Informational Interactions and the Future of Cities[1]

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1. Introduction

Almost every day we are overwhelmed by statements about the excessive cost of cities, overcrowding, overdevelopment and the damaging effects of modern metropolises. However, none of these claims has proved an obstacle to city growth. After a slight downturn, city growth has been on the rise since the 1980s. At present, almost 50 percent of the world's population lives in cities, with that figure exceeding 70 percent in most developed countries. Thirteen cities have more than ten million inhabitants.

Even if population data are not the main criterion for evaluating the economic importance of cities, most of the biggest cities of developed countries are at the head of the world economic hierarchy and some cities of developing countries are joining them. In most countries, what happens in big cities largely determines what happens in the economy, as well as in a particular society or culture, and in all areas of human undertaking. The largest cities have become centers of world economic power, notably London, New York and Tokyo, at least as centers of financial and business services.

Contemporary quantitative city growth has gone along with a qualitative change in the role of cities. The new economic power of cities is related to significant changes in their economic nature and composition. Nineteenth-century urbanization went hand-in-hand with industrialization. Present-day city growth is chiefly the result of new tertiary activities such as financial and producer services, R&D, design, business administration, or more generally activities of decision, conception and control. It seems that these activities need to be more spatially concentrated than traditional manufacturing activities. These new trends affect both the structure of cities and the structure of city systems.

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The specific nature of the new activities concentrated in city centers makes them information intensive. These activities consume human capital, knowledge and high-tech capital, which are all rapidly changing inputs; they are based on complex decision-making processes; this renders them highly information-dependent.

Inasmuch as these activities are the main key to understanding the city, information must play a leading role in explaining urban forms and urban growth.

Because new urban activities are information-dependent, their location may be assumed to depend on easy information exchanges. The conventional assumption is that, other things being equal, distance is an obstacle to the spread of information (Hägerstrand, 1965), so that urban proximity appears to be the obvious way to maximize the efficiency of information exchanges.

New telecommunications technologies allow instantaneous and almost costless informational interactions between remote individuals. In view of these advances, it is legitimate to ask whether proximity continues to dictate the location of information-dependent activities. Everybody has heard tell of "the demise of cities".

And yet cities continue to grow and information-dependent activities continue to agglomerate. This is a puzzling feature and calls for closer analysis of the nature and role of information exchanges.

In this empirical context, economic analysis of city formation and city growth has expanded and been renewed. One of the most recent and most promising attempts at explaining this urban evolution is provided by Economic Geography. This approach seeks to explain the emergence of spatial patterns, and especially of cities, on the basis of economic interactions between individuals. Although it contains only a few in-depth analyses of the spatial effects of information, Economic Geography does provide a conceptual framework which can give insight into the links between information exchanges and spatial urban structures.

But the actual role of information in shaping space can only be ascertained by using a *more thorough analysis of the nature of information*, of information needs and exchanges. Such an analysis may possibly be found in less standard approaches to space and information, although these provide less formal models. We have to learn from both, and we could gain from bringing them together.

In the theoretical framework of Economic Geography, we propose to examine *the ways in which cities and city systems are affected by information exchanges and telecommunications technology*.

This analysis is conducted in three main stages. We begin by stating the methodology of Economic Geography and suggesting the limits of the usual treatment of information as a standard spatial externality (section 2). Then we examine the way in which the differentiation and the interdependence of information exchanges can be included in the models of Economic Geography and can imply new results about the shape and growth of cities (section 3). Next, we suggest how information exchanges and telecommunications infrastructures could help to explain the form and the consolidation of city systems (section 4). The paper ends by drawing lessons about the theoretical and empirical meaning of these developments.

2. Economic Geography and information

2.1. Methodology

Mainstream economic theory has concentrated primarily on determining who produces what. The spatial organisation of those economic activities has been a secondary consideration. Land use, spatial competition and the formation of cities are topics that are seldom covered by economic theory. It is as if production, consumption and exchanges took place in a single, dimensionless place. Yet these activities consume land and are unevenly distributed in space. Krugman (1993) describes a map pieced together from night-time satellite photos of the Earth. There are intense concentrations of lights and vast expanses of darkness. The illuminated areas are where intensive economic activity goes on, that is to say mainly urban areas. As classical spatial economics, Economic Geography sets out to explain this uneven distribution of economic activities, but it uses an original approach.

Economic geography can be characterized by the following main features:
(1) it deals with the basic puzzle of spatial economics, i.e. the formation of heterogeneous economic space and mainly the formation of cities, assuming no given center; in order to solve this problem, it must *simultaneously determine the locations of firms and households in a general equilibrium approach*.
(2) it adopts the microeconomic perspective where spatial patterns *emerge* from the combination of individual behaviors; but it *rejects the assumptions of pure competition and of non-increasing returns* because they are logically incompatible with the existence of an uneven economic space (Koopmans, 1957; Starrett, 1972);
(3) Consequently, the reasoning in Economic Geography is essentially based on three concepts: *increasing returns, monopolistic competition and spatial externalities*.
(4) In Economic Geography models, equilibrium urban configurations are the outcome of the balance between two opposing forces, namely *agglomeration forces and dispersion forces*. Agglomeration forces, such as agglomeration economies or preference for variety, lead to the concentration of economic activities and people in cities. Dispersion forces, such as immobile and dispersed factors, commuting and congestion costs, incite economic agents to move further apart from each other.
(5) The interplay between at least one agglomeration force and one dispersion force generates *cumulative processes* which result in the "instability of spatially uniform steady-state" (Papageorgiou and Smith, 1983) and in the emergence of cities or of irregular regional patterns. These spatial configurations are very sensitive to initial conditions such as natural endowments or "historical accidents". As a result, "history matters".

Let us be more precise about the method followed to analyze the spatial impact of information.

Economic geography employs two categories of models. In the first one, which is the most developed, the agglomeration force refers to market effects such as the differentiation of products combined with the preference for variety in a structure of monopolistic competition. But in this paper, we focus on a second category of models where spatial equilibrium results from non-market interactions between firms and households which take the form of spatial externalities. A positive spatial externality

exists when proximity between agents gives them some non-market advantage. As a result, spatial externalities generate an agglomeration force for economic activities.

Information can be considered as a public good (Arrow, 1962) inasmuch as the value of a piece of information is not necessarily reduced when it is used by several agents. Hence information exchanges generate positive externalities. If we adopt the idea that information exchanges are less easy and more costly when distance increases, these externalities are positive spatial externalities. This assumption is compatible with the empirical results of Hägerstrand (1965) and his followers about the spatial diffusion of information.

As a matter of course, information exchanges are introduced in certain urban models, but mostly simply as generating a non specific positive externality (Papageorgiou and Smith, 1983). Few authors go further and try to treat information more specifically.

In order to understand how information shapes cities and affects the evolution of cities and city systems, we have to consider the role of information as far as possible *all things being equal*. Of course, it does not mean that information is the single determinant of contemporary urban evolution. Indeed, information has to be combined with a number of other factors if we want to have a complete view of the present-day city. It only means that we focus on the specific effect of information on spatial organization.

In this context, we wonder whether information will reinforce or contradict the tendencies resulting from Economic Geography models without information and we will try to show how information exchanges generate agglomeration and/or dispersion forces, both at the urban and inter-urban levels.

2.2. Modelling information as a standard spatial externality : scope and limits

Fujita and Ogawa (1982, 1989) developed a seminal general equilibrium model of firm-household interactions whereby information exchanges appear as a non-specific, positive externality. This model attempts to determine the equilibrium configurations of a city where information exchanges between firms act as an agglomeration force. Opportunities for information exchanges increase with the number of firms sharing the same location. Furthermore, different firms are assumed to have different information. Consequently, by facilitating a large number of diversified contacts, geographic proximity ensures agents can acquire a large quantity of varied information. Proximity between firms thus cuts their operating costs and has a positive effect on profit levels. Households consume land and have to move toward these firms for work. But the clustering of many firms in a single area pushes up land rent and commuting costs: these are dispersion forces which are disincentives to any further agglomeration by firms. At equilibrium, the distribution of firms and households exhibits typical patterns with one or more centers formed by agglomerations of firms. These patterns are the result of the balance between these two opposing forces.

The results of this model would be unchanged if information exchanges were replaced by any other positive spatial externality. Therefore this analysis is inadequate for gaining any real grasp of the consequences of information exchanges for the spatial

organisation of economic activities. In particular, it does not allow us to understand two contradictory stylized facts.

On the one hand, advances in telecommunications technology now provide almost instantaneous and very low cost long-distance transmission of an impressive mass of information. These advances are reflected by the huge expansion in telecommunications resources and the much wider audience of users. This has fired debate about the long-term effect of the advances in telecommunications technology on the concentration of activities in cities. It seems, at first sight, that these advances do away with the constraint of proximity in information exchanges. Many commentators believe that these advances will lead to the decline of cities (e.g. Webber, 1973; Down, 1985; Kellerman, 1984) as the most efficient places for information exchanges. They argue that the new telecommunications technology provides the same advantages as cities for efficient information exchanges without the economic, social and environmental diseconomies of urban concentration. In other words, information-dependent activities are no longer dependent on proximity.

"For the first time in history, it might be possible to locate on a mountain top and to maintain intimate, real-time, and realistic contact with business or other associates. All persons tapped into the global communication net would have ties approximating those used today in a given metropolitan region." (Webber, 1968).

If this were true, advances in telecommunications technology release economic agents from their proximity constraints for the information exchanges. This would leave scope for other factors to determine the locations of agents. These factors may be agglomeration and dispersion forces which are conducive to the formation of cities. Here information would play a passive role reinforcing the influence of other locational factors, and would give more relevance to all those models of city systems formation which omit the information factor.

On the other hand, it is noticeable that economic agents still feel a need for proximity for their information exchanges whether for business purposes or otherwise. There have never been as many meetings, congresses and seminars; casual encounters in corridors or bars are still much sought after. Consequently, cities are still the preferred place for information exchanges.

But considering information exchanges as simple spatial externalities leads us to overlook the specific character of information and hence to neglect the specific effects of information. It is impossible in this way to understand how information exchanges still have a structuring effect on space and the city despite the advances of information technologies. It is impossible to say whether these quantitative and qualitative advances eradicate the proximity constraint for information exchange to the advantage of other factors.

To clearly identify the ties between information, concentration and dispersion, we need to analyse the specific characters of information more closely and show how they can be integrated in the rationale of Economic Geography.

Some meaningful specific features will be successively introduced and their consequences analyzed in the following sections. First, we will differentiate information on the basis of its exchange modes and adopt the well-known distinction between tacit and codified information. Second, we will recognize the interdependence

of these two types of information, which should now be considered as complements rather than substitutes. Third, the localized character of certain sources of information has to be taken into account. Fourth and finally, information cannot be analyzed independently of the communications infrastructures which allow it to be exchanged. The first two features allow us to speak more accurately of urban forms and urban growth; they are introduced in section 3. The third and fourth ones reinforce the classical results of Economic Geography concerning the existence and evolution of city systems; they appear in section 4.

3. Information and the city

3.1. Differentiating information

Information in itself is meaningless. It only takes on meaning in a process involving one or more particular senders and one or more particular receivers. Each receiver and sender has his or her own intentions, expectations and capabilities to impart meaning to the information that is exchanged. Uncertainty is therefore inherent in this exchange. Information codification is an operation that reduces uncertainty. This operation consists in expressing information in a compact, standardized form everyone can utilize and understand. *Codified information* can then be transported using communication technologies regardless of distance and in a reliable fashion.

But this procedure can only be carried out with information that is systematic and repetitive. Not all information has these properties. Some information requires dialogue between parties and gradual clarification. It is highly personalized and can only be properly transmitted between people who share the same experiences, the same habits, and the same language. For this kind of information, the codification operations entails too great a loss of meaning to be exploitable by economic agents. This information, which is known as *tacit information*, cannot be transmitted regardless of distance (Foray and Lundvall, 1996). This distinction is not absolute and does not depend on the intrinsic nature of information. It refers rather both to the demand for a certain degree of complexity of a given piece of information and to the transportability of this piece by means of communication networks. We could imagine that the same piece of information might be exchanged by face-to-face contact or by telecommunications, depending on what we want to do with it. Nevertheless, we don’t aim at intergrating all the aspects of information, but only retain the most significant in terms of their spatial effects. In this sense, it seems that the distinction between tacit and codified information is a convenient and useful first step toward a better understanding of the spatial role of information.

Tacit information is of strategic value. An economic agent may have a wealth of codified information but make decisions that are not to his or her advantage because he or she lacks some piece of tacit information.

The need for geographic proximity is particularly intense when the information exchanged is tacit. In this case, proximity facilitates and enhances face-to-face encounters for several reasons. First, the probability of face-to-face encounters

occurring is greater where there is a greater density of individuals. Next, proximity means that the time spent arranging contacts can be saved, and therefore more interactions are possible. That is also a guarantee of efficiency when, as often, the decision that depends on the information sought must be taken quickly. Finally, geographical proximity is conducive to multiple contacts and so brings about other forms of proximity ties between agents, that are closer, richer and more lasting. These ties in turn are conducive to the collection, dissemination and processing of information. Mutual confidence and relational networks develop between agents, precluding opportunistic behavior. More and more reliable information is then exchanged. In addition, sharing the same world views, the same culture, and common objectives allows improved transmission, more refined interpretation, and consequently better use of the information.

"...informal conversations were pervasive and served as an important source of up-to-date information about competitors, customers, markets, and technologies. [...] In an industry characterized by rapid technological change and intense competition, such informal communication was often of more value than more conventional but less timely forums such as industry journals." (Saxenian, 1994, 33).

3.2. Tacit information and the city

These factors explain why the city is often viewed as a place that favors information exchanges in general and tacit information exchanges more particularly. The city can be defined basically in terms of the two concepts of agglomeration and diversity (Baumont, Beguin and Huriot, 1998). It brings together different agents such as firms, households but also more specifically urban actors such as research centers, universities, libraries, administrative and political authorities. Because individuals are different, they have different information. This heterogeneity between agents is the source of information exchange. The city is therefore a place where diversified information can be readily exchanged, particularly by face-to-face contacts (Webber, 1964). The city is also an organization allowing agents to coordinate their activities. Written and unwritten rules regulating competition and cooperation between firms appear after repeated contacts between agents in close proximity. These rules generate an atmosphere of trust which is beneficial to the diffusion of information, and easier selection and appropriation of the information received.

The continued existence of tacit information in the economy can provide initial insight into the explanation of the continued need for proximity in information exchanges. *The development of new information technologies only amplifies the potential for transmitting codified information over distance and does not alter the proximity constraint relating to the exchange of tacit information* (Rallet, 1997).

Empirical analyses of innovation in the United States confirms this point. Innovation is concentrated in a small number of places such as Silicon Valley and New York State. One question comes to mind: "Why does location matter to innovative activity?" (Feldman, 1994). Innovation is a complex process whose essential input is information. The information used is varied and concerns products, techniques, and consumer expectations. In addition, the information exchanged between participants in innovation is complex. Location and proximity matter for innovation (Audretsch and

Feldman, 1996) because of the complexity of the information exchanged in these processes. "Knowledge traverses corridors and streets more easily than continents and oceans" (Feldman, 1994).

Apart from innovation, a series of activities involving conception, control and services have the same complex information needs. This is the case of central administration, research centers, advertising, market research firms, culture, consulting companies, law services, and so on. On the contrary, traditional manufacturing activities need simple information only and can therefore be decentralized.

As a result there is a growing gap between the spatial effect of exchanges of codified information and tacit information. The former is compatible with increasing dispersion while the latter still involves proximity between information users.

3.3. Differentiated informations and differentiated locations

In Economic Geography, Ota and Fujita (1993) take up the general equilibrium model of Fujita and Ogawa (the main features of which are given in subsection 2.2) integrating differences in the firm's information needs and functions. Each firm is thus broken down into a front unit and a back unit which can be located separately. This spatial segregation of the firm is made possible by advances in telecommunications technology.

The front unit of each firm centralizes activities such as business or control while each back unit focuses rather on manufacturing or billing activities. Each front unit is supposed to exchange information with the front units of the other firms, whereas each back unit interacts with the front unit of the same firm exclusively. Even if Ota and Fujita do not distinguish tacit and codified information, their model seems to us to be a way of differentiating between the respective roles of tacit and codified information in the structuring of space.

Indeed Ota and Fujita implicitly assume that activities centralized in the front unit require a high level of face-to-face contacts while activities realized in back units use fewer direct contacts. If we combine this assumption with the specification about information we made in 3.1, it follows that information exchanged between front units is mostly tacit and information exchanged between the front and the back unit mainly codified.

Futhermore in this model, communication between front units is assumed to be mesurable in terms of level of contact activity i.e. by the number of face-to-face contacts per unit of time. As a result, we can argue that the agglomeration force consists in *tacit* information exchanges between firms. The advantages in communication increase with the number of firms in the agglomeration, as far as different firms are assumed to hold different information. As in Fujita and Ogawa's model, the rise in commuting costs and land prices slows the trend toward agglomeration.

In this context, each firm is assumed to choose the location of its front and back units so as to maximize profits. At equilibrium, all firms achieve the same maximum profit level, all households the same maximum utility, and the land and labor markets are cleared.

For each set of parameters there is a single state of equilibrium, but when the parameters are modified there are no less than eleven different possible equilibrium configurations. These configurations are the result of two combined effects: (1) if the commuting cost of workers falls, segregation between firms and households increases and (2) if intrafirm communication cost falls, segregation of front and back units occurs.

As a result, *advances in telecommunications technology within the firm are a major reason for suburbanization of firms*. Of course, firms can conduct all their activities in the center. In this case, both interfirm and intrafirm communications can be maintained more efficiently. But in this configuration, high commuting costs and floor rents appear. On the contrary, a firm can conduct all its activities in the suburbs but severe disavantages in face-to-face communication with other firms will occur. Therefore, given recent developments in telecommunications technology, the firm can keep its front office in the center and delocalize the remainder of its activities to the suburbs.

The figures below shows a "long narrow city" (Solow and Wickrey,1971), represented by a strip on which the locations of households (H) and firms are marked. The city center is at the geometric center of the strip. Three of the eleven possible configurations in the model (figures a, b and c) have production activities at the periphery. The front (F) and back (B) units are spatially separated and located in the city center and at the periphery of the city respectively, with their respective workers. These configurations appear when the costs of communication within the firm are low by comparison with households' commuting costs.
Configuration (b) is especially interesting. It shows three areas of residence which depend on the location of the firm's unit in which individuals work: in the city center close to the front units; in the intermediate suburbs from where workers commute to the front units; in the remoter suburbs when the individuals work in the back units.

Fig. a

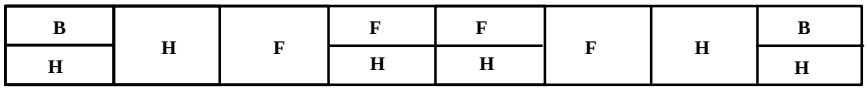

Fig. b

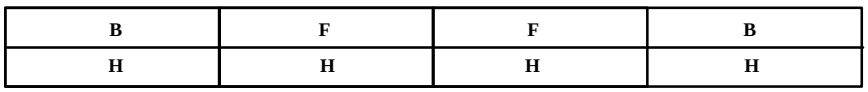

Fig. c

The New York metropolitan area is a good illustration of location pattern (b). For instance, the largest investment bank in the United States, Merrill Lynch, keeps its

front unit in Manhattan while its back unit is located in Princeton. The two units are connected by modern telecommunications equipment.

Finally, this model is able to show how the center-periphery pattern is affected by the tacit-codified information dualism. Furthermore, the explicit differentiation of the firm's functions and the resulting implicit differentiation of the information exchanged imply differentiation of location behaviors. Activities which use a lot of tacit information agglomerate whereas activities consuming codified information above all may be more dispersed.

3.4. The interdependence between tacit and codified information

The preceding informational dualism is a simple key to understanding the evolution of the city, but the two types of information cannot be defined and therefore analyzed independently. The relations between tacit and codified information are complex and cannot readily be strictly identified. Therefore, this cloudes the probable consequences of progress in the exchanges of codified information. There are very few empirical elements for enlightening the debate and the theoretical results are still poor. Nevertheless we can draw limited conclusions related to the persistence of urban growth.

A large part of the literature on the effects of the advances of telecommunications technology implicitly considers that tacit information and codified information are substitutes. From this point of view, it could be argued that technological progress means we can codify more and more information, so that it can be diffused over long distances without friction. Eventually, all shades of meaning will be transmissible by telecommunications networks. The development of the internet and of e-mail seems to be heading in this direction.

But we have grounds enough to believe that face-to-face and long distance information exchanges complement one another rather (Gaspar and Glaeser, 1996). Organizing a face-to-face contact often begins by phone or e-mail. Conversely, a first direct contact, when used for putting into shape the conditions of future routine and standardized interactions, can initiate further utilization of telecommunications. If this intuition is true, *the advances in telecommunications technology are bound to increase both long distance exchanges and face-to-face contacts*. And the fact is that both types of exchange have increased in the last twenty years.

Is there any evidence to confirm this intuition? There are so many factors affecting urbanization and the use of telecommunications that the results of empirical studies must be interpreted with caution. A number of results could illustrate the above mentioned complementarity. But there is no absolute empirical confirmation of this complementarity. We can only say that none of the evidence suggests that telecommunications and face-to-face contacts are substitutes.

Three examples from Gaspar and Glaeser (1996) support this claim.

First, we can observe that the telephone is most frequently used by individuals who are physically close to each other, especially within cities. In Japan, it seems that people living in cities tend to be more avid phone users. In the United States, telephone

spending is lower in big cities than in small ones, but higher in big cities than in medium ones; overall, telephone use is not declining in cities.

Second, the increase in the number of business trips supports the link between face-to-face contacts and telecommunications. The telephone, fax and e-mail facilitate the organization of these trips and allow people to keep in touch with home or the office while away. Despite the major change in the conditions and cost of business travel, this suggests that the advances in telecommunications technology are conducive to increased face-to-face contacts.

Third, co-authorship in economic journals has risen and currently applies to more than half of the papers that are published. It is noteworthy that the proportion of non-local joint papers is increasing, without any corresponding decline in local cooperation. This suggests that telecommunications are conducive to the development of local and non-local interactions alike.

We could add the example of scientific conferences which are increasingly organized by e-mail and over the internet. The utilization of more efficient means of telecommunication has not reduced the need for direct scientific interaction, and may even have boosted the development of meetings.

Formally, Gaspar an Glaeser consider the interplay between telephone (representing whatever telecommunications means you wish) and face-to-face interactions. They suppose that initial contacts are made by phone, allowing users to determine the quality of future interactions. Those interactions can subsequently be established either over the phone or face-to-face. It is assumed that the phone is used for more simple relationships and face-to-face exchanges for more complicated interactions. The model shows two effects: a substitution effect and a complementarity effect. The first effect appears when the telephone or e-mail is increasingly used in place of face-to-face contact while telecommunications improve. The second effect arises if the future interaction is direct. The result depends on the relative importance of these effects.

The city is viewed as a factor that reduces the fixed cost of face-to-face interactions, with the result that an increase in face-to-face contacts brings about urban growth.

The results show that the effect of improved telecommunications depends on one decisive factor. *It increases the incentive to agglomerate in cities if telecommunications are used more in cities than in the countryside*. This is supported by the observation above about the urban use of the telephone.

Even without any improvement in telecommunications, *we can expect urban growth if the degree of complexity of interactions increases*. In this case, the complexity of the information exchanged grows, which entails an increase in face-to-face contacts and thus promotes agglomeration in cities.

The work by Gaspar and Glaeser is one of the first theoretical analyses of the influence of the complementarity effect on agglomeration. Both theoretical and empirical studies should be developed along these lines.

In any case, the idea that telecommunications and face-to-face communications are complements rather than substitutes is an important element in explaining that cities continue to grow while telecommunications technology advances. This form of growth

is essentially the result of the agglomeration of information-dependent activities such as financial and producer services. Moss (1987) claims that "the rise of the modern city is integrally linked to advances in communications technology: the telephone was essential to the development of the office building, the key architectural innovation of the twentieth century city".

Nevertheless, let us point out that the complementarity between tacit and codified information is more complex than stated here. We should distinguish at least two forms of complementarity. Firstly, agents may need to exchange a series of different complementary pieces of information in order to execute a complex project. Here the complemetarity is between separate pieces of information. Secondly, a given piece of information can be exchanged for the most part in a codified form but complementary face-to-face exchange is necessary to allow the best use of this piece of information, for example at least to know how to decode that information (Cowen and Foray, 1997).

4. City systems, agglomeration and networks

It should be recalled that in Economic Geography models, city growth generates dispersion forces which limit the size of a single city. Then if population grows, other cities should appear, creating a city system.

City systems have long been subjects for study, particularly since the well-known works of Christaller and Lösch on central places. Three series of models emerge in this context: gravitational models, hierarchical models of the central-place type and stochastic models. Most of these works are geographic with quite a lot being based on purely statistical relations and cannot readily link the global spatial patterns to individual decisions and economic motives (Krugman, 1995).

Recent development of new models of city systems in Economic Geography shows the formation of more simple structures but on the basis of economic micromotives, and by explicitly introducing market structures of monopolistic competition. These models fail to consider other types of interaction, namely information exchange.

First, we set out a number of features of the economic theory of city systems. Then, we show how certain specificities of information exchanges can shape or reinforce city systems.

4.1. City Systems without information

The endogenous formation of city systems was first developed by Henderson (1974). He assumes a market for cities with free entry for a developer or local government who creates cities. With a low population, a first city is formed. This city is at equilibrium when the advantage of agglomeration generated by increasing returns (Marshallian economies, external to the firm but internal to the industry) equals the disadvantage resulting from commuting costs (which increase with city size). New cities are then created as a consequence of population increase and with the same equilibrium condition, forming a city system. Inasmuch as increasing returns are

internal to each industry, it is shown that each city in the system takes advantage of specialization in a single traded good. Because of different degrees of scale economies, different cities specialize in different goods. Henderson thus shows the emergence of a system of differentiated cities. But the spatial form of the system is undetermined because *distance and transport costs betweeen cities are absent.*

City Systems have given rise to an abundant literature. Abdel-Rahman (e.g. 1990, 1994, 1996) explores the question of the formation of systems of cities with varying degrees of specialization. In these models, agglomeration forces are the differentiation of a specialized intermediate good, scope economies, search costs on the labor market, transaction costs on the capital market and public infrastructures. What tends to agglomerate population is the consumption of differentiated goods (preference for variety) and of a local public good. There is a single dispersion force, as in Henderson: the cost of commuting. As in Henderson again, *the location of cities does not matter*. In the case of an endogenous industrial structure, cities are specialized when transport costs are low and diversified when they are high.

A third series of models is developed by Fujita, Krugman and Mori (Fujita and Krugman, 1995, 1998; Fujita and Mori, 1994; Fujita, Krugman and Mori, 1994). Fujita, Krugman and Mori's version is the most advanced and most general. Those authors present an evolutionary analysis of the formation of a hierarchical and specialized city system when population is growing. This emphasizes the role of the historical path and of the selection of a single path from among a continuum of possible paths. The agglomeration force is generated by differentiation of manufactured consumer goods. Internal scale economies are transformed into external increasing returns by means of a cumulative process between firms and workers: workers with a preference for variety agglomerate where numerous firms producing differentiated goods are located, and more firms concentrate where more consumers with a preference for variety live. Here the dispersion force is the increased costs of transporting agricultural goods to the city and manufactured goods to the periphery, as the agricultural hinterland spreads with city growth. This model generates an almost systematic hierarchical city system similar to Christaller's central place system.

Information exchanges never appear in these models. This means city systems can emerge from different processes, and information exchanges are not a necessary condition for the formation of city systems. It does not mean, however, that information does not matter. *What we are trying to suggest is that information exchanges can affect the processes of formation and evolution of city systems*. Even in the last model we examined, the nature and composition of cities is very simple and does not include the main stylized facts emphasized in subsection 2.2. In all these models, the main agglomeration force results from product variety, and the dispersion forces come from the cost of transporting workers, agricultural or manufactured goods. These models emphasize important features of contemporary urban life, but they fail to grasp an important part of the new nature of cities. Information can help us to go further.

4.2. Agglomeration and localized information

It will be recalled that face-to-face exchange of tacit information is a factor of agglomeration in cities. But tacit information can also be considered as a new dispersion factor. *Information is localized and dispersed* because many sources of information are immobile and dispersed. Thus face-to-face exchanges are sources of agglomeration, but in several places. This is not exactly a means of creating new cities and generating a city system endogenously. In fact, information is dispersed only if economic activities are already dispersed, i.e. only if a system of cities has already been formed. The local character of information then appears more as a *factor reinforcing the multilocalization of information-dependent activities*. The globalization of the economy strengthens this process inasmuch as it develops the need to receive everywhere specific information coming from a given place.

These principles can be illustrated by the case of the location of a financial center which is well described in a non-standard study by Sassen (1991) and modeled by Gehrig (1998; Gehrig, Stahl and Vives, 1994).

The main financial centers are located in a few big cities which are culturally and politically dominant: New York, Tokyo, London, Hong Kong, Singapore, Paris, Frankfurt, Zurich, Amsterdam, Milan, Toronto. It is widely accepted that the core of this financial system is formed by London, New York and Tokyo. These three cities have the highest concentration of service firms in the world. They are home to 24 of the largest brokerage companies, 63 of the world's leading banks, and 84% of world capital (Sassen, 1991). Nevertheless, two features should be pointed out: (1) the development of secondary centers can be observed in Asia, in Eastern Europe or in the Near East; (2) certain financial activities, such as foreign exchange dealing, are decentralized.

How has this global system been formed? What can be the effect of information on its spatial structure? Specialized services and finance are the most information-dependent activities and the prime users of telecommunications infrastructures.

Let us examine the agglomeration and dispersion forces at work in financial markets.

Among the specific centripetal forces, we find scale economies in the payment mechanism, liquidity (realized when individual transactions have only a weak influence on prices) which makes the market less risky, and informational externalities: the proximity between several financial intermediaries stimulates communication between agents and allows access to specific information which is not available on computer screens (Gehrig, 1998). Decisions on the financial markets must be taken rapidly on the basis of complex information. Face-to-face contacts are the prevalent means of exchanging such information. Just as for any other activity, a diversified labor market, allowing better matching, is an agglomeration force too.

Under these circumstances, there should be a single enormous market concentrating all transactions. If traders were all risk averse, all trade would take place on the most liquid market.

But the main question is why is there not just one financial center. Well, because of dispersion factors, the most interesting of which, for us, is *localized information*. Information relative to production, tastes, and policies, is local. If it is a necessary

component of strategic decisions, it creates a domestic bias which generates dispersion. Gehrig, Stahl and Vives (1994) have shown theoretically that sufficient information asymmetry between markets is a condition of a dispersed equilibrium of financial places. If this asymmetry vanishes, a single concentrated market appears.

Now advances in telecommunications technology can reduce the impact of information asymmetry and access costs, which could increase the possibility of greater concentration of financial centers. But financial traders use complex information which cannot be standardized and which is only locally available, and locally exchangeable through face-to-face contacts. True, simple information can be transmitted almost instantly. Yet the speed of transmission of complex or sensitive information is more problematic. Numbers can certainly be easily transmitted at high speed. Interpreting them may require interaction, the use of speech, and face-to-face communication.

New technology can only affect certain routine activities such as foreign exchange or simple financial services. These activities are more or less independent of complex information exchanges and of the other preceding agglomeration factors and can then be located anywhere. This is a special case of the general analysis of the separation of front and back units by Ota and Fujita (1993) which we referred to in the previous section.

To conclude on this point, the source of information here plays the same role as the first nature factors in Krugman's models. The multilocation of financial centers is due to the localized character of a strategic input which is not readily transportable : tacit information. This factor results from existing concentrations of economic activities and is therefore a cause of reinforcement of the polarization of a city-system.

This analysis could be generalized to any type of information-dependent services when the tacit information it consumes comes from already localized production activities.

4.3. Informational infrastructures: agglomeration and networks

On the basis of the preceding developments, we are already able to state that information exchanges could giverise to the current development of systems of tertiary cities and even a reinforcement of polarization in certain more-favored metropolises.

We have pointed out that when telecommunications improve, complementarity involves an increase in both electronic and face-to-face information exchanges. The first type of exchange develops through intra- and above all inter-urban telecommunications networks; the second type takes place through face-to-face contacts, mainly in cities. Insofar as the two types are closely related in every interactive project, cities are not only places where people and activities agglomerate using face-to-face exchanges but also the sources and destinations of most long distance information exchanges.

At this stage, it seems that we accept the assumption that exchanges of tacit information take place mainly in cities while exchanges of codified information will occur mainly between cities. Sure, this could be considered as a simplification because (1) many exchanges of codified information occur in cities and (2) individuals located in remote cities do exchange tacit information by means of business trips. But the

simplification is not meaningless insofar as (1) because tacit information and codified information exchanges are complementary, both take place in cities and then both generate agglomeration forces, directly or indirectly ; (2) business trips confirm the necessity of proximity for tacit information exchanges; but they can only be used to meet specific informational needs, because these trips are costly, mainly in terms of time; hence they cannot be a usual means of tacit information exchanges.

Cities have two roles with regard to information: (1) they are places of agglomeration facilitating exchanges of tacit information, and (2) they are privileged points of entry into networks for standardized information exchanges.

Let us look more closely at the second point. It is in itself a sufficient reason for dismissing the "demise of cities" syndrome. Even if telecommunications could replace face-to-face contacts entirely, we could still believe in the durability of cities. The reason for this lies in the economic and technical constraints on the structure of physical networks. Here we must introduce the distinction between information and telecommunication infrastructures.

First, a number of technical characteristics of telecommunication networks have been emphasized. In the United States, telecommunication infrastructures are developed using optical fibers which allow very high-volume information exchange between centers (Moss, 1987). This may involve some form of scale economies in the transmission of information, which gives a comparative advantage to big cities as points of entry into the network. This is just one example of the suspected general feature of scale economies in the entries into a telecommunications network.

Satellite communication, on the other hand, is more conducive to information exchanges from one centre to many others or vice-versa. This technique gives rise to more decentralized exchanges and is less advantageous to big cities (Moss, 1987).

Second, even if standardized information can be exchanged instantly at a very low variable cost, the dispersing role of telecommunications advances is not so obvious, because actual entry into the network can be costly and is often based on comparatively high investments.

The boom in cybercafés offers only a small illustration of a more general phenomenon. But it is indicative of a need to concentrate the points of entry to the worldwide web. It is probably the result of scale economies in entry costs. But it is also evidence of a further type of complementarity between our two forms of information exchanges. Cybercafés are not only agglomerations of points of entry to a network, they also allow direct contacts between users. These contacts can provide help in learning to utilize the network and induce new contacts through the web.

More general and significant is the point that information techniques still use complex physical infrastructures including real estate which imply large investments in capital and innovation (Sassen, 1991, Castells, 1996). This gives existing telecommunications centers a comparative advantage. Communications facilities have not been dispersed. If only a small number of centers appear and if entry costs are sufficiently high, further entries will concentrate in these centers and increase the polarization of the city system. This gives rise to a cumulative process which is typical in Economic Geography, although it was first suggested by observers from other disciplines (Moss, 1987; Castells, 1989, 1996; Sassen, 1991).

The following description of this process resumes most of the preceding arguments.

Firstly, observe the concentration of certain information-dependent specific activities such as producer services. The advances in telecommunication technology allow these activities to be located away from their respective customers and from commodity production. But these specialized services use frequent face-to-face contacts with each other, because the information needed is complex and urgent. Therefore these activities agglomerate in cities. But they need long distance contacts too, because they are remote from other economic activities and because localized factors, such as local information, sustain a system of cities. Accordingly the new telecommunications infrastructures are built where existing firms are located, creating a series of information centers which in turn attract new user firms, which stimulate the expansion of the telecommunications infrastructure, and so on.

This description conceals two interconnected and reinforcing processes.

(1) The informational dualism allows the spatial separation of traditional production activities and intensively information-dependent activities. The greater the extent of decentralization of the former, the greater is the tendency of the latter to agglomerate.

(2) Agglomeration of information-dependent firms attracts information infrastructures and creates nodes of information networks which, given entry scale economies, attract information-dependent firms.

Finally, we could view the complementarity city-network as the result of interplay between two economic forces: agglomeration economies and network economies. Being located in a city reduces the cost of face-to-face and long distance information exchanges alike.

4. Conclusions

Current models of city systems in Economic Geography are based on market interactions and essentially on product differentiation. It is suggested here that information exchanges could be the source of cumulative processes which can reinforce urban concentration. In view of the preceding arguments, the following concluding propositions can be advanced:

(1) Simply treating information as a special case of non-market interaction fails to account for the current pattern of urban growth and new forms of city systems.

(2) The permanence and growth of cities crucially depends on the permanence and increase of face-to-face contacts and on the complementarity between tacit and codified information.

(3) The localized character of information can contribute to explaining the existence or the persistence of a multicentric spatial structure.

(4) The existence of costs of entry and scale economies in telecommunication networks can reinforce the polarization in cities as nodes in telecommunication networks.

It should be possible to construct an information-based theory of urban growth and of city systems if the foregoing factors are incorporated into a formal model.

Even if it is based on some important stylised facts, the preceding analysis is mainly theoretical. A next step might be more empirical. But testing information-based models of urban growth and of city systems empirically raises a number of methodological problems. Krugman (1991) stresses the importance of the diffusion of information and knowledge between the firms and the existence of borders to informational flows, more particularly for tacit information. But he avoids the problem, considering that anything can be assumed about informational externalities. There is no « paper trail » to measure and to track them. Two main troubles arise. First, tacit information exchanges do not leave any mark. So it seems impossible to know how much information is exchanged and where and how the exchanges take place. Second, codified information exchanges seem easier to locate. New technologies are used to exchange codified information, so that emission and destination places can be easily identified. But the amount of information transmited is unknown: for instance, when you send a fax, there is one information flow but more than one piece of information can be diffused. Furthermore, if we take into account only codified information exchanged by new technologies, we forget the codified information that is exchanged by face-to-face contacts.

Nevertheless, empirical studies have been conducted into the local character of the diffusion of tacit information. Most of them confirm the importance of the exchange of tacit information in the agglomeration of activities, arguing that activities using tacit information intensively are highly concentrated. Such an observation can only be considered as an indirect and imperfect test of the role of information, first because other things are not equal, so that other factors may affect the concentration of these activities, second because these studies do not grasp the underlying process which can explain why and how tacit information interactions generate agglomeration. It seems difficult but necessary to go further and to initiate both theoretical and empirical research on informational needs and on information flows.

Finally, we wish to suggest some controversial prospects. The growing role of information, together with the advances in telecommunications technology, seems to favor urban concentration and the polarization of economic space in a system of global metropolises exchanging information with each other. We are entering upon a new era in the history of cities. The city-states of Ancient Greece came to dominate civilization and they grew quite independently of their hinterlands. During the Renaissance, world trade was dominated by cities rather than by states or regions. Because contemporary big cities allow face-to-face contacts and facilitate entry into telecommunication networks, they concentrate key economic activities. They will therefore form a system which –at least for certain key-activities– will operate almost independently of nations or regions.

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Abstract

Present-day city growth is chiefly the result of new tertiary activities such as financial and producer services, R&D, or business administration. It seems that these activities need to be more spatially concentrated than traditional manufacturing activities. These new trends affect both the structure of cities and the structure of city systems.

The specific nature of the new activities concentrated in city centers makes them information intensive. These activities consume human capital, knowledge and high-tech capital, which are all rapidly changing inputs; they are based on complex decision-making processes; this renders them highly information-dependent. Inasmuch as these activities are the main key to understanding the city, information must play a leading role in understanding urban forms and urban growth.

In the framework of Economic Geography, we propose to focus on a number of features showing that information and telecommunications technology not only are compatible with contemporary city systems, but also help explain the formation of these city systems. We then examine *the ways in which cities and city systems are affected by information*.

The following points can be made:

(1) Simply treating information as a special case of non-market interaction fails to account for the current pattern of urban growth and new forms of city systems.

(2) The permanence and growth of cities crucially depends on the permanence and increase of face-to-face contacts.

(3) The complementarity of face-to-face exchanges and telecommunications can explain agglomeration in cities.

(4) The existence of costs of entry and scale economies in telecommunication networks can reinforce the polarization in cities as nodes in telecommunication networks.

Key-words

Information, Urban Economics, Urban Growth, City Systems.