economic agents? Or is it rather the case that *space and time can be constructed through observation:* and if so, to what degree? This is perhaps the most fundamental issue because it explains the nature of space as a construct, by history, but through how it is seen by those engaged in research and modelling. Is space self-evident or is it simply a language invented by man as a way of understanding his environment? In this last case, the notion of space has more to do with the nature of human thought processes than to any sort of 'reality'.

In Section 2, a number of contributors to equilibrium theory (from Walras to Krugman) are brought together. The approaches they use are characterised by their historical relationships with physics and mathematics. In short, their view is that space

Table 1. Treatment of space and time in economic theories

	Exogenous versus endogenous space and time	Space as an unchangeable natural endowment versus inherited and malleable space	Abstract versus concrete space	Objective space and time versus that constructed by the researcher
Equilibrium approaches inspired by classical mechanics (from Walras to Krugman)	• Neutral and independent containers which are external to, and have no effect on, economic activities.	• Contents (an initial distribution of points if there is more than one point) are unchanging. Space cannot be altered by human activity.	• Space and time are abstract (Euclidean geometrical figures) • Outcomes in terms of 'space' are quantities. No real structural change. Transformation is solely quantitative.	• Space and time are taken as objective • Results are mechanical constructs
Territorial economics	• Space and time are both exogenous and endogenous. No clear separation. At the cross point of the 'geographical object' and a socio-economic construct.	• Space and time are both given and constructed.	• Territory is always concrete, specific and general at the same time.	• Territory is an objective construct that can be conceptualised by the researcher.
Complexity theory approach	• There is no longer a distinction between exogenous and endogenous. Phenomena are inseparable from their context.	• Space and time are simply human constructs and are dependent on the researcher modeller's plans.	• Everything is both an evolving representation of the researcher and subject to experimentation	• Space and time are simply terms that are shared between researchers and players within society who give them particular value.

Source: Taxonomy developed by the authors.

is exogenous, unchangeable, objective and abstract. The third section concentrates on schools of thought rather than specific contributors. Institutional and territorial economics have developed different conceptions of space and time, drawing their inspiration from social science and complexity theory. Space and time are always concrete. Space is marked by contrasts: it is both specific and generic, given and constructed, endogenous and exogenous. Finally, in the context of territorial economics and complexity theory, the part played by those engaged in research and modelling is addressed in terms of the way space is constructed.

When reading this article it is important to know that we are academics working in what is called further down territorial economics. We try to link both applied research and more theoretical and epistemological issues. When we started with this article, our intention was to make comparison between different streams of thought as honestly as possible. Our tacit hope was to show how better the territorial approach is. Indeed, to write the first part, dedicated to the critique of the equilibrium paradigm, was quite straightforward. However, writing the second one about our own underlying premises proved to be much more difficult than expected. The territorial approach takes into account many more aspects of space and time than the equilibrium one. Thus it is also more complex. It has been much more difficult to identify and formulate relevant critical issues that have to be raised as well for these approaches. We hope to have done some contribution in that direction and that the text lets this intellectual travel show!

2. Neo-Walrasian theories that have been inspired by mechanics: Walras, Arrow–Debreu, Krugman

Over a century ago the natural sciences, and mechanics in particular, provided economic theory with a means of understanding the workings of economic systems (Facchini, 1999). While many studies have drawn attention to the obvious links between the principles of mechanics and their application to economic theory (for example Mirowski, 1989; Ingrao and Israel, 1990), few have examined space and time. To gauge the extent to which economists have drawn on the Newtonian spatio-temporal 'framework' to build their own theories, it is first necessary to review Newtonian concepts of space and time (Section 2.1) and then outline how a number of economists associated with theories of equilibrium have made use of these concepts (Sections 2.1.2 and 2.2).

2.1. An exogenous, unchangeable, abstract and objective space

Before turning our attention to economic theory, we first of all have to examine space and time in classical mechanics. These have had a profound impact on equilibrium-based economic theories, and their influence is still being felt today. It will then be seen that, paradoxically, Walras discarded space and time (as they were understood in physics); or at least reduced them to a zero dimensional space–time framework. It was only later that economists brought back the concept of space in order to understand an economy's spatial aspects.

2.1.1. Space and time in mechanics

Newton likened real or concrete physical space to a 3D Euclidean space, so that Newtonian space is, above all else, geometric. What are its main features? It is viewed as a fixed, intangible structure, an 'empty backdrop' to what is being played out (Lachièze-Rey, 2003). Furthermore, it is homogeneous and isotropic. Its homogeneity expresses the equivalence of points in space, while its isotropic property expresses the equivalence of direction. In the former case, all places are the same and are represented by a point. In the latter case, all directions are identical. In other words, when space is homogeneous and isotropic, there is no qualitative difference between points and all directions are equally valid.

Newtonian time is a spatial, geometric time, which passes in the manner of a journey along a time line. As such, the time line is an independent entity existing side by side with a given, pre-existing space. As Lachièze-Rey (2003) notes, each point on this line can be marked out by a real number. As a result it can be represented by the set of real numbers (*R*) as a 1D continuum. This line can be open ended or its ends can join together. In the first case, it boils down to a straight line, while in the second case it is equivalent to a circle. Thus, *in principle*, there are only two types of time: linear time and cyclical time (Klein, 2003). (The latter lies behind the metaphor of the eternal return or recurrence.) The continuity represented by the time line thus gives rise to the possibility of looking at the way time passes in terms of being a succession of moments. Taking the moon's trajectory as an example, each succeeding moment passes through a series of points. Each of these moments can be considered as equally valid as the departure point towards a future or the arrival point from a past (Piettre, 1996). Newtonian time is thus symmetric, reversible and entertains no thought of the new. There is thus no time's arrow or uncertainty about the future and nothing to distinguish temporal direction. All are perfectly interchangeable, and there is nothing to stop us calling the future the past or vice versa. In such a world, no structural change can be envisaged because neither the object nor the laws of causality change.

Newtonian physics aims to explain the position and motion of bodies in space and time. Objects and relationships between them, have no qualitative dimension and are purely quantitative in nature. Indeed, bodies are reduced to *points* located in space and time. They differ from points in pre-existing space through having a mass. The idea of mass comprehensively defines each body's *matter*. This is tantamount to saying that bodies as points are qualitatively indistinguishable. It is only a *quantity*—their mass—that defines their nature.

With regard to *relationships* between bodies the law of gravity states that in space each body is, at any point of time, in relation with all others. Space can therefore be described as *full*: there are no divisions and subgroups operating in isolation. As is the case for bodies, the relation between objects is reduced to a single physical magnitude, namely the distance between them. Thus appearing within the pre-existing space–time 'vacuum' is a space defined in terms of bodies and points and the relations and distances between them.

To sum up, there is in classic mechanics one conception of space–time which is 3D for space and 1D for time and which existed before bodies and the motion of bodies. It is a neutral, independent framework through being an exogenous space which is unaffected by the phenomena taking place within in it. Furthermore, it is unchangeable, abstract and objective. Points and moments resemble each other perfectly. Bodies have a position in this space–time representation and all are necessarily related to each other. Bodies and their relationships, form a second space–time, defined this time by its content. They have no distinguishable qualities. They are all exclusively defined by measurable physical quantities (metres, hours, etc.), which are regarded as universal and absolute. In other words, they are independent of the observer.

2.1.2. Theories of general equilibrium: space reduced to a single point

This section reviews how Walrasian economic thought, while being greatly influenced by Newtonian physics, totally eliminated space and time from its core concept of equilibrium. It is then shown how time and space partially found their way back via the framework developed by Arrow and Debreu.

The purpose of general equilibrium theory is to determine the optimal allocation of scarce goods and resources. It is through markets that the most efficient allocation possible is achieved. From a spatial perspective, each market is reduced to a point determined by the interaction of supply and demand; a process which is driven by two quantitative magnitudes: price and quantity. Furthermore, all markets are at the same point, meaning that there are no separate spaces for production or demand.

It is paradoxical that Walrasian general equilibrium theory lacks a spatial or temporal dimension, given that it was inspired by a theory seeking to explain how bodies were positioned in space and time. Equilibrium no longer results from bodies moving within a space–time system through gravitation. Instead it is achieved by the market mechanism operating to adjust the quantities produced and consumed in each market. The consequence is that space disappears as a result of a relationship between distance and mass being replaced by one based on price and quantity.

Historically, the relation between these models and disciplines has not been direct and is much more complex than the description given above, as can be seen from Mirowski's (1989) study of the way concepts from the physics of energy were adapted to economics.

However, not considering space amounts to saying that the market (the place where transactions take place) is spatially unique. This completely rules out any consideration of how economic agents (acting as producers and firms and as consumers and households) are located and distributed. As Moran (1966) has noted, in a Walrasian world the cost of moving across space is zero. Thus markets are set within an n-'dimensional' vectorial space (R^{n} space) where the spatial dimension is zero. Furthermore, it is not known where this point is situated. It could conceivably be everywhere and nowhere: it could be on paper or in the head of the economist who is doing the calculations!

So if, in the Walrasian scheme of things, the 'market place' is reduced to a point what becomes of the temporal dimension? It is equally zero! Indeed, market clearing is instantaneous and the issue of future adjustments is unresolved, at least theoretically.

Arrow and Debreu's (1954) approach to general equilibrium theory contained several innovations. Two are especially important for our purposes. First, their theory introduces a spatial component by considering the cost of transporting goods. By definition, transport costs are meant to correspond to a particular 'distance' and thus explain the way in which economic activities are distributed across space. This view raises a number of problems and leads to the seemingly naive question that if distance is supposed to separate two elements, and goods are on one side, what is on the other? Is it the market? Nothing is said about this. It would be assumed that the market is indeed located somewhere. That being the case, where are the consumers? Are they in the same place? That would imply that producers are there too, since consumption requires production. But if producers are located at this single point then how is it that goods are somewhere else? It is, to say the least, hard to depict a space which would correspond to such a form of economic organisation. The problem stems from the fact that the term ‘transport costs’ has been arbitrarily tagged to a cost vector, which is identical to one representing any input. So is space regarded as just another input? Has there been undue haste in associating transport costs with space?

Such a tortured conception of space originates from a confusion between mathematical spaces—the vectorial ‘spaces’ of costs which can only be part of abstract mathematical spaces—and physical space (Crevoisier, 1996). Effectively this model and its successors treated physical space as an ‘added dimension’ of multidimensional mathematical space. As though this was a means of moving from an economy characterised by points to an economic system located in concrete space.

This illustrates the major difficulty of providing a convincing treatment of space within the Walrasian tradition. The Arrow–Debreu model and its successors used an added ‘abstract space’, in this case a vector of transport costs, and assumed that it provided a means of moving from an abstract representation of a system situated at a single point to one located in a concrete space. The main criticism that can be levelled at this approach is why is it that only transport costs are considered to be a space-dependent variable, given that we know full well that enormous differences exist in land, labour and transaction costs?

In short, the spatial structure generated by the workings of the model is only a projection of vector coordinates in Euclidean space. It only assumes a spatial aspect because transport costs are arbitrarily brought into the model. The same thing could have been done by using labour costs; and we would have obtained another projection on to Euclidean space. What would happen in a model which gave each of these variables a spatial aspect? We would get coordinates in R^{n} which could not be projected in a 2D Euclidean space. How then could we understand the relationship between this multi-dimensional economy and a real economy in real space?

There is a misunderstanding somewhere. By pushing reasoning to such an extreme we see that approaches like these, by projecting the coordinates of a single variable on a Euclidean plane, reveals nothing. They leave from one point and arrive at a set of points in two dimensions. It is hard to identify what the relationship is between this description and concrete space. Is there not indeed a confusion between concrete space and the abstract space of mathematics?

Arrow and Debreu’s second innovation concerned the temporal aspect in the form of intertemporal calculations made by economic agents. The prices shown concern all economic goods, *present and future*, and enable all economic agents to remain perfectly informed (Guerrien, 1996). This result is obtained by introducing ‘contingent’ markets for future goods (i.e. goods which have yet to be produced). This is the means by which Arrow and Debreu introduce future time into the model. However, it is done in a way which eliminates all uncertainty over the future. This is because such a model requires consideration of each possible outcome—each present and future ‘state of nature’—through forecasting the price of each good for every possible situation (Moureau and Rivaud-Danset, 2004). Calculations are indeed made for the present as well as for all future periods. But it is only a once-and-for-all operation done in the present. In other words, the whole future is in the present. In such a world, the issue of agents’ perceptions and expectations does not arise. They have complete knowledge of current and future prices and are able to make firm and perfectly informed choices (Guerrien, 1996).

As Sapir (2000) has noted, the notion of a system where nothing is missing (all scenarios are taken into account for all products) and which is based on perfect markets (all the information required for decision-making is provided by the coming together of supply and demand) is tantamount to either assuming that all economic agents are omniscient or positing a perfectly stationary universe where there is neither a future nor a past. A complete and perfect system, where there are contracts for all current and future opportunities, amounts to assuming that time no longer exists and that the future merges into the present. As Sapir has observed, in practical terms, it indicates that the buyer of a horse-drawn carriage in 1850 already knew the relative price of a model T Ford relative to that of the horse-drawn carriage.

To sum up, how should the explanation of time and space, from classical mechanics through Walras and on to Arrow and Debreu, be presented? Newtonian physics has put forward a number of premises which make a distinction, firstly, between a containing space that is unchangeable and perpetual (within which physical phenomenon take place) and, secondly, the space defined by bodies and their relationships in terms of forces of attraction. It needs to be emphasised again that time is only an added 'dimension' and from then on is dealt with in the same manner as space. Walras' approach can trace its origins to classical physics but, paradoxically, containing space, together with the space contained and time are reduced to a zero dimension of a point or pinhead economy (Thisse, 1997). Consequently, how are economists going to move forward in order to explain the spatial division of an economy? Arrow and Debreu's general equilibrium model brings in transport costs which are supposed to explain a given spatial division. However, nothing is known about where economic agents and markets are located. In fact, the same approach for bringing transport costs into the picture can be used for any input. Finally, this mathematical 'vectorial space' for transport costs is, in our view, wrongly put into the same category as concrete space.

2.2. Paul Krugman and the new economic geography (NEG): space becomes more formal and abstract

With regard to space and time, what is the basic difference between general equilibrium theories and more recent work known as New Economic Geography (NEG)?[1] It is argued here that, as with other scientific disciplines, particularly physics, economics aims to develop models which are appreciated for their formal elegance and which can be validated through *quantitative* comparisons with the real world. To appreciate the difference between the general equilibrium and NEG approaches the status of mathematics within science during the 20th century needs to be looked at again.

1 This article is dedicated to the conceptions of space and time within economics theories. Consequently, we do not treat the corpus of standard international trade theory as such because we claim that the conceptions of space and time are the same than in the NEG. Of course, Krugman brings with the NEG some novelties, particularly regarding increasing returns. Some factors are now more mobile (industry workers for example while agricultural workers are still generally considered as immobile) at a subnational level. That's new in regard of standard international trade theory. Nevertheless, these elements do not alter the underlying conceptions of space and time. From our point of view, Krugman simply 'imports' from trade theory the conception of space and time in new economic geography and applies it at subnational levels. The 'nature' of space and time between these two theories are the same: space and time stay in both cases exogenous, abstract and objective.

2.2.1. Mathematisation of reality: from analogies drawn from mechanics to formal analogy

Israel (1996, 2000) argues that since the emergence of classical mechanics, there have been two successive ways of viewing the world, each with their own particular approach to modelling.

The first approach regarded the universe as a unified entity governed by one or more universal laws. Theoretical and methodological approaches were based on a deterministic perception of reality. This was often indistinguishable from the Galilean view, which saw the world governed by the principles of harmony and perfection based on the mathematical language written by God. The universe created by this divine watchmaker was founded on a number of unchanging principles which govern the workings of a wide variety of phenomena. Thus economic and social phenomena were regarded as having the same nature as physical phenomena. Scientists working in various disciplines (ranging from biology to economics) look for an underlying unity through applying analogies drawn from mechanics.

However, the belief in a unified world—a belief which implies that different branches of science can and must share the same analytical tools was undermined at the end of the 19th and the beginning of the 20th century.[2] Reluctantly, hypotheses which took a unifying view of content were abandoned. For Israel, a new way of looking at things and a new form of reductionism was thus established. This time, as the world could no longer be confined to physical phenomena, it was viewed in terms of formal logic and mathematical thinking. A new unity was sought which moved from unity of content to unity of form. In this way, mathematics and its corollary formal analogy became predominant. The world becomes one which is expressed in terms of structures and mathematico-logical languages. From this viewpoint, mathematics was established as a powerful tool which could unify findings and data. It was no longer seen as merely a means of calculation but *a way of developing knowledge*.

While the unity and coherence of Walrasian system was borrowed, at least in part, from mechanics (the pure Walrasian economy centres around analogies from mechanics) the move towards favouring formal analogies began to take shape throughout the 20th century. Von Neumann is a central figure in this change in the way of viewing things. The influence of cybernetics was having an effect; and the view of economic agents as automatons was followed by the idea of agents as computers (Mirowski, 2002), capable of carrying out an unlimited number of calculations.

Consequently, as Sapir (2000) has noted, the abandonment of rigour of content in favour of rigour of form meant that within economics, mathematico-logical structures progressively became the main criteria for assessing the scientific basis of a theory.

In short, at a theoretical level, elegance of formulation became the principal yardstick. What about the empirical level? In an article written at the start of the 1950s

2 Most of the premises underlying classical mechanics have been called into question (2nd Law of Thermodynamics, chaos, quantum physics, etc.). Furthermore, in mathematics the logician Gödel showed, through his Incompleteness Theorem, that all formal theories that can be expressed arithmetically have a proposition which is undecidable; in other words, where it can neither be 'proved' nor 'disproved.' This result is very important, since it excludes once and for all the possibility of mathematics being reduced to logic. It takes the side of those who argue that mathematics, just as in physics, is ultimately based on intuitive concepts. As Morin (2005) has noted, undecidability opens a breach in the whole (meta) system by making it uncertain. If the proposition which is undecidable can be proved in another (meta) system, that system will nonetheless equally have its own logical gap . . .

and which most economists still use as a methodological point of reference, Friedman set out to justify the unreal assumptions underlying neoclassical economic theory. He defended the view that the only thing that matters is a theory's predictive ability. His argument was, in effect, that the nature of hypotheses were unimportant as long as they enabled him to make good predictions. For Sapir (2000), logical positivism thus gave way to logical empiricism.

2.2.2. Krugman and formal analogy

Walras, like Arrow and Debreu, took the view that the various elements and relationships within their models painted a picture of reality. Admittedly it was a simplified and 'abstract' picture but it was meant to explain how things were organised in the real world. Hence, differences between the results of the models and reality should be seen in terms of imperfections in the model or that its *qualitative* aspects were not fully worked out.

The hypo-deductive approach of modern economics abandons this view in favour of formal mathematical elegance and how it fits with quantitative empirical data. The argument set out here is that the view of space found in Krugman's NEG (Krugman 1995, 1996, 1998a, 1998b, 2000) falls within this framework.

At first sight, Krugman's manner of bringing space back into the picture is strikingly similar to the way that it was viewed by the first economic 'geographers'. Space, in terms of being the framework within which economic activities take place, is considered as a homogeneous, isotropic plane. In this containing space, content is shaped in terms of a *set stage*. For example, two points separated by a distance representing regions, cities or even countries *A* and *B*.

In our opinion, however, Krugman was not aiming to paint a convincing picture of reality. He makes it clear that his work is firmly rooted in formal analogy. He asks why economists like Galbraith or Hirschman are completely ignored by 'mainstream' economists. 'The answer—which is obvious to anyone immersed in economic research yet mysterious to outsiders—is that to be taken seriously an idea has to be *something that you can model*. A properly modelled idea is, in modern economics, the moral equivalent of a properly surveyed region for the 18th century mapmakers' (Krugman, 1995, emphasis added). From a spatial perspective, this has led Krugman to construct many models, where it is not evident that the shapes representing a set stage are anything like some sort of 'real' space: such as an infinite dimensional circle, a flat spatial structure, or a 1D city (Krugman, 1996). Krugman justifies the relevance of his models in terms of the well-known Zipf's Law or rank-size law. This law has no theoretical basis, it is solely an empirical observation. For Krugman, it does not matter that the explanatory models are varied or even contradictory. The two main factors remain the degree to which the results generated by the theoretical model match the empirical data together with the elegance of mathematical modelling. To sum up, at a conceptual level Krugman's spaces are ever more formal and lead us away from any form of concrete reality, while at an empirical level he just looks for correlations using numerical data without checking if the qualitative elements and relations of the model exist in the concrete situation.

From a temporal perspective, Krugman's models seek to explain how the agglomeration process takes shape over time. However, the predictions and conclusions of the models continue to be grounded in an equilibrium-based static analysis.

Economic agents are endowed with perfect rationality and their location decisions are simultaneously made at a set point in time (Boschma and Frenken, 2006). In short, economic agents are able to calculate an optimal location from a vantage point which gives them knowledge of all possible future situations. Change can only occur as a result of an exogenous shock. For example, a reduction in transport costs results in a new spatial division of activities.

Why does one region develop and not another? Reasons advanced by Krugman are 'accidents of history', namely exogenous events which are micro-economic in nature, or 'self-fulfilling expectations' without knowing how they are formed. Both are grouped under factors exogenous to an evolutionary process. The study of 'real place' (Martin, 1999) or concrete space is neglected. Furthermore, these models are applied 'universally' to explain agglomeration or specialisation processes in a way which is independent of a spatio-temporal context (as well as various spatial scales) and without any of the mechanisms and causalities being described experiencing any change. These mechanisms are independent of both context and scale.

While Krugman reintroduces multiple equilibria, and while non-linearities enable him to explain the cumulative nature of certain phenomena (he uses non-linear simultaneous equation models), things continue to evolve in a closed space or system where time is also closed. Krugman does not explain innovation. Time is therefore identical to that described by earlier writers: a calculation made here and now in a world where the future is known and where there is no room for new forms to emerge or for qualitative changes. Of course, irreversibilities occur as new spatial structures arise through simulations based on changing a number of the model's key parameters. However, these structures are *quantitative* in nature and result from going beyond certain quantitative thresholds, or by obtaining a given mass arising from a process of agglomeration, branching out, etc.

The causal relationships that are brought together remain static and universal (Facchini, 1999). In using non-evolving, static causal relationships nothing is added by time since everything is defined in the past (the initial conditions and parameters chosen by the researcher). These universal causal relationships are set down once and for all, they do not evolve over time, they are not situated in space, and they assume that economic laws are the same. Whether one lives in Washington, Paris or Beijing, in an economy at the beginning of the 19th century or at the dawn of the 21st, the process is hypo-deductive. The explanatory principles stemming from it are absolute and universal and therefore valid anywhere and everywhere.

2.3. Conclusion

Section 1 surveyed and commented on economists, ranging from Walras to Krugman, whose work is firmly rooted in equilibrium theory (general or partial spatial and non-spatial).[3] Their approach to space and time can be summed up by saying that:

- Space and time are exogenous. They act as independent, neutral containers which are external to, and have no influence over, economic activities. In the other

3 'Disequilibrium' theorists are included among the ranks of equilibrium economists, since disequilibrium can only be understood by reference to various types of equilibrium models. So neo-Keynesian economists (from Malinvaud to Stiglitz) fall within this category.

direction, economic activities have no influence on spatial forms. In the models used, the point representing a city remains a point, even if the city's economy grows.
- Space is taken as given, it is endowed by nature and does not change. In other words, human activity cannot alter space and its contents.
- This spatio-temporal framework—container and content—has an abstract form (Euclidean geometric shapes). No real structural change can be thought of: the 'spaces' that emerge as results from the model are quantities and 'changes' are purely quantitative. A point still remains a point.
- Space and time are objective entities. They exist independently of observers and researcher modellers.

The issue of market location remains unresolved. In equilibrium models, markets and economic agents are in contact with one another in the same way that, in physics, each mass exerts a force of attraction on any other mass. Such a premise is tantamount to saying that *the market is everywhere*, as each point containing a good or economic agent is in contact with all others. But one can equally say that the market is *nowhere*. Indeed, it is not possible to identify a concrete place, a 'market place', where supply and demand 'meet' and where bargains are struck.

Finally, is it really possible to talk about the transformation of economic space in equilibrium theories? First, there is an inert, containing space then an immutability that can be likened to a set stage. Lastly, in the spatial economy or the NEG, there is a 'spatial' division inferred by the existence of transport costs. In fact, such a division does not square with a transformation of the departure point's geometry. The outcome is *solely quantitative*. Strictly speaking, space is not transformed. For example, within the NEG, a city which grows or shrinks remains contained within a point. There is no link between a city's economic growth and its physical growth.

As for the way time is viewed, the economy is regarded as a mechanism; a closed system characterised by immediate and spontaneous equilibrium where, right from the start, all points are known or knowable.[4]

3. From institutionalism to territorial economics: objective constructs of concrete space and time

In this section the apparent limitations of equilibrium-based approaches are examined in terms of the following four issues regarding space and time.

- How should the emergence of new spatial forms be regarded? Because the future, new spatial forms and innovation are more than mere reorganisations of the past (3.1–3.2.1).
- How to move from a point to a malleable, evolving form? The idea of a point is very restrictive because it prevents any sort of mental picture being built of the way forms change shape (3.2.2).

4 Attention should be drawn to recent developments, where uncertainty is likened to a risk which can be expressed as a numerical probability. Regardless of whether this probability is subjective or objective it cannot take us out of an unchangeable paradigm of a set scene. These developments liken the world to a game of chance based on the mathematical formalism of drawing items from an urn-like container. Such a container has no transforming properties. Under the same easily reproducible experimental conditions, equivalent results would be obtained. We remain in an ergodic world (Davidson, 1995).

- How to move from abstract geometry to concrete space (3.2.3).
- What is the researcher modeller's role in constructing space and time (3.3).

How can we think of time which is simultaneously irreversible, uncertain and the medium for transmitting innovation? An increasing number of writers are looking at issues of time and uncertainty in economics. For Keynes and the post-Keynesians, for example, the future is radically uncertain in the sense of not being completely knowable and thus not calculable. Our horse-drawn carriage buyer of 1850 cannot know what a future 'horse-drawn carriage' will look like, whether it will take the form of a Model T Ford, a Renault Clio or something else.

From this viewpoint, institutions are not regarded as imperfections but rather as organisations which give economic systems some form of stability (Lavoie, 2004). By acting as 'common references' (Orléan, 2002) they serve to reduce uncertainty in many situations (Facchini, 1999). Consequently, institutions, conventions, routines, social rules, etc. will guide, to a large extent, the decisions and actions of individual and/or collective players. In the end, it is players' memories of the past as well as their hopes, actions, opinions, expectations, etc. regarding the future that will determine their behaviour and, ultimately, how future 'reality' will be shaped. The irreversibilities described here are not just quantitative but qualitative as well. Time thus regains an historical substance since the future cannot be identical to the past or present (Lavoie, 2004).

It will be noted, however, that while most of the heterodoxical approaches in economics—whether post-Keynesian, regulationist or institutionalist—agree on rejecting a vision of instantaneous equilibrium and reintroduce time that they would describe as historical, they generally ignore space. Most of the time the 'spatial dimension' is reduced to something like a single time line (Massey, 1999). Space remains passive and exogenous. For example, when we use terms like 'advanced', 'backward', 'developing' or 'developed' to describe the stage of development of such and such a space (regions, countries or other types of area), it amounts to saying that the spaces in question have reached a given point in the queue. Nonetheless, if nothing hampered their development, they would all follow the same trajectory and pass through identical stages. When things are seen in terms of a place in the queue at a given point in time, it denies any possibility of space-differentiated forms of evolution. It is difficult to sum up spatial differences as points in a temporal sequence. Recognising the existence of spatial difference amounts to acknowledging spaces can follow different paths and develop in their own way and in a manner that is not preordained. Recognising differences acknowledges that multiple trajectories exist within open systems and spaces so that more than one story is possible and the future is not pre-programmed.

It is necessary to ask why heterodox schools of thought in economics have ignored space, given that they succeeded in putting time on a theoretical footing. It has to be pointed out that the majority of current approaches in economics have no concept of observable differences between spaces. In so far as there are distinctions, they exist in terms of going forwards or backwards or are expressed in terms of 'remnants of history' which are sure to disappear in the near future.

It will be seen here how *institutional economics* (Commons, 1934; Samuels, 1995; Hodgson, 1998; Bazzoli, 1999) radically changed the way time and economic relationships were viewed. However, institutional economists did not develop a new way of looking at space. Over the last 25 years or so *territorial economics* (made up of schools associated with industrial districts, science parks, regional innovation systems, learning regions, etc.) has developed in parallel with institutionalism (for an overview see Benko and Lipietz, 1992). Surprisingly, and in spite of powerful convergences (Martin, 2000), the two have hardly made reference to each other. Thanks to their treatment of space and time, the two schools of thought, when taken together, allow a full understanding to be gained of the emergence of innovation, the transformation of economic space and the construction of regional and national trajectories. In view of this, the two bodies of knowledge are presented together in this section. Differences between institutional and territorial economics can be seen to centre around three issues. The first (3.1) is the idea of *futurity* (Commons, 1934), which underpins ideas of the nature of institutions and transactions. It equally enables us to understand the way in which the future can be represented (i.e. change and innovation) before contributing to its construction. The second (3.2) is the idea that the economy has to be understood in a real life situation, that is to say that players are in a specific situation, inherited from the past, where certain perspectives are open to them while others are closed. This is the idea of *path dependency*. Space is seen as evolving sets of relations between entities. In contrast to the hypo-deductive approach, this method is based on the construction of ideal types (3.3). This last element is particularly important because it allows one to think in terms of difference and sameness and is indispensable for thinking about how innovation arises (3.3–3.5).

A final question concerns the intervention of the researcher modeller in the construction of space and time. In the works of the institutionalists, just as in territorial economics, there are objective and subjective concepts of territory. This question is quite important because it is at the heart of much current thinking in geography (see subsequently); thinking which is ahead of that in territorial economics.

3.1. Futurity in institutionalism

At a general level and if equilibrium economists develop a conception of the economy as organised and guided by market mechanism, institutional economists consider that the real determination of whatever allocation occurs in any society is the organisational structure of that society—in short, its institutions. In this perspective, markets are organised by and give effect to institutions which form them (Samuels, 1995). If most institutionalists would agree with such a general argument, this school of thought is quite fragmented implying a great diversity of researchers and interests. In this article, the New Institutional Economics of Williamson, in the line of Coase, is considered as part of the equilibrium approach, even if this stream of thought can obviously not be considered as ‘neoclassical’. Nevertheless, we find that Williamson’s approach, for example, shares its rationality, maximisation and market-like orientation and tends to seek, with less formalism, the conventional, determinate, optimal equilibrium solutions to problems than in the approaches presented in Section 2. Thus, in this part, we will mainly deal with the view of ‘old institutionalists’, including the contemporary followers like Samuels or Hodgson. Commons is a prominent figure in the institutionalist school and he developed an interesting temporal concept of *futurity*. Institutionalism is thus, for Commons (1934), a theory of collective action set within a context characterised by uncertainty. Understanding institutions is only possible through the (quasi)certainties that they provide to players regarding the future behaviour of others. Institutions are only effective because they enable players to live together in the future and to achieve goals via collective actions. At the centre of the views developed by Commons (1934)—see also Gislain (2002)—is the idea of *futurity*; the way in which players in the economy act together so that they can succeed in coordinating their actions, starting in the present and continuing into the immediate or longer term future. Thus in the bargaining process aimed at effecting a transaction it is assumed that one side expects the other to fulfil its obligations once agreement is reached. We are no longer in the instantaneous time associated with equilibrium, but in *futurity*.

By contrast with the equilibrium-centred schools of thought, institutionalism's premise is that current and future behaviour is not so much explained by the past (factor endowments or path dependency) as by thinking which focuses on the future. Time is no longer a mere mechanical extension of the past. Time is constructed through thought and action. Since time is under construction, it depends in part on economic agents' imagination and capacity for action, so innovation and change become possibilities. Past still plays an important role in the building up of the cognitive and action capacities of the players and in the shaping of the present situation. Nevertheless, the influence of the past is no longer deterministic as the players are considered as having capacities to imagine qualitatively new solutions and implement them. This perception of time is akin to the Austrian School's conception of time, especially within the works of Hayek.

3.2. The territorial economy: toposity and territoriality

Of course, not all economic players are in an identical position in terms of planning the future. The concept of territory takes account of these differences. Somewhat surprisingly, Commons did not introduce the notion of *toposity* (Gislain, 2004) as an accompaniment to *futurity*. *Toposity* can be understood as a set of *topos* (place, address, position, etc.), each of them corresponding, for a player, to inherited experiences with other players and resources of the environment that may or may not be mobilised in a future (collective) action of the player. In territorial economics, human action can only be understood in *a real life situation*; in other words in relation to place, with all its many dimensions. Place cannot be reduced to a physical metric. Depending on a given player's location, the possible ways in which they can act will be very different (for example, barring exceptional cases, the same training courses cannot be followed, or the same professions taken up, according to whether one was born in Beijing or Berlin). If institutions are path dependent, then they vary with place (Martin, 2003). These situations are constructs which are social in nature and which have been passed down. It is a question of *concrete* places whose history is always—according to the premises of the institutional and territorial approaches—both *specific* and *comparable* with others.

Hence territorial economics is distinguished by a very considerable—and still controversial—output of *ideal types*. For example, *local (or territorial or regional) systems of production* (Courlet, 1989; Courlet and Pecqueur, 1992), the planned concentration of high-tech industries in *technopoles* (Saxenian, 1994), *industrial districts* (Becattini, 1992; Garofoli, 1992), *innovative milieux* (Camagni, 1991; Maillat, 1995; Vazquez-Barquero, 2002; Crevoisier, 2004), *global cities* (Sassen, 1991), etc. Each of these concepts is the expression of an economic system and a *territory*, in other words a set of relations—between players and between players and objects—that is *inherited* from a place's history. Furthermore, these relations are determined by *prospects of* *future action* for players engaged in production and innovation; that is, collective action (Bathelt and Glücker, 2003).

Institutionalism widely developed in opposition/complementarity with equilibrium schools. This perhaps explains why, right from the start, Commons defined institutionalism's field of study as that of coordination exclusively between human beings. This deliberately set him apart from classical and neo-classical economists, who regarded property, for example, as a *material* relation between human beings and objects. Territorial economics claims to be more integrative, by taking on board concepts of territory originating from geography. It is equally about relationships with things, whether they are produced by natural or social processes. Thus technology is not just seen through institutions but also as a material relation: nuclear technology does not give rise to the same coordination methods as textile technology.

3.2.1. The specificity of territories and the emergence of innovation

Specificity is a concept which is central to institutional and territorial approaches. It is indispensable when considering the emergence of innovation. If we return for a moment to the NEG's view of space as a 'set stage' made up of points, the points representing particular categories ('regions', 'firms', 'individuals', etc.) can only be distinguished from one another by numbers, quantitative differences (for instance region A has nine firms and region B has four firms, but each region has a certain quantity of 'firms'). New points cannot appear or disappear, but they can take zero values. By the same token, certain relationships can be triggered or, on the contrary, can represent empty flows. Various configurations are thus seen to take shape, depending on the numerical values taken by different points and relations in equilibrium. This approach posits that all entities are qualitatively the same, undifferentiated but expressed in a *common unit*. By assumption, difference cannot be qualitative, only numeric. Innovation, in other words qualitative change, is not possible within such a way of thinking. The product launch of the mobile phone could not be conceived because it assumes that new production functions, new utilities (in the sense used by economists) etc. are created.

The territorial approach on the other hand can deal with innovation through introducing the idea of *specificity*, a term which encompasses the ability to compare along with the perception of *differences*. The relation to another (player or place) allows varied self-images to be constructed. It also enables one to become aware of possibilities of change and the creation of a potential future in which things evolve. Specificity is thus the opposite of an approach where using numbers is the only form of differentiation. It marks a split between generalising and particularising approaches (Crevoisier, 1999), meaning that specificity enables *change* and *innovation* (which are by definition qualitative) to be understood.

The school of thought which made the greatest contribution to understanding the process of innovation through the interplay between a situation and its surroundings is that of the *innovative milieux* (Camagni, 1991; Maillat Quévit and Senn, 1993; Maillat, 1995; Ratti et al., 1997) developed by GREMI (*Groupe de recherche européen sur les mileux innovateurs*), the European Innovative Milieux Research Group. The milieu is defined as a localised set of players who will develop, through interaction within the milieu and between the milieu its surrounding environment, collective knowledge leading to ever more effective ways of mastering technologies and collectively managing resources. The milieu is defined as a collectivity endowed with a frontier. Those within it interact according to a given number of shared institutions, whether they are specific or not. These interactions enable potential future additions to the milieu to be considered, and then for them to be fully or partly brought to fruition. Innovation does not take place in isolation. The border does not establish an autarkic way of working, but on the contrary a way of collectively interacting with other areas through recognising (or not) constraints and opportunities that the environment offers. It will be noted that in this type of approach, players can make plans and influence the future. Conversely, equilibrium theories remain in a mechanistic and pre-programmed world, where players have only one objective (or 'plan'): to discover the optimal solutions to problems.

It is understood, however, that stressing exclusively the specificity of each situation leads as much to an impasse as does saying that all entities are identical and can be reduced to a common measurement. Indeed, new spatial forms and innovation are only possible if the entities being considered are both similar and different: similar because to be compared it is necessary to have something in common; different because it enables us to understand its own identity and to develop it. A territorial approach must therefore articulate these notions of 'difference' and 'sameness' (Martin, 2001).

3.2.2. The emergence of innovation and the transformation of the economy

Territorial economics shows how economic systems influence spatial form and vice versa. It goes beyond the concept of a point, which can neither be changed nor serve as the basis for new forms to emerge through transformation (the process whereby new forms emerge over time by building on what already exists). These new forms do not amount to being merely numerical variations of unchanging entities or reconfigurations of relationships between fixed entities. Some of the ways in which transformation can take place are through merging, breaking away, growth, disappearance or an entity's qualitative evolution. If a city's economy grows, the city spreads out or gets denser, changes in internal and external relationships are brought about and its infrastructure is altered. Within territorial economics the innovative milieu school has made a particular study of the processes of breaking-affiliation (Aydalot, 1985) and regional trajectories. A region regenerates from a given starting point. New players emerge while others disappear. Frontiers, core and adjacent areas and distances can all be changed. Ratti et al. (1997) provide many examples of regions which, even though they possess the same industries, have experienced radically different forms of change. Territory determines innovation and economic change.

Unlike the models used by the NEG, where a city or region always remains a point, the *form* that a region or city takes evolves along with economic change. In the other direction, an area's form will influence economic change. For example, only areas possessing higher education and research facilities (namely, urban areas) make it possible for high technology activities to be developed.

3.2.3. Contextualising and putting economic causal relationships and phenomena into perspective: space that is both specific and general but always concrete

The central criterion that distinguishes the scientific approach of the territorial school is the way in which knowledge in all its forms explains a 'real' situation at a given location and time. As a result, by abandoning the concept of abstract spaces, it goes against the idea of space as understood by spatial economics or the NEG. Hence there is no abstraction from real life through taking a generalised approach towards understanding 'economic phenomena'. Attention thus focuses on the socio-historic situation 'in' which—or 'on' which—actions and events take place (there is some uncertainty over which preposition to use). At the heart of the thinking associated with this school is the view that territory is both specific and general; however, it nonetheless remains *concrete* (Raffestin, 1980).

Does that mean, however, that by abandoning any sort of theoretical approach all the methods used by the territorial and institutional schools are doomed to be purely descriptive? The answer is definitely no. It is the very status of theory (and space) which is different. Territorial approaches do not shy away from borrowing ideas, concepts or theories from other schools of thought. However, they regard these contributions as *ideal types*. In other words, ways of seeing things that have been developed in other comparable (but different) contexts, but which are used to provide answers to comparable, but different, questions. Theory is not regarded as complete and definitive. All the same, there are bodies of knowledge which have a more general reach insofar as their ideas, concepts and theories are sources of inspiration for other scientists working in other domains. Nevertheless, these same scientists keep them in perspective. So when these ideas and theories are applied anew they are accommodated to the specific nature of new situations. For example, the concept of the *industrial district*, which was first developed by Marshall and then updated by the Italian School (Garofoli, 1992; Becattini, 1992), is regularly cited by scholars who will use concepts like *innovative milieux* or *localised systems of production* in ways which are both similar (they all explain localised systems of production) and different (for example, those associated with the innovative milieux school attach greater importance to factors like innovation and networks and less importance to links with local communities).

The territorial approach is often criticised for its lack of rigour and its vague or 'fuzzy' concepts (Markusen, 1999). We can agree with Markusen at an empirical research level. We all urge researchers to develop in-depth empirical case studies, to tie them to policy-relevant questions as well as to avoid obtuse and self-referential mode of writing that makes it difficult for policy practictioners to operationalise research findings. In short, science must be communicable and teachable (Le Moigne, 1999). At a more conceptual, methodological and epistemological level we clearly disagree with Markusen. Fuzziness is the price that has to be paid for abandoning premises based on a view of space which is homogenous and something exogenous to the system (i.e. space has no influence over economic phenomena). The result of this is something which is always empirical in nature and never stable. However, this approach has two advantages. First, there is a better balance between the phenomena that are being described and the real—as opposed to theoretical—conditions under which they occur. In concrete situations, when comparing two regions, one can always find further differences, *specificities*. Region A is never identical to region B and the notions and concepts used to describe it have, up to a certain point, to be accommodated to the specific situations. On the contrary, between abstract Euclidean spaces, one can say that they are perfectly identical, or that they differ only by some numerical quantities. Concrete *situations* are both distinctive and similar to others. Secondly, society evolves and issues and meanings change as well. The way these are analysed also has to change (Chick and Dow, 2001). As they will change over space and time, this inevitably creates a certain degree of ‘fuzziness’ from a conceptual perspective. These changes can be taken into account if ways of looking at them are also able to evolve. For example, with regard to relations between the economy and space, is it reasonable to use the same description to cover today’s large, multi-establishment companies and financial conglomerates as was used for the single establishment firm of the 19th century? In short, as notions, concepts and theories have to evolve over space and time, scientists who work within this approach have to abandon definitely the quest for universal theories that would be valid at every time and every where. Specificity and qualitative spatial differences on the one hand, differences and changes in reality and in questionings on the other hand, provoke an ever renewed quest for specificities, and at the same time oblige to lean on identical or comparable elements. Concepts and theories are continuously put in the balance again and this perpetual discussion is intrinsically part of the territorial and particularising approaches. Therefore, if fuzziness is scientifically undesirable it is also the mark of the necessary opening of science towards evolving and contextualised questionings.

Moreover, the above distinctions between the space of mechanics and containing and contained space (the latter being understood as a set stage) are not, as such, transposable for territorial space. Indeed, it is an ambiguous space which is both given and built, exogenous and endogenous. Therefore, territory is always both a given medium (an initial situation inherited at the start of a process) and part of the transformation process. It is both exogenous and endogenous (to take up again terms used in mechanics) to the process. It precedes but is also (to a greater or lesser degree) inseparable from the transformation process. For example, economic agents participate in these processes and causal relationships, but they are also constituents of territory.

3.3. A complexity theory approach to constructing space

In geography, the way in which the researcher intervenes in the construction of space is the subject of ever-increasing attention, whether it is through ways things are perceived and expressed (Barnes, 1991) or through action (Werlen and Brennan, 1993). The issue arises to some degree in economics, but thinking on this matter is at a less advanced stage. Thus all work in territorial economics still assumes that territory is generally constructed by men, but only a small part of this work takes the role of the researcher modeller into consideration.

On a number of occasions, complexity theory has been used to explain the autonomy of territorial systems of production with regard to the researcher-modeller’s aims (see for example Grosjean and Crevoisier, 2003; Conti, 2005). The comments in this section rely heavily on the works of Le Moigne (1999, 2001), Varela (1989) and Morin (2005). These authors deal with a complexity theory whose epistemological foundations are clearly constructivist (see Le Moigne (1999) for an explicit description of these foundations; see Eriksson (1997) for an introduction to the work of Le Moigne in English).

The view underlying complexity theory is one of a multi-level reality, where each level has its own emerging properties. Thus complexity refers to the phenomenon of order emerging from complex interactions among the components of a system. Nevertheless and from this point of view there is a strong acknowledgement that reality cannot be reduced to the methods of simplification, where reality is broken down into separated and isolated components which are easier to study and understand (Conti, 2005) and, where the whole will strictly results from the agregation of these individual components—the whole beeing the perfect sum of the parts, not more, not less. Methodological individualism used by equilibrium economists is representative of this way of doing. Complexity theorists focus rather on the properties of interactions and the differents types of relations that a system exhibits than on the isolated and intrinsic properties/characteristics of some isolated and self-sufficient components. Furthermore, reality is understood in terms of the specifics of the knowledge-creating process rather than in absolute terms. Thus people are knowledge seekers and knowledge is built up through their interactions. The recursiveness of cognition recognises the interdependence between the subject and the object and a reflexivity process (Eriksson, 1997). This reflexivity refers to the capacity of a system to represent itself, so that the players that compose it are aware of belonging to a larger whole (Conti, 2005). In short, complexity theory is more a different way to see the world at an epistemological level, a different way of developing knowledge, than a field attached to a particular area of studies.

Humanity is not a homogenous group and cannot be understood by taking a unifying approach. There is a *plurality* of relations and dimensions and hence explanations. In line with the *dialogistic* nature of reality (Morin, 2005), several explanations of the same situation can be relevant and valid even when they are at variance with one another! For example, a Marxist interpretation of the hierarchisation of space (such as that suggested by Lipietz, 1977) explains the same phenomena as Paul Krugman's NEG. However, the meaning and explanation that arise from the two approaches focusing on the same subject are very different. Complexity theory has no problem with these contradictions because its focus is on the position of the observer rather than some sort of 'nature of reality' gained through a single meaning approach. Moreover, note that the quest for evidence and objective truth generaly involved in positivo-mechanistic paradigms is replaced in complexity theory by a quest for pertinence and projective feasibilty (Le Moigne, 1999).

There are two consequences arising from a multi-explanatory view of the world. The first is that it is necessary to select a point of view if one wants to take knowledge forward. This means that the *researcher's role* cannot be ignored, because their choice, reflecting their own value judgement, will be a fundamental determinant in how knowledge is produced (3.3.1). The second is that it is no longer possible to gain an overall view of reality. Thus it is necessary to abandon any sort of attempt at being *exhaustive*. As a result, researcher modellers have to define a *relevant field* for their projects and, at the same time, a context for it (3.3.2). According to the complexity theory approach, space and time are constructs which reflect the researcher's actions. Space and time do not predate the researcher's experiments, it is the very action of research that gives rise to them.

3.3.1. Malleable stage: the researcher defines a relevant field (space?)

At the start of any knowledge-creating process the research programme will define a *field of inquiry* setting the scope (on the basis of the researcher's information and knowledge) of their investigations in the course of their research. This is not arbitrary but has to be *relevant* to the questions being asked. *A priori*, the researcher will put together the concept of reality that will define, in accordance with their *plan*, the field of inquiry and a set of interacting elements. Of course, if the researcher does their job well, this construct has to be put into perspective as the research progresses; and it may turn out that the chosen field was not relevant, or only partially so, compared with the initial plan (Grosjean, 2001).

This field of inquiry is understood to be a set of interacting elements which is itself *set within a context* with which it interacts.

What is the underlying view of space and time in such a plan? The notion of interacting elements is very close to the concept of territory. Here, however, it is the relationships that make up the system which define the frontier. Territory is no longer approached in terms of being an objective entity (in other words as an historical legacy or where its construction is independent of the researcher's actions).

What might be called 'space' is defined internally by these interacting elements. However, it is a 'metaphorical' space defined by functional relationships. In short, there is no 'containing space' predating the research, but there is a field that might be likened to 'contained space'. It may be hard to visualise a contained space without having some notion of what contains it. However, this stems from the premises of complexity theory. Space cannot exist in an 'objective' sense which is independent of people's viewpoints and actions.

Besides, any notion of 'space' must itself be considered as a construct. If we 'think' of space it is because in the past we were able to do so through individual experiences or ones which were passed on.

In a knowledge-creating process a *field* is defined *a priori* by the researcher. This can be called a *malleable stage* in the sense that it is the starting point for the research process that will enable knowledge of its elements and relations to be taken forward. The research process will clearly be about changing the initial space through qualifying initial classifications and hypotheses.

For the researcher modeller, it will be a matter of examining, through considered action and thought, the scope at the start of the project and to develop the initial model by a comparison with 'reality'. Knowledge is progressively created through the modeller interacting with reality.

3.3.2. Context is not containing space

The second constructivist hypothesis is that coverage *cannot be exhaustive*. As a result, when the researcher modeller specifies what the relevant scope of inquiry will be, it marks a 'border' between the field of study and its context. The field of study is assumed to represent a coherent entity operating within a wider 'whole'.

This context cannot be compared to containing space as it is understood in mechanics. There, containing space is something 'objective' eternal and infinite which exists independently of the phenomena within it. Complexity theory works by only considering as valid, what can be learnt through action and thought. It abandons any claim to construct a view of the wider 'whole' through giving it characteristics. On the other hand, it takes the wider context into consideration insofar as a system is considered from the start as something which is active within its environment. Phenomena are not independent of context. At the heart of complexity theory is the necessity of constructing some form of representing the way the system interacts with its context.

However, this context or 'wider entity' cannot of course be likened to a space. It is 'space' or 'territory' only insofar as the word is used a means of explaining the knowledge that human beings develop.

To sum up, the view of space that lies behind the complexity theory approach is extremely radical. Indeed, it excludes any notion of space being 'objective'. Space and time can only become known through experimentation. If the reasoning behind this is pushed to its limits, this view of things calls into question the idea that space and time are 'dimensions' of a reality which is different from other components. The nature of space and time is formed through knowledge developed from the project that is being undertaken by the researcher. It is the outcome of thinking being translated into action.

The complexity theory approach uses 'spatial terms' in the sense of 'context', but context is not 'external'. The central issue, which remains unresolved and insoluble, within the paradigm used in complexity theory is knowing whether these terms refer to a reality that is 'beyond' humanity or simply to purely human thought processes and language. Is 'reality' organised according to types of 'space' and 'time' or is it a highly imperfect portrayal invented by the human mind and which has up to now has sufficed to keep it going? Today, isn't science and technology generally able to take space out of the picture? If this notion is no longer needed for us to survive shouldn't it simply disappear? Without subscribing to this last point of view it needs to be acknowledged that it raises the main issue of space as a relative concept.

From this angle, space does not have any particular status in relation to any other form of knowledge. It exists only because some people use it in relation to the knowledge they have generated and which is dependent on both their plans and way of thinking. Space thus becomes a construct of the human mind, which others can recognise and become involved with. It is perfectly possible to picture a society where space does not exist.

However, in the societies in which we live, this knowledge persists because it has a recognised value and because many economic, social or cultural issues focus around it.

4. Conclusion

Within political economy, few studies have sought to explain economic organisation within society from a spatial perspective. However, all the theories have an explicit or underlying view of space and time (a synthesis of these views can be found in Table 1). By surveying different schools of thought, the article has attempted to show how underlying concepts of space and time greatly influence the premises and results of each of these schools.

When the equilibrium approach emerged, spatial organisation of the economy, or the economic organisation of space, was not a main concern. Subsequently, spatial economics and then the NEG, developed an approach which moved on from single point notions of the economy to a multi-point economy. These developments were, however, shaped by their Walrasian legacy. By using analytical tools from physics, the weight of this legacy was felt through assuming that market mechanisms were spatially unique through operating at a single point regardless of how economic agents were spread over different points.

Conversely, territorial economics posited from the very start an interdependence between concrete forms of spatial organisation and economic processes.

The approaches inspired by the concept of territory regarded space and time as socio-historic constructs thus enabling them to consider structural change and innovation. Within these approaches, aforementioned factors like structural change will play an important role which will vary according to context and time. This approach is 'particularising' (Crevoisier, 1999), meaning that it recognises the specifics of a situation in the sense of not neutralising the variety of explanatory factors by taking an approach which imposes a homogenising mathematical formalism. Instead, it seeks to take variety into account its analyses and to enhance its value when using the analysis as the basis for recommendations. This is an important point because if indeed a theory 'explains reality' it should not be forgotten that it also constructs it. It is performative in the sense that it will influence, to a greater or lesser degree, players' ways of thinking and behaving.

Equilibrium theories are characterised by a single method approach using universal validation criteria and by adopting a 'set stage' view of contained space. By contrast, particularist approaches believe that there is no point in seeking 'laws' or universal causes which are independent of context or period. As Chanteau (2001) has pointed out, on the one hand space is something that is given for an economic agent, because it is a socio-historic construct handed down from the past and imposed on the player. On the other hand, it becomes a construct by being the outcome the actions of economic players; and one that will be 'passed on' to future economic players. Territory becomes both the mark left by the operation of economic mechanisms and the framework for their operations. Moreover, the latter cannot be considered independently of spatial and temporal characteristics and the way in which they are described. In addition, as each society or spatial system develops, methods and assessment criteria must also develop within space and time. Looked at in this way, a theory must be open to the world and the way it changes. It also means that the concepts of time and space which support it have to develop as well.

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