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URBANIZATION AND DEVELOPMENT
THE TEMPORAL INTERACTION BETWEEN GEOGRAPHICAL AND SECTORAL CLUSTERS

by

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1. INTRODUCTION

In a previous paper,[1] we tried to clear the main theoretical basis of growth pole theory from the encumbering detailed pieces developed for its application. In our opinion, the hypothesis originated with Perroux. Following Schumpeter's lead, Perroux stated that economic development results from the adoption of innovations; then, extending Schumpeter's view, Perroux[2] implicitly advanced the main hypothesis that innovations in several subsidiary lines will follow in the wake of an innovation in a dominant industry, and that they locate in geographical clusters around the same industry. For these clustered imbalances (in sectoral and geographical space) he coined the name "growth poles" (pôles de croissance).

Ever since, the basic hypothesis has been neglected. In consequence, the concept has been misused and its significance reduced. As a result, a great part of its potential analytic value has remained unused. This can be mostly attributed to semantic confusion,[3] and also to the special twist the French School has given to the line of research Perroux started, through the incorporation of ready-made analytical tools (with different theoretical foundations) in which the School has indulged as a means of bringing about the immediate transformation of the theory into a planning method.[4]

1/ J. R. Lasuén: "On Growth Poles" in Urban Studies, June 1969.

2/ F. Perroux: "Les pôles de développement" in Economie Appliquée, 1952 and "Note sur la notion de Pôle de Croissance" in Economie Appliquée, January-June 1952.

3/ All reviewers of French growth pole literature have made this point: Darwent, Hansen, Hermansen, Lasuén, etc. Hansen was the first; see his "Development Pole Theory in a Regional Context" in Ky-Klos, XX.

4/ Immediately after the appearance of the growth pole concept, the French School tried to use it in policy. This had two consequences. In the first place, in order to quantify the notion, the French School relied on the only available congenial accounting device, input-output analysis. This drained the concept of geographical dimensions, practically reducing it to that of an inter-industry cluster. In the second place, it stopped further theoretical research on Perroux's approach. For a more general exposition, see J. R. Lasuén "On Growth Poles" in Urban Studies, June 1969, pp. 140-141.

In another paper,[5] we hinted at how the growth pole concept could be reformulated in a manner more consistent with present regional planning needs and yet compatible with the traditional and subjacent extended Schumpeterian framework.

Later,[6] more specifically, we have suggested that, in order to serve the main purpose of regional planning today (the regionalization of national development), growth pole theory should refer to the system of poles, rather than to the single pole. The concept of a system of poles has also the additional advantage that it unavoidably introduces the notion that, although obeying the same type of polarization forces, growth poles need to be differentiated by size and composition; thus, it directs attention towards the general factors responsible for polarization and towards the specific factors creating the different kinds of poles. Hence, it makes the notion more general and more applicable to different environments; satisfying the diverse planning demands of nations at different levels of development.[7]

But in order to pass from the conventional idea of the large heavy industry pole to that of a system of diversified poles, some changes in the concepts and hypotheses of growth pole theory are required. In the paper referred to, we advanced the following ideas which seem both feasible and necessary: (a) The growth pole is a regional (instead of national) sectoral

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5/ See J. R. Lasuén "Urban Hierarchy stability and spatial polarization" in Urban Studies, January 1970. A more general argument about the relations of the concept with the different branches of regional economics, which amounts to the same, is made by H. W. Richardson: Regional Economics, London 1969.

6/ J. R. Lasuén: "A Generalization of the Growth Pole Notion". Paper for the International Geographical Association Meeting, Vitoria 1971.

7/ As expressed in papers concerned with the highly developed countries case, like N. Hansen's "How Regional Policy can benefit from Economic Theory" in Growth and Change, January 1970; and in those concerned with developing countries, like R. P. Misra's "Growth Pole Hypothesis Re-examined", paper presented at the Madrid Conference on Growth Pole Hypotheses and Policies, September 1970.

cluster of establishments (instead of industries) linked to a regional export activity (instead of a leading industry), which is located in one or various of the geographical clusters of the region; (b) The system of growth poles, and any one of them, grows through the impulses generated by national demand, transmitted through the regional export activities and adjusted by inter-pole competition; (c) Growth is transmitted to the sectoral peripheries of the pole through the forward and backward market linkages (instead of input-output linkages) between the establishments, and to the geographical periphery through the effect of the same mechanism corrected for locational factors.

In other words, to pass from the single pole to the system of poles, it seems necessary to relate the framework of growth pole theory with those of central place theory and industrial structure analysis, after correcting the specific hypotheses in any one of those analytical bodies that made them more adequate for the specific purposes for which they were originally developed.8/

Specifically, to explain the growth of the system of poles, it is necessary to use a mixture of central place structure and industrial structure analysis mechanics. We need, in effect, to conceive the growth of the cities in a country as being the reaction of a system of differentiated and interrelated nuclei, each specialized in one or several export activities around which the other activities coalesce with varying intensity to the impulses generated by national growth. But for the explanation of the evolution of the system of cities, we need the growth pole approach, for no other framework is as well fitted to explain why and how the newer activities will come about and locate. Thus, it can easily be

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8/ Conventional growth pole analysis to explain big-industry clusters; Central place theory to understand service activity location; Industrial structure analysis, to relate national and regional growth patterns.

hypothesized that the present system of poles is the result of the impact of a past system of innovations and that newer systems of poles will be brought about by newer systems of innovations.

The latter general hypothesis, however, needs to be completed, for Perroux went no further than stating that the pole results from an innovation in the leading industry which induces further innovations among its dependent activities. The object of this paper is precisely to enlarge upon this thesis and to aim at the elaboration of a hypothesis that will explain how the successive innovations originate, are diffused and adopted and finally result in successive sets of growth poles.

The main purpose behind this object is to complete, though tentatively, the principal lines of a framework initiated in the papers quoted. This can help us to understand the interrelations between the processes of technological change (and derived economic growth) and geographical use of space or, in brief, between economic development and urbanization.

The method used is determined by the purpose and object of the analysis. It consists in differentiating the two components that can be appreciated in a growth pole, from the economic development and urbanization perspectives respectively, finding the explanation of each of the two and relating them at the system of poles.

However, in more precise terms, in the extended Schumpeterian frame-work, a growth pole is both a set of highly interrelated activities (sectoral cluster) highly concentrated over the territory (geographical cluster),[9/] as Perroux hypothesized. The analysis of the interaction between poles, therefore, needs to provide three sets of hypotheses: those explaining the sectoral clusters; those indicating how geographical clusters occur; and those revealing how the interactions between sectoral and geographical clusters result in a system of growth poles.

In developing these three sets of hypotheses, we begin by setting up an analytical frame of reference. This frame is drawn up in accordance with two principles: (a) That in order to analyse the interactions between a temporal economic analysis (development) and a spatial economic analysis (urbanization), the frame-works of both analyses need to be related; and (b) That temporal economics is a much more solidly built analytical body than spatial economics, hence integration of the two should be carried out, redesigning the latter along the analytical lines of the former.

9/ The first author to formulate clearly the distinction between the two concepts (sectoral and geographical clusters) within the growth pole notion, was D.F. Darwent "Growth Poles and Growth Centres in Regional Planning. A Review", in Environment and Planning; vol. 1, 1969. The sectoral cluster, he called growth pole; the geographical cluster, growth centre.

On the basis of these two principles, we select the analytical units and the approach to be followed. The units chosen are cities and establishments (industries). The approach is dynamic-geographical, that is to say: (a) Exogenous impacts, generated at different points in time, change the values of the variables (cities and establishments) and result in structural changes in the economic and urban systems; (b) The variables are not adjustable to the same spaces; (c) The magnitude of the variables in space is influenced by their initial value and by the space lag between them.

Within this frame we first proceed to formulate operationally the main hypothesis to explain the system of poles. This hypothesis consists of two parts: (a) Development and urbanization patterns (as defined by the changes in the systems of activities and cities) are the temporal and spatial traces of the process of innovation adoptions; (b) Innovations occur in clusters, which causes the sectoral and urban traces of innovations to be discontinuous.

Next, we move on to search for the specific hypotheses explaining why sectoral and geographical clusters form and what are the interactions between them, drawing, in a final section, some general policy conclusions.

Some words of caution are needed before we begin developing the argument. First, regarding the names of clusters. Several authors have attempted to differentiate clusters by size, by the type of activities involved, etc.[10/] and have given them different names. If used wisely, this may be a useful procedure. The meaning we give to sectoral and geographical clusters is quite general and functional; it ranges from the very small to the very large, from the simple to the complex, because the mechanism explaining them is functionally the same. Differences in magnitude and quality among clusters need to be explained by differences in the impacts received by the clusterization mechanism, not by differences in the mechanism.

Secondly, throughout this paper, we identify the development process with that of the generation and adoption of innovations. The generation of innovations is hardly a national process, but an international one. Nations may develop to a greater or lesser extent relatively to others by the more

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10/ See, for example, R.P. Misra, op. cit. (see 2, above).

or less rapid adoption of innovations brought forward internationally. This depends on the policies they follow; but, in most cases, the over-all development process itself is hardly influenced, and national development policies are, therefore, necessarily adoptive. Urbanization is also a world-wide phenomenon, but its national patterns, although subject to a common trend, vary significantly, depending upon the climate, size, history, population, etc. National urban policies are therefore less conditioned by the world urban patterns, and can be considered autonomous and creative. What we do, then, is to establish a frame in which an international phenomenon --the development process--affects countries according to the way national phenomena--the national urbanization processes--react to it.

Apart from the above technicalities, two broader qualifications are needed. In the first place, we conduct the argument mostly in economic terms. This does not mean that we find the social, political, institutional, cultural, etc., factors to be inconsequential in the processes analysed. Rather, we believe, for example, that a process of economic growth necessarily implies the growth (i.e. increase in the magnitude) of all other social, cultural, etc., indicators; we also believe that a process of economic development necessarily implies equivalent structural changes in the social, political, etc. dimensions. Neither do we mean that strict economic or urban planning should be the active policy and that all other social and cultural policies should be adapted to it. In fact, we argue that organizational policies (normally well within the institutional realm) are critical and neglected elements in the fields of development and urbanization. In other words, our simplification is exclusively a reflection of professional specialization.

Finally, as will be obvious throughout the paper, our experience is restricted to the Western world. Our conclusions, therefore, if the argument is valid, can only be directly addressed to that world. This last limitation has been unintended. The industrial location study by the United Nations European Economic Commission [11] made us aware of the great concern and

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11/ A. Kuklinski: Criteria for Location of Industrial Plants (Changes and Problems), United Nations, New York, 1967.

considerable work done in the Eastern world on the inter-relations between sectoral and regional planning. Consequently, we have gone through the relevant literature published or translated into Western languages. Although we have learned enough from it to conclude that a comparative analysis of the two experiences, both Eastern and Western, would be very illuminating, we do not feel competent to extend our analysis to cover the Eastern world at the same level as the Western one.

2. URBANIZATION AND DEVELOPMENT: A FRAMEWORK OF ANALYSIS

Present-day interest in spatial economics is similar to that of the thirties in temporal economics. Both are a rejection of the abstraction of time and space in classical economics, and a product of deep dissatisfaction with the distribution of economic events within the two dimensions.

For a while, the two interests, temporal and spatial, were pursued independently. In the past few years, however, great concern for the inter-relations between the two has developed. This concern has crystallized out in the need to analyse the interactions between the development and urbanization processes.

The development and urbanization fields are partial areas within temporal and spatial economics respectively. Accordingly they follow different analytical lines. The possibility of relating their respective theoretical frameworks is a sine qua non for the analysis of their interactions. It is because this condition is not actually met by economic analyses that existing attempts to study the relation between the two processes are purely statistical manipulations of indexes relating to the two.[12/]

12/ Since the appearance of the Kingsley Davis papers (K. Davis "The Origin and Growth of Urbanization in the World" in American Journal of Sociology, March 1955, and K. Davis and H.H. Golden "Urbanization and Development of Pre-Industrial Areas" in Economic Development and Cultural Change, October 1954), several authors have tried to test empirically the relation between the urbanization and development processes.

Next, we attempt to formulate the basic lines that such an analytical framework might have. These basic lines are consistent with Perroux's insights. In other words, we use the "growth pole" notion as the starting point and develop it in the hope that it may serve to integrate the relevant fields (development and urbanization) of temporal and spatial economics.

We start with a simple proposition on which we base the argument: temporal economics is a much more solidly built analytical body than spatial economics. Consequently, integration of the two should be carried out by redesigning the relevant fields of spatial economics along the analytical lines of temporal economics.

Our starting point sounds more radical than it is. Redesigning spatial economics has few costs because: (a) in its present state, it has no definite form. As Meyer has pointed out,[13/] it is, in some sort, standard economics "scaled down" to regional and urban levels; (b) the miniaturization approach it follows is inadequate under current conditions. As an illustration: temporal economics would not fulfil its present demands if it were formulated as the analysis of economic events in smaller time units (months instead of years); instead, temporal economics focusses upon the effect of time on economic relations; correspondingly, spatial economics should be concerned with the effect of space on economic relations.

To find the analytical framework spatial economics should take, we must first lay bare the analytical guidelines of temporal economics and then discover their logical equivalent in the space dimension. This we do next, as briefly as possible.

13/ J. R. Meyer, "Regional Economics. A Survey", in Surveys of Economic Theory, 2, MacMillan, London 1965, pp. 240-270.

2.1 The analytical framework of temporal economics

Temporal economics has two main components: growth economics and development economics. Both deal with different questions, have diverse structures and use different units and types of analysis. Yet, they can be related, and, in fact, are commonly related both in research and in policy-making. In what follows we stress the differences between them.

Growth economics originated in response to the need to control business cycles; consequently, it is a short-term analysis. Development economics has existed since classical times as a response to the problem of secular stagnation; it is, therefore, a long-term analysis.

Growth economics focusses on the causes and characteristics of the system's growth, (a process in which the increments of the system take place by means of proportional increments in its component units, i.e. without structural change). Development economics concentrates on the causes and characteristics of the system's development (a process in which the increments of the system take place by means of differential increments in its component units, i.e. with structural change).

Of course, in real life it is hardly possible to find instances of growth without development as parts of a single process. Yet the differentiation in the two above-mentioned processes is needed because of the methodologies elaborated to tackle the two original problem areas. The business cycle has always been considered a temporary malfunctioning of an otherwise efficient machine; secular stagnation, a permanent symptom of an inefficient machine. Logically, then, in the second case, the problem is to build a new machine, to create a new structure; in the first, to repair the existing machine—to bring all the pieces to the original level of performance. The different evaluations of the problem areas have affected the basic analytical structure of the two disciplines. Both of them, like most predictive sciences, consist of two analytical parts: one depicting the "normal" behaviour of the system (to be maintained), the other, the deviations from it (to be corrected). In growth economics, the normal behaviour, abstracted into a "steady state" path, is the highest potential performance of the system's structure. In development economics, the

"normal" behaviour to be achieved cannot be, and is not, the optimum performance of the existing structure, but rather an idealized path obtained by means of projecting the performance of successive structural changes; contrarywise, abnormal behaviour (to be changed) is the past performance.

The character of the two analyses, and the selection of the system's components as analytical units are also influenced by the factors indicated. Most authors today agree that the basic cause of short-term fluctuations is disparity between ex-ante savings and investments caused, and subject to correction, by changes in fiscal and/or monetary instruments. Consequently, the variables of growth economics are neo-Keynesian income and monetary aggregates, and growth analyses are restricted to the study of the patterns of change and carried out mostly in "dynamic causal" form,[14/] i.e. are mainly directed towards determining the pattern and form of the changes in variables over time as influenced by the time-lag between them and their initial value (not by the causes determining their initial value). Development economics, on the other hand, although also interested in the form of its normal behaviour pattern, is much more concerned with the causes of it, simply because these are not well known. Consequently, it is forced to follow a "dynamic historical" approach [15/] aimed at determining: (a) which factors are needed to create the successive structural changes; and (b) what is the pattern of change of the variables over time, as influenced by their time-lag and by the successive changes in their initial value, subsequent to the changes in the system's structure. Also, since the causes are not well known, there is no definite agreement on which the analytical units should be. Both income aggregates and inter-industry sectors and branches are used, though the tendency seems to be to prefer the latter.

14/ For this, and the subsequent definitions, see P.A. Samuelson: Foundations of Economic Analysis, Cambridge, 1947; pp. 311-349.

15/ See 14, above.

Since human beings normally value time more than space, as is revealed by tradeoffs between time and space preferences when these are in conflict,[16] it is difficult to ascertain whether a specialized subject will ever develop in spatial economics for the purpose of determining the changes over space of economic variables, as influenced by the space-lags between them and their values in the initial situation. But, as has been said above, urbanization economics, to which it should be related, is in great demand. After the foregoing comments, we can attempt to outline the basic characteristics of such an analysis.

2.2 A framework for spatial economics

To start with, this analysis should study long-term changes in the magnitudes of the economic variables over space accompanied by the corresponding structural changes in these variables.[17]

This analysis should be subdivided into two main parts. One dedicated to determining a normal process of structural change. The other directed towards explaining the divergences, present and future, from that normal behaviour.

16/ This can easily be observed in everyday planning experience, both in the West and in the East. The conflict between higher efficiency (faster national rates of growth) and greater regional equity (more similar regional income per capita levels) is normally solved in favour of the former. For an evaluation of the conflict in the West, and for an attempt to provide an analytical framework for decision making see, among others, W. Alonso's papers: "Urban and Regional Imbalances in Economic Development" and "Equity and its relation to Efficiency in Urbanization", mimeographed papers, Centre for Planning and Development, University of California, Berkeley. For the East, see, among others, papers by the Polish economists and planners: K. Secomski, K. Dziewonski, A. Kuklinski, etc. For a summary of their views see J. Pajestka: "Over-all Economic Planning and Regional Planning in Poland", paper for the Third Meeting of Senior Economic Advisers, Geneva 1964.

17/ To be the logical opposite of development economics.

The analytical approach be dynamic-geographical. By this, which is directly equivalent to Samuelson's definition of a dynamic-historical approach, we mean a construction in which: (a) the variables of the system are systematically affected by exogenous impacts which are generated at different points in space and change the system's structural relations; (b) the variables do not become adjusted in the same space; (c) the magnitude of the variables over space is influenced by the initial values they take after each successive structural change, and by the space-lag between them.

The units of analysis should be the more relevant spatial units, namely, the ones that refer most directly to the basic structural changes to be analysed.

Our framework needs to include the previous analytical characteristics, plus those derived from its purpose to relate the analysis with development economics. We determine the latter following the main traditional assumption of space economics, which considers the development and urbanization processes to be roughly the time and space projection of each other. The assumption, in effect, implies the following characteristics.

In the first place, it means that the units of one analysis need to be convertible into the units of the other. In its turn, this demands, for example, that development needs to be explained in terms of industries and regions and urbanization in terms of regions and industries. In other words, the need to relate the pattern studies by the two analyses results in the need for common units in the two analyses. Which should these units be? Urbanization is normally studied in terms of cities and/or regions; since it appears that the old discussion about polarized or homogeneous regions has been settled, and most authors agree that a region is centred around a city and a city does not make sense without a region, it is analytically irrelevant which one we choose. We have selected cities, because data on cities are easier to collect. Development is analysed in terms of industries and/or income aggregates. Since, in our

definition, the sectoral cluster is a set of establishments,[18] and industries can be disaggregated into establishments, we have selected cities-industries (establishments) for the two analyses.

In the second place, if one hypothesizes, in conformity with common opinion, that the patterns of the two analyses are the respective rough projections of each other, this implies that the two processes obey a common set of actors with only a few independent ones which account for the divergences among the pattern projections.

In accordance with this, we have chosen the simplest possible scheme. We first hypothesize that the two processes obey the same general factor; that is to say, that national development and urbanization patterns are the temporal and spatial traces of the process of the adoption of innovations. Yet, that those spatial and temporal traces can differ among countries, at a point in time (and for the same countries, at different times), owing to the different sets of geographical conditions which control the adoption in diverse countries and to the changing characteristics over time of the international innovation process.

Our second main hypothesis is that the temporal and spatial traces of innovations are discontinuous. In other words, that innovations occur in clusters both in space and time, and that sectors and cities will be adapted to successive time and space sequences until new cluster-like impacts of successive innovations take place. As we shall see, there are reasons for maintaining that, in effect, innovations occur in packages. There are also reasons for stating that innovations take place continuously. The decisive factor for selecting the hypothesis of a discrete flow of innovations has been that it is easier to handle.

18/ J. R. Lasuén, op. cit. (see 6, above).

The framework introduced is based on previous contributions. In development economics, since Schumpeter,[19] it has been accepted that the basic agent of development is technological and organizational change.[20] In urbanization economics, Lampard has put forward the same factor.[21] At least implicitly, Perroux was the first author to hypothesize that both development and urbanization resulted from the innovation process.[22] We follow Perroux, adding that innovations progress in cluster-like fashion affecting the system of growth poles.

Our next endeavour is to explain why innovations cluster in sectoral and geographical space, causing structural change in the two spaces, and how the systems of activities and cities are adapted to those impacts. Later we analyse the interactions between the clusters in the two spaces and their effects.

19/ J. A. Schumpeter: The Theory of Economic Development, Cambridge, (Massachusetts), 1954.

20/ In all textbooks. For example, B. Higgins' Economic Development, New York, 1968.

21/ E. E. Lampard, "The History of cities in the Economically Advanced Areas" in Economic Development and Cultural Change, January 1955.

22/ F. Perroux, op. cit. (see 2, above).

3. SECTORAL CLUSTERS

3.1 The static view of sectoral clusters

There is a fairly precise notion of sectoral clusters, which abstracts these from space —as it should— and also from the time co-ordinates of the cluster, which it should not. This static notion, coinciding with Perroux's first ideas, was developed at the end of the fifties, in the work of Hirschman,[23] Chenery and Watanabe,[24] and Isard and Schooler,[25] for different purposes.[26]

The notion originated in the context of inter-industry analysis and is heavily dependent on input-output hypotheses. In a triangular matrix system, a sectoral cluster is constituted by an industry which buys and sells mainly from and to a subset of industries and through that subset.

In a universe of firms, the sectoral cluster would be constituted by a firm that sells and buys mainly from and to a group of firms and through those firms. As in the case of industries, the relative importance of those clusters will depend on the technological characteristics of the firms' production functions; but being firms, it will also depend on the organizational traits of those firms. Thus, an economy of single-product firms is likely to show more sectoral clusters than an economy of multi-product firms; similarly, an economy of vertically integrated firms will be less likely to show significant sectoral clusters than one of horizontally integrated firms.

Clusters of firms may be relatively more intense than clusters of industries, because firms can cluster both because of the technological reasons of industries and on account of their own organizational factors. Yet, we do not have any indication of the significance of such clusters, because research on sectoral clusters has been restricted to industries, and regardless of technological and organizational change.

23/ A. O. Hirschman: The Strategy of Economic Development, New Haven, 1958.

24/ H. B. Chenery and T. Watanabe: "International Comparisons of the Structure of Production", in Econometrica.

25/ W. Isard and E. W. Schooler: "Industrial Complex Analysis: Agglomeration Economies and Regional Development" in Journal of Regional Science, Spring, 1959.

26/ See evaluations in D. F. Darwent, op. cit. (see 9, above) and J. R. Iasuén, op. cit. (see 6, above).

Nor do we have any data on clusters of establishments. Yet, since establishments can be directly aggregated into industries and their mutual inter-changes are not so subject to organizational changes, we can use industry clusters as proxies for establishment clusters. Although this procedure systematically underestimates the importance of establishment clusters, because clustering of the interchanges between establishments within the industry can take place without being taken into account in the industry clusters, at least it permits us to refer our concept of regional sectoral clusters [27] to available experience on industry clusters, provided two corrections are made: one, for the underestimation mentioned above; the second for the differences in the definitions. Thus, to qualify as a regional establishment cluster, an establishment cluster (and its proxy) has to be based on a regional export activity.

The concept of industry clusters is firmly rooted in the idea of the technological complementarity of industries. The same idea is the basis of policies that use industry clusters as their main instrument: the existence of industry clusters is normally interpreted as a means of inducing the growth of other industries. Thus, the installation of the leading industry in a cluster is thought to call for the installation of industries linked to it via its input-ouput linkages.[28]

3.2 Sectoral clusters in a time perspective

The notion of technological complementarities, however, is too restrictive. Industry clusters are the product of complementarities, but not exclusively technological ones. In effect, shifting to a historical perspective, it is easy to show that present input-output industry complementarities within a cluster are the resulta of the previous clustering of activities which has resulted in industry clusters. Since today production functions are dated final developments of dated innovations, the cluster-forming complementarity requirements observed among production functions, at a point in time in an input-output table, must have existed at all previous points among the temporal processes from the innovation to the installation of the respective industries.

27/ J. R. Lasuén, ibid.

28/ This is Hirschman's original argument. For an example of its use in connexion with growth pole theory, see J. R. Boudeville, Problems of Regional Economic Planning, Edinburgh, 1966.

The observation of sectoral clusters in the time perspective they have originated leads to the conclusion that they are not the haphazard result of high technical complementarities between industries. Rather, they are the final materialization of complementarities between the ways of doing different things, which exist throughout the processes of development of those ways, from their inception to their application. Industrial clusters must have been preceded by innovation clusters. Present inducements to instal a cluster of an industry's complementary technologies have been preceded by equivalent inducements to invent, innovate, try out and adopt the clusters of activities that have resulted in that industry complex.

3.3 The relative relevance of the atemporal and temporal hypotheses on sectoral clusters

Next, we comment on why this phenomenon has not received any attention in the past, why attention has recently been turned to it and, finally, why it should from now on be considered central to economic development.

In the past, the successive cluster-forming adjustments to these complementarity inducements at all the stages in the invention-installation processes, have been long. Hence, people have not become aware of these complementarities, and attention has remained fixed on the final technological complementarities.

In effect, the time-lags between each phase in the process (invention, innovation, try-out, installation), and the time-lags within each phase, between the originator and the final adaptors, have taken many years, because all the decisions involved have been made individually (and in isolation) in response to the impacts registered and transmitted through imperfect markets, where transportation and communications have been deficient and slow. The time-lags have, indeed, been so long that the cluster-forming mechanism of complementary inducements at the different stages of the innovation processes has been of no practical significance for policy-making. In turn, the lack of policy significance explains why the topic has not received any theoretical attention.

The factors indicated have in fact brought to the fore, in the past, the inverse concerns. Slowness in the process of the adjustment of technological complementarities has stressed the importance of bottlenecks. And this, together

with the emphasis on technological complementarities, has finally resulted in the policy criterion of leading and following industries, as indicated above, and in the theoretical hypothesis that innovations result from maladjustments in the previous structure.

Doubtless, the latter policy criterion and hypothesis are real and useful, because there is a two-way interaction between technological complementarities and product-development complementarities. But there is no reason why the emphasis should remain placed exclusively on one side of the interaction.

Recent developments are drawing attention precisely to the other side. As a consequence of the changes in transport and communications (which have strengthened and shortened market reactions), of the re-organization of the business world (which has resulted in the integration and internationalization within firms of decisions taken previously by isolated individuals), and of governmental research policies (which have established goal-oriented and integrated programmes), technological and organizational change has been progressively accelerated. This has resulted in ever shorter time-lags between the phases and within the phases mentioned, and has clearly brought forward the clustering complementarities all along the innovation process.

First, we shall briefly indicate the degree of acceleration: research on the history of technological change has begun to provide documented evidence of the amount of acceleration experienced.[29/] At the beginning of the twentieth century, the time-lag between successive industrial innovations was thirty-seven years; since the Second World War ir has been fourteen years. Technological forecasters see further reductions in the time-lag in the future, following the general trend envisaged by computers for successive generations. Next, we will indicate how the acceleration has come about and what effects it has had.

Research on recent major technological break-throughs [30/] shows that the acceleration of the process has been due to the integration of basic, applied

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29/ For a review, see D. A. Schön, "Forecasting and Technological Forecasting" in Toward the Year 2.000, Daedalus 1968, and quoted bibliography.

30/ See review and evaluation by R. R. Nelson et alia, Technology, Economic Growth and Public Policy, Washington, 1967.

and experimental research programmes, carried out to develop a wide range of products. That is to say, precisely to the recognition of complementarities between product development processes, and to the establishment of research policies based on the solution of those complementarities.

The integration of research programmes, favoured by a general policy backed by different sorts of incentives (grants, tax benefits, etc.) has been achieved in several ways: (a) within firms, which have enlarged their range of products and set up large complex laboratories; (b) by means of closer interaction between firms (legal and illegal), and among firms and universities and other research institutions, and (c) by the creation of special government-sponsored research projects.

As was to be expected, recognition, in research planning, of complementarities among the different phases of the product-development process has resulted, through research and development successes and consequent reduction in innovation time-lags, in fuller recognition of these complementarities, which, in turn, has brought about importante changes in business firms' behaviour, reinforcing the clustering of innovations.

Before we deal briefly with the reinforcing consequences, let us mention some additional forces which, together with the success registered in research, have been of critical importance in the recent understanding of product-development complementarities. Scientific communication between members of research teams engaged in different product lines, commercial scooping by the new and prosperous business intelligence networks, and market and technological analysts' forecasts, have resulted in an increasingly acute perception of the interdependence of the different stages of product development in the different industries.

Let us also indicate some proofs of this new awareness. The rapid rise of conglommerates in the United States has been no doubt influenced by income tax laws; yet their rise in most countries, under different tax structures, must be taken as an indirect proof of the new awareness of product development complementarities, for the conglommerate business structure is the most favourable among existing forms of business firms to integrate product-development (from innovation to marketing) in different industries. The best direct proof is the "system

planning" approach undertaken by N.A.S.A. in order to carry out its research targets. The system planning approach is now widely used by businesses elsewhere, for it is an adroit recognition of the fact that in order to achieve a high-performance goal in a short time in one line, basic, applied and experimetal research have to be conducted in planned sequence in the widely different lines of all its constituent elements.

Turning now to the reinforcing consequences mentioned above, realization of the complementarities in the product-development process and of the acceleration of innovation, which results from integrated research, has increased the interest of business firms in: (a) branching out in complementary industries, (b) tomorrow's innovations.

Influenced by these two complementary decisions, business firms have learned to act in the present in conformity with the guidelines of long-term plans based on alternative industry market and technological forecast.[31/] This radical change from their past exclusive concern with single products and current events has determined the following changes: (a) business firms have gone over the narrow frame of decisions assigned to them by micro-economics; over and above their traditional role of choosing among variable input combinations within one rigid fixed input combination, their basic choice today is between alternative fixed input combinations; (b) The rationale for public indicative planning has also been superseded, for firms now carry out research and know the future of different industries better than planning bureaux,[32/] a development undoubtedly due to the fact that they have changed their opinion of planners and forecasters and pay them higher than governments; (c) Capital markets have lost part of their role as guides to the future structure of investment and are being increasingly relegated to the role of long-term bankers. Their allocating function of today's profitable returns to tomorrow's promising endeavours is being increasingly pre-empted by multi-product corporate boards which, favoured by income tax laws, short cut the market and decide directly in which alternative industries their firm should invest

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31/ J. K. Galbraith, The New Industrial State, Boston, 1967.

32/ P. F. Drucker, The Age of Discontinuity, New York, 1969.

its profits. Gone, together with it, is the economist's expedient of considering firms as parts of industries.

Naturally, all these organizational changes in business firms have further strengthened the acceleration of innovations and the complementarities between them. And there seems to be no clear limit to the process. Unless the trends indicated are altered by unforeseen events, the circular set of mutually reinforcing factors described will, in the near future, force firms to pursue a growing substitutability between present and future technologies within all lines of activity, and to establish increased complementarity between the various stages of product-development across the different activity lines.

As we have indicated, these two trends reinforce each other. In consequence, successive innovations in the future are likely to come about faster and in tighter clusters.

If that is the case, and the normal planning horizons are not decreased, in the interaction between production complementarities and product-development complementarities, we find it more pertinent to emphasize the second. Production complementarities ought to be dominant if the conditions were reversed.

3.4 Specification of the temporal hypothesis

Consequently, we consider the historical evolution of technological changes as a sequence of dated complementary innovation sets. These sets can be conceived either as a continuos or as a discrete flow. For reasons of simplicity, we consider them as a discrete flow. Each successive set is less efficient than the next and the time-lag between the sets grows shorter over time. Sectoral interindustry clusters, as observed in an input-output table can, therefore, be better viewed as resulting from the materialization of successive bunches of innovations into sectoral clusters. In the same way, regional establishment clusters, regional sectoral clusters, as the final outcome of product-development complementarities, materialize in the successive innovation sets pertaining to goods and services of joint regional location.

4. GEOGRAPHICAL CLUSTERS

Geographical concentration of firms and industries must have always been an obvious trait of economic activity. This is the conclusion to be drawn from the permanent concern of economic literature on the issue, and from the notion of the inevitability of geographical concentration, which pervades all types of economic analysis. In fact, as Lefeber has shown,[33] the sense of the inexorability of the phenomenon is not absent even from the most abstract of economic approaches: general equilibrium analysis.

Yet, in spite of its having long been recognized as an area of research and of the explanations proposed, present understanding of the phenomenon is unsatisfactory. The explanations provided are exclusively atemporal and, even then, are not totally convincing in all contexts. This is because the framework of prevailing explanations is still that advanced by Marshall:[34] in a nutshell, geographical concentration of economic activities results from the existence of agglomeration economies, and this approach, which, broadly interpreted, may still explain why there are geographical concentrations, can hardly explain (except "ex post facto") where and how the concentrations take place, which is the central question to be answered by a spatial analysis.

Since the above why and where questions are interrelated, the object of this section is to present a tentative hypothesis to explain why, where and how agglomeration economies tend to develop.

As in the previous section, we shall first deal with the atemporal explanations; later, we shall discuss a temporal hypothesis. Contrary to the previous section, however, we shall have to make a brief evaluation of agglomeration economy hypotheses, for the static explanations are not as well formulated for geographical clusters as for sectoral ones.

33/ L. Lefeber, Allocation in Space: Production, Transport and Industrial Location, London 1958.

34/ A. Marshall, Principles of Economics, 9th ed., MacMillan, New York, 1961.

4.1 The static hypotheses: (A) Internal and external economies

Marshall indicated that agglomeration economies result from the existence, at certain points in space, of external and internal economies, which attract firms seeking to profit from them, Marshall's argument implies both that internal and external economy benefits cannot be appropriated except by moving to their location, and that firms can substitute the lower unit costs for the potentially higher input and output transport costs they may incur in moving to their location.[35/] Economists ever since have detailed the several functional types of internal and external economies, their magnitude, effects and consequences and the different types of factors causing them,[36/] but have not evaluated the relevance of the concepts to the objective they are concerned with. Because of this, we proceed, first, to analyze the limitations of the concept of external and internal economies, explaining, within our horizon, why geographical clusters exist and, secondly, to consider the question of whether other analytical tools can be used to the same end.

The problem can be set as follows: in a universe in which physical, biological and social factors (such as property laws, institutional structures, etc.) determine the necessity of multiple economic agents in segmented markets, both internal and external economies can be considered the result of production and indivisibilities.[37/] As a result, agglomeration economies can be considered to be the product of indivisibilities, whether these indivisibilites need necessarily be explained in terms of internal and external economies, or can be accounted for by other mechanisms.

A brief glance at the production indivisibilities shows that they are quite different for the diverse types of economic units (plants, firms, industries, sectors, etc.) at a given time, and that they vary significantly over time for the same type of units. Thus, for example, indivisibilities within the plant

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35/ E. A. G. Robinson, The Structure of Competitive Industry, University of Chicago Press, 1958.

36/ For a rapid coverage of all the issues, see the pertinent entries in The International Encyclopaedia of Social Sciences, MacMillan and the Free Press, 1968.

37/ In the context of regional economics, see, for instance, H. W. Richardson, op. cit. (see 5, above).

give rise to internal plant economies (and/or diseconomies); indivisibilities external to the plant, to external economies (and/or diseconomies), but most external economies to the plant can be internal economies to the industry.

In other words, a summary evaluation of production indivisibilities indicates that, in order to define unequivocally internal and external economies, one needs to limit precisely the decision sphere of the economic unit the analysis refers to and the factors creating the indivisibilities. If the factors are internal to the unit's sphere of influence, the indivisibility creates internal economies (and/or diseconomies); if they do not belong to it, to external economies (and/or diseconomies).

A conclusion follows from this: internal and external economies cannot be the same in spatial firm, spatial interindustry and spatial income analyses because the analysis units are different. In a time perspective, it can be further concluded that, since both the firm's sphere of influence and the factors creating the indivisibilities (technology, for example) change, previous internal and external economies are bound to vary. Alterations in the size and structure of firms, and modifications in the production and distribution functions may result in the internalization and/or externalization of pre-existing economies, therefore changing the relative locational attractiveness they might have had.

This suggests that the concepts of internal economies are likely to be more useful in a static analysis of micro-units than in a long-term temporal analysis of macro-units, for the smaller the units' size and the less changeable their technical and organization parameters, the greater will be the effect upon them of internal and external indivisibilities.

This is, of course, the reason why internal and external economies are essential elements in the theory of the location of the firm and in regional development theories based upon it.[38/] This may also be the reason why they play little or no part in regional development theories based on industry or sectoral behaviour, which are not supported by equivalent industry locational theories.[39/]

38/ Central place theory, from Christaller to Tinbergen.

39/ Export base, industrial structure and sectoral stage models.

4.2 The static hypotheses: (B) Production complementarities

Up to now, we have suggested that external and internal economies are a useful way of analyzing the role of indivisibilities in explaining the existence of geographical clusters in a spatial static microeconomic framework, but are of little use in other frameworks; now we need to tackle the question of how the indivisibilities which explain the existence of geographical clusters can be analyzed in other frameworks.

We restrict this inquiry to the spatial-interindustry dimensions, because the interindustry framework is the one that we have used in the section on sectoral clusters, and we need to relate it.

To most authors writing on interindustry analysis and development (which use mostly the same framework), the notion of geographical clusters is also closely associated with indivisibilities. Yet, no formulation of industry internal-external economies (equivalent to the internal and external economies of the firm) is given. The reason is obvious: firm theory is mostly centred on the analysis of input substitutability, interindustry analysis on the study of input complementarity. In consequence, firm location theory can contemplate the substitutability of input combinations at different locations, while industry location cannot be built on that choice of alternatives so that its analysis cannot take internal and external economy alternatives into consideration.

How, then, can inter and intra-industry indivisibilities be incorporated into interindustry analysis? Hirschman 40/ pointed out a logical solution, later followed by others.41/ Instead of building on the price theory principle of substitutability, he constructed his argument on the basic complementary hypothesis of interindustry economies, reasoning that the technical complementarity of production functions, coupled with space frictions (transport costs, but also

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40/ A. O. Hirschman, op. cit. (see 23, above).

41/ Hilhorst brought the point forward. J. Hilhorst, "La Theorie du Developpement Regional. Un essai de synthese" in Aspects Multidisciplinaires du Developpement Regional.

communication difficulties and resource immobilities, especially of entrepreneurship), acting upon their input calls for the geographical concentration of industries.[42/]

We do not challenge his position within the integrated sectoral-geographical setting he presented. However, since we are trying to separate the causation mechanisms in sectoral space from those of geographical space, we cannot take his short-cut. We cannot take the mechanism which explains sectoral clusters, project it over geographical space (corrected for space friction) and use it also to explain geographical clusters. Technological complementarities subject to space friction certainly result in additional geographical concentrations --as we shall see when we relate sectoral and geographical clusters-- but the question remains: are there other complementary indivisibilities, apart from technological complementarities, resulting in geographical clusters?

4.3 Static hypotheses: (C) Marketing complementarities

To answer the latter question properly we should need a special interindustry location theory. This theory does not exist. The only pointers to such a theory are contained implicitly in the two main types of spatial classification of industries available: the traditional "resource-oriented, market-oriented, footloose" type and Tinbergen's [43/] "local, regional, national and international industries".

The first classification groups industries according to the relative spatial pull of their inputs and outputs. As the reader will observe, this classification is not adequate for building spatial complementarities but substitutabilities.

Tinbergen's classification qualifies industries according to the spatial delivery ranges their outputs may have. Local industries, for example, are those whose outputs cannot be exported and need to be used in the place where they are produced, because they are either personalized products or services, part of a more complex and inseparable package of goods, perishable products, etc. This method of classification favours the analysis of spatial complementarities

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42/ A. O. Hirschman, op. cit. (see 23, above).

43/ J. Tinbergen, "International, National, Regional and Local Industries" in Trade, Growth and the Balance of Payments, Amsterdam, 1965.

between industries. But not of the input-output type; rather of an output-output variety. The classification, in effect, does not exclude the possibility of establishing an interindustry location theory based upon the spatial complementarity of industries' outputs, imposed by similar spatial indivisibilities on their product's marketing ranges. This theory would be, in essence, very similar to central place theory.44/

Needless to say, we do not intend to develop such a theory. We just advance the general hypothesis on which it can be constructed: differences in the spatial ranges of goods and services (due to indivisibilities controlling the delivery of their outputs) and complementarities in the delivery mechanisms of those outputs call for the geographical concentration of activities. This process of geographical clustering is independent of whether or not indivisibilities in the production process and complementarities in the procurement of the inputs of other activities create sectoral concentration of those activities; it is also independent of and complementary to the other process of geographical clustering which may result from the effect of locational factors on the regional sectoral clusters.

As will be observed, the foregoing hypothesis does not differ much from the interindustry analysis interpretation of the existence of geographical concentrations. Both agree that geographical clusters result from the complementarity of indivisibilities. It only differs from the interindustry analysis in separating production indivisibilities and complementarities (the static independent reason for geographical clusters) from marketing complementarities and indivisibilities.

This distinction is found necessary because: (a) Marketing indivisibilities and complementarities, though neglected, seem to be, for some geographical clusters, a better static explanation than production indivisibilities and complementarities weighted by locational factors;45/ (b) We need a static

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44/ See, for instance, J. Tinbergen's "Un modéle de la dispersion géographique de l'activité economique" in Revue d'Economie Politique, 1, 1964.

45/ This is the case for services and other local activities.

independent cause of geographical clusters that can be seen as the end-product of a process of historical complementarities (in the same way that we have viewed static production complementarities as the end-product of historical process of product-development complementarities), in order to explain the interactions between sectoral and geographical clusters. Marketing complementarities and indivisibilities can be conceived to have played that role.

The first reason calls for some explanation. Both production and marketing are essential aspects of any industry. Yet, on an average, the relative success of international and national activities is mainly determined by the efficiency of their fixed and variable inputs in production, while local and regional activities, on the contrary, seem to be relatively more dependent on the efficiency of their marketing networks. Indivisibilities in production, in one case, and in marketing, in the other, act as the limits of potential efficiency and should be considered as critical elements in the planning of those two types of activities. In consequence, the drive towards complementarity of activities can be viewed in all activities as a rational procedure for minimizing the risks arising from the existence of indivisibilities. Given certain locational factors, it results in geographical clustering. But the type of complementarity and location sought will be different depending on the most prevalent type of indivisibility in the industry. Industries in which production indivisibilities are critical will tend to coalesce around sites where most inputs can be procured; industries in which marketing indivisibilities are essential will tend to locate at sites where most outputs can be sold.

Next we shall see which process of historical forces can be identified as producing marketing indivisibilities and complementarities. Before that, however, it may be as well to show the relative utility of the hypothesis in its static form vis a vis alternative static hypotheses. For this evaluation we first need a brief tour d'horizon on available knowledge.

The only alternative proposed to the marketing hypothesis is the purely technological (production oriented) hypothesis mentioned above. According to this, geographical clusters are the spatial mappings of technological sectoral clusters.

If one accepts this hypothesis, it is practically impossible to predict where future geographical clusters will be, because first it is necessary to predict how technology is going to evolve in all sectors and its geographical implications, geographical factors being purely passive conditioning elements. In reality, the only projection that could be made, that would be consistent with this perspective and with available knowledge of technological evolution, would be that geographical clusters in the future will be less conditioned by the location of natural resource and more by accessibility to markets.

This is a most paradoxical and embarrassing situation. Common sense alone lets us make a more accurate prediction of the future use of space! Nobody, apart from conservative economists, doubts that, no matter how technology evolves, the structure of regions and cities in the different nations will not change drastically in the near future. Everybody, except tradition-laden economists, is fairly confident that, if any relative change occurs, the present patterns of the use of space will be reinforced because, among other things if technological change really threatened to change radically the prevailing structure of geographical uses, the new technologies would not be introduced. Indirect confirmation of the gross irrelevance of conventional economic hypotheses, in this respect, is the fact that projections in the domain of geographical use are based on models from other disciplines. A direct confirmation contrary to what would be expected from the doctrine, the historical past shows considerable stability in the evolution of the patterns of urban systems.[46/]

Admittedly, then, the existing alternative to predicting where the new geographical clusters will locate is poor. A temporal version of our own hypothesis cannot be much worse. On these grounds alone, we feel justified in proceeding to give further details of the hypothesis advanced, setting it in a temporal dimension.

46/ J. R. Lasuén "Multi-Regional Economic Development. An Open-System Approach"; paper presented to the October 1969 Lund Seminar on Information Systems for Regional Development (Lund University and the UN).

4.4 A temporal hypothesis: Complementarities in the market-development processes

To develop an independent temporal hypothesis of geographical clusters we need to proceed by a method analogous to the one we used in the case of sectoral clusters.

In the latter case, we viewed the static production complementarities as the end-result of complementarities all along the product-development process. Now, we have to realize that the static marketing complementarities cannot be other than the final result, at any point in time, of complementarities all along the market-development process.

In other words, in a temporal perspective, it cannot be accepted as a general rule that the creation of geographical clusters is the product of marketing network complementarities. It makes much more sense to hypothesize that the existence of clusters of population, whatever their origin, has motivated the appearance of markets and the accumulation of complementary marketing networks and linked productive activities.

In essence, because this can be a very long argument, and in consequence needs to be dealt with briefly, we hypothesize that the reasons for the clustering of population have been many in the past and can be many in the future, apart from the strictly economic ones; but that, once created, there is an inevitable logic in the development of markets for local and regional outputs in the clusters. Owing to the population's need to have immediate access to the widest possible selection of these outputs, this logic determines a drive towards the complementarity of the markets of the individual outputs. In due course, market complementarities will result in a graduation of the aggregate markets of the different clusters; the larger clusters having larger and more diversified aggregate markets, and finally, owing to the marketing indivisibilities of the activities catering for the markets and their complementarity, in the establishment of clusters of plants servicing the markets.

4.5 The role of the temporal and atemporal hypotheses in the framework

We have now a pair of independent hypotheses explaining geographical clusters of activities; one static (marketing complementarities) and one temporal (market

development-complementarities). They are the logical equivalents of those advanced for sectoral clusters: production complementarities and product-development complementarities.

Yet, we do not intend to use one pair to explain atemporal and temporal geographical clusters, and the other to explain (temporally and atemporally) sectoral clusters.

The two pairs, with due corrections, can be used to explain both sets of clusters. In the case of production complementarities, we have already advanced that this hypothesis, together with comparative cost analysis, can serve to explain (atemporally) geographical clusters of international and national activities. Similarly, we may as well indicate that marketing complementarities, with the help of input-output analysis, can explain (atemporally) sectoral clusters of local and regional activities. The same can be said of the temporal hypotheses.

What we intend to do is to separate, first, the two sets of causes, and then mix them together, in order to gain new partial insights into the interactions between the evolutionary patterns of urbanization and development, and yet have a final balanced view.

We propose to achieve this result in a temporal framework of interactions with two sequences: in the first, one set of hypotheses is active and the other conditional; in the second, the inverse occurs.

We feel justified, in the light of historical experience, in using this dual-sequence scheme.

In effect, in the past probably more rigidly than in the present, technology conditioned which geographical spaces could be used. Yet, since technology did not change over long periods of time, within those time spans and within those spaces, changes in geographical clusters necessarily obeyed their other more changeable (though less conditioning) causes. These other factors (social, cultural, political, etc.), which varied more frequently over time, modified the structure of settlements and, in consequence, the previous market-development complementarities, reinforcing and conditioning the evolution of the urban systems,

as geographers have always indicated.[47] Yet, they were never able to overcome the geographical limits imposed by technology.

When technological change began to accelerate significantly (with the industrial revolution), the situation was reversed, because the more rapidly changing indivisibilities and complementarities were the production ones. Technology thus became the active element in the promotion of changes in the urban systems, as geographers have also always acknowledged.[48] But its influence was never uncontested. The urban systems conditioned the acceptance of the new innovations and the location of the new sectoral clusters in such a way that the new technology never changed drastically the previous structure of urban systems, except in countries without complete urban networks.[49] As we shall see later, in this second sequence, technology's main impact has been to strengthen the pre-existing hierarchical and functional orders of the urban systems.

In order to clarify our position concerning geographical cluster causation, we have been forced to indicate in advance some of the main lines of our argument. We may as well present the complete outline now, in order to evaluate the overall role of geography vis a vis that of technology, and also to facilitate the evaluation of the more detailed hypotheses of the next section, concerning the interaction between geographical and sectoral clusters.

We can do this in terms of the most general hypothesis available on the temporal evolution of urban systems. This hypothesis is an application of biological open-system theory [50] to urban systems. It was first used by

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47/ R. E. Dickinson, "The Growth of the Historic City" in H. M. Mayer (ed) Readings in Urban Geography, Chicago, 1959.

48/ Ibid.

49/ The new vacant lands settled by Europeans in the nineteenth century in the United States of America, Canada, Australia, Siberia. Latin America had a complete urban network previous to the industrial revolution, which has not basically varied.

50/ A comprehensive bibliography on open-systems can be found in the yearbooks (1-13) of the Society for General Systems Research. For a rapid survey, see L. von Bertalanffy: "General Systems Theory" in General Systems Yearbook, 1956, and his "General Systems Theory. A Critical Review", in General Systems Yearbook, 1962.

W. Berry.[51] It establishes that urban systems tend, like all systems, towards their more probable state, which is the homogenous structure of their units (i.e. all geographical clusters being alike) as a result of the systems' entropy; yet, they do not reach that state (as all closed systems do) because urban systems are open (learning) systems; that is to say, systems which behave according to an initial code transmitted by an information input. In short, urban systems are open systems which evolve in a definite pattern, which is the balance between the homogeneizing influence of the systems' entropy and the morphogenetic influence of their programmed behaviour.

Berry's is a single sequence one-shot open-system model of urban system evolution. Our framework can be formally reduced to a multi-shot open-system model [52] with two sequences. The first sequence corresponds to the period when technology conditions and geography determines the urban system form. The second, to the period where geography conditions and technology determines. The multiplicity of information shots is brought about by the successive innovation sets.

The second sequence in our model can be built as a straight generalization of the one-shot model. The successive innovation clusters are the successive information outputs, which have their impact on the geographical clusters of every urban system structure that reacts to them. The urban system structure is modified accordingly, the system adopting a new congruent and fixed pattern of evolution until a new innovation cluster arrives, is absorbed, and results in a new urban structure and in a new pattern of evolution. The first sequence can be built very simply by assuming that the initial urban system structure results from the first innovation cluster and varies within the limits permitted by the technology, but is not affected by another innovation cluster until the sequence ends.

In the next section and within the outline of the interactions in question, we seek to explain how the innovation clusters affect the geographical clusters, and how these react.

51/ B. J. L. Berry, "Cities as systems within systems of Cities" in John Friedman and W. Alonso (eds), Regional Development and Planning, Cambridge, Massachusetts, 1964.

52/ Present formulation is a slight modification (the two sequences instead of one) of a previous more detailed presentation of an open-system multi-shot model by the author. See op. cit. (see 46, above).

5. SECTORAL AND GEOGRAPHICAL CLUSTERS

Up to now, we have maintained that the best way to study the interrelations between the development and urbanization processes, is to conceive the process of development as creating a temporal sequence of sectoral clusters, and that of urbanization another sequence of geographical clusters. We have also suggested that the two sequences, the first international and the second mainly national, are related, and that in order to understand their interaction, it is necessary to assume the sequences obey some different, independent causes and many common ones.

It has further been suggested that, in a temporal perspective, the basic independent causes of sectoral clusters are the inherent complementarities between innovations which manifest themselves, statically, when they are implemented, in the form of production indivisibilities and complementarities between the different industries. On the other hand, it has been suggested that the main independent cause of geographical clusters and the market-development complementarities which, statically, appear as marketing indivisibilities and complementarities. We have also presented the main lines for a framework capable of relating the two processes.

Since the first sequence in our model can only apply to very primitive societies, and is included only for reasons of logical completeness, at present, our object is to consider the second sequence in our framework, namely, to suggest tentative explanations of how the traits of geographical use condition the generation, diffusion and adoption of innovations, and how the characteristics of the innovation process, when they are adopted, influence the future use of geographical space.

5.1 The effects of the use of geographical space on the innovation process

To analyze the effect on innovation of the use of geographical space, it is necessary to distinguish the following sub-processes: (a) Generation, (b) Diffusion and (c) Adoption of innovations. Within each of the, it is also necessary to distinguish types of innovations (consumer and entrepreneurial innovations) because, as we shall see, the geographical patterns of innovation diffusion and adoption of consumer goods and services, among households are different from those of new techniques or products among producers.

5.1.1. The innovation generation sub-process

On innovation generation, Wilbur Thompson [53] has advanced the hypothesis, unrefuted by tha data he has marshalled to test it, that inventions tend to generate and become innovations in large cities with large and diversified labour pools, mixed and open cultures which favour the communication of new information, fluid financing facilities, heavy endowments of infra-structural capital and potent educational and research institutions. Thompson's hypothesis also accounts for past experience. As W. McNeil [54] reports, inventions and innovation generation all through history has taken place in the larger metropoli open to the interchange of newer products and ideas. It is also generally consistent with Pred's findings [55] for more recent times, and with D. Schön's [56] conception of inventions and innovations: products analogue reasoning, derived from knowledge obtained in other fields, and carried out in response to newer needs.

Thompson's hypothesis, however, can be made more precise. Present and historical data,[57] show that innovations generate not only in large open cities but also in those in the few most developed countries of the time. Today, most innovations in the West originate in four large megapoli: the eastern and western United States' seaboards, the area of the Ruhr-Rhine valleys and the London-Midland plain. In the distant future, innovation-generation may shift to some other zones, but these again will be very concentrated.

This hypothesis simplifies our task. If innovations always take place in a few advanced countries, for the rest of the world it is irrelevant which those countries are: what matters is to explain how the innovations spread to the other countries. In our framework, this can be accommodated if we assume that the innovations take place exogenously and in a few relatively constant areas. Therefore, contrary to authors concerned with the advanced countries, who are

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53/ W. Thompson, A Preface to Urban Economics, Baltimore, 1965.

54/ W. H. McNeil, The Rise of the West, Chicago, 1963.

55/ A. R. Pred, Spatial Dynamics of U.S. Urban Industrial Growth 1800-1914, The M.I.T. Press, 1966.

56/ D. A. Schön, Displacement of Concepts, London, 1964, New York, 1967.

57/ Op. cit. (see 53 and 54, above).

logically focussing on innovation-generation,[58] and contrary to the nationalist school of Latin-American economists,[59] which aims at the creation of innovational bases in the developing world, we focus the analysis on understanding better how to adapt conditions to innovations and not on how to innovate.

Consequently, in our analysis, the critical sub-processes are those of innovation-diffusion and adoption. To them we turn.

5.1.2. Innovation diffusion

Once inventions have become innovations, knowledge about them gets diffused in other areas. The diffusion process follows different communication mechanisms depending on the kind of innovation.

58/ The author to whom my own approach is more closely related is E.S. Dunn, Jr. See his forthcoming Economic and Social Development: A process of Social Learning. Among the econometricians, E. Mansfield, especially his Industrial Research and Technological Innovation, New York, 1968. For more general economic approaches, see Nelson et alia, op. cit. (see 30, above); also D. Schön op. cit. (see 29, 56, 61, above).

59/ This is not nineteenth century nationalism, but protectionist nationalism at the sub-continental level aiming at developing an autochthonous Latin American Technology.

The trend of thought has grown out of the pioneering work of specialists such as J. Leite Lopes (Ciencia e Libertacao, Rio de Janeiro, 1969; Ciencia e Desenvoluimiento, Rio de Janeiro, 1964) and J. Sabato ("La Ciencia y la Tecnología en el Desarrollo Futuro de America Latina", paper delivered at the World Order Conference, Bellagio, September 1968).

It has spread to the major economists in the area. See, for example, N. Gonzales ("Planteamientos sobre el Desarrollo Económico en América Latina", mimeo); R. Prebisch ("Transformación y Desarrollo: La gran tarea de América Latina", Report to the B.I.D. April 1970).

The best summary of this school of thought is H. Jaguaribe: "Ciencia e Tecnología no quadro socio-politico de America Latina", paper presented to the Meeting of the Interamerican Association of Planners, Bahia, 1970. For an evaluation, see J. R. Lasuén: "Tecnología y Desarrollo", paper presented at the Seminar of O.E.A., Caracas, 1970.

If a consumer innovation is in question, that is to say, one in which the majority of the population is potentially interested, information about it is carried through all the general communication media. Consequently, the spatial form of the diffusion resembles that of an oil stain, spreading out and gradually slowing down from the innovation centre towards a periphery. The pattern is described adequately by the general epidemiological model.[60/] In a temporal scale, representing the total number of persons who have received the information at successive times, the model's pattern is a curve which grows at successsively smaller rates. In a graph cutting the oil stain across and representing vertically the frequency of diffusions at different points of space and/or time, to the right and left of the innovation diffusion centre, the pattern of the model is a pair of diminishing curves from the centre's vertical. This is the basic model of consumer innovation diffusions.

More complicated models have been proposed.[61/] These models are marginal modifications of the above-mentioned centre-periphery scheme. They are based on the argument that when and where the diffusing power of the centre wanes, some recipients transform themselves into subsidiary emission centres. The resulting pattern is that of a centre-periphery set of concentric circles orlated by smaller centre-periphery sets. These centre-periphery and derived models are the ones that have been used traditionally in economic geography.[62/] Depending on the degree of receptivity of population to the innovation and the intensity and speed of the communication media used, the diffusion is larger and faster within the pattern described.

60/ As explained in A. Rapoport "The diffusion problem in mass behaviour" in General Systems Yearbook, 1956, reviewing the field.

61/ D. A. Schön, in Chapter 5 (Diffusion of Innovation) of his forthcoming book, explains the evolution from E. Rogers' Diffusion of Innovations simple centre-periphery model to the orlated centre-periphery models.

62/ For a detailed list of publications and examples of application see R. P. Misra, Diffusion of Agricultural Innovations, University of Mysore, 1968.

Entrepreneurial innovations, on the other hand, do not interest the whole population. They interest producers directly affected by the innovation. Consequently, the diffusion of entrepreneurial innovations is carried out through specialized communication channels mostly directed to people in the trade, i.e. people producing previous goods or services addressed to the same need (for instance, carriages, automobiles, radio and television stations, etc.), distributing and/or servicing them.[63/] The spatial pattern of entrepreneurial innovation diffusion resulting from these specialized communication networks is that of the spokes of a wheel; the radii linking the innovation centre to the different locations of specialized recipients are irregular in length, because the speed of specialized communications makes completion of the diffusion depend almost exclusively on the sensitivity of the recipients.

5.1.3. The adoption of innovations

Turning now to the other sub-process, we find that the adoption of innovations is both uncertain and risky,[64/] if the distinction between uncertainty and risk is relevant,[65/] and this deters firms from rapid adoption. Firms resist the adoption of new innovations because these tend to disrupt their existing structure and functions. This is true of both "insignificant" and "significant" innovations.[66/] A "significant" innovation has high uncertainty and risk values and its adoption represents a considerable disruption, not only in the previous production lines, but in the firms' financial, commercial and over-all organization. An "insignificant" innovation is both less uncertain and more compatible with most of the firms' structural traits. Obviously, people and firms resist "significant" consumer and entrepreneurial innovations more than "insignificant" ones; yet they are more

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63/ This is a short rendering of a longer exposition, J. R. Iasuén in op. cit. (see 1, above).

64/ Op. cit. (see 61, above).

65/ Arrow has challenged P. A. Knight's famous distinction.

66/ For a complete definition of significant and insignificant innovations see op. cit. (see 61, above).

attracted by the higher expected profitability of "significant" innovations. However, even "insignificant" innovations are not accepted easily. The model that seems to give the best description of the process of adoption is that of general learning:[67] innovations are only accepted under the competitive need to adapt; and then only gradually and experimentally.

The adoption of innovation takes the same spatial pattern of their diffusion. The adoption of consumer innovations spreads out in oil-stain fashion. Entrepreneurial innovation adoptions spread out spoke-wise. Also, adoption spreads normally reproduce the temporal sequences of their diffusion because the earlier adopters tend to be the earlier informed. This is certainly the case of consumer innovations and, most frequently that of entrepreneurial innovations. Similarly, too, the speed of the adoption spread depends, coeteris paribus, on the level of uncertainty, risk and disruption associated with the innovation. Insignificant innovations are adopted faster than significant ones. But clearly, no matter how significant the innovations are, the relative strength of a host of general factors conditioning their adoption greatly influences the speed of the spread of the innovation. Roughly, the more developed the economy, the faster the spatial spread of innovations, because the degree of competition is higher and, at the same time, factors external to the would-be adopter which facilitate the learning process (technical, financial and commercial expertise, financial intermediaries, etc.) are more readily available. The same conclusion can be reached by analyzing the nature and behaviour of the would-be adopter of entrepreneurial innovations.

In developed countries, W. Thompson [68] has hypothesized the way innovations spread out spatially from the industrial heartlands to the peripheries. Thompson's reasoning is the following: the adoption of new innovations requires diversified skilled labour, imaginative management,

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67/ See E. R. Hilgard, Theories of Learning, New York, 1948.

68/ Op. cit. (see 53, above).

highly research-orientated technical manpower and significant external complementarities in the fields of finance, commerce, etc. That is why they normally take place in a large metropolis. As the production of the new goods becomes more standardized, it pays to shift production to the peripheral areas of low cost unskilled labour, for production does not require any more than the factors listed above.

Undoubtedly, in the developed countries, the spread of innovations has been accelerated by the existence of multi-plant firms. The filtering-down of multiple plant firms is much faster than that of single plant firms.

In developing countries, hardly any multi-plant firms exist. In consequence, the spatial spread of innovations cannot be carried out within the firms, from their central to their peripheral plants. Generally, in developing countries, the plant is the firm. The spatial spread is therefore the successive adoption of innovations by different firms located successively further from the centre of the adoption spread. This distinction clearly indicates that under similar conditions the speed of the spread will be slower in developing countries. This, in spite of the fact that, normally, the uncertainty and risk of every single innovation is considerably lower in developing than in developed countries, because developing countries' adoptions lag behind corresponding adoptions in developed countries, and, in consequence, they adopt the product when it has become internationally standardized. In other words, even though all innovations in developing countries are close to being "consumer" innovations, it takes longer to adopt them fully than in developed countries because of the lack of external complementarities to innovations. Their spatial spreads are even slower because they are carried out as a result of a host of unrelated individual decisions.

It is precisely the consumer-type features of entrepreneurial innovations in developing countries which help to explain the pattern of innovation adoptions in those countries. The first thing to explain is why adoptions occur at all. We have already indicated that the lack of external support of

innovation adoptions in those countries is in part offset by the lower risks resulting from the fact that most of the innovations are already standardized practice abroad. A second factor reducing risks is that, in most cases, the innovation to be adopted is already well-known in those markets; habitually, all goods and services, whose output is later initiated locally, have been formerly known to the users via exports from developed countries. In other words, the product-demand is there. But what about the relatively high cost of adoptions? In most cases, the small scale and resulting high cost of production are not an adoption deterrent because innovation adoptions are forced on the countries. In fact, most innovation adoptions are the result of import substitution policies, desired or undesired, but imposed by balance of payments difficulties.

This is confirmed by the nature of the adopters and it explains in turn the spatial pattern of adoptions. Adopters, normally, are previous importers, distributors, service-people, producers of substitution goods (bicycle manufacturers in respect to motorbike imports, for example) etc., familiar with the marketing, financing and technical characteristics of the product. They adopt in order not to be driven out of business by import substitution. They do it, individually (in make-shift operations), or under different types of assembling and manufacturing agreements with the former suppliers. But, in any case, they undertake the production of the previously imported goods to satisfy the needs of their commercial clientele.

As a consequence, the spatial structure of the new productions clearly follows that of the former marketing network of the product. Innovation adoptions start where the largest former market areas of the product are found. Normally, in the largest city. The other market areas gradually follow suit, in spite of their smaller captive markets, as import-substitution policies tighten up, because the new national producers have their hands full trying to keep up with their own local demands and cannot supply the smaller towns. Most innovation adoptions, then, start in the larger towns and gradually go down the urban

system, from larger to smaller towns, catering for their local demands. This, no matter whether the product is market-oriented or resource-oriented because, at this initial stage, production is tied up functionally to the producer's captive demand, and the producer is tied to the location of his market. The reasons why the producer cannot move are obvious: lack of adequate resources (being normally a small middle-man) make it impossible for him to contemplate moving to a more appropriate industrial location elsewhere, and, which is more fundamental, for a long time to come his distributing function will be more important than his make-shift production.

The reasons advanced above not only help to explain why adoption spreads are slower in developing countries but also other differences: (a) Entrepreneurial innovations in developing countries, although maintaining the main spoke-wise pattern, are on many occasions close to the oil-stain form, revealing less spatial specialization than in developed countries; (b) The spoke rays are more similar because all innovations follow the urban system from the top downwards.

Summing up, the answer to the first question, namely, how the system of geographical clusters conditions the pattern of development, can be: the spatial patterns of successive innovation diffusions and adoptions spreads are largely conditioned by the spatial structure of geographical clusters. For entrepreneurial innovations this conditioning is stronger in developing countries; for consumer innovations, the situation in developed and developing countries is more similar. In this sense geography, broadly, and the urban network, specifically, can be said to be a conditioning factor in the economic development of countries.

5.2. The effect of innovations on the use of geographical space

To answer the other main question, i.e. how the international development process influences the future use of space in countries, we need to concentrate on the study of the temporal patterns of the international process of innovations, and relate them to the spatial and temporal patterns of

innovation adoptions in individual countries. In this domain the first basic analytical contribution was Schumpeter's snowball effect.[69] Our procedure is to detail how the snowballing of innovations takes place among producers in time and space.

We have already indicated the main temporal characteristics of the general innovation process: (a) The time-lags between successive innovations catering for the same need (i.e. lighting, transport, etc.) are being progressively reduced; (b) Complementarities among innovations in the different lines are growing tighter; this results in more and more concentrated innovation clusters over time. We have also advanced that both are consequences of the increasing integration of policy-making (which specified product performances to meet new goals), basic (theoretical) model and experimental research, and product development.[70]

These two main temporal characteristics of the innovation process condition the temporal snowballing of innovations in the various countries and, given the rigidities in the spatial pattern of the diffusion and spread and in the speed of the innovations, determine the future use of geographical space in those countries. Let us then trace the spatial impact of those temporal characteristics for the innovation subprocesses.

Concerning the generation of innovations in the countries that create them: the shortening of innovation lags and the increasing temporal clustering of innovations demand either the creation of research and development special programmes (private and public) to integrate independent research lines, and/or the location of research activities in places where unplanned integration of those research lines reaches a maximum. In other words, and as we have already indicated, the main temporal characteristics of the innovation process call for either continual geographical concentration of research and development in a few central places, and/or the establishment of special research and development programmes integrating geographically separated activities.

69/ Op. cit. (see 19, above).

70/ First reported by Nelson et alia, op. cit. (see 30, above).

The temporal patterns of innovation diffusion and adoption in developed and developing countries have also been referred to above. In brief, the snowballing starts at the centre and stops at the periphery of the urban network. Innovations spread faster from central to middle-sized towns, than from these to smaller ones; in general, the adoption-lags between the successive types of towns increase in length as the town size decreases.

The interaction between the acceleration of the international innovation process and the temporal and geographical pattern of diffusion and adoption in developing countries helps to explain the two types of polarization to which development literature refers.

5.2.1. The degree of hierarchization in urban systems

If the international process of innovation is accelerated (i.e. the time lag between successive innovation clusters is shortened), and the total adoption lag between the centres and the peripheries in the less developed countries is not shortened proportionately, the two basic alternatives open to these countries are: (a) To adopt at the centre the newer sets of innovations before the previous ones have been adopted in the rest of the country; (b) To delay the adoption of the newer sets at the centre until the whole country has adopted the previous set. In the first case, a situation similar to the one described by the dual economy model tends to develop; the country becomes spatially polarized around a technologically advanced centre and a retarded periphery. In the second case, all the country's regions operate under similar technological conditions. In this fashion, the country avoids the dual economy trap, but at the cost of becoming less developed, for the whole country operates under older, less efficient technological processes that the other adopting countries. National strategies (planned or unplanned) for the attainment of regional technological equilibrium facilitate the growth of polarization between developed and underdeveloped countries.[71]

71/ J. R. Lasuén and F. Wasservogel: "Quelques aspects du processus de Dévéloppement du Système des Nations: Stabilité, Polarisation, Diffusion", in Revue d'Economie Politique, January 1970.

The above argument can be applied to nearly all countries, except the very few which control the global process of innovations because they generate most of them. Of course, it is more pertinent the poorer and less populated the country (because the successive sets of innovations have greater minimum scales), and the larger it is in terms of area. However, it is not irrelevant even in high-income countries of medium size (both in population and area). In these latter, the rising minimum scale of operations of the succesive sets of innovations--an important characteristic previously left unmentioned in order to avoid complicating the discussion--coupled with the other factors deterring adoptions, have forced them to continue to specialize in older production lines. Thus, many European countries have been unable to enter the newly developed lines of aviation, electronics, computers, etc. chiefly because of market limitations, but also on account of rigid business practices and policies, lack of adequate capital markets, etc. Servan-Schreiber 72/ has denounced the dangers for Western Europe implicit in such a trend; Eastern Europe also seems to be very concerned about its relative backwardness in the adoption of modern computer techniques.

In real life, countries choose solutions between the two extremes represented by the alternatives indicated; the most frequently chosen being closer to the first. This means that most countries prefer a dual economy to a homogenous retarded one. This is basically why most countries show persistent and considerable differentiation in the rate of growth of their different types of towns and cities (in the long run, the larger cities grow faster, and the middle-sized ones less and the smaller ones even less fast), which results in the progressive concentration of their population and income in the larger geographical clusters.73/ In other words, the progressive clusterization and the acceleration of the international innovation process, coupled with the impossibility of spreading the adoption of the innovations over the whole of the individual

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72/ J. J. Servan-Schreiber, Le Defi Americain, Paris, 1967.

73/ The most comprehensive set of data is contained in K. Davis and H. Hertz: "Patterns of World Organization" in United Nations Report on the World Social Situation Including Studies of Urbanization in Underdeveloped Areas, New York, 1957; in the same report and in H. Hoyt's World Urbanization: Expanding Population in a Shrinking World, Urban Land Institute, Washington, D.C., 1962.

country's territory at the same speed, creates in most countries a tendency towards the accelerated concentration of economic activity in a few large and in middle-sized cities. This is the general sense in which development can be said to influence the pattern of urbanization.

Taking the two general conclusions together we can say in brief that the pre-existing network of geographical clusters conditions, coeteris paribus, the pattern and speed of the allocation of the successive international development impacts over its territory. Obversely, the main characteristics of the future international process of innovations determine the future changes in the pattern of geographical clusters. The interaction of the two, normally results in increasing hierarchization of the urban system. But is the hierarchization stable? In other words, are the large and small geographical clusters of today those of yesterday and those of tomorrow? Or, is it a functional hierarchization of clusters with no stable geographical basis?

5.2.2. The degree of stability in the ordering of the urban system

In the previous section, we have already, when presenting the main outline of the argument hypothesized, in conformity with historical experience, the geographical stability of the growing urban hierarchy. Now, we need to examine the hypothesis in detail. This we shall do by relating the successive dated interactions between pairs of sectoral and geopgraphical systems of clusters. Before undertaking this, however, we should state the main arguments for our case.

There are several general reasons to account for the geographical stability of the urban system, the most obvious being that of the stock-flow variety: the geographical implications of every succeeding cluster of new technologies will be much smaller than the accumulated geographical impacts of previous technological changes embedded in the urban system, therefore its effects will be hardly noticeable even in the absence of other correcting factors. Besides, it will be much smaller owing to two additional causes: first, the urban system reacts to the technological impacts, absorbing or repelling them with different

intensities, according to whether they are consistent or inconsistent with its existing form; secondly, the successive sets of sectoral clusters existing do not necessarily have similar geographical repercussions; normally, the deviations they tend to induce in the urban system structure cancel each other out.74/

How can we, within our framework, account by more detailed hypotheses for the geographical stability of the urban hierarchies? The growing differences between international innovation lags (interval between successive innovation clusters) and adoption lags (time elapsed between adoption by the first and the last adopting towns) in most countries, and also of the preference shown by most countries for the adoption of most innovations, at least in their largest centres, have been our grounds for positioning the growing hierarchization of urban systems. To explain further why these increasingly hierarchized urban systems are the same orderly collection of the towns of yesterday, we simply need to hypothesize (and show the basis for the hypothesis) that the spatial adoption spreads of successive innovations in a country are the same.

Within our framework, therefore, the geographical inertia of the urban system is to be explained basically by the geographical inertia of the different spatial adoption patterns and additionally, by the fact that, when some innovation adoptions deviate from the general pattern, their impact on the long-run evolution of the urban hierarchy tends to be minimal because the successive deviations tend to have counter-balancing effects.

Why are the adoption spreads of successive innovations similar? Hägerstrand has been the first author to blaze this trail.75/ He and his school initiated

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74/ As an example of the self-cancelling geographical impacts of successive innovations, see op. cit. (see 46, above).

75/ T. Hägerstrand: The Propagation of Innovation Waves, Lund Studies in Geography, Series B, Number 4, 1952; "Migration and Area" in Migration in Sweden, Lund Studies in Geography, Series B, Number 13, 1957; "On Monte Carlo Simulation of Diffusion" in W. Garrison (ed) Quantitative Geography, Northwestern University, 1967; "Quantitative Techniques for Analysis of the Spread of Information and Technology" in E. A. Anderson and M. S. Bowman (eds) Education and Economic Development, Chicago, 1963.

research on the behavioural traits of successive innovations, reported several historical instances, and developed special methods of analysis. His analysis, however, is restricted to consumer innovations. Recently, Pedersen 76/ has analyzed the patterns of entrepreneurial innovations. Building on existing knowledge, Berry 77/ has attempted a synthesis of the two.

Hägerstrand states that, in all adoption spreads, there is a hierarchy of centres, each dominating lower echelon centres, which is very stable over time. Furthermore, he indicates that this is due to the fact that adoptions follow diffusion, once information repetition has overcome certain resistance thresholds, and diffusion patterns (which are carried out dominantly by private or group conversation) originate at the centres because the earliest informed and the earlier emissaries are at the centres. These centres, owing to historical inertia (the role of stabilized centralized bureaucracies), functional (the larger external linkages of larger centres) or purely statistical reasons (the higher frequency with which information is received in larger populations), remain the same over time.

Pedersen, on the basis of Chilean data, has developed a diffusion model for entrepreneurial innovations which gives basically the same results; a growing hierarchization of the urban system. His is basically a diffusion gravity model, corrected for three adoption conditioning factors (also considered in our framework): the willingness to adopt innovations, the feasibility of innovation adoption and the existence of entrepreneurship in the different cities.

Berry, building mainly on Hägerstrand and Pedersen, has put forward another model, also of the gravity type, whose main distinguishing feature is that entrepreneurial innovations are diffused and adopted down the urban system

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76/ P. O. Pedersen, "Innovation Diffusion within and between National Urban Systems" in Geographical Analysis.

77/ B. J. L. Berry: "Hierarchical Diffusion: The Basis of Developmental Filtering and Spread in a System of Growth Centres", paper presented at the Austin Seminar on Growth Poles, 1969.

until they reach a certain minimum level. All the adopting cities and towns become in turn centres of diffusion of the consumer goods obtained through the producer activities adopted. They spread those goods in their surrounding areas.

None of these models is adequate for our purpose, since they do not seek to relate the innovation sub-processes to the patterns of urbanization and development. Therefore, their coverage or structure is not amenable to the basic extended Schumpeterian framework that we use: Hägerstrand's is restricted to consumer innovations, whilst Berry's applies only to very advanced countries (where consumer innovations necessarily follow entrepreneurial innovations), and Pedersen's whose structure is closer to our own, does not detail and include the adoption conditions as endogenous variables interacting between the successive stages of innovation adoptions; consequently, his model only enables us to draw very general policy conclusions.

We are therefore obliged to advance our own specific hypothesis regarding the similarity of the successive spatial patterns of entrepreneurial innovation adoptions.

We have already hinted at this hypothesis. In order to present it clearly, we need to move from the traditional classification of products and activities to one of functions. We have to remember that, for example, the different instruments of private transport, evolved sequentially in history and used concurrently today--donkeys, horses, carts, bicycles, motorbikes, automobiles, etc.-- and the different sub-types within them, which we distinguish according to their differential characteristics, are but specialized means for achieving the ever-present function of individual transport. Similarly, tabloids, magazines, newspapers, radio and television are specialized, historically dated, means of catering for the constant need of public informations. Functions, in this sense, are time-constant; instruments to satisfy them, time-relative. Activities can be viewed, as industries, in the same perspective. The time-constant need for producing and delivering the aforementioned

instruments to the users has been achieved under different, time-relative forms of division of labour, with corresponding organizational forms of business units. These business unit forms have evolved from the most primitive handicraft to the more complex conglomerate industries. A function, therefore, can be satisfied more or less efficiently, with different instruments and by different activity forms, and instruments and activities can both be considered as interchangeable sets of elements in the satisfaction of a function.

We hypothesize that this is the way in which people in the functional sphere view instruments and activities. Because of it, entrepreneurial innovation adoption patterns tend to be geographically stable. People in the various activities (producers or not) of the trade (of the function) receive information on new instruments for the function earlier than those in other trades, because they are linked to the special information network internal to the function. Also, most likely, either producers or suppliers (for they are competitive within the function) adopt innovations earlier because competition forces them to do so, and they face less risks (being acquainted with the market) than people outside the function. In this way, the new instruments tend to be produced or delivered where the old ones were already, thereby reproducing the previous spatial pattern. All this, regardless of the type of business organization that prevails. As we have said, in the case of an economy of single-product, single-plant, single-city firms, the process is slower and closer in form to the consumer innovation adoption spread; in multi-product, multi-plant, multi-city firms, since the substitution of instruments over space is carried out within single firms, it is more rapid and less continuous over space.

In short, for entrepreneurial innovations the mechanism determining the geographical reproduction of the successive innovation adoption spreads is the natural substitution of more efficient for less efficient instruments satisfying the same need, carried out in their previous location by the several specialized agents in the function, under various organizational forms.

With the last hypothesis, which is not contrary to observed trends,[78] we have completed the argument. Needless to say, we only present it as a consistent set of hypotheses which do not seem to be refuted by reality; future research will determine how well it accounts for the processes it seeks to explain. Next, we present briefly some of the new uses the foregoing set of hypotheses may serve.

78/ Op. cit. (see 46, above).

6. CONCLUSIONS

The main conclusion to be drawn from our analysis is that, if it is not refuted, definite possibilities exist for the use of urban policies for faster national development, and development policies to achieve urban goals. These possiblities were already implicit in Perroux's growth pole concept.[79] We have only sought to develop them explicitly.

Since we believe that the scope of national development processes is, for most countries, limited to the question of the best and fastest way of adapting the economy to the international process of innovations, we have to conclude that there is less latitude in this respect for national development policies, than for urban policies, for we also believe that the dynamics of urban systems, although subject to impacts originated abroad, are more responsive to national factors. For this reason, we are inclined to side against W. A. Lewis,[80] with the authors who claim that urbanization policies are important for national development planning.

Yet we need to qualify our position in several respects. First, we do not think that because urbanization policies are more amenable to control they have a higher pay-off. In fact, our argument shows that urbanization policies leave little room to manoeuvre. Secondly, we are as far as Lewis himself from agreeing with those authors who recommend a purely physical policy of urbanization. The physical approach to urbanization policies, based on unsophisticated central place theory and/or crude derivations from Perroux, concentrates on the shell and forgets the animal who lives inside.[81] We have

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79/ Op. cit. (see 1, above).

80/ W. A. Lewis, Development Planning, London 1965.

81/ This is the typical approach of growth pole policy in most of the Western World.

chosen the opposite perspective. The systems of city-shells throughout history have been very similar because the relations between the animals within them remain similar over time; the shells change in the same direction as the relations between the animals, not the reverse. Therefore, contrary to the physical policies of urbanization, our argument suggests that urbanization policies can be pertinently directed to change all sorts of organizational traits of activities in geographical clusters and between them. This calls for a revision of the different types of habits, customs, institutions, labour and business practices, administrative and legal rules, political participation and decision-making schemes. For it is clear that no amount of physical planning, however ingenious, will render consistent the amount of freedom won through economic development with rigidity imposed by our time-honoured organizational traits.

We are also proposing the same type of policies (organizational) in the domain of economic development. How adaptation to new innovations can be best and fastest attained is a problem which requires the solving of questions such as: how to increase savings, investment and human resources; how to mobilize credit, capital and qualified personnel accordingly; in which sectors and with what intensity to allocate resources; where to instal the new projects, etc. That is to say, the solution of all the questions considered by economic development literature. Yet, innovation adoptions are carried out by firms, private or public; therefore, unless the organizational traits of firms are irrelevant elements in the firms' adoption decisions, policies concerning inter and intra-firm organizational change need to be included as essential components in the national strategy of adaptation to technological change.

This is why we have chosen the organizational traits of firms as our main explanatory variables. Better or worse, the other questions mentioned above have been fully analyzed in development literature. But the organizational characteristics of firms have received little attention in spite of their significance for the other questions. Indeed, we have not developed the

point explicitly for lack of space but it is our belief that every one of the behavioural traits analyzed by economic development literature (savings, investment, etc.) is heavily dependent on the prevailing form of organization of the business firm.

We think that this type of analytical approach can help to improve present and future development practice, for in fact, in connexion with development policies (not theories) the crucial importance of organizational change in the business world is appreciated, but, in the absence of ad hoc theoretical information it is pursued on the basis of guesswork and with inadequate means. Thus, for instance, "concertation policies", followed in countries influenced by French planning, aim at reconstructing firms and groups of firms, supplementing them with the means (financial and others) necessary to achieve development targets both in sectoral and geographical spaces.[82/] But because they are restricted to a static version of these spaces, owing to the crude version of Perrouxian analyses on which they are based, their maximum potential is to attain the business structures demanded by present technologies and by the present form of urban system, which will rapidly become obsolete when the new set of innovations arrive. Instead, our organizational perspective permits the elaboration of dynamic criteria for business organization policies consistent with the need to adapt national conditions to the international innovation process.

We are, indeed, proposing as essential the implantation of organizational policies in the domain of both national development and urbanization. These organizational policies cannot be the same in the two domains because they are aimed at different goals: in one case the more rapid absorption of all in-coming innovations; in the other the more rapid spread of those innovations over the whole country. Yet, centred on the organizational change in the relations of business firms (inter and intra firms), the two can be more easily reconciled.

82/ For a description of concertation policies in relation to growth pole theory and policy, see Boudeville, op. cit. (see 28, above).

Although at the level of the general analysis we cannot elaborate specific policies, it seems convenient to illustrate briefly the point just made. Thus, for example, in order to absorb more rapidly future innovations of rising minimum scales, granted the existence of necessary competition (international and national) and externalities (capital, special services markets, etc.), the choice between organizational extremes seems to be between the concentration of existing resources in a few large single-product firms per sector or in fewer larger multi-plant, multi-product conglomerates; contrarywise, in order to spread innovation adoptions more rapidly over the whole territory, the relevant extreme choices are different: between the concentration of resources in a few large single-city firms or in fewer larger multi-city firms, no matter whether they are single-product or multi-product. Given the country's size and the resources available, the best solution in one domain may conflict with that found in the other. Knowledge of the sectoral and geographical consequences of the alternative solutions and the country's preference for faster or more geographically balanced development will help to find a compromise solution.

The extreme choices can be reduced even further on certain assumptions: the fastest adoption of innovations (dual spatial economy tendency) calls for multi-product, multi-plant conglomerates; the greatest geographical spread of innovations (spatially balanced economy tendency) calls for single product firms, evenly distributed. Those can be taken as the limiting permissible trade-offs and as the limiting feasible organizational policies. Within those limits there is a wide range of alternatives.

Even at the level of the general analysis, we may fill in details within those extremes. In many cases, a successful way to face the strong challenge of technological change is to strengthen single-product, single-plant firms by establishing stronger inter-firm realtions. Firms can be almost as closely related to their varied buyers and suppliers by procurement, licensing, custom manufacturing, management, marketing, research and development contracts, etc. than by vertical or horizontal conglomerated incorporation. Chains of firms linked through this type of long-term contract can often face the impacts of technological

change, and can adapt themselves to it almost as well as the diversified corporations. After all, the latter are, functionally speaking, nothing but permanently linked chains of single product, single-plant firms.

But in the presence of great technological change, the two alternative solutions of permanent and long-term integrated activities (multi-city conglomerates or large single-city firms) seem to be better organizational solutions than the short-term integration of activities (different types of contracts as above, assuming that they do not result in monopoly or diseconomies).

In general terms, our analysis also shows how the organizational change required in the sectoral and geographical domains can be brought about. We have hypothesized in this respect, that innovation adoption is a learning process, and that the likely adopters are people in the different activities within the function to which the innovation pertains. If innovations are delayed for want of an adequate organizational base among the would-be adopters, the way to accelerate them is to facilitate the operation through the creation of an effective scheme for the integration of relevant individual activities.

But how is this to be done? The simplest way, once the would-be adopters are identified, is to design ad hoc organizational arrangements to minimize the cost and the risks of the learning process. At present, the emphasis of development policies (national, regional and local) is placed on production. Policies are geared to promote producers. According to our analysis the emphasis should be placed on marketing and technical know-how. The provision of facilities warranting complete commercialization of the products: commercial credit, publicity, marketing, sales-servicing, etc., and of the know-how required to start a smooth and standardized production —via licensing contracts, custom manufacturing agreements or technical assistance and research and development programmes, is a roundabout but most effective way of guaranteeing the promotion of specific productions.

The requirements indicated have been met by all successful agricultural extension programmes. Seen in our perspective, it is clear that long-term sales contracts and constant technical assistance have been the real key to the success

of these programmes, because they have reduced the adoption risks of corresponding agricultural innovations. In industry and services the same criteria should be applied to favour the adoption of innovation. These should be the basic criteria in setting up adequate organizational schemes to facilitate successive innovations.

What can be achieved if this type of policy is followed, assuming that our analysis is valid and that more operational hypotheses are derived from it.

In the domain of national development policies, we may expect the growing disparity of national levels to stop. We can hardly conceive of a decrease in existing disparities, for the enormous differences in size, human and natural resources of countries, make it impossible for the developing countries to absorb, at a faster pace than the developed countries, the successive innovation clusters so as to reduce their technical and organizational lags. The only feasible way to overcome this obstacle seems to be to override national boundaries and plan the necessary multi-national firms for continental areas. Recent experience of continental policies suggests this as a possible way out, for even countries ready to pool their markets, such as the EEC countries, have considerable difficulty in merging their firms in multi-national enterprises. As everybody is aware, the only really multi-national firms in the Common Market are the subsidiaries of the large multi-product, multi-plant American conglomerates.

In the domain of national urbanization policies, we can expect less shifts in the relative size of cities in the pre-existing urban systems, i.e. a more stable growing hierarchization of these systems. In the past, when time-lags between innovation clusters were longer and adoptions spread through space more slowly, and as a result of unrelated individual reactions, exceptions to our model resulted in sudden shifts of cities within the urban system. Geographical clusters adopting a new innovation cluster jumped ahead of those which did not, and for long periods maintained the relative distance achieved. This was the period of "growth poles" <u>strictu sensu</u>. Large and small urban centres shifted up and down the scale in relation to towns of similar size depending on whether they adopted or not the innovations pertaining to the activities in which they

were specialized. Gradually, these shifts have been reduced, even in the United States, the USSR and in other open frontier countries,[83/] as a result of both the reduction of innovation lags (which minimizes the permanence and magnitude of the induced deviations of any sectoral cluster) and of the spatial integration of adoptions (due to public policies, to the increased interrelations between individual producers brought about by transport and communication changes, and to the organizational changes mentioned above). In the future, we can expect that this trend will be strengthened: large towns will grow relatively larger than middle-sized ones; and these latter larger than the smaller ones, with the obvious exception of urban centres absorbed by others and cities created in new open areas; but all of them will tend to grow maintaining their relative places in the urban system, because more and more the whole system will participate in the adoption of new techniques. This trend will accelerate naturally if organizational policies of the type indicated are applied to geographical clusters at all levels, in order to integrate them tightly in the national innovation adoption process.

83/ The data for the United States have been closely analysed by E. Lampard in his "The Evolving System of Cities in the United States: Urbanization and Economic Development" in H. Perloff and L. Wingo (eds.) Issues in Urban Economics, Baltimore, 1968. Data for the other countries appear, at first sight, to show similar trends.