

The monocentric model and after

Catherine BAUMONT

Jean-Marie HURIOT

LATEC (CNRS), University of Burgundy

Introduction

Both the history of economics and economic methodology investigate the way in which theories succeed one another, focusing on the reasons why some theories outlive their usefulness or the way others are rejected in favour of alternatives. In analysing the development of theories, the idea of the progress of knowledge is ever-present, even if it is of limited epistemological significance. It seems that all epistemologists have now relinquished the idea of the gradual accumulation of scientific knowledge. Likewise, the belief that the purpose of such knowledge is to get closer to some absolute truth has become obsolete. No theory can be anything more than a particular representation of the phenomena it seeks to understand. Thus, economic phenomena are amenable to several different theoretical representations. Some are sometimes judged better than others on the strength of more-or-less objective criteria. It may also be that different coexisting theories complement one another rather than serving as real alternatives. But it may also be that successive theories offer such radically different views of economic phenomena that they are beyond comparison.

More generally, the evolution of theories and of scientific knowledge seems to follow a non linear pattern. The dual phenomena of continuity and change provide useful insight into this pattern of evolution and many authors resort to this dualism more or less directly. For example, the ideas of epistemological obstacles and epistemological breaks in Bachelard [1938] relate to the opposition between resistance to change and revolution. These concepts can be found in Schumpeter [1954], who emphasises the role of filiation of ideas in the development of economic analysis, but accepts that there are irregularities and even forms of scientific revolution, which are all the more marked when the old theories have long resisted change. Kuhn [1970] contrasts periods of constant development of normal science with the sudden transformations of scientific revolutions that lead to radical changes in paradigms. Continuity and discontinuity are found again in Granger [1995] or Walliser [1994].

But this insight must be used with care. The concepts of continuity and change have no absolute meaning and can only be defined by convention. The study of the evolution of theories may turn up many forms of continuity and change, depending on the time scale used or the magnitude of the change in question (Baumont and Huriot [1998]).

Thus, the time scale or the tempo of change may conceal discontinuity behind apparent continuity. The same events that may look rather regular and cumulative over the long term may show up as major breaks when viewed over a shorter term. In the same way, the slowness of change may give the impression of continuity where a radical transformation is, in fact, underway (Bachelard [1953]).

Thereafter continuity and change take on different forms depending on their intensity and their field of application. Walliser makes a distinction between stages of continuous development of a theory, characterised by a series of "micro-revolutions", *i.e.* by processes of generalisation, improvement and mutation and stages of "macro-revolution" akin to Kuhn's scientific revolutions. Elsewhere, Granger draws a distinction between external and internal discontinuities. The former designate the transition in an area of thought from the "proto-scientific" to the scientific stage, while the sequence of theories within the scientific stage is described under the concept of internal discontinuity.

Finally, there may well be continuity of ideas interrupted by a purely temporal discontinuity. This is the case, as pointed out by Schumpeter in particular, of theories that have been partly or completely forgotten for some time and then re-appear, as happened with spatial theory which is our subject here.

The history of spatial economics does not escape from this dualism of continuity and change. It is the product of an ongoing struggle between the tradition of old paradigms and a more or less marked tendency toward change.

Of the old paradigms, von Thünen's has stood the test of time particularly well until recently (Huriot [1994]) despite a long period of oblivion. For more than a century and a half it has provided the framework of analysis for a spatial organisation based on dependence on a single centre. The earliest version of this "monocentric model" was developed in 1826 by von Thünen himself to explain the formation of agricultural areas around a market town. There was scarcely any follow-up until Lösch [1940] reformulated it in simpler terms which were used as the basis of most explanations of the model. Despite many developments, the model would have been left by the wayside nowadays if it had not been applied to urban areas by Alonso [1964], thus giving rise to New Urban Economics. This transposition gave new impetus both

to the monocentric model and to urban economics which thus gained a foothold in microeconomic theory.

Yet the urban monocentric model was soon to display a double weakness. Empirically, the monocentric model is unable to cast light on more complex urban structures with several centres, or to explain the emergence of secondary centres or edge cities. Theoretically, the very strong economic and spatial assumptions of the monocentric model do not help solve the problem of the formation of cities, *i.e.* the problem of the simultaneous location of firms and households in a model of general spatial equilibrium. There is need for a radical change in assumptions and the adoption of a new standpoint, developed by microeconomic theory of agglomeration and more generally by New Economic Geography to account for the rise of urban centres.

We aim to interpret this history in terms of continuity and change. In view of the relative nature of these concepts, we have opted to assess the style and size of the transformations observed by analysing semantic changes: do the theoretical propositions in the models of von Thünen, of New Urban Economics and New Economic Geography always have the same content, the same scope and the same relevance? We therefore put changes in meaning before formal innovations, even if, as we shall be led to show, the former are sometimes largely dependent on the latter.

More specifically, our priority shall be to look into the way the spatial organisation of activities is worked into economic theory, *i.e.* both at how space makes it possible to understand the workings of the economy and the way economic theory can account for locations. The basic question is for what reasons and by what processes is the spatial economic order built up. The monocentric model goes some way to answering these questions by describing the ordering of agricultural space in von Thünen or of residential space in New Urban Economics. It is, though, unable to answer the general question of how economic space forms. The agglomeration theories proposed by urban microeconomics or New Economic Geography provide clues as to the direction in which the monocentric model needs to evolve, or even be abandoned, in order to respond to the current concerns of spatial economic theory.

We must now attempt to apply these principles and identify the lines of continuity and the changes that occurred from von Thünen through to contemporary urban microeconomics. We shall endeavour to understand in what way continuity may be a factor of excessive fixity, *i.e.* an obstacle to innovation and to the ability to resolve new problems. We shall also try to understand how change has made it possible to renew urban economics. The answers to these questions are set out in the three parts of this paper. The marks of continuity reflected by the preservation and adaptation of the monocentric model appear in

part 1. The shift from the agricultural model to the urban model and its consequences are developed in part 2, while the emergence of the theory of city formation as a major change is emphasised in part 3.

1 The longevity of the monocentric model

“The modern theory of urban land use is essentially a revival of von Thünen’s theory of agricultural land use” (Fujita [1986], p. 73).

Like Fujita, most scholars in urban microeconomics acknowledge their debt toward von Thünen, and his *Isolated State* has given its name to the *Isolated City-State* of Papageorgiou [1990]. We shall trace the ancestry of the idea and then look at its theoretical and empirical consequences for contemporary urban theory.

1.1 The revival of von Thünen’s theory

The monocentric model as we know it today is not the end-result of a continuous temporal process, as the idea was forgotten for a long period of time. Nevertheless, a comparative examination of the ways of thinking, of the assumptions and results shows clear signs of continuity in reasoning between *The Isolated State* and the urban monocentric model. Both theories are included under the same “von Thünen’s paradigm” (Huriot [1994]).

One of the primary reasons for the long life of von Thünen’s theory lies in economic methodology. While von Thünen’s work was not fully understood by his contemporaries, it was rediscovered by economists trying to construct rigorous formal spatial economic models. This may well be because of von Thünen’s method. *The Isolated State* is an abstract and deductive model, like modern theoretical models. The quantitative and descriptive aspect of the work is secondary. It is essential to understand that the idea of a simple monocentric space with crop circles came prior to detailed observations of the region of Tellow. Von Thünen first had the intuition of his theoretical model in 1803 and *The Isolated State* was published in 1826. This is evidence that von Thünen’s many numerical examples are constructed on the basis of theory. Moreover, von Thünen argues that general laws do not result from observations, but must be established by deductive reasoning. He starts with very simple assumptions in order to build an elementary model. He eliminates secondary factors so as to isolate the action of a single factor: the cost of transportation from the production place to the market town. Then he makes the assumptions more flexible by introducing secondary factors.

The same method is used in modern microeconomics. Urban microeconomics first constructs a basic model with simple restrictive assumptions intended to be relaxed or generalised in order to obtain a more relevant representation of urban space.

Signs of continuity are present in both the first set of assumptions and in the second, more general set.

The opening lines of *The Isolated State* give a highly simplified representation of space:

“Imagine a very large town, at the centre of a fertile plain which is crossed by no navigable river or canal. Throughout the plain the soil is capable of cultivation and of the same fertility. Far from the town, the plain turns into an uncultivated wilderness which cuts off all communication between this state and the outside world.

There are no other towns on the plain. The central town must therefore supply the rural areas with all manufactured products, and in return it will obtain all its provisions from the surrounding countryside.

The mines that provide the State with salt and metals are near the central town which, as it is the only one, we shall in future call simply ‘the town’” (von Thünen [1826], English translation [1966], p. 7).

These highly abstract assumptions are merely transposed to urban space, giving rise to the New Urban Economics. The central market-town is replaced by the unique city-centre where all firms and jobs are concentrated. The plain to be covered by crops becomes the space to be occupied by urban households. As in von Thünen’s model, we can say that outside the centre, the urban area is closed, homogenous, displaying circular symmetry around the centre, and that all lines of communication are radial. In both models, everyone is supposed to pursue his or her own interests independently, and land at any given place is allocated to the use that yields the highest rent, or the greatest willingness to pay, through a bidding process.

Although von Thünen only tackles the question in a short appendix, he clearly sees how his model could be altered by relaxing the most restrictive assumptions one after the other. He constructs a multicentric space by locating a second city away from the central city. He breaks the circular symmetry by introducing a navigable radial route where transport costs are lower. He abandons homogeneous space for areas with different levels of fertility. He even superposes a micro-spatial concentric structure (around each farm or each village) upon the same type of structure that is described at the macro spatial level of *The Isolated State*. He thus ends up with a highly refined description of the agricultural space, in a framework capable of reflecting practically all the possible deformations and complications of the basic monocentric

design. Unfortunately, the formal instruments available to von Thünen were a long way from being capable of integrating all these factors into a comprehensive formal model.

In the same way, New Urban Economics attempts to break free from the most restrictive assumptions (see Derycke [1992] for a survey). Among the various alterations made, we shall only refer here to those which follow on from von Thünen's ideas. Alterations have been made to the isotropic assumption and it has been shown how the urban circles are deformed in the presence of varying numbers of rapid radial and/or peripheral connections (e.g. Mohring [1961], Alonso [1964]). Spatial heterogeneity is reflected by the fact that factors other than the cost of transport to the centre may vary with location. These may be wages or the quality of location related to the amenities or characteristics of the social or racial environment. The introduction of several centres raises formal problems that von Thünen could not have suspected and which may underlie the changes we shall illustrate in part 3.

In the context of such spatial assumptions, we seek to localise crops or households around the centre, and to explain the spatial behaviour of variables such as the price of land and the type or intensity of land use. It follows directly from the spatial assumptions that the main explanatory variable in both models is distance to the centre.

In view of the close similarity between the spatial assumptions, it is hardly surprising that the results of the basic models should be very similar too. The consistency of results can be illustrated by the law of intensity. Von Thünen's law states that "for production of a given commodity, farming is more intense as one approaches the central city" (Huriot [1994], p. 221). Likewise, in the basic version of urban residential equilibrium, it can be easily shown that residential density — which is a form of intensity of urban land use — decreases with distance from the centre. Land rent decreases from the centre to the periphery in the urban model as in the agricultural model. In both cases, the basic assumptions imply that different economic agents take up locations in concentric rings, whether they are producers of different agricultural goods or residents with different levels of income.

1.2 Theoretical reasons for the model's survival

In some sense, the continuity between *The Isolated State* and New Urban Economics is the consequence of the same choices made in response to the same basic question about understanding economic space.

In an undifferentiated Euclidean space, we know that it is theoretically impossible to construct an ordered economic space compatible with the assumption of competition (Starrett [1978]). The sole solution

distributes all activities uniformly through space, *i.e.* in the greatest disorder. In such “backyard capitalism”, it is as if space did not exist. To escape this absurd solution, an agglomeration force must be introduced. The simplest way to do this is to fix a single centre, *i.e.* to fix the location of certain activities in one place. The location of the other activities can then be deduced from the relations they have with the former. Von Thünen located all non agricultural activities in a given market town and sought to deduce the locations of crops. New Urban Economics locates all jobs in a given city centre and the program then consists in locating the households. If transport costs are non zero, economic agents will seek to be as close as possible to the centre. So the assumption of a given centre combined with the need to be close to this centre serves as a force of agglomeration. This force is then combined with a dispersion force, represented by the exclusive consumption of a certain area of land by each economic agent. Activities are then ordered in concentric rings at varying distances from the centre depending on the way they relate to these two forces. The simplicity and generality of such spatial assumptions seem to be a first factor in explaining the durability of the monocentric model.

In von Thünen’s theory, as in New Urban Economics, this way of simplifying space is, at the same time, a way of maintaining the basic assumptions of pure competition and non-increasing returns. We know that these assumptions long hampered attempts to elaborate a general theory of economic space. Until Dixit and Stiglitz [1977], it was impossible to handle increasing returns in a formal general equilibrium framework. As Krugman [1991a] says, theory follows the line of least mathematical resistance and is more readily developed in directions where formal models are more easily constructed. Accordingly the compatibility of the monocentric model with pure competition and constant returns can be considered as a second factor in explaining its strong resistance.

1.3 The relevance of the monocentric model

Where agricultural space is concerned, some observations seem to confirm the presence of concentric spaces at micro-spatial scales (farm and village) and meso-spatial scales (the region around a large city). However, many of these observations are relatively old or concern developing countries, which limits their scope (Huriot [1994]).

It is doubtful whether the cost of transport to a central market is still the main factor in agricultural locations: other factors may become preponderant, such as soil quality and labour costs, or regional specialisation (Kellerman [1977] [1981]). The development of means of transportation have brought about the diversification of spatial rela-

tions. The extension of mass production implies that production is no longer solely for the local market but also for a national, or even the world market. It seems then that von Thünen's model has lost some of its relevance for the agricultural world.

The urban monocentric model at times provides acceptable results. Many observations confirm, in particular, the law of diminishing residential density away from the centre, often in the precise form of a negative exponential function (Clark's law), the theoretical foundation of which was established by Muth [1969]. In North American cities, household income generally increases from the centre toward the periphery as predicted by New Urban Economics.

However, the monocentric assumption leads to a restrictive representation of urban space. The reasons can be seen in the theoretical foundations of the monocentric approach. Three points should be emphasised.

First of all, positing an a priori centre pre-supposes that a certain number of activities are located there. This implies that the problem is partly solved from the outset: the distribution of activities in space cannot be explained in its entirety. A partial equilibrium is established for a subset of activities whose locations depend on given locations, without any feedback effect. Accordingly von Thünen's theory cannot be extended to a general theory of economic space without making radical changes. As New Urban Economics assumes all firms are located in the given centre, it is nothing more than a residential location theory.

Next, households are linked to the single centre only, and therefore movements are exclusively radial. This is an inadequate representation of the complexity of the relations that are built up inside a city where each agent is located and acts relative to several places in a multicentric space, and where the locations of consumers and of firms are interdependent.

Finally, the monocentric assumption implies that, apart from the single centre, space is supposed *ex ante* to be completely empty and the equilibrium is determined instantaneously and statically, giving rise to the "instantaneous metropolis" (Zoller [1988]). Equilibrium is a sort of realised ideal: ideal because there is no inertia in land use, no constraints limiting the available locations or preventing them from being freely allocated by the land market; realised because the questions are about the properties of this equilibrium and not about how it is achieved.

The instantaneous formation of a perfectly concentric spatial arrangement around a single given centre means New Urban Economics is incapable of accounting for more complex urban spatial arrangements.

It is unable to explain what happens in polycentric cities (Baumont [1993]) and above all fails to explain the formation of cities or the rise of secondary centres or edge cities (Krugman [1995] [1996]). These shortcomings led to the major change described in part 3 below.

2 Forty years of adaptation

From von Thünen's seminal work through to the current state of urban microeconomics, we shall identify a number of adaptations that have had repercussions on different aspects of the theory such as its object of analysis, its mode of reasoning, and its temporal framework. It should be remembered that the criterion we are using is that of the construction of spatial economics and the mode of handling space. From this point of view, these adaptations are not major changes, even if some relate to the transition from a classical to a neo-classical approach, simply because the shortcomings of the monocentric model persist. Thus these changes take the form of Walliser's "micro-revolutions".

2.1 From field to city

We would no longer speak of von Thünen today other than as an important but outdated episode in spatial economic thought if his analysis had not been applied to the question of urban equilibrium. It is the transposability of his spatial model to the analysis of cities, probably enhanced by the fact that he initialised marginal productivity theory, that makes von Thünen a modern thinker.

The first and most obvious adaptation of the monocentric model is that of the subject matter. This change, for which the works of Beckmann [1957] and Wingo [1961] made way, was effected by the key work of Alonso [1964] who conducted the first complete analysis of the monocentric equilibrium of the city on the basis of individual behaviour of optimisation and by the aid of the generalisation of von Thünen's concept of rent curves as bid curves.

The transition to the city can be accounted for by two factors. On the one hand, we have shifted from a world dominated by agriculture to an urban civilisation. On the other hand, we have witnessed at the same time a decrease in the monetary costs of transporting commodities between cities and a spectacular increase in the time cost of commuting within cities. These are good reasons for trying to apply to the city a form of reasoning which seeks to explain the structure of space essentially in terms of cost of transport to the centre.

This change is not necessarily related to the internal rationale of the development of theories. It does not therefore necessarily imply

discontinuity within the theoretical approach itself and could be judged secondary to our problem. In fact, the whole question is whether the change of subject matter involves a change in reasoning, *i.e.* the question is that of the urban specificity of the analysis. The connection between the specificity of the subject and the specificity of reasoning is complex and does not obey any general rule. But it may be thought that the simple transposition of the same reasoning from agricultural space to urban space depends on the implicit assumption that urban space is only a formal category of space with no distinguishing features when compared with agricultural space or with space in general. If this is so, then what is true of urban space is not fundamentally different from what is true of any other space. If, on the other hand, we hold that urban space is qualitatively different from any other space, we need to know whether a non-specific method is capable of bringing out this specificity or whether we need a revised or completely new method.

The transposition of von Thünen's model directly entails at least one other change concerning the agents involved in the analysis and their relations with land. We are now looking at built land and this entails new problems. While on the one hand, we analyse the behaviour of farmers who use land as a production factor, on the other hand, we have residents who consume land or housing. We could, of course, introduce the producers of housing who, like farmers, use land as part of a productive combination. But house builders, unlike farmers, are not themselves located while producing a clearly localised commodity.

2.2 New modes of reasoning

The change of subject matter accompanied changes in the approach and reasoning, although it was by no means the only cause of those transformations. They were also related to the development of economic thought itself and of its mathematical tools, independently of the specific subject of the city.

Von Thünen was writing at the height of the classical period. Although he is known as the pioneer of the theory of marginal productivity, his approach to spatial structure is still for the most part connected with classical modes of thought. He was interested first and foremost in production, in assigning to the conditions of production a decisive place in spatial economic equilibrium. He generally considered fixed production techniques as if he were thinking of production functions without substitution between factors, but with joint products in fixed proportions.

In New Urban Economics, the emphasis was switched from production to consumption. It could be considered that this reversal is simply the result of a change in the subject of analysis: country to city.

This is not a valid reason, or not a sufficient one. Even if New Urban Economics seeks only to explain the structure of residential space, the analysis could be conducted through modelling of housing production. If we leave aside the few models following Muth [1969], who integrates housing production in the analysis, land is no longer considered as a production factor but rather as a consumption good. Giving priority to consumption and consumers, of land or housing, involves something more than just a shift in the subject of analysis.

At the same time as we have shifted from mainly classical to mainly neo-classical thinking, we have adopted the framework of analysis of microeconomics and the high degree of mathematical formalisation that characterises its advances.

By using the approach of contemporary microeconomics, the urban economist introduces the question of urban space into the framework of the hypothetico-deductive studies of equilibrium based on optimising behaviour, which has proved easily adaptable to a wide array of problems and productive in formal theoretical propositions. But to take advantage of this approach, we must force the problem to fit into the analytical framework, thus determining a number of characteristics of the theory. Thus individual optimisation behaviours underpin the entire construction.

With microeconomics comes mathematics. Von Thünen himself, although he did not use it very much, advocated the use of algebra to establish sufficiently general propositions and to avoid the pitfalls of particular cases. Von Thünen's model, like Ricardo's, can be easily converted into mathematical terms.

"Algebra provides us with the necessary tool; for if the nature of the subject allows letters to be substituted for numbers, and if the calculation made with the letters reach the same result as those made with figures, then this result will be generally valid, not merely a local rule" (Von Thünen [1826], English translation [1966], p. 33).

2.3 Toward contemporary urban issues

The change of subject matter naturally entails an extension of the range of problems. The flexibility of the microeconomic approach to New Urban Economics has made it possible to include in the analysis a whole series of probing questions about contemporary cities and has given rise to extensive literature that could be interpreted in terms of "expansive" works (Walliser [1994]).

The earliest and most significant advance concerns the treatment of urban externalities. These may take the form of environmental amenities: the utility of an agent can be affected by the quality of the air

he breathes, noise, the residential density of the neighbourhood or the presence of ethnic or social groups he either seeks out or seeks to avoid. Another category of urban externalities includes the effects of traffic congestion, which have given rise to calculation of the social costs of congestion. A third group includes spillover effects from public goods: residents may benefit from public infrastructures (*e.g.* transport) without contributing to their funding, because they pay taxes in another district. These different externalities are at least as important as travel to the work place in explaining both individual location and urban equilibrium.

Another contemporary although not specifically urban problem, unemployment, is beginning to be included in New Urban Economics models (Zenou [1996]), which thus becomes more akin to labour economics by what Walliser termed a "hybridisation" phenomenon (Walliser [1995]).

The flexibility of the standard microeconomic model of the city means it can be used outside the city to describe peri-urbanisation. Again, the city is considered as a centre, but we are now interested in the location behaviour of households in peri-urban rural areas on the basis of the trade-off between urban attraction and rural amenities (Goffette-Nagot [1996]).

A further step forward has been the transition to dynamic models where historical time, that of non-reversibility of phenomena, comes into play. This substantially changes the capacity of the models' to handle contemporary urban problems. Dynamic models introduce durability of urban constructions and the resulting costs of replacement. These factors are signs of the inertia of land occupation which Lösch [1940] remarked on without going further into it.

In the static model of agricultural location, nothing opposes the achievement of equilibrium: the crop grown at each place is simply the one which yields the highest rent. But inertia may arise: if the introduction of a new crop is incompatible with traditional practice, it may give rise to a sub-optimal arrangement (the new crop is not located according to the highest rent criterion) which may or may not be maintained depending on the strength of tradition compared with economic pressure for change. But these budding ideas went unused until recently.

The introduction of durable constructions and therefore of high costs for changing urban land use entails substantial differences compared with the static model (Fujita [1986]). These models handle issues such as discontinuous urban expansion, urban rehabilitation, filtering on the property market and urbanisation in uncertain situations (see

Brueckner [1998] for a panorama of the “state of the art” in dynamic urban models).

Even if this approach breaks with the standard static urban model, it has not so far produced a tidal wave comparable with the one which was to introduce the formation of cities by endogeneising the city centre.

3 A major change: The theory of the formation of cities

Our spatial viewpoint leads us now to inquire into the consequences of a more profound change concerning spatial assumptions and their effects on the nature of the problem and to ask whether we are not heading down the road to a new paradigm.

New Urban Economics produces household location models in an *ex ante* monocentric space. We have suggested that the most restrictive aspect of this approach is the fact that it does not explain how and where cities form, *i.e.* how and where centres appear. In order to solve this enigma, agglomeration theory describes the endogenous process which generates centres.

3.1 From exogenous to endogenous centrality

Concern with adhering more closely to the realities of contemporary urban life, with enhancing representations and providing more general results, has led some authors to fix several centres of attraction in order to define spatial behaviour and determine the city structure. While this can lead to a more satisfactory representation of location behaviour, current theory has not followed this line for two reasons. First, the introduction of several fixed centres involves serious technical difficulties (Baumont [1993]). Second, we still face the same problems of pre-determined and unchangeable spatial centres.

What may be considered as a real weakness of New Urban Economics is more the exogeneity of the single centre (or centres) which makes it impossible to explain its formation and development.

It should be emphasised that it is impossible to generalise from the basic model to the simultaneous location of all agents without abandoning exogeneity of the economic centre. Alonso's attempt to construct a model of general equilibrium of location of all types of agents (households, firms and farmers) in a monocentric space, despite its pioneering role, proved a failure. The model obtained is, in fact, no more than a juxtaposition of partial equilibrium models and leads to an inconsistency: on the one hand, households are located as if firms occupy the

city centre and, on the other hand, the location of firms is determined as if households occupy the centre.

It is impossible to contemplate studying the simultaneous location of all agents unless we are in an urban space with no pre-existing centre. Fujita and Ogawa [1982] term such a space "non-monocentric". This raises a problem of general spatial equilibrium. It is the agents' need for interaction that generates spatial concentration.

This new framework of analysis is a genuine change compared with the initial corpus of New Urban Economics. This change is the transition from the study of the internal organisation of a city around a given centre to the analysis of the formation of cities, *i.e.* the birth of the theory of agglomeration developed by New Economic Geography.

When we ask how economic centres arise, we immediately destroy the monocentric arrangement for which we have no way to explain, because of the assumptions, how the centre is formed and where it is located, or by extension why new centres appear in previously monocentric urban structures. The key to a general theory of space formation is in the inclusion of indivisibility and increasing returns and therefore in abandoning the assumption of pure competition, as was suggested by Koopmans [1957] and shown by Starrett [1978], Krugman [1991a] [1995] and Thisse [1992]. More concretely, agglomeration economies cause agents to group together because they derive advantages from proximity. The main sources of agglomeration economies are (Fujita [1990], Fujita and Thisse [1997]):

1. non market interactions, which generate spatial externalities or proximity effects: this is true in particular of social or business interactions and information exchange requiring personal contact;
2. monopolistic competition structures where firms produce differentiated goods and consumers express a preference for variety;
3. strategic externalities that appear because of the geographic proximity of competing firms and refer back to the theory of spatial competition derived from Hotelling's model.

The most simple example of advantage due to proximity relates to the simple need for social contacts between identical individuals. This is a sufficient condition to generate a non uniform distribution of individuals in a bounded space with a higher concentration closer to the geometrical centre (Beckmann [1976]; Borukhov and Hochman [1977]).

More generally, the need for proximity in interactions between firms and households gives rise to an irreversible process of agglomeration. Let us assume activities are perfectly uniformly distributed

in space. This equilibrium is unstable: the slightest disturbance, say from a single agent relocating, produces spatial heterogeneity which is amplified by a cumulative process reminiscent of Myrdal's circular causality. This can be illustrated quite simply. Let us assume there are two categories of economic agents, *A* and *B*, linked by a mutual need for proximity: each *A* finds it advantageous to be close to many *B*s and vice-versa. If any one location brings together more *A*s than other locations, that will be sufficient for *B*s to be attracted to it, which will attract new *A*s and so on. For instance, in the framework of monopolistic competition, consumer preference for variety attracts firms manufacturing differentiated goods, which in turn attract consumers seeking variety.

Spatial externalities can also explain the formation of multiple centres when agglomeration gives way to diseconomies caused by saturation of the monocentric space: the formation of other centres then becomes a more efficient means of organising urban space.

For example, the works of Fujita, Ogawa and Krugman (Fujita [1994]; Fujita and Ogawa [1982]; Fujita and Krugman [1995]; Ogawa and Fujita [1989]) and of Clarke and Wilson [1985] formalise this type of analysis. They show how the process of interaction among agents, combined with different hypotheses about the shape of space and the form of agglomeration economies, enables the emergence of varied urban structures with more or less specialised areas. The areas of concentration of firms appear as the economic centres of the city. A city may have no centre (uniform distribution of activities), a single centre, or several centres. Their models show that the different urban structures arise as a result of bifurcation processes, depending on the values allocated to parameters such as the transport costs and the rate of substitution between differentiated goods. The cities thus obtained are qualitatively different from each other. (See Fujita and Thisse [1997] for a more complete presentation of agglomeration models.)

At the same time as the monocentric assumption vanishes, other underlying assumptions must be reconsidered: this is the case, for example, of the radial displacement arrangement. In the non-monocentric model, any type of movement is possible *ex ante*. But *ex post* the shape of the commuting network will depend on the form of urban equilibrium achieved. However, if we are in a two dimensional space, the need to consider omni-directional movements considerably hampers the formal resolution of general urban equilibrium, unless we assume that urban space is symmetrical around its geometrical centre. Under this condition, Ogawa and Fujita [1989] demonstrate that the radial pattern of movement becomes a result of the non-monocentric model. But assuming circular symmetry amounts to a return to the concentric arrange-

ment of space. That limits the analytical consequences of the change introduced by non-monocentric models.

3.2 The limits of endogenisation

Hypothetico-deductive reasoning is necessarily based on initial statements. There are a minimum number of basic postulates about activities and about space without which we cannot explain the formation of cities.

A first set of assumptions answers the question of why people and activities tend to be concentrated. We encounter the assumption of indivisibility suggested by Koopmans [1957] and largely illustrated since. We also come upon the economic advantages of proximity grouped under the general heading of agglomeration economies. These advantages appear as a consequence of the interaction of agents. They may be endogenous, if they are generated in the course of the agglomeration process. But the existence of these advantages and their link with proximity must be postulated a priori for us to be able to determine an equilibrium exhibiting spatial concentrations.

A second set is required to determine where spatial concentrations will show up. In a uniform, unbounded space all locations are identical and the location of an endogenous centre is undetermined. To localise the centre, we need to be given factors of spatial heterogeneity. We commonly take natural heterogeneity relative to endowments in natural resources, what Krugman calls the "first nature" causes (Krugman [1993]), or we emphasise the chance factor of "historical accidents" (Arthur [1990]).

But even when theory seeks to study the pure effect of space (*i.e.* by assuming the equal distribution of natural endowments), it must still introduce a certain form of exogenous heterogeneity if it is to succeed in locating a first agglomeration. Such heterogeneity may be achieved simply by imposing bounds on the space studied. It is easy to show that a bounded space is non homogeneous by definition, simply because the very existence of a boundary means that the relative positions of points in space are differentiated (Papageorgiou and Thisse [1985]). The different locations are not therefore identical. Just compare the one dimensional spaces of the segment and the circle: a segment, which is bounded by definition, has a geometrical centre and differentiated locations compared with the point of best access, whereas on a circle all locations are equivalent until we introduce an exogenous differentiation factor.

Thus in Fujita and Ogawa's general equilibrium models, space is bounded and firms and households are clustered around the geometric

centre. If several concentrations of activity are localised, these are symmetrical about the geometrical centre.

3.3 The scope of the change

Agglomeration theory does not dismiss New Urban Economics and the monocentric model. New Urban Economics has a clearly stated objective, which it is practically the only theory to achieve so completely: to set out the consequences of the operation of a perfect land market on the structure of a monocentric urban space. Although it is frequently considered that New Urban Economics does not provide a satisfactory explanation of cities, we must reckon with its great capacity for adaptation. Monocentric models are still regularly developed, integrating new aspects of contemporary urban life, such as congestion, pollution or unemployment, in a partial equilibrium analysis. But there is a legitimate fear that New Urban Economics is leading to numbers of theorems with ever less meaning. Despite these numerous adaptations, New Urban Economics is still unable to say anything about the central issue of spatial economics: the formation of economic space.

The theory of city formation derived from the endogenisation of centres takes place in a more extended movement relative to the theory of space formation based on the same principles of increasing returns, monopolistic competition and spatial externalities, and including theories of interregional equilibrium initiated by Krugman [1991b]. It is worth noticing the convergence between these two approaches, clearly proved by the direct cooperation of two leading authors (Fujita and Krugman [1995] [1997]). The theory of space formation relates to the understanding of spatial self-organisation (Krugman [1996]) as it was already developed by Schelling in his book *Micromotives and Macrobehavior* [1978]:

“We feel that we have really managed to shed light on a phenomenon when we show how that phenomenon, the “macrobehavior”, emerges from the interaction of decisions by individual families or firms” (Krugman [1996], p. 15).

Finally, the new approach to agglomeration theory leads to new statements about the question of regional convergence and the consequences of regional policies. The existence of spatial cumulative processes may lead us to predict the growth of inequalities and the polarisation of European geographic space (Jayet, Puig and Thisse [1996]). Furthermore, insofar as this process, which is highly dependent on its initial stage (and therefore on history), is highly cumulative, it leads to the “entrenchment” of locations that regional development policy may find it difficult to counteract. In the same way, the theory explains the achievement of strong urban growth despite the costs of such growth

which occasionally entail predictions of the end of cities. One of the most noteworthy results of the new theory is that agglomeration may be encouraged by lower transportation costs. Explanations are given in particular as to why economic agents invariably seek out proximity despite the development of possibilities to communicate from a distance.

Conclusion

After having developed urban monocentric models —in the von Thünen tradition—, current urban microeconomics has set itself a more general objective and is turning toward the study of the formation of cities and the creation and transformation of monocentric or multicentric space. So, is urban economics not in the process of founding a new paradigm? The filiation with von Thünen is no longer as clear as Fujita claimed in 1986 in the terms quoted earlier. Can we still speak of “von Thünen’s paradigm” for recent agglomeration models which address the question of spatial economics at the grass roots, the formation of a heterogeneous space and the formation of cities. They go as far as “unifying” the tradition of von Thünen and those of Chamberlin and of Hotelling (Fujita and Krugman [1995]; Fujita and Thisse [1986]). Finally, they have the dual property — which is only an apparent paradox — of being increasingly better integrated in mainstream economic theory and coming ever closer to certain heterodox contributions relative to economies of proximity, local productive systems or “milieux innovateurs”. With respect to the first point, it must be emphasised that the radical change of assumptions leading to the theory of city formation is an important factor in integration of spatial economics into economic theory. It forges new links between spatial theory and other fields of economic theory. Increasing returns, monopolistic competition and externalities play an important role in the theory of space formation as in endogenous growth theory, new international trade theory and industrial economics. This illustrates the role played by a new and increasingly widespread mode of reasoning in the evolution of the questions theories can deal with: for example, city formation for urban economics, uneven growth for growth theories, strategic behaviours for industrial economics. As for the second point, the theory of city formation is based on the concept of agglomeration economies which is still for the most part a black box.

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