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INTERNATIONAL INSTITUTE FOR IIASA APPLIED SYSTEMS ANALYSIS

ISSUES IN THE MANAGEMENT OF URBAN SYSTEMS

Harry Swain and Ross D. MacKinnon,

editors

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Papers and Proceedings from a IIASA
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The views expressed are those of the contributors and not necessarily those of the Institute.

The Institute assumes full responsibility for minor editorial changes made in grammar, syntax, or wording, and trusts that these modifications have not abused the sense of the writers' ideas.

PREFACE

Interest in national settlement systems, urban growth policies, and regional development has been growing rapidly in recent years. Two international conferences[1] in 1971, in Eastern and Western Europe, signalled the academic coming-of-age of the field, and the forthcoming United Nations Conference on Human Settlements in Vancouver will set the final seal of respectability on the notion that urban and regional issues matter in national development plans.

From the inception of urban-related work at IIASA in early 1974, there has been a keen interest in settlement systems and planning policy.[2] In December 1974, some forty-three scholars from fifteen countries gathered here to share insights on research and policy in these areas. Two other volumes[3] of contributed papers are separately available.

The present volume contains a brief account of the proceedings of the conference, abstracts of all contributed papers, and the full texts of many of the papers not published in the other two volumes. Naturally enough, what remains after the special-interest papers have been pared off is a bit of a hodge-podge, but, we hope, not an uninteresting one. In fact it is here, among the contributions too diverse to be classified under neat a priori headings, that much of the really intriguing and interesting material is to be found.

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[1] G.C. Cameron and L. Wingo, eds., *Cities, regions and public policy*, Oliver and Boyd, Edinburgh, 1973; and *Geographica Polonica*, 27 (1973), "Contemporary urbanization processes," Proceedings First Polish-Soviet Geographical Seminar, Szymbark, May-June 1971.

[2] H. Swain, ed., *The IIASA Project on Urban and Regional Systems: A Status Report*, IIASA SR-75-1, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1975.

[3] H. Swain, M. Cordey-Hayes, and R.D. MacKinnon, eds., *Environment and Planning*, 7:7 (October 1975); and H. Swain, ed., *National Settlement Strategies East and West*, IIASA CP-75-3, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1975.

Grouping these papers into four categories sometimes does rough justice to their authors' ideas. Still, it seems useful to begin by contrasting policy issues with current practice, to move on to the theoretical issues thus raised, and to close with some consideration of where we go from here. At the beginning of each section we have tried to set the individual essays in a somewhat larger context.

None of the research scholars in the Urban and Regional Systems group at IIASA anticipated the sheer volume of work involved in running an international conference and preparing the results for publication. Thanks are due to a number of colleagues and friends whose generosity with their own time made the whole enterprise possible. Trudy Dittmer, Olivia Carydias and Eva Matt took care of conference logistics, and Julie Swain prepared presentation graphics for many participants. Our colleague Martyn Cordey-Hayes, now gone to his just reward as Professor of Transport Assessment at England's Cranfield Institute of Technology, was indispensable in many ways. Terry Seal and Maria Sachs shouldered most of the technical editing burdens, and various drafts were typed by Patricia Bartos, Elizabeth Ann Drew, Elfriede Herbst, Heidrun Mayr, and Linda Samide. Many illustrations were re-drawn by Helmut Frey. Each of these people has not only helped make this volume a reality; they have also enriched our all-too-brief association with a truly unique Institute.

H.S. and R.D. MacK.,
Laxenburg, Austria
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PART ONE: SUMMARY OF PROCEEDINGS

Summary of Discussions

Background and Organization

In 1971, the University of Glasgow played host to the first international conference on urban growth strategies and settlement systems. Sponsored jointly by the University and Resources for the Future, the conference was concerned mostly with British and US policy developments. It was the outcome of an accelerating awareness of what Wingo, Alonso, Lithwick and others have called an implicit urban policy in many Western countries, and of the recognition that inaction is itself a policy.

In that same year, the first Polish-Soviet Geographical Seminar focused on urbanization policies in centrally planned economies. Subsequent English publication of the proceedings in *Geographica Polonica, 27* (1973) forcefully brought Socialist approaches to analysis and planning to the attention of Western scholars.

In 1972, six years of preparation culminated in the formal creation of IIASA as a consortium of the Academies of Science of a dozen of the world's more industrialized countries. Located in neutral Austria, the new Institute was given a mandate to study complex and important questions of concern to all nations. In the general area of urban and regional systems analysis, it was decided to focus efforts on the management of urbanization; the conference reported here was the first fruit of that long-term research interest. For the first time, there was an institutional home for studies of the management of urban development which spanned East and West. Some forty-five invited participants and observers from fifteen countries attended the conference, and thirty-six papers were presented for discussion.[1]

The papers were presented and discussion notes taken in an order that was arrived at, somewhat arbitrarily, from the "policy paradigm" in the paper by Swain and Logan. Strategies in a number of market and centrally planned economies were reviewed, followed by a general discussion of spatial objectives. The agenda moved on to cover particular aspects of the behaviour of parts of the urban system, and to examine

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[1]Lists of participants and papers are appended to this discussion summary, along with exact bibliographic information. Elsewhere in this volume, conference papers are referred to by author only.

two attempts at program impact prediction in decision environments. The second part of the agenda included a panel discussion on research priorities for IIASA's urban and regional systems group, and for multinational urban studies generally. In its final sessions the conference considered a proposal for a comparative international study of urban systems in evolution which had grown out of earlier discussions at the Seminar on International Comparative Study of Megalopolises in Tokyo eighteen months previously.

Readers will have noted that the ordering described is not exactly that followed in the rest of this volume, an inconvenience for which the editors apologize while pleading necessity. Since only a selection of papers is presented here, a coherent flow of thought demanded a modified order.

Urban Strategies in Market and Centrally Planned Economies

After opening remarks on the relation between urban and energy systems by Wolf Haefele, IIASA's deputy director, Harry Swain gave a presentation of the policy perspective on urban systems developed with his colleague Malcolm Logan. Reading the conference preprints had only reinforced their view that a theory of the spatial structure of socio-economic systems adequate for basing policy on was a long way off, and they presented as an alternative approach their version of a rational, self-adapting paradigm for generating settlement strategies. However, this systems-analytic approach required specifying national goals and deducing spatial objectives from them, two rather difficult steps. Swain reviewed several attempts in those directions and noted reasons for the striking lack of success in a number of nations where urban growth policies have become important. These and other difficulties led to a consideration of other models of the policy planning process and to their differentiation in terms of the roles, priorities, and styles of research that were implied. Their conclusions about new directions for public policy were a good deal less sanguine than has been common in the literature of the last few years. On that mildly gloomy note the conference got under way, turning to a comparison of recent policy developments in market and centrally planned economies.

The first paper presented in this section was a review of frameworks for decision making in the preparation of national urban strategies, in which Larry Bourne drew on his recently completed study of urban growth policies in Australia, Canada, Sweden, and the United Kingdom. He noted a number of problems in this sort of comparative study: agreed terminology, ways of setting the urban system in its socio-political context, ways of comprehending environmental relationships, and an understanding of the functioning of urban systems. He concluded that international research on urban systems should seek precision in the concepts and terminology used, eschew single universalistic models, and deliberately include exploration of politically sensitive value questions.

Extemporizing on the theme of the paper he had co-authored with David Wilmoth, Malcolm Logan noted that the Australian experience in formulating effective urban development strategies is limited in its transferability, since international migration still plays a critical role. He outlined the state of evolution of settlement policies and programs and described what appear, from the present close vantage point, to be some of the major achievements and failures to date. He attributed the failures to malfunctions in the institutional system, noting in retrospect that the Commonwealth government planners should have paid more attention early on to involving the other levels of government in the policy making process. His descriptions of the means by which interdepartmental committees can reduce grown men to tears or teeth-gnashing drew rueful smiles from a number of conferees.

In the ensuing discussion, someone asked whether settlement policies in Australia and Canada took into account those nations' capacity to be major world food producers. Logan said that this may have been indirectly considered by the Australian government in its growth centres program which, although primarily concerned with redistribution of population, also deals to some extent with the development and intensification of agricultural land use. Ian Dawson reported that the development of Canadian agriculture for both domestic and world markets has led to growth in the size and wealth, though not number, of Prairie towns.

Piotr Korcelli characterized the approach of Poland as being more positive and hopeful. Abstracting from his paper, he outlined the development of the practice of national urban planning there which culminated in the *National Plan of Physical Development--1990*. The *Plan's* basic objective and achievement were just what Swain and Logan had said was so difficult: a spatial projection of general socio-economic goals in the long term. The presentation of the *Plan's* content was followed by a discussion of selected policy and planning alternatives.

Stanislaw Komorowski began his presentation by refuting a statement in Brian Berry's paper to the effect that "only the Poles are unconcerned with the inflow of rural people into their metropolitan areas." They are concerned, he said, but are not trying to staunch the flow since both agricultural and industrial productivity will increase with the movement of workers from farms to town. Komorowski also wished participants to note an updating of the organization chart of spatial planning in Poland which appeared as an annex to his paper. A State Council had just come into being, comparable in status to the sectoral planning mechanism, which will directly assist the Council of Ministers and which is expected to greatly influence Polish planning. In explanation of the current approach to urban planning in Poland, he referred to a "marriage" arranged two years previously between socio-economic planners and spatial planners; this had led to the *National Plan of Physical Development--1990* mentioned by Korcelli.

Richard Meier inquired whether the "marriage" implied a shift back to the traditional educational systems for planners, and if so, how this was embedded in the planning system. Komorowski argued that the necessary feedback occurs through the mathematicians who, as explainers of the system, inform new practitioners. Such multi-disciplinary, systems-analytic procedures demand continuous communication, based on a common language, among individuals involved in the planning process.

Ian Dawson asked whether the concept of optimum city size is given much credence in Poland. Korcelli replied that although some calculations were carried out in the 1960's, the concept had been heavily criticized on theoretical grounds: costs dominated any concern with benefits. In any case, most such calculations were concerned with delimiting areas for city expansion, overall growth rates, or allocations to new housing estates, rather than with absolute city size. On the other hand, Komorowski averred that optimal city size was a relevant, practical concept. Poland is against oversized cities: that is one of the basic principles of the *Plan*. Trends are carefully monitored for their larger implications and instruments are put into play when the situation calls for slowing certain kinds of movement.

The emphasis in the paper by Miklós Koloszár was on the interrelation between the settlement system and socio-economic development in Hungary. Hungary's history had left its mark on the settlement system structure, and the predominantly agricultural sector has determined its development level. It was Koloszár's opinion that development of the settlement system should be seen not as a static exercise, but as one requiring deliberate analysis, coordination and long-term planning.

Heinz Luedemann presented the paper jointly authored by Grimm, Kroenert and himself. Urbanization in the German Democratic Republic is closely connected with the realization of one of the important socio-political goals of socialism--that is, overcoming the main differences between cities and rural regions. There, one of the main aspects of urbanization is the planned intensification and rationalization of the relationship between city and hinterland. The planning of regional settlement systems must therefore be integrated in national long-term development plans.

Objectives for Urban Policy: Panel Discussion

A panel of seven, chaired by William Jewell, focused discussion on problems related to responsible goal-setting in national urban policy contexts. Jewell opened the session with some observations on the preceding discussions, stressing that he was an applied mathematician and engineer and not an urban analyst. Urban problems, he said, are at a predictable stage of development, characterized by a growing realization of the crucial importance of technology and innovation. The need for new modelling strategies and formalisms appropriate to the design problem has been recognized, as has the likelihood of actually being able to effect changes in the settlement system. He suggested the concept of "solution sets" instead of the narrower word "objectives" as more appropriate to the present historical stage. He identified some gaps in the discussions, especially the paucity of models of the dependency relations between cities. As possible guidelines for policy makers in this still hazy area, he stressed the importance of 1) variety and diversity of style among cities, and 2) valuing a city's capacity to support innovation.

Komorowski continued by calling the Swain-Logan paper too pessimistic, since he believed it possible to cope with these problems more positively. Regarding Swain and Logan's "commonly accepted non-spatial goals" he thought economic growth not an end but a means. Swain and Logan also stated that goals are "non-controllable," while Komorowski thought goal development can be controlled to a reasonable degree through the use of appropriate instruments. Value judgments, as discriminating devices, were shaped to suit interested parties and should therefore be set out before plans are formulated.

Some conflicting opinions about planning processes in market and socialist economies were aired. Komorowski asserted that the basic difference lay in the treatment of value premises, which in socialist economies are exogenous but in market economies endogenous. Moreover, the instrumental policy box (Swain and Logan's Figure 1) in socialist economies is larger, thereby allowing greater control and eliminating the need for a supra-coordinating structure.

In addition to the differences on the input side, Brian Berry pointed out that in a market system the outputs on which positive or negative values are placed are outcomes of the market process rather than things specified ex ante. When used to select alternative sets of endogenous variables, a market-oriented system is an existential as opposed to a goal-oriented system. Variances may also be seen in the control mechanisms.

According to Korcelli, the differences are in the decision making process rather than in the policy making process, since in the socialist system a relationship exists between the planner and the decision maker which is implied in the plan itself.

The role of planners in urban development was introduced into the discussion. In Peter Hall's opinion, planners may affect some details of growth processes but cannot affect the growth rate of the total urban system by more than a marginal amount. He attributed this to the limited operational capacity of policy instruments as well as to certain institutional factors. Optimal city size differs from country to country, and more comparable data are needed about the rate of growth of cities of different sizes in different countries.

Although planners may well be able to affect city size, Ed Mills believed that there is no reason for a national government to have a policy for redistributing population in a market economy. He questioned the need for policies for retarding the growth of large cities, noting that if large cities present social problems, governments should work on solving these problems directly. For example, there were better ways to control pollution than controlling city size.

Swain observed that governments nevertheless seem to be trying to translate a set of social goals into some set of spatial ideas--as for example, city size. More knowledge about the relationships involved was needed before scholars could in conscience advise on policy.

What Martin Beckman thought was missing from the discussions was the systems point of view. Heavy concentrations of people in cities is the problem, not city size; and therefore attention should be focused on optimal size distribution.

Two myths prevail that Brian Berry wished to dispel--namely that a value-free social science exists, and that there can be value-free scientific formulations of social and urban policy. By recognizing the substantial differences in policy making and planning styles as well as in terminology, he believed an explanation is possible for the diverging patterns of present urbanization. He said if Swain and Logan, in their now controversial Figure 1, could get away with a concept called PIP, he felt free to propose a paradigm called POP POP POP: "the pitfalls of policy are in the perception of problems and in the perversity of populations." On that note, we broke for lunch.

General Approaches to the Functioning of the Urban System

Three speakers presented rather disparate approaches to the study of the functioning of urban systems.

Vladimír Šipler explained that a broadly-based systems approach was used to solve settlement problems in Czechoslovakia because of difficulties encountered in applying mathematical models to development planning at the regional and metropolitan levels, and in particular to planning residential, industrial and transport complexes. A number of studies are being performed on the theory that the structuring of the verbal base of systems analysis contributes to the improvement of mathematical modelling.

A multiple-layer theory was employed by Koichi Mera to explain the distribution of urban population in Japan. His work indicated that, to a large extent, the distribution of administrative activities determines the distribution of manufacturing activities. Thus if government aims at the decentralization of urban population, it should decentralize administrative activities, among which central government activities are an important element. Past decentralization efforts in Japan had relied too much on decentralization of manufacturing activities alone. Mera pointed out that central government activities would have a much less critical impact on other urban activities in such countries as the Federal Republic of Germany, India, and the United States.

Gunnar Törnqvist inquired how the roughly 40 percent of employment in manufacturing that was administrative in nature had been classified in Mera's data on sectoral employment by city size. Mera replied that since the relevant breakdowns were not available in Japan, he had included these administrative jobs in the manufacturing sector.

Introducing his paper, Richard Meier noted some good reasons for using Hong Kong as a case study. Unlike most places, Hong Kong has an excellent data base. It carries some dimensions of urbanism to extremes yet remains vibrantly functional. Moreover, its patent lack of local hinterland challenges some of the received wisdom about the causes of urban growth.

Several alternative explanations for Hong Kong's remarkable history were offered by discussants. Walter Stöhr elaborated on one of Meier's minor points, namely that Hong Kong was exceptional since it was tacitly supported by patron powers; this was a fragile situation and could collapse overnight. Ed Mills speculated that Hong Kong's strategic trading location on the South China Sea alone could account for its prosperity, to which Meier replied that his calculations showed that trade would support about three-fourths of a million people and not the five million there now. Meier speculated about a possible future world in which some hundred major cities competed for investment capital on a comparative advantage basis, rather in the way multinational corporations now compete. He agreed with Joel Bergsman's point about the peculiar importance of the refugee flow to Hong Kong's economy and policy.

Policy Instruments and Their Evaluation

Niles Hansen led with a paper on growth centre policy. Such policies, he argued, ought to pay more attention to people's revealed preferences and utility functions with respect to location. Failures of growth centre programs in the United States could be attributed to the designation of inappropriate areas as growth centres. The ultimate solution he saw to problems of lagging areas was investment in human resources--that is, manpower programs, schools, health facilities and other factors that improve the quality of life and broaden choices in these areas.

Swain noted that a study recently carried out in Canada by Ellis Roberts showed that of the twelve least attractive cities in the country, at least seven had been officially designated growth centres at some time.

Peter Morrison mentioned the favourable outcome of relocation or assisted migration programs in the United States; but in Hansen's opinion, relocation was successful only if the movement of people was combined with an array of personal services. Follow-up studies on these programs showed that, after a three-year period, a significant percentage of the relocated population had returned to their home communities.

The question was posed whether a sufficiently stimulating intellectual environment could be established in growth centres to attract and hold professionals. Hansen believed that telecommunications now made it at least technically possible to fill any cultural and intellectual gaps that might exist.

In the second paper of the session Walter Stöhr offered a number of suggestions for growth pole strategies derived from spatial economic theory, and a study of existing national strategies for growth centres. He stressed the overriding importance of innovation. In response to the question whether growth was possible from routine investment without innovation, he added that innovation must be differentiated from economic impulses and should not be considered as development per se.

Gunnar Törnqvist suggested that a contact-system approach could also be used; Swedish experience showed that public investments in raising contact potentials would yield the desired regional economic effects rather efficiently.

One of the high-priority areas where economic and urban policy makers need help, according to Lloyd Rodwin, is in evaluating the likely consequences of alternative urban growth strategies in relation to national development objectives. Rodwin reported on a simulation model being developed by himself and his colleagues A. Fleisher and J. Harris that can be used for carrying out such evaluations. He believed that the model had particular application to urban systems in developing countries, since these have more opportunity to shape the future patterns of their urban and regional development. He acknowledged that in many countries there may be temporary difficulties, such as lack of personnel and equipment, as well as longer-term problems of inadequate knowledge and data, but added that the urgency of the problem demanded that efforts begin now.

In Komorowski's opinion, the model would be a major achievement. Based on his extensive Third World experience, he thought that sufficient data were available in many developing countries to undertake the exercise.

Migration Dynamics in Urban Systems

Martyn Cordey-Hayes was the first of six speakers to discuss various aspects of migration dynamics in urban systems. He offered a personal perspective on some existing models of national settlement systems, drawing particular attention to the importance of migration in these models. He outlined current inadequacies of some models of inter-urban migration for analyzing the dynamic interaction between the demographic and economic sectors of a system of post-industrial cities. In conclusion, he stressed the need for structural analyses, for building simple models geared to individual circumstances, and for adopting a problem-solving pragmatic approach.

John Goddard asked whether the UK work reported in the paper considered total migrants or labour force migrants, because the migration of the retired can distort analyses of economically motivated moves. Cordey-Hayes replied that the analysis considered only labour force migrants by restricting the analysis to the age range fifteen to sixty-four.

Koichi Mera suggested that equilibrium models do not adequately describe migration movements. Cordey-Hayes agreed and said that this is why a dynamic theory of inter-urban migration had been developed in the paper. However, equilibrium models can provide useful first-approximation information in some cases, provided that the limitations are known and acknowledged. The paper contains a hierarchy of models, some static, others kinematic and dynamic.

Egon Matzner suggested that economic theory described the movement of blue collar workers and that the mobility theory described in the paper was appropriate to the migration of professionals. Cordey-Hayes referred to evidence suggesting that the dynamic analysis described in Section 3 of his paper was relevant to an occupationally disaggregated population, but agreed insofar as correlations were more significant for the migration of skilled and professional groups.

Ross MacKinnon reviewed his paper in which he evaluated possibilities for constructing models of a Markovian type for controlling interregional migration. Time-dependent probability distributions (stochastic processes) must be explicitly recognized in such a model. Since no widely accepted preference function exists with respect to national urban settlement systems, goal-setting must not be necessary in the control model. All control-theoretic models, he noted, should be used within a broad heuristic framework that includes direct interaction between the modeller, the data, and the policy maker.

In view of the lags in public policy, Meier wondered whether it was not better to have monthly data for these models. In MacKinnon's opinion, annual data are sufficient to ensure the model's effectiveness. Waldo Tobler raised an unanswered question: whether it would be possible to construct a model in which lags between data and current policy are built in.

Joel Bergsman concentrated his discussion on two studies in which he had been directly involved. The first concerned an econometric model of population and employment shifts among metropolitan areas, which was generally successful in predicting migration. He referred also to some modelling work carried out in Brazil that simulated two sets of factors--the interactions between industrialization, urbanization, and migration on the one hand, and public services and taxes on the other.

Peter Morrison contended that policy makers too often have pretended knowledge and power that they simply do not posssess. Turning his attention to migration and return migration studies carried out in the United States, he noted that in many cities return migration is a key indicator of what is happening at the national level. Niles Hansen asked whether many of these return migrants were not young Negro professionals moving back to the South. Morrison responded that the study showed the return migrant group to be usually older non-professionals who were returning to their place of birth, although there is a simultaneous migration of northern-born Negro professionals to the South.

Urban planning for the year 2000 was discussed by Hisayoshi Haruta. Current projections for the 1975-2000 period required an economic growth rate in the 6-8 percent range if present metropolitan infrastructures were merely to hold their own. Japan's major problem in urban development policy was going to be coming to terms with the harsh new realities revealed in the world economy in the last few years. A second general planning problem would be the involvement of broader sections of the populace without losing the valuable Japanese capacity for speed in innovation following expert consensus.

Commenting, Meier recalled a competition held in 1972 on what should be done with central metropolitan areas in Japan. Architects had to a man sensed the emotional need of people to get away from cities based on GNP maximization, and to return to a more humane and possibly traditional urban environment.

T. Matsuzaki reported on a large-scale systems analysis of the development problems and opportunities facing the prefecture of Hyogo. The venture was a cooperative one, involving officials from several levels of government, university experts, and the facilities and expertise of IBM Japan. Relatively new, at least in the Japanese context, was the deliberate and structured involvement of Hyogo residents and their representatives in the planning process.

Carlos Ferrán began his presentation by pointing out that Spain has few trained urban planners; most of the people active in the field were, like himself, renegades from related professions. He reported on the 1972 Madrid Metropolitan Development Plan, in which the concept of corridor development was used to structure the physical form of the rapidly growing region. He believed in a problem-solving approach based on the use of fairly simple techniques so that results could be more easily communicated to policy makers.

Aspects of Urban Systems Analysis

Three papers on aspects of urban systems analysis were presented. The first, by Martin Beckmann, offered an income determination model for central place systems. Regional input-output analysis and traditional central place theory were used in developing the model. While designed primarily for use in market economies, with some refinement the model would be applicable in centrally planned economies. He referred to an earlier comment about the need for a theory of inter-urban systems and pointed out that central place theory could be much further developed.

In the discussion that followed, Bergsman suggested using--with some modifications and deletions--international trade theory to explain different specializations of cities and different income levels. The weakness of this theory, countered Beckmann, was its inability to classify activities as central or non-central. Beckmann agreed with the observation that transportation did not appear explicitly in his model. Berry noted that the model's initial derivation in market relationships was based on transportation costs and the demand cone but that these were not really considered in the formulae. This raised the question of ranking activities and the matching of activity sets to urban sets. Beckmann acknowledged that the two assumptions must be derived from spatial considerations--that is, transportation costs plus fixed costs. His model had not considered in depth a situation where distance as such is no longer a cost factor.

Information flows in organizations comprising the urban system were the subject of John Goddard's presentation. His contention was that the spatial structure of corporate organizations, and their information flow networks, underlie and steer a number of urban and regional development processes such as the spatial diffusion of technical innovation, multiplier linkages, polarized development and regional external economies. An important policy instrument for both organizations and public sector agencies concerned with regional development is the establishment of contact networks through investments in advanced telecommunications.

Gunnar Törnqvist's paper outlined a Swedish analytical model of regional and organizational information flows with respect to redistribution of employment in contact-intensive occupations. The study showed that the decentralization of contact-dependent activities--for example, moving governmental agencies out of the capital--reduced the ability of employees to keep up their personal contacts. In Törnqvist's opinion, regional development policies would be most effective if directed towards improving the transportation system. He also reported on a similar study currently being carried out on the European systems of cities which is expected to yield similar results.

Several comments were addressed to Goddard and Törnqvist. Meier referred to the games people play with the communications system as communications become more prevalent. As a result, firms learn how to use the system to salable advantage. Since these types of firms are growing rapidly, he stressed the importance of looking at their communication inputs.

To a question about optimal investment strategies for transport where demand and cost were considered globally, Törnqvist replied that his work had taken a more micro approach, concentrating on solution of individual conflicts. An organization, which after all is composed of numerous individuals, can have no uniform demand for locations. The geography of conflicting preferences was therefore more relevant than the geography of optimal solutions for unreal organizations. Recognition of this in Swedish management was leading to the separation of units in large firms, with headquarters staying in large, central urban regions and operating units in peripheral locations.

Beckmann thought it might be interesting to try to link the notions of contact landscape and central place systems.

Egon Matzner asked whether information and contacts were being treated as homogeneous and whether, in fact, causality could be fairly inferred in Goddard's model. Goddard noted that the quality of information is not the same in all urban areas and that this can have major implications for differential regional development. Although difficult, studies should be made of actual and potential information flows so that a distinction can be made between contacts related to ongoing processes and contacts for instrumental changes in the future.

Program Impact Prediction and Evaluation

Reports on large-scale modelling efforts to measure program impacts in France and Canada were presented. The French model REGINA, as explained by Raymond Courbis, is expected to be fully operational for the preparation of the Seventh Development Plan in 1975. It is a medium-term model of some 7,000 equations which examines national and regional development, with the five major regions in turn described separately by rural, small-town and large urban components. With this model, it should be possible to simulate the impact of a wide variety of macro-urban policies on a number of indicators of national and regional development.

Some of the problems encountered in the construction of Canada's Macro-Urban Program Impact Model (MUPIM) were discussed by Ian Dawson as background to the more detailed picture of one of its sectoral submodels presented in the paper co-authored by Martin Ulrich. MUPIM's seven sectors were but loosely interconnected. This was done deliberately so that snags in one area would not bog down the whole project, and so that partial results would be available very early in those sectors closest to current policy considerations. Major conceptual difficulties remained (in the treatment of uncertainty, for example) for which the theoretical literature offered at best incomplete guidance.

Comments on the two models were presented by William Nordhaus. He could find no answers to two important questions: what are the policy variables, and what is the objective function? Without a priori answers to these questions, he wondered about the usefulness of such models for regional planning. Or, he asked, is regional analysis so complicated that answers to these questions are not feasible and an inductive approach must be used? As for the design of the models, he noted that there was some use of theory in both. Underlying relations were treated as behavioural equations, and in this connection he stressed the importance of good econometric and statistical technique. Weaknesses were observed in the models: the projections are weak because no systematic approach to error or sensitivity appears to have been used, perhaps because the models are too large; and there is no discussion of the validation of the models. Some other problem areas included

a) the modelling of trade between regions;

b) no treatment of lags (and here he noted that for policy studies, time series models are important);

c) the optimal spatial and temporal resolution of these models, which he believes is the most crucial and difficult factor.

Bergsman said that the objective function varies from person to person and is thus not definable. It has been his experience that policy makers more readily accept simulation models without the objective function, as opposed to optimization models.

Peter Hall observed that the limited spatial element of the REGINA model--five regions--might present difficulties in studying the spatial implications of national planning.

Analysis and Monitoring

A management information system for population distribution is planned in the Soviet Union as a subsystem of the nationwide planning data collection system. Vladimir Kulba outlined the principles of dataware design for this application, focusing on the design of appropriate data banks and the structure of the planned subsystems. In response to a request for further clarification of his terms "rational structure" and "objective function," he noted that when many vague criteria are involved, no globally optimal results are possible, but simulation models may be used as a first step in decision making.

The Chairman noted that Valery Sokolov's paper on models aiding national settlement policies in the Soviet Union should be read in conjunction with Kulba's remarks.

Joseph Haring reviewed a study that analysed the impact of alternative transportation systems on urban structure and compared representative US and European cities.

Referring to one of Haring's conclusions, namely that US urban structure appears to resemble European urban patterns as transportation modes proliferate, Richard Meier mentioned conflicting studies carried out at Berkeley which demonstrated that the United States showed little similarity to Europe in travel behaviour and in the adaptation of land use in metropolitan areas. The crux of the problem, noted Haring, lies in understanding the present meaning of "European behaviour"--which shows a preference for short commuting distances. Moreover, the preference system explains why Americans use private transportation modes.

Friedrich Schindegger outlined an approach to the delimitation of urban boundaries which stresses the importance of political-administrative functional areas in explaining settlement systems and their dynamics. A method was also proposed for selecting optimal areal delimitations under the constraint of a politically defined goal function.

Meier mentioned a number of additional factors that he felt could have been included in the Schindegger-Sauberer paper. Parameters were needed that would be sensitive to the age of the system itself, as well as some means for measuring the amount of resources needed by the unit to function within the system.

The third presentation focused on a planning-oriented approach to a system of urban indicators. In Egon Matzner's view, urban indicators are needed because of the improper functioning both of the "invisible hand" in market economies, and of central planning agencies in socialist economies. Some prerequisites for urban indicators are the use of a theoretical base, linkages to planning instruments, and integrating devices.

Heinz Luedemann questioned whether such an approach could be realized in a society characterized by a large measure of privately controlled economic resources, and asked what practical instruments were needed for implementation. Matzner referred to large-scale public investments where the location of infrastructure, for example, influences the structure and functioning of a city. He stressed the importance of analysing market processes so as to identify intervention points where indirect instruments can influence urban development.

Research Requirements

Some research guidelines applicable to IIASA's work and to multinational work on urban systems were discussed in a panel session chaired by Tjalling Koopmans.

Komorowski characterized the problem as twofold: organizing research on national models as well as on systems for connecting these models. To bring continuity and objectivity to the work, he believed that IIASA should concentrate on the latter activities.

Among criteria for effective research mentioned by Mera were: 1) broad participation of as many countries as possible; 2) a policy-oriented approach; and 3) usefulness of research for both policy makers and scholars.

Efforts to improve the general level of knowledge of urban and regional systems should be coupled with those for solving specific problems of particular urban systems.

Since much urban decision making is made without knowledge of or participation by scholars of urban systems, William Pendleton urged that research aim to strengthen the relationship between research findings and actual decisions for infrastructure investments. He underscored the need for multinational comparative urban research, and expressed the hope that the incipient debate about city size would be fleshed out. More analysis of the impact of policy instruments was needed, especially with respect to Eastern European countries. The real value of such comparative research in the long run would be its contribution to urban development in Third World countries.

According to Michel Rousselot, national policies for urban development may only be possible under two conditions: that there is a decision making process working on a long-term basis, and that there exists a competent organization at the city level. He listed the following prerequisites for national urban policies: a) improved descriptions of historical processes of national urban settlements; b) impact evaluation of policy instruments already in use; and c) the use of simulation models (though for limited purposes only). He anticipated difficulties in promoting multinational urban research because of different decision making processes and the different socio-economic and political environments of urban systems.

Per Lindblom briefly reviewed the nature and scope of the human settlement project being carried out at the International Federation of Institutes for Advanced Study (IFIAS). In the initial phase, case studies form the core of the activities, to be followed by the establishment of standards and definitions aimed at creating a common language. A final effort will be concerned with identifying universal parameters for use in developing an overall model of human settlement.

With respect to settlement patterns, Niles Hansen pointed out that the regional separatist movements worldwide were an unexplored area which might yield some valuable insights.

Work on a behavioural theory of decision making in a spatial context would, in Beckmann's opinion, be a high-priority area for study.

Referring to the time lag of about twenty to thirty years before the effects of research can be judged, Meier suggested that an index other than GNP be found for the really valuable thing, knowledge maximization in social units. Lloyd Rodwin countered this viewpoint, stating that it was unwise to try to optimize something over so many years. Since the problem is pragmatic, it was best to identify how the system works at the present time. He suggested that useful study areas included an examination of where growth should be encouraged, what growth patterns to encourage, what performance standards the development patterns should satisfy, what trade-offs are involved in reconciling goals, how decisions on these matters are made and what institutional changes might help to improve them.

Rodwin added a personal note by expressing his disappointment that the discussions had not yielded specific information on *failures* occurring in different systems in the member's home countries. He stressed the importance of studying successes *and* failures in relation to pragmatic issues for clues on the behaviour of systems which, along with modelling, could lead to improvements in the system. He believed that the pragmatic activities of a team of specialists, as opposed to modelling exercises, gave the greatest return on investment.

Throughout the conference many statements were made about the need for a common language among urban scholars and policy makers. In Vladimír Šipler's opinion this should be the primary task of research.

John Goddard supported the future-oriented approach mentioned by Meier because of the impact of technological change on the urban system. Behavioural research, he noted, was too retrospective and not particularly useful for the long-term analysis of urban systems development.

Tjalling Koopmans cautioned against overemphasizing the importance of optimization. The fact that optimization techniques are so highly developed and well stated leads to the desire to apply them sometimes without sufficient examination of whether the model to which they are applied reflects reality and justifies the use of the techniques. Also, a meaningful choice of objective functions is needed for optimization, and for the twenty-to-thirty-year horizons mentioned, accurate predictions of the future are not possible. Thus it is important to remain flexible and to optimize something that is instrumental rather than goal-oriented. The accumulated evaluation of models is the first step in obtaining greater flexibility.

Several final comments were made on the goal function in national urban policy. Rousselot maintained that the decision makers know or think they know the goals; the weaknesses lie in ways and means of implementing goals. Rodwin, Meier, and Morrison objected to this viewpoint, arguing that the area of least knowledge was that of defining goals. They suggested that research look into ways of correcting the kinds of errors that will be made in formulating initial goals so that the processes of reformulation can be improved over time.

Prospectus for a Multinational Comparative Study of the Performance of Urban Regions

The conference studied a proposal by Peter Hall for a comparative international study of urban systems in evolution. Comments and suggestions were directed towards the project's feasibility, objectives, and substantive requirements; it was agreed that the organization and financing of the project could be determined at a later stage.

Hall outlined the nature of the problem and possible objectives of the project. The problem is essentially to define Daily Urban Systems (DUS's) for universal application; and in this connection he mentioned work going on in Canada, the Federal Republic of Germany, France, the German Democratic Republic, The Netherlands, Japan, Spain, the United Kingdom, and the United States. Within a short time, he believed a common framework would exist for analyses covering Western Europe, North America, Japan, and possibly Eastern Europe. If the study concentrated on major metropolitan areas, sufficient data bases already existed to carry out such initial basic analyses as population and employment changes, growth of retailing and other services, shifts in services and population, and divergent growth patterns in different urban systems. The study could be two-phased: intra-national studies, and international comparisons which combine co-operation among various institutes on the national level with the co-ordinating function of IIASA.

Brian Berry suggested a problem-oriented approach since he did not believe an international comparative inquiry was feasible because of different cultural values and policy orientations in different cities. He proposed studying the city as a spatially arranged stratification system and extending this notion to urban change generally.

France has experienced difficulties in transferring concepts used in other countries for description and analysis of urban systems, especially those coming from countries with high population densities. While it was technically feasible to reaggregate statistics from some areas in France to obtain the data sets mentioned by Hall, Rousselot did not believe such difficult and complicated work could actually be done.

Edwin Mills underscored the desirability of using available national data to put together an international data set for urban analysis which IIASA might consider publishing for broad distribution. Meier questioned whether sufficient data existed in most countries, noting that a University of Michigan study had encountered difficulties in obtaining basic urban data on the United States.

According to Šipler the problem could be seen as that of comparability of data and transferability of systems. With particular reference to Eastern European involvement in the study, he noted that a common language would have to be worked out before systems could be transferred. He presented a systems view of the problem and some possible solutions which he felt could be applied to both market and centrally planned economies. He did not feel that sufficient urban data of the type mentioned, structured in a way useful for the proposed study, were available in Czechoslovakia for national studies.

In Vladimír Kulba's opinion, the methods used in the Soviet Union for urban problem solving could provide a common framework in which to act.

Piotr Korcelli noted that Poland has an adequate data base with which to carry out the proposed research, but restated the need for a common definition of daily urban systems in terms that embrace the entire territory.

Since there was much to be learned from an in-depth study of one system, Morrison suggested that the project centre on an intensive examination of a limited number of daily urban systems. According to Swain there were two ways of approaching this: a study of contiguous sets of urban systems and their relations--as for example in Europe; and a study done on a comparative basis of daily urban systems in several cities with highly different systems but with good data bases.

If resources allowed, Joel Bergsman felt that both approaches would prove valuable and noted the periods of the 1950's and 1960's as being interesting from a comparative viewpoint. He believed that the role envisaged for IIASA in the study would provide a backdrop for future work, citing an EFTA study that helped launch further studies on the national level.

Homogeneous measures are needed for international comparison. Since this is practically impossible to obtain, Matzner suggested focusing the study on the input side of urban systems. For example, analyses of energy inputs would make optimal use of IIASA's urban and energy projects. Swain said he would like to obtain--even in highly aggregated form--comparable data on flows of energy and basic material resources through cities.

Although diverse urban regions show great resilience in spite of government policies, Berry suggested a study of the significance of changes arising from different forms of policy interventions. Attempts to control critical background variables dictate that initially the study be broadly drawn rather than restricted to highly select cases.

In Mera's opinion, Japan has a good data base for carrying out the type of research mentioned. He stressed the importance of time-series data for the study.

Bourne thought it advisable to link the study in some manner to the United Nations Environment Program, and to the 1976 Conference on Human Settlements to be held in Canada. In his view the proposal should take the following form:

a) an updating and standardization of existing national studies, with IIASA acting as co-ordinator of this activity;

b) a comparative international study that asks to what extent national studies can be used, to be carried out at the urban systems level and backed up with case studies of individual cities and individual expressions of the urban process;

c) a study by IIASA of the international interdependencies in urbanization--for example, the impact of "turbulence" on expressions of urbanization in particular countries.

Rodwin noted with amazement the lack of discussion on the opportunity costs of the project. He felt that the study should concentrate on four points of inquiry:

1) the kinds of data that exist in key cities;

2) ways of using these data for urban studies and for policy making;

3) the adequacy of data for such studies;

4) deficiencies in the data that could be improved by modest investments.

It is through an evaluation of such inadequacies and potentials that policy makers and urban researchers can best be helped.

While there were possible areas of co-operation with respect to Hall's proposal, Luedemann stressed the difficulties that would be encountered in working with different socio-economic systems, statistical units, and time scales of statistical data. He believed that the concrete work of studying urban systems should be carried out on the national level using similar methods; IIASA should concentrate on improving the theoretical and methodological bases to be applied to the national work and later to an international comparative study.

Walter Stöhr suggested that planners and researchers in data-poor cities could be assisted by pressing their statistical officers to improve the data needed for the study. IIASA could study the type of data needed in certain strategic areas. As a footnote, Rodwin emphasized the importance of reaching not only statistical officers but also key ministries involved in policy making. Less urbanized countries should be included in the study, for mutual learning purposes and also because these countries are in a better position to reorganize their statistical services.

For the type of data system to be used, Gunnar Törnqvist suggested the Swedish-type system built on co-ordinates, which was efficient and inexpensive. Swain observed that if the proposed study is undertaken by IIASA it would have to use existing data bases, though suggestions on possible improvements might be a useful byproduct.

Hall concluded by summing up a number of points based on the discussions. There was no general agreement about whether the proposed study should proceed, or await improved statistical series while at the same time pressing governments for improved data. He restated his belief that the study should begin with available data and undertake an empirical review of past and ongoing work. As to the various suggestions made for improving the theoretical base for analysis, he suggested that IIASA carry out some in-house research so that within twelve to eighteen months a sufficient theoretical framework could be provided. IIASA would then be in a stronger position to make detailed and more ambitious research proposals about many of the points raised in the discussions.

Swain thanked the participants and formally closed the conference.

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Abstracts of Papers and Bibliography

Alperovich, Gershon, Joel Bergsman and Christian Ehemann, *Environment and Planning*, *7*:7 (1975).

An Econometric Model of Employment Growth in US Metropolitan Areas

The paper reports on tests of hypotheses about the determinants of employment growth in US metropolitan areas. All urban employment covered by Social Security is included; the hypotheses are tested for each of forty groups of four-digit SIC industries. The units of observation are 284 areas, including all SMSA's as of 1970 plus some smaller places. The time period is 1965-1970.

The two main findings are the following. First, ease of attracting labor is shown not to have an important influence on local employment growth. Secondly, access to markets is the most important factor, followed by localization economies, and--for some industrial groups--low wage rates and access to input. Urbanization economies (measured by city size) are a negative factor for some groups. The research is part of a larger study of the determinants of migration and employment growth.

Avdotjin, L. , IIASA CP-75-3, pp. 1-11.

Principles of Regional Settlement in the USSR

The objective of economic and territorial development in the USSR is the comprehensive satisfaction of the material and intellectual needs of the Soviet people. Industrial development is considered the key means to this end.

Systems analytic approaches to the generation, evaluation, and selection of alternative patterns of the spatial distribution of productive forces are advocated. Current directions in research and policy are sketched. [Abstract by editors.]

Beckmann, Martin J., *Environment and Planning*, *7*:7 (1975).

An Income Determination Schema for Central Place Systems

A system of central places is called hierarchical if the set of economic activities of any city depends only on its hierarchical rank $r(r = 1,\ldots,R)$ and if the activity sets of higher-order centers include those of lower-order centers:

$$A_{r+k} \supset A_r \quad , \qquad k > 0 \quad .$$

A given city (and its hinterland) receives higher-order goods from the nearest higher-order central place; it produces all lower-order goods locally. Assume a linear production technology: an input/output system. Let demand be described by expenditure functions linear with respect to income.

The paper develops an input/output matrix for the entire urban system, using as building blocks technological coefficients describing the transformation of goods classified by ranks. (The rank of a good is the lowest rank of any city in which it is produced.) Given the technology and demand structure and the exogenous demand, the incomes and sizes of cities of various rank may be determined recursively: income or size of first-order cities is derived from exogenous (non-central, agricultural) demand plus local demand. The income of an r^{th} rank city is derived from the incomes of all lower-order centers in its region. Even without knowing the exact values of the coefficients, statements are possible about the size distribution of central places and about changes in size distribution generated by changes in demand and/or technological coefficients. The paper concludes with some remarks on the statistical problems of measuring the coefficients.

Berry, B.J.L., in this volume, pp. 66-79.

Comparative Urbanisation Strategies

Divergent paths in twentieth-century urbanisation are related to differences in urbanisation strategies, and the differences in these strategies in turn to variations in socio-political structure and to differences in the centralisation of control. It is concluded that political power is becoming a major element in urbanisation, and that it can be directed to the production of new spatial forms and social outcomes, towards goals rather than towards the curing of yesterday's problems.

Bourne, Larry S., IIASA CP-75-3, pp. 86-118.

Conceptual Issues in Designing and Evaluating Strategies for National Urban Settlement Systems

Comparative policy research requires a consistent terminology and a clear conceptualization of the different policy-making processes involved. The recent interest in establishing national urban settlement strategies is one example. Here we have seen little concern for uniformity in the language or methodology of analyzing urban goals, identifying policy issues or responses, or in reference to our assumptions on how urban systems actually work. Consequently, the international dialogue on national policy problems has been confusing and often counter-productive.

This paper poses a number of basic questions in the design and evaluation of national urban strategies. What do we mean by the terms urban systems and urban strategies? What alternative modes of decision-making are involved in such strategies? What are the basic preconditions which constrain the types of policy responses we observe in different countries? What issues stimulated those responses? What role do expectations of the future hold for national urban strategies? Who needs a national urban strategy? The paper then sets out a series of conceptual frameworks to display alternative concepts of what such strategies may look like and how they may be evaluated. The paper concludes with a brief discussion of the problem of bringing the institutional arrangements for managing urban systems into closer correspondence with the geographical and hierarchical scales at which urban problems are manifest. Specific examples are drawn from a recent comparative study by the author of urban policy developments in Britain, Sweden, Australia and Canada.

The comparative review not only documents the need for a common research language and clarification of alternative decision-making styles applicable in different political systems, but the need to link statements of goals and issues with the consequent policy response. The diversity of these styles suggests that no one model of settlement systems, or of strategies for managing those systems, is appropriate for all political contexts. Far too frequently we assume that a given policy instrument is a response to similar goals or perceptions of urban issues. This is seldom the case. The social preconditions of policy formulation, including the framework of future expectations, ensures that the response of governments to the national settlement debate will vary.

Among those preconditions the most uncertain at the moment is the influence of events whose origins are external to the political system under study. This uncertainty, the result of an increasingly turbulent external environment, renders comparative studies of national urban policy both more difficult and more essential.

Cordey-Hayes, Martyn, *Environment and Planning*, 7:7 (1975).

Migration and the Dynamics of Multiregional Population Systems

This paper gives a personal perspective on some models of national settlement systems and draws attention to the importance of population migration within these models. It includes a discussion of the inadequacies of current models of inter-urban migration for the analysis of the dynamic interaction between the demographic and economic growth sectors of a system of post-industrial cities. The paper is not, however, a review; instead, the aim is to obtain insights on how to progress towards a framework and strategy for research that will usefully contribute to the analysis of national settlement policy.

Section 2 considers recent developments in multiregional demographic analysis and argues that these are of limited usefulness unless they are integrated with models of regional economic growth. Results are presented which show that multiregional demographic analyses are extremely sensitive to the assumptions made concerning migration movements. Section 3 outlines three models which interrelate demographic and economic growth, stressing the links between the two sectors. Each model considers population migration a key link, and two of them assume that the movement of workers provides an equilibrating mechanism between labour supply and demand. Section 4 questions the validity of this traditional approach to migration and argues that for a system of post-industrial cities a new approach is required. A conceptual framework emphasizing information flows, differential mobility and inhomogeneity of labour is sketched.

A final section concludes that no single model or approach provides a royal road to models of national settlement systems, owing to gaps in our understanding of the dynamics of interactions amongst cities. It is suggested that a hierarchy of models be developed at varying levels of approximation.

Courbis, Raymond, *Environment and Planning*, 7:7 (1975).

Urban Analysis in the Regional-National Model REGINA of the French Economy

Proposed in 1971 by the author, the REGINA model is being elaborated under his direction for the French Planning Bureau. It will be operational in 1975 in time for the preparation of the Seventh Plan. REGINA is a medium-term econometric forecasting model of some 7,000 equations; in it, France is divided into five large regions whose rural, small urban, and big city sectors are treated separately. Thus the effects of urban development on regional balance and national growth, and conversely, the impact of macro-urban policies, can be explored in a national economic planning context.

Dawson, Ian, and Martin Ulrich, in this volume, pp. 267-302.

Program Impact Models for Policy Research: The Case of Transportation

The creation of the Ministry of State for Urban Affairs in 1971 was a major step in a coordinated and growing response by the Canadian government to urban problems. The Macro-Urban Program Impact Model (MUPIM) project was launched within the context of the Ministry's mandate. The main objective of the model is to predict the impact of alternative government programs and policies on the Canadian urban system.

The model is composed of six sub-models: demography/income, environment/resources, industrial structure, urban land/housing, public finances, spatial linkages.

The function and basic structure of five sub-models are briefly reviewed, while the Spatial Linkages Sub-Model (SLSM) is discussed in detail. Based on a transport network of some 100 nodes, the SLSM is composed of six modules: inter-city commodity flow, commodity transport supply, inter-city passenger flow, passenger transport supply, urban travel demand, vehicle energy and emissions.

Initial formulations of the inter-city commodity and passenger flow forecasting modules are described in detail. Gravity and linear programming models are the basis for demand forecasting for inter-city freight flows; gravity and abstract mode models are used for passenger flow forecasting. Application of these models to specific program impact problems has commenced, some major policy variables of interest being transport taxes, inter-modal competition levels, and labour cost.

The urban travel demand projection module has a regression-based structure calibrated on cross-section and time series data pertaining to such factors as automobile ownership, population density, and transit availability. The outputs of the module are required for estimates of anticipated public investment in urban transport facilities and modes.

Other modules, which will represent the supply of transport facilities, the energy inputs and emissions are currently under development. The supply-oriented models are required for an understanding of the full effect that policy variables have on transport demand.

The Spatial Linkages Sub-Model relies upon other sub-models, mainly demography/income and industrial structure, for both input data and complete output processing--that is to say the generation of urban system impacts.

Some of the difficulties in large-scale urban systems modelling are attributed to the paucity of specific tools for impact prediction and evaluation coming from the research community at large. MUPIM is similar in some respects to the REGINA model, although it is much more decentralized in terms of model structure.

Ferrán, C. and E. Mangada.

Patterns of Growth and Regional Interaction
of Metropolitan Madrid

The paper summarizes a number of studies about the physical structure of metropolitan Madrid made by the authors and their colleagues for the 1972 metropolitan plan. A number of organizing concepts were tried, and the notion of a development corridor seemed best suited to both the empirical reality and the planning context. Two concerns of all the preliminary studies were simplicity and transparency in methodology, both in order to give at least exploratory attention to a larger number of attributes pertaining to the final decisions, and to enable those required to make the decisions to fully appreciate the technical analyses. While it was felt that the studies meet these criteria, the authors also stress that modern urban analysis is relatively new in Spain and that much more detailed and more methodologically sophisticated work remains to be done. [Abstract by editors.]

Fleisher, Aaron, John Harris, and Lloyd Rodwin, in this volume, pp. 320-347.

A Proposed Approach to the Development of a
Simulation Model For Evaluating Urban Growth Strategies

Economic and urban policy makers currently need and want help in evaluating the likely consequences of alternative urban growth strategies in relation to national development objectives, particularly from the standpoint of: 1) employment, output and income; 2) distribution of income across social groups and regions; 3) growth rates; 4) movements of population and economic activity; 5) development and welfare policies; 6) organizations and levels of decision making; 7) consumption patterns; 8) quality of life and environment; 9) health and education; and 10) maintenance (or disruption) of traditional values.

The proposed approach indicates a research program for the development and testing of a simulation model which might serve these ends, at least for the first six categories noted above. The plan is to introduce policies (or strategies) as exogenous variables and the model outputs would be the development targets sought by goverments and planners. The policies focus on altering balances between major sub-national regions or in the scale and distribution of population within these regions. Cities are linked as sub-models within a region and regions are linked as sub-models within a nation. The basic sub-models, urban or regional, will contain three principal sectors: demographic, production and public. The dynamic model will focus on demographic transitions and investment in the production sector and in infrastructure. The sub-model structure is consistent with either highly aggregated or finely disaggregated sectoral specification.

The modelling would start sequentially with only a few regions and a few industries. In the process of operating a simple version of the model, it should be possible to determine the parts of the model's policy to which the results are most sensitive; this will stimulate further refinement of specification, disaggregation of sectors, collection of data and estimation of parameters. Making the model will require obtaining and analyzing data, formulating relations, fitting the parameters of the equations to the observed behavior of the economy, validating the formal structures and operating the model.

For almost all the software required for the procedures a computing system such as TROLL 1 can be used at the outset. TROLL was written for the IBM 360/67. The system is easy to learn and requires no particular competence in programming. The organization behind TROLL is a special division of the National Bureau of Economic Research located in Cambridge, Massachusetts.

Goddard, J.B., in this volume, pp. 180-225.

Organizational Information Flows
and the Urban System

This paper argues for a closer linkage between research on the behaviour of organizations viewed spatially and aggregated studies of urban systems. The basic contention of the paper is that the spatial structure of corporate organizations, especially when defined in terms of the location of non-manufacturing functions and their information flow networks, underlies and steers a number of aggregate urban and regional development processes--like the spatial diffusion of technical innovation, multiplier leakages, polarized development and regional external economies. In this perspective the paper reviews theoretical and empirical studies under three headings:

1) Changes in the aggregate distribution of employment in various non-manufacturing activities.

2) Change in the spatial structure of corporate organizations, particularly the division of functions between locations.

3) Studies of intra- and inter-organizational information flows.

Under each heading particular emphasis is placed upon research that has aimed at building bridges between different aggregation levels. The paper concludes by discussing how the management of contact networks through investment in advanced telecommunications, "communication audits," and the designation of growth centres based on information exchanging functions can become an important policy instrument for both organizations and public sector agencies concerned with regional development.

Grimm, Frankdieter, Rudolf Kroenert, and Heinz Luedemann, IIASA CP-75-3, pp. 74-85.

Aspects of Urbanization in the German Democratic Republic

Urbanization is an important feature of territorial development in the GDR. As a socialist state our country is faced by the task of *planning* this process in such a way that it serves the welfare of the people and the increase of productivity of work. Urbanization in the GDR is influenced by specific conditions:

- the GDR is a socialist state;
- the degree of urbanization and industrialization is already a high one;
- the natural population change is stagnant;
- house building is concentrated in towns;
- agriculture is becoming a more structured industry.

Because of the *stability of the settlement network* and the *concentration of production*, city-hinterland relations are of increasing importance. Investigations of such relationships have been a main task of research work at the Institute of Geography of the Academy of Sciences of the GDR.

For the aims of the socialist planned economy it is appropriate to differentiate between territorially fixed relationships and territorially flexible relationships in city-hinterland relationships. For the *territorially fixed relationships* the spatial spheres of operation are laid down by the government. This refers to political-administrative relations and to numerous other functions and relationships derived from them, for example national education, medical care, local newspapers. The spheres of influence of *territorially flexible relationships* are not determined by state rulings primarily but are shaped by the influence of actual material conditions and the ways and habits of the people, for example in commuting, retail trade, recreation. *Commuting* is most important: it is of great significance for the inhabitants of rural settlements as a guarantee of a wide variety of job and cultural opportunities for individuals. From a national planning point of view, commuting is necessary for an efficient utilization of the labor potential in the hinterlands.

Planning of city-hinterland relationships means planning of the towns as centers of their hinterlands, direct planning of city-hinterland relationships, and planning of regional settlement systems. As a basis for the planning of the centers the Institute of Geography worked out a typology of all centers in the GDR according to their significance for the hinterland. The direct planning of these relationships is confined to territorially fixed relations and to the planned development of transport facilities. Special attention is given to the planning of regional settlement systems, especially to the development of the *Zentrumsregionen*, for example regions formed by large- or medium-sized towns and their hinterlands.

Hall, Peter, in this volume, pp. 371-386.

International Urban Systems: Outline of a Research Project

It is proposed to make a comparative international study of urban systems in evolution, if possible employing the concept of Daily Urban Systems (DUS) developed by Brian Berry in the United States. There may be problems in reconciling this with definitions based on the concept of the Standard Metropolitan Statistical Area (SMSA), first developed in the United States, but now widely employed by workers in other countries. Whatever the definition, there is evidence of widespread decentralization of urban population and employment in both North America and Western Europe, producing complex multi-centred megalopolitan regions in place of the former simple core-ring dichotomy within each city. The proposed study would focus on North America, Western Europe and Japan, and would study comparative growth rates (including the explanations of differentials), internal change, social indicators and resource/energy stocks and flows.

Hansen, Niles M., *Environment and Planning*, *7*:7 (1975).

An Evaluation of Growth Center Theory and Practice

This paper examines empirical and theoretical issues associated with the growth center approach to regional development, and argues that despite many difficulties the major themes of the growth center literature still have relevance to regional policy. Although there has been increasing interest in analyzing the nature and significance of spontaneously growing urban places, the growth center approach is most meaningful in the context of induced growth. There is little evidence that induced growth centers generate significant spread effects on their economically lagging hinterlands; but they can properly serve as regional centers of immigration.

It is difficult to derive an adequate growth model from a market-oriented hierarchy of central place schemes. If one is concerned with innovations and impulses of economic change, using the central place model as a locational matrix or landscape, it should be recognized that information and innovations can be transmitted upward through the hierarchy or laterally among centers of the same level, even though the diffusion process is likely to operate in a downward direction. Recent studies by Pred, Törnqvist and Goddard indicate that these issues may be clarified by shifting attention to organizational information flows within urban systems. Nevertheless, attempts to focus on the functioning of the "post-industrial" society should not detract from the opportunities that manufacturing decentralization represents for many non-metropolitan areas. Of course, better access within national (or even international) communications networks can be of considerable help to these areas, not only in attracting more manufacturing activity, but also in upgrading its quality. This in turn depends on the ability of people in lagging regions to take advantage of opportunities, i.e. on the quality of rural human resources. The failure of most growth center theory and practice to include explicitly human resource and manpower dimensions is at least equal to the neglect of information circulation.

Haring, Joseph E., Thomas Slobko, and Jeffrey Chapman. Forthcoming in *Journal of Urban Economics.*

The Impact of Alternative Transportation Systems on Urban Structure

This paper extends a recent von Thünen-type model of urban structure by Mills to include two competing forms of transportation, and then compares simulated representative American and European cities with respect to size, density and land rents. Assuming consumers minimize costs in choosing between competing travel modes, the nineteen-equation model demonstrates that land rent differentials are diminished by adding an alternative travel mode, and that transport capacity is far more important than fare structures in determining transit patterns and land use. American urban structure appears to resemble European urban patterns as transportation modes proliferate.

Haruta, Hisayoshi.

A Prospect Toward the Year 2000

The extraordinarily rapid economic growth of Japan in recent decades has resulted in massive urbanization, shocks to the traditional social system, and decay in traditionally valued elements of the environment. The system is self-limiting, but the recent recession, accompanied as it was by large uncertainties about raw materials supply and by strong domestic inflation, brought about a broad realization that Japanese society faced a fundamental crisis; and that within it, the successive national physical development plans needed drastic revision. The paper deals with several major elements of a possible late twentieth century Japan as background for a revised development plan. The likely transition was identified as one characterized by economic growth rates of about one-fourth of those experienced in the 1960's; social and political polarization, mostly to the disadvantage of the middle class moderates, increased corruption and a revival of traditionalist values possibly involving renewed spiritualism on the one hand and violence on the other. [Abstract by editors.]

Koloszár, Miklós, IIASA CP-75-3, pp. 64-73.

Interrelations Between Settlement Systems and Socio-Economic Development

The settlement system inherited by the postwar government of Hungary is described. War damage, gross regional inequalities including a strong urban-rural disparity, and a generally low level of urban and economic development characterized the 1949 baseline situation. Since then, the development of the settlement system has been closely bound to the general progress of social and economic development. Recent changes and future plans emphasize 1) the relatively greater growth-rates of larger settlements outside the Budapest area; 2) the decrease of urban-rural differences through planned provision of services, infrastructure, and cultural opportunities to threshold levels at least; and 3) a partly spontaneous process of residential agglomeration and capital formation in districts near the larger cities. [Abstract by editors.]

Komorowski, S.M., IIASA CP-75-3, pp. 41-48.

Countrywide Spatial Planning as an Integral Part of Long-Term Development Planning: The Case of Poland

The paper gives a broad idea about the working of the spatial planning system seen as an integral part of the central planning system in Poland. Considering that changes in the country's spatial organization can occur only within relatively long periods of time, they can be planned only within the framework of the long-term strategic socio-economic development plan. Thus the spatial plan becomes one of the different modes of its presentation which emphasizes the spatial features and implications of the overall development.

Consistent with this conceptual basis, four principles are observed in the spatial planning practice: 1) the spatial plan is an integral part of the country's socio-economic development plan; 2) the supremacy and the steering role of the central planning level; 3) close cooperation of the planners and scientists; and 4) systematic confrontation of the plans at their different stages of elaboration with the society. The implementation of the spatial elements of development plans is secured through the system of medium-term (tactical: five years) and short-term (operational: annual) national planning.

Korcelli, Piotr, IIASA CP-75-3, pp. 49-63.

Aspects of Polish National Urban Policy

The paper starts with a historical overview of urban policies which have been formulated and followed in Poland since World War II. Four stages are distinguished: 1) the late 1940's, when planners and policy makers were faced with the task of redefining the spatial pattern of settlement after the war's destruction within the new social and territorial contents, and the first postwar national plan of physical development was elaborated; 2) the early 1950's, the stage of extensive industrialization, when sectoral planning received the prime consideration, while physical (spatial) planning on a national, as well as on a regional scale, was recognized as one of the methods of economic planning; 3) the late 1950's and the 1960's, when regional planning and city planning concepts expanded rapidly, and national urban policies were heavily influenced by efficiency (optimization) calculations developed within city planning; 4) the early 1970's, when bases for the *National Plan of Physical Development for 1990* were worked out.

In Section II three prognostic models of the settlement system of Poland are presented, including: a) the model of a concentrated urban pattern, b) the model of urbanized belts, and, c) the model of metropolitan centers. The content of the *National Plan of Physical Development for 1990* is reviewed in Section III;

the *Plan* is based on the principle of moderate polycentric concentration, emphasizing the role of urban agglomeration and selected middle-sized cities as growth centers. Section IV contains a discussion of selected planning and policy alternatives, such as: 1) specialization versus standardization of urban functions, 2) concentrated versus dispersed urban development, 3) standard versus differentiated city size, 4) new versus existing towns, 5) urban redevelopment versus urban spatial expansion, 6) dominance of the capital city versus deconcentration of the capital functions; and the way those alternatives are dealt with in the urban policies in Poland. In the concluding section of the paper some further research and planning issues are enumerated.

Kudinov, Oleg V., IIASA CP-75-3, pp. 12-40.

<u>Strategy of the Spatial Distribution of Productive Forces and Population in the USSR</u>

The main principles and institutional instruments for spatial planning on a national scale are described. Industrial (sector) planning and spatial planning are coordinated through long-term general schemes for the distribution of productive forces, including population, which are prepared ultimately by a council of GOSPLAN. In accord with these plans, the fastest growing areas of the Soviet Union are now the peripheral areas of Siberia, with consequent great demand for new and expanded urban infrastructure. An important new organizing concept is the group settlement system, a cluster of urban places with internal sharing of functions and exhibiting hierarchical structure. An extensive bibliography of recent Soviet literature on these topics is appended. [Abstract by editors.]

Logan, M.I., and David Wilmoth, IIASA CP-75-3, pp. 119-178.

Australian Initiatives in Urban and Regional Development

As a manifestation of the growing involvement of national governments in matters concerning urban and regional development, the Australian government established a ministerial Department of Urban and Regional Development in December 1972. The Department's functions are broad, extending from strategy and policy formulation and resource planning on one hand to program implementation on the other. The paper attempts to describe some of the Department's achievements to date and to outline current attitudes to a number of important policy issues. The paper is presented not as a polished final document but in the context of the evolving state of knowledge about urban and regional policy issues. The national urban system is reviewed to point out the historical dominance of the metropolitan cities and the role of various components of urban growth. The Department is attempting to translate the government's social objectives into spatial policies relating specifically to the national settlement system, the metropolitan areas, regions and to transport and communications. The paper concludes with a review of programs of various kinds which are already operational in these areas.

MacKinnon, Ross D., *Environment and Planning*, *7*:7 (1975).

Controlling Interregional Migration Processes of a Markovian Type

A framework is suggested within which normative modelling strategies can be used to make simple dynamic migration models more relevant to policy makers. A job vacancy model is explicitly linked to a migration and population distribution model. Some suggestions are made regarding the ways in which the models could be modified in order to make them more realistic. Also other areas of application are briefly indicated.

Mamikonov, A.G., V.V. Kulba, and A.D. Tsvirkun, in this volume, pp. 303-318.

Principles of Dataware Design in Solving the Problem of Population Distribution in the USSR

The management of population distribution in the USSR relies increasingly on sophisticated information systems. This paper discusses the nature of the problems faced by such systems, gives an example of a recently operationalized subsystem (for urban housing allocation), and concludes with general considerations in the semi-automated design of similar dataware systems. [Abstract by editors.]

Matsuzaki, T., S. Ogasawara, and Y. Sawaragi.

A Computer-Assisted Long-Range Comprehensive Planning System for Regional Project Impact Assessment: A Subsystem of a Regional Management System

A systems approach has been taken to assist planners in making a regional plan as part of a comprehensive plan through the use of Hyogo Dynamics--a computer-assisted planning system. Regional development projects are assessed according to their economic, social, and environmental impacts. A multilevel model structure is employed both for industrialized regions along the Seto Inland Sea and for the rest of the Hyogo District.

Computer simulation results have been successfully presented in symposia with the region's inhabitants. Remote sensing data are to be incorporated for land use constraint analysis.

A computer modelling system is developed to describe the major internal and external forces controlling the balances of population growth, industrial environment, natural resources, etc. Interactive and recursive use of a high-speed computer is combined with systems analysis.

Matzner, Egon, in this volume, pp. 111-133.

Approaches to a Theory of Urban Interventionism

Urban development is conceived as a problem of allocating the activities of individuals, firms and public authorities in space and time. The relevance of neoclassical theory is analyzed and recommendations for an urban interventionism derived: 1) Since essential assumptions of the neoclassical model are notoriously violated in urban areas, "market failures" occur. An investigation of specific situations is necessary for appropriate interventions to be drafted. 2) These are to be aimed at targets formulated as indicators (norms) by application of Hägerstrand's Time-Space Model. A political process, however, is needed to make them "acceptable." 3) As an economic criterion for evaluating urban interventions the concept of multi-objective analysis is recommended.

Meier, Richard L., in this volume, pp. 348-370.

Analysis of the Contemporary Urban Ecosystem: An Appraisal of Hong Kong's Future

It is exceedingly difficult to find pure urban data that fit all the dimensions of human activity--usually the statistics are diluted to an unknown degree by hinterland, exurbs, and distant suburbs. The best dataset in the world, and with the longest history, is available in Hong Kong. It is 98 percent to 99 percent pure city, with a population of 4.25 million and GNP per capita of about $1,500.

Urban information was treated within an ecological context, so as to identify those factors that would make transition to steady state conditions most difficult. Although human population is still growing, despite the densest settlement in the world, the vehicular population growth seems to be the most immediate threat. Registered organizations are growing more rapidly than GNP, but telephone calls and financial transactions are multiplying still faster. Urban density, even at this extreme, appears not to be inhibiting.

Three paths to a steady state are traced. They follow from different assumptions about the permeability of the boundary with China, which is determined by conditions and decisions within China, not Hong Kong. The major uncertainty in these projections is the Communist Chinese doctrine with respect to resource use and ecosystem.

Mera, Koichi, in this volume, pp. 134-154.

A Multiple Layer Theory of National Urban Systems

There have been basically two approaches for explaining the distribution of urban centers: the central place theory which is principally based on agricultural activities, and the economic base theory which is largely based on manufacturing activities. The relationship between the two, however, has not been clarified. In addition, these theories have not been very successful in formulating policies aimed at controlling the growth of different urban centers in size and location.

In this paper, the following hypothesis is advanced: the urban population in any geographic unit is a sum of three layers of urban population, each associated with one of the three groups of "basic" activities: agriculture, export manufacturing and export service. The hypothesis synthesizes those two approaches by superimposing urbán populations explained by each theory.

The hypothesis has been tested with recent data on the Japanese urban population with good results. However, it has been found that the distribution of manufacturing activities can be well explained by the distribution of administrative activities. As a result, the three layers could be reduced to two, agricultural and administrative activities, with the latter having far greater city building impact than the former.

A policy implication of the analysis is that the distribution of administrative personnel, in which the central government employment is a significant element, is an important factor for regulating the distribution of urban population.

Mills, Edwin S., in this volume, pp. 80-90.

Do Market Economies Distort City Sizes?

The subject of the paper is whether market choices of firms and households in non-socialist economies are likely to produce a distribution of city sizes that differs from the social optimum. The analysis employs the framework of modern welfare economics.

The first section is a brief review of theoretical and empirical research on the determinants of city size distributions within countries or large regions.

Surprisingly, empirical research is further along than theoretical research on the subject. Empirical research shows that city size distributions are invariably skewed and show great persistence through time, though they vary from country to country. Theoretical research stems from the writings of Lösch, but remains unsatisfactory.

The second section analyzes the contention that market forces produce cities of excessive size. The contention is based on certain external diseconomies of large cities, especially pollution and congestion. The section concludes that these externalities may make cities too big or too small and that national policy should try to correct the resulting resource misallocation directly without concerning itself with city sizes.

The third section analyzes the contention that small towns and cities need government assistance to reach viable sizes in market economies. It is shown that this allegation is similar to the "infant industry" argument in international trade theory. It is unlikely that the argument for artificial stimulation of growth centers has more merit than that for protecting infant industries in industrialized economies.

Morrison, Peter A., in this volume, pp. 91-107.

<u>A Policy Planner's View of</u>

<u>Urban Settlement Systems</u>

This paper considers the interplay of three types of influences that affect the national system of urban settlement: 1) *Cultural predispositions*, the basic values and axioms that define a society's aspirations and direction, even though they may seldom describe its actual performance; 2) *Migratory predispositions*, the highly focused but as yet inactivated streams of potential migration that are defined by the history of past population movements; 3) *Government activities and programs*, whose inadvertent secondary effects exert a powerful but undirected influence on the redistribution of population.

Cultural predispositions include Americans' intense individualism and privatism and their predilection for social and geographic mobility. The policy planner's view needs to recognize that the migratory dynamics of the US settlement system are to a considerable degree attuned to these facets of the national character. It is suggested that migration may to a considerable degree sort people out spatially as the more mobile individuals seek to elevate their status.

If important self-selections come into play as the population circulates among cities, migration may present significant opportunities for guiding redistribution. By recognizing impending tendencies for people to sort themselves out among places, it may be feasible to strengthen or guide these tendencies according to a deliberate plan. The potentiality for return migration, a case in point, is considered in detail.

Finally, policy planners must allow for the arbitrary and (in the US, at least) overwhelming influence of "hidden" policies. Efforts to intervene in any nation's system of urban settlement must begin with an assessment of such hidden policies.

Explicit recognition of a nation's *emergent* (as well as apparent) cultural geography, coupled with sensitivity to its underlying values, may clarify the purposes that territorial policy might serve. Once it is recognized that places change people, as well as vice versa, then it may be that in strengthening the separate identities of the former we serve the diverse ambitions, tastes, and needs of the latter.

Rousselot, Michel, IIASA CP-75-3, pp. 179-192.

National Urban Policies in the French Sixth Plan

Following a brief overview of the French system of indicative planning, the urban objectives of the Sixth (1971-1975) Plan are reviewed. These include a slowing of growth in the Paris region, stimulation of eight major counterpoised metropolitan areas, and in general, more attention to the role and equipment of medium-sized towns. However, there are weaknesses in the instruments mobilized in support of these objectives. Relatively efficient programs include the positive restraints on building and job creation in the Paris basin, and the special program of new town building. Less successful is public investment in the counterpoised cities and in regional development generally. In general the relation of programs to action towards objectives is poorly understood and a case is made for some well-focused policy research. [Abstract by editors.]

Sauberer, Michael, and Friedrich Schindegger.

<u>An Approach to the Evaluation of Changing Urban Borders</u>

The territorial extent of political jurisdictions has more effect on the actual functioning of a settlement system than theorists often credit. A practical example of communal consolidation and border reform in Niederösterreich raised a number of questions for urban theory and for planning practice. With respect to the latter, several possible aids to community decision were evaluated, ranging from full-fledged formal optimization techniques through cost-benefit to goal achievement analysis. The first presumed the quantification of factors very difficult to measure and also imposed overly high costs. The second was too simple, failing to catch many of the factors of relevance to the communities and representatives involved. The third offered a reasonable compromise: reasonable attributes for five general objectives could be specified and the political weights attached to them elucidated by a variety of formal and informal participatory mechanisms. Missing in the analysis, however, was an adequate theory of the evolution of intrasystem interactions resulting from the change of administrative boundaries; the authors call attention to this neglected area of analytic development. [Abstract by editors.]

Šipler, Vladimír

An Attempt at a Systems Approach to Settlement Problems

The *gnoseological process* can be defined as the creation of a reflex, an abstraction of a concrete phenomenon in the consciousness of man, and its communication. The extent of this abstraction can be various, from a simple representation of intuitive character to mathematical expressions, the latter being appreciated as a systems approach par excellence. In the case of settlements, mathematical models may be used only to deal with certain selected phenomena: One reason is that urban phenomena have not yet been sufficiently analyzed for an exact formulation. It is questionable, however, whether it makes sense to try exact formulations and quantification at all in such spheres as the creation of cultural or aesthetic values. Practical problems of settlement policy exist next to one another and at the same time must be satisfied by means of both exact and non-exact solutions, while any systemic framework to unify the whole problem does not exist.

It thus seems indispensable to comprehend the process as a multi-stage matter, the first being the creation of a systems analytical framework in a uniform *verbal* form. It is necessary to consider at this stage the general philosophy of the settlement system, to elucidate its hierarchical character, to classify and define the principal elements and relationships of the system, and to describe general aspects of behavior valid on all levels. Only after building this initial framework may it be expected that the construction and application of formal models can be successfully undertaken.

With this as background the paper deals with the settlement system, its main elements and sets of relationships, with the differentiating levels, and with the problem of behavior of the settlement system in a verbal and uniform format.

Sokolov, Valery, *Environment and Planning*, 7:7 (1975).

Models Aiding National Settlement Policies in the USSR: A Survey

This paper presents a survey of formal models used as aids in solving practical NSP management problems at different levels. The models surveyed may be conveniently classified into two groups. The first deals with population, while the second describes settlement systems and solves allocation problems. The list of models presented is not exhaustive but illustrates the main principles of model design. Thus, the models do not necessarily belong to a single bibliographical source, but may be combinations of similar ideas represented by different sources. To identify the source, only basic references are given.

Stöhr, Walter B., in this volume, pp. 155-179.

New Towns and Growth Centres in National Urban Systems--Some Spatial-Economic Considerations

An attempt is made in this paper to formulate growth pole policies by introducing the spatial dimension of the distribution of agglomeration economies, of economic hinterland effects and of the spatial diffusion of innovations in urban systems. These three factors are available to a varying degree at different distance from the existing cities of a country. Agglomeration economies usually are a function of city size and decline with increasing distance from them. Hinterland effects, on the contrary, increase with distance from existing major cities. The probability of innovation diffusion, finally, can be predominantly a function of distance from the major city (typical for little integrated underdeveloped countries) or a function predominantly of city size (typical for well integrated developed countries).

Assuming a largest-city focused urban system, the implications of these theoretical considerations are analyzed for growth poles at varying distance from the largest city: 1) new towns on the fringe of the major metropolitan centre, 2) in medium-size cities, at intermediate distance beyond the largest city's commuting radius and 3) at large distance from the largest city in non-urban or non-developed areas. The results are related to empirical evidence of new towns or growth pole policies in Great Britain, France and Latin America.

Swain, Harry, and M.I. Logan, *Environment and Planning*, 7:7 (1975).

Urban Systems: A Policy Perspective

In some countries, enthusiastic beginnings in the planning and management of national settlement systems (or urban growth, or regional development) have run against some intractable problems. This paper points to dilemmas for research under the rationalistic paradigm that has come to dominate orthodox thinking about the policy planning process, discusses the inconvenient nature of the urban system's time constants, reviews some problems of policy implementation, and suggests shifted research directions. In the face of general ignorance about policy outcomes and public values, the policy directions that now seem appropriate are less ambitious than those of a few years ago.

Törnqvist, Gunnar, in this volume, pp. 226-265.

Swedish Industry as a Spatial System

The aim of the report is to focus attention on the relationships between the spatial structure of organizations and the growth of urban systems (national and international systems of cities).

Conclusions

It has been observed that behind the economic structural changes, the spatial concentration of jobs and population, the land-use changes and the increased mobility emerging in Sweden and other countries, a pattern has developed of increasing specialization and horizontal cooperation among human activities. The underlying movement toward more pronounced division of labor and interdependence has required a growing volume of inter-urban interaction involving information flows and the transportation of people and goods. Also observed is the declining role of goods transportation as a locational determinant and the growing impact of information, especially as an influence on the location of administrative units within industrial and non-industrial organizations. To reach these conclusions a series of investigations have been carried out, examples of which are given in the paper.

Contact and Flow Networks in Urban Systems

In the first stage of research work all kinds of flows and contacts have been surveyed. Micro-studies are then based on descriptions of direct personal contacts, telephone contacts, the buying and selling of services and goods for individual companies and other organizations. The macro-studies are based on aggregations of these flows within and between entire urban regions.

Changes in the Spatial Organization of Employment

This section of research contains investigations of the changing spatial structure of organizations and employment in the post-industrial society. It shows the increasing specialization and division of labor between job functions and urban regions in the national system of cities.

Limitations and Possibilities in Real and Hypothetical Urban Systems

In the last stage of research, interest shifts to studies of the limitations on and possibilities for the functioning of different kinds of activities in varying locations in the national urban system. In the micro-studies the observation units to be located are job functions, workplaces or entire organizations. Measurements are made of the effects of hypothetical relocations on contact activity on these units. Effects are measured in terms of time and costs.

The macro-studies presented are analyses of so-called contact landscapes. These are based on aggregated data and then show the balance or imbalance in the urban system between contact requirements and the travel supply available in the existing transport network. The contact landscapes are not only used for analysis of real situations, but also for experiments. The idea is to study the long term effects of different assumptions about future spatial organization and various policy measures. The operational models presented are no more than hypothetical contact landscapes depicting a complex system where every change within a single urban region and every altered travel possibility has an impact on the entire studies system. Till now these analytical models have been used in studying the Swedish urban system. But examples are also given of similar studies currently being carried out in the Western European system of cities.

Comments on the Contributions to "Program Impact Prediction and Evaluation"

Edward H. Blum

In examining the Courbis and Dawson-Ulrich papers, I noted a set of key questions that both of them raised. In retrospect, it seems that these questions apply to almost all modelling efforts which are meant to be taken seriously in formulating or evaluating policy. They are thus put forward both as 1) specific questions about the major models presented, especially those designed for program impact prediction and evaluation; and as 2) a more general "test" that can (should) be made of all models designed for serious use in developing, assessing, quantifying, and evaluating important policies or programs.

These questions are not meant to harass, embarrass, or demand impossible rigor of analysis in an area that is still more art than science. Rather, they reflect basic methodological considerations which one ignores only at considerable peril, plus personal experience with government programs which highlights certain points as critical to this kind of policy analysis.

Question No.1: To what extent are the models (and their bases) valid for examining *major changes* as well as perturbations?

Motivation: Major changes--whether deliberately induced, such as accelerated development programs, or exogenous shocks, such as the recent oil price rise--are no longer rare events. Their efforts are--or at least are felt to be--significant and far-reaching, with reverberations throughout many social, economic, and political sectors. They thus greatly concern much governmental (and industrial) top management, as well as much of the public--who will have to bear the consequences.

Moreover, such major changes provide some of the few real and widely perceived justifications for detailed and sophisticated modelling analysis.[1] Most people understand that they transcend simple analysis, conventional wisdom, or informed intuition. The opportunities are there for analysis and planners to prove their worth--if the analysts, and their tools, are equipped to treat the relevant issues and problems.

Are these models valid for major changes? The answer is not obvious. Because of gaps in theory and the lack of experience in dealing with the complexity of many parts of the system modelled, many of the representations used are based more on empirical reflection ("curve fitting") than on basic understanding. These may suffice for small extrapolations; but what happens when future states, rates of change, or policies lie well outside the domain of past experience? Are there neglected high-order terms (e.g., in linearized approximations) that can blow up? Are there possible discontinuities (e.g., thresholds where capital takes flight, or major technological substitutions occur) dramatically altering the fate of whole industries and regions? Where are the non-smooth features of state and policy spaces: the ridges, the passes and tunnels to opportunity, the traps, the abyss?

Additionally, about the methodology: have important explanatory models been checked for fit, or better, confirmed by testing predictions against new observations? Are parameters in longitudinal models (e.g., elasticities) estimated appropriately--e.g., by "system identification" techniques or time-series analysis--or have they been obtained from cross-sectional analysis, relying on ergodic hypotheses incompatible with societal dynamics? To which assumptions and model segments are key results most sensitive? Are the samples of societal experience ("slices of life") used to develop and estimate these large enough to yield meaningful confidence ellipsoids for the joint distribution of all the critical parameters? Have results from key sectors been compared with those from much simpler models, which might make more effective use of the limited available data?

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[1]Perturbations can often be handled quite well with very simple models--often acceptably with just well-trained intuition. And interactions (through feedback loops, etc.) can often be treated satisfactorily through relatively straightforward nested models and experience-based elements of control theory, some modellers' protestations notwithstanding.

Question No.2: How readily and how well can the model handle a range of *alternative policies and programs*? What about non-urban or macro-policies (e.g., to increase or decrease defense spending significantly, cut energy consumption twenty percent in five years, dramatically improve old-age benefits, impose rigorous environmental controls) that can have major urban and "settlement" consequences? What about continuing controls (e.g., resource rationing, selective and variable freight subsidies, work and residence permits) versus discrete efforts (e.g., reducing interest rates, launching specific new towns)?

How should these be represented? Can one supply input that looks like an executive or legislative policy action or a program, or must one represent the action secondhand in terms of its (independently derived) consequences?

How readily can the results be interpreted? Are estimates of sensitivity, reliability, and statistical significance easily supplied, so that the results can confidently be used to shape or assess real programs? Are the outputs generated those likely to matter most to prospective users or consumers of the model's results?

Motivation: Extensive experience in successfully applying sophisticated analysis to real government policies and programs has shown these considerations to matter greatly. If the model is really to be used, and to have an impact, then it must really be useable and meet the needs of its potential customers.

Question No.3: How well can the model *compare* policies or programs, rather than just show the nominal consequences of each one separately? Technically--how accurately can it estimate *changes* or *differences*, rather than just absolute levels?

Motivation: Policies and programs do not exist in a vacuum, as isolated entities. They are always considered relatively--at the very least compared to implicit norms or yardsticks of acceptability, based on past experience (historical comparison) or expectations of what ought to be feasible (nominal comparison). New proposals must always be compared with logical extensions of the status quo; in good analysis, several alternatives will be explicitly compared, as well.

What matters most for real assessment or evaluation, then, are the differences between two or more implicit or explicit alternatives. Where the differences occur, how large they are, how significant they are, etc.--these are the keys to effective technical resolution[2] and eventual choice.

Experience with complex models in other fields--for example, quantum chemical models for computing molecular energy levels--shows, however, that models designed to calculate absolute levels often do so adequately, but fail in calculating differences and thus in estimating the quantities of real interest (in the example, chemical reaction probabilities). The reason is simple: small percentage errors in absolute level can produce huge percentage errors in differences.

Recognizing that differences are particularly important and tailoring models to estimate them more directly often yields superior results and, not so incidentally, often reduces or simplifies the computation that must be done.[3] Especially where a model is not or cannot be recast, it is crucial to make sure that inputs to be compared are treated *consistently*--that model assumptions, handling of uncertainties, and sensitivities to data error do not bias comparisons in unsuspected or undesired[4] ways. Recognizing that accurate differences are needed also calls for closer attention than is usually given to *experimental design*--the choice of conditions under which successive simulations are run.

Question No.4: Is the model designed to estimate the effects of dynamic transients, which may be much greater than the "final" effects at "equilibrium"? If so, does it contain enough information valid for such dynamic estimating?

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[2]Two programs whose effects do not differ noticeably are, for technical purposes, equivalent, and must be distinguished on political or administrative criteria.

[3]See, for example, E.H. Blum, "Deployment Research of the New York City Fire Project", Chapter 7, in A. Drake, R. Keeney, and P. Morse, *Analysis of public systems*, MIT Press, 1972.

[4]If one alternative is believed a priori to be superior, one may want to stack some comparisons against it to see whether it still fares well. Such a deliberate bias is a standard technique in a fortiori analysis.

Motivation: Transients do not always approach "equilibrium" (often more a theoretical construct than a truly observable or attainable state) smoothly from below or above. Real systems often evince sizeable disruptions ("overshoots," in physical system terminology) that may be more important than the eventual steady state, which may never be allowed to occur because of reaction to the intermediate states. Unemployment, interest rates, local housing prices, and commodity production, for example, are variables that have been seen to have behaved this way. Unless a model can estimate these potentially disruptive transients--or its creators be certain they will not occur--it runs a significant risk of notably mis-predicting or of overlooking the need for carefully designed controls to handle the transition period.

Many of the submodels commonly used for social and economic processes, however, are derived from equilibrium as assumptions or theories, and thus are likely not to apply to transient situations (where things are "out of balance"). It may be necessary to rethink or redo such models, in some cases ab initio, to ensure that suitable dynamic considerations are represented.

PART TWO: PAPERS ON POLICY ISSUES

What are the controls available to agencies attempting to guide the growth and distribution of urban settlement systems? Should they try? What "natural" processes are susceptible to change? What "non-urban" policies may unwittingly shape urban developments? What is the appropriate degree of government intervention consistent with individual freedom of action on the one hand, and with equity considerations on the other? These and other policy questions are discussed in this section.

A number of fundamental policy issues emerge in any discussion of national settlement system planning. Many of them are essentially related to the ideological bases of societies within which urban systems are embedded. Berry's paper nicely delimits some of these ideological premises and gives some interesting examples of how they can affect the development, both planned and unplanned, of urban systems. Four modes of planning with successively increasing degrees of future orientation and interventionism are outlined.

The following paper, by Mills, takes a much stronger, almost polemical stance, arguing that for the most part national urban policies are at best unnecessary and often counterproductive. If pollution and congestion problems exist, then they should be attacked directly, and not by limiting or stimulating the size of cities. Mills argues that, at least with respect to economic systems where markets play a dominant role, government intervention should be limited to cases where it can be demonstrated the market is misallocating resources.

This section on policy issues closes with Morrison's summary of some recent developments in the United States. The role of migration as a social filtering and upgrading mechanism is discussed as well as the interesting and neglected phenomenon of migrants returning to the regions from which they migrated perhaps a generation ago. Some of the policy implications of such migration patterns are outlined. Finally, Morrison provides an interesting list of implicit urban policy variables--policies which have had unintended and sometimes undesirable consequences on differential growth within urban systems.

Comparative Urbanisation Strategies

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To entitle this paper "Comparative Urbanisation Strategies" undoubtedly is presumptuous, for it implies that there are in the world today identifiably-different policies regarding urban growth and development, that these policies are being translated into workable programs, and that the policies and programs lend themselves to worthwhile systematic comparison because they are altering urban growth directions. For this to be so, something significant must have happened in the past quarter-century. As Lloyd Rodwin remarked in *Nations and Cities* [2], "before World War II almost no one wanted the central government to determine how cities should grow." But he did go on to say that "radical changes in technology and in analytical and planning methods now make significant changes in the urban system not only feasible, but to some extent manipulable," and, because of this, "today, national governments throughout the world are adopting or are being implored to adopt urban growth strategies."

Rodwin put his finger on two important bases of comparison of urbanisation strategies, the planning method and the political process, linked as they are ideologically in terms of world view, which involves both the perception of urban problems and the specification of goals to be achieved, and practically in terms of the power to implement the means thought likely to achieve the ends. Societies differ in their planning capabilities, and this introduces one important element of differentiation of urbanisation strategies. But more importantly, cultural differences have produced divergent goals, divergent planning methods, divergent plans, and now divergent paths being followed by urban development in the world today.

I will thus begin my comparative analysis of urbanisation strategies by examining their socio-political bases, turning thereafter to the question of planning styles and details of strategies, for they are firmly derivative of the cultural context. It will be evident that I find no reason to change what I set down in 1973 in my book

The Human Consequences of Urbanisation [1] when I concluded:

> The diverse forms that public intervention is taking, the variety of goals being sought, and the differences in manipulation and manipulability from one society to another are combining to produce increasingly divergent paths of deliberate urbanisation. This makes it all the more important to understand the relations between socio-political forms and urbanisation, because the socio-polity determines the public planning style. Urbanisation, in this sense, can only be understood within the broad spectrum of closely interrelated cultural processes; among these processes, planning increases rather than decreases the range of *social* choice as modernisation takes place, while simultaneously restricting the range of *individual* choice to conform to the social path selected. ...Images of the desirable future are becoming the major determinants of that future in societies that are able to achieve closure between means and ends. Political power is thus becoming a major element of the urbanisation process. Combined with the will to plan and an image of what might be, it can be directed to produce new social forms and outcomes, making it possible for a society to create what it believes *should be* rather than extending what *is* or what *has been* into the future.

Socio-Political Form and Urbanisation Process

Free Enterprise Dynamics

At one end of the urbanisation spectrum are free-enterprise, decentralised, market-directed societies. Traditionally in such societies, decisions are made by individuals and small groups, and interact in the marketplace through free interplay of the forces of demand and supply. Economic and political power, vested in claims of ownership and property, are widely dispersed and competitively exercised. The instruments of collective or government action are used only to protect and support the central institutions of the market and to maintain the required dispersion of power. Thus, the public role is limited to combating crises that threaten the societal mainstream, as privately-initiated innovation produces social change. Legal systems are mainly regulatory, too, functioning to preserve established values; thus, to cite one example, the reliance of American law upon the regulatory approach to city building has meant the atrophy of city planning as a constructive element in social change.

One consequence is to be seen in North American political science, in which there has developed an explicit belief system concerning the process by which policies change, which in turn influences the way in which a problem is perceived. The dominant mode of thought on this subject in American political science is that of *incrementalism*. As Charles E. Lindbloom said in 1963: "Democracies change their policies almost entirely through incremental adjustments. Policy does not move in leaps and bounds." The political processes of bargaining, log-rolling, and coalition-building are the major factors producing a situation in which past decisions are the best predictors of future ones. Under such conditions, no explicit policy guides urban growth. Impetus for growth derives rather from preoccupation with economic achievement, and this limits urban planning to an ameliorative problem-solving role, which is reinforced by an attitude that accepts the *inevitability* of a continuation of the processes inherent in the present.

What are some of these process? Increasing organisational scale and concentration of power is a dominant characteristic of today's post-industrial democracies. As the scale of economic and bureaucratic organisation increase, changes are taking place in the dynamics of social and economic change. Increasing numbers of the more salient developmental decisions are made by negotiation among large-scale autonomous organisations and by voluntary associations, profit-oriented but not necessarily maximisers, countervailing and countervailed against, negotiating together and existing in a context of negotiated relationships, rather than delivered by the guiding hand of an unseen and more neutral market. Power is determined as a matter of policy or agreed upon by counter-balancing powers. Under such conditions there is organisation of production by large corporations run for the benefit of stockholders, while labor negotiates wages through large-scale unions. The consumption of end products is partly determined by individual choice, and partly by governmental policy. The collective power of organisations, collective power of the government, and the free choice of individuals are all part of the system. Hence, the "market" is no longer the single master. Rather, elaborate negotiation for "satisfactory" solutions tends to prevail; instead of maximisation, there is "satisficing" and, increasingly, each of the large-scale organisations engages in planning in terms of corporate goals, often with systems analysis staffs at their disposal to help them select desirable courses of action. The resulting combination of scale, power and corporate planning means that developmental leadership, the innovative "cutting edge" of urbanisation, is now more frequently in the hands of corporate oligarchs, responding to their particular economic agendas, for in spite of the opportunity for the collective power of the government to be exercised as a significant countervailing force--Canadian and Australian experiments notwithstanding--no governmental bodies can be credited with the development and execution of an urban policy in the world's free-enterprise societies at the present time. What substitutes is a complex set of uncoordinated and often contradictory public policies and programs provided in the wake of strong economic forces which set the agenda for urban growth. Thus, if in the past urbanisation has been governed by any conscious public objectives at all, these have been on the one hand, to encourage growth, apparently for its own sake; and on the other, to provide public works and public welfare programs to support piecemeal, spontaneous development impelled primarily by private initiative. In contrast, development of a national urban policy suggests a shift in the locus of initiative, imposing on public authorities an obligation to orient, rationalise, and plan the physical, economic, and textual character of urban life. Thus, through a complementary set of policies and programs, an urban policy represents an explicit statement of the purpose of urbanisation, its pace, its character, and values that are to prevail.

Public Counterpoints in the Redistributive Welfare State

It has been the greater radicalism of the welfare states of western Europe that has produced modification of the free enterprise system (and its large-scale twentieth-century heirs) by governmental action, to reduce social and spatial inequities and to provide every citizen with minimum guarantees for material welfare--medical care, education, employment, housing and pensions. This has been achieved most usually through differential taxation and welfare payments, but it also increasingly involves extension of more centralised decision making designed to make the market system satisfy social goals in addition to its traditional economic functions. In this way, what has emerged are mixed economies, the hallmarks of which are pluralistic societies with multiparty governments, relatively high levels of development and per capita output and built-in capacity for continued growth, but with substantial public sectors alongside elaborate private markets and "modern" economic institutions.

Public involvement in urbanisation in the mixed economies is to be seen as more than merely a counterpoint to private interests, however. By directing society towards goals of redistribution and equity, the competitive drive is reoriented. By constructing a large share of all housing in existing towns, and by constructing new towns, the public exercises developmental leadership. Urbanisation is deliberately led in new directions.

The particular form of policy varies from country to country. Ebenezer Howard's new towns philosophy and the apparent successes of British planning have induced other countries to attempt to control physical development, to direct new settlement away from congested metropolitan centres, and to stimulate economic and urban growth in peripheral regions. For example, the French have been concerned for a decade and a half over the steady concentration of people and economic activity in Paris. The Finns have seen the population of the northern half of their country pour into Helsinki or leave Finland entirely. The Swedes are concerned because most of their people are concentrated in Stockholm and two other metropolitan areas of southern Sweden. They are not concerned because their metropolitan centres are too big, as the French are over Paris, but because the depopulation of the Swedish north threatens to erode the social structure in that section of their nation. The Hungarians share a similar concern over the domination of their national economy by Budapest. Only the Poles are unconcerned with the outflow of rural people into their metropolitan areas. Lagging behind the rest of Europe in their rate of modernisation, the Poles see metropolitanisation as a process essential to absorb a "surplus" rural population.

Despite these differences in forms, however, the central concern of urban policy in all of Europe is the regional distribution of growth. Economic growth is viewed as the basic means to achieve social objectives such as improved income, housing, education, health, welfare, and recreational opportunity. European growth policies are intended to ameliorate disparities in income and welfare between regions of the country and, to a lesser extent, to minimise deleterious effects of economic growth on the natural environment.

As noted, the goals and objectives of urban growth policies vary from country to country, but to some degree all are aimed at: 1) *balanced welfare*--achieving a more "balanced" distribution of income and social well-being among the various regions of the country, as well as among social classes; 2) *centralisation/decentralisation*--establishing a linked set of local and national public institutions which make it possible to develop, at the national level, overall growth strategies, integrated with regional or metropolitan planning and implementation that is partly a product of a reformed local governmental system and is directly accountable to local officials and the affected constituency; 3) *environmental protection*--channelling future growth away from areas suffering from environmental overload or which possess qualities worthy of special protection, towards areas where disruption of the environment can be minimised; 4) *metropolitan development*--promoting more satisfactory patterns of metropolitan development through new area-wide governmental bodies and the use of special land use controls, new towns, housing construction, new transportation systems, and tax incentives and disincentives; 5) *non-metropolitan development*--diverting growth into hitherto by-passed regions by developing "growth centres" in presently non-metropolitan regions, constructing new transportation links between such regions and centres of economic activity, using various incentives and disincentives to encourage or compel location of economic activity in such areas, and forcibly relocating certain government activities into them.

Given such goals, the urban future that is unfolding in each case, represents a delicately-orchestrated balance between individual and corporate interests on the one hand, and the collective power of the state at the other. Much of this power is exercised in a negative fashion, to constrain individual or corporate drives, but the best appears when the public sets in motion new growth directions by exercising developmental leaderships, thereby initiating new and exciting trends.

Directed Change in the Socialist State

From a public counterpoint and developmental leadership, the next step is to the command structure of the socialist states, where monolithic governmental systems are dominated by a single party, there is state operation of non-agricultural industries (in some, agriculture, too), and centralised direction of the economy. Each of the socialist nations shows strong commitment to economic growth, but on the social side there is also a desire for elimination of most of the status differences based upon economic rewards that are the hallmark of free-enterprise competition. A greater uniformity and lack of specialisation is to be seen in the urban fabric, alongside more highly regimented life styles and building patterns. It is easier to command with an explicit set of rules and procedures to be followed; in this way urban development has been both bureaucratised and standardised under socialism.

This should be no surprise. The Communist Revolution of 1917 marked the beginning in Russia, and later in eastern Europe, of yet another path in urban development. The revolutionaries had great faith in the power of the government to transform society for the betterment of man, in seizing the government not to restrict its power but rather to use it. They aspired to remould society through a state monopoly of the production of goods, of means of communications, of education, and of science.

The great modernising revolutions that took place much earlier in the west and at a more leisurely pace of gradual transition came concurrently in the Soviet Union and took a more dramatic and radical form. The religious revolution, which in the west found expression in the Reformation, the Counter-Reformation and the gradual secularisation of most aspects of life, took the form in the Soviet Union of militant atheism. The economic revolution, which as the Industrial Revolution in the west extended over more than a century, took the form in the Soviet Union of state ownership and management of the entire economy to promote social goals and to speed industrialisation. The democratic political revolution, which found expression in the west in the American and French revolutions and the gradual diffusion of political power in Britain through a series of reforms, in the Soviet Union took the form of transfer of power from the autocracy of the Tsars to the dictatorship of the proletariat through the leadership of the Communist Party with centralised authority but democratic participation. The intellectual revolution, which in the west flowered in the Age of Reason and in which faith developed in the perfectibility of man and social institutions, in the ability of man by rational thought and scientific investigation to improve himself and society and to rule the universe, in the Communist Revolution took the form of an optimistic faith in the ability of the Party and the government, through science and industrialisation, to transform society and social relations and to create a rational communistic world order.

What has been sought in urban development was what Lenin had called "a new pattern of settlement for mankind," the city of socialist man. The classic writings of Marxism-Leninism suggested ways in which the goal might be achieved: planning was to create cities without social or economic divisions; there was to be a commitment to the socially integrative value of housing and a wide range of social services; city planning was to be responsive to economic planning, which would determine industrial location and set limits to the rate of urbanisation in developed regions and major urban complexes; and thus city planning per se was to be restricted to a basic physical-engineering-architectural profession, providing high-density new developments in approved styles.

The accomplishments of the Soviets in urban development are unquestionable. During the Soviet period the USSR has been transformed from a rural society to a predominantly urban one, through a combined process of industrialisation and urbanisation achieved as the outcome of a series of five-year plans. The authoritarian role of the central government and the priority of the economic goals of the state have been expressed at all levels of urbanisation, down to the precise physical nature of the new urban developments that have been built, which are said to be consistent with.

The resulting spatial patterns are held to be consistent with socialist principles of urban development (the antithesis of the European industrial urbanisation of the nineteenth century that so angered and repelled Marx and Engels). The "principle of social justice" is realised, for example, by using the official norms and standards which determine per capita living spaces, population density, and quantity of services, without class distinctions. The only basis for differentiation of available environment among urban families is the biological characteristics of the families. Similarly, the functional and the spatial structure of new residential areas and towns correspond, according to the conception of a socialist urban community.

The Third World: Fragmented Centralisation

Increasingly affirmative and effective planning and action to eliminate problems perceived to be the products of colonialism is something to which all of the countries of the Third World aspire. But the Third World countries constitute a diverse mosaic in which traditional self-perpetuating, self-regulating, semi-autonomous, pre-industrail "little" societies welded by colonial powers into ill-fitting states, coexist with and are being changed by post-war modernisation. Traditional forms of authority and the centralised controls of colonialism have been replaced by one-party governments or military dictatorships. There is frequent instability, and limited capacity for public administration. The public sectors are small. There is fragmentation of economies along geographic, ethnic and modern-versus-traditional lines, imperfection of markets and limited development of modern economic institutions, limited industrial development and continued predominance of agriculture, low per capita product and market dependence on foreign economic relations.

The urge for more and better control of urban development results from accelerated urban growth, a compounding of the scale of the primate cities and their associated peripheral settlements, perceived increases in social pathologies, growing attachment to national urban planning as a means of securing control of social and economic change, and an increasing willingness to experiment with new and radical plans and policies. The countries of the Third World are reaching for powers, controls and planning best exemplified by the welfare states of Western Europe on the side of innovative planning, and by the command economies of Eastern Europe and the USSR in the sense of more complete and effective controls. At the same time many are seeking to preserve significant elements of their traditional cultures, so that modernisation and westernisation are not synonymous.

A variety of radical solutions to urban development are being proposed, but what characterises most of the planning efforts in the Third World is the absence of a will to plan effectively, and more often than not, political smoke-screening. Most urbanisation policy is unconscious, partial, unco-ordinated and negative. It is unconscious in the sense that those who effect it are largely unaware of its proportions and features. It is partial in that few of the points at which governments might act to manage urbanisation and affect its course and direction are in fact utilised. It is unco-ordinated in that national planning tends to be economic, and urban planning tends to be physical, and the disjunction often produces competing policies. It is negative in that the ideological perspective of the planners leads them to try to divert, retard or stop urban growth, and in particular to inhibit the expansion of metropolises and primate cities.

Elsewhere, in Maoist China for example, this anti-urban bias is also clear. In China it has obvious historical roots in the history of the Chinese Communist Party and its struggle for power before 1949 and in the modern history of a China dominated by treaty-port colonialists who controlled and shaped nearly all of its large cities. These cities were also the homes of the Chinese bourgeoisie. They were felt to have been reactionary in the past, potentially revisionist now and in the future, and alienating at all times. Thus, their growth in China continues to be controlled by an unprecedented policy which limits their size and which channels new industrial investment into new or smaller cities in previously remote or backwards areas, or into rural communes, which are to be made industrially as self-sufficient as possible without acquiring the morally corrupting and alienating qualities of big cities, nor their damaging effects on the environment. City-dwellers, especially white collar workers, must spend a month or more every year, whatever their status, in productive physical labor in the countryside, where they may regain "correct" values. The distinctions between mental and manual labor, city and countryside, "experts" or bureaucrats and peasants or workers are to be eliminated. The benefits and the experience of industrialisation and modernisation are to be diffused uniformly over the landscape and to all of the people, while the destructive, de-humanising, corrupting aspects of over-concentration in cities are to be avoided.

Planning Style and Urbanisation Strategy

The keys to the Maoist reconstruction of China have been a will to plan, clear objectives, and totalitarian powers, and indeed, wherever there has been affirmative pursuit and a modicum of success with an urbanisation strategy the necessary ingredients have been future-orientation, agreement upon goals, and the power to act.

An urbanisation strategy is, axiomatically, concerned with the future. It involves goals; it involves motivated and informed decision makers; it involves the will to act and the power to achieve. A society with an urbanisation strategy is, necessarily, a planning society.

But the nature of planning varies with socio-political structure, as does the nature and degree of future-orientation and the capability to achieve consensus on goals. In consequence it is possible to identify a sequence of planning styles--and by extension, of urbanisation strategies and of determinants of the future--roughly paralleling the sequence from free-enterprise conditions to the directed state.

The simplest, as outlined in Table 1, is simply *ameliorative problem-solving*--the natural tendency to do nothing until problems arise or undesirable dysfunctions are perceived to exist in sufficient amounts to demand corrective or ameliorative action. Such "reactive" or "curative" planning proceeds by studying "problems," setting standards for acceptable levels of tolerance of the dysfunctions, and devising means for scaling the problems back down to acceptable proportions. The focus is upon present problems, which implies continually reacting to processes that have already worked themselves out in the past; in a processional sense, then, such planning is past oriented. And the implied goal is the preservation of the "mainstream" values of the past by smoothing out the problems that arise along the way.

A second style of planning is *allocative trend-modifying*. This is the future-oriented version of reactive problem-solving. Present trends are projected into the future and likely problems are forecast. The planning procedure involves devising regulatory mechanisms to modify the trends in ways that preserve existing values into the future, while avoiding the predicted future problems. Such is Keynesian economic planning, highway building designed to accommodate predicted future travel demands, or Master Planning using the public counterpoint of zoning ordinance and building regulations.

The third planning style is *exploitive opportunity-*

Table 1. Four policy making styles.

	Planning for Present Concerns	*Planning for the Future*		
	Reacting to Past Problems	*Responding to Predicted Futures*		*Creating Desired Future*
	Ameliorative Problem-Solving	*Allocative Trend-Modifying*	*Exploitive Opportunity-Seeking*	*Normative Goal-Oriented*
	Planning for the Present	*Planning towards the Future*	*Planning with the Future*	*Planning from the Future*
Planning Mode	Analyse problems, design interventions, allocate resources accordingly.	Determine and make the *best* of trends and allocate resources in accordance with desires to promote or alter them.	Determine and make the *most* of trends and allocate resources so as to take advantage of what is to come.	Decide on the *future desired* and allocate resources so that trends are changed or created accordingly. Desired future may be based on present, predicted or new values.
"Present" or Short Range Results	*Ameliorate Present Problems*	*A Sense of Hope* New allocations shift activities	*A Sense of Triumphing Over Fate* New allocations shift activities	*A Sense of Creating Destiny* New allocations shift activities
"Future" or Long Range Results of Actions	*Haphazardly Modify the Future* by reducing the future burden and sequelae of present problems	*Gently Balance and Modify the Future* by avoiding predicted problems and achieving a "balanced" progress to avoid creating major bottlenecks and new problems.	*Unbalance and Modify the Future* by taking advantage of predicted happenings, avoiding some problems and cashing in on others without major concern for emergence of new problems.	*Extensively Modify the Future* by aiming for what could be "Change the predictions" by changing values or goals, match outcomes to desires, avoid or change problems to ones easier to handle or tolerate.

seeking. Analysis is performed not to identify future problems, but to seek out new growth opportunities. The actions that follow pursue those opportunities most favorably ranked in terms of returns arrayed against feasibility and risk. Such is the entrepreneurial world of corporate planning, the real-estate developer, the industrialist, the private risk-taker--and also of the public entrepreneur acting at the behest of private interests, or the national leader concerned with exercising *developmental leadership,* as when Ataturk built Ankara, or as the Brazilians are developing Amazonia today. It is in this latter context in already-developed situations that the concept of strategy planning was developed.

Finally, the fourth mode of planning involves explicitly *normative goal-orientation.* Goals are set, based upon images of the desired future, and policies are designed and plans implemented to guide the system towards the goals, or to change the existing system if it cannot achieve the goals. This style of planning involves the cybernetic world of the systems analyst, and is only possible when a society can achieve closure of means and ends, i.e. acquire sufficient control and coercive power to ensure that inputs will produce desired outputs.

The four different planning styles have significantly different long-range results, ranging from haphazard modifications of the future produced by reactive problem-solving, through gentle modification of trends by regulatory procedures to enhance existing values, to significant unbalancing changes introduced by entrepreneurial profit-seeking, to creation of a desired future specified ex ante. Clearly, in any country there is bound to be some mixture of all styles present, but equally, predominant value systems so determine the preferred policy making and planning style that significantly different processes assume key roles in determining the future in different societies.

The publicly supported private developmental style that characterises the American scene, incorporating bargaining among major interest groups, serves mainly to protect developmental interests by reactive or regulatory planning, ensuring that the American urban future will be a continuation of present trends, only changing as a result of the impact of change produced by the exploitive opportunity-seeking planning of American corporations.

On the other hand, hierarchical social and political systems, where the governing class is accustomed to govern, where other classes are accustomed to acquiesce, and where private interests have relatively less power, can more readily evolve urban and regional growth policies at the national level than systems under the sway of the market, local political jurisdictions, or egalitarian political processes. This is one reason urban growth policies burgeoned earlier in Britain than in the United States. Controls are of several kinds. Most basically, use of the land is effectively regulated in conformity to a plan that codifies some public concept of the desirable future and welcomes private profit-seeking development only to the extent that it conforms to the public plan. Such is the underpinning of urban development in Britain, in Sweden, in France, in the Netherlands, in Israel's limited privately owned segments or within the designated white areas of South Africa. Such a situation also obtains, it might be added, in the planning of Australia's new capital, Canberra. To understand the developmental outcome in these circumstances, one must understand the aspirations of private developers or of public agencies involved in the development process on the one hand, and the images of the planners built into the Master Plan on the other. It is the resolution of the two forces that ultimately shapes the urban scene. In Britain, the planners' images of the desirable future have been essentially conservative, aiming to project into the future a belief that centrality is an immutable necessity for urban order, leading to the preservation of urban forms that are fast vanishing in North America. Thus, the utopian image that becomes embedded in the specific plan and the efficacy with which the public counterpoint functions to constrain private interests, are the key elements.

Nowhere has the imagery of the social reformers been more apparent than in Soviet planning for the "city of socialist man." Reflecting the reactions against the human consequences of nineteenth-century industrial urbanisation, the public counterpoint of the "mixed" economies has been the realisation that such sought-after futures can be made to come true.

Images of the desirable future are becoming determinants of that future in societies that are able to achieve closure between means and ends. Political power is becoming a major element of the urbanisation process, and can be directed to produce new social and spatial forms and outcomes, making it possible for a society to create what it believes *should be* rather than extending into the future what *is* or what *has been.*

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Do Market Economies Distort City Sizes?

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This paper is about the welfare economics of urban settlement sizes. In it, I ask whether location decisions of households and firms in market economies are likely to produce a distribution of settlement sizes that is different from the one that would be socially desirable.

In what follows I assume that an urban settlement is a well-defined concept. Of course, that is not really true in practice. Urban activities shade off into rural activities at the fringes of urban settlements and census takers expend much effort trying to decide where urban areas stop and rural areas begin. In addition, urban areas that were once separate grow into each other as population grows and becomes more urbanized. I will ignore these important but theoretically uninteresting issues and assume that each urban settlement is distinct and well-defined. I will be concerned with generic urban settlements, including central business districts and surrounding commercial, industrial and residential land uses that are urban in character. I will refer to such settlements as "cities" regardless of legal titles, political boundaries or size. Thus, the city is the generic urban settlement in this paper. In the United States, the census term "urbanized area" is the closest approximation to my "city." The main difference is that the census designates a settlement as an urbanized area only if the settlement has a legal central city with at least 50,000 population, whereas I want to use the term "city" to refer to both large and small settlements.

There is a curious pattern to urban research in market economies. During the last decade, a large volume of high-powered theoretical research has appeared regarding the complex and fascinating internal structure of cities. But to date almost no correspondingly sophisticated empirical research has appeared. Regarding the size distribution of cities, the situation is the opposite. For several decades, elaborate statistical studies of city size distributions within countries and regions have been undertaken. By now, that is probably as well-documented a subject as any in the social sciences (see [2] for a survey). On the other hand, there has been very little theoretical research on city size distributions.

The reasons for this pattern of scholarly endeavor are not hard to find. There are lots of data on city size distributions since such data are collected by censuses in almost all countries. But data on internal organization of cities are very scarce indeed. Thus, there are many empirical studies on the topic of city size distributions for which data are available. At the theoretical level, it is much easier to apply the tools of the economist's trade to analysis of internal city structure than to the larger question of the relationships among cities in an entire region or country. Thus, theoretical studies of internal structure are much more common than are those of city size distributions. Nevertheless, theoretical studies of city size distributions are beginning to appear. The lessons that can be learned from theoretical and empirical studies of city size distributions are the subject of this paper. I will have nothing to say regarding the internal structure of cities.

Positive Analysis of City Size Distributions

It is not possible or necessary to survey here the vast empirical literature on city size distributions. I will merely point out some salient conclusions of this research, so that I can use them in later parts of the paper.

A universal conclusion of city size distribution studies is that city sizes vary enormously within a country or large region at every point in history. Every country has large numbers of cities clustered near the minimum size that is recorded, usually between 2,000 and 10,000. And every country has at least a few cities that are 10 or 100 times those sizes. In the twentieth century, most large countries have had at least a few cities with populations in excess of a million. In the US, there are more than thirty urbanized areas with more than a million population.

A second universal conclusion of city size distribution studies is that city size distributions are highly skewed, with large numbers of small cities and a few very large ones. A statistical distribution which embodies this skewness property is the rank size rule, in which the population of the city of rank n is proportionate to 1/n. In an earlier period, many scholars thought of the rank size rule as a natural law of city sizes. But perceptive students of the subject now realize that any of several closely related skewed distributions, such as lognormal, fit most of the data about equally well.

The following are other important conclusions of city size distribution studies:

1) The distribution varies considerably from country to

country. In particular, the sizes of the largest cities relative to the sizes of other large cities vary greatly from country to country. This concept is referred to as primacy. The most common measure of primacy is the population of the largest city divided by the sum of the populations of the four largest cities. Industrialized countries mostly have smaller primacy measures than developing countries. The United States has a smaller primacy measure than most industrialized countries (see Mills [7]).

2) The city size distribution changes only slowly over many decades within a country. In the US, although the number and sizes of cities have grown rapidly, the size distribution has changed little in nearly 200 years (see Madden [6]).

3) National policy can affect the size distribution of urban areas, but it requires massive national control over land use and construction. This statement is based on the experience of countries that have tried to control the growth of large urban areas in various ways. For example, governments in the United Kingdom have tried to slow the growth of London and the southeast of England since World War II by a variety of land use controls and modest subsidies for people and businesses to locate elsewhere. But it has had no perceptible effect. Israel, on the other hand, has had a determined policy of population dispersal since independence in 1949, based on military and other considerations. The instruments of the policy have been large scale public ownership of land and complete central government control over construction. The result has been that Tel Aviv, the largest urban area, has grown little, and most population growth has occurred in small urban centers (see [7]).

Theoretical analysis of the determinants of city size distributions stems from the work of Lösch [5]. The most sophisticated model is Beckmann's [1]. The basic idea underlying all this research is very simple. Production is distributed over a homogeneous plain where input prices and availability are uniform. A variety of goods is produced. Each production function exhibits scale economies characterized by the number of customers needed for a firm to produce at an efficient scale. The extent of scale economies, so measured, varies from product to product. Some products require many customers and hence large market areas, and other products require only few customers and hence only small market areas. Thus, each product has a network of market areas which, according to Lösch, are hexagons of varying dimensions. In Lösch-type models, large cities are places that are production centers for many products and small cities are places that are production centers for only a few products. In this way, Lösch and his followers build up a distribution of city sizes.

There are several more or less widely accepted criticisms of the Lösch model. Most important, and least widely recognized, is that there is really nothing in the Lösch model to induce producers of different products to locate in the same centers or cities. There are not intermediate goods in Lösch's model, so one producer is not motivated to locate in a city to be near a producer who buys his output or produces his inputs. Indeed, there is not even an articulated labor market in Lösch's model, so producers of one good are not motivated to locate near producers of another good in order to sell their products to its workers. Thus, there are no inter-industry relationships in the Lösch model and thus no reasons for producers of different products to locate in proximity to each other and form a settlement or city. Second, the Lösch model ignores geographical diversity which gives comparative advantage to regions within a country. Lösch's assumption that the world is a homogeneous plain implies a peculiar circular trade pattern among cities in which cities of given size export to smaller cities and import from larger cities. But no pair of cities has mutual trade in the Lösch model. Lösch's assumption of spatial uniformity also implies a peculiar and unrealistic spatial distribution of cities. In it, New York would be about where St. Louis is and Chicago and Los Angeles would be about where Pittsburgh and Denver are. It is not accidental that most empirical research inspired by Lösch's model has pertained to the implied size distribution rather than to the implied spatial distribution of cities. Indeed, most research on spatial distribution has been carried out with reference to cities in plains dominated by agriculture.

What city size distribution would be implied by a satisfactory theoretical model? It is impossible to say since, as I believe, no satisfactory theoretical model exists. A satisfactory model would not predict the same city size distribution in every country since the geographical character of comparative disadvantage varies from country to country. A guess is that a satisfactory theoretical model would not imply city size distributions very different from those implied by Lösch-type models and observed in reality.

A satisfactory theoretical model would imply the city size distribution that market forces would generate and would enable us to ascertain whether the implied distribution satisfied social welfare criteria such as those for Pareto optimality. In the absence of a satisfactory theory, it is necessary to lower our sights in welfare analysis of city sizes. The most we can do is to identify forces that are plausibly believed to make big cities too big and small cities too small and evaluate the strength of the claims.

Distortions Affecting Large Cities

The first point to be made in this section is that the most common way of formulating the question of optimum city size distribution is wrong. Many writers ask what is *the* optimum city size. But the entire intellectual history of the subject makes it clear that the cities in a country form an interrelated system and it is inconceivable that an optimum system would consist of all or most cities of a given size. Some social scientists have even conducted surveys to ascertain the city size that people prefer to live in. Most such surveys are unhelpful in studying welfare aspects of city sizes because they take as given many conditions of life that depend on city sizes. Moreover, they take as given the respondent's income and employment. But income and employment opportunities are not independent of the city size distribution. Large cities have grown up because they have been able to offer more favorable income and employment opportunities than smaller cities.

The right question to ask about optimum city sizes is "Would you prefer to live in a city of size A at an income B rather than in a city of size C at an income D?" But this is precisely the question that market choices put to people. If because of its large size or other reasons, city A is a less pleasant place to live than city C, then wages and salaries compensate for undesirable features of each city. Nobody should think that this equilibrating process works perfectly. There are rigidities in both wages and prices. But there are large interurban differences in wages and employment opportunities, and they are important factors affecting the movement of human and other resources.

Serious economic literature on market distortions of city sizes, such as [10], is based on the claim that growth of a city by migration or natural increase provides benefits to newcomers that induce them to live in the city, but that growth imposes costs on other residents of the city. If so, location decisions based on self-interest fail to take into account all the social costs they entail and a distorted distribution of city sizes might result.

To fix ideas, consider the following example. Suppose a person lives in B and earns $7,000 per year. Suppose he is offered a job in A that pays $10,000. Suppose B is a small town and A a large city and that the person decides that the extra amenities of small town life are worth $2,000 a year to him. Then the move will improve his standard of living by $1,000 per year and he will make the move. Now suppose that each new resident of the large city adds to congestion there and that the marginal congestion costs to all residents of A resulting from the addition of a new family to A's population are $1,500 per year. (Suppose congestion costs in B are negligible.) Then the person is induced to make the move from B to A by market incentives even though total social costs of the move exceed total social benefits. The conclusion is that too many people will be induced to move to large cities and that their populations will be excessive relative to smaller cities.

This situation has been analyzed in an important paper by Tolley [11]. If the costs imposed on others are a function only of the city's population and if these costs are larger the larger the city, then the conclusion is correct. Market forces induce too many people to live in large cities and too few to live in small cities. That is, there will be too much dispersion in the city size distribution.

The fault in this statement is that costs imposed on city residents are a function not just of the city's population. They depend also on how resources are allocated in the city. Suppose disamenities that result from large city populations can be lessened by the use of resources for the purpose. Suppose further that there is a way of charging residents for the cost of the resources needed to reduce the disamenities. This induces people to live elsewhere and thus reduces the city's population. Second, it increases the amenity of life in the city. This has the opposite effect, it increases the city's population.

There is no way to predict the net effect on the city's population of the use of resources to improve amenities. It may increase or decrease. Much more important, it does not matter. The right issue for public policy is to find the justifiable amount of resources to devote to improving amenities in the city. That may increase or decrease the city's population. Whichever happens, public policy need not be concerned. The foregoing is really an abstract way of saying something that is merely good common sense: if there is a problem, it is much better to work on the problem than on a related phenomenon. The implication of this analysis is that public policy should aim to improve resource allocation in cities, but should not concern itself directly with the size distribution of cities. If resources are allocated appropriately, the city size distribution will take care of itself and need not be the object of specific programs. It may, of course, nevertheless be affected by public policies to improve urban resource allocation.

A variety of social disamenities are sometimes said to result from large urban size. An interesting analysis of the relationship of several such amenities to city sizes is by Hoch [4]. I will illustrate the preceding theoretical analysis with some more detailed remarks concerning air pollution.

Air pollution is correlated with city size, although not strongly. With given techniques of production and given modes of transportation, larger city populations and higher densities impose greater stress on the natural capacity of the city's air mantle to absorb the effluents discharged to it. The correlation is not high because air pollution indexes also depend on natural conditions and on the mix of economic activities in the city. The desirable public policy to deal with air pollution over a city is to limit discharges of pollutants to the air to the extent justified by benefits and costs of doing so. This can be done by regulating discharges or by effluent fees or by some combination of the two. Whichever way it is done, abatement cost should be imposed on activities that result in effluent discharges. That will make such activities more expensive in the city and will, to some extent, limit the city's population. It will also cause resources to be devoted to abatement of discharges. That will increase the attractiveness of the city and will induce people to live there. The net effect may be to increase or decrease the city's population. But it does not matter. The important thing is that the atmosphere will be cleaned up to the extent that it is justifiable to do so. The effect on the city's population is incidental and is unlikely to be large.

As a practical matter, public policies to limit population growth of large cities directly are likely to have little effect on air pollution. The reason is that air pollution depends mainly on specific urban activities such as burning fossil fuels in specific and uncontrolled ways. Limiting population growth has little effect on these activities. They need to be controlled directly by planning, regulation, taxation, etc.

The conclusion of this section is that there is no justification for a government policy to limit the growth of large cities. Disamenities of cities such as congestion and pollution are only loosely related to city size and should be dealt with by controls on specific activities that cause the disamenities. Effects of such controls on urban populations are incidental and unpredictable.

Distortions Affecting Small Cities

Sometimes it is claimed that small cities are subject to distortions of a similar but opposite nature to those discussed in the previous section.

The most common claim is that if large cities are too large, then small cities must be too small. A variant is that urbanization is emptying small towns and rural areas of people and that public policy must try to reverse the flow. But since I do not accept the premise that big cities are too big, I do not accept the conclusion that small towns are too few or too small. In fact, it is not true that small towns are being emptied of people, at least in the US. There is no evidence that the lower tail of the city size distribution has changed in recent decades. The total number of people in rural areas has certainly grown, although their percentage has fallen. Of course, the massive migration of people to cities has resulted in large shifts among the rural population. This inevitably means that some rural areas have lost population.

A more sophisticated argument is that some small towns with a great growth potential are unable to realize that potential because they cannot reach a size at which they can realize scale economics. Crudely interpreted, the argument is faulty because large numbers of formerly small cities have grown to substantial sizes in recent decades. Small cities must be placed in the urban hierarchy. Many of them serve rural areas and are prevented from growing because of the smallness of the rural market which they serve. Thus, the fact that they could function more economically if they served larger markets does not imply that they should be larger.

The most sophisticated form of the argument is similar to the infant industry argument in international trade. It used to be argued that domestic industries had to be protected from foreign competition until they reached efficient size. So, it is sometimes claimed, small towns, especially those with growth potential, must be assisted with outside funds until they are big enough to realize their potential. There might be something to this argument in a poor country in which development capital was scarce and expensive, and where there were few cities. In such countries there are often large size gaps between the biggest urban areas and the rest. But most developed countries have a large number and a full range of city sizes. Cities grow and shrink throughout the size distribution and there is no evidence of particular size barriers. Development capital is relatively plentiful and is mobile. In addition, the amounts required are not large by comparison with amounts of industrial capital. In the US, for example, the national capital stock, including housing, is about twice annual output. GNP is about $4,000 per capita, and reproducible capital was about $8,000 per capita in 1970. Thus, for an urban area to grow from 25,000 to 50,000 people requires an investment of $200 million. This is less than the assets of a relatively small corporation, and much of the investment, especially structures, provides excellent collateral. This suggests strongly that communities which are perceived to have genuine growth potential should have little trouble attracting public and private capital over a period of years.

Some people believe that national governments have information, perspective or forecasting abilities that enable them to make better investments in small cities with growth potential than private markets and local governments are able to make. I have strong doubts whether that is correct. Certainly, there is not a shred of evidence in its favor in the US. But if governments did have information that permitted them to identify centers with potential for growth, they could simply publish the information for use by private citizens, investors and local governments. There would be no need for governments to subsidize, plan or control the growth of small cities.

Concluding Observations

This has been a very brief survey of a complex subject. All governments do many things, such as land use controls and infrastructure investments, that affect city sizes. These are proper functions of government and their effects on city sizes are inevitable, although incidental. But I am skeptical whether governments ought to adopt programs whose specific goals are to influence the size distribution of cities. My judgment is that such programs inhibit the ability of families and firms to engage in economic activity by imposing controls on prices and uses of land, and that the programs accomplish very little in solving specific urban problems such as housing, congestion, pollution and transportation.

Another conclusion of this paper is that, despite a great deal of research and writing on growth centers and on specific government policies to implement controls on city sizes, there has been relatively little basic research on the desirability of policies to influence city sizes.

Theoretical and empirical research is needed on the determinants of city size distributions in market economies. We simply do not yet have an acceptable model of the way city sizes are affected by various assumptions about scale economies and about the interactions among firms and between firms and households in cities. And we need to know how geographical irregularities, especially the existence of harbors and ports, affect city sizes. It seems likely, for example, that the primate nature of cities in developing countries is to be explained by the scarcity of potential ports or of capital to develop them. But we do not know. I believe that, in contrast with most areas of economics, empirical research is ahead of theoretical research on city size distributions. At present, the need is for theoretical research to explain the findings of empirical research on city size distributions.

In addition to positive research on the determinants of city size distributions, we need normative research on whether market economies generate city size distributions that depart from the ideal. We have at present no satisfactory model in which the question of optimum versus actual city size distribution can be posed, let alone answered. The first need is for imaginative theoretical research to formulate models in which the notion of an optimum city size distribution can be discussed meaningfully. Once such models have been formulated, the next need will be for theoretical and empirical research on departures of actual city size distributions from the ideal.

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Toward A Policy Planner's View of The Urban Settlement System

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I. Introduction

Since its earliest stages, national urban policy in the United States has been marked by grandiose schemes and ill-defined objectives. A proposal in 1969, for example, envisioned a national program to build from scratch ten new cities with populations of at least one million, and 100 new cities with populations of at least 100,000.[2] The logic of this proposal appeared to be: if cities are overcrowded, siphon off the excess people by building new cities. Bankers, government officials, and other people in powerful positions took the new-cities idea seriously because it was an appealing solution to a new "problem."

Other problem solvers catered to the national nostalgia for an earlier and simpler era. Alarmed by the exodus of population from rural America--as though "rural America" were all one kind of place--they called for a policy of "balanced growth." No one yet has precisely defined "balanced growth" or the social purposes it would serve.[3] In his first annual report to the Congress last January, the Secretary of Agriculture seemed to say that it means creating a job for everyone,

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[1]Paper prepared for a Conference on National Settlement Systems and Strategies, held at the International Institute for Applied Systems Analysis, Schloss Laxenburg, Austria, December 16-19, 1974. I thank my colleague Ira S. Lowry for helpful comments on this paper.

[2]National Committee on Urban Growth Policy, "Key National Leaders Recommend Large Program of New Cities for U.S.," Washington, D.C., Urban America, Inc., news release dated May 25, 1969.

[3]These issues are explored systematically in William Alonso, "Balanced Growth: Definitions and Alternatives," unpublished paper, September 1973.

regardless of where he lives, and reversing the longstanding trend of rural out-migration.[4]

These problem-solving ideas show a remarkable absence of appreciation of the constraints that demographic processes--migration in particular--impose on the attainment of stated or implied objectives. In the realm of urban growth policy, at least, policy makers have too often pretended to knowledge and power they simply do not possess. They have made a caricature of the real, enormously complex system of urban settlement by reducing it to a set of repetitive orderly relationships.

In retrospect, it is apparent that the objectives of these schemes were murky, that the views of how the urban settlement system works were oversimplified, that the sense of what policy has in its power to do was exaggerated. But out of these exercises in urban policy making has come a recognition that if we are to have an explicit national urban policy, it must be development oriented rather than problem oriented; it must build on processes of change under way instead of ignoring or attempting to thwart them, and it must evolve as understanding evolves instead of succumbing to the penchant for master plans.

In the United States, we are beginning to appreciate the interplay of three types of influence that affect the national system of urban settlement:

1) *Cultural predispositions*, the basic values and axioms that define a society's aspirations and direction, even though they may seldom describe its actual performance;

2) *Migratory predispositions*, the highly focused but as yet inactivated streams of potential migration that are defined by the history of past population movements;

3) *Governmental activities and programs*, whose inadvertent secondary effects exert a powerful but undirected influence on the redistribution of population.

This paper reviews what we know, and still need to know, about these factors in order to discern the *implicit* urban policy that now exists and to evolve broader strategies that are process-perfecting rather than problem-oriented.

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[4] *Rural Development Goals*, First Annual Report of the Secretary of Agriculture to the Congress (Washington D.C., US Department of Agriculture, 1974), pp. 1-5.

II. Cultural and Migratory Predispositions

Policy planners need to understand something of their culture to get a "feel" for the dynamics of its urban settlement system. I use the word "feel" because gleaning the salient aspects of a culture that bear on urban policy requires a mixture of interpretive insight and scientific skill. This mixture does exist in, for example, the work of Alonso, Beale, Berry, Boorstin, Lee, Pierson, Zelinsky, and others.[5] I have taken the liberty of embellishing several cultural motifs suggested by Zelinsky to show how directly germane they are to the dynamics of an urban settlement system as policy planners must view it--that is, in terms of leverage points and constraints.

One motif is the intense *individualism and privatism* that are part of the American national character. Both characteristics are expressed through migration rooted in the earliest history of US settlement and nurtured by an expanding national frontier, and still recur in many facets of personal and political life. The spatial fragmentation of political authority is a case in point. The US metropolis, however unified a socioeconomic entity, is balkanized into dozens and sometimes hundreds of politically sovereign entities. The atomistic strain in the American national character evidenced in this patchwork of governing bodies does not necessarily prevent government agencies from charting long-range social and economic plans, but it generally blocks the effective execution of such plans, as many programs of the last decade show.

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[5] William Alonso, "Balanced Growth: Definitions and Alternatives"; Calvin L. Beale, "Rural Development: Population and Settlement Prospects," *Journal of Soil and Water Conservation*, 29, 1 (January-February, 1974), 23-270, Beale, "Rural and Nonmetropolitan Population Trends of Significance to National Population Policy," in US Commission on Population Growth and the American Future; *Population Distribution Policy*, ed. Sara Mills Mazie, Vol. V, Commission Research Reports (Washington D.C., Government Printing Office, 1972), pp. 665-677; Brian J.L. Berry, "The Geography of the United States in the Year 2000," *Transactions of the Institute of British Geographers*, Publication No. 51, November 1970; Daniel J. Boorstin, *The Americans: The Democratic Experience* (New York, Random House, 1973); Everett S. Lee, "The Turner Thesis Reexamined," *American Quarterly* (Spring 1961); Lee, "Migration in Relation to Education, Intellect, and Social Structure," *Population Index*, 36 (October-December 1970), 437-444; George W. Pierson, *The Moving American* (New York, Alfred A. Knopf, 1973); Wilbur Zelinsky, "Selfward Bound? Personal Preference Patterns and the Changing Map of American Society," *Economic Geography*, 50, 2 (April 1974), 144-179; Zelinsky, *The Cultural Geography of the United States* (Englewood Cliffs, N.J., Prentice-Hall, 1973).

Another facet is the relentless American pursuit of a neo- or perhaps pseudo-rural residential setting. To opinion surveyors, Americans state a strong desire to live in rural and small-town settings. But further probing and careful analysis reveal that their anti-urbanism is qualified: the settings favored by most such respondents lie within thirty miles of a big city.[6] Americans, then, do not want to live *in* big cities, but neither do they want to be very far from one.

The rapid territorial expansion of the US metropolis since World War II shows how people have managed to have their cake and eat it too. But the outward extension also has given rise to functional reorganization of metropolitan activities into daily urban systems that reach far beyond the defined boundaries of metropolitan areas. In the non-metropolitan hinterland of the daily urban system, a particular locality's growth has come to depend chiefly on its distance from the metropolis and its endowment of natural amenities.[7]

Cultural predisposition, coupled with hidden policies (to be discussed further on), has decisively shaped patterns in and around metropolitan centers that will linger on for years. Further generations will have to contend with a low-density, spread-out, energy-inefficient system of settlement whether they subscribe to present priorities for urban organization or not.

Individualism and privatism are likely to persist as salient motifs of the American national character, but how they will be expressed in the future is a matter for speculation. Cultural predispositions seem to have gained prominence as transportation technologies have reduced the relative importance

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[6]Glenn V. Fuguitt and James J. Zuiches, "Residential Preferences and Population Distribution," forthcoming. Other revealing studies are: Donald A. Dillman, "Population Distribution Policy and People's Attitudes: Current Knowledge and Needed Research," paper prepared for the Urban Land Institute, October 15, 1973; Donald A. Dillman and Russell P. Dobash, "Preferences for Community Living and Their Implications for Population Redistribution," Bulletin 764, Washington State College Agricultural Experiment Station, Pullman, November 1972.

[7]Richard F. Lamb, "Patterns of Change in Nonmetropolitan America, 1950-1970," draft manuscript, n.d., pp. 237-253.

of transportation costs as a locational constraint. Likewise, communication innovations may allow previously repressed locational desires to dictate new settlement patterns. Telecommunication policy could well have as profound an impact on settlement over the next two decades as transportation and housing programs have had during the past two.[8]

Over most of history, efficient interaction among people has depended on spatial proximity. Advanced communication technologies have weakened this dependence. In the United States, this communication function no longer occurs within the narrow or sharply delineated frame of the past core-oriented city. Time-saving and space-spanning communication technologies, along with easy access to once-distant places, have dissolved the core-oriented city in space.[9] Telecommunication may enable the US population finally to reconcile what seem to be two fundamental but conflicting needs in American society: access to others and separation from them. It may hasten the advent of what one observer described as its destiny: an urban civilization without cities.[10]

Interesting new manifestations of atomism are detectable now at a collective level, where communities' growing recognition that they can lose control of their individual destinies through demographic excess has fostered attempts to restrict further growth.[11] Reacting to such symptoms of overpopulation

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[8]This remains largely a speculative topic. See Peter C. Goldmark, "Communication and the Community," *Scientific American* (September 1972), 143-150. For an exhaustive review and synthesis of the literature, see Richard C. Harkness, "Telecommunications Substitutes for Travel: A Preliminary Assessment of Their Potential for Reducing Urban Transportation Costs by Altering Office Location Patterns," Diss. University of Washington 1973.

[9]A major factor in this dissolution has been the proliferation of controlled-access highways. Within the daily urban system, proximity to a highway is an important determinant of small-town growth or decline. Detailed evidence on this point is given in Craig R. Humphrey and Ralph R. Sell, "The Demographic Impact of Controlled Access Highways on Nonmetropolitan Communities, 1940-1970," n.d.

[10]Irving Kristol, "An Urban Civilization Without Cities," *The Washington Post*, December 3, 1972.

[11]Earl Finkler and David L. Peterson, *Nongrowth Planning Strategies* (New York, Praeger, 1974). For the demographic perspective on this issue, see Peter A. Morrison and Judith P. Wheeler, *Local Growth Control Versus the Freedom to Migrate*, P-5330, The Rand Corporation, December 1974.

as congestion in urban spaces and environmental decay--or to the threat of them--some communities have tried to slow or block in-migration by restricting the number of new dwelling units that can be built; others have adopted ordinances that would force newly-arrived migrants to leave. The courts deny communities the right to enact such measures on the grounds that citizens have a right to settle where they please. But tenacious champions of local self-rule reject the idea that a community has to make room for newcomers without limit.

Americans' predilection for *mobility and change* is, in fact, a second cultural predisposition suggested by Zelinsky. The typical American's life resembles a prolonged odyssey. Marriage, childbearing, military service, higher education, changes of employment (or shifts from one plant or office location to another with the same employer), divorce, retirement--all are likely to entail changes of residence and locale.

Migration itself is deeply rooted in the American experience. Now as in the past, people continue to migrate for reasons that are connected with the workings of national economic and social systems. A characteristic of modern economies is the quick exploitation of newly-developed resources or knowledge, a process that requires the abandonment of old enterprises along with the development of the new. Such economies depend on migration to alter the labor forces of localities more quickly than could be accomplished by natural increase. Without a tradition of migration, which moves people from areas where jobs are dwindling to places where workers are needed, US economic growth would be sluggish and less efficient than it actually has been.

Migration is also an important vehicle of social mobility. Many people are prevented from bettering their circumstances, less because of inherent personal limitations than because of rigidly drawn social barriers in their communities. The generally positive experience of blacks who have left the rural South and of ethnic groups that have left city ghettos confirms the value of geographic mobility as a means of access to conditions fostering improvements in personal status.[12]

The policy planner's view needs to recognize that the migratory dynamics of the national settlement system in the United States are to a considerable degree attuned to this cultural predisposition for upward social mobility, in distinct contrast to some other societies. But migration may be equally noteworthy as a sorting mechanism, filtering and sifting the

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[12]Evidence on this point is discussed in Peter A. Morrison, "Population Mobility: How the Public Interest and Private Interests Conflict," in US Commission on Population Growth and the American Future.

population as its members undergo social mobility.[13] This possibility recalls a central ambiguity: whether the act of migration, by freeing an individual's energies, leads to subsequent observed improvements in his life, or whether, as a prism separates light, the act is merely selective of certain persons who would have improved their status irrespective of the decision to migrate.

A look at two competing models that describe the placement of migrants in the urban class system will flesh out this point.[14] According to the "urban escalator" model, newcomers start at the botton of the economic ladder and edge up as they learn city ways, leaving their low-level jobs to succeeding groups of newcomers. By contrast, what might be called the "filtering" model sees migrants as distinctive types of persons selected from the population at large. Such persons circulate among the cities, tending toward certain ones.

Although these two models are not incompatible, each has a distinctive emphasis and implication. According to the "urban escalator" model, migration is noteworthy as a means of upward social mobility. With the "filtering" model, what is noteworthy is the possibility that distinctive types of persons may become concentrated in the places to which migrants flow the fastest.[15] Together, these two models imply that

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[13]There is, at best, only fragmentary evidence on this point. See, for example, Charles W. Mueller, "City Effects on Socioeconomic Achievements: The Case of Large Cities," *American Sociological Review,* 39 (October 1974), 652-657.

[14]Stephan Thernstrom, *The Other Bostonians: Poverty and Progress in the American Metropolis, 1880-1970,* (Cambridge, Massachusetts, Harvard University Press, 1973), pp. 30-33.

[15]Today's migrants to urban centers tend to rank higher in education and work experience than do their residents. See Peter M. Blau and Otis Dudley Duncan, *The American Occupational Structure* (New York, John Wiley and Sons, 1967); Charles Tilly, "Race and Migration to the American City," in *The Metropolitan Enigma,* ed. James Q. Wilson (Cambridge, Massachusetts, Harvard University Press, 1968), pp. 135-157.

The case of black migration from the South to the North appears to be more complicated. See Larry H. Long, "Poverty Status and Receipt of Welfare Among Migrants and Nonmigrants in Large Cities," *American Sociological Review,* 39 (1974), 46-56; Larry H. Long and Lynne R. Heltman, "Income Differences Between Blacks and Whites Controlling for Education and Region of Birth," Annual Meeting of the Population Association of America, April 18-20, 1974, New York, New York.

migration sorts people out spatially as the more mobile individuals seek to elevate their status.

III. Undirected Migration Currents

If important self-selections come into play as the population circulates among cities, migration may present significant opportunities for guiding redistribution. Zelinsky gives the name "voluntary regions" to areas where most people are there by migratory choice rather than reproductive chance.[16] When combined with the view of migration as a sorting process, his concept contains certain policy implications that I would like to explore.

One possibility is that through self-selection, the labor markets of some areas may acquire greater resiliency to change than do others. It is known that a large part of the moving that occurs in the United States is done by a small part of the population, who migrate repeatedly and frequently. Consequently, the population in places that have grown through waves of past in-migration acquires a characteristic structure differing from that in places which have grown principally through the simple lottery of birth.[17] Specifically, areas of intense migratory growth become heavily weighted with the most footloose members of society, many of whom subsequently move on. The places through which they pass resemble, demographically, a pool that a stream flows into at one end and drains at the other. Accordingly, it would be expected that adjustments to changes in the overall demand for labor, or to shifts in the mix of required skills, could occur promptly because of the brisk inflow and outflow of workers. By providing settings for voluntary job turnover, such contexts also may be conducive to occupational mobility.[18]

Another possibility is that by recognizing impending tendencies for people to sort themselves out among places, it may be feasible to strengthen or guide these tendencies

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[16] Zelinsky, *The Cultural Geography of the United States.*

[17] Peter A. Morrison and Daniel A. Relles, "Recent Research Insights into Local Migration Flows," P-5379, The Rand Corporation, February 1975.

[18] Martyn Cordey-Hayes, "Migration and the Dynamics of Multiregional Population Systems." Conference on National Settlement Systems and Strategies, December 16-19, 1974 (Laxenburg, Austria, International Institute for Applied Systems Analysis, 1975).

according to a deliberate plan. The phenomenon of return migration is one such tendency which, until recently, has gone largely unnoticed.

"Return migration" means migration back to an area in which a person formerly resided. (In conventional usage, the area has been defined as a county, metropolitan area, state, or region.) In the United States, return migration is a phenomenon of growing demographic significance. During the 1955-1960 interval, return movers constituted 17 percent of all white movers and 14 percent of all black movers in interstate migration. By the 1965-1970 period, these percentages had risen disproportionately to 20 percent for whites and 21 percent for blacks.[19] Although only about one-fifth of all migrants are returning to a place they once lived, a fuller understanding of their actions would illuminate the prospective actions of the considerably larger segments of the population who are *potential* return migrants to somewhere. Many past migrants, especially those who have left rural areas, maintain connections with their hometowns through family and friends, and some look forward to returning there one day. What mechanisms or policies--inadvertent or deliberate--might translate such latent impulses for migration into action? By examining individual motives for return migration, we may gain some insights into these questions.

Predispositions to return somewhere appear to depend upon a complex interplay of economic, sociological, and cultural factors. Return migrants, like others, mix economic and non-economic reasons for moving, but seem to be directed somewhat more by family considerations or life-cycle-related factors, such as retirement. There is evidence that the decision making of return migrants differs from that of non-return movers: there is a general lack of consideration of alternative locations and virtually no reliance on alternative information sources among returnees.[20]

Evidence of the potential for return migration is also revealing, although generalizations in this instance are restricted to certain classes of rural-urban migrants who were asked on surveys to contemplate the possibility of returning.

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[19]Anne S. Lee, "Return Migration in the United States," *International Migration Review*, 8 (Summer 1974), 283-300.

[20]John B. Lansing and Eva Mueller, *The Geographic Mobility of Labor* (Ann Arbor, Michigan, Survey Research Center, Institute for Social Research, 1967).

Studies by both Price and Collignon indicate that a sizeable minority of rural-urban migrants desire to move back to their area of origin and can describe circumstances that would cause them to do so.[21]

From the standpoint of places, several additional points are germane. The "population at risk" for return migration (i.e. the pool of ex-residents) varies widely by place. Not only are numbers different, but the intent to return also differs by type of stream: for example, 26 percent of Appalachian out-migrants, but only 7 percent of black out-migrants, indicate a desire to move back to their former place of residence.[22]

Owing to its extensive history of migration, a considerable fraction of the US population qualifies at any given time as potential return migrants to somewhere. The presence of these masses of like-minded but "as-yet-unmigrated" persons with common affinities for place has potentially dramatic implications. This can be grasped if, for a moment, we imagine that the complex odysseys that have marked twentieth-century US history were to reverse themselves. The migration of young blacks from the South would become a return of retirees; the California-bound exodus from the rural Ozark-Ouachita region in Missouri, Arkansas, and Oklahoma in the 1930's would become a return to common rural affinities.[23]

Contemporary migration patterns offer striking evidence that long-standing directions of movement are in fact reversing. The historically dominant northward stream of black migrants is now exceeded by its counterstream: between 1970 and 1973, five blacks migrated from the North to the South for every three who

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[21]Daniel O. Price, *A Study of Economic Consequences of Rural to Urban Migration*, Office of Economic Opportunity, Washington, 1969, Vol. III, Chapter 13; Frederick C. Collignon, *The Causes of Rural-to-Urban Migration Among the Poor*, Institute of Urban and Regional Development, Berkeley, 1973; also see Gene B. Petersen and Laure Sharp, *Southern In-Migrants to Cleveland* (Washington D.C., Bureau of Social Science Research, 1969).

[22]See Collignon.

[23]This epic and highly focused movement is treated in Walter J. Stein, *California and the Dust Bowl Migration* (Westport, Connecticut, Greenwood Press, 1973).

followed the traditional path in the opposite direction.[24] Both diminished out-migration and increased return migration account for this reversal.[25]

Other recent net reverses have been documented, but the extent of return migration involved cannot yet be established.[26] The Ozark-Ouachita region now withdraws many more migrants from California than it sends there: between 1965 and 1970, two persons migrated from California to this region for every one who followed the traditional path leading west. During that period, over one-third of the region's net migratory gain origninated in California alone.

Such examples of areas in which decades of out-migration have reversed suggest that the paths beaten by migrants can run both ways. It is worth considering whether and how the sentiments for other kinds of return migration might be translated into action. Policies might deliberately foster selected return flows by building on rural proclivities embedded in the American national character and strengthening the process whereby sentiments for return migration come to be translated into action. The above examples of spontaneous reverse movements, which echo earlier epic migrations, demonstrate that it may at least be possible to stimulate reversal.

One group--those who are in or near retirement--merits close attention as potential return migrants. With a steady income assured regardless of location, people are economically footloose. Those who migrated as young adults during the 1920's and 1940's, when the flow of rural-urban migrants was

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[24]Daniel M. Johnson, et al, "Black Migration to the South: Primary and Return Migrants," n.d. It should be noted that for the periods 1955-60 and 1965-70, about two-thirds of the blacks who migrated from the North to the South were returning to their region of birth. This return migration appears to select persons quite unlike those who are migrating, but not returning, to the South. The return migrants tend to be less youthful and frequently more elderly than the primary migrants (although the majority of both groups are twenty to thirty-four years old).

Other studies of this phenomenon are: Rex R. Campbell et al, "Return Migration of Black People to the South: Data from the 1970 Public Use Sample," n.d.; Daniel M. Johnson, "Black Return Migration to a Southern Metropolitan Community," University of Missouri--Columbia 1971; Larry H. Long and Kristin A. Hansen, "Trends in Return Migration to the South," 1974.

[25]Long and Hansen.

[26]Beale, "Rural Development: Population and Settlement Prospects."

numerically large, have been approaching the retirement age since the 1960's. Where they choose to live and how many of them return to their regions of origin are matters of considerable import.

New sources of income such as the federal Supplemental Security Income program[27] and other income maintenance programs likely to be enacted in coming years, will expand the options of this group and may be viewed in the present context as a potential new hidden policy of population redistribution. They could create a population of floating consumers predisposed to migrate in highly directed ways to locales offering a favorable cost of living. These locales often may be the same places such people departed from in their youth.

All of these points suggest that analysis of a settlement system's past evolution may reveal subtle and possibly effective ways to guide its future growth by a selective strengthening of cultural and migratory predispositions. Such predispositions might even afford opportunities to plan and program the evolution of "voluntary regions." By drawing like-minded individuals together from widely scattered origins, certain policy objectives might be furthered simply by activating latent sentiments for migration.

These interesting possibilities pose a more general question: What does a nation need in the way of new places and regions? Are there "gaps" in the national system of settlement? It would be unsafe to presume that existing population centers (a legacy from the industrial age) have necessarily filled all the best sites of the impending post-industrial age, with its anticipated higher incomes, earlier retirement, and orientation toward recreation and retreat.[28]

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[27]The Supplemental Security Income program replaces federal and state programs of aid to the aged, blind, and permanently and totally disabled. In general, SSI yields an increase in cash income for the aged poor, and eligibility conditions for the program are uniform across the nation.

[28]Wilbur Thompson, "New-on-Old Towns in the System of Cities," in *New Towns: Why--And for Whom?* ed. H.S. Perloff and N. Sandberg (New York, Praeger, 1973).

IV. "Hidden" Policies Affecting Urban Settlement

In addition to considering a society's cultural and migratory predispositions, policy planners must allow for the arbitrary and (in the US, at least) overwhelming influence of "hidden" policies. Agencies that build highways, award defense contracts, and choose locations for federal installations are simultaneously redistributing employment and altering incentives for private investment. These and other programs and activities, although uncoordinated, tend to accumulate and exert a powerful but undirected influence on migration. (The influence of US aerospace and defense expenditures were, without doubt, major factors drawing population to the nation's Gulf Coast and Southern California.)

Efforts to intervene in any nation's system of urban settlement must begin with an assessment of such hidden policies--a difficult task, given the range and diversity of what governments do and the complex linkages through which settlement patterns come to be influenced. To cite three of the best-known examples of major federal programs that were undertaken for "non-urban" purposes, but that have decisively affected US metropolitan settlement:[29]

- Federal welfare programs, enacted to support minimal living standards for poor families, have encouraged the concentration of low-income and minority populations in the cities and thereby created the demographic basis for some of the nation's most intractable urban problems.

- The federally aided interstate highway program, created to improve the US transportation system has been instrumental in determining the growth patterns of metropolitan areas and the roles of cities relative to their suburbs. "The city determines the road," it is said, "and the road recreates the city."

- Federal income tax deductions for homeowners and federal support for mortgage credit, both intended to improve the nation's housing, have provided overwhelming economic incentives for middle-class families to move to surburban, owner-occupied housing, thereby weakening the central cities economically and strengthening tendencies toward racial and economic segregation.

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[29] These examples and the following discussion of impact assessment are drawn from an unpublished paper by my Rand colleague, Stephen M. Barro.

The officials who designed and implemented these policies did not intend and were not aware that their actions would have profound consequences for settlement patterns. Nevertheless, each of the programs or policies mentioned above has probably had a greater impact on American cities than all the explicitly urban programs combined.

If there is to be such a thing as coherent urban policy making at the federal level, a major concern of the policy makers will have to be assuring that major programs not specifically designated "urban" have desirable rather than counterproductive effects on the settlement system. But that presupposes a capability for identifying and assessing the urban impacts of a wide variety of existing and proposed policies. No such capability is now available to policy makers. It is likely, however, that many of the analytical models and other components that would be needed to create an impact assessment capability do exist in some form, although probably not in forms suitable for policy analysis and, of course, not in any overall integrative framework.

The following list offers a partial illustration of what a set of impact categories for assessing policy effects on cities might look like for the US:[30]

1) Fiscal impacts on urban governments with regard to:

    a) expenditure levels,
    b) tax relief,
    c) tax bases.

2) Impacts on urban income, economic welfare, and consumer demand with regard to:

    a) income level or distribution of income,
    b) employment,
    c) cost of living,
    d) demand for housing,
    e) demand for other private goods,
    f) demand or "need" for public services.

3) Impact on the attractiveness of the city as a residential location with regard to:

    a) locational convenience (e.g. city relative to suburbs),
    b) quality of the physical environment,
    c) level/quality of public services,
    d) supply of housing,
    e) "quality of life."

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[30] Drawn from a study currently under way by Stephen M. Barro.

4) Impact on the attractiveness of urban location to businesses with regard to:

   a) locational convenience,
   b) racial and economic segregation,
   c) recreational and cultural facilities,
   d) social and political participation.

Federal programs and policies must be grouped according to the kinds of effects they are likely to have on urban settlements. One useful approach would be to categorize according to mode of federal intervention, as illustrated below:

1) Transfer payment to individuals:

   a) unrestricted payments,
      welfare payments,
      negative income tax,

   b) restricted payments,
      food stamps,
      housing allowances.

2) Federal grants to state and local governments:

   a) unrestricted grants--revenue sharing,

   b) grants for social service programs,
      education grants,
      health services grants,
      manpower training grants,

   c) grants for public facilities and environmental services,
      highway grants,
      rapid transit subsidies,
      water and sewer grants,
      solid waste disposal grants.

3) Consumer subsidies (including "tax expenditures"):

   a) income tax deductions for home mortgage interest and property taxes,

   b) mortgage guarantees.

4) Producer subsidies:

   a) railroads, airlines,
   b) agricultural price supports,
   c) development subsidies (urban renewal).

5) Direct federal programs:

   a) defense,
   b) space,
   c) public works.

6) Regulatory and control activities:

   a) fiscal and monetary policy,
   b) credit market controls,
   c) price controls,
   d) equal opportunity and desegregation efforts,
   e) environmental quality and safety enforcement.

Major uncertainties surround the "hidden" policies. Consider, for example, two possible effects of an income maintenance program on migration, each carrying vastly different policy implications. First, such a program might enable many would-be migrants to leave depressed areas or unattractive cities with reduced economic risk, for they would be assured an income wherever they moved. Second, it might subsidize the return of former out-migrants, who could combine important personal advantages (e.g. friends and relatives) with satisfactory economic security. Clearly, these divergent effects would have dramatically different consequences on the communities in question, but there is currently little basis for guessing which personal choice would predominate.[31]

V. Conclusions

In the United States, fertility decline has enlarged the relative importance of migratory growth. More so in the future than in the past, an area's population may be shaped by a process of deliberate and self-selected migration as well as by the simple lottery of birth. Whereas in the past the traditional flows of rural-urban migration and high fertility bestowed some measure of growth everywhere, many localities will now experience rates of growth hovering around zero.

Through decades of migration, particular regions have become differentiated according to their migratory histories. As forcefully as its current circumstances, an area's past settlement (or resettlement) may limit or enlarge possibilities for change. Each of the individual centers comprising a national settlement system must be considered with the following questions in mind:

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[31] Julie S. DaVanzo, *An Analytical Framework for Studying the Potential Effects of an Income Maintenance Program on U.S. Inter-regional Migration*, R-1081-EDA, The Rand Corporation, December 1972.

1) *What fraction of the population consists of recent settlers from elsewhere rather than native or long-term residents?* Centers with a large fraction of recent settlers are high-flow-through areas, which pass more people through the filter of place.

2) *Why did the settlers come?* Although economic impulse is dominant, the exceptions to the rule are what matters. The motives for moving shed light on the assortative forces operating--hence the kinds of like-minded people around whom "voluntary regions" are taking shape.

3) *What fraction of the population has left, and for where?* The special significance of this question, of course, is the potential for return migration: an earlier odyssey lays the foundation for potential new directions of redistribution.

Finally, the recognition that a nation may have a significant cultural geography suggests that one worthy policy objective may be to nurture rather than eradicate the distinctive complexions that become attached to places (for whatever reasons). Such complexions signal purposes, as evidenced by the long list of places which serve the diverse needs of retirees (Arizona), the environmentally concerned (Oregon), and the religiously united (Utah's Mormon region). Explicit recognition of a nation's *emergent* (as well as apparent) cultural geography, coupled with sensitivity to its underlying values, may clarify the purposes that territorial policy might serve. Once it is recognized that places exchange people, as well as vice versa, then it may be that in strengthening the separate identities of the former, we serve the diverse ambitions, tastes, and needs of the latter.

PART THREE: CONTRIBUTIONS TO THEORY

The theoretical basis underlying policy analysis and plan implementation in urban systems contexts is exceedingly weak. Textbook assumptions are generally not fulfilled in the world in which government agencies operate. As a consequence, government officials are frequently and justifiably skeptical of proposals arising from these theories. Decisions therefore continue to be made for the most part on intuitive and highly subjective grounds. Improved theoretical structures are necessary not only to increase the power and effectiveness of quantitative models, but also to give quantitative insights into urban processes so that even the essentially subjective judgments made by policy makers can be enriched.

In this section, five papers representing quite different approaches to national settlement systems theory are presented. As a possible theoretical frame of reference, Matzner first considers the general equilibrium model of a market economy. He then presents an extensive critique of the assumptions of this framework, suggesting that a framework which includes cumulative processes would be far more appropriate for the study of urban systems. Finally, Matzner outlines three major starting points for a theory of intervention of the public sector in a market economy.

An often suggested remedy for some of our urban and regional problems is to establish or stimulate the development of a small number of growth centres. Economic considerations tend to make growth feasible only in intermediate or large centres; moreover, towns could be planned so as to avoid many of the mistakes of cities which have grown up with little or bad planning. Although these proposals have some merit, they can also present major difficulties. The paper by Stöhr presents a survey of some of the strengths and weaknesses of these approaches not only in theoretical terms, but also drawing upon empirical evidence from a number of countries.

Much of the theory which has been developed for national urban settlement systems is piecemeal and uncoordinated. Often, quite different theories have been developed to deal with apparently related aspects of urban systems. Only a few attempts have been made to coordinate these separate theories. Mera's "multiple layer theory" attempts to integrate theories of economic base, agglomeration and central places. Although the assumption that these theories are additive is perhaps overly simple, it is at least testable. Mera's attempt at synthesis is a useful first step.

One of the principal shortcomings of many of the conventional theories based on economics is the strong assumption that information is costless and, in effect, all people and institutions possess perfect information. The papers of Goddard and Törnqvist report one of the broadest and most promising attacks on this assumption. The critical role of intra- and inter-firm flows of information in influencing the location behaviour of industries, services, and people is discussed by both authors. In view of the importance of such flows, public decentralization policies must be adjusted if they are to have any possibility of becoming feasible.

Approaches to a Theory of Urban Interventionism

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1. An Outline of Problems and Tasks

The problems of urban development and control are essentially classical allocation problems. Allocation in the urban context must be interpreted as the distribution of the activities of individuals, enterprises, government agencies and other institutions in space and time. The utilization of land and its physical organization are both the fundamental subject of allocation decisions and their dominating starting point.[1] Since such decisions are not made in an isolated manner but rather in keeping with the possibilities of competing and complementary forms of land utilization, the problem under consideration is highly complex.

The following study will be confined to the urban allocation problem in a social system which is characterized by a large measure of private control of economic resources including land. A decisive criterion of efficiency in that area is economic profitability in the sense of possibly high returns on the invested economic resources, which in monetary terms are described as capital. The result of allocation decisions is determined in two ways:

1) by the intended success on the market, which depends on competitive advantages of a specific enterprise; and

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[1]See T. Haegerstrand, Tidsanvaendning och omgivningsstruktur, p. 4:7, in: *Urbaniseringen i Sverige, Statens offentliga utredningar 1970:14*, Stockholm. See also H. Linde, *Sachdominanz in Sozialstrukturen*, Tuebingen, 1972, especially p. 63 to conclusion.

2) by the available scope for planning, which is allowed for by the political authorities and for which the instrumentarium of infrastructure policy,[2] i.e. laws, rules and prohibitions, taxation and subsidies, as well as the supplies of public installations and services are available.

Appropriately enough, the classical problem evokes a classical set of questions: we must

a) define the area in which market allocation can take place in the city; and, if necessary,

b) develop adequate methods of intervening in the process of market allocation.

Before discussing these questions in greater detail, a few words should be said on the present fame of reference for decisions.

2. The Present Frame of Reference for Decisions Affecting Urban Development

The actual development of a city is the result of a multitude of more or less far-reaching decisions, which are frequently made in a rather isolated manner by authorities, households, enterprises and organizations. Therefore, it is often impossible to establish a direct causal relationship between a decision and its effect. We might as well accept the fact that urban development just "happens" and should avoid describing the present situation with misleading words such as "control" or "planning" which might lead one to think that urban development is deliberately brought about.

Within the institutional framework of a market economy, allocation decisions in a market sector are aimed at the highest possible profitability or--in the private or household sector--at the highest possible personal advantage. The large majority of social and/or economic activities are directly made in the market sector; in addition to the production and allocation of the usual investment and consumer goods these

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[2] In this context the term "infrastructure" must be understood in its widest sense; following R. Jochimsen's definition it comprises the material, personel and institutional infrastructure. See R. Jochimsen, *Theorie der Infrastruktur, Grundlagen der marktwirtschaftlichen Entwicklung*, Tuebingen, 1966, pp. 103, 117 and 133.

activities also include those relating to real estate, housing and leisure. Even decisions in the non-market area, i.e. decisions taken by public authorities, churches and other non-profit-making institutions, cannot fully evade the logic of the market model. How else are we to explain, for instance, the construction of an underground garage next to St. Stephen's Cathedral by the Arch-Diocese of Vienna? However, this is not surprising in view of the frequent shortage of funds, which requires and necessitates the use of criteria of efficiency, such as a cost-benefit analysis. J. A. Schumpeter rightly noted that in a free market economy all social spheres were permeated by the spirit of capital.[3]

In addition to being influenced by the market sector, decisions in the administrative sector are characterized by what may be called *practice without theory*, i.e. something ranging from conventional (traditional) behavior to the presently prevailing attitudes. For town planning and urban development decisions there is no objective which is as unequivocal and comprehensive as the criterion of profitability, and consequently there are no unequivocal, useful evaluation standards. Therefore, one often encounters any amount of good intentions, occasionally touches of genius, common sense, but just as often dilettantism, short-sightedness, ineptitude or tentative actions under the "dictatorship of circumstances,"[4] which often serves only to hide massive interests or ill-defined ideologies. In this theoretically unresolved situation science nevertheless has its role to play; in the absence of well-founded knowledge, science is to supply the reasons for what is happening anyway. Where perplexity prevails, science may even acquire the role of political decision making. Its part will be a relatively harmless one, however, where it is confined to a mere collection of data in the sense of "measurement without theory"[5] for the extrapolation of existing conditions.

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[3]See J.A. Schumpeter, *Capitalism, Socialism and Democracy*, especially chapter 11, "The Civilization of Capitalism." He says that the economic pattern is "the matrix of logic" (p. 123). Similarly, before Schumpeter, see K. Marx and F. Engels, *The Communist Manifesto* (1843), London, 1930 (ed. D. Ryazanoff), London, Martin Lawrence, 1930, p.31.

[4]See H. Linde, especially the chapter "Anmerkungen zur aktuellen Sachzwangproblematik," pp. 63-65.

[5]T.C. Koopmans, "Measurement Without Theory," *Review of Economic Statistics* (August 1947), 161-172. See also J.D. Reinberg and W.E. Oates, "On the Adequacy of Economic Data for Urban Areas," unpublished manuscript, Princeton, no date.

At any rate, the situation outlined here is unsatisfactory for all concerned, particularly for those immediately affected. As an economist I would, therefore, like to analyze the theoretical frame of reference of market allocation in the urban context.

3. The General Equilibrium Model (GEM) as a Theoretical Frame of Reference of Market Allocation

The General Equilibrium Model (GEM) developed by the Lausanne School serves as the theoretical frame of reference of market allocation.[6]

3.1 Central Theses and Definitions

The central theses of the GEM refer to the *optimal* allocation of resources and to the *equilibrium* of the economic system. According to the GEM an economic system tends toward an "equilibrium" characterized by maximum social "welfare," which in turn is a function of the aggregate of individual welfare indices. *A state of equilibrium* will occur when allocation is carried out in a competitive market and when strict conditions of optimality and stability are fulfilled.

Now let me define some terms:

1) "Welfare" is the psycho-physiological equivalent representing the extent or degree of satisfaction produced in the individual by the consumption and/or use of goods in the widest sense, including the state of the environment (neighborhood).

2) By "tendency" we mean a process resulting from a combination of forces which leads to a development in a given direction. The combination of forces is defined by the "criteria of optimality."

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[6]Foundations were laid by L. Walras, *Elements d'economie pure* (1874), 3rd edition, Lausanne, 1968. Up-to-date and stringent formulations of the GEM were established by K.J. Arrow, "An Extension of the Basic Theorem of Classical Welfare Economics," *Proceedings of the Second Berkeley Symposium on Mathematical Statistics and Probability*, Berkeley, 1951, and G. Debreu, *Theory of Value. An Axiomatic Analysis of Economic Equilibrium*, New York, 1959. Further improvements have since been achieved. J. Kornai offers a critical survey in *Anti-Equilibrium. On Economic Systems Theory and the Task of Research*, Amsterdam, 1971.

3) "Equilibrium" in this context[7] is a state in which the variables of a system do not tend toward change. There are states of equilibrium for stable and dynamic models. The following definitions are taken from R. Frisch: A *stable* equilibrium is characterized by numerical values for variables that reproduce the model in the course of time. In a *dynamic* equilibrium some variables remain unchanged while others are subject to regular change.

In addition to the "equilibrium" concepts of the GEM, which defines equilibrium explicitly:

a) as a systemic state according to the definition of R. Frisch; and

b) as the state toward which an economic system tends under certain conditions of market allocation, the term "equilibrium" is associated with three further concepts:[8]

c) as a description of historical situations;

d) as an objective; and

e) as an analytical instrument for explanatory purposes.

3.2 A General Critique of the GEM

The central theses of the GEM have been subject to critical examination from various viewpoints for a long time: one school of thought questions the factual content of the assumptions, which in some important instances must be negated even on superficial examination.[9] Where assumptions are brought into line with reality--e.g. abandoning the postulate of convexity--the tendency toward an equilibrium

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[7]See B. Hansen, "The Notion of Equilibrium," *Lectures in Economic Theory*, Lund, 1966, p. 29, and R. Frisch, "On the Notion of Equilibrium and Disequilibrium," *Review of Economic Studies*, 1935-1936, pp. 101-105.

[8]F. Machlup, "Equilibrium and Disequilibrium: Misplaced Concreteness and Disguised Politics," *The Economic Journal* (March 1958), 1-24.

[9]See J.A. Schumpeter, *History of Economic Analysis*, New York, 1954, chapter 7, "Equilibrium Analysis," pp. 951-1073. See also J. De V. Graaff, *Theoretical Welfare Economics*, London, 1967; G. Myrdal, *Economic Theory and Underdeveloped Regions*, London, 1957; O. Morgenstern, *Spieltheorie und Wirtschaftswissenschaft*, Vienna-Munich, 1963.

solution is suspended.[10] Basically, this school of thought can be traced back to the criticism[11] of transferring a model from the field of physics[12] to the realm of society. G. Myrdal[13], O. Morgenstern[14] and N. Georgescu-Roegen,[15] who for more than forty years have pointed out the inappropriateness of the GEM as a representation of reality from different angles, are representatives of that school. Recently, these critics of the GEM were joined by J. Kornai[16] and N. Kaldor,[17] two economists who previously had themselves made important contributions to the GEM. Finally, we must not forget to mention the criticism raised by Marxist theoreticians, who have always emphasized the apologetic character and, above all, the neglect of social power, the denial of conflict situations, the failure to appreciate essential motivating forces in economics and society--in short, the unhistorical character of the GEM.[18]

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[10] J. Kornai, *Anti-Equilibrium*, p. 367.

[11] O. Morgenstern, see especially the chapter "Games Theory and Economic Behavior," pp. 71-110.

[12] Thus W. St. Jevons called economics "the mechanics of utility and self-interest." W. St. Jevons, *The Theory of Political Economy* (1871), 4th edition, London, 1924, pp. 11, 21.

[13] G. Myrdal, *Economic Theory and Underdeveloped Regions.*

[14] See especially the recent study of O. Morgenstern, "Thirteen Critical Points on Contemporary Economic Theory: An Interpretation," *Journal of Economic Literature*, 10,4 (1972), 1163-1189.

[15] N. Georgescu-Roegen, *The Entropy Law and the Economic Process*, Cambridge, 1971.

[16] J. Kornai, *Anti-Equilibrium*

[17] N. Kaldor, "The Irrelevance of Equilibrium Economics," *The Economic Journal*, 82,238, (December 1972), 1237-1255.

[18] P.M. Sweezy, *The Theory of Capitalist Development*, Cambridge, 1942, see Introduction.

3.3 The Influence of the GEM School

This vehement unrefuted criticism, however, has not prevented the exponents of the GEM from dominating economic thought at the universities and research centers today.[19] Only "a tiny minority of neoclassical economists have honestly admitted the degree to which reality differs from their ideal."[20] The majority is probably still convinced that this reality bears a recognizable likeness to their model. *This is also true for the theories of regional and urban economics, economic policy and planning, which are important for the problem under discussion* and which have taken over some of the basic concepts from the GEM, such as behavioral assumptions, optimum and equilibrium. The works of some leading representatives of regional economics,[21] such as W. Alonso, E. v. Boeventer, L. Lefeber and R. Thoss, may serve as examples. However, the Theory of General Equilibrium is "true" only in the sense of the theoretical concept of mathematics and logic, where a statement is "true" only if it is derived from a number of mutually consistent axioms.

3.4 The Search for an Appropriate Theoretical Concept

In the *empirical sciences* this concept of truth does not suffice. In the social sciences a theory is seen as a systematic description of the essential relations between the variables of the phenomenon under consideration. Only statements which are derived from assumptions based on reality and describe the latter with sufficient accuracy are "true." The words A. Einstein puts into the mouth of his sceptic, "It may well be true that this system of equations is reasonable from the logical standpoint. But this does not prove that it corresponds to nature,"[22] hold true for the social sciences as well. Thus, we must be satisfied with a more modest claim for our theory: We must start from the assumption that the

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[19] See J. Kornai, pp. 23-30 and N. Kaldor, pp. 1237, 1251.

[20] E.K. Hunt and H.H. Sherman, *Economics. An introduction to Traditional and Radical Views.* New York, 1972, p. 244.

[21] L. Lefeber, *Allocation in Space. Production, Transport and Industrial Locations*, Amsterdam, 1958. E. v. Boeventer, *Theorie des raeumlichen Gleichgewichtes*, Tuebingen, 1962. W. Alonso, *Location and Land Use. Toward a General Theory of Land Rent.* Cambridge, Massachusetts, 1964. R. Thoss, "Ein Vorschlag zur Koordinierung der Regionalpolitik einer wachsenden Wirtschaft," *Jahrbuecher fuer Nationaloekonomie und Statistik*, 182 (1960/69), 490-529.

[22] A. Einstein, *Opinions and Ideas*, New York, 1960, p. 355.

main task in every discipline is the selection of the relevant facts and not the degree of "sophistication" with which irrelevant facts are analyzed.[23]

4. Critique of the Assumptions and Concepts of the GEM Relevant to Urban Problems

On the basis of these considerations only those assumptions (concepts) out of the twelve central theses of the GEM listed by J. Kornai which have a particular bearing on urban economics shall be discussed in the following, viz:

1) the assumptions concerning the production function;

2) the assumptions concerning the external effects; and finally

3) the concepts of "equilibrium" and "welfare."

From the assumption[24] that the production possibility curve is convex follow:

a) the unlimited divisibility of products and factors, which can consequently be described in terms of continuous functions; and

b) constant returns-to-scale.

Both assumptions are notoriously unrealistic in the urban context.

4.1 Indivisibilities

It can easily be understood that the areas required for the performance of all the essential urban functions cannot be divided at will. A street, a church, a home cannot be

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[23] N. Georgescu-Roegen, p. 340. The author refers to similar thoughts in H. Poincaré, *Foundations of Science*, Lancaster, Pennsylvania 1946, p. 363, and P.W. Bridgeman, *Reflections of a Physicist*, 2nd ed., New York, 1955, p. 447. See also G. Myrdal, "Economic Models and their Usefulness for Planning," *The Asian Drama. An Enquiry into the Poverty of Nations*, New York, 1969, III, p. 1965; W. Leontief, "Theoretical Assumptions and Non-Observed Facts," *American Economic Review*, 61,1 (n.d.),1.

[24] J. Kornai, p. 21

produced on an infinitesimally small area.

These space-requiring installations, "utility systems" in D. Boekemann's terms,[25] which constitute the urban system, are not only characterized by spatial indivisibility. These utility systems are installations whose potential is of necessity functionally related with discrete minimal capacities. Their potential, in turn, cannot be expressed by a continuous variable, i.e. a flow variable regarded as a stock distributed over time, as is the case with inventory items, for example, coal. Potential is defined as a fund of services which can perform only if it does not fall below a minimal degree of coherence and consistency.[26] Thus, urban functions are linked with indivisibilities in a twofold manner: on the one hand with respect to their space requirements and on the other hand as technically coherent performing systems (D. Boekemann).

As T.C. Koopmans and M. Beckmann have shown, the GEM does not offer any solution for the efficient allocation of indivisible resources.[27] Thus, the location theory derived from the GEM cannot explain why big cities and small towns exist side by side.[28]

4.2 Increasing Returns-to-Scale

There is still another way in which the existence of indivisibilities implies the insufficiency of market allocation. Frequently, indivisibilities are at the root of the increasing returns-to-scale,[29] which are neglected by the GEM. The explanation is a relatively simple one. If "utility systems" are regarded as *technically coherent performing systems* characterized by discrete system boundaries, the total system input per performing unit will tend to decrease with a growing system output. This is the familiar phenomenon of describing average costs. The supply of "utility systems" is positively correlated with the utilization probability. If several "utility systems" are offered at a time, the utilization probability increases. These are the

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[25] D. Boekemann, "Utility Systems as Determinants of Settlement Patterns: A Typology, in: *Recent Developments in Regional Science*, ed., R. Funck, London, 1972.

[26] N. Georgescu-Roegen, p. 227.

[27] T.C. Koopmans and M.M. Beckmann, "Assignment Problems and the Location of Economic Activities," *Scientific Papers of Tjalling C. Koopmans*, Berlin and New York, 1970, p. 276.

[28] T.C. Koopmans, p. 258.

[29] T.C. Koopmans, p. 258.

underlying reasons for a considerable portion of modern regional growth and decay processes. In this context, the standard of reference can be the population as well as the utilization of land and its physical organization (buildings).

4.3 Technical Progress

Our modern cities would not have come into being without technical progress. The speed and extent of their growth are at the bottom of our problems. Indivisibilities have technical reasons, and technical progress constitutes a necessary prerequisite for growing returns to scale and external effects. An allocation theory which excludes technical progress will remain largely inoperational in the urban context.

4.4 External Effects

In the strict version of the GEM utility and production functions are independent of each other: there is no divergence between private and social costs and returns. Since cities can only be understood as places of particularly intensive contacts and consequently of spatial proximity, this will necessarily give rise to external effects. A city may well be defined as a locality of external effects. A theory which abstracts from external effects can explain the development of the city as neither a center of production nor of consumption.

The GEM school tries to cope with this phenomenon by assuming that a body outside the sphere of production and consumption, viz the state, triggers off a mechanism which compensates the divergence between private and social costs and returns.[30] Where private costs lie below social costs, compensation is to be achieved by product (ion) specific taxes; where social returns are higher than private returns, compensation is to be achieved by product (ion) specific subsidies. Provided that:

1) cost and return curves are known;

2) competitive conditions prevail; and

3) external effects are of a special quality, viz separable according to type,

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[30] See W.J. Baumol, *Economic Theory and Operations Analysis*, (1961), 3rd ed., 1972, pp. 392-398. See also "On Taxation and the Control of Externalities, *American Economic Review*, 72,5 (n.d.), 305-320.

the tax/subsidy scheme offers appropriate instruments of intervention which are not contradictory to the GEM.[31] Even if premisses 1) and 2) do not apply, the quality of the external retains its special relevance for intervention.

According to O.A. Davis and A. Whinston, external effects are *separable*[32] if they enter the cost (return) function additively. Separable external effects do not affect marginal costs or marginal returns and thus have no influence on the optimal decision of a company or household. The optimum remains unchanged, independent of the extent of the externalities; what changes is merely the absolute level of profit or return. It is highly important that in this case the decision of firm A is independent of a possible decision of firm B.

External effects, according to Davis-Whinston, are *nonseparable*[33] if they appear multiplicatively in the cost (return) function. In this case the external costs of firm A are included in the marginal costs of firm B and vice versa. Thus, marginal costs are not only defined by variables which are controlled by A (B) but also by variables which are subject to decisions made by B (A). Thus, the optimum is influenced both by the decision of the originator of external effects and the decision of the affected party. Nonseparable external effects lead to an interdependence of decisions. In this type of allocation situations a competitive system and price mechanism, in short the GEM, will not produce an optimal decision.

There is good reason to suspect--and this should be submitted to empirical investigations--that external effects in the urban sphere are frequently of a nonseparable kind. This holds true for questions of land allocation as well as for problems concerning the utilization of public traffic areas. Davis and Whinston have shown that situations which are characterized by the interdependence of the decisions of the acting parties can be represented and analyzed in game theoretic terms. By using the "Prisoner's Dilemma" model, Davis and Whinston examined a special situation of urban decay.[34]

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[31]O.A. Davis and A. Whinston, "Externalities, Welfare and the Theory of Games," *Journal of Political Economy*, 70, 3, (n.d.), 241-261.

[32]Davis and Whinston, pp. 244 ff.

[33]Davis and Whinston, pp. 253 ff.

[34]O.A. Davis and A. Whinston, "The Economics of Urban Renewal," *Law and Contemporary Problems*, vol. 26, 1961, pp. 105-117.

The authors start from the assumption that private ownership of homes predominates in the selected urban district. The owners try to obtain maximum net returns on invested capital through letting. Rents are not subject to any administrative restrictions. Considering that every owner, under the assumption of profit maximization and given the validity of the price system, ought to be interested in maintaining the value of his property, a deterioration of urban districts would in theory appear unthinkable. Nevertheless, a loss of housing value and subsequent changes are a fact even where zoning regulations prevent an elimination of one form of utilization through another.

It can be easily understood that the value of a rentable flat or home depends not only on the design and state of repair of one's own property but also on that of one's neighbor's property. This is reflected in demand and consequently in capital value and returns on capital, and of course also in the return on investments. Let us now take the case of two noncooperating property owners. They are both faced with the decision of whether to invest in repairs or not. The additional investment will, of course, affect the returns of the investing owner as well as the returns of the other owner, and vice versa.

The following situation--illustrated by quite realistic figures--calls for a decision: If both owners invest, the increased value of their dwellings will render a return on investment of 7 percent to both of them. If owner A invests, but not owner B, the returns of owner B will rise to 10 percent as a result of the increased attractiveness and value of the neighbouring property. Since the property of owner B remains in a state of disrepair, however, the neighborhood of owner A's property deteriorates and his property will yield him only a lower return of, say, 3 percent. The reverse will happen if owner B invests, but not owner A. In both instances the "good housekeeper" is the loser while the "bad manager" gains an advantage. In the case of decisions on restoration investments, therefore, the returns which can be gained from investments in other fields will be considered. Let us make the plausible assumption that they produce a return of about 6 percent. Since this is more than the return on renewal investments when the other party fails to invest, noninvestment will yield the highest *certain* return in the case of noncooperation and uncertainty about the action of the other party. This strategy, therefore, is the rational decision. Since noncooperation is probably the rule in the case of fragmented property holding, the interdependence of the decision situation is an important part of the dynamics behind urban decay, which results from the conditions of production. When dilapidated property is sold to well-to-do institutions, returns can be considerably increased as a result of profit expectations. Similar interdependent situations occur when a decision must be made as to whether private or public transport should be used in view of the traffic jams during rush hours. On plausible assumptions the rational decision of the individual will be to use his private car. Likewise, an interdependent situation exists between the tenant of an apartment and the stress resulting from the use or nonuse of a nearby road; in this situation the individual rational behavior in certain instances will be the decision to move to a different neighborhood.

A common feature of these situations is that the price system does not and cannot suffice to solve the allocation problems. The interdependence of decisions as a result of nonseparable external effects necessitates administrative interventions: Mandatory renewal investments in the case of decaying districts, restricted use of private cars where the requirements of public transport and other road users are in conflict or where the rights and comfort of the inhabitants of residential areas are impaired by traffic. A necessary prerequisite, however, is that the disturbances caused by nonseparable external effects are felt to be "nonacceptable."

5. The Methodological Hypothesis of Cumulation

5.1 Cumulative Processes as a Result of Market Failure

The fact that the assumptions of the GEM with a particular urban relevance do not even come close to the reality of our cities explains the need for interventions into market allocation. Although such interventions have always been made, there was no reflection on their nature, so that this was an example of the previously mentioned practice without theory.

Indications as to the nature of interventions, however, can be derived from the dynamics resulting from the lack of realism of the relevant assumptions of the GEM.

The majority of the problems of modern cities are connected with cumulative processes, as pointed out by W.J. Baumol[35] in particular. This holds true for the migration of people

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[35]W.J. Baumol, "Urban Services: Interaction of Public and Private Decisions," in *Public Expenditure Decisions in the Urban Community*, ed. H.G. Schaller, Washington, 1963, pp. 1-18; "Macrocconomics of Unbalanced Growth: The Anatomy of Urban Crisis," *American Economic Review*, 57 (n.d.), 415-426; (together with W.E. Cates and E.P. Howrey) "The Analysis of Public Policy in Dynamic Urban Models," *Journal of Political Economy*, 79, 1 (n.d.) 142-153; "The Dynamics of Urban Problems and its Policy Implications," *Essays in Honour of Lionel Robbins* (to be published shortly).

and industries, the deterioration of city centers, suburban growth, the daily plight of traffic jams and chaos, and presumably the costs of water and power supply as well as of sewage and refuse disposal;[36] and it is particularly true for the phenomena summarized under the slogan of an "environmental crisis." In general terms this means that owing to causes which cannot be sufficiently influenced by individual agents (households or companies) there is a cumulation of decisions in one particular direction (e.g. immigration or emigration).[37]

This cumulation can be intensified through additional external sources of interference (e.g. individual traffic interferes with public transport, thus increasing the trend toward individual transport; or heating technology pollutes the air in a residential district which, owing to the interdependent decisions of urban renewal, is in a process of decay; or the social structure of the inhabitants changes at an increasing rate, thus accelerating decay, etc.). According to G. Myrdal, therefore, growth or decay processes can reinforce each other, i.e. they can produce a "circular cumulation." It should be borne in mind that primary or endogenous causes (e.g. interdependence of decisions) will be intensified by secondary or circular causes (e.g. air-polluting heating technology).

G. Myrdal was the first to explicitly define circularly caused or intensified cumulation as a methodological hypothesis, although other before him (e.g. K. Marx and K. Wicksell) had used this analytical instrument. Myrdal describes it as the "principle of circular interdependence within a process of cumulative causation" and presents it as a hypothesis for the entire field of social relations.[38]

E. Olsen was the first to formulate Myrdal's methodological hypothesis as a cybernetic model and to use it for an explanation of the development of income differences in the USA in time and space.[39]

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[36] W.J. Baumol, p. 424.

[37] "Cumulation ... is denoted by an increasing number of subjects ... acting in the ascending phase and by a decreasing number of subjects ... acting in the descending phase." J. Akerman, The Cumulative Process, in: *25 Economic Essays in Honor of Erik Lindahl*, Stockholm, 1956, p. 411.

[38] G. Myrdal, especially chapter 2, on the principle of circular causation with cumulative effects.

[39] E. Olsen, *International Trade Theory and Regional Income Differences*, Amsterdam, 1971, pp. 81-98.

It has been shown that the endogenous causes of cumulative processes are indivisibilities with growing returns to scale and nonseparable external effects. To these should be added the uneven distribution of market power and information.[40]

The efficiency of these causes is increased by the fact that we are not faced with a timeless causality but rather with a hysteretic process.[41] It is particularly in urban deterioration processes that we see the causes of the past become cumulatively effective in the present. According to N. Georgescu-Roegen, aging (or decay) can be interpreted as the "cumulative effect of causes in time."[42] This is as important for adequate interventions as the fact that growth and decay processes are irreversible--one need only think of the loss of aesthetic values through the destruction of historic city centers--and frequently irrevocable.[43] The things of beauty which we have inherited from the past are often unique, cannot be recreated and hardly imitated. These features of hysteresis, irreversibility and irrevocability of urban phenomena, highlight the urgent necessity of interventions.

5.2 The Relevance of the Concepts of "Equilibrium" and "Welfare"

From these considerations it should be obvious that in many important instances market allocation in the urban sphere does not even come close to an "equilibrium," i.e. a state distinguished, by and large, by the absence of forces aiming at change.

Admittedly, cumulative processes may correspond to the formal definition of R. Frisch's concept of equilibrium--viz when a constant quantity of system variables is subject to regular change. In reality, however, the number of system variables will only rarely remain constant. We need only think of the emergence of innovations understood as products, factors or combination of elements. The addition of just one new variable changes the system and can lead to deviations from equilibrium.

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[40]See K.W. Rothschild, "The Neglect of Power in Economic Theory, in: *Power in Economics*, ed. K.W. Rothschild, London, 1971, p. 17.

[41]N. Georgescu-Roegen, p. 123.

[42]Georgescu-Roegen, p. 205.

[43]As to the concepts "irreversible" and irrevocable" see N. Georgescu-Roegen, pp. 196-210.

In the present author's opinion, equilibrium must not simply be understood as the occurence of mathematical-logical qualities. Although cumulative processes which terminate in infinity or nonexistence may correspond to the formal concept of equilibrium, such developments contradict the "equilibrium" of reality if, applied in urban contexts, they end in a single world-wide conurbation or in the complete decay of the phenomenon of the "historic city center." It is reasonable to describe cumulative processes as being in disequilibrium if there are limits to the development of a system beyond which we would not go for reasons of values.

As is generally known, the "equilibrium" of the GEM is identical with maximum "welfare." In this sense this concept could also be used as a criterion for the evaluation of given conditions; one could then judge the desirability of change and the required direction of interventions if, owing to the absence of decisive optimality conditions, there is no trend toward an "equilibrium."

Is it possible to attribute such an "intervention relevance" to the concept of "equilibrium"? The answer is negative.

Recourse to the concepts "individual utility" or "individual welfare" of the GEM and its behavioral assumptions of utility maximization does not take us any further. Statements such as "each individual acts according to his wants" or, in the language of the GEM, "each individual acts so as to maximize his utility in any given situation" are tautologies; they are nonoperational as utility cannot be measured and preferences change and--at least to philanthropists (Christians, Socialists)--they are contrary to the intentions of the utility theory.[44] Further considerations regarding "utility" and "welfare" seem to be irrelevant and superfluous.[45]

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[44]For an essay on "abnormal" utility functions see H. Frisch, "Die Kontraktkurve bei Interdependenz im Konsum," *Kyklos*, 24, 4 (1971), 644-659.

[45]E. Streissler states, "The still swelling flood of innumerable studies of the neoclassical school should not mislead the student into believing that they have any deeper meaning.... In view of the relatively inconsiderable significance of approximately rational decisions in the global complex of consumption activities...it appears to me...that for practical purposes..any serious study of the gossamer of the theory of utility value is hardly worth while." E. and M. Streissler (eds.), *Konsum und Nachfrage*, Cologne-Berlin, p. 25.

Of the five previously mentioned contents of the concept "equilibrium," therefore, four can be eliminated as being irrelevant to our present problems. The concept of "equilibrium," which implicitly lies also behind the analysis of the observed phenomenon of "cumulation," has an explanatory function only as an analytical concept.

As a description and evaluation criterion for urban intervention the "equilibrium" concept of the GEM is useless.[46] What is needed for this purpose is the definition of an *"acceptable" actual state or condition.*

This "equilibrium" concept, which has been detached from the GEM, is nothing absolute, however. Its realization does not correspond to the "optimum optimorum" but is based on the more modest assumption that any state or condition in this world is capable of improvement.[47] Seen in this light, the realization of "acceptable conditions" cannot mean the end of all human endeavor in the sense of the equilibrium concept of R. Frisch, but can only be a starting point for further efforts.

5.3 Instruments for the Analysis of Cumulative Processes

5.3.1 Endogenously Caused Cumulation

A characteristic feature of cumulative processes is the concurrence of physical and technical, economic, social, physiological and psychological factors. The Prisoner's Dilemma model, developed in game theory, as well as a model of elementary differential equations have proved to be useful instruments for the description of this form of change. Prisoner's Dilemma is a static model; nevertheless it exemplifies the dynamics of the decision situation, which gives rise to the endogenously caused cumulative process.

For the presentation of time sequence W. J. Baumol chose a model of elementary differential equations, which can also be presented as a standard differential equation diagram. Both Prisoner's Dilemma and the differential equation model clearly demonstrate the nature of the necessary intervention: measures of price policy, taxes and/or subsidies are not only little suited to stop a cumulative growth or decay process. What is necessary is administrative intervention in the sense of

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[46]See F. Machlup, "Equilibrium and Disequilibrium: Misplaced Concreteness and Disguised Politics," *Economic Journal*, 68 (1958), 13.

[47]See Streeten, Introduction, pp. XIV ff. in G. Myrdal, *Value in Social Theory*, London, 1958.

partial and/or total exclusion of certain types of use causing nonacceptable conditions from the urban area. In this context W. J. Baumol states: "Increasing population density, pollution problems, the crisis in transportation... clearly require increased public services, more stringent regulation, and greater intervention generally. A municipal government which is committed to a hands-off policy can only expect these problems to grow increasingly critical of their own accord." He goes on to say: "Our analysis has indicated that only a really radical change which modifies the very structure of the situation can offer real hope."[48] Palliatives can merely delay cumulative decay temporarily.

5.3.2 Circularly Caused or Intensified Cumulation

We have distinguished between an endogenously caused cumulation and a circularly caused or intensified cumulation. This differentiation is derived from an appropriate definition of the system boundary. In the decision-making situation of the two property owners the boundary is drawn beyond the sphere of influence of the two parties. This is reasonable since the endogenous dynamics can thus be isolated. In circularly caused or intensified cumulative processes, however, influences emanating from systems beyond the chosen system boundary are included in the analysis. In the previous example the deterioration dynamics of the nonseparable externalities are joined by influences of the transport and/or environment systems. Again, there may be nonseparable externalities between the original system, i.e. the real estate market, and the transport and environment systems. The important thing is the effect on the endogenously caused cumulative process. For many processes an intensifying effect will result. Thus, it becomes necessary to consider a further spectrum of causes in the formulation of the intervention strategy. It is obvious that a phenomenon of circularly intensified cumulation will be particularly important where reality is characterized by very complex interdependencies. This explains their great importance for the recognition and explanation of urban development problems.

Finally, circularly caused or intensified cumulation can be represented with the help of the analytical tools of system dynamics.[49] The concept of feedback effects illustrates circular causation. Other constituent elements of system dynamics are the rate variable, the flow variable and the level. Rate variables act on the levels and accumulate or decumulate them via flow variables. Status quo levels are compared with target levels. By means of system dynamics it is possible to simulate interventions designed to achieve target levels in the sense of

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[48] W.J. Baumol, p. 14.

[49] Cf. J.W. Forrester, *Principles of Systems*, Cambridge, Massachusetts, 1969.

"acceptable conditions." Since it is possible to model complex systems with the help of system dynamics, it is possible to test the efficacy of interventions, provided that the model is valid. In this way, measures which are intuitively accepted as being appropriate but miss their goal because of the feedback loops typical of complex systems can be recognized as counter-intuitive. The potential value of system dynamics can thus be said to be heuristic. It helps to reveal weak points which would not show up in conventional representations as well as interdependences which must be recognized if the nature, direction and extent of interventions are to be established.

5.3.3 A Note on the Weakness of System Dynamics as Applied by J. W. Forrester

A positive evaluation of the possibilities of system dynamics must not be taken as an unconditional acceptance of urban dynamics as applied by J. W. Forrester.[50] Forrester's use of this method reveals two weaknesses. The first one is due to the present state of development of system dynamics; the second source of error is the carelessness with which J. W. Forrester himself applies this method.

Basically, it must be noted that system dynamics is the transfer of a model from electrophysics to social systems. The significant distinction between "stock" in the sense of "stock piles" and "stock" in the sense of "funds of services" is neglected. Furthermore, the difference between irreversibility and irrevocability of states or conditions, which is important for urban processes, is neglected. Finally, the system ignores the quality component, which is of a dialectic nature and largely unsuited for representation in a mathematical model.[51] Of course, these objections apply not only to the use of system dynamics as practiced by Forrester; they rather concern the method as a whole, which must be improved and developed in several respects.

Let us now examine the specific weakness in Forrester's application of system dynamics. First of all, there is his total neglect of institutional aspects. He implicitly assumes the institutional framework of US cities, i.e. the hardly

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[50] J.W. Forrester, *Urban Dynamics*, Cambridge, Massachusetts, London 1969.

[51] See N. Georgescu-Roegen, especially chapter III, "Change, Quality and Thought," pp. 60-64

restricted American-type capitalist market. Endogenously caused cumulation is disregarded. Circularly intensified cumulation is based on intuitively assumed feedback loops. In short, system dynamics is not based on empirically tested behavior analyses,[52] which among other things would be necessary for an examination of the interdependence of non-separable externalities. Thus, system dynamics classifies counter-intuitivity according to the ideological position of the author of the model.[53] The counter-intuitivity of social welfare programs is a symptomatic example.[54] They are counter-intuitive because they do not abolish poverty owing to the immigration of poor people from beyond the system boundary. As long as there is freedom of movement, however, poverty cannot be abolished by urban communities alone but only by a national policy.

Owing to this ideological bias, system dynamics is not a concept relevant for intervention but rather an apology for the status quo: "The temptation to seize upon an analysis that indicates that not much can be done and that what can be done is more wrong than right is likely to be powerful at a time when public officials feel strongly that fiscal and organizational resources are in short supply."[55] This is how two notable critics sum up the position.

In view of the previously mentioned advantages, however, it would be wrong to eliminate system dynamics from the methodological armory of urban development policy on account of Forrester's failure to apply it appropriately.

6. Approaches to a Theory of Urban Interventionism

6.1 Analysis of Market Allocation under Urban Conditions

The existence of indivisibilities, growing returns to scale and nonseparable external effects gives rise to important urban growth and decay processes.

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[52] M. Shubik, "Modelling on a Grand Scale," *Science*, 174, 3 (December 1971).

[53] W.O. Narr, "Zur Weltanschauung der Systemdynamic," *Levisthan. Zeitschrift fuer Sozialwissenschaft*, 2 (1973), 276-280.

[54] J.W. Forrester, pp. 51-70.

[55] H. Averch and R.A. Levine, "Two Models of the Urban Crisis: An Analytical Essay on Banfield and Forrester," *Policy Sciences*, 2 (1971), 143-158.

If the resulting conditions are regarded as "nonacceptable" on account of prevalent value judgments, one will speak of market failure. This gives rise to the necessity of interventions in market allocation in the form of partial interventions in the production relations and to define the type, direction and scope of these interventions. Such an analysis of the modus operandi of the market under urban conditions, therefore, is the *starting point of a theory of urban interventionism.*[56]

6.2 T. Haegerstrand's Time-Space Model as an Integrating Instrument for the Formulation of "Acceptable Conditions"

So far "acceptable conditions," which require a definition in concrete terms, have occupied a key position. What are "acceptable conditions" and how can we describe them?

"Acceptable conditions" can be described in many different ways.[57] They can be maximum traveling times, population densities, solar angle of incidence, minimum tree population and other supply indicators in the sense of maximum or minimum demands. *Levels of demand* are values which cannot be achieved through a process of laissez faire and consequently call for intervention. In any case the central point in this approach is that the sum total of the partial solutions constitutes a physical environment for the individual in which he must find his way although this sum total often appears rather labyrinthine.[58] It is important to help the individual find his way through this maze produced by isolated decisions on partial problems taken by politicians and their technical, legal and sociological advisers in business and administration and to facilitate an integral and comprehensive view. Such an integral approach must start from the fact that the individual acts in various roles in his working and family life and in his leisure time.

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[56]See G. Myrdal's recommendation for development planning in underdeveloped countries. See *Economic Theory,* p, 90.

[57]"Acceptable conditions" imply conflicts of interests and a search for a consensus. The factual competence for their determination is open to various emancipatory and technocratic models of dominance.

[58]T. Haegerstrand, Tidsanvaending, p. 4:7. Similarly see I.G. Cullen, "Space, Time and Distribution of Behavior in Cities," *Environment and Planning,* 4 (1972), 459-470.

This is the case in the time-space model developed by T. Haegerstrand.[59] It considers both the fact that the individual has a limited amount of time at his disposal and the fact that the daily change of roles usually entails the need to overcome time-consuming distances. Consequently, the time-space model is a useful tool for the analysis of the fundamental problem of the allocation of limited resources. Thus, the individual will not be able to understand traffic in the overall urban complex unless its allocative function is properly evaluated. This also implies a rejection of the traditional view of urban transport problems, according to which it is merely a question of satisfying a demand, as transport planners often say. Haegerstrand rightly points out that such an approach means "...sweeping the really critical points under the carpet.[60]

The formulation of "acceptable conditions" as levels of demand--either as standards or indicators--and, above all, their incorporation into the time-space model is the *second starting point for a theory of urban interventionism*.[61]

6.3 Effective Opportunity Costs as a Criterion of Evaluation

"Acceptable conditions" must neither be regarded as a fantastic utopia nor as a circumscription of a hardly tolerable status quo. In this context we should perhaps ask whether our "sense of realities" should be permitted to prevent us from developing an "awareness of possibilities."

Allocation decisions are always characterized by the aspect of scarity. A decision in favor of one alternative means renunciation of another one. Rational decision-making, therefore, presupposes an evaluation of all alternatives and consequently appropriate evaluation criteria. An evaluation

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[59] T. Haegerstrand, "Konturorna av en tidsgeografisk samhaells modell," in Tidsanvaendning, pp. 4:14-4:37. English translation *The Impact of Transport on the Quality of Life*, Report to the International Symposium on the Theory and Practice of Transport Economics at the Conference of European Ministers of Transport (Athens, October 22 to 25, 1973).

[60] T. Haegerstrand, p. 22.

[61] W.J. Baumol suggests a similar approach for the control of polluting external effects. See his chapter on "Taxation and the Control of Externalities," pp. 307-322.

criterion frequently suggested today is cost-benefit analysis, which in the Federal Republic of Germany was even made mandatory by the 1968 Act on the Promotion of Economic Stability and Growth.[62]

Decisions on the allocation of scarce resources constitute the basis for the making and organization of physical and institutional facilities, thus determining the scope and extent of individual behavior in time and space. For various reasons we are of the opinion that the calculation of a one-dimensional social net gain does not facilitate allocation decisions. These reasons lie mostly in the assumptions underlying the cost-benefit analysis, which are derived from the GEM, and also in the fact that the cost-benefit analysis is based on data and forecasts derived from the market. By the same token we must reject, to a large extent, the evaluation of alternatives for urban allocation by means of shadow prices calculated with the help of linear optimization methods.[63]

In keeping with the majority of urban decision situations we focus our attention on multi-dimensional evaluation criteria which are a *concrete* reflection of "acceptable conditions" (goals) and their achievement (degrees or levels of goal achievement). On the basis of these considerations cost effectiveness analysis seems to be a promising starting point for research. The elaboration of factual evaluation criteria, expressed as vectors of effective opportunity costs,[64] is the *third (and, for the time being, final) starting point for a theory of urban interventionism.*

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[62] *Kommentar zur Foerderung der Stabilitaet und des Wachstums der Wirtschaft*, ed. A. Moeller, Hannover, 1968.

[63] H. Ben-Sahar, A. Mazor, D. Pines, "Town-Planning and Welfare Maximization. A Methodical Approach," *Regional Studies*, 3 (1969), 105-113. For a critique see J. Parry Lewis, "Misused Techniques in Planning: Linear Programming," *Occasional Paper No. 1*, University of Manchester, Centre for Urban and Regional Research, September 1969.

[64] Similarly, see G. Myrdal's recommendations for development planning in underdeveloped countries. See the section, "Planning must be done in real terms," *Economic Theory;* see also J. Steindl, "Servomechanism and Controllers in Economic Theory and Policy," in *On Political Economy and Econometrics*, Essay in Honor of Oskar Lange, Warsaw, 1964.

A Multiple Layer Theory of National Urban Systems

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1. Introduction

The spatial distribution and growth of urban centers within a country both have been given serious attention by politicians. Governments in a number of countries have been attempting to achieve a more "balanced" regional development by encouraging the development of less developed areas and discouraging the development of already developed areas (which invariably include large urban centers), but their attempts have not been very successful. A major reason for the failure appears to be insufficient understanding of the mechanics of development in space by scholars in this field. Specifically, the available theories have not been successful in answering the following central questions:

1) what are the determinants of the spatial distribution of urban centers of various sizes, and

2) what would be the implications of a public policy which is supposed to alter the system of urban centers?

Existing theories in this field are numerous, but each is valid or useful with respect to a particular aspect of spatial development. There is a need for a more comprehensive understanding of the relationships between policy tools and their impact on the spatial distribution of development. What is attempted in this paper is a small step toward building a comprehensive theory useful for policy makers concerned with regional and urban development.

We shall first review existing theories and then present a new approach in which it is intended to integrate some of the existing theories. Then, some empirical tests of the theory will be presented. The paper is concluded by a tentative assessment of the theory and statements concerning future directions of research on this subject.

2. Review of Existing Spatial Theories

There are a number of approaches to the understanding of the spatial aspects of development. We shall review some of them in order to prepare a framework for an integrated theory. This review is not intended to be exhaustive, but to highlight major drawbacks in the state of the art in this field.[1] We shall review the following theories or empirical regularities:

a) the regularity between urbanization and economic development,

b) location theory,

c) economic base theory,

d) central place theory,

e) rank-size rule,

f) neo-classical theory,

g) urban agglomeration economies, and

h) productivity of infrastructure.

There has been a clear recognition among scholars that there is an indisputable relationship between urbanization and economic development.[2] Clark [4] pointed out a long time ago that economic development leads to a reduction of the proportion of the primary sector and increases in the secondary and tertiary sectors. As urban activities are, almost by definition, those in the secondary and tertiary sectors, and secondary and tertiary sector activities tend to cluster together, economic development necessarily leads to an increase in the percentage of urban population. This is called urbanization. Consequently, the association of urbanization with economic development is indisputable as shown in Figure 1. But, this observed regularity does not have anything to do with the spatial distribution of the urban population.

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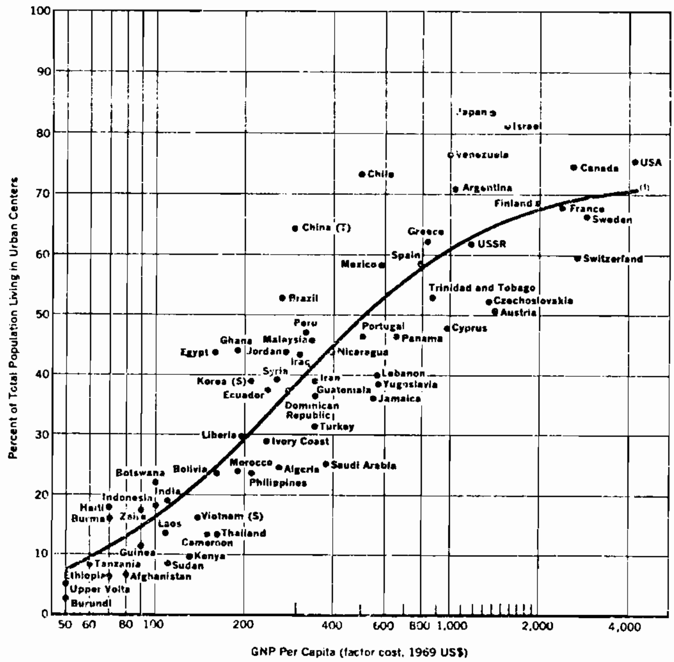
[1] For more comprehensive reviews of theories on spatial development, see Richardson [19], Nourse [18] and Isard [7].

[2] A qualitative analysis of the relationship is given, for example, by Lampard [10], and a quantitative analysis is carried out, for example, by Kuznets [9].



Source: International Bank for Reconstruction and Development, World Bank Operations: Sectoral Programs & Policies, Baltimore, Johns Hopkins University Press, 1972.

(1) Curve fitted to type $y = \dfrac{a}{1 + be^{-c(\log GNP)}}$

Figure 1. Degree of urbanization compared with GNP per capita.

The location theory provides a useful entry to understanding of the spatial aspect of development decisions on the establishment level, but its usefulness is largely limited to manufacturing plants.[3] Non-manufacturing activities such as administrative and service activities can hardly be dealt with adequately by this theory.

The economic base theory is a useful, practical one for predicting the growth of particular urban centers by linking activities at the establishment level to the level of urban centers.[4] With the aid of the location theory, the growth of the export or basic sector can be predicted, and then the growth of the residual or service sector is predicted by the use of the observed proportion of the service to the basic sector. This is a useful technique for planning of a new town envisaged in connection with an impending basic activity such as a steel mill. But, for existing urban centers, the usefulness of this theory can be challenged as it is not particularly easier to predict the growth of the basic sector than to predict the growth of the total level of activities.

However, a more serious limitation of this theory for understanding the entire urban system in a country is the fact that it refers to only individual urban centers. The theory does not touch upon the distribution or the growth of different urban centers in a country in any interrelated way.

The central place theory fills this gap, at least in part. It is addressed to the explanation of the distribution of urban centers in different sizes over space.[5] The theory is based on a uniformly developed agricultural region. The location of service activities is determined, first, by the economic size of the market area of the particular service activity and, second, by economies obtainable through agglomeration. Empirical analyses have proved that the theory is valid for explaining low-order urban centers in predominantly agricultural, featureless regions but the theory is powerless in explaining the distribution of large urban centers. As the theory is based on agricultural activities, it is less valid for developed areas than less developed areas.

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[3] Principal literature includes Weber [24], Hoover [5] and Isard [6].

[4] Andrews [1] and Tiebout [21].

[5] Christaller [3] and Losch [12].

The rank-size rule is merely an empirical regularity observed in a number of developed countries on the relationship between the rank of the city in size and its size of population in relation to the largest city.[6] This empirical regularity is particularly relevant to large urban centers not well explained by the central place theory. Nonetheless, this rule does not refer to the locational distribution of individual urban centers or their growth.

The neoclassical theory has been applied to regional analysis, resulting in two prime variations. One starts with the postulate that the actual spatial distribution of factors is not in an equilibrium but is approaching one, and the other variation is based on the proposition that the distributions of factors and activities are in an equilibrium.[7] While the latter approach has largely stayed on the theoretical level, the former has been tested empirically with mixed results. Nevertheless, it is becoming clearer that neoclassical approaches have not been very successful in explaining the spatial distribution and growth of urban centers within a country. The major reasons for the failure appear to be based on the basic production assumptions employed in the neoclassical analysis, i.e. the production function is homogeneous of degree one and the production process is not characterized by externalities. Therefore, recent writers have attempted to employ modified production assumptions even within the framework of neoclassical analysis.[8] This point is further elaborated in connection with the review of agglomeration economies and the role of infrastructure.

The existence of agglomeration economies in urban areas has been recognized by a number of scholars recently.[9] Agglomeration economies can be explained in various ways, such as savings in transportation and utility costs or ease of having face to face contacts. In addition, empirical evidences are abundant for indicating the existence of agglomeration economies.

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[6] Zipf [25].

[7] The former is represented by Borts and Stein [2] and Romans [20], the latter by Isard and Ostroff [8], Lefeber [11] and Mera [13].

[8] For example, Mera [15] postulates production functions with non-constant returns to scale and heterogeneous labor.

[9] Early theorizing is seen in Weber [24] and Hoover [5]. Recent developments include Vernon [23], Isard [6] and Mera [14].

However, little is known about the sources and the nature of agglomeration economies. Consequently, scholars have been debating endlessly if a particular metropolis is too large or too small.

Then, finally, the role of infrastructure in determining and influencing regional development must be mentioned. This is a particularly important subject since policy makers in a number of countries are using or have attempted to use the provision of infrastructure as a principal vehicle for spreading development to less developed regions. The close relationship observed between development (as measured by either per capita income or the rate of return to investment) and the intensity of infrastructure as found in Japan, for example, may not be a universal phenomenon.[10] Even with the Japanese case, the direction of causation is not clear. But, it is highly likely that development invites infrastructure investment and infrastructure investment invites development. Nonetheless, the analysis shows that the infrastructure has a production elasticity of about 12 percent, a not insignificant figure but a not spectacularly large figure either. This fact appears to explain mixed results of regional development policies based on the provision of infrastructure. However, more must be known about the effectiveness of infrastructure provision for inducing development. In particular, the role of physical infrastructure must be separated from that of administrative and technical infrastructure.

3. The Formulation of the Theory

The theories which we have surveyed do not give sufficient explanations to central policy questions which have been stated earlier. Each of the theories which has been surveyed gives an answer to some of the aspects of these general questions. But they do not as a whole provide a systematic answer to the questions.

As a step for building up a comprehensive theory, we postulate the following series of hypotheses:

1) the degree of urbanization within a country is determined by the degree of its economic development;

2) the spatial distribution of urban population depends upon the distribution of basic activities with the following qualifications:

    a) the basic activities can be grouped into the following three sectors, i.e. primary, secondary and tertiary, and the basic activities in one sector have a different multiplier effect from those in another sector;

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[10] Mera [16] and [17].

b) the activities in an urban center are the sum of those associated with each type of basic activity (a layer concept);

3) there are explainable relationships among the intensities of some of the three types of basic activities within each geographic subdivision of a country.

Hypothesis 2) is an elaboration of the layer concept. As far as the distribution of the service or residual sector is concerned, it is hypothesized that it is independent of those related to each type of basic activity.

When this layer concept is granted, then the relationship among different types of basic activities will be examined. This is the task described under 3).

These three hypotheses are obviously very crude in explaining the actual development of urban systems, but they are postulated as a useful theory for explaining the principal characteristics of urban growth in a country.

4. Examinations of the Theory

The layer theory presented above can be tested empirically. Each hypothesis is examined below with empirical evidence.

Hypothesis 1)

It can hardly be denied that there is a close positive relationship between the degree of urbanization and economic development. Using varying definitions used by different countries, the World Bank shows the relationship in a diagram which is shown in Figure 1. For example, the abnormally high percentage of urban population of Japan is due to the particular definition of cities used in that country. When these definitional differences are smoothed out, the fitting of the curve improves. Obviously there are some other determinants of the percentage of urban population. These may include the overall density of population, the nature of the agricultural sector, and the timing of economic development. Nonetheless, the observed relationship is unambiguous. We conclude that there is a sufficiently reliable empirical regularity in this relationship on which a theory can be built.[11]

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[11]This hypothesis is also supported by the empirical findings derived in the process of testing Hypothesis 2). In other words, in Section 4, we find manufacturing and government service activities have a greater city building impact than agricultural activities.

Hypothesis 2)

This hypothesis becomes a tautology if the basic activity is defined so as to conform to the hypothesis. To avoid the circularity, we shall adopt the definition that the basic activity is an export activity from the viewpoint of a particular community or area under investigation. This definition calls for a precise definition of a community or an area. For the purpose of our analysis, we shall use an exhaustive set of geographical subdivisions of a country such as provinces or prefectures in unitary nations, or states in federated countries, since we are concerned with the entire system of urban centers and its relationship with the rest of the country. Precise identification of the export sector requires a detailed analysis of the flows of products for each area. Short of this effort, it can be estimated by the computation of the localization coefficient for each of the activity groups.

Such precise work would be desirable for refining the theory, but at this stage of testing the general plausibility of the theory, a crude approach can be justified. Accordingly, the following activities are defined as export activities:

Primary Sector: agriculture, fishery and forestry;

Secondary Sector: manufacturing;

Tertiary Sector: services of national government.

All other activities are considered as service or residual. Of course, some of those excluded from the above list may have to be considered as export and not all of the above can be considered as export. For example, coal mining is an export activity in most of the coal producing areas. But, some other types of mining or quarrying is a service activity, as stones or gravel for construction is usually procured from the nearest available location. As for manufacturing, some types of manufacturing like baking are predominantly service activities. But, some others like steel or watch making are largely export. Within the tertiary sector, there are activities other than national government which are frequently more export-oriented than service-oriented. They include some types of banking and insurance activities, and wholesaling and professional activities. Thus, it is granted that the above specification of the export activities is crude. To remedy this problem, the concept of "net export activity" is applied to manufacturing and central government activities as explained in the following section.

The layer concept included in the hypothesis is central in this theory. This is a way of linking the agriculture-based central place theory with the manufacturing-based economic base theory. This theory merely postulates the additivity of two types of urban activities and ignores the multiplying effects of the two. If empirical tests support this hypothesis, urbanization can be taken as a sum of at least two separable factors: the service for the primary sector activities outside of cities and that for the secondary and tertiary sector basic activities within cities.

The role of the tertiary sector basic activities is considered to be quite similar to that of the secondary sector activities, i.e. they have a multiplier effect. But, in addition, they are considered to be a determinant of the location of secondary activities as described below.

Hypothesis 3)

This hypothesis contains three sub-hypotheses, one for each sector. First, the geographical distribution of agricultural activities is considered to be determined by soil fertility, accessibility and a host of other factors. As it is difficult to express geographical distribution as a function of primary variables, we shall assume it as exogenously given. This simplification would not weaken our theory as the agricultural development can rarely be used as a tool for national urbanization policies.

The geographical distribution of secondary sector activities is considered to be determined by a variety of factors including physical conditions for ease in transportation, accessibility to material sources, markets and administrative and financial services, agglomeration economies and the availability of land and water. Among them, it is postulated here that the proximity to agricultural population and central government services are important determinants. The proximity to agricultural population must have been an important determinant in early stages of industrialization and is a proxy measure for the accessibility to the market. The significance of the proximity to central government services may depend upon the degree of control exercised and services provided by the central government. This factor appears to be significant in most countries outside of large federated countries such as the USA and India.

The only basic activity within the tertiary sector, i.e. the central government services, can be spatially allocated at the will of the government. Therefore, this factor is a direct control variable in this theory. If the distribution of urban activities is significantly influenced by the distribution of central government activities, as postulated in this theory, decentralization of central government activities would be necessary if the decentralization of urban activities is an important policy objective.

5. Empirical Tests of the Theory

We shall assume that the hypothesis 1) is granted and proceed to empirical tests of hypotheses 2) and 3). Our tests are based on data on the Japanese economy around 1970. First, brief explanations on the nature of data will be given.

Geographical Subdivisions

Prefectures, which totaled forty-six in number in 1970, will be used as geographical units.[12] Most prefectures have a population of one to two million persons and an area of 4,000 to 8,000 square kilometers. Except for several prefectures near Tokyo and Osaka, all prefectures form virtually self-contained labor markets in the sense that commuting across prefectural borders is not significant.

Urban Population

There are two ways of measuring urban population according to the Japanese census. One is to measure the population residing in municipalities of at least a certain size. But, municipalities in Japan are not necessarily defined on the functional basis. For example, even large cities, on the basis of population, frequently contain large agricultural areas.

The other measurement is the population in Densely Inhabited Districts (DID).[13] The areas covered by DID's are much smaller portions of jurisdictionary delineated "cities." The DID appears to represent the physiologically-defined urban areas more accurately, but tends to miss smaller functionally-related urban centers. Consequently, the population in DID will be used as one measurement of urban population, U_1. In addition, two other measurements of urban population will be used. One is the population residing in municipalities with a population of 50,000 or more, U_2, and another is that residing in those with a population of 30,000 or more but less than 50,000, U_3.

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[12]Okinawa joined as the forty-seventh prefecture in 1972. But, for the lack of comparable data for analysis, it is excluded from analysis.

[13]DID is defined as "a group of contiguous census enumeration districts with high population density (4,000 inhabitants or more per square kilometer) delineated within the boundary of a city, town or village, constituting an agglomeration of 5,000 inhabitants or more."

Basic Employment

Agriculture, manufacturing and government activities are considered as basic activities. In addition, administrative and managerial activity, an occupational category, is also considered as a basic activity. The intensity of these activities is measured by employment. The manufacturing and government activities were measured in the gross and net terms. The gross export activity level refers to the total employment in the sector and the net export activity level refers to the total employment minus the minimum required employment in the sector for servicing its own area.[14] However, in the case of government services, the net export activities is defined as the central government's headquarter activities in Tokyo alone.

Definitions of the Variables

The following variables have been used for the empirical analysis and their values are shown in Appendix:

P - the population in thousands of persons in 1970;

E - the total employment in thousands of persons in 1971;

U_1 - the population in thousands of persons in densely inhabited districts (DID) in 1970;

U_2 - the population in thousands of persons residing in municipalities with a population of 50,000 or over in 1970;

U_3 - the population in thousands of persons residing in municipalities with a population of 30,000 or over but less than 50,000 in 1970;

Ag - the workers in thousands of persons in agriculture, forestry and fishery in 1971;

M - the workers in thousands of persons in manufacturing in 1971;

Mn - the workers in thousands of persons in "net export" manufacturing activities in 1971;

G - the workers in thousands of persons in government services in 1971;

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[14] The minimum requirement of any "export" activity for domestic services is defined by the least proportion of this sector in the total employment found within the observations multiplied by the total employment of the area. See Ullman and Dacey [22].

Gn - the workers in thousands of persons for the central government's headquarter activities in Tokyo in 1971;

Ad - the managers and officers in thousands of persons in 1971 in the "net export" basis.

Test of Hypothesis 2)

Results of regression analysis of the Japanese case show that hypothesis 2) can be empirically supported. Equations (2) through (6) in Table 1 show the relationship of urban population with basic employment in each sector. First, it should be noted from Equation (1) that the labor force participation rate is relatively constant for all parts of the country. Therefore, the figures for urban population can be interpreted as a fixed multiple of the total employment in the urban-area.

Equations (2) and (3) indicate that the variables for three types of net basic employment as identified in this analysis explains very well the population in large urban areas, i.e. DID or urban places of 50,000 or more.[15] The results of analysis imply that, regardless of which indicator of urban population for large urban areas is used, the urban population comprises three layers, each of which is associated with one of the three basic activities existing within the prefecture. More specifically, one agricultural job in the prefecture is considered to induce 0.7 to 1.1 persons of urban population (0.3 to 0.5 persons in urban employment), and one net export manufacturing job gives rise to 4.8 to 5.6 persons in urban population (2.3 to 2.7 persons in other jobs including export manufacturing itself if such manufacturing is located within a large urban area). In the case of central government employment, an identical interpretation should not be made as Gn is in fact a dummy variable for Tokyo and, therefore, its coefficient reflects all peculiarities of Tokyo which are not represented by other variables. But, if Tokyo's excess urban population is explained by the presence of the central government's headquarter activities alone, one central government job is revealed to give rise to eighty-six to 102 persons in urban population (forty-one to forty-nine persons in other jobs). The impact of basic employment on the

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[15]The sum of the net basic employments is on the average less than 20 percent of the total employment of the prefecture. Therefore, these equations are far from being mathematically determined. In addition, independent variables are not closely correlated with the exception of Mn and Gn which have the coefficient of correlation of 0.55.

Table 1.

Eq. No.	Estimated Equations	R^2
(1)	$P = \underset{(139.16)}{2.084}\ E$	.998
(2)	$U_1 = \underset{(1.41)}{0.660}\ Ag + \underset{(14.32)}{4.819}\ Mn + \underset{(6.75)}{102.08}\ Gn$	.939
(3)	$U_2 = \underset{(2.67)}{1.072}\ Ag + \underset{(19.41)}{5.578}\ Mn + \underset{(6.63)}{85.656}\ Gn$	.962
(4)	$U_3 = \underset{(13.56)}{0.955}\ Ag + \underset{(3.00)}{0.152}\ Mn - \underset{(0.45)}{1.023}\ Gn$	.883
(5)	$U_3 = \underset{(10.17)}{0.819}\ Ag + \underset{(4.32)}{1.565}\ G$	.896
(6)	$U_3 = \underset{(14.37)}{0.964}\ Ag + \underset{(3.39)}{0.138}\ Mn$	.883
(7)	$U_1 = \underset{(6.68)}{1.425}\ Ag + \underset{(47.24)}{41.550}\ Ad$	.984
(8)	$U_2 = \underset{(7.35)}{2.248}\ Ag + \underset{(34.49)}{43.529}\ Ad$	.972
(9)	$U_3 = \underset{(15.92)}{1.009}\ Ag + \underset{(3.12)}{0.817}\ Ad$	.879

Note: The figure in the parenthesis refers to the t-statistic of the estimated parameter directly above. The sign of the t-statistic is ignored.

generation of urban population is smallest with agricultural employment and largest with central government employment. Even if we assume all net export manufacturing employment is within large urban areas, the additional jobs generated by net export manufacturing is 1.3 to 1.7 for each job, and this is substantially larger than the city building impact of agricultural employment. Nonetheless, the most remarkable result of this analysis is the likelihood of an extremely large multiplier impact of the central government activities.

As to the urban population in municipalities with a population of 30,000 or more but less than 50,000, the situation is quite different (see Equations (4) through (6)). The central government employment is a poor explanatory variable and the agricultural employment is an important determining factor. The gross government and net export manufacturing activities are also important individually, but not so significant as the agricultural employment.

Another way of examining the layer theory is to employ an occupational employment category as a source of urbanization. As urban activities are organized by managers regardless of industrial classification, it is hypothesized that "administrators and officials," an occupational employment category used in the Japanese census, was used as a basis of urban population along with agricultural workers within the same prefectural boundary. This bi-layer theory has been tested with the results shown in Equations (7) through (9) in Table 1.

For large urban areas such as DID or municipalities with a population of 50,000 or more, the urban population can be very well explained by the number of agricultural jobs and the number of managers and officials. For each variable, the t-statistic is large and the multiple correlation coefficient is greater than the comparable tri-layer equation.[16] One agricultural job is considered to give rise to 1.4 to 2.2 persons of urban population (0.7 to 1.1 persons in urban employment) and one manager or official to give rise to forty-two to forty-four persons in urban population (twenty to twenty-one persons in urban employment). On the other hand, smaller urban areas are largely supported by agricultural activities.

The results of the tests of hypothesis 2), based on the data of Japan around 1970, can be summarized below. First, the layer theory well explains the population of both large and small urban centers. The central place theory and the economic base theory can be superimposed. Second, for large urban centers, the central government activity appears to have by far the largest multiplier impact among the three categories of basic employment, although the real quantitative magnitude

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[16]The coefficient of correlation between Ag and Ad is 0.24.

of the multiplier of central government employment cannot be estimated due to the peculiarity of the data.[17] Nonetheless, the enormity of the city building impact of "administration" can be readily seen in the multiplier of "administrators and officials" in the bi-layer equations. On the other hand, the city building impact of the agricultural activity is, not surprisingly, the least among the three. Third, for small urban centers, the agricultural activity within the prefecture is undoubtedly a decisive element for their existence.

Test of Hypothesis 3)

Hypothesis 3) can be tested first by examining the relationship of the geographical distribution of manufacturing employment with the geographical distribution of other activities. Equations (10) through (12) in Table 2 show the results of the analysis. These equations indicate that manufacturing employment, regardless of whether it is defined on the gross or net basis, is inversely related to the distribution of agricultural employment and is heavily associated with the distribution of government service employment. If we remove agricultural employment from consideration, one government service job is associated with six persons in net export manufacturing employment. In addition, the coefficient of correlation for these equations indicates that there is an excellent likelihood that the manufacturing employment is causally related to government employment.

The direction of causation cannot be uni-directional. It is highly likely that both are related through accessibility. In other words, a location with good accessibility becomes the center of both manufacturing and administration. However, it is also plausible that manufacturing activities gravitate toward centers of administration and the results of empirical analysis cannot reject this proposition.

6. Multiple Layers and Their Links

In the preceding sections, two variations of the layer theory of urbanization have been examined. First, the urban population in each geographical unit is considered to comprise three layers of urban population, each one being associated with one of the three sectors of basic activities. However, it has been revealed that two of the three basic activities are closely related, i.e. the distribution of manufacturing

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[17]Due to the lack of geographical distribution of the workers in the central government, only the headquarter personnel in Tokyo is taken to be Gn.

Table 2.

Eq. No.	Estimated Equations	R^2
(10)	$M = \underset{(3.01)}{-0.560}\ Ag + \underset{(12.70)}{10.661}\ G$	.884
(11)	$Mn = \underset{(3.32)}{-0.538}\ Ag + \underset{(11.09)}{8.094}\ G$	.791
(12)	$Mn = \underset{(11.29)}{6.359}\ G$	.739
(13)	$Ad = \underset{(9.55)}{0.079}\ Mn + \underset{(2.66)}{0.166}\ G + \underset{(12.80)}{3.267}\ Gn$	.965
(14)	$Ad = \underset{(9.02)}{0.069}\ M + \underset{(0.77)}{0.058}\ G + \underset{(12.47)}{3.301}\ Gn$	.963
(15)	$Ad = \underset{(19.06)}{0.074}\ M + \underset{(12.83)}{3.335}\ Gn$	.962

Note: The figure in the parenthesis refers to the t-statistic of the estimated coefficient directly above. The sign of the t-statistic is ignored.

activities is closely related to the distribution of government activities. Therefore, it should be possible to reduce the number of layers from three to two.

This was in fact done with Equations (7) through (9) by the use of "administrators and officials" as the variable representing the basis for non-agricultural activities. The results are encouraging. The bi-layer hypothesis is even better than the tri-layer hypothesis. The next question is, then, to find out determinants of "administrators and officials."

This was done in Equations (13) through (15). It has been revealed that the gross manufacturing (M) and the central government headquarter (Gn) activities are the two major determinants of the spatial distribution of "administrators and officials." Equation (15) shows that 100 manufacturing workers require or support 7.4 administrators and officials. On the other hand, one central government headquarters job attracts roughly three administrators and officials,[18] although literal interpretation of the derived coefficient is dangerous due to the nature of the data on Gn.

7. Conclusions and Implications

The examination of data on the Japanese economy around 1970 has revealed that the urban population in a geographical subdivision of the country can be well explained by a layer concept in which the central place theory and the economic base theory are subsumed. It has been found that large cities have two distinct layers: one for servicing agricultural population around them and the other clustered around administrative personnel for secondary and tertiary activities. The distribution of the administrative personnel is, then, determined by the distribution of manufacturing activities and the location of the central government. Of the two, the central government employment has a significant chain of multipliers: central government headquarter activities attract administrators and those administrators attract additional urban employment and population.

This paper examined the layer theory with a very limited case. Therefore, the general validity of the theory cannot be ascertained. In order to further develop and refine the theory, time-series analysis and international comparisons should be made. For example, the central government activity would have a much less determining impact of other urban activities in federated countries such as the US, Federal Republic of Germany and India, whereas in unitary nations such as France and Thailand, many similar results to this case might be obtained.

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[18] Including himself if he is an administrator or official.

Although the direction of causation between the location decision of administrative activity and that of manufacturing activity cannot be ascertained at this stage, a significant policy implication can be derived from the analysis: if the government aims at decentralization of urban population away from primate cities, it should also decentralize the distribution of administrative activities in which central government activities are an important element. Past decentralization efforts are considered to have relied too much upon the decentralization of manufacturing activities alone.

Appendix

Japanese Regional Data Used for Analysis

Prefecture	P	E	U_1	U_2	U_3	Ag	M	Mn	G	Gn	Ad
1. Hokkaido	5,184	2,358	2,969	2,766	590	461	281	86	112	-	47
2. Aomori	1,428	676	503	657	162	261	56	0	27	-	1
3. Iwate	1,371	695	328	448	271	285	77	19	21	-	0
4. Miyagi	1,819	859	749	826	183	232	125	54	34	-	12
5. Akita	1,241	607	305	369	202	225	67	17	23	-	2
6. Yamagata	1,226	625	394	488	308	223	108	56	19	-	2
7. Fukushima	1,946	955	514	954	190	326	196	117	28	-	4
8. Ibaragi	2,144	1,103	469	632	440	387	249	158	36	-	2
9. Tochigi	1,580	820	444	790	192	214	231	163	23	-	6
10. Gumma	1,659	881	512	811	218	219	268	195	23	-	8
11. Saitama	3,866	1,878	2,126	2,708	464	222	665	510	63	-	41
12. Chiba	3,367	1,647	1,706	2,270	323	333	421	285	54	-	36
13. Tokyo	11,408	5,338	10,876	11,077	187	47	1,697	1,255	175	47	282
14. Kanagawa	5,472	2,654	4,290	4,973	212	84	1,003	783	79	-	92
15. Niigata	2,361	1,233	865	904	470	333	270	168	34	-	10
16. Toyama	1,030	552	352	490	226	108	161	115	17	-	5
17. Ishikawa	1,002	522	350	514	113	96	150	107	20	-	7
18. Fukui	744	408	269	372	109	82	128	94	12	-	4
19. Yamanashi	762	380	220	233	68	103	93	62	15	-	2
20. Nagano	1,957	1,078	563	786	342	304	286	197	33	-	13
21. Gifu	1,759	928	595	780	251	142	337	260	27	-	9
22. Shizuoka	3,090	1,594	1,418	2,200	132	254	506	374	35	-	21
23. Aichi	5,386	2,797	3,074	4,270	262	245	1,123	891	59	-	59
24. Mie	1,543	775	476	820	127	175	226	162	22	-	5
25. Shiga	890	472	192	302	155	106	147	108	15	-	4
26. Kyoto	2,250	1,067	1,635	1,727	196	92	349	261	39	-	31
27. Osaka	7,620	3,527	6,863	7,330	110	60	1,397	1,105	89	-	133
28. Hyogo	4,668	2,199	3,141	3,470	410	177	775	593	71	-	64
29. Nara	930	422	343	504	105	67	120	85	18	-	11
30. Wakayama	1,043	494	421	482	137	101	125	84	16	-	4
31. Tottori	569	306	135	222	84	89	56	31	12	-	3
32. Shimane	774	407	165	237	150	139	66	32	16	-	1
33. Okayama	1,707	902	496	922	106	213	253	178	25	-	11
34. Hiroshima	2,436	1,237	1,265	1,216	324	182	377	275	43	-	24
35. Yamaguchi	1,511	741	609	867	208	146	165	104	26	-	8
36. Tokushima	791	388	187	343	41	118	77	45	15	-	2
37. Kagawa	908	483	288	398	78	110	112	72	19	-	6
38. Ehime	1,418	692	499	675	157	199	149	92	18	-	5
39. Kochi	787	404	255	240	106	127	52	19	17	-	3
40. Fukuoka	4,027	1,794	2,273	2,512	456	218	362	213	77	-	32
41. Saga	838	399	196	279	118	125	65	32	17	-	1
42. Nagasaki	1,570	663	581	791	111	174	96	41	32	-	6
43. Kumamoto	1,700	802	516	597	225	305	94	28	34	-	2
44. Oita	1,156	549	353	609	74	169	66	21	26	-	5
45. Miyazaki	1,051	503	278	499	156	179	63	21	26	-	1
46. Kagoshima	1,729	813	478	533	238	331	102	35	36	-	2
Total	103,720	50,625	55,535	65,891	9,785	8,789	13,794	9,603	1,677	47	1,029

Source: Bureau of Statistics, Office of the Prime Minister of Japan, Japan Statistical Yearbook 1973/74, 1974.

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New Towns and Growth Centres in National Urban Systems--Some Theoretical Spatial-Economic Consideration

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National urban systems and the spatial structure of a national settlement system can be considered to reflect the spatial pattern in which external effects in a broader sense are distributed over a national territory. These external effects may manifest themselves in economic terms (external economies or diseconomies), in social terms (communications or information fields) or in political terms (authority-dependency relations). In this paper I shall be mainly concerned with the external economic effects entailed in national urban systems.

I. Economic Factors Determining National Urban Systems

Let us assume a national urban system determined by the following groups of factors:

1) A set of activities with different interaction radii (supply and market hinterlands, areas of social interaction, areas of political contol, etc.) from the national to the local scale, each trying to maximize its market access. Differences in factor costs are assumed to be of little relevance. The result is a hierarchy of activities from national to local [30], each at the gravitation centre of its respective market area, which is limited towards the outside by the maximum accepted range of interaction (itself a function of activity-specific transfer costs and of demand elasticity over space) and towards the inside by the minimum production or interaction threshold size (a function of activity-specific scale economies). Unless these activities can supply the entire national market they will try to maximize distance between each other (repulsive forces) in order to benefit as much as possible from "hinterland effects" [8]. While national activities will tend to locate close to the gravitational centre of national demand (factors 2) and 3) below are excluded for the moment), other activities with smaller interaction radii will be spaced out at an increasing number of locations at successively smaller distances from each other the lower the scale of their market radius. On the whole these factors will represent a gravity-centre oriented, Christaller-type spatial pattern.

2) A set of irregularly distributed natural resources or what Richardson [27] calls natural "locational constants" (mineral or agricultural resources, special climatic conditions, natural transshipment points, special relief conditions, etc.). These resources represent input factors, are usually available in certain areas only, and may therefore facilitate the emergence of export base activities. These activities are predominantly input-oriented, as against the predominant market orientation of activities under 1) owing to their often world-wide market areas, competition in space will normally be of minor importance compared to differences in production costs and in quality of resources. In view of the fact that many resource conditions tend to be regionally defined, similar activities will tend to agglomerate.

3) A set of historically evolved determinants or "societal locational constants" such as previously established infrastructure, fixed industrial investment, specialized skills, existing urban sites, historically evolved centres of power, etc. Some of them may facilitate export base activities by providing urbanization and agglomeration economies.

II. Structural Characteristics of National Urban Systems

Different combinations of these three groups of factors will produce differently shaped urban systems with regard to the spatial distribution of cities, their size distribution, their economic structure, the growth performance of urban centres, and the interurban transport network.

2.1 A national system relying heavily on factor 1) will tend to have a hierarchical urban structure, both in its spatial as well as in the size distribution of cities. The spatial distribution will approach a Christaller type central place hierarchy, while the size distribution will approach the rank-size rule and can be represented by a lognormal distribution such as curve 1 in Figure 1 (cf. [5,3,30,26]). The economic structure of cities will be such that the largest and most centrally located city will contain all activities from the national down to the local market range, while smaller cities will have all activities from their respective level of market range downward.[1] As a rule export base goods and services will only move up or down the urban hierarchy, not across it, in accord

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[1]In some cases, these national functions may also be shared by several large cities so that the size distribution approaches curve 1a in Figure 1 (case of the FRG, cf. von Böventer [7]). Such a division of functions is usually due to drastic changes in the delimitation of national territories in the past (see also 2.3 below).

with our assumption that no major "locational constants" of a very uneven spatial distribution exist. The transport network will equally be centre-oriented and follow the hierarchical urban system branching out from the central, highest-level city to the next lower centres and so forth. Cross links will be rare.

Regarding urban growth performance: as long as returns to scale increase, marginal transfer costs remain a decreasing function of distance, and as long as no agglomeration diseconomies emerge, growth in per capita product will be positively related to levels in the urban hierarchy.

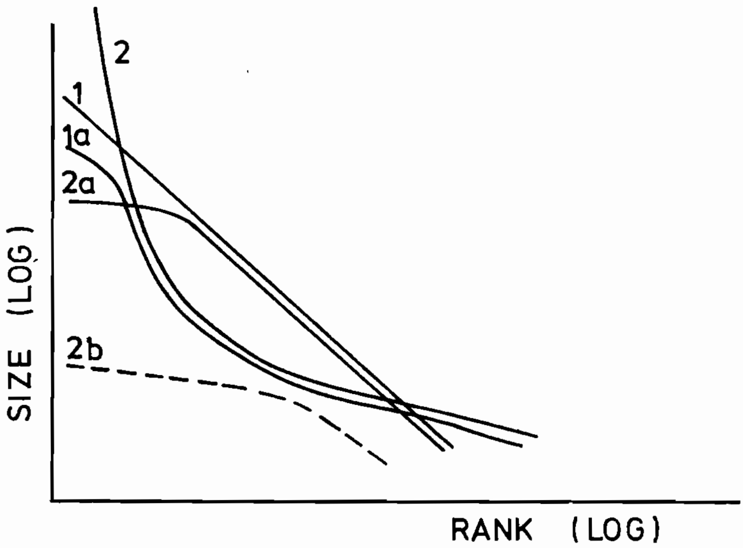

Figure 1.

2.2 Urban systems in economies which rely heavily upon the exploitation of natural resources (factor 2)) will tend to have a distribution of cities biased towards the locations of these relatively immobile resources (e.g. mining or agricultural marketing towns) and towards other "locational constants" [26] such as natural transshipment points. This is typical for many countries presently in their early stages of development. If these resources are little diversified and unevenly distributed, as they normally are, or only partly used, the urban system will diverge from a Christaller-type hierarchical spatial structure. If these resources constitute major national export products the spatial pattern of cities is almost invariably non-centric--the largest city will often be on the fringe of the national territory--and the size distribution usually tends towards primacy (curve 2 in Figure 1), typical for an economy based only on a few development factors [5].

The transport network will likewise be outward-orientated and approach a tree-type structure connecting the peripheral port city with major natural resource areas. If these resources are exploited under no strong national political authority (e.g. foreign-owned mining or plantation enclaves) they might produce a series of regional and urban systems hardly integrated amongst each other, or even spatially separated systems. In sum their cities might at best represent a truncated primate city structure (curve 2a in Figure 1) or simply a series of cities of similar size (curve 2b in Figure 1). The growth performance of cities will depend on the magnitude of resources exploited in their hinterland or handled by them for transshipment. Once a greater number and variety of resources are mobilized for national economic development, more areas will acquire an economic base and interregional disparities will tend to decrease. As national economic integration proceeds, the city system may tend towards lognormality. Berry and Horton [5] have found that the number and diversity of forces affecting the development of a spatially integrated national economy is one of the major factors associated with lognormal city size distributions.

2.3 A national urban system can also deviate from a centre-oriented hierarchical pattern due to a strong predominance of historically evolved societal "locational constants" stemming from previous spatial patterns of activities, of interaction, or of dominance. This applies to countries which are, or until recently have been, only partially settled [26, p.168], such as Brazil, to countries which are heavily export-oriented on a staple product basis [17], to countries which are dominated by a highly centralized decision-making system, or which depend considerably on external decisions. A similar deviaition from a centre-orientated spatial pattern is often also found in countries which have undergone drastic territorial changes either by spatial extension (e.g., multinational integration) or by curtailment (e.g., Austria after World War I, or Germany after World War II). Special cases in point are the former colonial empires which became segregated. Spatial remnants of such historical conditions may remain as relics in the motherland (e.g. London in Great Britain) or in the formerly dependent colonies: the urban systems of many Third World countries. In all such cases the urban system established in an earlier period will act as a set of locational constants which by way of "cumulative causation" [25] will heavily influence the spatial distribution of further urban and regional development. Equally influenced by this deviation from a hierarchical urban system will be the spatial pattern of transport infrastructure which will frequently be orientated in a non-centric form towards the major fringe centres or towards the exterior. The persistence of such a bias in the urban system may be particularly strong if, on the basis of these locational constants, export base activities have evolved which have stimulated strong central place functions. Along with this persistence in the urban system, such hinterland effects will provide local and regional communities with considerable stability against the hazards which changes in national or international demand and supply variables might bring through sometimes sweeping spatial shifts in the utilization of specific locational constants. Such locational constants may also cause substantial interregional disparities of income and a primate city size distribution: compare the findings of Linsky [17] and Berry-Horton [5] that a colonial past was often associated with primate city size distribution.

The location of important national functions on a country's fringe as a remnant of former spatial interaction or dominance patterns may, however, reduce the efficientcy of the entire national economic system. This is particularly true if these activities would potentially be market-orientated, like government and other high-level services, but for historical reasons are tied to a fringe location with relatively poor market access. Furthermore, such activities may, through agglomeration economies, act as a magnet for retaining or attracting other national activities for which, from the point of view of market access, these locations may be equally inefficient. For such a system to subsist economically, savings from external economies in these fringe locations will have to be greater than the additional transport costs these locations cause. Shifts in such societal locational constants from fringe areas to more central locations have been induced by explicit policies only in a few countries, however. Cases in point are Great Britain (policies to induce a shift away from London) and Brazil (induced shift away from Rio de Janeiro to Brasilia). In most of these cases substantial external diseconomies in the major fringe cities, the objective of developing the country's interior, or political motives like the better control of remote areas or the restructuring of decision-making powers were crucial in bringing about such an induced shift in the national urban system. These spatial changes in the urban system are usually accompanied, and sometimes even preceded, by changes in the transport system from a fringe- or externally-oriented structure to a centre-orientated one.

In practice, these structural characteristics of national urban systems are mixed to a varying degree. We shall later on in a policy context distinguish between two prototypes, namely a) a centre-orientated system in which either market orientation of activities prevails or in which natural and societal locational constants are distributed in such a way that individual deviating influences balance out mutually, and b) a fringe-orientated urban system with the largest city at the geographic margin of the national market due to important non-centric locational constants of a natural or a societal kind. Intermediate patterns or variations of these prototypes, such as urban systems with several cities of similar size sharing the role of the major metropolis in either pattern a) or b), will not be followed up further here.

III. The Role of New Town and Growth Centre Policies

Policies to change these spatial patterns of development have been undertaken by many countries, particularly with the objective of reducing the problems of high concentration in major metropolitan areas (congestion, environmental pollution, social disintegration, political unrest) and/or to promote the development of under- or undeveloped parts of national territories. The structure of the urban system has great influence on the spatial pattern of welfare and of economic growth throughout a country. Berry [4], for example, has found that welfare and income levels fall consistently with increasing distance from cities. Another empirical study [10] has shown that relative employment growth is largest in major metropolitan centres and that smaller urban centres grow in inverse relation to their distance from the major metropolitan centre.

Different urban patterns are therefore often related to specific national conditions of spatial development. Fringe-oriented urban systems will often be accompanied by large-scale underdeveloped areas in the interior or on opposite fringes of the country. If these areas have high natural resource potential or are significantly populated, spatial development policies can be a tool for modernization. Centre-orientated urban systems may provide a more satisfactory pattern of interregional living levels particularly if the system approaches a hierarchical structure close to log-normal form (Figure 1, curve 1)--but it may also be accompanied by low welfare levels in fringe areas, particularly if the rank size distribution approaches a primate city structure; this fact may also prompt regional development action. If such policies are undertaken, the relative distance over which development impulses need to be transmitted evidently differs between these two types of urban patterns independently of size of country. The first needs to operate from a gravitational centre to the less-developed periphery, the second, all the way from one periphery to the other, which is often on the opposite side.

The support which existing urban structures can give to such policies will vary. In centre-oriented spatial systems the entire country will usually be integrated by an urban system which can be instrumental in transmitting development impulses (flows of migration, capital, innovation, control, etc.) throughout the national territory. In fringe-oriented spatial systems different peripheral areas often vary greatly in the degree to which their urban system has become articulated. This is particularly true of many less developed countries where development programs for interior or peripheral areas often have to be undertaken with hardly any support from existing urban systems. Growth centre policies in new resource frontiers of developing countries, and to a lesser degree also in fringe areas of developed countries are cases in point.

Spatial development policy may therefore emphasize the promotion of a) growth centres or new towns at large distance from existing major metropolitan areas, b) the promotion of existing towns at intermediate distances from the major metropolitan centres as new growth centres, or c) the establishment of new towns in the vicinity of the major metropolitan centres.

Policies to change the spatial pattern of national development are in part geared towards influencing factor and commodity flows in the direction of an equilibrium state and towards convergence of per capita income along the lines of neoclassical economic theory. Related measures are oriented towards increasing the mobility of factors and commodities and/or towards reducing factor prices for areas in which development is to be promoted (spatially differentiated capital incentives, wage or migration subsidies, subsidies on the price of land, etc.) or towards regional transfers of demand (welfare payments, tax transfers, etc.). These policies are also geared, explicitly or implicityly towards influencing disequilibrating factors via changes in the distribution of external economies, including infrastructure investment; in the distribution of flows of information and innovation; and in the redistribution of decision-making powers. Growth centre policies are essentially of this latter type.

No commonly accepted definition of growth centres exists (Parr [21]). I shall here define them as clusters of interrelated activities with high innovative capacity (Friedmann [11]). From an economic point of view growth poles comprise the following elements [16,13,27]:

1) a highly innovative "leading" sector usually, though not necessarily, of the export-base type,[2]

2) a series of local or regional sectors linked to it via input-output relations through which the impulses

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[2] A "leading" sector, comparable to Perroux's "industrie *môtrice*" is an activity which is relatively new and advanced technologically, faces rapidly increasing demand and is able to create and transmit innovations to other sectors (Richarson [27]).

"leading" sector are transmitted to--and retained within--the rest of the respective urban or regional subsystem; and

3) a spatial clustering to provide urbanization and agglomeration economies.

The term "new town" is often used almost synonymously with that of "growth centre." Both are used loosely in practice and their distinction is fuzzy. However, the term "new town" is usually applied to recent concentrations of population, related service activities and often, though not always, employment opportunities. The concept operates predominantly in physical space and emphasizes the provision of urbanization economies, the last-mentioned element of growth centres, whereas interactivity linkages, "leading" sectors and innovative capacity are usually not explicitly taken into account. "Growth centres" add elements of spatial development theory, particularly export base and central place theories, with special emphasis on the interrelations between the two, and the theory of innovation diffusion.

Growth poles, due to their characteristic innovative capacity and interactivity linkages, will generally be able to create self-sustained development, whereas "new towns" as defined above usually act as urban satellites, lacking internal growth dynamics.

New towns and growth centres are of interest as potential agents for changing the existing spatial pattern of development via changes in the national urban system. This can take place either by stimulating the emergence of completely new towns in formerly non-urban areas ([12], p. VIII), or by changing the growth rate and/or function of certain cities in an existing national urban system.

Problems of spatial development arise in general:

a) if most or all of the growth centre determinants mentioned above occur in one or in a very few locations, attracting to them such a proportion of economic activities and population that problems of overconcentration emerge, while in other areas density becomes so low that minimum standards of economic and social performance are not maintainable; and/or

b) if a change in the spatial incidence of these determinants takes place which is not followed by a similar redistribution of population so that strong spatial disparities in living levels become aggravated.

In both cases a spatial redistribution of growth determinants is usually necessary to redress the situation.

IV. A Spatial Typology of Growth Centres and New Towns

Growth centres or new towns can basically be implanted at any point of the multidimensional urban system with regard to the system's spatial distribution, its size distribution, and its structural characteristics, as stated at the beginning of Section II. In the following I shall deal particularly with three urban dimensions, namely the spatial distribution, the size distribution and the structural characteristics of growth centres or new towns to be inserted into an existing urban system.

I assume a spatial system in which one urban centre exceeds all the others in size and rank, according to the market range of its activities, its interaction potential, and authority-dependency relations, and therefore dominates the system. The spatial and size distribution of all other centres is variable, depending on the relative weight of the factors discussed in Section I. With regard to the spatial distribution they may therefore be gravity-centre or fringe-centre oriented, and with regard to size distribution they may be of a lognormal, a primate city structure, or a truncated version of either of the two (Figure 1). With regard to structural characteristics they may be oriented predominantly towards central-place activities or towards extraregional "export-base" activities. In reality there will exist different combinations of these spatial, size or structural prototypes.

For such a largest-city focussed urban system I shall discuss the implantation of a new town or growth centre at three alternative locations in relation to the Major Metropolitan Centre (MMC). These three alternatives are:

A) a location on the fringe of the existing MMC, i.e., outside of the most densely used area but still within a radius where the urbanization and agglomeration economies of the MMC can be used;

B) a location at an existing town or city which lies outside the commuting area of the MMC and has a central place hinterland of its own (usually an intermediate-size city); and

C) a location in a rural or non-developed area outside the commuting radius of the MMC and with no central place hinterland of its own (often a peripheral natural resource location).

The three alternative locations are thus distinguished by the fact that location A) benefits mainly from urbanization economies and common agglomeration economies with international and national activities and societal locational constants, but has to compete with them for inputs including land and labour (Böventer [8]), while B) benefits mainly from hinterland effects of spatially protected markets and inputs, whereas C) has none of these advantages but may possess specific natural resources as a potential economic base in terms of locational constants.

V. The Spatial Incidence of Growth Centre Elements and their Openness to Policy Intervention

These aspects of growth centres are to varying degrees defined in spatial terms: leading sectors as well as input-output linkages between leading and regional/local sectors are determined primarily in economic space (which may be reflected in geographic space) while other elements such as natural and societal locational constants, hinterland effects of local/regional sectors, urbanization and agglomeration economies and patterns of innovation diffusion are explicitly determined in geographic space. Some of these elements furthermore are open to policy intervention, such as urban investment, innovation diffusion or the indentification of leading sectors. Others are barely or not at all open to policy intervention, e.g., the exogenously determined locations of natural resources as a possible basis for leading sectors, or the functional (input-output) relations between sectors in economic space.

We shall now analyse the growth centre elements enumerated in Section III from these two points of view to see the extent to which they are available for growth centre or new towns policies at different locations:

5.1 Availability of a *highly innovative leading sector:* Two sub-elements are relevant here, a) innovative capacity, and b) economic characteristics of a leading sector. We shall deal with them separately.

5.1.a *Innovative Capacity* is a function of the process of generation and diffusion of innovations. From the vast literature on this topic I shall select only a few aspects. A major feature which distinguishes innovation from other production factors is that its transfer is not directly competitive, i.e. its transfer in space can increase production possibilities at the point of destination without reducing production capacity at the place of origin even if all other factors are fully employed[3] (Siebert [28, p. 76]). This means

[3] A competitive effect may only arise indirectly via changes in commodity flows.

that flows of innovation, unlike other production factors, are not regulated by supply and demand and therefore do not innately tend towards equilibrium. Instead, determinants such as distance from the place of origin or first adoption of the innovation (distance decay being a function of the efficiency and the structure of the communicaiton network) and the adoption capacity of potential receivers (often a function of city size) have been found to be relevant. Richardson [27] has formulated innovation diffusion by combining a gravity model with an urban rank-size function:

$$I_{ij} = KP_1 \underbrace{N_i^{-r} \; N_j^{-r}}_{\substack{\text{hierarchical} \\ \text{distance}}} \; \underbrace{d_{ij}^{-b}}_{\substack{\text{physical} \\ \text{distance}}}$$

where I_{ij} is magnitude of diffusion between ij, P_1 the population of the largest city, N the rank of the respective cities i and j, d_{ij} the distance between i and j, and K a constant. As $b \to \infty$ physical distance becomes more important, while as $b \to 0$ hierarchical distances become relatively more significant. Empirical research has in fact shown that in early phases of economic development when formal communications systems are still poorly established (large b), innovation diffuses primarily as a function of distance (Pedersen [22]) while in later stages of economic development (when b becomes smaller) diffusion takes place primarily as a function of city size (Berry [6]). If this model generally holds true it would imply that locations on the fringe of MMC's have the greatest innovation advantage. In early stages of development this advantage prevails over that of any other location outside the MMC. In later stages of national development, second, third or fourth ranking cities at some distance from the MMC tend to get a comparatively good innovation potential. The model also indicates that for more remote parts of a country the existence of a city ranking relatively high in the national urban hierarchy is an important aid for its innovation potential. For new towns or growth centres in remote resource locations, this is an important handicap which usually can only be overcome by the establishment of autonomous communication channels (e.g. on the intra-organizational basis of a multi-plant company), for which highly profitable resource deposits are usually required. Even for innovations entering a spatial system not through the largest but through a small city via the above mentioned intra-organizational mechanism, the MMC would tend to be an early adopter because of its high contact probability with a great number of other places (Pred [24, p.36]). This is based on Pred's assumption that information and innovation flows closely follow the pattern of goods and service transactions. Relative city size influences the probability of interaction frequency, as formulated in the gravity model, and gives bigger cities advantages in innovation and adoption against smaller ones [24, p. 52].

5.1.b The second sub-element contains the economic characteristics of a *leading sector*. Leading sectors were defined above as relatively new industries (in the widest sense), working at an advanced technological level, facing rapidly increasing demand and able to generate, adopt and transmit innovations throughout their sphere of influence. The first two and the last of these criteria relate to innovative capacity, which has just been dealt with. The criterion of rapidly increasing demand relates to products or activities with high demand elasticity combined, if possible, with low supply elasticity. Effective demand in absolute terms will furthermore be relevant and will be the greater the higher demand density per unit of area (for products with high transfer costs) or the greater the market area (for products of low transfer costs).

All this indicates that locations with the greatest chance to develop leading sectors are those with the best innovation access, locations with high demand density such as major cities, locations with good access to national and international markets (MMC or transshipment points), and locations of natural resources with a rapid increase in world demand but limited supply elasticity (e.g., many non-renewable resources). In terms of the growth centre types mentioned above this means that the best chances to develop leading sectors exist at locations like 5.1.a), whereas peripheral locations either have to dispose of a valuable natural resource (or other locational constant) or must have a high rank in the urban hierarchy giving them a relatively large market potential.

5.2 The second element of growth centres is the existence of *local or regional sectors linked to the leading one* via input-output relations. This element again contains two sub-elements, namely a) the existence of local or regional sectors, and b) the linkages between the latter and the leading sectors (which themselves might be local or regional ones, so that in fact interactivity linkages of the leading sectors within the region are the essential criteria).

5.2.a The growth of *regional and local activities* can be expected to be a function of the rank of a city in the urban hierarchy and its hinterland effect [8]. Empirical results have also shown that trade area population or income, the city's rank in the urban hierarchy, and the distance to the closest larger city explain about 70 percent of employment change in regional industries [20]. Ambivalent in this context is only distance to the closest larger city, where one would from a theoretical point of view expect regional industries to grow faster the greater the distances from the next larger (or competing) city [8], while empirical evidence [20] seems to indicate an inverse relation, namely that regional industries grow faster the smaller the distance to the next larger urban centre. There is no clearcut explanation for this ambivalence, although one might reason that aggregate growth performance of regional industries includes both a regional growth component induced by final demand (income multiplier) and another one induced by leading national industries (input-output multiplier). While the first would be positively related to distance from the next larger city (the *larger* the distance from competing centres the greater the growth potential), the latter might well be negatively related (the *smaller* the distance from functionally related activities the greater the growth potential). It follows that policies to promote the development of regional and local sectors (apart from the export base multiplier, which is not dealt with at the moment) can aim at increasing population in the target city via employment or residence incentives, by increasing the city's rank in the urban hierarchy by locating or concentrating public services there, and finally by manipulating distance friction to the next larger city.[4]

5.2.b *Interactivity linkages within the city or region* are primarily a problem in economic space [23]. Policy guidance from a spatial point of view is possible, however, by orienting infrastructure investment and promotional activities particularly to sectors which find favourable input conditions in the region and at the same time have substantial local or regional input-output relations [15,19].

5.3 *Urbanization economies* are very clearly defined in space as far as past investment and existing stock is concerned. Their distribution can be expected to be similar to that of city sizes whereby differences between marginal and average urbanization economies may cause deviations of the relative attractiveness of individual cities from the existing spatial distribution of urbanization economies [7]. From an overall efficiency point of view, it would seem desirable to concentrate urban investment in locations where marginal urbanization economies are greater than average. If we assume an S-shaped curve relating urbanization economies and city size, this would mean that intermediate-size cities offer the greatest effect for a given investment. Future shifts in the spatial

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[4]The ambivalence of the latter has been shown in theoretical terms clearest by Hoover [14] and empirically by Pedersen [22].

distribution of urbanization economies are open to policy intervention through public investment, however, and have therefore generally been the hard core of all new town policies. They may have local income effects and/or local capacity effects: increasing the efficiency or production capacity of local activities for local/regional or extra-regional demand.

To sum up, one can say that growth centre elements are partly vested in purely economic space, such as input-output relations between economic sectors. These are essentially "givens" which can be utilized for growth centre policies but can hardly be influenced. Other elements, however, are determined substantially in geographic space and therefore constitue the levers for spatial development policy (Table 1 below).

Table 1.

Growth Centre Elements	determined primarily in	
	geographic space	economic space
1. Innovative "leading" sector		
a) innovative capacity	x	(x)
b) "leading" sector		x
2. Local and regional sectors linked with "leading" sector		
a) existence of local/ regional activities	x	
b) links between "leading" and local/regional sectors		x
3. Spatial clustering (urbanization and agglomeration economies)		
a) stock of urban investment	x (fixed)	
b) marginal increase in urban investment	x	

The growth centre elements discussed above have a varying probability of being found in different geographical locations. For those determined substantially in geographic space, the probability of their incidence in the three types of potential growth centre locations are summarized in Table 2. Urban investment is determined in space essentially as a policy variable. In relation to the two forementioned growth centre elements it may increase the probability of innovation adoption by increasing the rank of a secondary city (and thereby reducing its hierarchical distance to the largest city, $N_i^{-r} - N_j^{-r}$). This will be particularly effective for potential growth centres at greater physical distance from the MMC, i.e. for those of type B or C. With regard to the development of local and regional sectors, urban investment may--through capacity effects--improve the capability of specific locations to satisfy potential local or regional demand and/or--through income effects--to increase demand for products of local and regional sectors. These local income and/or capacity effects are likely to be stronger the higher demand density in areas at distance from existing major centres, i.e., in type B growth centes.

VI. Implications for New Town and Growth Centre Policies

We shall now examine the three hypothetical new towns or growth centre locations (outlined in Section IV) in the context of the above mentioned theoretical points. For each of these locations I shall discuss the preconditions which, on the basis of theory, one would expect to find there for the establishment of a new town or a growth centre (expected dynamics based on market forces), the additional conditions or actions which urban development policy would have to provide if their establishment were a policy objective, and finally some national criteria which might serve to evaluate the feasibility and consequences of new towns or growth centres at each of these locations in the context of a national policy of urban and regional development.

6.a Location on the Fringe of An Existing MMC

An above-average growth rate of the MMC's due to the high proportion of international and national activities, the high representation of innovative industries in early and therefore dynamic phases of their life cycle and the

Table 2.

Growth Centre Elements determined in geographic space	Probability of their incidence in locations of		
	type A (at short distance from MMC)	type B (in existing towns outside commuting radius of MMC)	type C (little developed locations at large distance from MMC)
Innovation diffusion	high probability in any case	probability the greater the closer B to the MMC (the smaller d), the more integrated the national **spatial** system (the smaller b) and the larger the existing nucleus of B (the smaller its hierarchical distance to the largest town: $N_i^{-r} - N_j^{-r}$)	low probability in all cases unless intra-organizational communication channels can be established (usually only on account of peripheral locational constants, e.g. high value natural resources)
Development of local and regional sectors	low probability because of small distance from competing MMC or other existing centres (except if the MMC is physically and economically growing so fast on the basis of export base activities that new potential hinterlands form on the perimeter of the MMC--or if the local/regional sectors cater directly to the latter)	high probability--the higher the greater existing hinterland effects and the greater the distance from competing urban centres	low probability because of low demand density in sparsely populated or underdeveloped areas

high degree of interactivity linkages facilitated through the great mix of industries [5] raises the demand for metropolitan resources and production factors and pushes their cost curves up and outward from the centre, particularly for factors with limited supply elasticity such as land and labour. Activities which find it difficult to substitute for these factors will be priced out of the centre. They will theoretically move to that distance where they can minimize the cost of scarce urban resources while retaining access to the external economies offered by the metropolitan centre, particularly access to its labour pool and its urbanization and agglomeration economies. The radius to which this will take place is a function of the rate of increase in demand for metropolitan resources, of the rate of transport and communicaitons improvement towards the finge areas (positively related) and of zoning restrictions on the fringe (negatively related).

Since the basic dynamics for this process are provided by the market mechanism, planning of new centres or new towns in such metropolitan fringe areas will have to provide primarily for the compatibility of adjoining land uses, for sub-metropolitan scale and agglomeration economies and for access to major national and regional activities which constitute the economic base of the metropolis. Other objectives may be to create wherever possible sub-metropolitan hinterland effects (apart from that of the MMC), to retain access to the metropolitan labour pool while enhancing freedom of choice of employment opportunities, and to remain within the radius of direct information and innovation access of the metropolitan centre. Such a policy will create essentially what we have defined above as new towns rather than new growth centres. Instead they will share in the growth centre characteristics of the existing MMC. Typical examples of such a policy are the new towns planned on the fringe of the Paris conurbation in accordance with the master plan for the Paris region drawn up in 1965 (Merlin [18], Stöhr [29]).

In a national context major emphasis on new towns on the fringe of MMC's would seem justified in the following cases:

1) if the country is too small to accommodate a growth centre at close to "optimum distance" (Böventer [8]) from the MMC to provide sufficient hinterland effects. This means that due to a country's reduced size a new centre can only be viable if it partakes in the common urbanization and agglomeration economies of the MMC as well as in its hinterland effects;

2) if the country lacks intermediate size cities as potential growth centres and if their establishment would withdraw scarce resources from other important national objectives;[5]

3) if no major potential resources or markets not yet integrated in the national economy exists in peripheral areas, the marginal benefits of which would be greater than the marginal cost of new towns or growth centres plus related infrastructure required to incorporate them into the national economy. These again are variables very difficult to qualify conclusively;

4) if disparities between peripheral areas and the MMC in levels of social development and political participation are not so great that other national objectives such as political stability or national unity might be endangered;

5) if for the above reasons the MMC is considered the optimal location for major development but negative external effects within MMC are so great as to make it advisable to develop new centres at its fringe.

Major requirements for the national transport network will be, on the one hand, efficient links between the MMC and the new towns on its fringe, and on the other, in a radial fashion from them to peripheral resource areas or to the exterior.

If these conditions do not apply then the remaining types of growth centres gain particular importance:

6.b <u>Growth Centres in Existing Towns at Intermediate Distance from the MMC</u>

These locations are characterized by the fact that they are outside the area in which relatively immobile

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[5]Alonso [1] has maintained this holds for many Latin American countries, Artle [2] even for a comparatively rich developing country such as Venezuela with regard to its growth centre Ciudad Guayana. As the quantification of alternative external economies plus the respective innovation effects are very difficult to operationalize (Boyce-Boisier [9]) such statements will necessarily contain a certain amount of arbitrariness.

external economies of the MMC can be utilized, and by a sufficient distance from MMC that activities of a local and regional scale, including central services, can develop a hinterland effect of their own. This distance would approximate what Böventer [8] has called "optimum distance." The existence of potential hinterland effects will be a major criterion for the selection of a growth centre in this type of location, possibly accompanied by a base of "locational constants." In practice the search for growth centres at such locations is often reduced to the search for a "minimum size" city for a new growth centre. City size should not be the major criterion, however, but rather the total supply and demand potential of the respective city plus its hinterland as the basis for its regional activities. Supply characteristics of the city and its hinterland will also be an important criterion in the search for leading sectors which could be promoted in order to bring about the growth centre characteristics required. The search for such leading sectors will in fact be the major task in preparing a growth centre strategy for peripheral areas. In this respect, the distance of the proposed growth centre from the MMC is of relevance: the farther a growth centre is from Böventer's point of "optimum distance" from the MMC, the more impulses from leading sectors, often on an export basis, it will require.[6] Although a certain amount of both leading sector and hinterland effects are necessary to sustain a growth centre, this minimum being defined by scale economies and regional interaction intensity of the specific sector, they are within these limits mutually substitutable depending on distance from the optimal location.

From a national point of view growth centres in B-type locations will be of particular importance:

a) in a fringe-oriented national urban pattern (Section II), if a type B location has a better access to the entire national territory (or to the foreseeable distribution of national demand) than the MMC or type A locations. This is frequently the case if the location of the MMC was historically determined by now outdated locational constants;

b) in any spatial pattern of the urban system, if not only the MMC but also type A locations suffer from substantial negative external effects;

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[6]This applies in both directions from the "optimum distance" and therefore both A-type locations as well as C-type locations require more leading sector (or locational constant) inputs than the B-type locations under discussion here.

c) if substantial locational constants can thereby be mobilized in the respective location or region; and/or

d) if any other of the conditions enumerated for A-type centres and for C-type centres are not available.

Major requirements for the national transport network will be connections between various type B growth centres or other intermediate-sized cities (Pred [24]), and connections between the new town and its potential hinterland to increase hinterland effects.

6.c <u>New Towns or Growth Centres at Larger Distances from the MMC in Rural or Non-Developed Areas and with No Central Place Hinterland of Their Own</u>

Such locations have no major potential unless they possess natural resources in sufficient demand to create an export base activity. If only these are exploited and no major resource processing activities nor hinterland effects develop, the location may emerge as what we have defined above as a new town without major growth centre characteristics. Locally, scale and urbanization economies would be created but in its growth performance the location would depend primarily on external demand. If self-sustained growth is to be created, the establishment of local or regional interactivity linkages and hinterland effects is necessary.

In practice, new towns for pure resource exploitation and without growth centre characteristics have been established in peripheral locations without causing significant changes in the national urban system nor in the rest of their surrounding region: cases in point are many mining based company towns in developing countries. If growth centre elements are initiated, however, changes both within the region and in the national urban system are to be expected through new centre-hinterland and interurban relations. These may cause spread or backwash effects to the surrounding hinterland, and through more diversified interactions with other cities may also change functional relations within the urban system, in its size and spatial distribution and in the structure of the transport network connecting it. This may bring about significant shifts in the national spatial system. A growth centre in such a peripheral location may facilitate the emergence of a system of central places in its hinterland (e.g. to provide agricultural products for the growth centre's demand, as in the surroundings of Brasilia (see Stöhr [29]), or through the stimulation of development in certain intermediate-size or larger cities with which the new growth centre is related either functionally or geographically. If such impulses are transmitted mainly to intermediate-size cities in less developed areas, the city size structure may be moved more towards lognormality and lead to a reduction in interregional dispartities of development. If on the other hand they are transmitted mainly to the MMC, an existing primate city size structure may be reinforced and so may interregional dispartities of development.

From a purely economic point of view the establishment of a new town for the exploitation of natural resources in a type-C location will seem justified if the marginal revenue to be derived from it is greater than the marginal cost of exploitation and of the necessary urbanization and infrastructure investment. A growth centre in the broader sense (Section III), however, will be justified from a purely economic point of view if, beyond the above, comparative locational advantages can be derived in the region for functionally related activities and if the marginal urbanization and agglomeration economies gained there are greater than in other areas of the country. The required variables for both cases are difficult to quantify conclusively, however.

In practice, decisions on the establishment of such growth centres are often taken not only on grounds of efficiency criteria (Artle [2]) but also for non-economic objectives such as the promotion of depressed areas or the development of strategically important border areas. Although in such cases an economic evaluation is not sufficient, it may still help to clarify the economic cost of realizing certain political or strategic objectives and thereby help to improve the basis for decision making.

National objectives such as the development of strategically, politically or economically important interior areas may in fact entail changes from a fringe-orientated, coastal urban system to one approaching a gravity centre oriented pattern. A prerequisite for this may be the development of new natural resources on the opposite side or interior of the national territory to create new locational constants to counterbalance those which historically led to the initial fringe-orientated coastal pattern. Such new interior resource developments, however, may not only be an important aid towards the establishment of a gravity centre oriented urban pattern but at the same time may require a gravity-oriented centre for its support. In the concrete terms of Brazil, for example, the new resource developments in the interior of the country consititute an important economic base for the further development of the new capital of Brasilia, while at the same time the new capital and the road network emanating from it constitute an important prerequisite for the development of the resources in the interior. Thus there often exists a close interrelation not only among new towns or growth centres at different type-C locations but also between them and cities of type B or A.

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Organizational Information Flows and the Urban System

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Abstract

This paper argues for a closer linkage between research on the behaviour of organizations viewed spatially and aggregated studies of urban systems. The basic contention of the paper is that the spatial structure of corporate organizations, especially when defined in terms of the location of non-manufacturing functions and their information flow networks, underlies and steers a number of aggregate urban and regional development processes--such as the spatial diffusion of technical innovation, multiplier leakages, polarized development and regional external economies. In this perspective the paper reviews theoretical and empirical studies under three headings:

1) changes in the aggregate distribution of employment in various non-manufacturing activities;

2) change in the spatial structure of corporate organizations, particularly the division of functions between locations;

3) studies of intra- and inter-organizational information flows.

Under each heading particular emphasis is placed upon research that has aimed at building bridges between different aggregation levels. The paper concludes by discussing how the management of contact networks through investment in advanced telecommunications, "communication audits" and the designation of growth centres based on information exchanging functions, can become an important policy instrument for both organizations and public sector agencies concerned with regional development.

The Regional Problem in the Post-Industrial Society

The basic factors about regional inequalities in economic and social development within economically advanced countries are becoming increasingly well documented. The emergence of the so-called "post-industrial society" with its associated relative decline of employment in purely manufacturing activities and increase of employment in "non-productive" administrative, research and technical functions has resulted in an increase rather than an amelioration of regional inequalities especially in certain key occupations. These occupations are generally office type jobs in which individuals are principally involved in the processing of information within organizations and its exchange between organizations especially through personal contact. Regional concentration of these occupations is having important social implications, for example in social mobility and migration, as well as significant economic implications in terms of processes of development and change that are steered by the diffusion of new information.

Theoretical Problems Posed by Structural Change

Some workers have described the phenomena of the growth and changing location of information activities but few attempts have been made to modify traditional location theory. Whilst several writers have referred to the inappropriateness of theory developed in the time of the single-product, single-plant firm to a situation where the multi-location, multi-product corporate organization dominates, a comprehensive body of theory that can satisfactorily explain the location of various corporate functions, particularly those not directly concerned with physical production, has yet to be developed. This may be partly because the focus of much recent behavioural research on organizations has been on location decision processes rather than on factors that affect the performance of various functions located in different places.

Some attempts have been made to apply traditional location theory (where the emphasis has always been on regional variations in operating costs) to the location of non-manufacturing functions. In this type of application flows of information have been substituted for flows of goods as a key variable in the cost equation (e.g. Törnqvist [45]). Although sources of information, like materials, are not ubiquitous, it is nevertheless doubtful whether the concepts or methods of analysis applied to commodity flows (or even personal movements) are appropriate for examining the effect of location on different organizational functions. In part this is because there are greater possibilities for adapting communication behaviour to different locational situations than there are for changing sources or market outlets for manufactured products.

The fact that considerable adjustments can occur in the spatial structure and behaviour of organizations--that is the divisions of various functions between locations and the contact patterns of these functions--with few physical manifestations such as new buildings, also creates considerable problems for planning control. Corporate mergers and re-organization can often lead to more significant changes in the geographical distribution of employment in non-manufacturing functions than of employment in physical production and such changes seldom enter the realm of public policy. Indeed public sector agencies often make such changes themselves with little consideration of their regional implications.

A Basis for Theory

The lack of an adequate theory for location of non-manufacturing corporate functions compounds the problem of policy intervention. Where can we begin to search for a basis for such a theory?

A body of research is developing on office location but this has mainly been concerned with head office location or the location of independent service firms in the "quaternary sector." Few attempts have been made to set head office location within the context of the spatial structure of corporate organizations. An obvious source for basic concepts therefore is modern organization theory which stresses the need for a holistic or "systems" view of organizations (e.g. Emery [17]; Haire [26]; March and Simon [30]).

However, few workers in organization theory have explicitly considered the effect of location on the operations of organizations. Yet location is obviously important. The so-called social-technical systems theorists emphasize the open nature of organizational systems and the importance of interaction between an organization and its social and technical environment (e.g. Emery and Trist [17]). To a regional analyst the word "environment" also has a particular spatial connotation. One of the key arguments of this paper is that the location of various non-production functions within a multi-unit organization will influence its pattern of access to an environment which will be composed of other parts of the organization located elsewhere and other organizations. These patterns of access will be reflected in information flows which can be mapped into geographical space. It is these information flows rather than the formal structure of the organization that ultimately define how the firm operates, particularly how it will be able to adapt to changes in the environment by developing new products, selecting new supplies and so on.

The Aggregation Problem and the Need for a Contextual Framework Linking Research on Organizations and Urban Systems

One of the most pressing issues facing those researching into the management of urban systems is the aggregation problem--that is the need to build at least a conceptual bridge between what is happening to individual organizations and what is happening to the urban system as a whole. It is a basic contention of this paper that the spatial structure of corporate organizations defined in terms of the location of non-manufacturing functions and their associated information flow networks which underlie and indeed steer a number of aggregate urban and regional developmental processes--like the spatial diffusion of technical innovation, multiplier leakages, growth poles and regional external economies.

The critical questions for urban systems development therefore seem to be: what is the relationship between the spatial structure of organizations and growth and change in these organizations? and how do these differences feed through into the aggregate performance of different cities and regions? The need to relate the behaviour of individual organizations to the overall pattern of urban change suggests the importance of a contextual framework for future research--that is one where the behaviour of various corporate units are examined in different regional and organizational environments.

The relationship between different levels of analysis are suggested by Figure 1. At each level discriminating or contextual variables enter into the picture which are sometimes more than the sum of behaviour at the lower levels. At the lowest level the geographical distribution of contacts of different types relate the organization to its external and internal environment. The actors who have these contacts may therefore be differentiated according to the amount and type of their contact as well as other non-contact or contextual variables such as salary, company age, length of time in this particular job at this particular place, etc. Establishments are composed of collections of actors classified in terms of contacts and other variables; they are also characterized by a number of variables that indicate the position of the establishment within the company (e.g. office space as a percentage of the total), its performance (e.g. R and D input, turnover, value added, changes in product line, etc.) and most important material flows with various segments of the environment (e.g. inputs and outputs from the establishment's own region as a percentage of total). Firms in turn may be composed of collections of establishments and have aggregate characteristics such as profitability which cannot be readily attributable to individual parts. At the

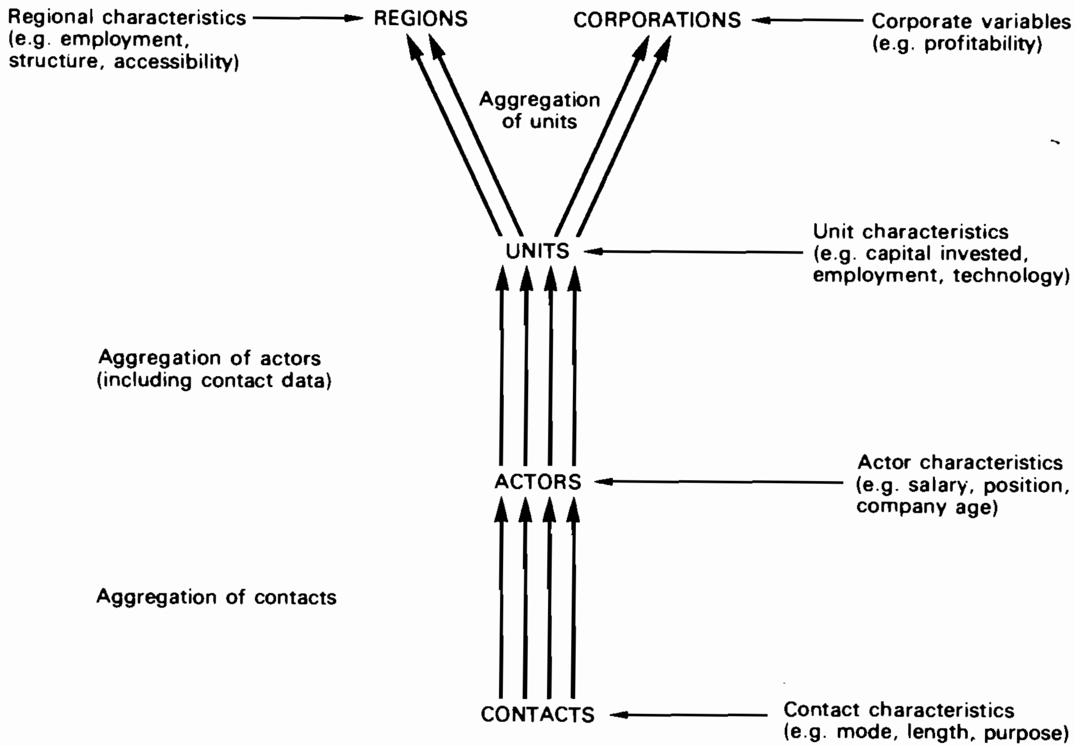


Figure 1. Aggregation levels: contacts, business units, organizations and regions.

same level, regions are composed of collections of establishments characterized by aggregations of *all* of the preceding variables plus regional factors such as industrial investment, industrial and occupational mixes and accessibility (particularly contact potentials).

This framework suggests three principal themes for empirical research aimed at substantiating the links between organizational and urban systems theory:

a) studies of changes in the aggregate distribution of employment in various non-manufacturing activities;

b) studies of changes in the spatial structure of corporate organizations, particularly the division of functions between locations; and

c) studies of intra- and inter-organizational information flows.

The remainder of this paper will be devoted to a review of recent research under each of these headings with particular emphasis on those studies that have aimed at building bridges between different aggregation levels. Each section is divided into a review of recent conceptual developments followed by supporting empirical studies.

The Spatial Structure of Corporate Organizations

1. Regional Development Processes: Theory

A number of workers have recently attempted to relate the structure of corporate organizations to the spatial structure of national urban systems (EFTA [15]; Goddard [20]). By structure here is meant the division of functions between spatially separate units of the organizations. The connection with the national system of cities has been stressed because many of these functions are administrative activities which are predominantly concentrated in urban regions. The simplest example is that provided by Wärneryd who has mapped three hypothetical organizations with a rigidly hierarchical bureaucratic structure into geographical space (Wärneryd [46], see Figure 2). In this example various levels in the organization (e.g. group head office, divisional head office, plant management) are located in cities all at different positions in the urban hierarchy (national capital, regional centre, local centre). A complex set of linkages or interdependencies exist within and between the units of these organizations at different levels of the urban hierarchy. Internal linkages take the form of lines of administrative responsibility and ownership ties while external linkage exists between different organizations--for example with service firms in particular urban centres.

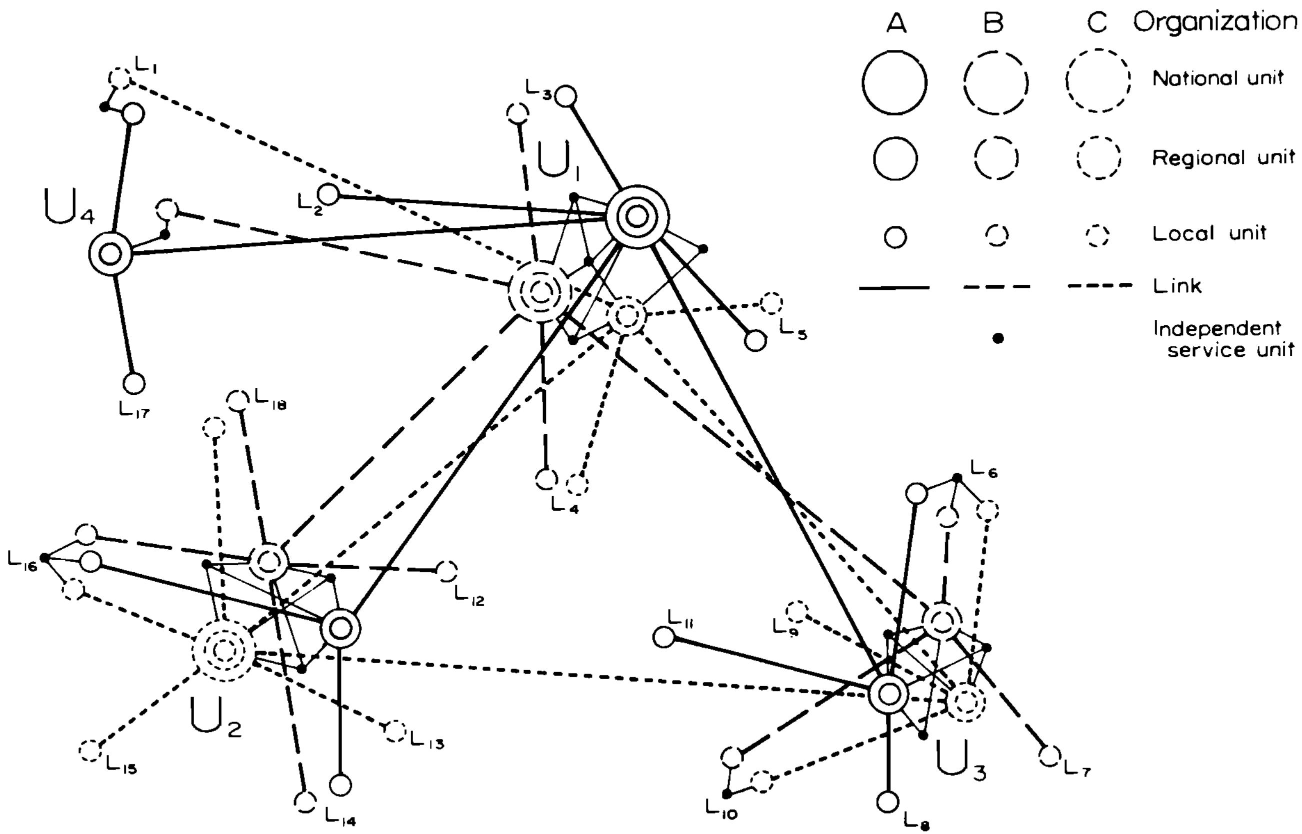


Figure 2. The spatial arrangement and functional character of units within three hypothetical organizations:

U_1 may be thought of as the highest-ranking member of a given system of cities,

U_2 as the second-ranking metropolitan area,

U_3 and U_4 as middle-ranking centers of regional importance.

L_1-L_{18} are lower-order cities of varying population and local importance.

Although this rather simple conceptual model may not apply to all corporate organizations, it is important in that it attempts to link the structure of organizations with that of the national system of cities. Following these lines Pred has further explored the relationship between corporate structure and regional development processes (Pred [33]). He has added to Wärneryd's original model an additional link across the hierarchy ("big city interdependence" or links between divisional headquarters) and suggests that the regional development process basically consists of three sub-processes:

1) the generation of non-local multiplier effects;
2) the diffusion of growth inducing innovations; and
3) the accumulation of organizational operational decisions at particular levels in the hierarchy.

All three processes tend to reinforce the existing form of the urban systems, particularly the dominance of the largest cities. Thus, the spatial structure of linkages within the organization tend to steer the spread of non-local multipler effects. Expansion of activities at a branch plant may lead to additional administrative employment at divisional or group head office rather than locally. If that expansion is an existing product area simply involving more inputs of the same type than previously, then decisions about purchase sources are predefined and may be made at the local level. But if new or specialized inputs are required this decision is likely to be made at a higher level and possibly not involve local sources. For example, specialist consultancy services may be purchased by the head office from its own local environment. The possibility of using such services is one of the chief external economies offered by urban areas to manufacturing organizations. Thorngren [42] has distinguished between two types of external economy, the controllable and the uncontrollable (Figure 3). Considerable direct financial savings can be gained by contracting out business services such as legal advice: the link between the administrative part of the organizations consists of information flows and parallel monetary flows. Such pecuniary economies are equivalent to those gained by contracting out part of the production process from the production unit: in this case material flows are paralleled by monetary flows. On the other hand uncontrollable external economies arise from information flows in which no monetary transactions are directly involved--for example, information about new markets, suppliers, production processes, etc. on which the long run survival of the organization might depend. This information that is vital to the third process, the spread of growth inducing innovations may, though not necessarily, flow along the established network of interdependencies within and between organizations. In the case of material and especially information flows considerable

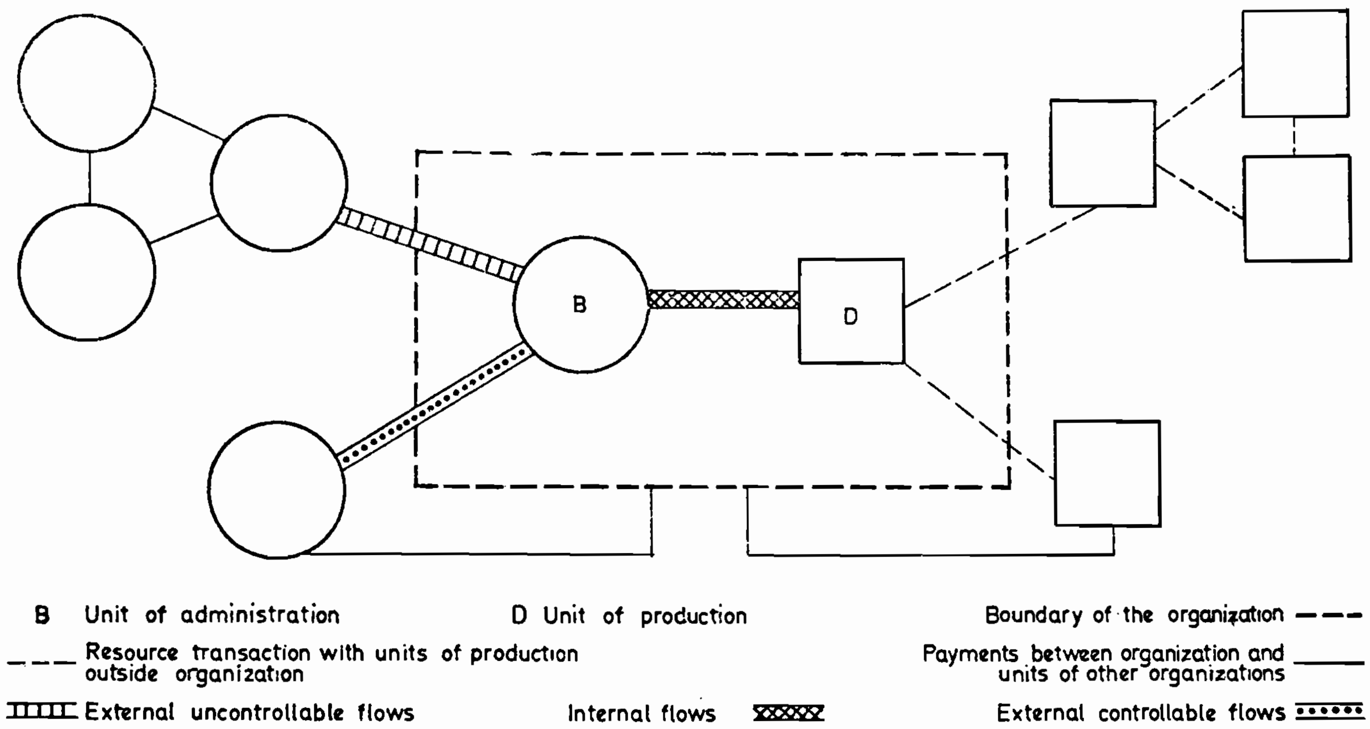


Figure 3. Flows of information and external economies (after Thorngren [42]).

advantages accrue from location in an agglomeration where complexes of interlinked functions can be found. Because of the steep distance decay effect on flows of specialist information, the industrial complex or growth pole has more meaning as a spatial concept in terms of this type of interaction than material flows (Hermansen [27]).

The increasing concentration of manufacturing production into a limited number of large corporate organizations makes these generalizations particularly relevant to regional development (Parsons [32]; Watts [47]). The regional implications of the development of organizations from small single-function firms through national organizations engaged in several activities in many regions to multi-divisional and finally multi-national corporations have been discussed by Westaway, drawing upon the work of business economists like Ansoff and Chandler and Redlich (Westaway [49]; Ansoff [2]; Chandler and Redlich [11]). The emergence of the national corporation has involved on the one hand a horizontal division of management into specialist departments--finance, personnel, purchasing, sales, etc. and a vertical system of control devised to connect and co-ordinate departments. In particular the head office's responsibility has been to co-ordinate, appraise and plan for the survival and growth of the corporation as a whole. The growth of such corporations through mergers and takeovers tends to lead to a considerable concentration of administrative employment as duplicated functions that existed in the separate organizations prior to amalgamation are eliminated. External services that smaller organizations had to contract out are internalized because they can now be economically provided for the larger group. In the multi-divisional corporation, each division is concerned with one product line and is supervised by its own divisional head office while a group head office plans for the enterprise as a whole.

Services for which there is a substantial demand may be contracted out to companies that are wholly or partly owned by the corporation. The service firm will meet the needs of the parent company at commercial rates and will compete in the open market for other work. In this way the linkages in the urban system become more complex and connections across the hierarchy (big city interdependencies) take on greater significance.

In order to see how the development of corporate hierarchy relates to the spatial concentration of control, Westaway draws attention to three levels of business administration, three time horizons, three levels of tasks and three levels of decision making within an organization which have a bearing on location.

In the early stages of corporate development, i.e. the small single-function, single-unit firm of classic location theory, all three levels are embodied in one entrepreneur. As the company expands into a national corporation, level three, which is concerned with the day-to-day management of production, is separated both functionally and geographically from the higher levels. Level two would be concerned with the medium-term co-ordination of a number of production plants probably from a head office located in an accessible large city. Level one compromises top management whose function is to determine long-term goals and plan company strategy, thereby setting a framework within which all other levels operate. In the multi-divisional corporation this highest level may be separated from level two in the form of a group head office located in a capital city--principally because of the need for close connections with the money market, the media, and government.

2. Empirical Evidence: the Location of Non-Manufacturing Functions

The empirical evidence to support these contentions concerning the spatial structure of corporate organizations and the urban system comes from studies of the changing location of administrative functions on the one hand and of non-manufacturing employment on the other. The territorial extent of large corporations is readily apparent when the location of various units are mapped out--an exercise carried out for Imperial Chemical Industries in Britain by Rees (see Figure 4, Rees [37]). If seen alongside a map of the distribution of urban centres in England and Wales the duality of the corporate and organizational system would be readily apparent. Nevertheless, the map of ICI establishments tells us little about the role of each within the organization and their relationship to one another. This information can only be obtained by sample surveys of the type reported by Parsons of 224 manufacturing corporations in the UK (Parsons [32]). This showed that although the South East region accounted for only 28 percent (507) of all operating units of these corporations, it contained 74 percent (fifty-one) of group head offices; 48 percent (fifteen) of central service units (i.e. those functions concerned with administering the corporation at geographically distinct locations from the head office); 69 percent (sixty-six) of corporate control units (i.e. group head office plus central services); 42 percent (thirty-six) of divisional head offices; and 48 percent (forty-one) of research and development units. Comprehensive figures collated by Buswell and Lewis emphasize the importance of the South East region outside London for research and development in the public and private sector (Buswell and Lewis [10]). They show that the South East contains 49 percent of all such establishments in this country.

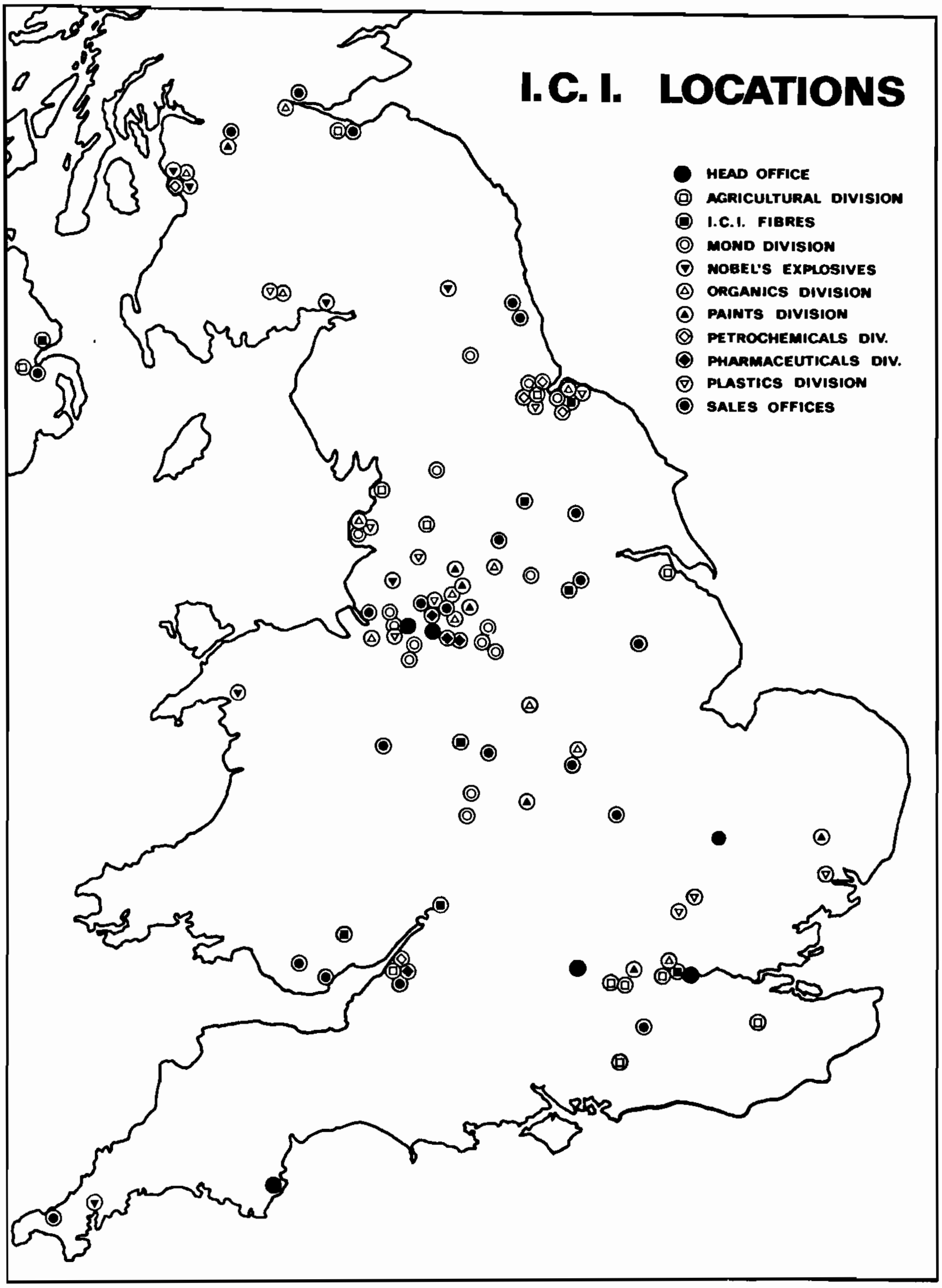


Figure 4. From Rees [37].

By far the greatest attention has been paid to the location of head office activities. For example, Westaway [48] has indicated that the head offices of the 1,000 largest companies in the UK are highly concentrated in London, with an almost perfect correlation between firm size and propensity to locate in the capital. For example, eighty-six of the 100 largest firms have their head office in London compared with thirty-two of the 100 smallest. This degree of concentration appears to be increasing over time: between 1969 and 1972 the number of head offices located in London increased by thirty while all of the other large cities recorded losses. Firms with head offices outside London tend to be those that operate in fairly narrowly defined sectors of the economy where production is localized in one part of the country.

Similar patterns of concentration have been documented in the United States (Goodwin [25]; Armstrong and Pushkarev [3] and Sweden (Pred [35]). The twenty-one largest SMSA's in the USA contained 348 head offices of the 500 leading industrial corporations in 1968 and 148 of these were located in New York City. Similarly of the 148 leading companies in Sweden, fifty-seven had their head office in Stockholm. The various studies suggest that three broad types of spatial structure could be relevant (Westaway [49]):

a) multi-unit corporate organizations with head offices *in* the national capital;

b) multi-unit corporations with head offices *outside* the national capital; and

c) small independent firms outside the corporate hierarchy.

3. Empirical Evidence: the Location of Non-Manufacturing Employment

Studies in the changing location of non-manufacturing employment have proved more difficult principally because product orientated industrial classifications have failed to isolate the non-manufacturing function within organizations. In view of the growth of such employment in all economically advanced countries the paucity of official data on the occupations of employees by place of work is remarkable.

The 1966 census was the first time such data were published in the UK. Prior to that only residence based occupational data were available, data which were generally considered to be meaningful only at the regional level. Analysis at this level has indicated the concentration of *all* office occupations in the prosperous regions of the Country (Burrows [8]; Rhodes and Kan [38]). No analysis of those employed in non-manual occupations in manufacturing industry which is available by region has been published. Residence based occupational data are only meaningful when referred to relatively closed labour market areas. Westaway's analysis of the changing distribution of professional, managerial, clerical and manual occupation groups between 1961 and 1966 for Metropolitan Economic Labour Areas has shown an increasing concentration of managerial and professional occupations in Labour Markets in the South East although there is some evidence of a regional redistribution as well as local decentralization of clerical occupations (see Table 1) (Westaway [48]).

It should be stressed that this analysis includes managerial and professional groups outside the manufacturing sector. Occupation by industry data has been equally difficult to obtain in the USA. "Central Administrative Office and Auxiliary" employment is reported by the US census but only for selected industry groups. Armstrong and Pushkarev's [3] analysis of these data by SMSA's has indicated that "manufacturing administrative jobs are either decentralizing gently to smaller metropolitan areas, in the wake of production plants, or if they have to be centralized, prefer to locate in or near New York." In general, growth rates for manufacturing office employment appear to be inversely related to the size of metropolitan area. With the exception of New York, there is a close correspondence between the industrial composition of all manufacturing jobs in a region and the industrial composition of office employment, but this is often due to the one or two large employers (e.g. General Motors with its US head office in Detroit). As in Britain, sectors that are highly concentrated in particular regions tend to have their head office in that region.

Not surprisingly the most comprehensive data on non-manufacturing occupations in the manuracturing sector is available in Sweden. All salaried employees in Sweden have a functional classification subdivided into up to eight status levels (e.g. production control occupations are subdivided into six status groups from production control director through to production control technician). The levels are aimed to be comparable in terms of salary across occupations and are used for collective bargaining purposes. Törnqvist [45] has analyzed the changing distribution of salaried employees at different levels in different industrial sectors for the whole of Sweden. This analysis has indicated that in manufacturing industry the highest level jobs have become increasingly concentrated into the largest city regions (Stockholm, Gothenburg and Malmo).

Table 1. Regional "balance sheet" of shifts in managerial and administrative occupations, 1961-66: for urban regions in Britain (from Westaway [48]).

Region	Professional & Managerial	Administrative
	(hundreds)	(hundreds)
Prosperous region		
South East	143	21
South West	6	35
West Midlands	41	79
East Midlands	15	48
East Anglia	1	6
Declining regions		
Yorks and Humber	-55	10
North	-27	50
Wales	-49	-23
North West	-17	-73
Scotland	-58	-153

Notes:

- Data refer to 116 functionally defined labour market areas (Metropolitan Economic Labour Areas (MELA's)).
- Figures refer to economically active males only.
- Figures are absolute differences between actual and expected change aggregated for all MELA's in each region; "expected change" is defined as growth or decline in the occupation groups at the national rate for urban Britain as a whole.
- Professional/managerial occupations include persons working in all non-manufacturing sectors as well as doctors, teachers, etc.

4. The Relationship between Regional Structure and Organizational Structure: Behavioural Research

While a number of studies have described the distribution of non-manufactuirng activities and employment, few have been directly concerned with relating these patterns to regional development processes. The research that has been done has principally been concerned with the relationship between organizational structure and the geographical distribution of service purchases. In the case of large corporations this has involved examination of the extent to which particular services (e.g. banking and finance or legal services) are provided within or outside the organizations. Britton [6] for example has carried out a number of case studies of service supply in contrasting regions of Canada for single plant firms and multi-plant corporations. He concludes that there are pronounced differences in the willingness of managements of single plant firms and branch plants to undertake certain tasks within the unit (i.e. to internalize). In the cases of branches, higher order services are generally provided by head offices directly or from service firms located near to the head office. Lower order services for both branches and single plant firms tend to be provided in the local area except around, for example, Toronto which exerts a shadow effect on the surrounding areas with both branches and single plant firms looking to the metropolitan area. At greater distances the local town is more important for higher order services for single plant firms than for branches (see findings on contact patterns reported later).

These findings have been corroborated for Norway by Stenstavold and Sweden by Byström (Geography Department, Norwegian School of Economics, and Business Economics Department, University of Umea, respectively). Both have examined service use from the point of view of manufacturing plants *and* supply by service firms. In less accessible regions of Norway, Stenstavold has observed that management tends to use low order service functions to provide high level services (e.g. the bank manager is asked to give advice on long range financial planning). Even though services may be available locally, branch plants tend to be steered to Oslo while single plant firms are often unaware of the existence of possible service suppliers in *nearby* towns. Byström has related expenditure on external services to size of firm. Expenditure on lower order services like accounting decline with size of firm while that on high order services such as advertising increase with size of firm. Routine services required frequently or at short notice tend to be supplied locally while infrequent services are supplied from more distant sources.

These studies of service provision relate principally to Pred's sub-process of "the spread of non-local multiplier effects" although they impinge to a certain extent on his category "the accumulation of operational decisions" (i.e. the level at which purchase decisions are made). Very few studies apart from Pred's own historical investigations (e.g. Pred [34]) have related the spread of innovations to the spatial structure of corporate organizations. The studies that have been made refer principally to non-industrial innovations (e.g. Berry [5]). Yet there is a considerable literature in organization theory on the innovation process, particularly the relationship between corporate structure and adaption to environmental change. The socio-technical systems theorists who have been working in this field place great emphasis on the environment when explaining innovation. Their main questions concern the kinds of formal organizational structure that can most effectively relate environment, technology and organizational members together. While a classical hierarchical structure may be appropriate in a stable environment more flexible arrangements are required in fields of activity subject to continual change (cf. Burns and Staulker [7]; Emery and Trist [17] Jefferson [29]). Insofar as "corporate structure" and the "environment" can be defined in geographical space, the spatial structure of organizations can have an important bearing on the innovation process. Few locational analysts have considered such issues, perhaps because too much emphasis has been placed on one form of (long term) adaption, namely locational change.

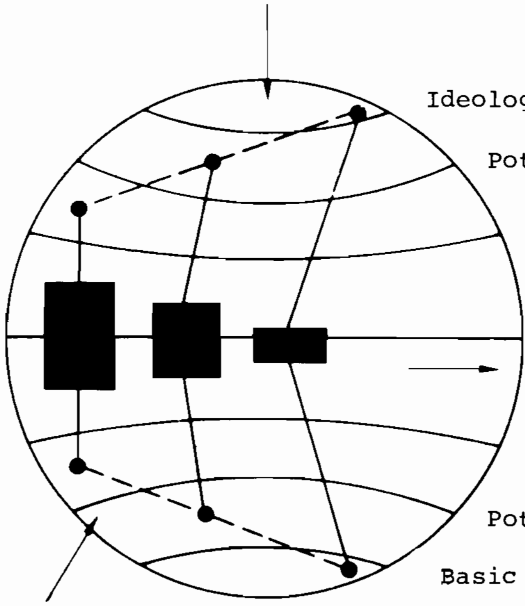
One study that has explicitly attempted to relate organizational and environmental characteristics in a spatial context is that by Back, Dalborg and Otterbeck [4]. They selected five regions in Sweden with varying population size, density and growth characteristics and then the six largest manufacturing firms with head offices in each region. Data were then collected for all units of these firms in the country as a whole. The final sample consisted of twenty-two firms with eighty units in fifty-five regions. Data on the changing organizational characteristics of units were then related to the characteristics of the regions within which the units were located. This contextual analysis therefore links the two highest levels in the hierarchy of investigations outlined in Figure 1. Organizational variables relate the unit to the organization as a whole (e.g. level of administration) and to the aspatial technical and social environment (e.g. variability in the scope of activity), while the characteristics of the spatial environment were defined in terms of the population size, growth and density of the immediate region. Linking the three sets of data through correlation analysis and cluster analysis suggested that dense growing regions contained units that were heavily involved in administrative activities (high percentage of salaried employees), research and development (R and D employees are a high percentage of the total), which had experienced a high degree of variability in their level of activity (average fluctuation in number of employees over a five year period) and scope of activity (technology, production mix and markets). In contrast, units with more stable activities tended to be found in the less dense and slower growing regions.

These findings together with those on service use, indicate the importance of the immediate environment for industrial establishments. The process by which the local environment influences management decisions (and vice versa) will be clearly reflected in the pattern of information flows between the unit and its internal and external environment. It is to this question that we now turn.

Information Flows and Regional and Organizational Development Processes

A number of writers have stressed the importance of information flows as a key process by which corporations monitor, manipulate and respond to their environment. For example Steed [40] notes that "To obtain some understanding of the manner whereby (organizations) adapt to changing conditions we must indicate the range of their information inputs and their processes of decision making." Here the "process of decision making" refers to the way in which information from the outside environment is channeled through the organization, hopefully to the places where appropriate action can be taken. Following Aguilar [1] and Dill [14], Steed suggests that an understanding of this process involves discovering how organizations scan their environment and their modes of scanning, particularly "which mode is associated with what information needs, how mode assignments are made and what procedures operate to alter their rules of scanning."

Thorngren [41] has suggested three principal modes by which organizations scan their environment. Following Jantsch [28] he suggests that the environment can be divided into two halves--a values and a knowledge environment (see Figure 5). Each part of the environment is divided into a series of distinct time horizons. The first type of interaction between the organization and its environment, referred to as "orientation" processes by Thorngren link the furthest segments of the knowledge and values environment (basic sciences and ideology). This type of relation concerns the very long run future organization. In the case of a motorcar manufacturer this might involve considerations of developments in basic science that could provide an alternative to the car and possible changes in societal values with respect to personal mobility. The second type of relation or "planning" processes link potential social values and technology and involve the development of specific



The development space (a concept introduced by Janstch [28] in connection with long run technological development) is divided into a values environment and a knowledge environment, with activities located in the central section. Most activities (programmed processes (1) operate within contemporary socio-economic and technological environments. The next largest group (planning processes (2)) link potential social values and technologies and are therefore concerned with likely changes in the more immediate environments within which programmed activities currently operate. Finally, a very small proportion of total activity (orientation processes (3)) is concerned with long term scanning of the environment, reaching out to ideology and basic science.

Figure 5. Sources of information in the development space (after Thorngren [41]).

products identified by earlier orientation relations. As Figure 6 suggests, planning relations involve a less random scanning of the environment than orientation processes. In the case of the car manufacturer these processes may involve the development of say a battery-operated vehicle. Finally, the bulk of an organization's external relations operate within established technological and social environments and are concerned with the control of existing resources. These "programmed" relations are structured according to a pattern laid down by earlier orientation and planning relations. In the case of the car manufacturer such relations might be concerned with producing next year's models.

The important point for regional and organizational development is that these three processes tend to involve different contact networks or "modes of scanning" with some types of spatial environment being more appropriate for one type of contact than another. Thorngren suggests that orientation relations tend to take place in large pre-planned meetings involving wide ranging discussions between people often coming into contact for the first time. It is the widening or divergent character of the contact network that distinguishes orientation processes. Only the largest metropolises offer the wide range of potential contacts with government, researchers, financial institutions, and other business organizations, contacts which are essential for the conduct of orientation processes (Meir [31]).

Planning processes on the other hand tend to involve limited sets of familiar individuals with more clearly defined objectives and information search tasks. Unlike orientation, planning activities are less dependent on random contact: indeed the great variety of information thrown up in the large metropolis may conflict with the development of a specific project and lead to communications overload (Ramström [36]). Being familiar with one another, individuals involved in planning contacts can use telecommunications provided there are opportunities for regular (e.g. monthly) personal meetings (Goddard [21]). The location of research and development activities in relatively remote locations in the outer South East of England is remarkably consistent with this theory.

Finally, the great majority of external relations are concerned with routine matters. They involve specific discussions between familiar participants who are in frequent contact usually about matters directly related to buying or selling. Theoretically there is no reason why such activities could not be conducted in relatively remote locations using telecommunications. However, the sheer volume of contact may prevent this. Because of their routine nature these types of

THE SPATIAL CONTACT PATTERN

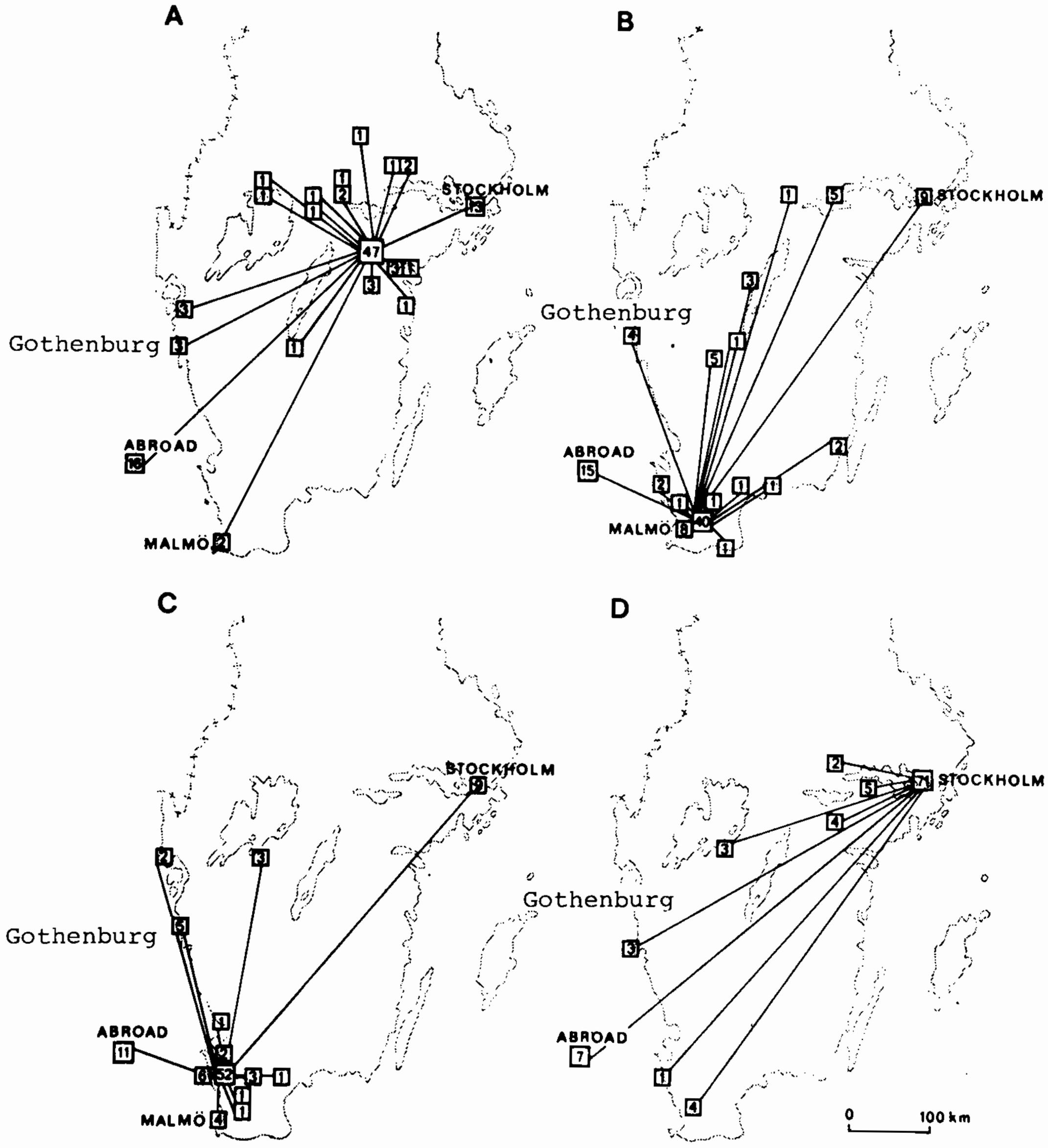


Figure 6. Percentage distribution of contact time for four manufacturing organizations with head offices located in different Swedish towns (from Törnqvist [45]).

contacts in particular are likely to have a relatively steep distance-decay function and therefore be confined to the local environment.

In terms of development processes, organizations without scanning units in information rich environments could be slow to adapt to changing circumstances. On the other hand if all units are located in such an information rich environment, conflicts could arise between the long and short term objectives associated with different processes. Relocation of activities to appropriate environments may therefore bring considerable benefits. For example, decentralization of routine activities from a city centre head office could release time for more essential orientation processes. However, relocating orientation functions to an environment dominated by programmed activities will inevitably mean that the orientation function diminishes. This is because the function of a particular unit is an expression of its interaction with the external environment; by relocating a unit the pattern of access to the environment will change.

Empirical Research on Intra- and Inter-Organizational Information Flows

A number of studies have been made in the UK and Sweden of flows of information within and between organizations. The most well-known are those of Törnqvist [45]. He has conducted a number of case studies of the gross amount of external contacts of manufacturing organizations with head offices in different locations in Sweden (Figure 6). The most striking feature of this analysis is the importance of the local environment regardless of the location. With the exception of the local environment regardless of the location. With the exception of Stockholm, between 40 percent and 50 percent of all contact time is spent at the home location. After that the other major urban centres account for the bulk of external contacts time. Not surprisingly the firms in Stockholm can meet 71 percent of their external contact needs in Stockholm itself. The picture that emerges then is one of an urban system composed of discrete and remarkably self-contained centres.

The importance of the near environment is also demonstrated by a number of other studies. In a communications survey of 100 units located in four different urban regions of Sweden (Stockholm, Gothenburg, Sundsvall and Umea) 76 percent of all contacts involving travel were with places less than thirty minutes away (Thorngren [43], see Figure 7). In spite of considerable differences in density a remarkably similar

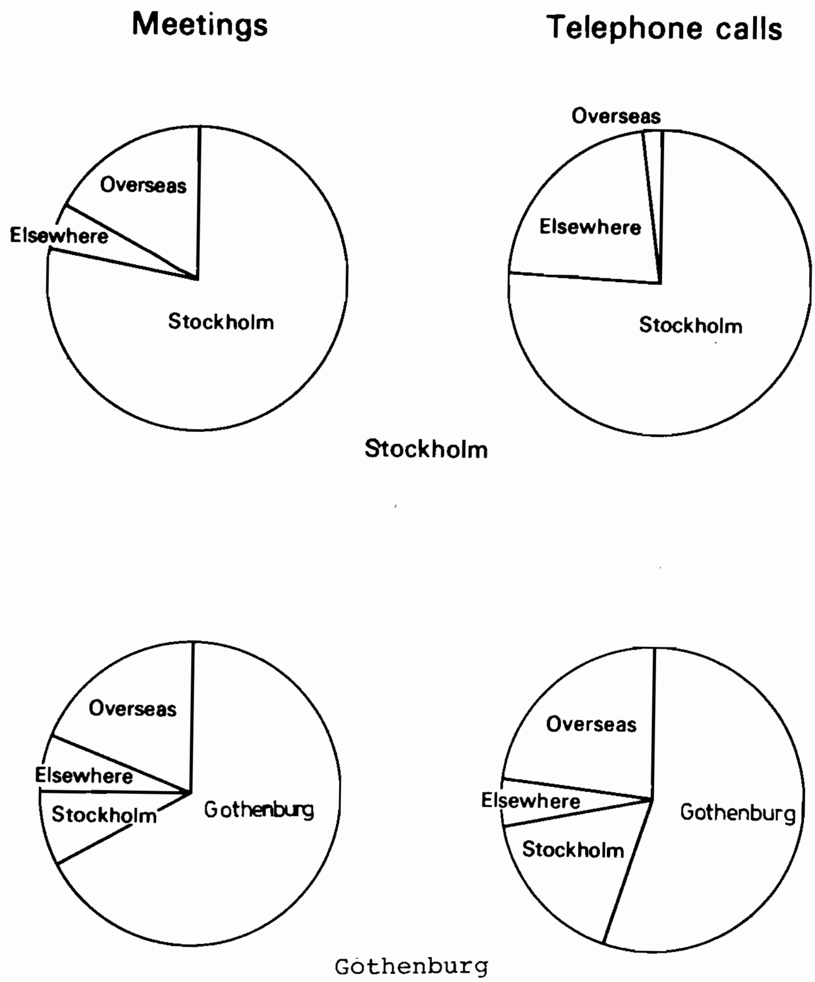


Figure 7. Geographical distribution of external contacts of firms located in four Swedish towns (after Thorngren [41]).

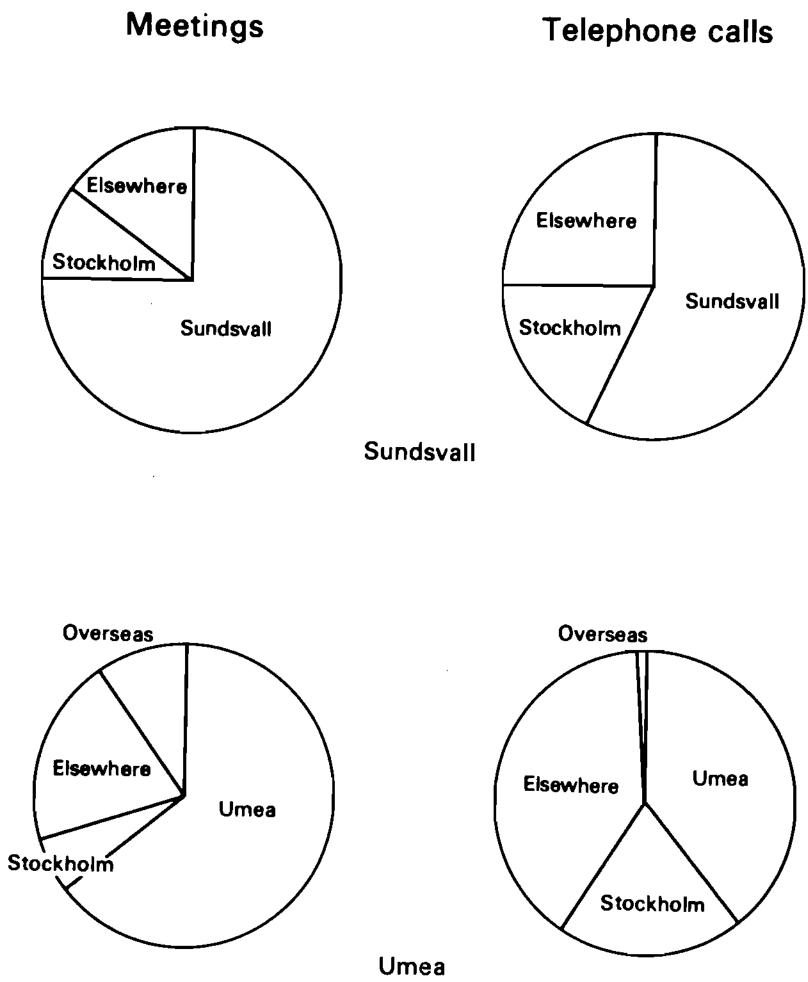


Figure 7. (continued).

figure (78 percent) was recorded in a survey of seventy-two commercial offices located in central London (Goddard [23]). Another communication survey of 115 establishments throughout the UK conducted for the post office has indicated that 70 percent of meetings involving persons from other establishments gave rise to journeys of less than thirty minutes while fully 87 percent of those involving no participants from other buildings required journeys as short as this (Connell [13]). An exception to this generalization is provided by twenty-two offices that have decentralized from London; these firms attempt to maintain contact with the capital and therefore involve themselves in long business journeys (Goddard and Morris [24]). Nevertheless decentralized offices in locations beyond London's shadow (over sixty miles) do have more local contacts and shorter journeys than those moving to locations in the South East (Figures 8 and 9).

The importance of the local environment therefore depends in part on the spatial structure of the urban economy. It also depends on the extent to which the sectoral composition of its local economy can meet the contact needs of the activity in question. This may be represented in the form of one row of an inter-sectoral inter-regional contact matrix (Figure 10). Figure 10 refers to the external telephone contacts of the head office of a wholesale and retail newsagent which has decentralized to Swindon just over sixty miles from London: contacts with the local environment are dominated by low order ubiquitous services such as transport and distribution; London is relatively unimportant except for contacts with the publishing sector which is nationally concentrated in the capital. Since manufacturing activity is dispersed throughout the country it is not surprising that the head offices of manufacturing firms in central London have a more widespread contact network than financial or service activities--although professional service firms have more of a national and regional rate than business service firms (Tables 2 and 3).

Törnqvist has revealed a close connection between occupational status and contact itensity. There are also considerable variations in contact intensity between functions and locations. For example, even controlling for status, individuals in decentralized offices have fewer contacts than their central London counterparts (Table 4). In part these differences are due to the extent to which individuals of different status and in different types of departments play an internal or an external role within organizations. Middle management has a more internal role as do accounts departments especially in decentralized locations. These findings suggest that regardless of the labels attached to them osten-

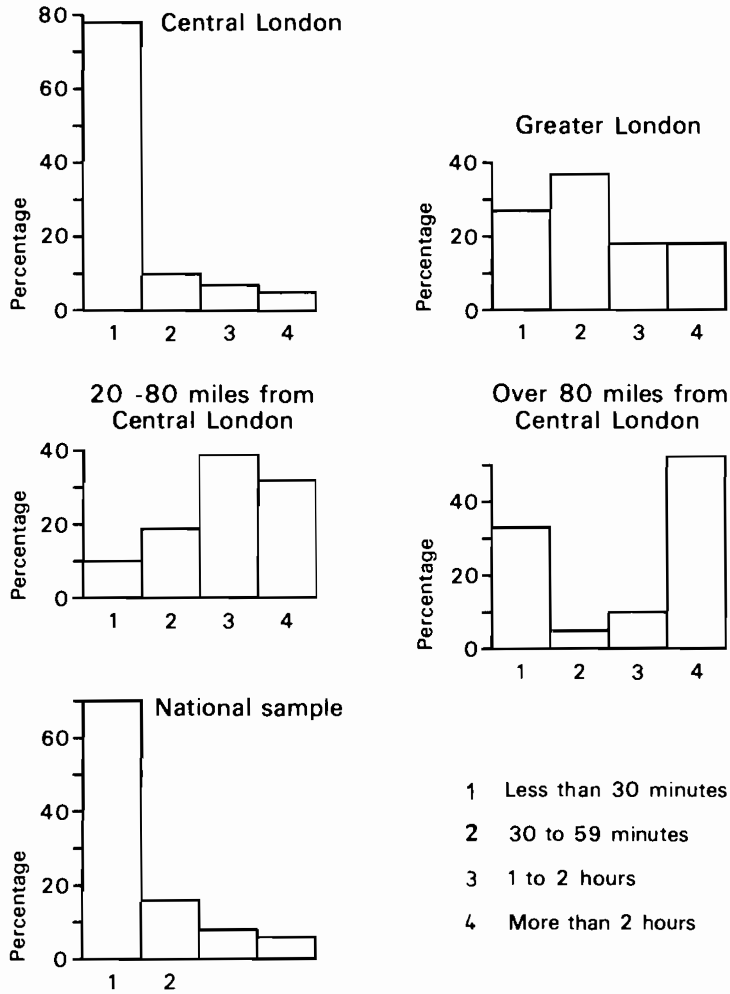


Figure 8. Length of journey for business contacts.

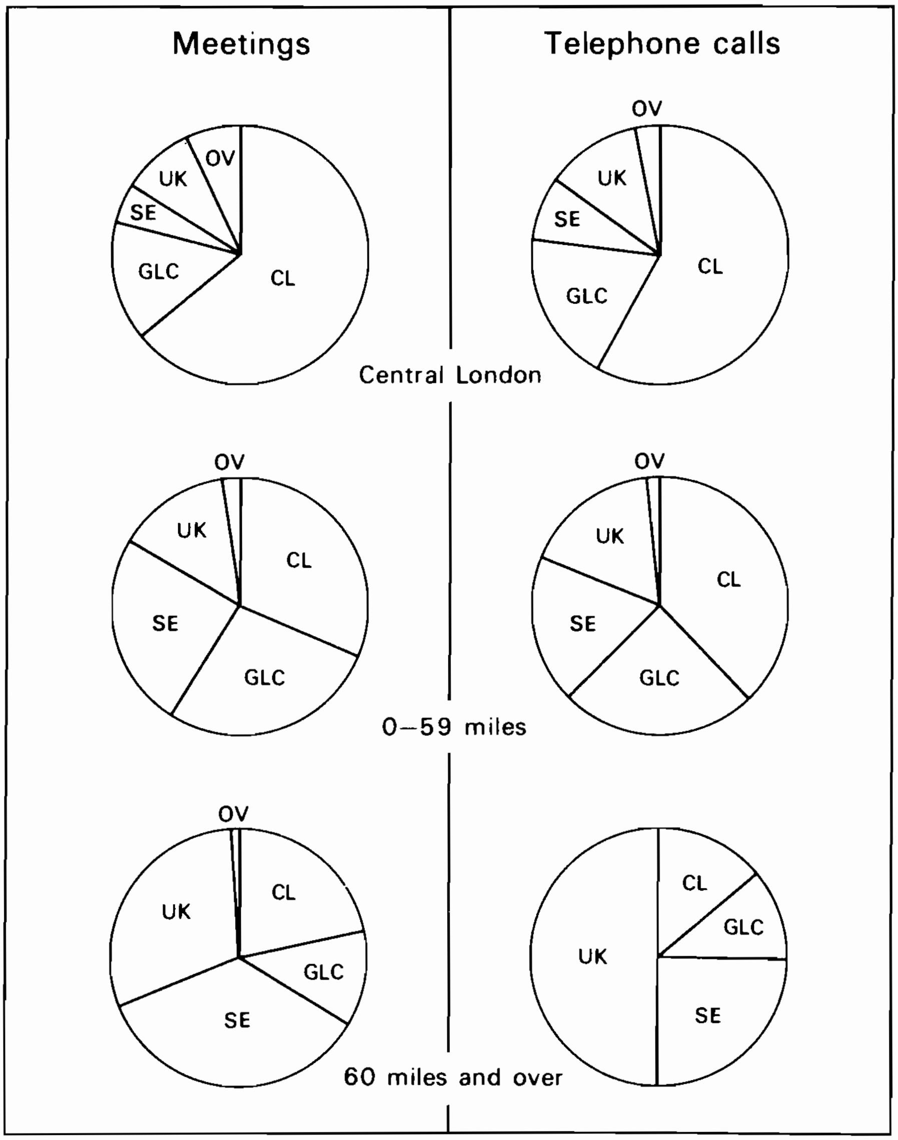


Figure 9. Distance moved by offices from London and the geographical distribution of external contacts.

CL - Central London
GLC - Greater London
SE - South East Region
UK - Elsewhere in UK
OV - Overseas

Sectoral and regional distribution of external telephone contacts

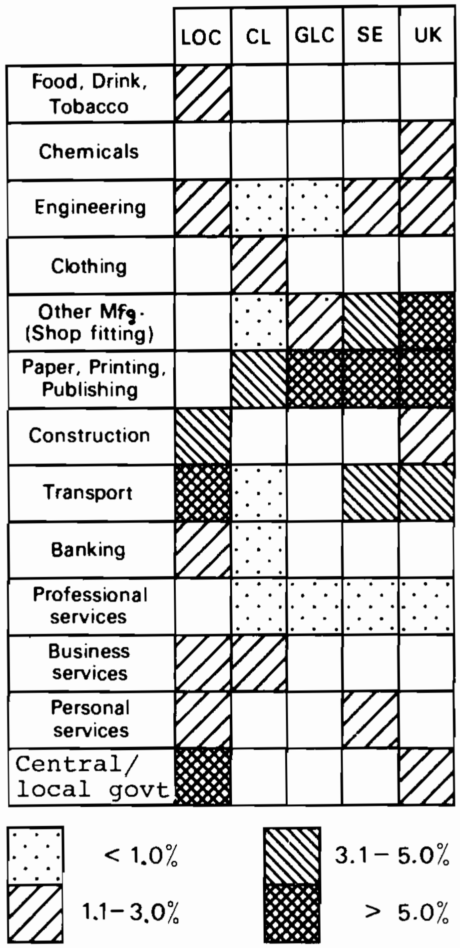


Figure 10. Sectoral and geographical distribution of external contacts of a decentralized office.

LOC - Local town (Swindon)
CL - Central London
GLC - Greater London
SE - South East Region
UL - Elsewhere in UK

Table 2. Geographical distribution of contacts of central London offices by sector (from Goddard [23]).

Telephone	Manufacturing	Finance	Business Services	Professional Services
Central London	47	74	71	37
Greater London	22	12	17	20
SE	11	4	4	11
Rest of UK	16	7	7	27
Overseas	4	3	1	5
Total (100%)	2,096	1,797	764	
Meetings				
Central London	53	76	83	37
Greater London	20	8	9	20
SE	7	3	2	11
Rest of UK	10	6	5	27
Overseas	10	7	0	5
Total (100%)	1,045	855	366	

Table 3. Number of contacts and time spent in contacts by employees in eight administrative job levels in seven organizations in Sweden (Törnqvist [45]).

	Job Level 1	2	3	4	5	6	7	8
Number of contacts per employee per week	19	10	6	3	2	-	-	-
Number of hours spent in contact per employee per week	37	20	12	5	3	-	-	-

Table 4. Contact intensity: Central London and decentralized offices (from Goddard and Morris [24]).

	Number of external meetings per respondent (3 days)		Number of external calls per respondent (3 days)	
	Central London	Decentralized	Central London	Decentralized
Managing Director, Chairman, Senior Partner	3.2	0.3	10.3	9.0
Director Company Secretary, Junior Partner	2.3	0.6	7.0	8.4
Manager, Section Head	2.6	0.8	7.9	3.5
Assistant Manager, Professional	1.9	0.4	6.7	3.0
Executive	1.3	0.6	8.5	3.6
Clerk	0.4	0.2	5.1	2.6

sibly similar departments function in a different way in different locations.

The differences in the tables between telephone contacts and personal meetings, moreover, suggest that contacts using the two media perform different roles within the organization. This becomes more apparent when the various characteristics of the two communication channels are considered. The telephone is used principally for short unarranged contacts which are concerned with one specific subject (Table 5). But the most interesting feature of Table 5 is not the differences between the two communication media but the way in which the same channel is used in different locations. In decentralized offices both meetings and telephone calls occur far less frequently; meetings last longer, are arranged further in advance, involve more participants and wider ranging discussions. Location therefore seems to have a quite fundamental influence on communication behaviour.

The effect of location on different contact networks can best be summarized if contacts are assigned to orientation, planning and programmed classes. Thorngren has pioneered the use of latent profile analysis to achieve this classification. Orientation contacts are assumed to take place in meetings where a large number of people come together for the first time for wide-ranging discussions. Planning contacts also involve a lot of feedback but occur more frequently and involve the use of the telephone as well as face to face meetings. Finally, programmed contacts are short, usually unarranged, regular contacts involving specific discussions (Classes 1, 3 and 2 respectively in Figure 11).

Although all three types of contact can be identified in most organizations in most locations the relative importance of each does vary. Table 6 indicates that orientation contacts are less important in decentralized locations than in central London, a reflection of the fact that fewer contacts are with the information rich environment of the city centre. The division of contacts into those that are internal and external to the organization suggests that the planning function is essentially an internal one. Table 6 also suggests that the characteristic of contact networks have an important bearing on location decisions. Firms that have rejected decentralization from central London (the non-movers) have significantly more external orientation contact than firms about to decentralize (24.1 percent compared with 14.8 percent) and also significantly more internal planning contacts (32.2 percent compared with 17.7 percent). These differences can again be largely attributed to the geographical distributions of contacts with non-movers having significantly more contacts with other firms in the city centre than the movers (63 percent

Table 5. External contact characteristics: decentralized locations and Central London (from Goddard and Morris [24]).

	Telephone		Meeting	
	DEC	C.L.	DEC	C.L.
	%	%	%	%
Length				
2 - 10 mins	90	87	7	19
11 - 30 mins	10	12	27	29
31 - 60 mins	0	1	19	19
1 - 2 hours	0	0	25	18
Over 2 hours	0	0	22	
Arrangement				
Not arranged	85	83	15	17
Same day	9	9	5	13
Day before	4	4	13	12
2 - 7 days	3	2	32	31
More than 1 week	1	2	35	27
Initiation				
Myself, own office	54	52	52	49
Other	46	48	48	51
Frequency				
Daily	8	18	0	14
Once a week	20	23	6	10
Once a month	16	14	18	13
Occasionally	40	34	42	38
First contact	16	11	33	25
Main Purpose				
Give order	16	13	9	7
Receive order	3	3	0	1
Give information	21	11	8	7
Receive information	26	26	14	9
Give advice	2	5	1	6
Receive advice	1	9	4	5
Exchange information	17	20	26	28
Negotiation 1)	8	3	13	8
General discussion	4	7	15	13
Other	2	5	4	16
Range of Subject Matter				
One specific subject	86	84	47	57
Several subjects	13	15	38	35
Wide range of subjects	1	1	15	8
Number of people at meeting				
One other			45	61
2 - 4			36	26
5 - 10 people			11	8
More than 10 people			7	5
Total Number of Contacts	1,160	5,266	193	1,554

1) Not strictly comparable with Central London.

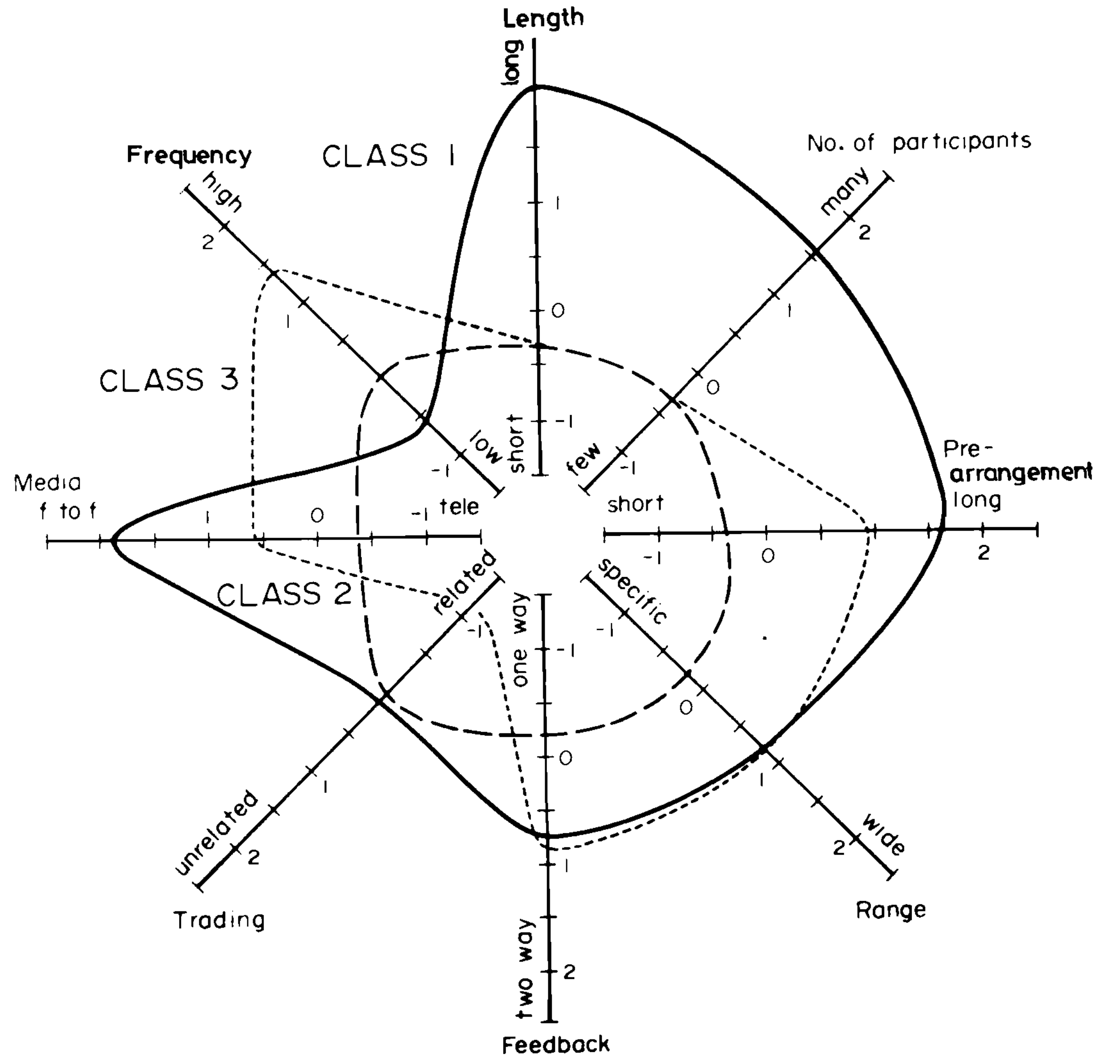


Figure 11. Multivariate classification of the external contacts of Central London offices (from Goddard [23]). The axes are in standardized units with zero being equal to the average for each variable.

Table 6. Classification of contacts (from Goddard and Morris [24]).

Location	Orientation %	Planning %	Programmed %
Central London			
External	14.5	4.2	81.2
Decentralized Locations			
Internal	7.3	17.7	74.9
External	10.3	1.1	88.6
Movers			
Internal	6.5	17.7	75.8
External	14.8	3.5	81.7
Non-Movers			
Internal	6.9	32.2	60.9
External	24.1	8.5	67.4

compared with 42 percent for telephone contacts and 79 percent compared with 50 percent for meeting contacts). Movers also record a lower intensity of contacts (an average per week of 6.2 calls and 1.3 meetings compared with 19.2 calls and 3.0 meetings for the non-movers).

The limited opportunities for orientation contacts with the local environment probably account for the lower intensity of this type of relation in decentralized offices. In his study of organizations located in four Swedish cities Thorngren has noted that orientation contacts are predominantly with Stockholm. Local orientation contacts are better developed in Umea which has a university than Sundsvall which is dominated by heavy industry. Yet there are few connections between the two centres even though they are relatively near to one another. The characteristics of the local environment and its accessibility to the national economy therefore have an important bearing on processes of information exchange.

The developmental significance of regional variations in opportunities for contacts of different types is difficult to assess. One attempt has been made by Collins who has used stepwise multiple regression to link Thorngren's contact data to the characteristics of the seventy respective establishments at one point in time as well as changes in these characteristics during the previous year (Collins [12]). This analysis corresponds to levels one and three of Figure 1. No attempt has yet been made to link this analysis with the higher level regional and organizational variables that were considered by Back, Dalborg and Otterbeck [4]. In one such model with the total number of contacts per head as the dependent variable, there were significant number of contacts per head as the dependent variable, there were significant (99.9 percent level of confidence) positive contributions from the following variables:

1) salaried employees as percent of total,
2) office space as percent of total,
3) turnover (in Kroner),
4) total number of products lines,
5) median salary level (in Kroner),
6) growth in proportion of office space,
7) growth in value added due to new products,
8) growth in proportion of value added accounted for by smallest product line,
9) growth in salary of highest quartile, and
10) growth in salary of lowest quartile.

There were also highly significant negative contributions from:

a) proportion of organizations' total employees in the unit,
b) proportion of all input from Sweden outside unit's own region,
c) proportion of output to unit's own region,
d) salary of highest quartile,
e) salary of lowest quartile,
f) service nature of product (0 = manufacture; 1 = service),
g) growth in proportion of all employees in unit,
h) growth in proportion of input from own region, and
i) growth in median salary.

The proportion of variance explained by this model is 64 percent.

These results suggest that units which have a large and growing office component, especially those on rising salaries rather than those in the middle levels tend to generate a large amount of external contact. The nature of the product and geographical environment also seems to have a bearing on contacts. Change and diversity in product structure leads to more contact activity while dependence upon the local region for inputs and outputs leads to less contact activity. Finally, the position of the unit within the corporate environment is important with small units in large organizations having the greatest amount of contact.

Conclusions for Further Research and Public Policy Towards Cross-National Comparisons

Many of the most interesting findings in this field have been based upon Swedish research. A number of isolated studies in Britain have begun to suggest that the Swedish findings are equally applicable in a different geographical context. Nevertheless there remains the possibility that many of the Swedish results, such as the importance of the local environment for organizational development and the connection between corporate structure and the urban system could stem principally from unique features in the spatial structure of the Swedish economy--namely a hierarchically ordered system of discrete cities separated by relatively "empty" areas. Sweden is a long way from urban Britain with its relatively easy access between cities, a more continuously industrialized area and "overlarge" conurbations with a decaying physical and industrial infrastructure. Nevertheless forces seem to be at work in the growth of corporate organizations which, when related to the development of national and increasingly international systems of cities, appear to transcend obvious geographical differences. If this is the case there is a pressing need to bring together researchers and policy makers concerned with understanding and managing both organizational and urban systems at the international level. And if the importance of inter- and intra-organizational information flows as a factor shaping corporate and urban system development is accepted, then this dialogue should include workers from the telecommunications field in order to identify how current advances in technology can be used to steer future development in desired directions. In the following paragraphs some possible elements in an international research programme are outlined.

The Spatial Structure of Corporate Organizations: The Organizational Environment

The most obvious task is to establish some inventory of the present and likely future changes in the distribution of various corporate functions within and between national urban systems. A great deal of simple information can be obtained from directory resources, company reports and the management press. But for a strategic view of corporate organizations and answers to difficult questions like the affect of recent mergers on the distribution of different functions, interviews with top management would be necessary. The aim of these studies should be to provide a spatial perspective to past and future developments in the structure of national and multi-national organizations.

The Changing Distribution of Employment in Non-Manufacturing Activities: The Geographical Environment

In order to assess the aggregate significance of changes in corporate structure for the development of the urban system it will be necessary to relate changes in the distribution of various functions to gross employment levels. Here we enter the thorny problem of comparable definitions of urban units and the availability of adequate occupational classifications of employment. In Britain a study of change in the British urban system during the 1960's is in progress. Standard Metropolitan Labour Areas (basically an employment core and its 15 percent commuting hinterland) defined for 1971 provide the areal units. The advantage of a labour market definition of urban areas is that residence based occupation data can be related to relevant employment centres. But the problem still remains that most census classifications of occupation inadequately describe the functions of non-production workers.

Information Flows Within and Between Organizations: The Link Between Geographical and Organizational Environments

Empirical studies of actual information flows within and between geographically separate units of large organizations can provide valuable behavioural insights into mechanisms underlying a wide range of organizational and regional development processes. More important data on contact patterns can provide information that can be used positively in the management of organizations and the urban system, the latter through public involvement in the strategic planning of decisions of organizations and influences on the contact environment in the form of investment in advanced telecommunications and the designation of growth centres based on information functions.

The importance of studies of information flows in both an urban systems and management context is that existing contact patterns can provide an early warning of future changes. Flows of information are a necessary precursor of other organizational changes: today's non-commercial contacts may lay the basis for future changes in, for example, suppliers which will ultimately be reflected in new patterns of goods and money flows with consequent impacts on employment levels for contractors in different regions. Already several Swedish companies are keeping track of meetings, telephone calls and correspondence inside and outside the company as a regular means of diagnosis and planning and even as a permanent and continuous management method (*Business International* [9]). Unlike financial data which refer to past performance contact data derived from diary surveys can indicate future potentialities and problems--for example "blind spots" in the external contact network (e.g. sectors of the environment not covered by any part of the organization), a failure to link up external and internal networks or an "over-concentration" of external links on particular individuals or departments.

The important point for urban systems development is that relocation and spatial re-organization can be one of the areas by which organizations can overcome some of these communications problems. Because of fundamental time-geographic consideration changes in the geographical location of administrative functions are bound to have a profound impact on the way individuals communicate and ultimately on the patterns of interdependence in an urban system. Our finding that individuals communicate in different ways in different places suggests that relocation can be used as a positive tool in management; for example it can be used to bring together departments that need to communicate more with each other and perhaps less with other firms; to improve linkages with other firms that are located elsewhere, perhaps in newly emerging spheres of interest for the organization; to encourage the devolution of some functions to lower levels in the organization thereby creating space and time in a head office for decision making activities.

The success or otherwise of the relocation will need to be maintained by regular communication surveys or "audits." These data may suggest additional changes in the formal organizational structure or new telecommunication devices that are needed in order to derive the maximum benefits from the new locations. In such contact surveys limited attention need be paid to the direct costs of communications. The extent to which old contact networks adjust to new organizational and locational situations suggests that attempts to formally determine the communication costs and benefits of particular location strategies are of limited validity. Because of the large area of uncertainty and the speed with which changes can occur in environmental conditions, a process of monitoring a selected strategy coupled with appropriate adjustments in that strategy is probably more appropriate than a "one shot" cost-benefit analysis. Relocation of administrative functions should therefore be seen not solely as a short run economic decision with respect to such factors as rents, labour costs and telephone bills, but as part of a process by which organizations can adapt to changing environmental conditions.

The Public Policy Implications

A number of writers have stressed the need for public policies of concentrated decentralization of activities from capital cities as a means of reducing regional inequalities in economic and social development (e.g. Rodwin [39]; EFTA [15]). Already a limited dispersal of routine administrative functions from metropolitan cities is occurring, a process encouraged in some countries by public controls on office development. But in the main this has consisted of short distance moves to relatively minor centres (Rhodes and Kan [38]). However, studies of intra- and inter-organizational communications could be used to identify opportunities for converting some of these moves into more significant transfers to distant centres high in the urban hierarchy. Such moves may not be to the disadvantage of individual organizations. Short distance relocation that predominates at present will not encourage the establishment of new local linkages which might be an essential component of an administrative decentralization strategy. It is therefore necessary to distinguish between *dispersal* of administrative functions--which is purely a geographical concept and *decentralization* which is also a functional concept which geographical separation may encourage.

A widespread dispersal of information processing activities is both undesirable and unrealistic. Existing investment in physical infrastructure in sub-national urban centres whose level of functional significance in the corporate hierachy may well be below their rank size in population terms suggests a considerable under use of scarce resources which can only be remedied by major decentralization programmes. Within such centres there will be possibilities for the use of relatively cheap "narrow band" telecommunications (e.g. document transmissions and group audio) for intra-urban contacts while public studios can be used for inter-city broad band video telecommunications. It is unlikely that a large number of dispersed locations will be equipped with such facilities, at least in the short run; furthermore most recent research on substitution between telecommunications and travel seems to suggest that the greatest potentialities exist for the use of cheap narrow band systems in relatively low level contacts, contacts which are characteristically intra-urban rather than inter-urban. Narrow band facilities such as document transmission devices can be provided in the user's office while broad band video facilities often necessitate travelling to a public studio. Having made this journey it is often just as economical to make a longer journey and gain the advantage of a personal contact. Most significantly, telecommunications are most effective where the participants are also in regular personal contact, which again is only possible in large urban centres.

In addition to telecommunications considerations, there may also be a number of other benefits to be gained by a programme of decentralization of decision making functions to major urban centres in development areas. In the larger urban centre there are greater opportunities for the establishment complexes of inter-related information exchanging activities which can provide external economies for each other but also act as a stimulus for growth and change in the surrounding region. Although the growth centre based on a propulsive industry may not be a realistic proposition in terms of material linkages, such a centre could have very real meaning in terms of the location of administrative functions and their associated information flows. The location of decision making functions in provincial centres may make such places the terminal points for intra-regional linkages rather than simply staging posts for connections on to the capital.

A concentrated decentralization of administrative functions within private sector organizations clearly requires some new policy instruments to bring about the detailed steering of economic activities that this strategy implies. Traditional systems of blanket controls on physical development applied over wide areas of a country are very blunt tools. The subtle ways in which firms can adopt to environmental changes through administrative reorganization which may include alterations in the division of functions between locations suggests that the location processes for non-productive functions is even more difficult to control from the point of view of regional policy than the location of manufacturing plants.

Because the process of environmental adaption is heavily constrained by information channelled through established networks, contact patterns are a very key element in the process of change *and* also control. It is well known that organizations frequently make sub-optimal decisions partly as a result of a failure to appreciate fully the information constraints imposed by their own limited contact networks. Communications audits administered by a public agency could be a very powerful tool in urban and regional policy by highlighting for firms opportunities for alternative locational/organizational arrangements, especially the advantages to be gained through locating different but complementary functions in the same city. While governments frequently become involved in the field of industrial re-organization, mergers and the like, attention is seldom paid to the spatial implications of the interventions. Communication surveys can reveal for example the possibility of linking up complementary functions in nearby cities; a public agency could thus become a "contact wholesaler" without becoming directly involved in the financial affairs of private organizations.

Nevertheless this approach will inevitably involve a much greater direct involvement of government in a collaborative way in the long run strategic planning decisions of organizations rather than the crude "carrot and stick" approach applied solely to the geographical environment. This is not to deny, however, the need for spatial policies which designate growth centres based on information exchange functions with such centres set in the context of a national framework for the urban system. The emergence of the post-industrial society emphasises more than ever the need for such an urban focus to regional policy. Without a national urban policy that takes account of the influence of contact possibilities on regional development, existing spatial inequalities are likely to remain. Indeed investment in communications infrastructure such as conference video facilities and advanced passenger trains that are uncoordinated with location policy are only likely to increase regional differentials in contact opportunities and ultimately in economic and social development.

Postcript: Some Analytical Models

As research in this area is still very much in its infancy only a few attempts have been made to model regional and organizational information flows analytically in order to evaluate in a systematic manner the possible consequences of alternative policy decisions. The work that has been done has primarily been concerned with evaluating alternative patterns of decentralization of central government agencies. Similar approaches have been applied to aggregate redistribution of employment in contact intensive occupations (Törnqvist [44]; Engström and Sahlberg [18]).

The key to much of the Swedish work is the notion of the "contact landscape" which is based on the concept of contact potential:

$$Pi = \sum_{j=1}^{N} (Ti_j - Di_j) . K_j$$

where

Ti_j = length of time in a single working day it is possible to remain in region j after a journey from region i;

Di_j = travel time by shortest route from i to j;

Ki_j = total number of persons employed in contact intensive job functions, weighted by the national average daily hours of contact for each job function (derived from a survey of business travellers on Swedish airlines).

Using this model Törnqvist and Engström and Sahlberg have evaluated various strategies for the redistribution of future increments of employment in information exchanging activities through the Swedish urban system. All of these strategies will reduce contact possibilities over the present situation although that of concentrated decentralization (Class 3) less so than others. However, if this strategy is connected with one of improving passenger transport connection by air between the larger city alternatives (i.e. across the urban hierarchy) then considerable improvements in contact possibilities result.

Similar conclusions have emerged in attempts to model the impact of the dispersal of government agencies from Stockholm and London--namely that any relocation will lead to an increase in travel but less so if groups of inter-connected agencies are concentrated into large centres. However, much of this work can be criticized because it represents a closed systems view of organizations--with the emphasis placed upon the impact of relocation on existing linkages and little consideration being given to the possibility of new patterns of communication developing in the new locations (Goddard [19]; Goddard and Morris [24]). If the adaptive view of organizations that is stressed in this paper is accepted, then it is clear that relocation is not simply a matter of stretching existing communication links. In the short run some contact sources, particularly those which are unique, will require more travel but others will be transferred to the new location; in the long run the nature of the activity is likely to change as the organization adapts to the opportunities and constraints presented by the new situation and the environment itself adapts to the injection of new employment. The open systems modelling of these processes is clearly a major priority for future research.

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Spatial Organization of Activity Spheres

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1. The Background and Aim of the Report

This report presents a selection of Swedish studies recently commissioned by the Ministry of Labour, Expert Committee on Regional Development. The purpose of the investigations summarized here has been to study the Swedish production system (or, in a broader sense, the Swedish activity system) from a geographical point of view. This geographical approach is partially illustrated in Figure 1, which shows a hypothetical production system in a geographical perspective. The figure shows work places or establishments distributed over a number of regions. The establishments are interdependent and are linked together by the transport of goods, persons and information. The links can be identified as purely physical flows, but in many cases also as flows of payments in various directions. The production system is also comprised of links in the form of ownership and power relationships.

According to Figure 1, the establishments in Region A form a comparatively closed sub-system, i.e. the units depend very little on units in other regions. In Regions B, C, D and E, on the other hand, a large proportion of the work places are linked with units in other regions. Regional borders cut up the studied production system in a way that inevitably makes it much more difficult to make useful comparisons between regions, particularly if such comparisons are based on aggregated data. In a modern society, the operations of different work places are often highly specialized. In other words, there is a marked division of labour within a national production system. Production results that can be measured in one region (e.g. Region E in Figure 1) are achieved by teamwork between units, some of which are nearby within the observed regions, but most of which are far away in other regions. Changes identifiable in one region may be the result of the events and circumstances in other regions; or vice versa, as a result of the links joining different work places, actions and changes in one region always have greater or lesser effects in other regions.

The following account will clarify in more detail that there is a complicated pattern of inter-dependence in a system of the kind illustrated in Figure 1. On the other hand,

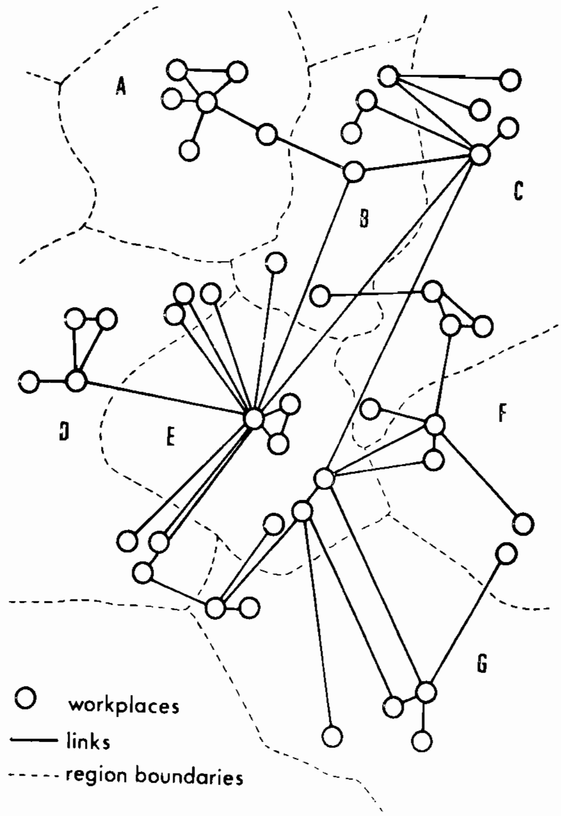

Figure 1. A hypothetical production system in a geographical perspective.

it is very difficult to *quantify* the importance of these interdependencies, as our knowledge of the processes at work in spatial systems is extremely limited.

2. The Planning and Organization of Research

The organization of work in the research project described in this survey is shown in Figure 2. Work has been divided into three stages--in the diagram termed survey, analysis and experiment. Work is now in progress in all three stages, but the emphasis has gradually shifted from elements in the lower part of figure to those in its upper area. Figure 2 also has a dimension called the aggregation level. At the lowest level the objects are individual employees and work places. The highest level comprises investigations based on aggregated data for entire urban regions within and outside Sweden.

Survey

When the research project started, it was assumed that a strong motive force in the urbanization process--primarily the concentration of certain activities in large urban regions--is the need for contacts in the exchange of information between increasingly specialized job functions in society (see Figure 3). In order to test the accuracy of this assumption a series of studies was made of direct personal contacts between employees in various kinds of companies and other organizations. These investigations made it possible to identify the characteristic feature of the contact patterns of various job functions and organizations.

Parallel with these investigations, a study was made of the spatial organization of employment in Sweden. The same functional classification of employment was used in this latter study as in the above-mentioned contact studies. The charting of personal contacts linking various activities and regions has later been complemented with inventories of telephone contacts and flows of goods. Thus far, work in the project can be said to be *observations of actual behaviour* in a national (activity system).

Analysis

In the next stage of research, interest shifts to studies of the *limitations on and possibilities for* the functioning of different kinds of activities in varying locations in the country. We have investigated the possibilities of maintaining direct personal contacts and telephone contacts and the possibilities of transporting goods.

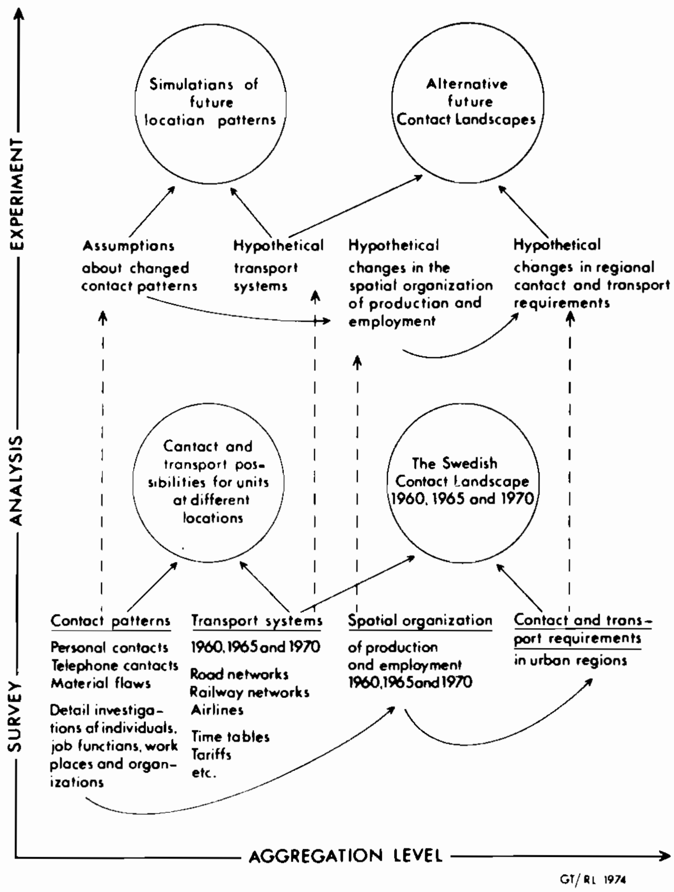

Figure 2. Organization of work.

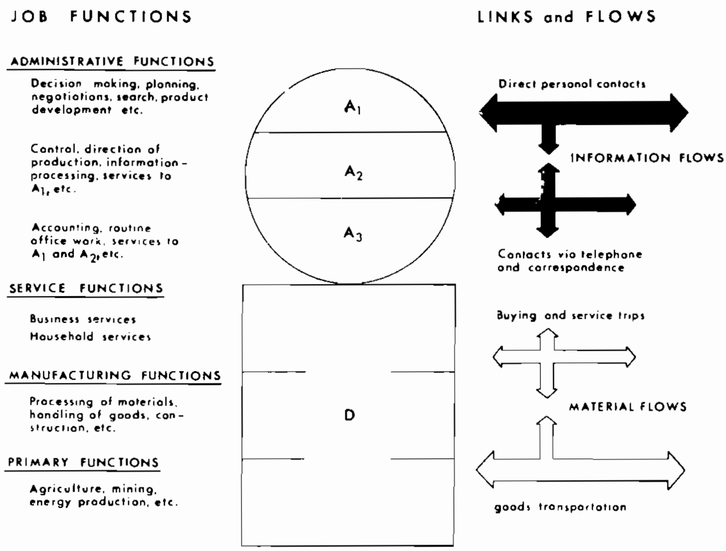

Figure 3. Diagrammatic representation of an activity system consisting of job functions connected by links and flows.

As a basis for these analyses of location conditions, the transport system (road network, railroads and airlines) was studied in some detail. The time-distances and costs characterizing the transport system have been used to determine the accessibility of different localities and regions relative to one another.

In the micro-studies, the observation units to be located are employees, job functions, work places or entire organizations. Measurements are made of the effects of hypothetical relocations on contact activity and transportation on these units. Effects are measured in terms of time and costs. The analyses have an empirical basis, as assumptions about the scale and orientation of transportation in various locations are grounded upon observation of actual contact-pattern and transportation behaviour. Moreover, all travel and transportation takes place in a real transport system.

The macro-studies are represented in Figure 2 by analyses of so-called contact landscapes. These are based on aggregated data. Contact requirements in various urban regions are calculated by imposing data of contact requirements of different work functions on the aggregate of functions in each region. The contact landscape then shows the regional balance or imbalance between these contact requirements and the travel supply available in the existing transport system. Consequently, these investigations are also analyses of real situations.

The macro- and micro-studies complement one another, for one thing, by revealing the advantages and disadvantages of these two study methods. The macro-studies give an *overall picture* of the interplay and interdependence between the location of economic activity and public administration on the one hand and the configuration of the transport system on the other. But the findings of analyses at this level of aggregation are very difficult to interpret. On the other hand, micro-studies, which can only be done in the form of a limited number of *case studies,* give a deeper insight into the links existing in a complex activity system.

Experiments

In this stage of the project, the studies of consequences are taken a step further. The idea is to study the long term effects of different assumptions about future spatial organization and various policy measures. By experimenting with operational models, it has been found possible to identify some of the constraints upon opportunities for shaping the society of the future.

In contrast to the investigations described above, these experiments are based on purely hypothetical distributions of work places and settlements and a purely hypothetical transport system. Both micro- and macro-studies form parts of these experiments. So far, the consequences of various alternatives and solutions have mainly been studies from the point of view of companies and administrative authorities. But some initial attempts also have been made to measure the consequences of various changes for private households and individuals.

This paper does not, of course, allow a description of all the investigations done within the framework of the research programme presented above. Instead, the account is restricted to a *small selection of examples*. These have mainly been chosen from the studies published in English. The reader can find more detailed descriptions of methodology and findings in these reports. The fact that many of the investigations illustrate specifically Swedish conditions also probably makes it desirable to limit this account to just a few examples.

3. Examples of Links in a National Production System

As a first step towards a more profound understanding of the processes that take place in a national activitity system it is necessary to take a closer look at the links binding together various work places in Figure 1. It is obvious that the nature of these links depends upon the type of activities carried on at the different work places. The following examples are taken from the earlier mentioned studies of regional interdependence.

Figure 3 shows four groups of job functions likely to be found in the units included in the studied production system (activity system). Examples of tasks typical of each group are given under each heading. Several of the given functions are to be found simultaneously in many work places or establishments within a production system. For example, functions concerned with physical production and handling of goods are usually predominant in units of manufacturing companies. But within each unit there are also service functions and administrative functions of varying significance. In what the official statistics classify as manufacturing industry, there are also work places of the head-office and sales-office type, which accommodate administrative and some service functions, but which entirely lack proper manufacturing functions.

Service functions are particularly characteristic of work places in commerce, transport and communications, education, health and medical services, social welfare, business services and recreational services. Administrative functions are probably present in all types of activity in a modern society.

The administrative share of total work input at a work place can, however, vary from very slight--on a farm for example--to overwhelmingly predominant, in an organization such as a public administrative agency.

Figure 3 also shows the types and flows of contacts that are characteristic of various job functions. As each establishment included in the studies production system (Figure 1) may simultaneously accommodate several job functions, the units are also linked together by several different kinds of contacts. Information is transmitted via direct personal contacts requiring journeys of one or more of those involved, and via telephone contacts and correspondence. Services also require the transport of people, whereas the manufacturing functions and primary functions are linked together by goods transportation. The flows that bind together the objects in the system often have corresponding flows of payments moving in the opposite direction.

All types and flows of contacts shown in Figure 3 have been identified, analysed and compared with one another. *Micro-studies* are then based on descriptions of direct personal contacts, telephone contacts, the buying and selling of services and the buying and selling of goods for individual companies and other organizations. The *macro-studies* are based on aggregated data and comprise direct personal contacts, telephone contacts, buying and selling of services and flows of goods within and between entire urban regions in Sweden.

It is impossible in this report to give an account of the different contact patterns. The direct personal contacts of organizations and urban regions have been described in an earlier report in English.[1] Partly in order to describe the techniques that have been used, a few examples are given here of other types of contacts in the Swedish production system.

Figure 4 is an example of a micro-study and shows the outgoing telephone calls from a manufacturing firm in Malmö in the course of one week in May 1973. Calls have been allocated to a mesh of squares measuring twenty by twenty kilometers. Squares receiving less than one-half percent of calls are shaded grey. This investigation used an *automatic traffic reader* which registers calls going through the exchange of the studied firm. The calls are located with the help of the dialling code and the first figures in each telephone number, which show which automatic telephone station in the country connects each outgoing and incoming call. In 1973, Sweden had 6,687 such stations throughout the country. As these stations are assigned coordinates, all the maps of

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[1] G. Törnqvist, "Contact Systems and Regional Development," Lund Studies in Geography, Series B, No. 35, Lund(1970).

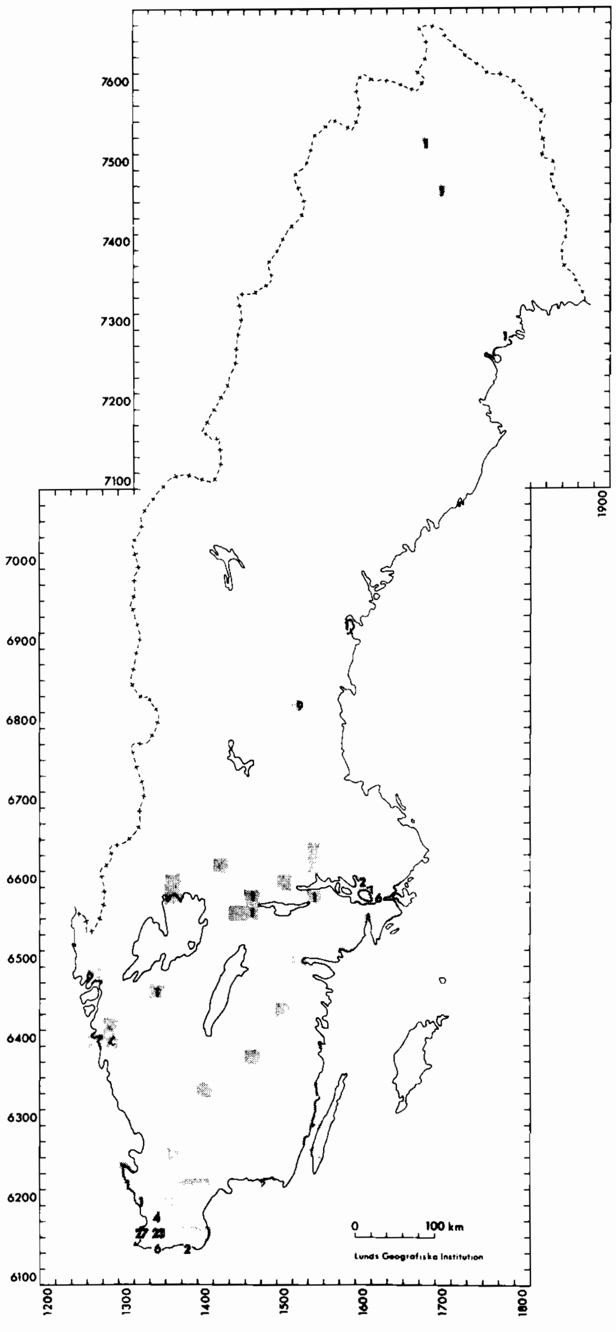

Figure 4. Outgoing telephone calls from one manufacturing firm in Malmö.

registered telephone call data can be done by computer. Telephone-call networks of this kind are registered for a great number of companies, other types of organizations, private households, as well as for entire urban regions throughout the country.

Figure 5 is an example of a macro-study and shows the geographical distribution of sales of goods by manufacturing companies in 1970. All the companies included in this study are located in Malmö and its environs, i.e. the southernmost urban region in Sweden. Deliveries, like the telephone calls, have been plotted over squares measuring twenty by twenty kilometers. Figure 6 gives a corresponding picture of the manufacturing companies purchasing of goods in the course of one year. Similar maps have been made for various urban regions all over the country.

4. Examples of Changes in Employment in Modern Activity Systems

Activity systems of the kind described in Figures 1 and 3 can be presumed to undergo constant processes of change. The effects these changes have on employment are of particular interest in regional policy.

Activity systems in countries which can today be described as post-industrial societies--e.g. the United States, Japan, Canada, Switzerland, the FRG, France, the Benelux countries, the United Kingdom and the countries in Scandinavia--have undergone radical transformation. To put it simply, these changes can be described as marked shifts in concentrations of gainful employment from primary functions, typical of the agrarian society, via manufacturing functions, typical of the industrial society, to service and administrative functions which account for a high proportion of gainful employment in the post-industrial society (see Figure 3).

Very probably, these changes in the structure of employment will become accentuated in the future. The primary and manufacturing functions will require less and less manpower. Activities comprising personal services requiring person-to-person contacts will absorb more and more of the labour force. Employment will rise very sharply in the administrative functions, which will be characterised by complicated information processing, decision making, planning, research and product development.

So far these structural changes have gone hand in hand with a heavy concentration of job opportunities and settlement in large urban regions all over the world. The growth of metropolises is largely due to the dynamic expansion of the

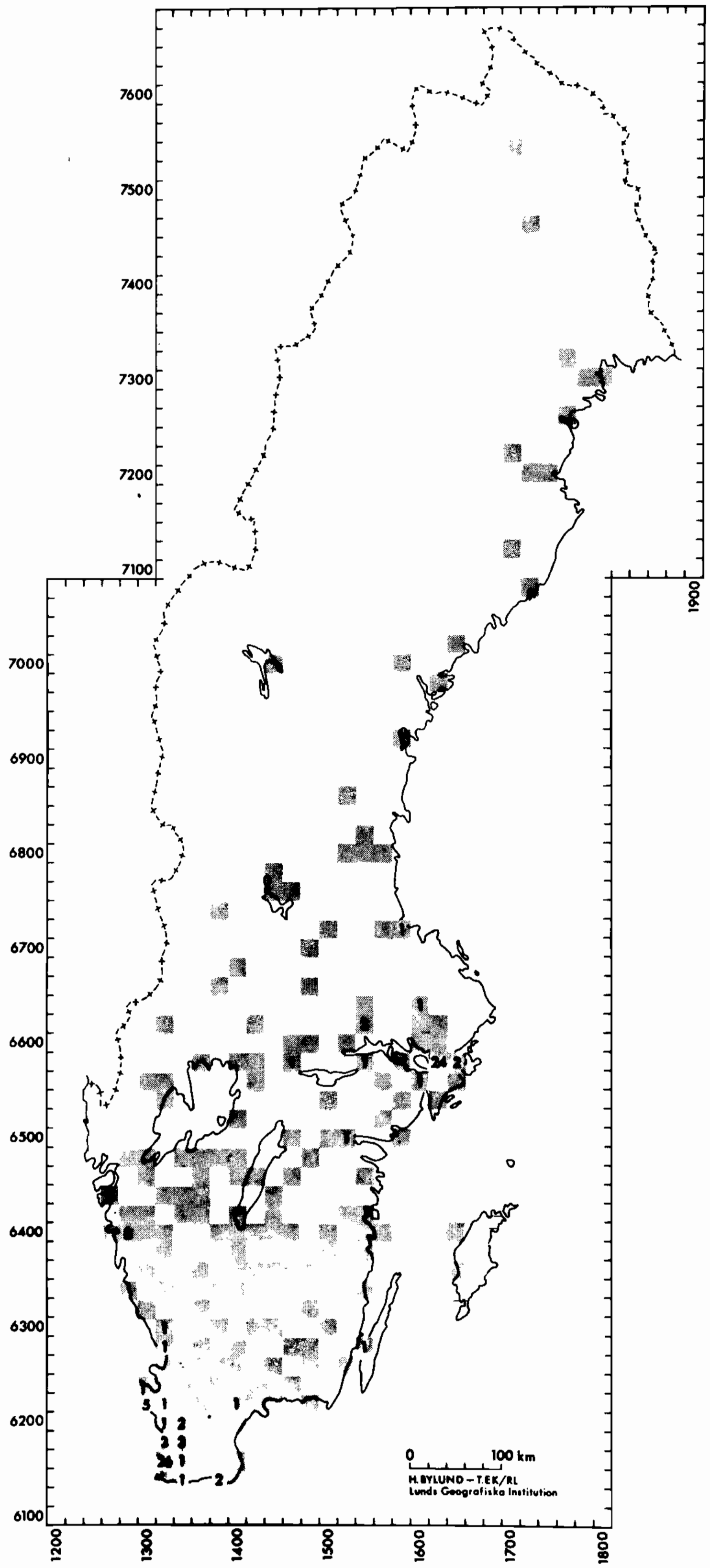

Figure 5. Sales of goods. All manufacturing firms in Malmö.

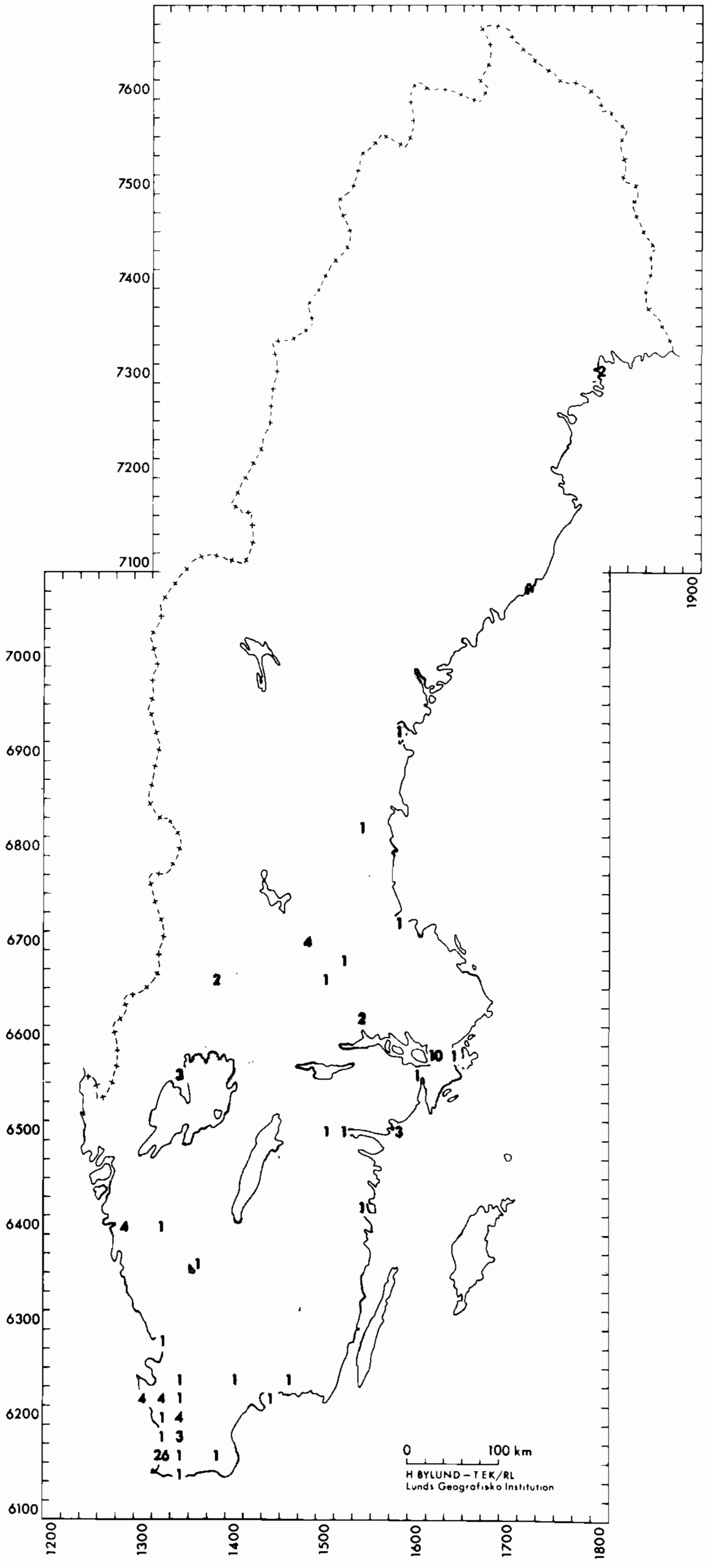

Figure 6. Purchasing of goods. All manufacturing firms in Malmö.

service and administrative functions. The head offices of companies are concentrated in the major urban regions. There the administrative and management personnel of related organizations, finance organizations and most of the growing public administration congregate. Around these conglomerations of control units congregate every imaginable type of service, together with radio and television corporations, newspapers, publishers, etc.

In Sweden, as in other post-industrial societies, the expansion in employment has shifted mainly *from* the primary and manufacturing functions *to* administrative functions (marked A in Figure 3). The number of employees in functions responsible for the exchange and processing of information--particularly the most contact-intensive (A_1)--has increased very rapidly. In 1960 the number of contact-intensive employees was 150,000 in round figures. In 1965 it had reached about 200,000, and by 1970 around 250,000. This means a rise of about 65 percent in the sixties. There has been a parallel decline in employment in functions responsible for the processing of materials and the handling of goods in the studied activity system.

The regional redistribution of occupational activity in Sweden in the sixties has been *selective*. The functional differentiation between the seventy major urban regions in the country has become increasingly pronounced. The information processing, control and administrative functions in both the private and the public sector have become increasingly concentrated in Stockholm, Malmö and Gothenburg, and in that order. At the same time, manufacturing and goods handling, particularly the more routine processes, have been decentralized and dispersed among the less populated urban areas in various parts of the country. These differences in regional distribution between the administrative functions and the manufacturing functions are partly due to the increasing number of organizations with regionally dispersed units. The latter are usually large organizations with a great number of employees and when they are divided up, the control units are located in a major urban region, whereas the other units are frequently given a more peripheral location.

Although the 250,000 contact-intensive employees may not constitute a particularly large occupational group, there are many reasons why they are *a very important group from the point of view of regional policy*. At least half of these employees are now working in the major urban regions and there exert a strong multiplier effect on employment. First, the contact-intensive employees attract other groups of personnel for services, registration and processing of information in their own organization (A_2 and A_3 in Figure 3). Second, clusters of control units in the major urban regions attract administrative sub-contractors and other types of business services. Third, the contact-intensive employees have an advanced education and an average income that is four times as high as the average income for all gainfully employed in the country. This means that the regional concentration of administration in society also leads to a concentration of purchasing power, which lays the foundation for specialized household services and for a rich and varied cultural and recreational life.

It is reasonable to assume that the development described here has accentuated regional inequalities in Sweden as regards, for example, the distribution of income, social structure and education. From the point of view of social and regional policy, this trend towards increased regional segregation can hardly be desirable. The question is whether transport economies are a sufficiently strong motive for this bunching together of contact-intensive activities (see Törnqvist, "Contact Systems and Regional Development").

5. Transport Cost and the Concentration of Production

As I mentioned earlier, a great deal of work has been put into analysing how *transport facilities* and *transportation costs* influence the localization of various kinds of activities. It should be borne in mind here that the researchers have gradually shifted their interest *away from* analyses of facilities for transporting goods *to* analyses of facilities for transporting people.

The following account is devoted to giving a few *examples* of analyses that have been carried out. This section deals with goods transportation, whereas various kinds of passenger transport are discussed in a later section. The conclusions can be drawn from the investigations done in Sweden on *costs for transporting goods.*

The Swedish production of goods is carried on at units which show greatly differing degrees of mobility from the transport-cost standpoint. Studies reveal that costs incurred for the transport of goods vary greatly between plants producing different kinds of goods. This means that the sensitivity to differences in regional transportation costs differs greatly from one industry to another. In the case of certain types of production, differences in transport costs between the different regions and localities in the country are equivalent to only a few percent of company turnover. For other types of production, these differences amount to a much greater proportion of turnover.

When it comes to installations whose location is subject to restraint exercised by transport costs, it is possible to distinguish a definite group where it is mainly sources of raw materials that immobilize installations, whereas for another group the main factor affecting transport costs is the geographical dispostion of the market. The characteristic feature of the *installations bound to raw material sources* is that they mainly process heavy, bulky, or fragile raw materials for more easily transportable semi-manufactures and finished goods. Examples of such installations are iron and steel works, potteries, glass and ceramics industries, sawmills, pulp and paper mills, chemical plants and some types of food manufacturing activity.

Earlier studies have shown that the number of installations bound to raw material sources increased in Sweden up to World War II. Since the war the number has declined heavily. At the beginning of this century these basic industries accounted for the greater part of employment in Swedish manufacturing industry. Today, probably less than 20 percent of industrial workers are employed at such plants, in spite of the fact that the volume of production has increased considerably. Parallel with this trend, the locational limitations exercised by transport costs on this category has lessened.

When it comes to industries whose *mobility is restrained by markets*, the geographical layout and scale of their markets often affects the size and localization of production in various parts of the country in a way that will be discussed in more detail later in this paper. In all probability, in this group, technological and economic trends also have lessened the comparative importance of transportation costs, and production has gradually been concentrated in larger and fewer units, with the result that employment has declined in many regions.

Finally, there is a large number of plants that can be described as *mobile* from the point of view of transportation costs. This does not signify that transport costs are of no importance for such plants in all locations, but only that factors other than costs of transportation of goods are usually of far greater importance for expansion and the location of such plants in different regions. These mobile units are to be found in the textile industry, plastics manufacturing, machinery manufacturing, electrical goods industry, transport equipment industry and the metal goods industry, just to mention a few examples. Many of these plants are primarily assembly plants. Their raw materials consist of semi-manufactures and finished components. They produce goods of a high marketing value in comparison to transported weight and volume. These industrial units are components in a vast system of assembly plants (see Figure 1) with sub-contractors in a long chain, spread over a large number of localities both in Sweden and abroad.

The great majority of the newly established units in manufacturing industry, units that have been relocated and those that have been established as branches in Sweden since World War II, belong to this foot-loose group. Today approximately half of the work places in manufacturing industry fall into this category, and these probably employ about two-thirds of all industrial workers in Sweden.

The same conclusions can be drawn from the findings of foreign studies of the mobility of industries from the transport-cost point of view. But it should be borne in mind that up to now the term "transportation costs" has been too narrowly defined as referring only to costs of goods handling alone. For future studies, there is reason to broaden the definition of the term, and examine more closely such factors as inter-regional disparities in *time consumption* and *regularity* in the case of deliveries of raw materials and finished products. That is the same approach as is used in the following account regarding studies of passenger transportation ought be applied.

The rest of this section will be devoted to an attempt to couple a discussion of differences in productivity and costs of production in industry with analyses of regional variations in transport costs. Attention will be focused on the linkages between production costs (excluding transport costs), transport costs and the geographical distribution of the market. These linkages are complicated and it should, therefore, be observed that the discussions here are mainly concerned with principle and that they are based on far-reaching simplifications and special assumptions. It should particularly be borne in mind that the discussion is limited to the variations in production costs depending upon the size of production units and to the costs of transporting finished products to a geographically dispersed market.

The following remarks should, in the first place, be relevant to the types of plants in manufacturing industry that I have here called market-bound from the point of view of transportation costs. The characteristic feature of this group is that distribution costs, or to be more precise, costs for transporting the finished products, account for a high proportion of total production costs. When a firm has a market that is spread over an area, say, of the size of Sweden, these transportation costs vary greatly, according to how production is divided up and located in the country.

In this market-bound group of industries, firms often produce goods that do not keep well (e.g. perishable goods) or goods that are heavy and bulky at the same time as they have a comparatively low commercial value. In other cases, the sensitivity to distance may be due to the fact that production presupposes close contacts with consumers if, for example, goods are made to order, or products have to be installed and serviced. The latter category of necessity involves passenger transportation, on which distance exercises a constraint. This category will be discussed in more detail in the next section. Another characteristic of the market-bound group of industries, is that the costs of transporting raw materials is of less importance for the location of units, e.g. on account of there being alternative sources of raw materials or suppliers being available in several places throughout the country.

Some examples of industries in the market-bound group are cement and concrete factories, brickworks, breweries, bakeries, dairies and other foodstuffs factories, repair shops, joineries and some types of printing works. It is common in this group of industries for the same or similar type of production to be divided up over several dispersed units, which may be competitive producers or regionally independent units within the same company. One result is that a national market is divided up into regionally or locally demarcated market areas, although these markets may overlap considerably. These conditions are reflected in the mean transportation distance per transported unit of production recorded for different products and types of goods. Products sold in Sweden in a market which, geographically speaking, is a national market are transported over distances averaging between 300 and 600 kilometres, according to where production is located in the country. Products from strongly market-bound units, on the other hand, are transported over distances averaging ten to sixty kilometres.

When discussing the connection between transportation costs and the concentration of installations we can start off by posing the following questions:

1) from the point of view of distributing costs, what is the optimum location of 1,2,3 ....n facilities or installations (e.g. factories or warehouses) within a geographically dispersed market, if account is also taken of the transportation costs of all (facilities)? and

2) how large should the different facilities be and how should they divide up the market between themselves to ensure that total distribution costs will be as low as possible?

Together, these two questions form a problem block within which several variables are allowed play. It is hardly possible to obtain a clear analytical answer. Instead, a heuristic technique has been developed, which is too complicated to explain in this short report.[2] With our heuristic methods it has not been possible to demonstrate that the optimum solutions arrived at are global. After a series of experiments with these methods it is clear, however, that it is very probable that this is the case.

The example chosen here is a building material, light porous concrete blocks, which in Sweden is sold under the trademark "Ytong" or "Siporex." The empirical point of departure is the distribution of sales of this product in Sweden ten years ago. At this time, the spread of the market corresponded approximately to the distribution of population and exports were very low. Then we calculated the optimum (see reservation above) locations of one to eight units from the distribution-cost standpoint. In all these calculations of transportation costs, it has been assumed that carriage is by truck and/or train, account being taken of the route and terminal costs prevailing ten years ago.

Findings are illustrated in the series of maps in Figure 7. Map A shows the best location in terms of transport costs of a single plant supplying the entire market. Map B shows the best location of two plants, with one plant accounting for 61 percent of supplies, the other for 39 percent. Maps C to H show the optimum location combination, sizes and distribution areas of three to eight units. Generally speaking, plants should be situated centrally in the market so that transport distances can be kept as short as possible. At the same time, plants should be spread as far away as possible from one another so that they cover the whole market. These two requirements counteract one another and the optimum locations we have worked out can be said to be the result of a compromise between these two requirements.

As a result of production being divided up between an increasing number of dispersed units, the total distribution costs for these units decline gradually on condition that it is possible to disregard the effect of scale economies on transport costs. Transport costs decline as shown by the lowest curve in Figure 8, i.e. from about thirty five million

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[2]For a more detailed presentation of calculations and methodology see G. Törnqvist et al, "Multiple Location Analysis," Lund Studies in Geography, Series C. No.12, Lund(1971); G. Törnqvist, *Studier i industrilokalisering* (Stockholm, 1963).

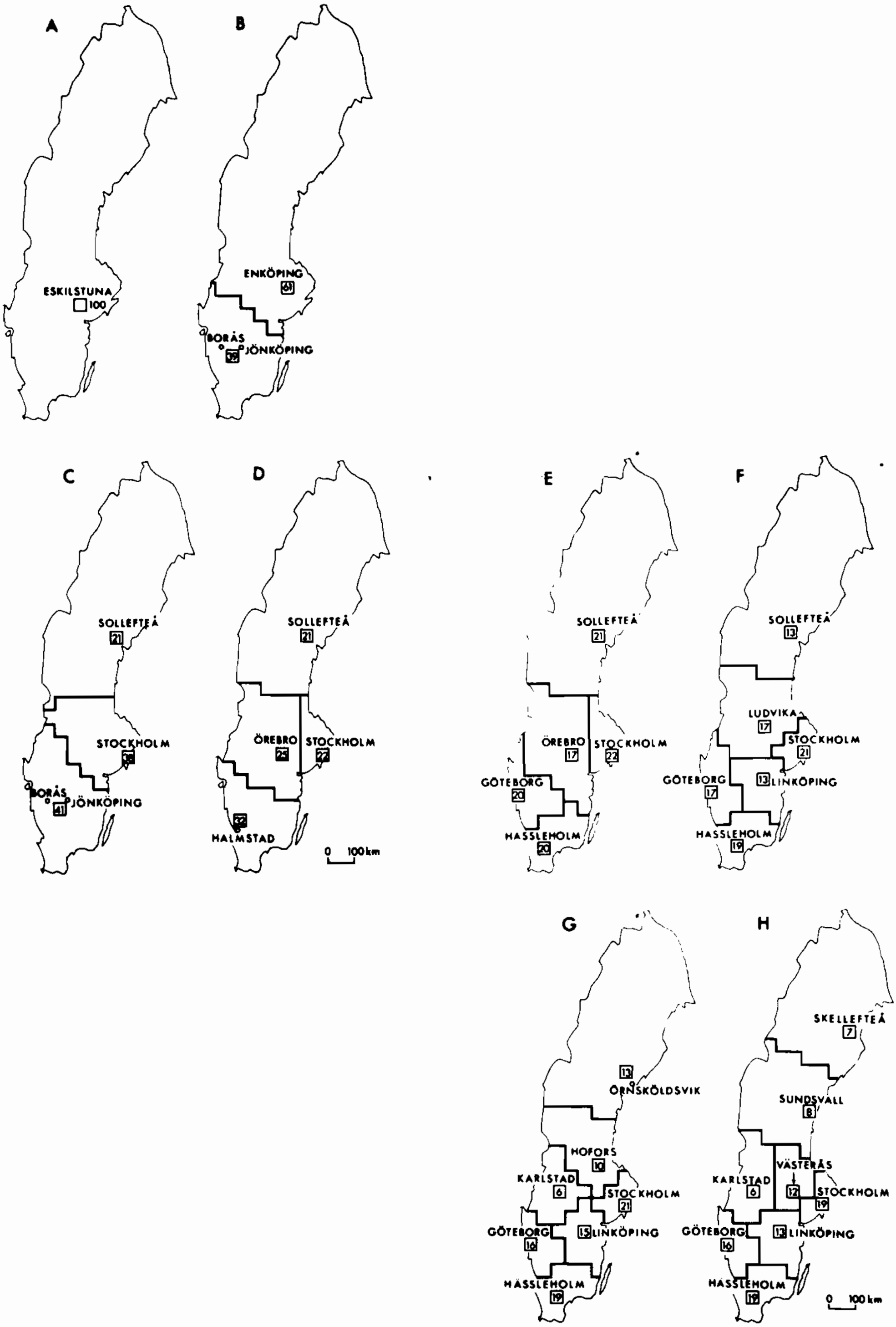

Figure 7. Optimal locations, capacities and market areas for one to eight plants (warehouses).

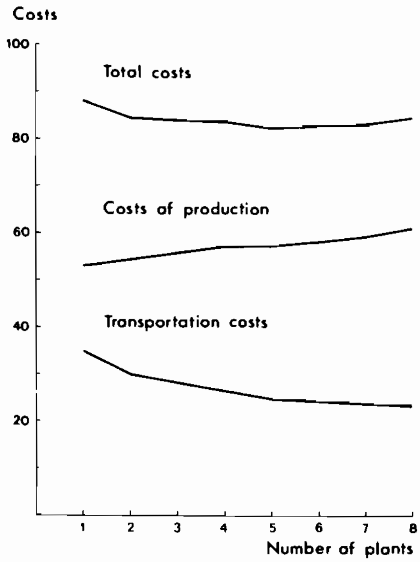

Figure 8. Cost curves for different number of plants on the national market.

Swedish crowns for one plant, about thirty million for two, and so on, to about twenty-three million crowns for eight plants. Presumably, costs continue to decline if production is further dispersed and divided up.

At the same time as transportation costs fall, however, production costs (excluding transportation costs) probably rise in the aggregate for all units, as scale economies cannot be fully exploited when production is divided up between smaller and smaller units. Figure 9 shows a hypothetical unit-cost curve depicted as A - B illustrating how production costs (excluding transportation costs) per unit produced fall as the size of the plant increases. According to the diagram, the smallest plant has a production capacity equalling a few percent of national demand, while the largest has a capacity equalling total demand. The scale economies shown in the diagram are probably due to the fact that payroll costs, costs of repairs and maintenance, certain administrative costs and capital investment per unit of capacity tend to decline on transition to larger production units.

Assumptions on variations in unit-costs are applied to the plants of varying sizes included in the alternatives A to H in Figure 7. This obtains the total production costs (excluding transportation costs) for one to eight plants as shown by the middle curve in Figure 8.

Finally, the upper curve in Figure 8 indicates the total costs for one to eight plants in optimum locations in terms of transportation costs. By total costs we mean the sum of the transportation costs and production costs included in our calculations. The curve shows a cost minimum at five plants, i.e. alternative E in Figure 7. The difference in total costs of production that occur when the number of plants is varied from two to eight are, however, comparatively slight, due to the fact that transportation costs and production costs in these alternatives more or less compensate on another. If we observe the *general rise* in transportation costs while holding unit-costs constant, the total curve in Figure 8 demonstrates that the transportation cost minimum goes down at the same time as this minimum tends to shift towards the right. Also, the location pattern in Figure 7 changes somewhat.

We now assume *a changed relationship between transportation costs and other production costs*. Transportation costs are assumed to remain unchanged from the preceding example. On the other hand, technological and other scale economies have increased, and piece-costs are now assumed to vary between plants of different sizes in the way illustrated by curve C - D in Figure 9. These assumptions result in the curves shown in Figure 10. The transportation-costs curve at the bottom

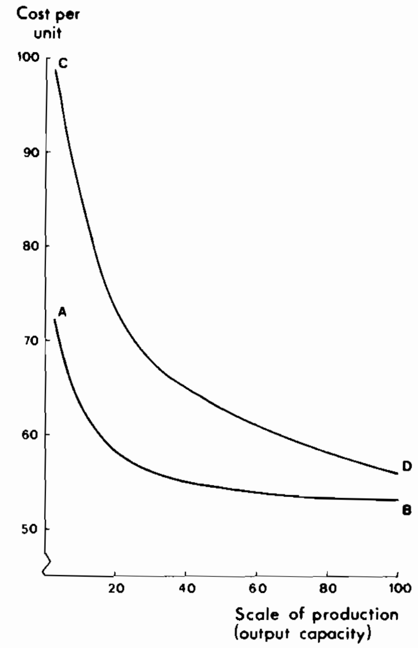

Figure 9. Unit-cost curves.

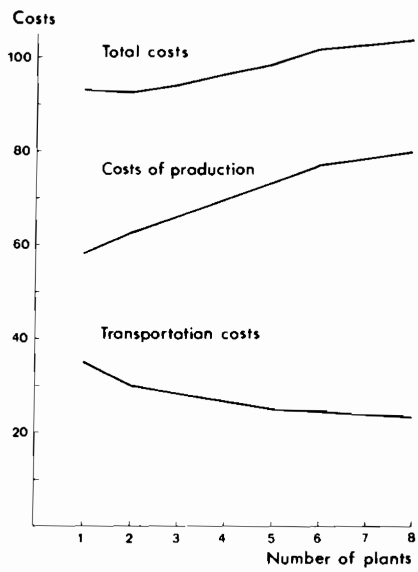

Figure 10. Cost curves for different number of plants on the national market.

is unchanged. Production costs rise as the number of plants increases, according to the function, illustrated by the middle curve in the diagram. The total costs curve at the top of the figure is quite different in this situation from the preceding example. It now appears to be economically advantageous to concentrate production in two units. Splitting production between several units results in considerable rises in costs.

The following conclusions can be drawn from the foregoing discussion of the linkages between transportation costs and the concentration of installations. In a society where transportation costs decline in *relative* importance, i.e. production costs per unit produced rise more rapidly than transportation costs per unit transported, there is a strong incentive to concentrate production in bigger and fewer plants even in industries that are closely tied to their markets. Concentration of this kind leads to an increase in total transportation effort and consequently in total transportation costs in society as a whole. The fact that the total costs of transportation in a society rise at the same time as they become a less important factor in location decisions is not paradoxical.

Technological and economic development has created a situation today where practically all industries find it profitable (unit-costs are lowered) gradually to step up the concentration of their installations. Reduced costs (operational costs) probably constitute by far the strongest motive force behind the transformation of the structure of production. The questions that obviously arise here are whether the rate of structural change and its orientation (the location of new investments) are the most desirable.

6. Personal Contacts and Location--Examples of Micro-Analysis

The fact that Sweden is one of the leading countries in the world when it comes to installations like railways, roads and power circuits in per capita terms is, of course, a sign of a highly advanced economy. At the same time, it is also a measure of the considerable economic burden implicit in long distances. Fortunately progress in the field of transportation techniques has practically neutralized the constraints exerted by distance. But there are still some difficult problems to be overcome. One fact, which seems almost too obvious to mention, but which is also of fundamental importance for the role played by transportation in production and social interaction, is that whereas goods and messages can for the most part be divided into small parts and be easily stored for short or long periods, people must be transported as whole entities and be supplied with a vast number of services both in transit and in situ. The result is that whereas distance has practically ceased to be an obstacle to the transportation of goods, the constraint exercised by distance on the transit of persons is considerable, and will also be in the future. This difference is a fundamental factor underlying urbanization. People functioning in day-to-day co-operation with one another must live fairly close together, a requirement from which the private motorist has, of course, extricated himself on the local plane, but this hardly applies when the daily pattern of movements is regarded on the national or international plane.[3]

The contact studies described in a foregoing section show how companies and other organizations in various parts of the country are linked together by direct personal contacts. It was found that the contact-dependent employees in these organizations are greatly involved in contact activity in the form of travel and meetings. Companies spend a lot of money on this kind of information transmission. It was also found that the amount of time these contacts took was burdensome for individual employees.

A method has been developed in the research now being carried out for calculating how a changed location affects the scale and orientation of contact activity.[4] This has made it possible to study how the costs of passenger transport vary from region to region, a study similar to that of regional variations in the costs of goods transportation.

The objects in the system studied can be selected from manufacturing enterprises, service enterprises or public administration agencies, all of which are dependent on the transmission of information via direct personal contacts or telecommunications. The units studied may be individual employees, departments, work places, entire organizations or blocks of organizations. Before presenting findings it is necessary to say something about the calculation methods which have been used.

After a contact study has been completed, in which the contact relationships (personal contacts and telephone contacts) have been registered, the contact situation at the location

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[3] Translation of a quotation taken from T. Hägerstrand.

[4] Ch. Persson, *Kontaktarbete och framtida lokaliseringsförändringar* (Lund, 1974). (*Contact Activity and Future Changes in Location Policies.*)

concerned can be described and evaluated. It is now possible to quantify and distribute by region the journeys and telephone calls necessary for maintaining contacts. The number of journeys and calls and their distribution are depicted in matrices, so that travel patterns and telephone call patterns can be studied. The degree of accessibility in the real transport system is depicted by matrices in a similar way. As the concept "accessibility" has different implications for different individuals, both an economic measurement and a time measurement have been used in the assessment of contact activity. The actual telephone system is also described but only from the economic point of view. These matrices are compared in order to evaluate the contact activity of the organizations in the location under review. Together with data concerning the time spent on contacts (length of meetings and calls) matrices can then be prepared indicating the total time spent and the total costs incurred by organizations on maintaining their contact relationships.

When the real location has been described and evaluated as above, the organizations are moved around to a number of hypothetical locations. Relocation is simulated, meaning that we no longer work with an observed reality but that assumptions must be made about the new reality confronting the organizations and the effects it may have on contact activity. These assumptions should, if possible, be empirically based.

Using a simulation technique, a number of model experiments are performed, where the effects of various changes in the travel pattern and the telephone-call pattern are tested. Account is taken of the adaptation of contact behaviour (contact frequency, choice of counterparts, meeting places and types of contacts) to the hypothetical locations.

Parallel with these experiments, a simulation technique is used to create a hypothetical transport system including, for example, new air routes and new timetables. A new telephone network is also tested by simulation. Here telephone charges are changed and new media introduced, e.g. conference television.

So far, this method has been used to study the effects on contacts of moving public administrative agencies out from Stockholm. *One example* will be described in this report, and this concerns the Swedish Telecommunications Administration. The account is also limited to describing the contact activity via face-to-face communication, thus not contacts via telecommunications.

The Telecommunications Administration was relocated in the model to ten different centres around the country (see

Figure 11). In every centre we allowed the Administration's employees to carry out a contact programme, designed on the basis of information we collected about the actual contact activity of the Administration.

Findings are presented in the form of variations in transit time between the different location alternatives. Throughout the experiments, findings are compared with the outcome for the actual location (place of location = Stockholm). The account is also limited to a description of the outcome for the organization concerned (Swedish Telecommunications Administration). Consequently, the volume of transit time spent by the Administration's contact counterparts is not included.

Technically speaking, transit time is calculated either from actual timetables for transport by bus, train and air or on the basis of a certain average car speed on roads (here seventy kilometres per hour). Calculations of transit time assume that the fastest single or combined means of transport is used. We also presuppose that contacts are made during office hours only (9 a.m. to 5 p.m.). This means that the stay time available is maximized at eight hours, a condition that affects the number of contacts possible during a day visit.

Relocation to different places (Figure 11) is tested partly with a completely unchanged contact behaviour and partly with a contact behaviour that is adapted to the new contact situation in which the Administration finds itself. In the latter case, the aim is not to reconstruct the actual behaviour of individuals or to construct a kind of average behaviour--variations in human behaviour are too great for such an exercise--but rather to indicate a possible *scope of action* within the framework of restrictions that actually exist. This is then allowed to influence travel in the new location.

A few words must be said about the component factors of an adaptation of contact behaviour. The first factor implies that journeys are arranged so that the actual meeting can take place at the operational base of one of the participants. Service contact, a second factor, i.e. contacts made in consultant work, office services of various kinds, deliveries and maintenance of equipment, etc., are assumed to take place in most of the A-region centres (the seventy major urban centres in Sweden). This means that the service contacts are not tied to the original location but can be transferred to the new location and thus limit the increase in time spent on contact travel. A third factor is the possibility of using telephone contacts instead of face-to-face communication in order to cut down travelling. The final factor included in the assumptions for model testing is the possibility of

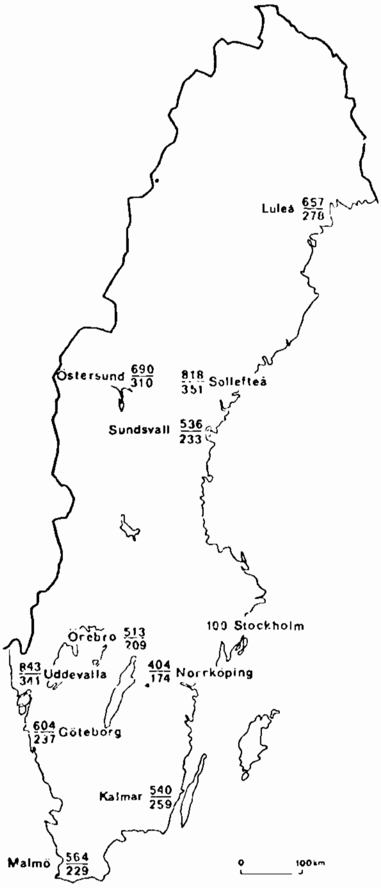

Figure 11. The effects of relocation of the Telecommunications Administration. Unchanged and adopted contact behaviour.

accumulating a certain amount of contact requirements so that more than one contact can be made per journey.

Figure 11 shows the effects of relocation *both with unchanged contact behaviour and with adapted contact behaviour*. The values shown there reveal that travel time increases very sharply if contact behaviour is assumed to remain unchanged (upper figure at each place). The average increase based on all localities is more than 500 percent. In absolute figures, this is an increase from about 2,300 travel hours to 14,000 travel hours per week. Of all alternative locations, Uddevalla gives the highest increase--about 750 percent. The reason for this is the town's poor position in the national transport system from the point of view of travelling time. Other towns in the far north of Sweden also show high values--Sollefteå, Östersund and Luleå. Moving the administration to the cities of Malmö and Gothenburg also results in considerable increases in transit time according to this method of calculation. Relatively speaking, the weakest increases are recorded by Norrköping (about 300 percent) and Örebro (over 400 percent); these two towns are situated fairly centrally in Sweden and therefore are well served by the land transport system.

Proximity to the Stockholm region (in terms of transit time) is a determinant of the relative increase in the number of travel hours consequent upon a relocation. This is due to the fact that the Administration has close ties with various sources of contacts in the Stockholm region, so that most journeys made after a relocation are to and from this region.

If contact behaviour is adapted to the new contact environment, increases in transit time are much less in the lower figure indicated for each locality. The percentage difference between the result for unchanged and adapted behaviour averages about 60 percent over all localities. The assumption that a meeting is generally held at the base of one of the participants accounts for about 75 percent of this difference. Relocation with adapted contact behaviour results in an average increase (all localities) of about 5,700 travel hours, or about 160 percent compared with the Stocknolm location.

The regional results for adapted contact behaviour correspond with the result obtained when contact behaviour was unchanged. The highest increases in transit time are obtained with the Sollefteå location (255 percent), Uddevalla (245 percent) and Östersund (213 percent). The major cities, Gothenburg and Malmö, however, are now much more favourable alternatives than other locations. But Norrköping and Örebro still offer the best locational environment in terms of transit time. Increases in the time spent in travelling to maintain contacts from these two towns are 74 and 109 percent respectively compared to location in Stockholm.

The regional differences in time spent on travel after the relocation of the Telecommunications Administration outside the Stockholm region can, as pointed out earlier, be explained by the geographical situation of the new location in relation to Stockholm, as most contact travel is to and from the Stockholm region. The length of time it takes to travel between two towns also affects the duration of the stay time, and this determines whether it is possible to plan more than one contact per journey in order to cut down the total number of journeys. The shorter the transit time, the longer the stay time and thus the greater the potential reduction in the number of journeys. Another explanation of regional disparities is the variation in the possibility of satisfying the need for contacts with specialized services in the new locality.

To sum up, we find that quite apart from the particular choice of location, the amount of travel done by an organization very much depends on the contact pattern and the travel pattern of the organization on the one hand, and by the transport system serving it on the other. In Sweden, the transport system has been planned so that the three major cities have good connections with one another, with Stockholm having the best connections with other centres in the country, particularly the larger centres. This means that Stockholm has the highest degree of accessibility in the system. Given this transport system, the travel input of an organization is very much determined by whether the travel pattern of the relocated organization generates journeys between the new location and Stockholm or other centres. In the latter case, many across-the-grain journeys have to be made, and this requires a very high travel input.

The methodology briefly outlined in this section has also been used in model experiments with several location units at the same time (cf. calculations of goods transportation above). Simulation techniques have been used to test the effects of hypothetical changes in travel patterns and telephone-call patterns. Simulation techniques have also been used to test a hypothetical transport system into which new air routes and new timetables have been introduced. New telephone networks and changed ticket prices have also been tested in some model experiements.

7. The Swedish Contact Landscape--Examples of Macro-Analysis

In conclusion, let me say a few words about the macrostudies carried out for testing the whole Swedish *system of cities* from the contact viewpoint. These studies are *not*, as in the foregoing section, based on the individual organization or company unit and their more or less individual contact situation in varying locations. The point of departure is the urban region and the intention is to show how the total number of possible contact combinations varies between different regions in the country. The aim has also been to study the regional balance in Sweden between the supply of and demand for travel facilities. The principle on which these studies of regional balance have been based is illustrated by Figure 12.

The analysis of contact facilities available to towns or urban regions is based on data of contact requirements in economic activities and public administration, the location of economic activities and public administration and the travel facilities available between the seventy major regional centres in Sweden. We have used data obtained from earlier contact studies of contact requirements of job functions, job levels and branches of economic activity. We have worked out a contact-requirement value per capita for each job function, job level and branch of economic activity. When determining the total contact requirement of each region, the number of employees in each job function, job level and branch of economic activity in a region has been multiplied by the per capita value of the function. The total contact requirement of all the job functions present in a region constitute the contact-requirement value of a region (demand side of Figure 12).

The study of travel facilities in Sweden has been limited to communications between the seventy major regional centres in Sweden. Data include times of departure and arrival, together with ticket prices, obtained from timetables for railways and domestic airlines in Sweden. The material comprises travel facilities between each pair of A-region centres at all times of day or night. The road network has been converted into transit time by car. The calculation of transit times, stay times and transit costs of journeys between each pair of A-region centres has been performed with the aid of special computer programs. Optional restrictions can be built into the program for the various computations. The computer program has also been used to test changes in timetables and route networks (supply side of Figure 12).[5]

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[5]These macro-studies of contact facilities in the Swedish system of cities of today and tomorrow will not be elaborated in this survey. Methods and study findings are presented in detail in the following publications: G. Törnqvist, "Contact Requirements and Travel Facilities"; A. Pred and G. Törnqvist, "Systems of Cities and Information Flows," Lund Studies in Geography, Series B, No.38, Lund(1973); M-G. Engström and B. Sahlberg, "Travel Demand, Transport Systems and Regional Development," Lund Studies in Geography, Series B, No. 39, Lund(1973).

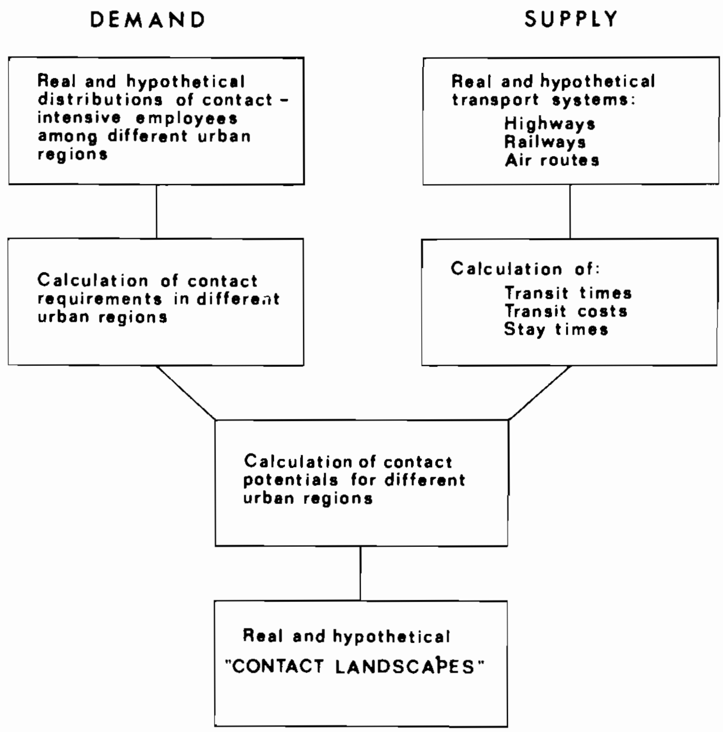

Figure 12. Diagrammatic representation of calculations used in study of the regional balance between contact requirements and travel facilities.

8. Synthesis and Conclusions

This section contains some of the conclusions which can be drawn from the studies exemplified in the foregoing section. Discussion will be based on Figures 13 and 14.

Figure 13 depicts a process of *adjustment between a changed organization of work and transport facilities*. In Section 4, examples were given of changes in a modern activity system, where the degree of specialization and division of labour between various job functions is very high. As a result of this change in the organization of work, activities have gradually become far more interdependent, and society cannot function without the constant transportation of goods, people and messages. Examples of contact patterns both for the individual organizations and for entire urban regions showed the present degree of this interdependence in Sweden.

Figure 13 assumes that interdependence leads to demand for greater accessibility. One way of satisfying this demand is to locate work places and housing in close proximity. As I have shown earlier (Section 4) regional concentration in just a few major urban regions, mainly of those activities which are dependent on direct personal contacts, has been a well-tried method of limiting long-distance transportation. The demand for increased accessibility can, however, also be satisfied by development of transport technology--the terms used in Figure 13.

The steamship, the railway, the automobile, the transmission of electric power and pipelines are historical examples of innovations in transport technology, all of which have transformed transport supply during and after the industrial revolution. Similarly, telecommunications and aviation have reduced the constraint exerted by distance in the industrial and post-industrial society. Changes, in isolation, that have not been epoch-making, but together have done much to improve technology, streamline transportation and raise the efficiency of distribution, have also reduced the importance of distance.

Parallel with this advance in transport technology, the nature of production itself has changed. Manufacturing has increasingly become a matter of teamwork within vast production systems, in which work has been divided up among a great number of component units specializing in one particular aspect of production. This has meant that more and more of all goods transportation between factories consists of semi-manufactures and components for assembly. In contrast to the primary raw materials that formed the major part of goods transportation in earlier days, these highly processed products can easily bear

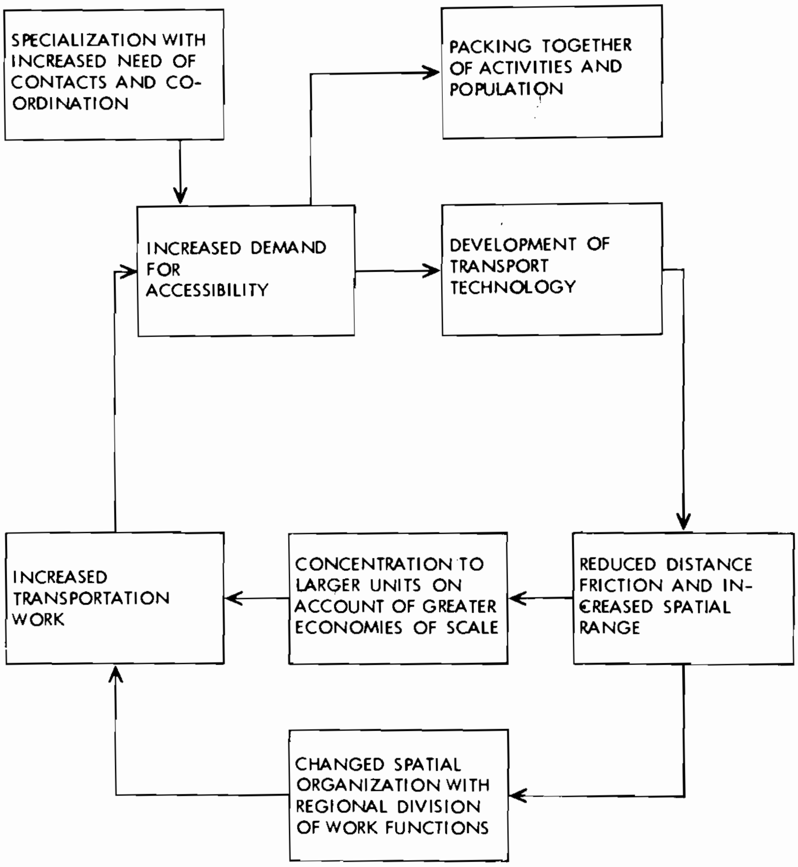

Figure 13. Process of spatial reorganization (Cf. D.G. Janelle, "Spatial Reorganization: A Model and a Concept," (AAAG 59, 1969).

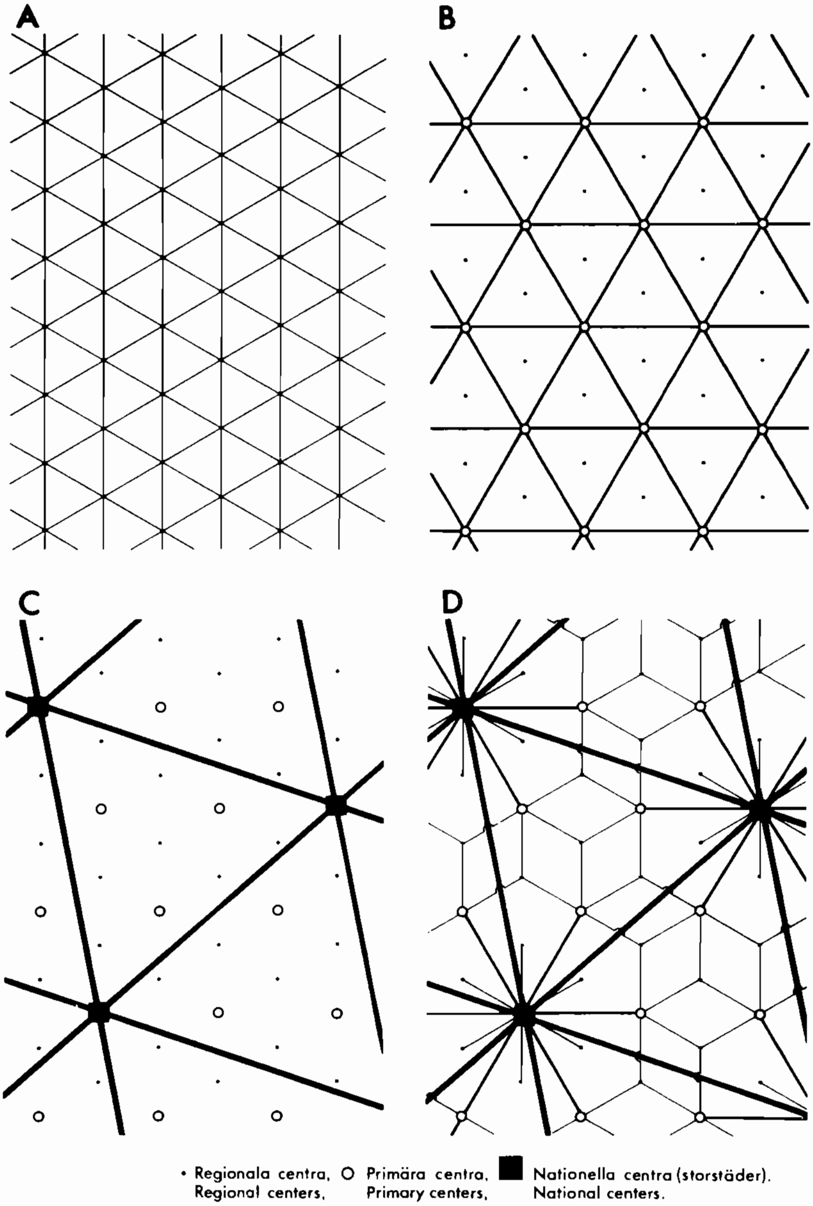

Figure 14. Transport routes in a hypothetical system of cities.

the costs of long-distance transportation.[6] The studies, examples of which have been described in this report, show that a great deal of the production of goods in Sweden is done in units (installations), which can be described as mobile from the point of view of transportation costs. These units account for a very high proportion of employment in the country.

So far, however, calculations have only taken into account the costs of actually handling the goods. It is probably necessary to study the time aspect of this transport, as has been done in the case of passenger transportation, i.e. broaden the definition of transport facilities. The time deliveries take and their regularity probably have an effect, some effect at any rate, on the conditions of production in various parts of the country. For example, in certain situations rapid deliveries would probably prevent production stoppages, and flexibility in delivery schedules would influence companies' costs for warehousing, etc. In the planned link-up between studies of passenger transportation and studies of goods transportation, we shall be broadening our definition of transport facilities in this way.

Figure 13 shows that as the constraint exerted by distance is reduced and, consequently, regional range is extended, it becomes possible to intensify *the division of work functions between localities* even further. At the same time, companies often find it more profitable to concentrate the handling of goods and services to *larger and fewer units*. In Section 5, I discussed in some detail how this trend in industry is linked up with the fact that much greater advantage is being taken of advances in process technology and of scale economies while the relative costs of transportation have declined or risen only very slightly.

In the case of the service sector, note must be made of the shifting of the cost burden that takes place between different sectors or interest groups in society. When planning services at the national, regional and local levels, the scale and location of various units is often determined by the efficiency criteria and costs estimates of the business world. When costs to consumers and other forfeitures resulting from more exten-

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[6]There is a great deal of literature on the subject of the diminished importance of transportation costs in various parts of the world. For example, a summary is given in Chapter 5 of P. Lloyd and P. Dicken, *Location in Space: A Theoretical Approach to Economic Geography*(Singapore, 1972).

sive transportation are not included in these estimates, scale economies have an enormous impact, as transportation costs no longer exert restraint. The result is a rapid concentration of social and commercial services in larger and fewer units.

The processes of change I have described involve increased transportation which sometimes hits the business sector, sometimes the public sector and sometimes the private sector of the economy. Then development has gone the full circle shown in Figure 13. When faced with the possibility of repeating the cycle again, it would be wise to recall how little we know about the future of energy resources.

It is impossible at the moment to make any exact assessment of how great the problem of energy resources will be in the future. The rationing of motor fuels and rapidly rising oil prices have shown us, however, that modern society is extremely sensitive to changes in transport economy which may result from a continuing shortage of energy. It is also clear that the effects on the spatial organization of society of such changes are very difficult to foresee. The linkages and the interplay between the location of housing settlements, service activities and work places on the one hand, and changes in transport facilities on the other, are very complicated. *Various courses of development are feasible in a society that is short of energy.* The different courses of development do not exclude one another and could very well function alongside one another. Given the components depicted in Figure 13, the following alternatives are feasible.

Alternative 1

Raised transportation costs and reduced mobility may lead to a decentralization of work places and services, at the same time as the exploitation of scale economies decreases, relatively speaking. This process of adjustment is illustrated in the lower part of Figure 13 if "reduced distance friction" is changed to "increased distance friction" and "concentration to larger units" is replaced by "division into smaller units," etc. A development of this kind could, for example, lead to a return to a more dispersed location pattern for the market-bound industries, decreased concentration in retail trade and a more even regional distribution of various service institutions. But one condition necessary for these changes in locational pattern would probably be that the distribution of population is not changed to any great extent (see further below).

Alternative 2

Figure 13 also shows another alternative for a society with a shortage of energy (see square top left). As demonstrated earlier, a high degree of specialization and division of work leads to increased transportation and rising energy consumption.

A society that is short of energy may need to organize work on much the same lines as we see in the activity system of older times, which was based on the principle that individuals and production units were largely self-supporting and therefore less dependent on interaction and collaboration. In concrete terms, one possibility would be a change in the modern production system bringing about *increased integration of work operations within independent work places instead of intensified division of work between work places*. These work places would have a high degree of self-sufficiency and less need of external transportation.

Alternative 3

Shortages of energy and reduced mobility may have effects of the kind depicted by the square at the top left of Figure 13. In a low-energy society with a highly differentiated distribution of work the transport economy is well served by *packing activities and population close together*. So increased concentration at national, regional and local levels is very possible. The congregation of activities in the central districts of the major urban regions, due to their mutual personal contacts, may increase, and this will mean that the interregional traffic between organizations diminishes. Manufacturers and wholesalers may find it beneficial to locate their activities in close proximity more than they do now. It may become so expensive for members of individual households to reach services and their work places that these costs influence housing patterns within various regions and localities.

Alternative 4

Future trends in transport technology are a key question in the entire discussion around Figure 13. It is more than likely that there will be changes in this field. These may be a matter of minor adjustments, such as a transition from energy-intensive means of transport to vehicles with a low energy consumption. But there is also the possibility of changes being very radical--technological innovations that completely transform transport facilities in society as happened at the beginning of the industrial revolution. Alternative 4 thus means a situation where, with the help of technology, development goes the full circle depicted in Figure 13 a few more times, even in a low-energy society.

There is little doubt that in an economically advanced country such as Sweden transport facilities have expanded considerably *in terms of the country as a whole*. But an important question from the point of view of regional policy is to what extent trends in transport economy have led to a *reduction of regional inequalities* in transport supply. The comprehensive studies done on the ability of variously located employees to maintain direct personal contacts *do not* indicate that development has noticeably reduced inequality at the national level. People in some regions and localities have much greater difficulty in maintaining contacts than those working in other parts of the country. In many cases, development in the transport sector has enhanced regional inequalities, because it has primarily benefited places which were in a favourable position from the start and brought little improvement to places which initially had a poorer transport supply. These trends are, of course, not unique to Sweden, but can very well be described as global.[7] I shall elaborate this line of thought with the help of a simple diagram.

Figure 14 depicts four versions of the so-called Löschian landscape.[8] This is abstract and extremely simplified. Work places and settlements are assumed to be located in forty-five places evenly spread over a surface. The places are linked up by transport routes. Otherwise the surface is entirely uniform (isotropic).

Version A depicts a situation where all the places are of the same size. The transport system is designed so that it offers all places equal transport facilities.[9] In version B it is assumed that fifteen of the forty-five places are larger than the others and have a better traffic base. In this situation, transport economy justifies a transport supply sytem superior to that in version A. The transport situation is now improved in the aggregate, at the same time as the degree of accessibility in the system changes in the case of those places which in the figure are called regional and primary centres. The thirty regional centres have to use the original transport apparatus, whereas the fifteen primary centres have the advantage of a more effective transport system *as well*, making them more accessible to one another.

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[7] See the survey and summary in A. Pred and G. Törnqvist, *System of Cities and Information Flows*, Lund Studies in Geography, Series B, No. 38 (Lund, 1973).

[8] See A. Lösch, *Die räumliche Ordnung der Wirtschaft* (Jena, 1944) and P. Haggett, *Location Analysis in Human Geography* (London, 1965), p.82.

[9] In principle, absolute equality applies only if the area is infinite. Within a limited area, centrally situated places obviously have a greater degree of accessibility than those situated on the periphery.

In all probability, differences between places will gradually increase, as new activities will in the first place be concentrated to places with good transport supply. Expansion in a small number of places creates the necessary conditions for further expansion and improvement of certain transport routes and so on. This development can be described as a *causal cycle*(cf. Figure 13) with interplay between the location of activities and the gradual expansion of the transport system. What is cause and what is effect in this course of development is a question similar to that of which came first, the chicken or the egg? In version C in Figure 14, three places have grown into national centres at the same time as new transport routes have been developed, e.g. express trains and airlines. We now have three levels of accessibility in this system of places.

In version D the different levels have been brought together. Here a principle has been applied according to which mobility(e.g. the quality of roads, the frequency of services and the capacity of public transport) is always highest on the routes linking a small place with a larger locality. Also, places at the lowest level are assumed to have better connections with centres at the highest level than with places at the intermediate level, when these are the same distance away (see pattern around the three major centres).

Empirical examples illustrating the developments I have just discussed using Figure 14 can be taken from various areas and for various kinds of transportation. I shall conclude by giving a concrete example of contact requirements and inter-regional travel facilities in Sweden.

My example is taken from studies that started with an analysis of the regional balance between travel supply and demand in Sweden in 1960, 1965 and 1970. We found that urban regions in different parts of the country differ greatly from one another when it comes to possibilities of maintaining direct personal contacts.

The main purpose of the model experiments that followed was to test how different measures of regional policy--through interplay between changes in employment structure and in the transport system--may increase or reduce regional inequalities in the future. First, a study was made of the effects of changes in the regional distribution of contact-dependent activities assuming we kept *Sweden's transport system as it is today*, i.e. travel facilities between different urban regions using all the means of transport available in 1970.

The model experiments gave the following findings. The regional concentration of contact-dependent activities results in a more efficient national contact system. The concentration of contact-intensive employees, primarily to Stockholm, makes it easier to maintain contacts, not only for those working in the capital but also for employees located in other urban regions throughout the country. The decentralization of contact-dependent activities, e.g. moving governmental agencies out of the capital, cannot be done without drastically reducing the ability of employees to keep up their person-to-person contacts. With only very few exceptions, this was true of all the localities we studied, even those to which contact-intensive occupations had been moved from the capital.

The reason why these effects arise from changes in the regional distribution of contact requirements in that the inter-regional transport system in Sweden, as in so many other countries, is adapted to the needs of a strongly centralized society. The transport system can be described as a hierarchical network with the primary centres serving as nodes. Some nodes--the cities and particularly the capital--enjoy a high degree of accessibility in this system. People working in these nodes have no difficulty in getting in touch with one another nor with their colleagues working in other nodes in the system.

People working in the smaller nodes also find it easy to keep in contact with functions which are concentrated primarily in the capital. But their ability to keep in touch with employees in other, smaller nodes is limited. In parts of southern and central Sweden where nodes are situated close together, the car is a good means of transport for maintaining contacts. When it comes to longer distances, requiring train or air travel, travel facilities between the smaller nodes are limited. These journeys must often be made via the major central node in the system, Stockholm.

Should the authorities wish for any reason to arrest a trend towards greater inequality between various regions in the country, it would seem that regional policy would be most effective if measures were taken in the transport sector. This was the finding of the final model experiment.

An extension of the inter-regional transport apparatus by means of cross connections between primary centres other than Stockholm, Gothenburg and Malmö leads to much greater equality between these major urban regions and other regions in Sweden. The decentralization of contact-intensive activities from Stockholm to a limited number of primary centres in different parts of the country can be done without detriment to the contact activities of employees only if simultaneous changes are made in the present inter-regional transport system.

PART FOUR: PRACTICE

The ultimate goal of most applied scientific research is to develop models with realistic data requirements, cast within sound theoretical frameworks, which provide quantitative information relevant to an actual decision making process. The detailed and careful specification of a multi-variate, multi-process model is an exceedingly demanding task. Not only must the theoretical structure be justifiable, but suitable data must be made available, parameters estimated, and the results be interpretable by researchers and policy makers alike. Relevance demands timeliness; thus in most cases, a variety of compromises need to be made.

Dawson and Ulrich, researchers in the Canadian Ministry of State for Urban Affairs, describe the transportation component of a much larger model which is designed to determine the impact of specific policy variables under the jurisdiction of the federal government. Dawson and Ulrich describe the interlocking set of transportation models primarily of a demand type which themselves are linked to demographic, environmental, industrial, housing and public finance models. While too early to evaluate as a unit, the Macro Urban Program Impact Model is an ambitious effort at detailed modelling of national urban settlement systems. The reader's attention is drawn to the discussion of this paper and the one by Courbis which is found on pp. 13-14 and 59-63. When a strong theoretical structure is lacking, it is often possible to substitute timely information for theory and effectively manage systems that in detail are poorly understood. Moreover, on-line responses to changing system indicators and the subsequent monitoring of the results of these responses is often a powerful way to learn about the system, so that eventually some of the information is replaced by firm knowledge of system relationships. Mamikonov, Kulba and Tsvirkun are concerned with how such information systems can be designed to aid the management of population distribution in the USSR. The authors are concerned not only with data banks in the narrow sense, but with the way in which data interact with the package of urban and economic planning models on the one hand, and the decision making process on the other. Insofar as is possible, decision making rules and guidelines are incorporated into the information system itself.

Program-Impact Models for Policy Research: The Case of Transportation

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1. Introduction

The creation of the Ministry of State for Urban Affairs in 1971 was the first step in a coordinated and growing response by the Canadian federal government to urban problems. The main functions of the Ministry are:

- to coordinate, plan and develop federal policies for dealing with urbanization;

- to conduct research into urban problems; and

- to coordinate federal policies and programs with those of other levels of government.

The MUPIM (Macro Urban Program Impact Model) project was launched in 1972 within the context of this mandate. The objectives of MUPIM are:

- to provide an effective tool for choice among the infinity of urban research tasks in addition to the usual criteria of "interest" and "academic excellence";

- to provide a mechanism for accumulation of knowledge in a readily accessible and usable form; and

- to provide a tool for rapid prediction of impact on macro-urban Canada of alternative program packages by the governments of Canada.

The domain of the model is delimited according to:

- spatial scale: a system-of-cities concept underlies the design of the model;

- temporal scale: the model is expected to predict program impact up to ten years in the future, in annual time intervals;

- type of research: explanatory, predictive, descriptive, as opposed to normative or prescriptive; and

- sub-model areas:

  - demography/income (DISM)
  - environment/resources (ENSM)
  - industrial structure (ISSM)
  - land/housing (HLSM)
  - public finances, and (PSSM)
  - spatial linkages. (SLSM)

In the following section, two sub-models are briefly reviewed with respect to their main objectives and structure. The third section describes the Spatial Linkages Sub-Model in detail.

Sub-Model Overviews

Public Sector Sub-Model

The main function of the Public Finances Sub-Model is to provide estimates of the budgetary impact of government programs. Impacts are measured for provincial governments and aggregates of local governments in each city area explicitly included in the model. In addition, the Public Finances Sub-Model provides estimates of total public employments, some measures of public service output, and intergovernmental transfers.

The major components are:

a) revenue;

b) revenue distribution;

c) service output and expenditure;

d) expenditure distribution;

e) budget and debt status; and

f) total public employment.

Only the two distribution components may not be sufficiently evident from the titles. Both refer to the distribution among government units. Where feasible, total revenue or expenditure from a public activity is estimated. The distribution component allocates the share to the individual government units.

Since several government units are included in the model and since our primary client is one of those governments, it is perhaps useful to note the treatment of intergovernmental impacts. Direct response of a province to a federal program change, for example, is left formally outside the model. This impact must be supplied by the user. The indirect impact through the private economy is, of course, represented through the model structure.

Demography-Income Sub-Model

Economic aspects are divided between the Industrial Structure Sub-Model and the Demography-Income Sub-Model. The best indication of the content of this sub-model is the set of components:

a) gross urban product:

  - aggregate city/region investment,
  - aggregate city/region personal consumption;

b) labour market/employment;

c) income formation:

  - wage and salary,
  - transfer income,
  - investment on rental income, profits;

d) income distribution;

e) demographic growth;

f) migration; and

g) urban price index.

The main information flows to this sub-model come from the Industrial Structure Sub-Model in the form of industry outputs and net exports. The secondary information flows are aggregate government expenditures from the Public Sector Sub-Model and variables used to estimate inter-city migration.

All components with the exception of inter-city migration are defined on a city-specific basis and are dealt with or to be dealt with in an ordinary econometric manner.

Industrial-Structure Sub-Model

Since the MUPIM model is concerned primarily with the spatial distribution of key economic aggregates such as industrial output, it estimates only the change in the portion of national output in each region. The key device is an industrial location equation component. For each commodity based on one-year lagged variables, this component estimates the change in proportion of national output. Net trade flows are estimated by calculation of aggregate demand (both intermediate demand and final demand in the input-output accounts sense) and aggregate supply.

The main explanatory variables for the location equations are:

a) location rents:

- wage rate differentials,

- taxation differentials,

- transportation cost differential; and

b) agglomeration variables.

This method allows, although not in the current version, supply constrained or "non-economic" allocation of production activity to be entered exogenously.

Housing-Land Sub-Model

There are three main components to this area of the model, namely:

a) national housing starts;

b) local housing starts and stock; and

c) local land price and stock.

Only the first two are reasonably developed now and are treated in an econometric manner. No inter-city flows are included in any of the three components.

Compared to the other sub-models (with the exception of Natural Environment) this model is somewhat peripheral. It tends to utilize information from other sub-models without substantial return flows of information. This local housing component does not mesh types of housing with family structure residing in each type of housing.

Natural Environment Sub-Model

Given recent awareness of the inter-play of natural environment and the socio-economic environment, we have attempted to integrate certain features of the natural environment in the MUPIM project. There are two groups of components: resources, and pollution/environmental quality.

The basic structure of the pollution/environmental component involves two sub-components:

a) production of residuals or pollutants by the socio-economic structure; and

b) conversion by natural or ambient environmental quality.

Pollutants in each of three media, air, water and land, are dealt with explicitly. The three basic sources of pollutants are industrial output, home consumption activity, and transportation.

Only energy has been dealt with in the resources field and, within this, emphasis has been on energy demand. Energy supply and energy prices, to the extent they are used elsewhere in the model, are entered directly and not from the Energy Module. This represents a key area for further development as does inclusion of other resources.

As described above, it is clear that at present both the Natural Environment Sub-Model and the Housing/Land Sub-Model are peripheral to the core of the MUPIM model. All aspects are defined on a city-specific basis. Only if the air or water flows from one city to another would inter-city interactions be involved.

2. <u>The Spatial Linkages Sub-Model: Technical Description</u>

Transportation is a key element in the Canadian economy, in government policy, and in the urban system. The term "spatial linkages" denotes an inter-connection between system components and program impacts which goes beyond traditional transport modelling from at least three points of view:

- within the transportation demand side of the sub-model the intrinsic pairing of cities may be taken into account;

- between the sub-model and other sub-models there exists a series of critical information flows and feedbacks; and

- beyond the present content of the sub-model, it is proposed to develop a separate Communications Sub-Model.

The Spatial Linkages Sub-Model is described from two major perspectives: its technical description (Section 2), and the empirical analysis to date (Section 3). References to "MUPIM: ONE" indicate the version of MUPIM that has been developed during the pilot study year September 1973 to November 1974. The purpose of the pilot study was to mobilize project resources, provide a detailed model design, evaluate the feasibility of the project's objectives, and provide usable interim outputs.

Broad Sub-Model Structure

The design criteria on which the Spatial Linkages Sub-Model (SLSM) is based are derived directly from the functions and responsibilities of the Ministry of State for Urban Affairs. The Ministry, in the course of its policy development and evaluation activities, requires estimates of the impact of federal programs and policies on urban Canada. MUPIM is a tool which will provide one means of delivering impact estimates to decision makers and to policy-development staffs.

First and foremost, therefore, the SLSM must be capable of estimating (i.e. predicting) the impact that federal transportation policies and programs will have on Canadian cities. The effects on cities which are assumed to be of greatest relevance to MSUA relate to urban form and structure, and urban growth and dominance. This suggests that the SLSM must be capable of transforming transport investment, pricing, and regulatory decisions into urban land use and urban pattern effects. The broad internal structure of the sub-model is shown in Table 1.

Table 1. Spatial linkages sub-model: internal structure.

Modules	Inter-City Commodity Transport (CTM)	Inter-City Passenger Transport (PTM)	Urban Transport (UTM)
	Commodity Flow (CFS-M)	Passenger Flow (PFS-M)	Urban Travel Demand (UTDS-M)
Sub-Modules	Commodity Transport Supply (CTSS-M)	Passenger Transport Supply (PTSS-M)	Vehicle Energy and Emissions (VEES-M)

The organisation of the sub-model into three modules is based on the notion that commodity, passenger, and urban travel are largely independent phenomena whose behaviours are not conditional, one upon the other.

Two modules, CTM and PTM, cover inter-city transport. They are designed to estimate flows of goods and people in response to changing socio-economic structures. Generally, the inter-city transport network is defined by seventy to 100 regions and/or cities, depending on data availability and inclusiveness. Clearly, it is more important to distinguish developments in rural areas for commodity transport than passenger transport.

The inter-city modules distinguish between the forces that change transport demand (flow) and those that manipulate supply. This is a largely artificial division; obviously demand and supply are inter-dependent. However, for practical model development purposes, this division into sub-modules, which can be identified as demand-oriented (CFS-M and PFS-M) and supply-oriented (CTSS-M and PTSS-M), is useful because:

1) demand-forecasting models have been extensively researched using supply variables (transport cost, availability, level of service, etc.) as exogenous inputs along with population, income, etc. Experimenting with previously-tested methodologies had distinct advantages.

2) little is known about scale economies in Canadian inter-city transport. Assuming they are close to zero under the existing transport industry structure, and that transport is widely available, transport prices will change in response to inputs such as labour, fuel, taxes, etc. If this is the case, predicting transport prices is separable from transport demand estimation. This is not, of course, equivalent to saying that transport demand is independent of transport price. It does mean, however, that holding the existing inter-modal ratios of transport prices constant is not entirely unrealistic in initial demand forecasts.

3) transport prices respond directly to regulation, direct input factors such as labour costs, and competition. These elements are partly under heavy government control, and they should not be allowed to vary in unknown ways. Changes in transport supply (i.e. price) must be modelled in their own right, not subjected to crude trend projections.

Empirical research has therefore concentrated on the CFS-M and PFS-M (see Section 3). Conceptual development of the supply sub-modules has started; during 1975 progress will be made on techniques to predict changes in transport costs and prices.

At the intra-urban scale the Urban Transport Module (UTM) is designed for two special purposes:

1) the Urban Travel Demand Sub-module (UTDS-M) predicts public sector (government) expenditures in urban

transport on a city-specific basis. These estimates are a Public Sector Sub-Model input.

2) The Vehicle Energy and Emissions Sub-Module of the UTM will, when fully developed, provide two main classes of prediction:

   a) energy consumed in urban transportation as an input to the PSSM so that tax revenues may be calculated; and

   b) vehicle emmissions as an input to the Environment Sub-Model (ENS-M) for the estimate of urban air pollution levels.

Urban travel demand estimates (vehicle mileage and number of trips, by mode) are a prerequisite to modelling energy consumption and emission levels. Empirical analysis is well advanced on energy consumption; the theoretical possibilities of modelling vehicle emissions levels are being reviewed.

While the relations between the SLSM and other sub-models of MUPIM are summarized in Figure 1, more detail on this subject is given in the sections on each sub-module currently developed.

<u>Passenger Flow Sub-Module</u>

The purposes of the sub-module are:

a) Policy relevance:

   1) to forecast origin-destination flows of passengers by mode of travel from estimated coefficients of theoretical models given characteristics of the cities and the modes of transport connecting them;

   2) to estimate elasticities of demand for travel and elasticities of inter-modal competition in order to investigate parametric changes in transport policy variables; and

   3) to assign estimated origin-destination flows to actual links of each transport network in order to determine eventually where transportation infrastructure is not consistent with urban policy.

b) Interdependency with other modules:

   The inter-urban passenger module is self-contained within the Spatial Linkages Sub-Model except to the extent that it shares, with the Commodity Module, inputs on the service characteristics of transport modes and assigns flows to the same networks.

Main Links Between SLSM and MUPIM Sub-Models

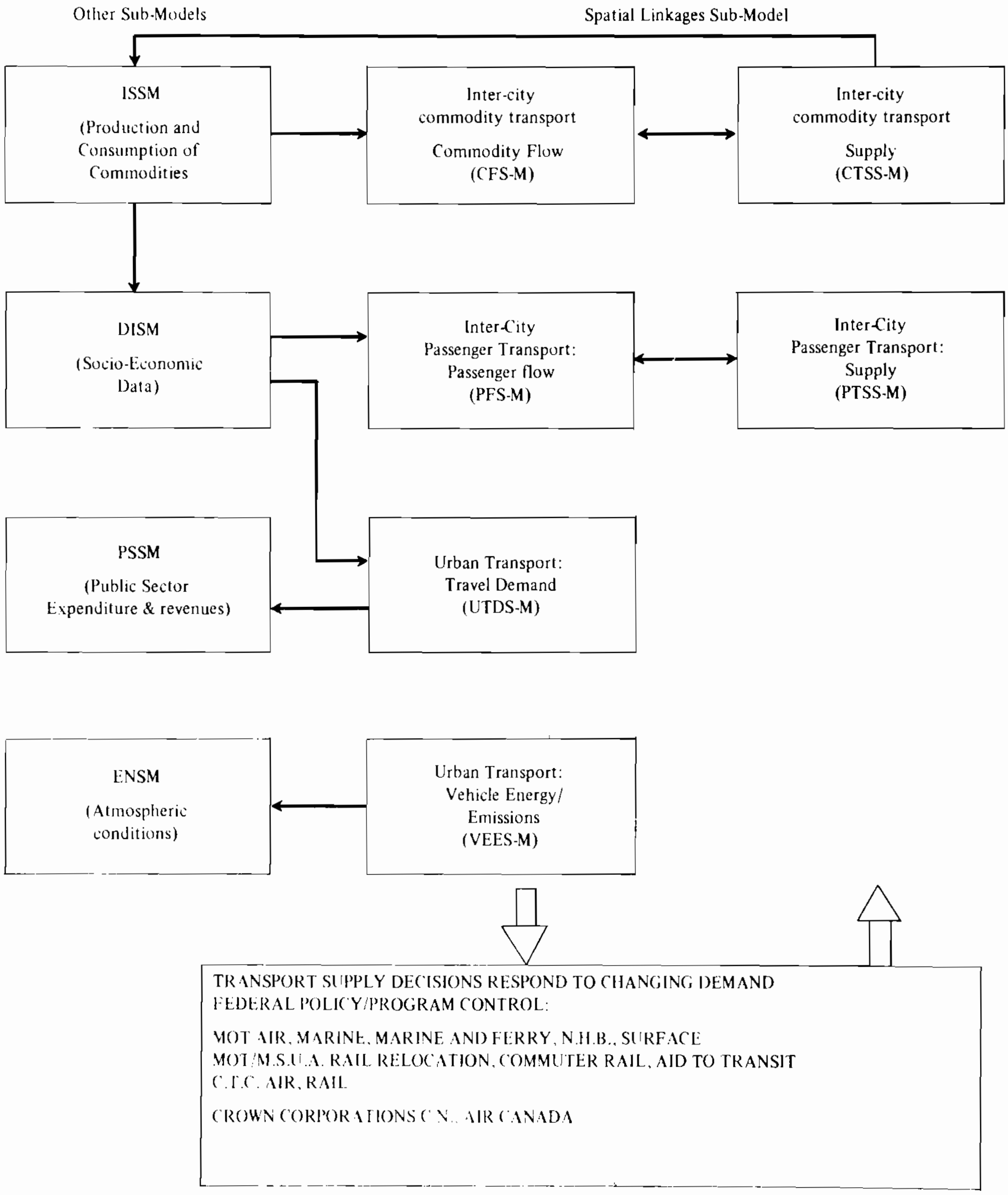

Figure 1.

Interdependencies within the Passenger Module are shown in Figures 2 and 3.

Conceptual Content

The Passenger Module consists of four interconnected sub-modules:

a) estimate of highway origin-destination flows from traffic counts;

b) abstract mode split models;

c) mode specific split models; and

d) log linear gravity model.

The context of these sub-modules and their interrelationships are shown in Figures 2 and 3.

a) Estimates of Highway Origin-Destination Flows from Traffic Counts[1]

This sub-module is designed to replace a data source which is not generally available, namely, origin-destination flows for highway travel. Using the shortest-path distances between all pairs of cities, an initial estimate of origin-destination flows is made with the initial parameter estimates. These flows are assigned to the network using the criterion that travellers choose the shortest route to their destinations. The residual sum of squares between the assigned flows and the observed flows of links is computed. To minimise the residual sum of squares, revised parameter estimates are obtained by an efficient algorithm which terminates when model parameters converge within a given tolerance level. The nature of the problem requires the gravity model to be estimated in its multiplicative form. This together with the assignment procedure results in a specification which is quite non-linear.

b) Abstract Mode Split Models[2]

Given that complete origin-destination data on passenger flows and transportation service characteristics are available, this sub-module attempts to model inter-city flows using the strong assumption that the demand for travel by different modes is determined by a single demand function. This allows observations on inter-city data relating to different modes

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[1] See Wills [7].

[2] See Wills [5].

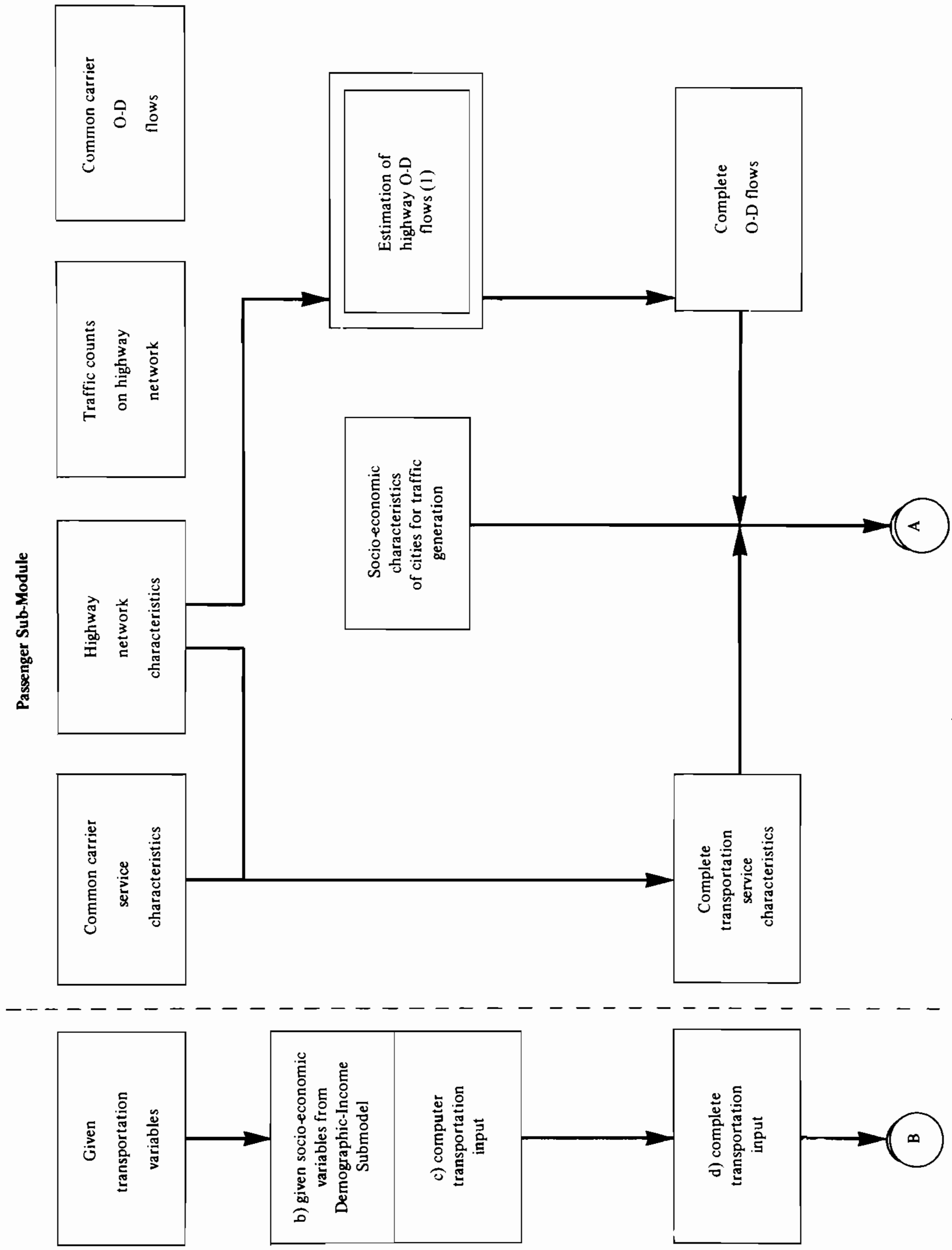
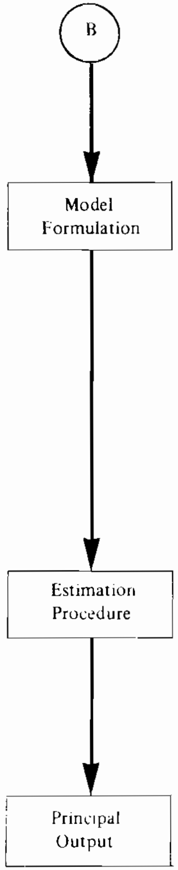

Passenger Sub-Module
Common carrier O-D flows
Traffic counts on highway network
Highway network characteristics
Common carrier service characteristics
Estimation of highway O-D flows (1)
Socio-economic characteristics of cities for traffic generation
Complete O-D flows
Complete transportation service characteristics
A
Given transportation variables
b) given socio-economic variables from Demographic-Income Submodel
c) computer transportation input
d) complete transportation input
B

Figure 2.



Model's Output

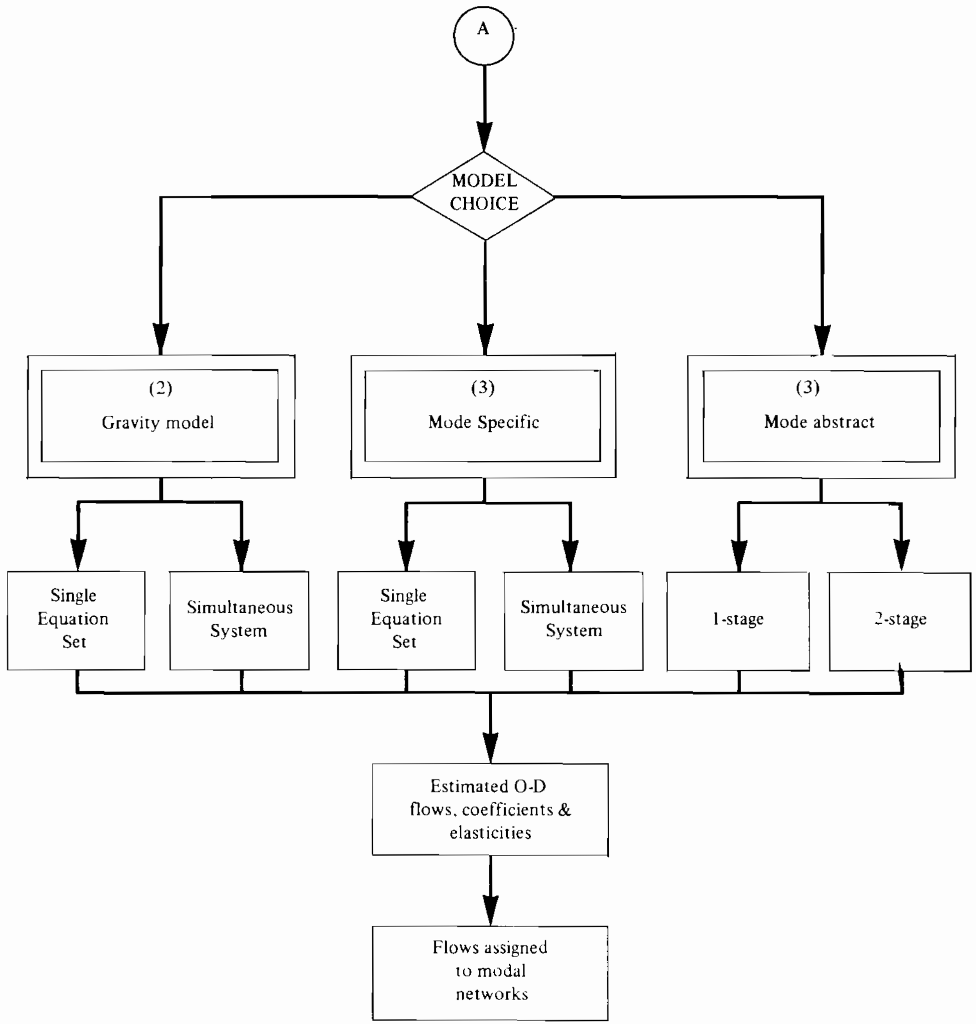


Figure 3. Models, estimation methods and principal output.

to be pooled and a single regression equation to be estimated for what is otherwise a simultaneous system or a set of single equations. Demand for travel is assumed to a function of a set of attributes common to all modes: fare, travel time and departure frequency.

If the assumption of a single demand function for travel can be sustained, the power of this methodology is that the introduction of new modes of transportation can be analysed in the context of a known demand function. The absence of mode specific terms allows this. All the models are multiplicative, and if estimated in their log linear form, have multiplicative error as well. They take the form:

$$T = [f(P)] \cdot [g(Q)] \cdot [h(R)] ,$$

where

T = observed travel by mode and city pair;

P = socio-economic variables measured on cities;

Q = composite impedance for a given city pair;

R = service characteristics of each mode relative to competing modes.

This methodology may be implemented as a one-stage model in which total inter-city travel demand and inter-modal competition are estimated simultaneously, or as a two-stage model in which inter-modal competition is determined prior to estimating total demand.

A one-stage model which has been estimated for the Windsor-Quebec corridor is as follows:

$$T_{ijm} = \exp(\alpha_0)(P_i P_j)^{\alpha_1} L_{ij}^{\alpha_2} Y_{ij}^{\alpha_3} (C_{ij}^{g})^{\beta_1} (H_{ij}^{g})^{\beta_2} (C_{ijm}^{r})^{\gamma_1} (H_{ijm}^{r})^{\gamma_2},$$

where

T_{ijm} = observed travel by mode m from city i to city j;

P_i = population of city i;

L_{ij} = a linguistic pairing index relating to cities i and j;

Y_{ij} = weighted per capita income in cities i and j;

$C_{ij}^{g} = (\prod_{m} C_{ijm})^{1/m}$ = geometric mean of travel costs by mode from city i to city j;

H_{ij}^{g} = as above, replacing cost by time (in hours);

$C_{ijm}^{r} = C_{ijm}/C_{ij}^{g}$ cost of mode m relative to the geometric mean of competing modes;

H_{ijm}^{r} = as above, replacing cost by time (in hours);

α's, β's, γ's = coefficients to be estimated.

Another example of the nineteen equations which have been estimated for the Windsor-Quebec corridor is a two-stage model:

$$T_{ijm} = \exp(\beta o)\ (P_i P_j)^{\beta_1} L_{ij}^{\beta_2} Y_{ij}^{\beta_3} \left(\sum_n C_{ijn}^{\alpha_1} H_{ijn}^{\alpha_2}\right)^{\beta_4} \left[\frac{\exp(\alpha_0)\ C_{ijm}^{\alpha_1} H_{ijm}^{\alpha_2}}{\sum_n \exp(\alpha_0)\ C_{ijn}^{\alpha_1} H_{ijn}^{\alpha_2}}\right],$$

where the definitions are similar to the one-stage model. The key difference is that in the two-stage model the α coefficients are estimated first to obtain both the mode split and the generalised impedance terms. These values are substituted into the equation and the β coefficients are estimated. The interested reader is referred to the background report for considerably more detail.

c) Mode Specific Split Models[3]

The hypothesis that the demand for travel by different modes is determined by a single demand function is a strong one to the extent of being heroic. As a result attempts are often made to reintroduce mode specific coefficients. In the context of the two-stage abstract mode models this modal dependency is usually achieved with the addition of a modal subscript to the constant term in the mode split expression. Modifications of this type produce a class of quasi-abstract models.

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[3] See Wills [5].

In their most developed form mode specific models take the form of a system of simultaneous equations with one equation for each mode. Although these models may give a better fit than the abstract models to a given set of data, their efficacy in forecasting is open to question since the stability of their coefficients may be impaired by the addition of a new mode or major upgrading of an existing mode.

d) Log Linear Gravity Mode[4]

This is the simplest of the sub-modules and requires only that the gravity model be estimated for each mode separately or, conceivably, as part of a simultaneous system. The key feature of this model is the absence of inter-modal competitive terms. Instead, travel demand by mode is related directly to a set of socio-economic variables and to the mode's own service characteristics. The multiplicative model therefore takes the form (with the modal subscript m being omitted):

$$T_{ij} = \exp(\alpha_0) \prod_k S_{ijk}^{\alpha_k} \prod_h D_{ijh}^{\beta_h} ,$$

where

T_{ij} = travel demand from city i to city j;

S_{ijk} = k^{th} socio-economic variable relating the $(i,j)^{th}$ city pair;

D_{ijh} = h^{th} impedance or distance variable separating i from j, e.g. cost, time, etc.;

α's, β's = coefficients to be estimated.

Empirical Estimate

Except for highway travel, demand data of adequate quality are in existence for estimating the above models. The scope of MUPIM: ONE has allowed only partial collection of the data. Sufficient data to estimate the abstract mode models were obtained for the Windsor-Quebec corridor. Collection of a large data set is currently in progress and indications are that it is a matter of time rather than of availability before this will be complete. Methods of circumventing the paucity of high-

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[4]See Wills [6].

way data are described in the background report.[5] Detailed empirical results are described in the background report.[6]

Commodity Flow Sub-Module

Purpose

This component of the Commodity Transport Module is designed to predict commodity flows over the inter-city transport network by mode of transport. The main purpose of this, as explained in Section 1, is to provide the basis for examining the impact of economic growth and development on the supply of transport facilities. Long run changes in demand (i.e. commodity flow) influence the quantity of transport provided and the cost of transport to users. This in turn affects the distribution of growth and relative accessibility.

Urban Impact Indicators

The Commodity Flow Sub-Module is involved in the production of several urban impact indicators:

- the extent to which the demand for a particular mode of transport grows will affect the provision of fixed facilities whose terminal impact is felt in urban areas;

- growth in modal demand also has implications for energy consumption and capital requirements; and

- change in the centrality of a place with respect to commodity flows is one indication of its growth potential.

Conceptual Content

The basic blocks of the sub-module are shown in the diagram in Figure 4.

Commodity Production and Consumption

These data are supplied by the ISSM, although during the pilot study estimates were developed for each of the thirty-one transportation commodity classes under external contract.[7]

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[5] See Wills [7].

[6] See Wills [5].

[7] See Hutchinson [2,3].

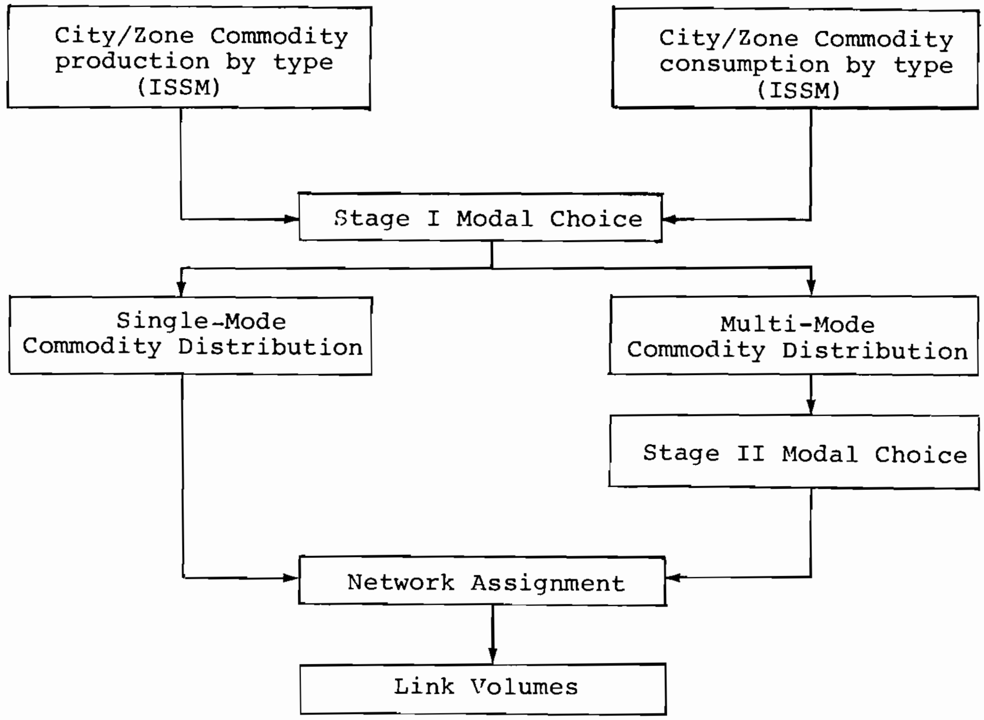
City/Zone Commodity production by type (ISSM)
City/Zone Commodity consumption by type (ISSM)
Stage I Modal Choice
Single-Mode Commodity Distribution
Multi-Mode Commodity Distribution
Stage II Modal Choice
Network Assignment
Link Volumes

Figure 4.

Stage I Modal Split

The main purpose of this block is to identify, for each commodity, groups of production and consumption zones which are effectively restricted to one mode of transport. For such zone and commodity identities, commodity movement patterns are calculated separately. Exogenous variables, that is, existing shipping patterns, are used to identify simple-mode commodities.

The following steps are carried out in the Stage I modal split:

a) conversion of consumption and production from dollar values to tons;

b) identification of simple-mode commodities;

c) estimation of simple-mode linkages;

d) estimation of simple-mode production and consumption by zone; and

e) multi-mode production and consumption by zone.

Multi-Mode Commodity Distribution

Prior to estimating the inter-zonal flows of the multi-mode commodities, minimum path distances between each pair of zones are calculated. At present, this is defined by distance.

A standard gravity model formulation is used to estimate inter-city flows of commodities:

$$T_{ije} = \frac{P_{ie}\, C_{je}\, D_{ije}^{\alpha}}{\Sigma (C_{je}\, D_{ije}^{\alpha})}$$

where

T_{ije} = annual flow of commodity e between cities e and j;

P_{ie} = production of commodity e in city i;

C_{ie} = consumption of e in j;

D_{ije}: where D_{ij}^{α} = distance between i and j distance exponent$^{\alpha}$, derived for commodity e.

The major steps in the multi-mode commodity distribution block are therefore:

a) calculation of minimum path distances; and

b) calibration of gravity model.

Single-Mode Commodity Distribution

The previously-derived single-mode commodities are distributed between cities using the procedures outlined above.

Stage II Modal Split

This block divides multi-mode commodity flows between competing modes of transport. A set of modal split probabilities is used to calculate total tonnage by each mode on each network link. Probabilities are expressed as follows: the probability of using air over all surface modes, of water over land modes, of rail over highway, and common carrier over private carrier. This formulation relies on exogenous information; further development of the sub-module will infer these probabilities from new data on transport flow volumes and transport prices.

Network Assignment

This component adds the single-mode and multi-mode flows to data on imported flows in order to develop a complete origin destination matrix. The total set of flows is allocated to the transport network, i.e. to actual works between cities. The procedure used is the "all-or-nothing" assignment: no single flow is allocated to more than one link.

Status of Development and Experimentation

At present, the computer programs are being modified to reduce running costs and increase data-handling efficiency. Experiments are also being conducted to consolidate Stages I and II in the mode choice calculations. Further research will refine the role of distance in the sub-module by using transport cost directly, test the feasibility of modifying the level of aggregation of commodities and zones, and calculate the probability of mode choice endogenously. These activities should be conducted parallel to the development of the Commodity Transport Supply Sub-Module.

Urban Travel Demand Sub-Module

The Urban Transport Module (UTM) is designed to predict, by urban area, the following:

- urban vehicle emissions;
- municipal highway construction and maintenance costs;
- transit capital and operating costs;
- gasoline sales; and
- automobile and commercial vehicle registrations.

These data, as discussed earlier, are required by either the Environment or Public Sector Sub-Models. Research into the Vehicle Energy and Emissions Sub-Module (VEES-M) has not seriously begun; discussions with the Department of Environment and the ENSM are still underway. This section therefore deals only with the Urban Travel Demand Sub-Module (UTDS-M).

Conceptual Content of the UTDS-M

The basic structure of the sub-module is shown in Figure 5. The input data are obtained as follows:

- urban socio-economic characteristics, i.e. per capita income, household size, population density. This is generally obtained from Statistics Canada and the Demography-Income Sub-Model;
- automobile operating costs, i.e. the total average costs of automobile operation per mile. This variable is exogenous at present, although components of the cost may eventually be obtainable from the ENSM, CANDIDE, and other forecasting models;
- transit level of service, i.e. total transit vehicle mileage and fares. Again, this is input exogenously at present; further development of the sub-module will allow the overall supply of transit service to be predicted, as will be done for inter-city transport supply in the CTSS-M and PTSS-M.

The other seven blocks in Figure 5 represent the dependent variables of a series of regression equations.

Block 1 estimates automobile ownership per household as a function of socio-economic city characteristics and automobile operating cost. The city characteristics included are per capita disposable income and population density. It is hypothesized that as per capita disposable income increases, the demand for travel and hence automobile ownership increases as well. The significance of population density is not yet entirely clear since: as population density increases, a) family affluence decreases and hence the demand for automobiles decreases, and b) intra-city trip distances decrease and hence a decrease in the demand for automobiles might result.

Urban Transport Sub-Module

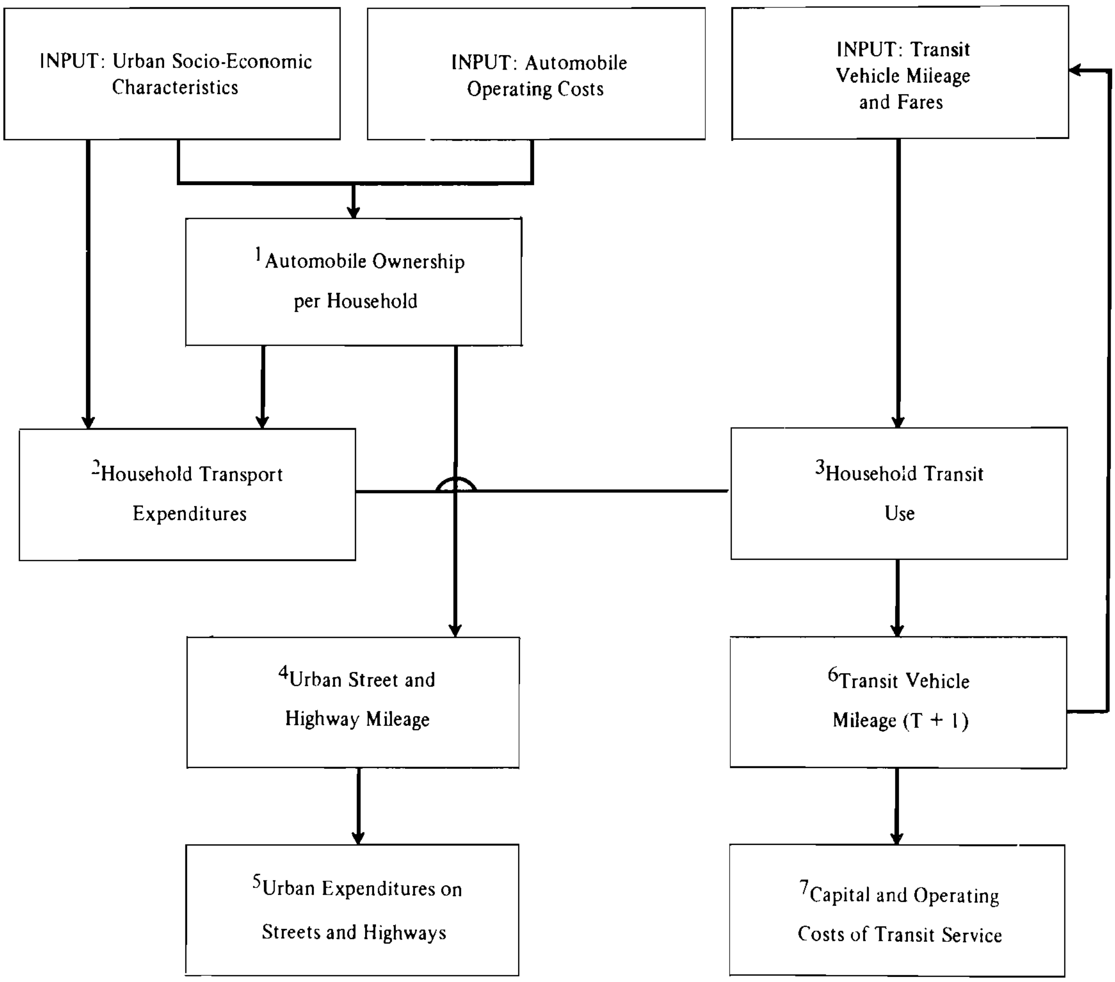

Figure 5.

Block 2 estimates total household expenditures on transportation. These are assumed to be a function of automobile ownership per household (*Block 1*) and socio-economic city characteristics. The city characteristics included here are per capita disposable income, average household size and population density. It is quite apparent that household expenditures on transportation are positively related to per capita disposable income. One might expect these expenditures to eventually reach a limiting value thus indicating a non-linear relationship. At this time, however, only linear estimate procedures have been attempted. Similarly, as average household size increases, household transport expenditures increase. The inclusion of population density in this regression is open to question. It might be related to household transport expenditures through the same "affluence" reasoning as in *Block 1*. However, it was decided to include it as an independent variable since it may be easily deleted at some later stage. It is important to include all variables initially even though it is felt some may contribute little towards the explanation of the dependent variable.

Block 3 estimates household transit use. In this model, household transit use (or transit trips per household) are seen to be a function of transit level of service and household transport expenditures (*Block 2*). The transit level of service indicators used are total transit vehicle mileage per household and transit fares. It is assumed that if transit availability is high then more transit trips per household will take place.

Block 4 calculates urban street and highway mileage. The mileage for each city is estimated from both population and population density as well as automobile ownership per household. Population and population density are assumed to give an indication of city size. These two variables may be collinear in certain instances. If such is the case, population density may be dropped. In future, better measures of city size and form will be included. Also automobile ownership per household is included with the reasoning that if its value is high, this may be an indication of a high degree of urban sprawl and hence high street and highway mileage.

Block 5 calculates the output data of urban expenditures on streets and highways. These expenditures are directly related to urban street and highway mileage.

Block 6 calculates total transit vehicle mileage by city. For the present, total transit trips taken (*Block 3* × the number of households) is used as the only independent variable. It is recognized that this is not an optimal indicator of transit vehicle mileage due to the non-monogeneity of transit trip totals (school busing versus public transit for example). However, due to the non-immediate availability of other variables this single independent variable was used. More detailed variables will be included in the future.

The flow chart in Figure 5 shows a feedback loop from *Block 6* to the transit input block. Transit vehicle mileage is calculated from household transit use in the previous year; in periods of declining demand for transit this will replicate the familiar "downward spiral in transit service." Consequently, one set of transit vehicle mileage values is required to be input exogenously to initialize the model which produces its own transit vehicle mileage value at each year thereafter.

Block 7 uses transit vehicle mileage as the only independent variable describing capital and operating costs of transit service. This suffices at present, but other variables will be tested in the future.

Status of Empirical Analysis

Empirical analysis of the Urban Travel Demand Sub-Module has been carried out. Errors in the predictions are the results of two factors, the first being the quality of data and the second being the variables included in the analysis. The quality of data is considered to be only fair since time constraints in MUPIM: ONE did not allow more detailed data investigation. For example, fifty observations were available for *Block 6* estimates whereas only eleven observations could be used in the estimation of *Block 2* because in 1969 Statistics Canada published household expenditure data for only eleven cities.

The same argument applies when considering the variables included. After this initial empirical analysis further development of the sub-module will include more relevant independent variables, as well as a higher quality data set.

3. Spatial Linkages Sub-Model: Empirical Analysis

Commodity Flow Sub-Module

Organisation and Objectives

The detailed development and initial empirical tests of the Commodity Flow Sub-Module were carried out for the Ministry under External Contract 2101-H29.[8] The computer programs and demonstrations of their use are described in the reports produced as part of this contract.[9]

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[8] Dr. B.G. Hutchinson and W. O'Brien, Department of Civil Engineering, University of Waterloo.

[9] "Computer Program Description"; "Computer Program User's Guide"; "Description of Analysis Zones and Networks"; "Preliminary Demonstration of Model"; "Analysis of Model Output."

The objectives of the research were to:

1) develop a model for estimating the annual inter-city commodity flows in Canada, given exogenously specified estimates of employment by industry sector and population by city;

2) develop the model in such a way that it is compatible with the ISSM and other sub-models in MUPIM;

3) develop a procedure for estimating the transport modal split of the annual inter-city commodity flows; and

4) formulate these models so that they rely mainly on data collected regularly by Statistics Canada.

Model Structure

The broad structure of the Commodity Flow Sub-Module is shown in Figure 6. The stages up to and including "zonal commodity production and consumption" will be part of the Industrial Structure Sub-Model, although they were included in the Spatial Linkages Sub-Model during the Pilot Study in order to generate the necessary data for testing the transportation model.

Delimitation of Zones, Industries, Commodities, and Modes

City-specific data were not generally available for empirical tests of the model during the pilot study. In order to simulate the spatial pattern of inter-urban commodity flows, Canada was divided into 100 zones with a separate zone for each metropolitan area and other zones consisting of aggregations of one or more census divisions. No zone was larger than one of Statistics Canada's economic regions. The use of census divisions as the basic unit has the advantage that complete coverage of Canada is possible, and that the units are compatible with published data. A sample of the zonal specification is shown in Figure 7. The rest of the world was divided with twenty-four external zones, nine of them in the USA.

Industries and commodities were also defined according to accepted Statistics Canada definitions. Commodity nine and commodities thirty-two to forty were omitted from the empirical analysis of transport movements; the former moves by pipeline, the latter group comprises non-transportable goods. Industries and commodities are listed below.

Broad Structure of Inter-Urban Commodity Flow Model

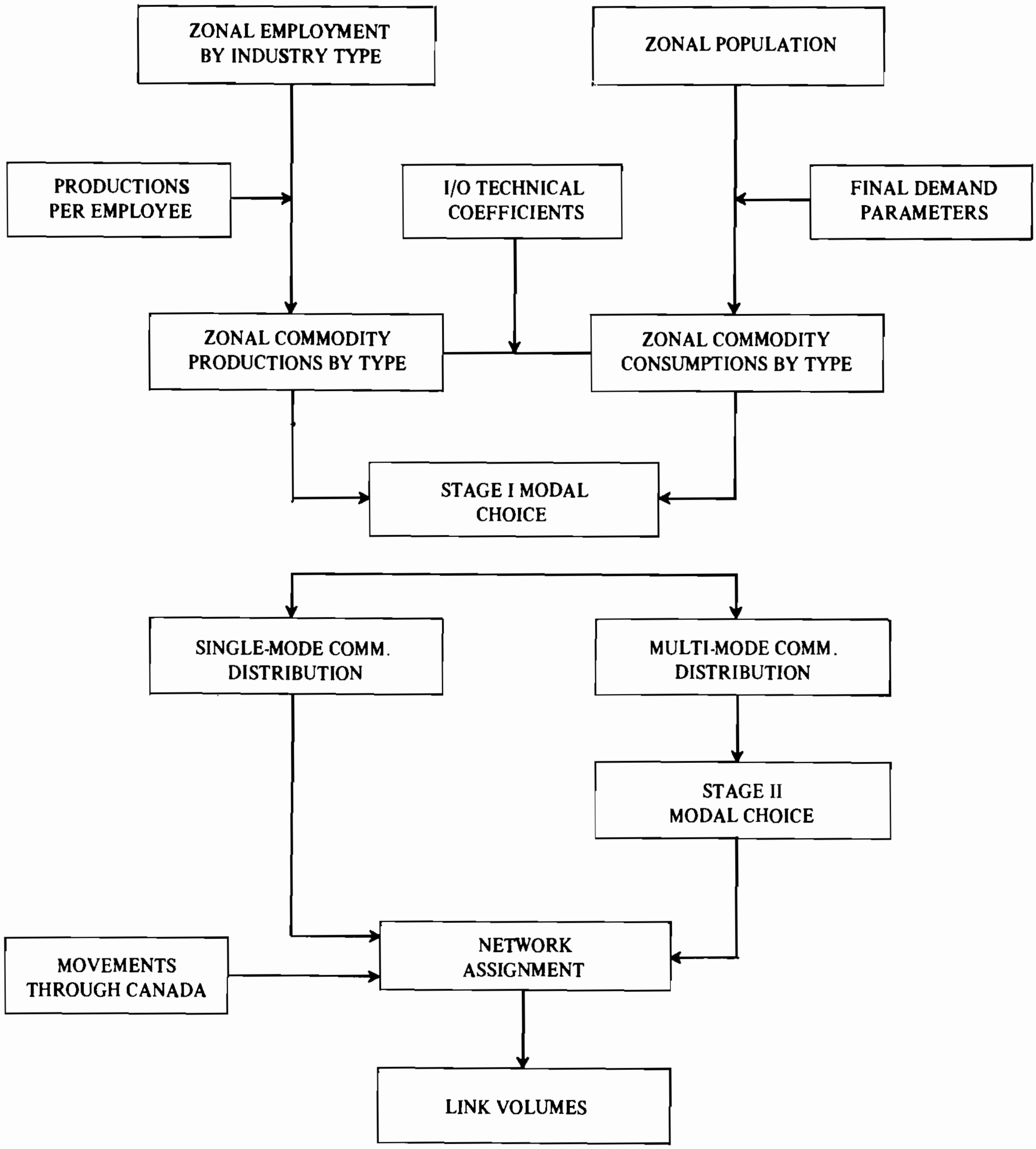

Figure 6.

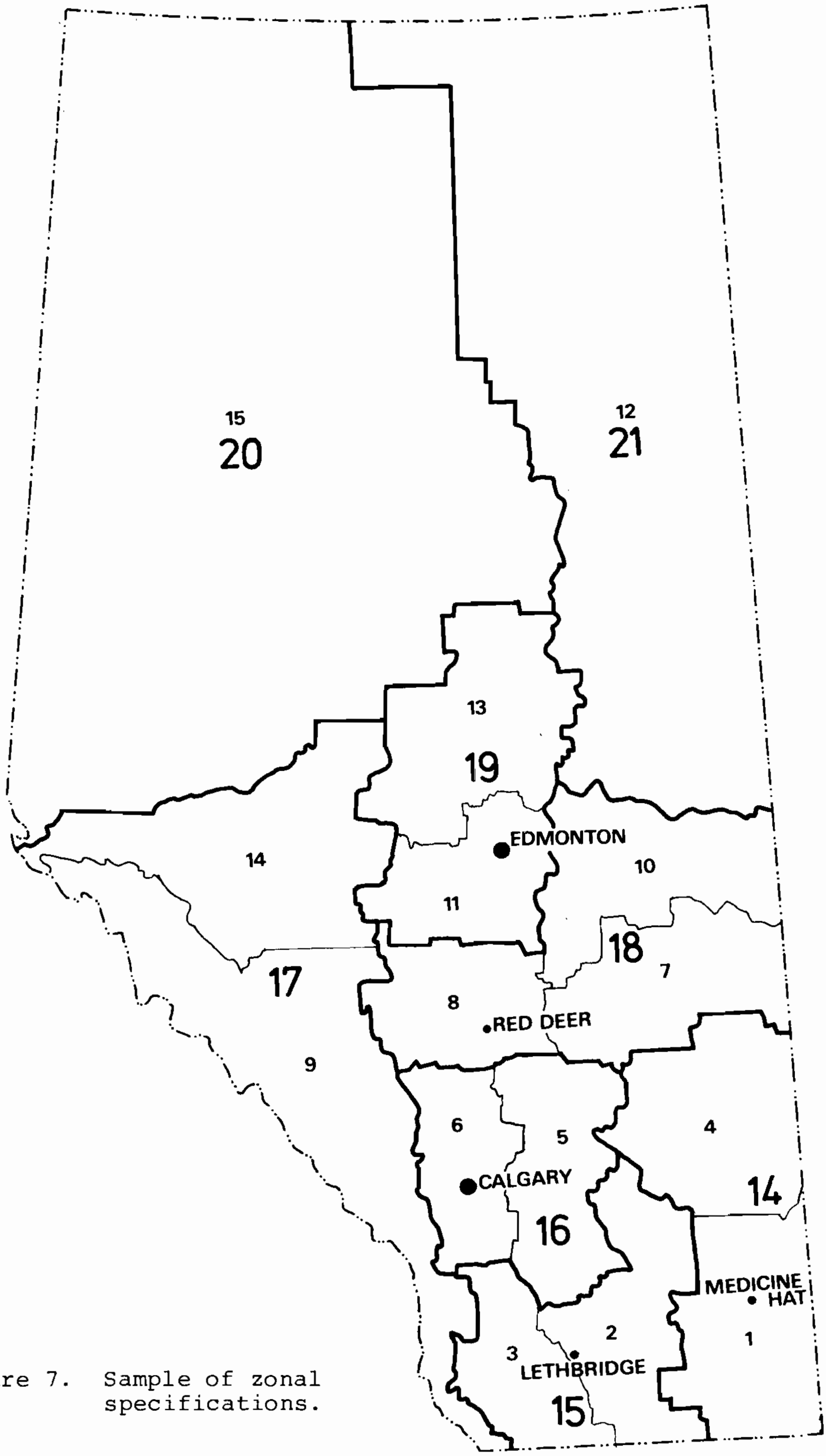

Figure 7. Sample of zonal specifications.

Industry Sectors

Sector	Description
1	Agriculture, Forestry, Fishing and Trapping
2	Mines and Quarries, excluding Coal Mines
3	Mineral Fuel Mines and Wells
4	Food, Feed, Beverage and Tobacco Industries
5	Textile Industries
6	Wood and Furniture Industries
7	Paper and Allied Industries
8	Primary Metal and Metal Fabricating Industries
9	Transportation and Electric Equipment Manufactures
10	Chemical, Rubber and Petroleum Products Industries
11	Other Manufacturing Industries
12	Construction Industries
13	Transportation, Storage and Trade Industries
14	Electric Power, Gas and Water Utilities
15	Communications and Other Service Industries
16	Miscellaneous Operating Costs Dummy Industry

Commodity Types

Commodity Type	Description
1	Live Animals
2	Grain
3	Fish and Fur
4	Forestry Products
5	Other Agricultural Products
6	Metallic Ores and Concentrates
7	Non-Metallic Minerals
8	Coals
9	Oil, Gas and Services Incidental to Mining
10	Meat, Fish, and Dairy Products
11	Fruit, Vegetable, Feed and Miscellaneous Food Products
12	Beverages
13	Tobacco and Tobacco Products
14	Leather and Textile Products
15	Clothing
16	Lumber and Sawmill Products
17	Furniture and Fixtures
18	Other Wood Products
19	Paper and Paper Products
20	Iron and Steel Basic Products

21	Non-Ferrous Metal Basic Products
22	Machinery and Equipment(excluding Agricultural)
23	Automobiles, Trucks and Parts
24	Other Transportation Equipment (including Agricultural)
25	Electrical and Communications Equipment
26	Rubber Products
27	Petroleum and Coal Products
28	Chemical Products
29	Printing and Publishing Products
30	Non-Metallic Mineral Products
31	Miscellaneous Manufactured Commodities
32	Construction
33	Transportation, Storage and Trade
34	Utilities
35	Finance, Insurance and Real Estate
36	Communications
37	Business Services
38	Personal Services
39	Advertising, Travel and Entertainment
40	Repair and Operating Supplies and Services

The transportation system was represented by four networks, one each for the following modes: air, water, rail, and highway. Sample graphical representations of networks are shown in Figures 8 and 9. These have been coded, and minimum path distances between modes calculated.

Transportation modes used in the empirical analysis were air, water, rail, highway common carrier and highway private carrier.

Empirical Analysis

Much of the pilot study on the Commodity Flow Sub-Module involved identification and manipulation of the data base. While zonal production/consumption data are intended to be fed into the SLSM from the ISSM, for pilot study purposes a starting set of such data was developed from the Census of Manufactures and other Statistics Canada sources. Empirical tests of the sub-module then concentrated on commodity distribution, mode split, and network assignment applications for 100 zones. Major runs of the model showed how inter-urban commodity flows and their split between modes (air, water, rail, private and common highway carrier) could be presented.

1) Zonal production and consumption of commodities

The estimates of production and consumption will normally be developed by ISSM. The pilot study estimation procedure used zonal industrial employment, population, productivity

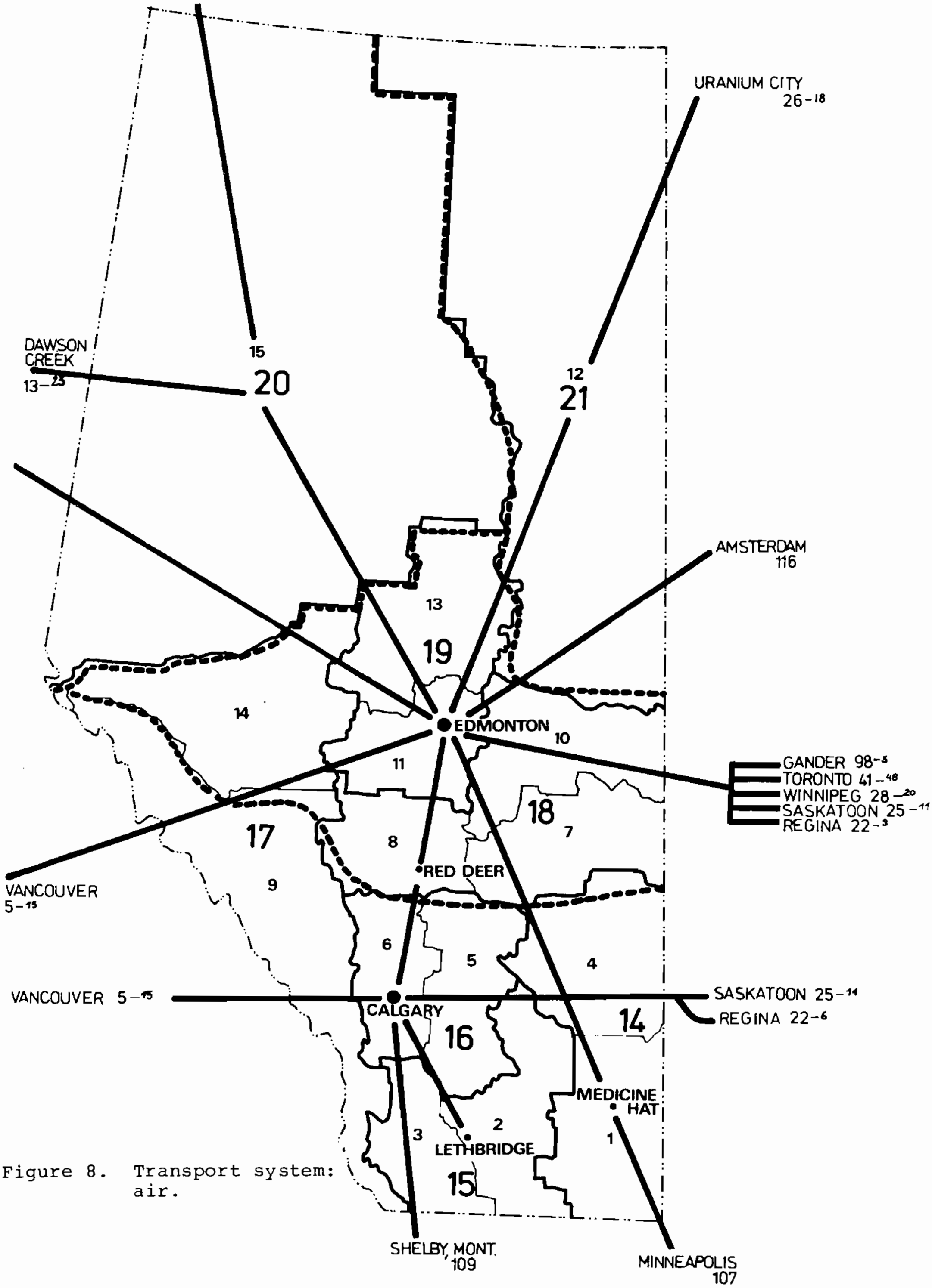

Figure 8. Transport system: air.

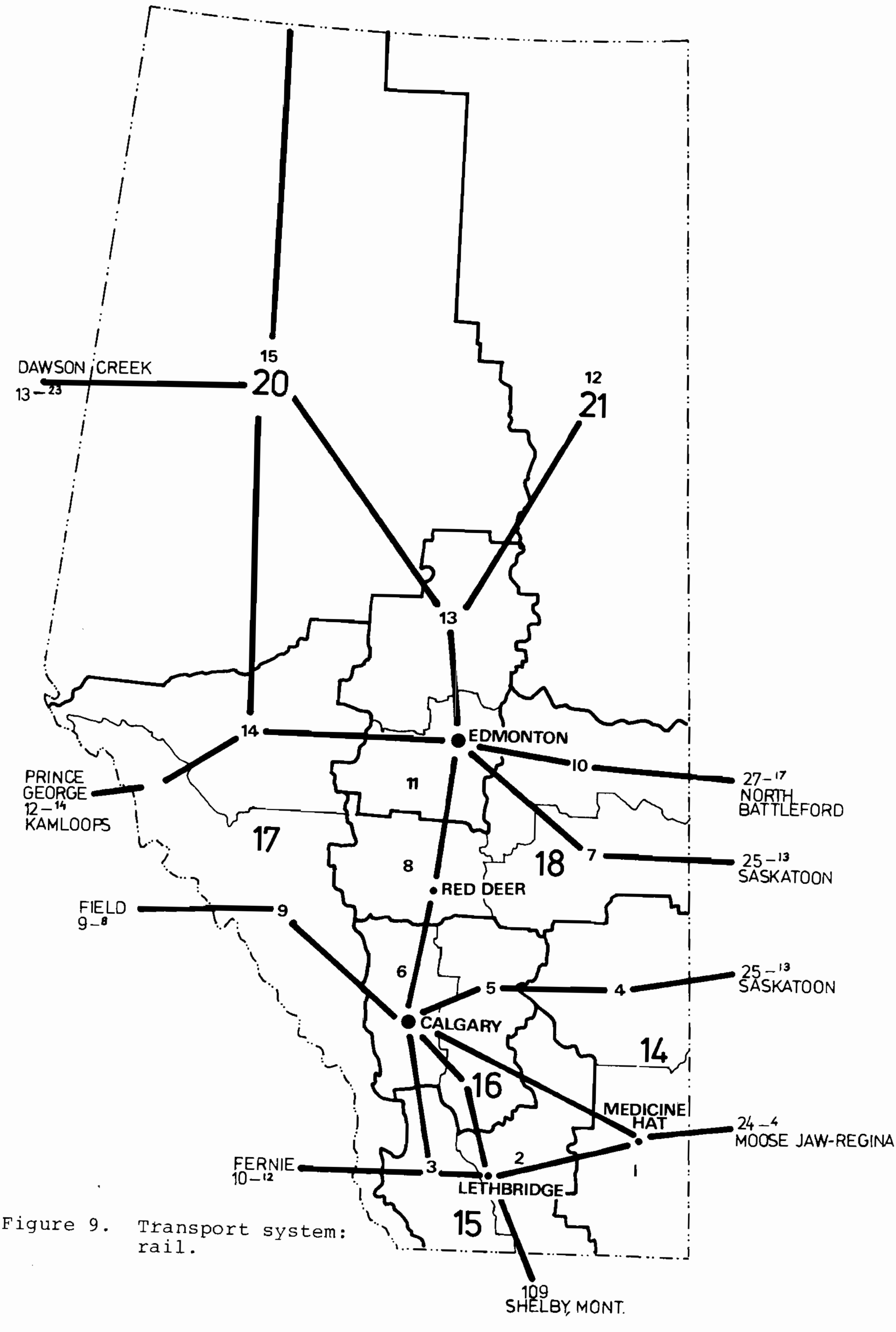

Figure 9. Transport system: rail.

per employee, and the 1961 Canada input-output accounts. The zonal estimates of production and consumption were checked against available data and revealed possibilities for future changes in the disaggregation of commodity classes. On average, however, proportional shares of production between zones was quite realistic.

2) Commodity distribution

The only systematic source of inter-zonal commodity flows available for assessing the validity of the model's output was Statistics Canada's 1967 survey of interprovincial shipments of each manufacturing industry. The effects of alternative distance exponents were tested. It was found that the model's predictions of commodity flow volumes are sensitive to the effects of distance (i.e. transport cost) and that the role of distance also varied between regions for any one commodity. This implies that shifts in transport policy will have different consequences from region to region. An important finding was that distance exponents developed on US data were not suitable for Canadian conditions.

3) Link volumes

Commodity flows were assigned to the actual air, water, rail and road networks. When checked against actual flows, the results were only marginally satisfactory. Such inaccuracies as resulted can be attributed to:

- imprecise production/consumption estimates in each zone;
- crude working assumptions about mode split;
- an inadequate representation of transport cost (i.e. distance is a superficial surrogate); and
- general assumptions about load factors on vehicles.

The first three of these can be redressed during immediate post-pilot study development. Much improved link volume estimates will result.

4) Linear programming approach

While the gravity model used in the above empirical analysis will give relatively accurate results, commodity distribution was also estimated using an LP program available at the University of Waterloo. The LP approach minimises total system transport costs (distance) for each commodity class.

The LP approach generally gave "distance" a much greater influence on commodity movement patterns than it actually has. The results so far are not totally conclusive, however, since LP methods have not yet been applied to bulk commodities in general. Further experiments may result in a sub-module which uses both LP and gravity model methods.

5) Regional development program test

The sub-module tested the impact on employment and, transport flows of moving employment in the chemical, rubber, and petroleum industries from Ontario and Quebec to Alberta and Saskatchewan. A distinct pattern of employment increases in the latter region were observed, along with a shift in transport flows. A brief representation of the problem and results is shown in Table 2.

Table 2. Original and alternative employment in chemical, rubber and petroleum products industries (industry sector 10).

Zone	City	1971 Employment	Alternate Employment
16	Calgary	1,000	5,000
19	Edmonton	3,200	7,200
22	Regina	600	2,600
41	Toronto	35,800	30,000
78	Montreal	20,150	16,150

Change in Movement of Chemical Products ($ million)

	1971	Under Alternative
Alberta to Ontario	20.4	46.5
Ontario to Alberta	33.9	39.5

Needless to say, such results can be obtained on a detailed region-specific basis and for all commodity classes. It is expected that the next major step will be to refine the representation of transport cost and thus allow estimation of the effects of transport policy change.

Generalized Program Impact Relevance

The Commodity Flow Sub-Module is the developed component of a larger tool: the Commodity Transport Module. The latter will include the means to estimate shifts in transport cost as a result of changes inter-zonal commodity flow volumes and policy changes. Meanwhile, the Commodity Flow Sub-Module uses "distance" as the cost variable. The effect of distance varies between commodity classes, and these variations are reflected in different distance exponents. Implied transport cost is therefore accounted for. Given this qualification, we can suggest that the Commodity Transport Sub-Module, at its current stage of development, may be used for the following classes program impact analysis:

1) urban pattern and regional development objectives raise general questions concerning the implications of modifying urban growth rates and the consequences concern changes in transportation patterns. Currently, the Commodity Transport Model can estimate shifts in the movement of goods on the Canadian transport system. Such shifts will have implications both for the function and form of cities and for transportation investments which match MSUA priorities;

2) over periods such as a decade, the Commodity Transport Model will estimate relative changes in the demand for inter-urban transport facilities. In other words, MUPIM and the ISSM and SLSM together project the urban distributional impact of gross changes in national and regional production and/or consumption;

3) similarly relative changes in transport costs cause the distribution and magnitude of commodity flows to change as the comparative advantage of affected zones changes. This in turn allows us to predict relative shifts in the growth potential of urban centers.

   The validity of projections involving these factors will depend on the accuracy of industrial consumption and production data. Transport cost (freight rate) data would also be desirable, and suggestions for its collection and use are under consideration.

Passenger Flow Sub-Module

Objectives

The objectives of the research were:

1) To estimate inter-city flows given characteristics of the cities and the modes of transport connecting them;

2) to derive a set of stable, reasonable and significant coefficients relating existing measurements on variables in order to forecast future inter-city flows; and

3) to use the above coefficients to investigate parametric changes in transport policy variables with particular reference to modal interdependencies and spatial impact.

Data

Data were obtained from the Canadian Transport Commission (1969) study of passenger travel on the Quebec-Windsor Corridor. The following variables were used in the analysis:

a) Transportation variables:

1) travel time, including terminal time by air, rail and bus;

2) fare;

3) passenger flow; and

4) driving time for automobile.

b) Socio-economic variables:

1) population;

2) linguistic composition (percent "English only");

3) percent of the population over $11,000 per annum, weighted by city size; and

4) per capita income of the city of origin.

Models

A set of nineteen equations from three distinct model structures were estimated using the abstract mode methodology. This involves the hypothesis that the demand for travel by different modes is determined by a single demand function. This allows observations on inter-city passenger flows by different modes to be pooled and a single regression equation to be estimated for what is otherwise a simultaneous system. Demand for travel is assumed to be a function of a set of attributes common to all modes: fare, travel time, departure frequency.

Results

All the models tested were able to fit the data well, but this was partly a function of the low ratio of variables to observations. The most significant criteria at this stage were considered to be stability and reasonableness of the estimated coefficients. Stability has two aspects:

a) how do the coefficients change over time? and

b) how do the coefficients vary between models?

The former could not be tested owing to the absence of more than one cross section of data, but the latter demonstrated that, for equations with comparable specifications, the estimated coefficients were quite similar. Stability was enhanced by the use of the geometric mean rather than the "best" mode criterion for the generalized cost and relative characteristics variables. If available modes are compared to the best mode, a discontinuity, hence instability, is introduced if the identity or performance of the best mode is altered. Some of the coefficients were particularly stable, for instance, the population products variable and the linguistic pairing index. Stability in these variables might be expected a priori, but it was also found in the relative modal characteristics variables using the geometric mean.

The signs and magnitudes of the estimated coefficients corresponded well to preconceived notions of the acceptable intervals in which coefficients should lie. Population coefficients were positive and close to unity as were the linguistic coefficients. Income coefficients were lower and unstable, their magnitudes being affected by the presence or absence of the linguistic variable. This apparent collinearity was not symmetrical, however, as the linguistic coefficient was not significantly affected by the inclusion or otherwise of the income variable. Travel impedance coefficients were, as expected, negative, and for those which can be interpreted as elasticities, their magnitudes were approaching two. Coefficients produced by the one-stage model could be interpreted as elasticities owing to the property that the coefficients relating logarithmic variables are measuring proportionate effects. This interpretation cannot be made so routinely with two-stage models in which modal characteristics are related to a base mode.

Statistical significance, as measured by the t-test, was high for the key variables. Naturally, it was high for the population, but it was also high for the linguistic variable. Among the transportation variables, mode choice variables based on relative characteristics were uniformly high, relative travel time being slightly more significant than relative fare. This latter finding was common to all equations, even though the position is consistently reversed with respect to the magnitude of the coefficients.

In summary, the empirical testing so far accomplished has been satisfactory from goodness of fit, stability, reasonableness and statistical significance criteria. It is expected that the analysis of more extensive data will produce only low order changes in the coefficients. Further testing will also involve the appropriateness of mode specific constants and coefficients in a simultaneous systems context.

Acknowledgments

The MUPIM project relies on the effort and expertise of a large number of professionals both within and outside the Ministry of State for Urban Affairs. No one paper, or component of the model, sufficiently reflects the breadth of this support.

However, particular mention should be made of:

- Dr. Bruce G. Hutchinson and William O'Brien, who performed research on the Commodity Flow Sub-Module under external contract;

- Thomas G. Burns, who was ensured, for the Spatial Linkages Sub-Model, a supply of data and compatibility with other sub-models, and has had the primary responsibility for the Urban Travel Demand Sub-Module; and

- Michael J. Wills, who performed developmental research on the Passenger Flow Sub-Module under external contract, and who wrote the corresponding sections in this paper.

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Principles of Dataware Design for Population Distribution Problems in the USSR

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I. Introduction and Context

As demonstrated in other conference papers by Avdotjin [1] and Kudinov [3], development of the population distribution system is one of the key issues in national economic management and is closely intertwined with economic growth. The rapid urbanization of the latest years, increased migration rates, and economic problems caused by these make population distribution more complicated. By 1990 the population of this country is expected to approach 300 million. The urban population will amount to 69 percent of the total as opposed to 56 percent at present. There will be more than 2,300 towns and cities and almost 4,000 townships. About 400 new towns will be built similar to today's Togliatti, Naberzhnye Chelny, Zelenograd, Sosnovy Bor, Shevchenko and others. Old cities such as Tomsk, Tobol'sk, Orenburg, Minusinsk, Yeniseisk, Abakan and others will develop intensively.

Comprehensive and in-depth analysis of population distribution requires study of rural areas as well as urban areas and cities. The success of urbanization is largely dependent on modernization of agriculture and changes in the life pattern of rural areas. Improved technology and modernization of agriculture contribute to total rejuvenation of areas and a more diversified structure of employment as well as to higher productivity. Thus a comprehensive program of agricultural development outside the black-soil zone in the Russian Federation will radically transform a vast territory (twenty-nine districts and autonomous republics) in the center of this country. Efforts to improve agricultural productivity and to industrialize the processing of agricultural products will result in the remaking of villages and townships into modern settlements with all kinds of amenities, technological facilities and comforts contributing to most favorable conditions for work, life and recreation.

Management is a major factor, as important as resources in contributing to desired growth rates. Analysis and forecasting for optimal management is unthinkable without studying national and international phenomena. Development of the national economy and progress in general are a function of the interrelation of many factors, and practical implementation of the program requires objective data on the most important dependencies and the factors that determine growth rates.

II. An Information System for Population Distribution Planning: An Overview

For this purpose a nation-wide data processing system is to be deployed in the USSR. Population distribution will be handled in one of the subsystems, which will supply data necessary for the optimal design of towns, urban areas and economic regions, and thereby the development of the entire population distribution system. Data will be supplied in timely fashion, in a user-oriented format for making management decisions. The basic features of this subsystem are as follows:

1) The process to be controlled is a city as a totality of natural and artificial subsystems which unite production, services, population and environment into an integral whole. At the present stage further improvement of the population distribution system means generation of economically intertwined conurbations. The towns and townships of assorted sized making up such "constellations" should complement each other in production, science and culture, and should all feature high quality amenities and well-developed transportation, communication and service systems.

2) The processes to be controlled include teams of people and personalities involved in everyday life and recreative activities, etc., as well as in productive activities. Human beings naturally make the process active.

3) There are multi-channel feedbacks, long delays at the higher level and large differences in response times for the higher and lower levels.

4) There will necessarily be inherent difficulties in collecting objective data on the states of the system, and long delays in feeding data to the managing body.

5) System relations will be characterized by wide variety and will often be stochastic in nature. There will be a high degree of uncertainty in the behavior of system elements.

6) The development of a mathematical model is not always possible because of complexity and uncertainty in the system processes. Therefore the subsystems should incorporate simulation units to imitate situations in order to determine rational solutions.

7) Client relations will be complicated by the wide variety of existing management structures at all levels.

The population distribution management information system should be developed as a subsystem of the overall system; therefore methodological, socio-economic, organizational, legal, technical and informational compatibility with other subsystems should be assured.

The effectiveness of operation with other subsystems is assured by the unification of software, or in creation of uniform data encoding and classification including the introduction of nation-wide classifiers, a unified system of documentation, a system of indices, formatting the flows of data on direction, amount, periodicity, credibility and priority, and unification of the sequence of data generation and processing.

The subsystem and the entire system rely on the state network of computing centers incorporating the interacting ministerial, departmental, republican, territorial and city computing centers and on the nation-wide system of data transmission which is an integral part of the united automated communication network.

The subsystem structure as well as the structure of the entire system should preferably consist of three levels of data processing. At the first (city) level the primary data circulating among the factories and primary organizations of the communal services, transportation, construction, trade, etc., are processed. In a number of cities, management information systems (MIS) will be deployed for the most important branches of the economy.

At the second level the data characterizing the functioning and growth of basic territorial units such as districts, economic regions and republics are handled. The upper level of the system is a set of computing centers under planning bodies headed by the Main Computing Center of the USSR State Planning Commission (Gosplan). Towns and small factories should be served by computing centers of the USSR State Statistics Board.

III. System Description

Let us consider in more detail the basic problems solved by the population distribution subsystem. The upper level handles problems in development of the overall distribution outlay which determines the number and size of cities and conurbations over a specified period and the rate of their growth, in particular the growth rates of housing and services.

In a general case the deployment of industries and the development population distributions should be posed and solved as simultaneous problems. Particular problems of population distribution may be posed, for instance, within a specified structure of industrial development and deployment. In a number of cases the problem is the inverse; it is selection of a rational structure of industrial development for specified alternative possibilities in the development of the population distribution system. Solution of these problems depends on the data from regional and city subsystems and from central planning and statistical bodies. The development of a population distribution system is a function of economic growth, the state of science and technology, capital investment, the existing system of population distribution, the numerical and qualitative composition of labor resources, the environment, etc.

The following problems are tackled on the regional level:

a) optimal deployment of industrial, scientific, agricultural and other enterprises in the region and its cities;

b) optimization of the interregional and inter-city transportation systems and of local communal services such as power, water and gas supply and drainage;

c) optimal deployment of recreational areas and facilities such as parks, recreation zones, sanatoria and sports and tourist centers;

d) optimization of conurbation planning and construction;

e) determination of a rational size for cities and settlements in the region; and

f) determination of optimal public service systems.

At the city level the following problems are handled:

1) optimal city planning and construction;

2) optimal deployment and reconstruction of production, housing and recreation zones;

3) optimal size and location of public centers;

4) determination of an optimal city transportation system and of communal services;

5) optimal organization of the public service system;

6) optimal planning of apartment distribution and redistribution with maximal possible satisfaction of the requirements on the part of the populace; and

7) determination of methods to manage the functioning of city subsystems.

The solution criteria at all levels may of course be economic, social, ecological, or some combination of these.

The population distribution subsystem data banks should contain an estimated 1.5 or two billion bytes of alphnumerical data for the upper and regional levels, and thirty or forty billion bytes for a medium city.

IV. Computer System Standards

In individual cases the above problems are difficult to formalize. To solve them a set of imitative models is under development that would incorporate optimization models enabling evaluation of decisions made. Imitative models should rely on a uniform and adequate mathematical description of components involved in solving the population distribution problem in the USSR. Such description will lead to general-purpose mathematical methods for the solution of management problems and for design of a general-purpose data processing system. In the latter, the format for collection of primary data must be made consistent with a unified internal computer structure (software, input, primary processing, storage and updating systems). This approach will ensure simple communication between parts of the system and a simple integration procedure.

The key elements in the proposed mathematical description are "production," "services," "citizen/family" and "natural resources." The derivatives of these are "city" and "region." The elements are described by name and level in the system hierarchy. The standard elements unify the features of all elements of the corresponding class; the mathematical description is invariant with element name and level. This satisfies the requirement that the system be general-purpose. For a set of standard elements of one class the unification operation can be defined so that the unification results in a new standard element. For a set of standard description elements of different classes another unification operation is defined, this time resulting in a standard element of the subsequent level with other characteristics. The "production" element is characterized in terms of type, number of employees in the age, sex and skill profile, area, resources used and effect on the environment.

The "services" element is described in terms of the kind, extent and productivity of services, the number and structure of employment, area, resources used and effect on the environment. The "citizen/family" element is described in terms of age, sex, skill, mean level of consumption, birth rate, etc.

The derivative elements are not mere sum totals of their components; thus a "city" is described in terms of size, location, population, demographic characteristics of the population and the employment structure, availability of amenities and services, resources used and effect on the environment.

The basic characteristics of a "region" are locations, size, number and other parameters of its cities; its natural resources and their conditions; population, demographic characterisitics and employment; chief functions of the region; structure, types and characteristics of the production and service systems; availability of goods and services; effects of resource use on the environment, etc.

The data banks of the subsystem should naturally contain data on the dynamics of basic elements for past years and the data for forecasting and planning resulting from the use of imitative models.

V. An Exemplary Subsystem: Urban Housing Allocation[1]

Let us note that to solve a number of partial city planning and management problems, more detailed data may be required, for instance for the apartment distribution and redistribution subsystem.

The list and structure of data arrays for the latter subsystem are given in Figure 1. The subsystem structure relies on specialized data banks integrated into the data-processing-and-management system of the city, and on treating apartment distribution and redistribution as one problem. The latter feature can increase, on the one hand, the number of people on the waiting list and on the other, the number of families whose needs are met through exchange.

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[1]Western readers should note that housing is a socially supplied good in the USSR, that is, a non-market commodity. Without going into detail, suffice to say that available housing is generally allocated among citizens, who are then free to make private Paretian trades without sidepayments. A good information system is the necessary lubricant. [H.S.]

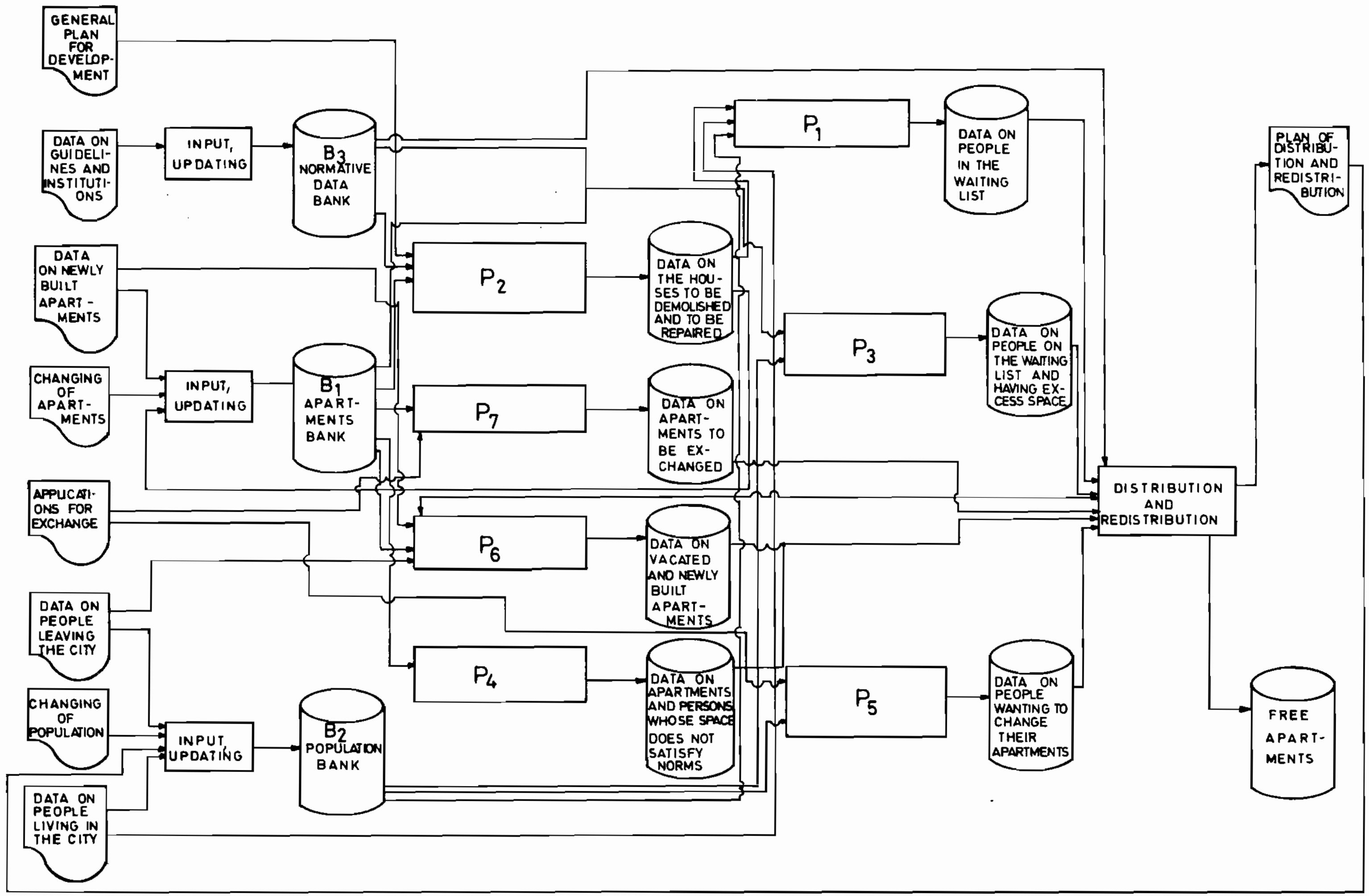

Figure 1. Apartment allocation subsystem.

The data base of the system is an apartments bank, B_1, a population bank, B_2, and a normative data bank, B_3, where the data is stored and updated and arbitrary access to all elements and their output to the users is assured.

B_1 contains data on characteristics of each flat, type of house, neighborhood, amenities, etc.

B_2 contains data such as age, sex, family, affiliation, social status, parameters giving the right to additional floor area, and data on the apartment currently belonging to the citizen.

B_3 contains guidelines and instructions on principles and criteria of population distribution, norms, deadlines for capital repair of buildings of each type, their expected life, etc. This bank also contains permanent data used in the system such as names of boroughs, streets, factories, a distance matrix, etc.

The initial data for apartment distribution and redistribution is a number of arrays from the banks plus data arriving from outside of the system. These are the data on population in need of improvement of housing conditions, newly built flats and flats intended for redistribution.

The array of people in the waiting list is formed by procedure P_1 using the data on people arriving in the city over the current period, data on houses to be demolished and to be repaired, and the data of B_2. The array of buildings to be demolished and repaired is generated by procedure P_2 using the local *General Plan for Development of Productive Forces and the City* as reference and the data of B_1 and B_3. The array of people on the waiting list and those having excessive floor areas in their apartments is generated by procedure P_3 using the data of B_1, B_2 and B_3. This array contains data on persons whose floor area does not satisfy the existing norms. Using the data of this array and of B_1, procedure P_4 generates an array of apartments belonging to them. An array of people who want to change their apartments is generated by procedure P_5 which uses applications for exchange and the data of B_2. The characteristics of newly built flats and flats intended for redistribution, in particular through exchange, are contained in the arrays of vacated and newly built apartments. This array is generated by procedure P_6 which uses data on newly built apartments and apartments just repaired, data on people leaving the city, and the data of B_1. The array of apartments to be exchanged is generated by procedure P_7 which uses the applications for exchange and the data of B_1.

The apartment distribution and redistribution system functions in discrete time. The apartments to be distributed at a given time are made of newly built ones and those vacated as the result of distribution in the previous period. The apartments that have been vacated and currently remain undistributed are to be distributed at the succeeding time.

The updating and monitoring of input data from B_1 - B_3 is handled by monitoring and updating procedures relying on newly introduced legislation, changes in the norms, changes in the apartment fund, changes in the population status and on people arriving in or leaving the city.

The population distribution subsystem is clearly very complex. A wilful decision on development of the system dataware (data bank and array structure and contents at each level, processing procedures) might lead to unjustified consumption of computer time and reduced effectiveness of computer use. Therefore a diagnostic analysis has been undertaken, resulting in the specification of system objectives and criteria and determination of the factors that would influence the achievement of the objectives. The necessary data for improvement of population distribution systems has been collected.

A set of first priority problems has been identified. The available methods for formalized representation of detailed MIS analysis and design results make it possible to use standard documents for formalization of the basic stages in analysis of systems such as study of the structure, objectives and constraints on the existing management system and its data flows processing algorithms. This standard representation of system design results in a format suitable for programming. In the USSR the methods of the Institute of Control Sciences and the Central Institute of Mathematical Economics [4;5] are most extensively used.

The MIS dataware features a well-developed multi-level structure and should establish connections both between nodes inside the system and with a large number of outside organizations. This requires special methods for the coordination of data processing systems at different levels and the development of special classifiers. Most problems handled in a MIS feature large amounts of data to be processed which determines a logical nature for the processing. Data input/output takes up a large fraction of the overall processing. Retrieval and sorting operations are used extensively.

In development of MIS dataware, first of all the necessary and sufficient data for management, the data processing subsystem, data arrays, and input/output data processing and monitoring algorithms and programs should be defined, data credibility assured and all units of the MIS should operate smoothly both separately and in combination (Figure 2). The criterion for dataware design may be either minimal computer time, or storage, or time taken for development and embedding, or it may be a generalized criterion combining some of those listed above.

Multi-version solutions are practically nonexistent now in the design of data processing systems. The programmers and system engineers normally use one version which, they believe, is most desirable. Many of them are of the opinion that the hardware and methods are of no importance provided that the system is workable.

Since the MIS design should be of higher quality and be completed in the shortest possible time, the design should be programmed and automated insofar as possible.

VI. Dataware Design

The graph-theoretic methodology developed by us for formalization of dataware represents the formal model of the system as an oriented multi-graph with AND/OR elements, $G = (I,F,D)$. Each vertex of the graph is associated with the data arrays, $I_k \in I$ $(k = \overline{1,k_o})$, and each bunch of arcs (an AND gate) which generates the array I_k is associated with the mapping $F_r \in F$ $(r = \overline{1,r_o})$ of some data arrays onto the desired one, $\{I_\eta\}^2_R \xrightarrow{F_r} I_R$ $(\eta = \overline{1,k_o})$. The matrix $D = ||d^2_{rk}||$ $(r = \overline{1,r_o};\ \eta,\ k = 1,k_o)$ defines the structure of the graph G over a set of elements $(I \times F)$ as $d^2_{rk} = 1$ if $I_\eta \in \{I_\eta\}^2_k$ and $F_\eta : \{I_\eta\}^2_R \rightarrow I_k$, $d^2_{rk} = 0$ if otherwise.

The model elements $I_R = I(S,x,v,\theta,\alpha)$ are univalently defined by the fourtuple (x,v,θ,α) at a certain fixed content of the data array S where $x = \overline{1,x_o}$; $v = \overline{1,v_o}$ are ways of organizing the records and the array respectively; $\theta = \overline{1,\theta_o}$ are types of media or storage units; $\alpha = \overline{1,\alpha_o}$ are retrieval strategies. The mapping $F_r = F(R,\gamma,\pi)$ of data arrays is univalently defined by the pair (γ,π) at a specified set $R = \{Rj, j = \overline{1,J_o}\}$ of the operators Rj, where $\gamma = 1,\gamma_o$ are

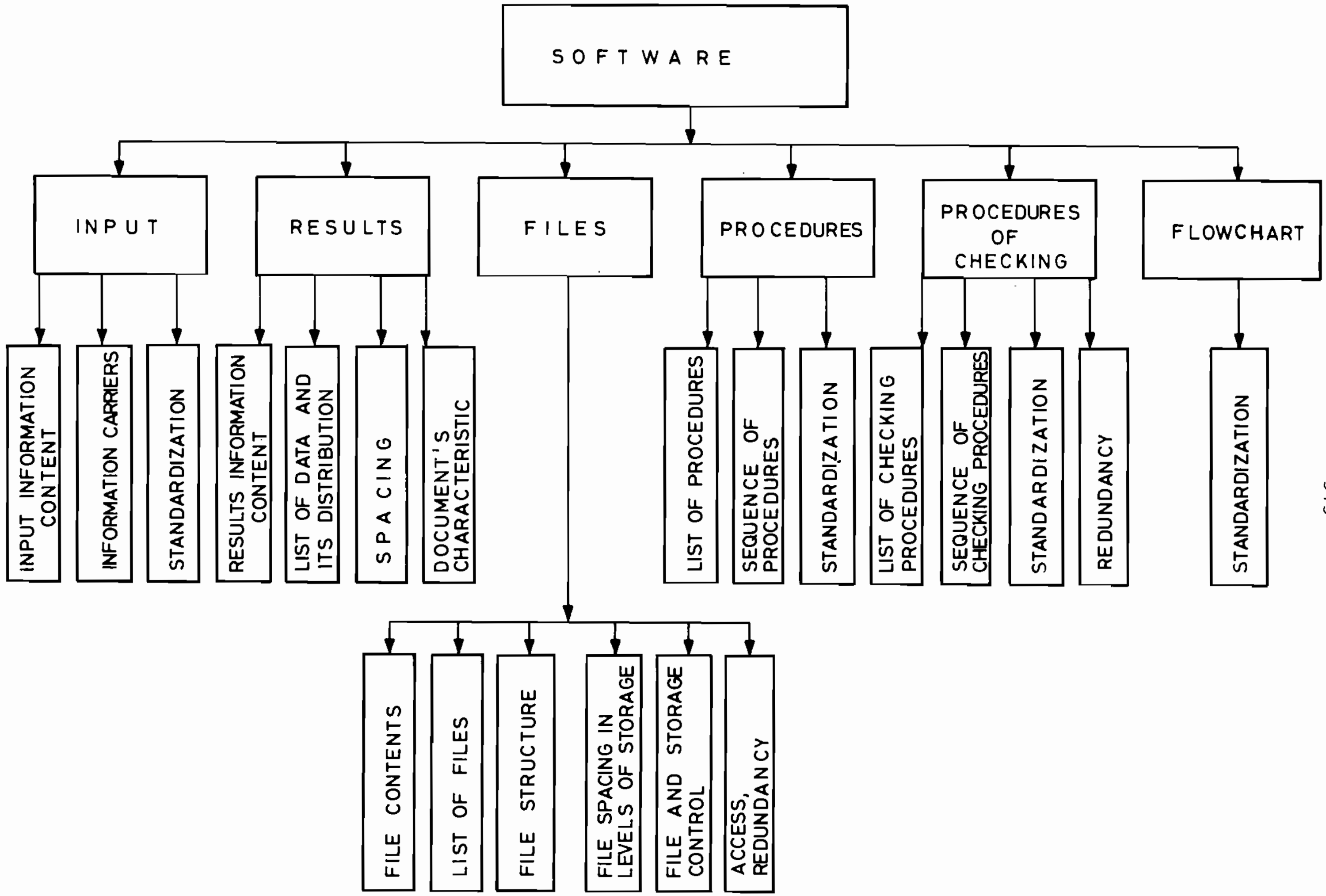

Figure 2. Procedures in developing dataware for management information systems.

facilities for implementation of the operators R_j and $\pi \in P$ is the sequence of implementing the operators R_j in the mapping F_r defined over a set of possible sequences P.

The basic characteristics (criteria) of dataware in the framework of this formalization can be expressed either in the additive form

$$Z_\lambda(G) = \sum_k [Z_\lambda(I_k) + \sum_r Z_\lambda(\{I_\eta\}_k^2, F_\eta, I_k)],$$

or in the recurrence form

$$Z_\lambda(G_k) = Z_\lambda(I_k) + \sum[Z_\lambda(\{\dot{I}_\eta\}_k^2, F_\eta, I_k) + \sum Z_\lambda(G_\eta)\alpha_{rk}^2],$$

where Z_λ is the characteristic of the λ^{th} type ($\lambda = \overline{1, \lambda_o}$) G_k subgraph generating the k^{th} vertex of the graph G.

A graph of feasible MIS dataware implementation, $G_o = (I_o, F_o, D_o)$ is obtained if for each k (or certain k) a selection of r is possible (an OR gate). The overall problem of datware design is formulated in the framework of the model developed as follows.

For a specified input and output a graph $G_o = (I_o, F_o, D_o)$ should be obtained, a graph of MIS dataware implementations feasible and best in terms of local constraints on characteristics of gates, and on parts and components of the system. One then selects an optimal version satisfying the general requirements to characteristics of dataware as a whole $G^* = (I^*, F^*, D^*) \in G$.

The basic idea lies in the successive identification of typical element, part and component design problems and their interrelated solution, with sequential elimination of all non-feasible and worst versions. At the initial solution stage an aggregated approach is used with gradual forced detailing leading to completion of the graph G_o.

This approach results in identification of typical problems of which the basic ones are a) design of chief elements of dataware, or data arrays and mappings; b) determining what data must be stored in the MIS memory; c) MIS memory organization; d) definition of MIS input and output; e) organization of intermediate arrays in the implementation of mappings; and

f) selection of the best (or optimal) implementations of MIS dataware components. In addition to these basic problems, other typical ones include selection of the best data sources and the optimal integration of different MIS into one system.

Mathematically the above design problems are combinatorial programming problems with nonlinear objective functions and constraints. In the graph interpretation, the algorithms developed reduce this problem to finding optimal subgraphs in graphs of special form. The FORTRAN algorithms and programs either handle sufficiently high dimensionality in computers with disc storage, or their applicability is constrained by the size of the operating store (thus in an ICL System 4-70 problem 2 the constraints are $k_o \leq 60$, $r_o \leq 80$, $\forall k = \overline{1,k_o}$; $\sum_{r=1}^{k_o} d_{rk}^2 \leq 16, \forall r,k$ which is quite sufficient for practical purposes).

In solving real life problems, however, the data on characteristics of certain procedures and arrays is often missing. Therefore much attention should be given to accumulating statistics on different dataware elements and to developing algorithms for determining the characteristics of dataware components.

The differences among memory units in the same computer and the resulting differences in the array access statistics give rise to the problem of data exchange between computer memory levels and between these and the central processor. The data exchange is usually optimized so that the losses (queuing time, sum of queuing losses, costs of improving the speed) are minimal. Data exchange optimality is largely a function of data array allocation. Optimal distribution requires solving the following basic problems: allocation of data arrays among computers, levels and types of storage of each computer, allocation of data arrays inside the store of the same type of memory of the same level, or determination of optimal deployment of data arrays in one medium.

In design of MIS dataware the data processed should be maximally credible with constraints on material and time consumption satisfied. The errors arise due to drawbacks of the data processing structure, drawbacks of the algorithms, drawbacks of the programs, unreliable operation of the hardware and human mistakes. Analysis of different data processing structures identifies a standard processing flowchart requiring successive stagewise iteration of data processing proper, monitoring and correction procedures.

A model for analysis of various flowcharts has been developed. Selection of optimal structures is handled by the method of dominating sequences, a modification of the dynamic programming method. The associated algorithm has been programmed. We have tackled the problem of determining the optimal processing structure minimizing the time or costs with a constraint on credibility of the data processed.

To solve any MIS problem several arrays of different characteristics are created. Therefore first the optimal redundancy strategy should be selected that would minimize the probability of array erasure (or maximize the probability of solving the problem) at specified constraints.

The following alternative redundancy strategies for data arrays were considered:

1) Copies of data arrays used are constantly made and stored.

2) K preceding samples (histories) are used as copies of the current array. If it has been destroyed the current array is restored by the updating program on the knowledge of preceding one.

3) For a current array, copies are made and a specified number of histories is stored.

The redundancy strategies are reduced to convex programming problems and the method of limited resource allocation can lead to integer solutions. The algorithms for standard design problems developed in the framework of this dataware design methodology permit automation of the most complex and labor-consuming stages in system design and thus lead to better results and reduce the overall development time.

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PART FIVE: NEXT STEPS

Future research on urban regional topics will undoubtedly develop in several different directions depending on the urban problems that are perceived to be of critical importance in various countries, and on the skills, personal biases, and even whims of urban researchers. In this section, three quite different approaches to urban systems research are advocated. The first, by Fleisher, Harris and Rodwin, represents a logical extension and synthesis of quantitative urban and regional models. Although some have argued that large scale simulation models promise more than they can in all likelihood deliver, previous experience with such models and recent developments in computer technology may make these approaches more successful in the near future than they have been in the past. In any case, much can be learned from the attempt to specify detailed process models of this kind.

Although Meier's paper would seem at first glance to be of more specialized interest, is should be viewed within the larger context of a growing concern for environmental quality, conservation of energy and other scarce resources--in short, a belief that the resolution of urban problems should be viewed within a much broader context than is typical in urban research. Many of the concepts and relationships are of a speculative nature, but there is an increasing concern among researchers, policy makers and the general public that the broader ecological interconnections and the essential vulnerability of many urban systems should be the subject of intensive study.

Finally, Hall briefly outlines a proposal to undertake a consistent empirical study which would in essence identify, in a consistent way, the state variables of urban systems in several countries. Broadening the empirical basis of research on urban systems to encompass the countries of Eastern and Western Europe deserves a high priority: too much of what we think we know comes from too few places.

A Proposed Approach to the Development of a Simulation Model for Evaluating Urban Growth Strategies[1]

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I. Objectives and Scope

1.1 Emergence of the Problem

Until the end of Warld War II, most countries had no national policies for the guidance of urban growth. Growth was considered desirable and the location of urban growth was not a national issue. There was, to be sure, fierce competition between cities and regions; and lags in urban development in particular regions were deplored, as were the problems of a booming metropolis. These problems, however, were regarded as local or regional, not national. But this view of urban and regional development has already changed radically in many countries in different parts of the world, and is in the process of changing in most other countries. Urban growth issues are being hotly debated; explicit national policies are being formulated; incentives, regulatory mechanisms and other tools designed to guide development in preferred directions are being

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[1]This paper is a revised and abbreviated version of a report prepared for the United Nations. The work was done by a team headed by Lloyd Rodwin who handled general policy. A. Fleisher dealt with the computer problems and J. Harris worked out the model. Each member of the team criticized the work of the others and collaborated in the preparation of the final version of this document. Thanks for helpful suggestions are due to G. Desmond, Economic Adviser of the UN, who initiated and supervised the project and to P. Towfighi who made helpful comments on all stages of the draft material. We had an opportunity to discuss a preliminary version of this paper at a UN Seminar for Housing, Building and Planning which included representatives from the Centre, the World Bank and other organizations. Participants or readers of the paper who contributed helpful suggestions included: R.J. Crooks, A. Ciborowski, W. Garces, J. Voss, V. Kandaswamy, E. Ergun, P. Towfighi, G. Desmond, R. Trusk, E. Keukjian, A. Kuklinski, R. Westebbe, D. Strombom, D. Keare, P. Bearse, J. Bergsman, J. Howenstein, R. Jones, R. Kaminsky, I. Nadiri, J.A. Ternent, and T. Vietorisz.

fashioned.

Viewed historically, this change in attitudes is arresting, and yet the reasons for the change are fairly obvious. The big city poses big problems, and these problems cannot be effectively tackled at the local level. The costs of infrastructure investments are staggering and the concentration of population and economic activities has led in many cases to a radical transformation, and often a marked decline, in the quality of the physical environment. At the same time, the prevalence of underdeveloped or lagging regions underscores the apparent imbalance of development and nourishes the commonsense judgment that it would be desirable to slow down growth in the big city and encourage development elsewhere. The increasing dissatisfaction with sector and aggregative planning tends to reinforce these views. It is easier to make plans for industry and agriculture, for trnasportation, housing, and other public facilities, and to make such plans at the national level where key budgeting decisions are made and the ablest staff concentrated. But plans for the functional sectors depend on decisions and programs in other sectors; and all of these developments must take place in particular locations. There is rarely adequate coordination or linkage of the policies in these different sectors. Information about developments in particular cities and regions is often poor or negligible. And the errors in project planning and programming and the lags and disproportions in development have often increased the costs and reduced the productivity of specific investments.

1.2 The Search for Better Planning Tools

On the grounds of efficiency as well as equity, therefore, national planners have begun to search for better ways of tackling these problems of development. Over time, the conviction has grown that the city is a tremendously significant--and neglected--variable for the planning of development, at both the regional and national level. The sector plans must come to fruition in particular cities and regions and therefore ought to be evaluated in terms of their relevance and effects on cities and regions. Thinking in terms of urban development may also provide a means of correcting the narrow perspectives of sector plans and the limited professional perspectives of the economic planner. Encouragement of development in particular cities may also produce more sensible patterns of development, patterns which we may have to live with for several generations, perhaps even centuries, as well as broader perspectives on the locational and human factors in development. The process of preparing and evaluating alternative plans for urban and regional developments might generate more productive as well as sounder and better coordinated projects than the ad hoc sector programs developed in the past. Finally, the clearer definition of the policies and programs for the development of particular cities and regions might provide a helpful lead for development decisions by the private sector of the economy.

It is relatively easy, however, to spot some of the programming deficiencies of the past. The evidence lies all about us. But it is less easy to ensure that the new approaches will not generate other defects equally, if not more, inhibiting to the process of development. Although many countries are groping persistently for workable policies and tools to guide urban development, the methods are still crude and improvised, and the decisions often reflect these limitations. It will take much effort and experience to improve these methods. But the present is a good time for such a start to be made because there is growing experience with diverse policies and programs and interest in them. Many countries have fashioned organizations whose mission is to analyze urban growth problems, obtain information to guide these policies and link them with national development policies.

However, to date, we have no effective means of evaluating systematically the social and economic consequences of different strategies for urban and regional development. Judgments are largely intuitive. Too little is known about the effects of different policies on investments, incentives, income distribution and welfare. Ad hoc measures of planning and coordination still waste scarce resources. We often fail to encourage development in regions with significant potential while directing resources where congestion phenomena cause sharply diminishing returns. Agricultural schemes without adequate marketing facilities, industrial development without adequate infrastructure, or infrastructure that remains underutilized are not uncommon. Separately derived regional and metropolitan plans end up requiring far more resources than can possibly be made available. The result is nonfulfillment of the regional and metropolitan plans. What is more, we have few mechanisms to insure that nonfulfillment results in foregoing the least productive investments. Although it is clear that some efficiency in resource utilization must be sacrificed to attain goals of equity, there is little if any idea of the magnitude of such trade-offs.

It has also been difficult to avoid conflict between the economic planners concerned primarily with aggregate national growth and physical planners who have been charged with responsibility for regional and urban planning. Part of the problem arises from their different conceptual frameworks. This makes communication and linkage of their efforts difficult. The problems are often reinforced when each group belongs to different ministries or agencies. However, some recent efforts to include regional planning within a single national planning agency have not been particularly successful simply because formidable technical problems arise in trying to integrate metropolitan, regional, and national sectoral plans.

Yet it is imperative to fashion effective strategies of urban and regional development. These strategies must ensure that regional, metropolitan and national plans will reflect national aims and that coherent and consistent sets of policies will be formulated which can be implemented and which will take account of both efficiency and equity goals.

One of the central areas of high priority in which economic and urban policy makers currently need and want help is in evaluating the likely consequences of alternative urban growth strategies in relation to national development objectives. More specifically, it would be especially valuable if they could assess the implications of these strategies from the standpoint of:

1) employment, output and income;

2) distribution of income--across social groups and regions;

3) growth rates;

4) movements of population and economic activity;

5) development and welfare policies;

6) organizations and levels of decision making;

7) consumption patterns;

8) quality of life and environment;

9) health education; and

10) maintenance (or disruption) of traditional values.

We believe it should prove feasible to devise a model which will provide more reliable methods of developing this information in most countries in the near future, at least for the first six categories noted above. The other factors would not be ignored. They would simply not be taken directly into account *in the model*--mainly because good quantitative indicators for these items are not currently available. To be sure, there may be temporary difficulties such as lack of personnel and equipment; and for a long time there will be more serious difficulties such as lack of knowledge, inadequate data, or the sheer hazards in making projections for the future. But surely it is wiser and certainly more trustworthy to make the necessary decisions after assessing all of these factors explicitly and in light of what we know or do not know.

1.3 Scope of this Proposal

This proposal, therefore, outlines a research program for the development and testing of an analytical tool, namely a simulation model which might serve these ends. Almost needless to say, such a model ought to be flexible so that it could be adapted to a variety of special circumstances or constraints.

It also ought to satisfy several other requirements. For example, it should take account of recent experience with evaluative models as well as innovations in concepts and methods in development theory, spatial economics, systems analysis and computer methods. It should be responsive to different technologies, values and preferences. It should be able to facilitate evaluation of costs, benefits and significant constraints. Not least, it should take account of the likely character of the information and feedback system as well as the problems of implementing the model, especially in middle-level developing countries where the model might be tested empirically and refined.

It may be asked whether such a model-building exercise is worthwhile. The limitations of formal planning models are well known--many important aspects of reality, including scale economies, externalities, and nonlinearities have been ignored in order to make models tractable; distorations are introduced through aggregation; only quantifiable variables can be examined; and data are frequently unreliable. Certainly, formal models alone do not provide a sufficient basis for making policy decisions. Human judgments and intuition must remain important components of actual decision processes for the forseeable future.

Nevertheless, models now exist that greatly increase planners' ability to understand the working of complex social and economic systems and rapid progress is being made in increasing the reliability and reducing the restrictiveness of large-scale models. However, the benefits accruing from a model-building effort go beyond the immediate utility of the final model itself. Building a model imposes a certain discipline on thought processes. One has to define variables clearly and unambiguously. Assumptions have to be made explicit. Gaps in existing knowledge are revealed. The need for certain crucial decisions becomes apparent. Sensitivity analysis allows assessment of the relative importance of particular pieces of data and thereby indicates where efforts on data refinement will have the greatest payoff. Furthermore, recent advances in the state of the art permit more reliable and less restrictive models to be contemplated. Given the speed and relative cheapness of modern high-speed computers a wide range of assumtpions and policies can be tested.

Contrary to common expectation, such model-building efforts are particularly appropriate in developing countries. Unlike the more industrialized countries that have already achieved almost total urbanization, developing nations have the opportunity to shape their future patterns of urban and regional development. Governments in these countries are required each year to locate a wide range of facilities, and these decisions will have disproportionate effects on the urban patterns that will emerge. A simulation model provides a relatively inexpensive method of experimentation that can at least point out some costly, irreversible and sometimes unintended consequences of policies that might otherwise proceed by intuition. Furthermore, the relatively simple economic structures of these countries increases the feasibility of constructing reliable models.

The present is a propitious time to commence this work. Advances during the past decade in theoretical conceptualizations of the problem, in computer technology and software systems, and in data availability make the proposed effort feasible. A number of technically-competent planners and computer programmers who have been trained in recent years now occupy posts in planning agencies, thereby providing the necessary base for institutionalizing the use of models as an integral part of the planning and policy-formation process. Governments today also have a sharp awareness of these problems not to mention commitments to devise regional and urban policies.

II. Description of Strategy Alternatives

The model must be adapted to probable urban growth strategies. For this purpose, it is helpful to distinguish between strategies focused on altering balances *between major subnational regions* and those focused on the scale and distribution of population and activities *within these regions*. By region we mean the largest subnational division considered for planning and particular policy purposes, e.g., a state in a federal system, a province or group of provinces, or in some cases a major metropolitan area.

The key growth issues for the major subnational regions are the relative levels of development and rates of improvement. Casual observation of a wide range of experiences suggests that these goals are likely to be conflicting although to what extent is not clear. Furthermore, these aims can be combined in various ways with plans for regional specialization in industry, resource exploitation, agriculture, or services. While conceptually separate from the goals, particular policy instruments are frequently included as part of an overall strategy. These instruments include public sector facility location policy, industrial licensing, and special tax-subsidy schemes.

In light of these diverse aims, a sample list of policy alternatives that we might evaluate includes development between regions which:

a) equalizes per capita income (or growth of per capita income) among major regions through acceleration of industrialization in lagging regions and restriction of investment in richer regions and the giant metropolitan area(s);

b) equalizes per capita income (or growth of per capita income) among regions based on regional specialization (e.g. resource regions, agricultural regions, industrial regions);

c) maximizes national per capita income (or growth of per capita income) without regard for regional inequalities;

d) same as c) but with compensating programs designed to speed the transfer of population and resources from low-potential to high-potential regions; and

e) is based on separately formulated regional objectives and plans in the absence of explicit policy (extreme decentralization).

The second set of strategies seeks to affect the distribution of development within the region. The main issues we shall explore concern the relative desirability of various scales and patterns of urban growth. There are proponents of concentrated urban growth in major metropolitan areas. Others favor various types of spread of population and activity among smaller centers. (As in the case of development programs between regions, these aims are often coupled with recommended policy instruments to implement the aims.) To simplify our task, we shall focus our analysis only on the likely effects of varying patterns of city size within each of the major subnational regions. Thus, a sample list of policy alternatives for development within regions which we may evaluate includes:

1) concentration of development in a single large metropolis;

2) spreading of development within and outside given regions among a number of small-to-medium-sized cities, each of which performs administrative and service functions for its hinterland and has an industrial base;

3) distribution of development within the same region in a regional hierarchy of cities; and

4) dispersal of development throughout the countryside or in small towns--large urban centers discouraged.

Clearly the "best solution" among these alternatives will not be independent of the strategies adopted with respect to regional development; and the converse, of course, also holds. However, because of the need for simplification, we shall not examine these relationships. The model we propose to test cannot cope with all of the possible combinations and permutations of the alternatives identified. Our intention, as a first approximation, is to identify a reasonable range of hypotheses for testing; and later (if funds are obtained and the inquiry reaches the second stage) we propose to focus on perhaps a half dozen of the alternatives deemed to be most significant and feasible by the staff of the principals of the research team and the representatives of the organizations sponsoring the research. Of course, the ultimate decision in the choice of urban growth strategies will be made by the decision makers in each country who must take account of a complex of considerations including, but also ranging beyond, those which we may deal with, such as: the relative comprehensibility and political feasibility of the alternatives; problems of implementation taking account of resources, data and other constraints; the perceived incidence of benefits and costs; and the consistency with prevailing values and development goals.[2]

III. Modelling Strategy

3.1 Criteria for Model Building

If these alternative strategies are to be evaluated, it is necessary to develop a model that will yield reliable projections of the consequences of different policy measures. This suggests three main criteria for model building:

a) the model must include as endogenously determined those variables which are of significance for policy evaluation;

b) policy instruments must be modelled as exogenous variables so that alternative policies can be fed into the model; and

c) the structure of the model and parameter estimates must be such that valid predictions of the effects of policy choices can be obtained.

Figure 1 provides a general schema. The top line represents a few of the several possible policy instruments that can be investigated. The policy variables feed into the structural relationships of the model and give rise to sets of outputs from the model. These include output, employment, and income measures for the nation and for each of the regions or cities included in the model. Growth rates of output, employment, and income can also be measured along with interregional migration. Once levels and growth rates are known for each region or city, measures of relative attainment or disparity can easily be calculated. Furthermore, the predictions of population composition, income distribution, and economic activity for each region and metropolitan area are the basic parameters required by physical planners in order to determine appropriate spatial relationships among facilities.

Although these model outputs are the variables that are most often used as development targets by governments and planners, it should be clear that rather than being ends in themselves, they are merely instrumental in allowing ultimate societal objectives to be achieved. It would be presumptuous of us to specify the ultimate objectives of any particular society but we would suggest that they probably include such considerations as individual satisfactions, equality or inequality of opportunity for individuals and social groups, quality of physical environment,

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[2] There are still other influential factors such as the presumed effect on national morale or myth making of proposed development of a major lagging or undeveloped region.

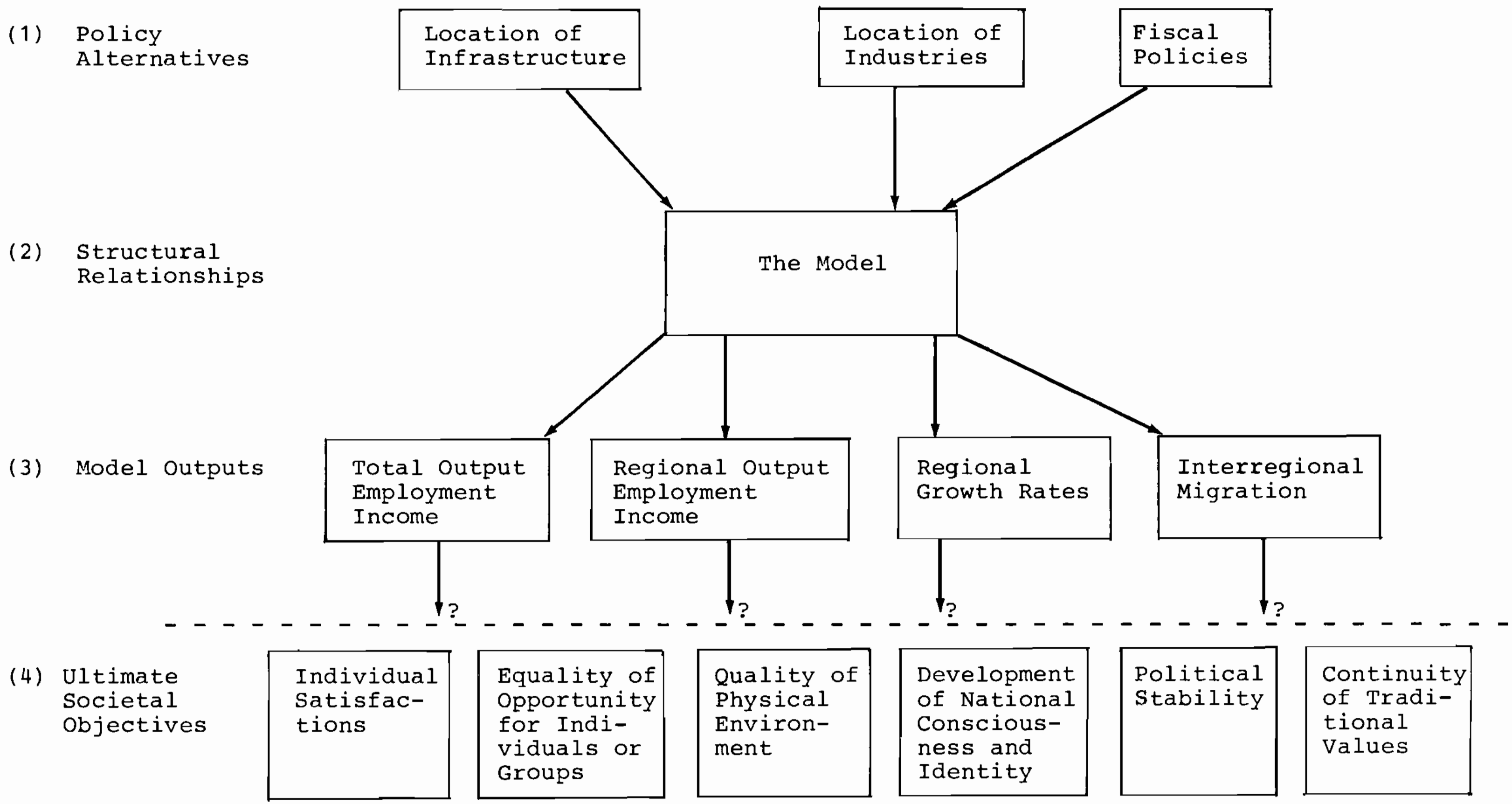

Figure 1. Levels of model construction for proposed simulation model for evaluating alternative urban and regional growth strategies.

nation building and identity, political stability, and continuity of traditional values. A broken line is drawn between these last two levels in Figure 1 to indicate that the model being proposed will not explicitly include the highest level of objective. This is so for at least two reasons. First, and more important, these variables are difficult if not impossible to measure at the present time, although some progress is being made in developing such social indicators. Secondly, even if we could measure these variables, we do not yet have satisfactory theories or evidence to model the relationships between these two levels with any confidence. Yet, there is reason to believe that levels of economic attainment and equality of distribution of material goods and services bear some relationship to individual satisfactions. Rapid changes and geographic mobility of persons are likely to erode traditional values but increase national consciousness. At this time we must leave the task of evaluating the relative importance of different ultimate objectives and of intuiting the relationships between economic and spatial relationships and those objectives to the political decision makers. In principle, the model can be extended at some later time to include these higher objectives. All that is required is to specify the ways in which level three variables affect those of level four. In fact, it may be possible immediately to include some measures of environmental quality much in the way that Hamilton et al.[3] treat water quality as being determined by particular concentrations of industry at certain points within a river basin.

Thus, the way in which the model is used is to consider a set of alternative policies. Each in turn is fed into the model and a set of predicted consequences is produced by the model. One obtains a set of alternative outcomes (Figure 1, stage 3), each of which corresponds to a particular policy (stage 1 of Figure 1). The policy maker is thereby provided information concerning means-ends relationships and can choose that policy which produces the most desirable consequences. As additional policies are proposed, they too can be tested and evaluated in relationship to previously considered alternatives. Experiments can be devised to identify additional policy alternatives that would be more successful than existing ones in achieving desired goals. Thus the model can be used in an iterative fashion.

3.2 Feasibility of Model Development

It will be necessary, therefore, to develop a model that exhibits regional and metropolitan detail within a nationwide context. In short, a national planning model with geographic as well as sectoral detail is called for. We are not aware of

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[3]H.R. Hamilton et al., *Systems Simulation for Regional Analysis: An Application to River Basin Planning* (MIT Press, 1969).

the successful implementation of such a model to date. Conceptual, computational, and data limitations have all restricted progress in this area. However, we believe that it is now possible and feasible to construct such a model given recent advances in all three areas.

Conceptual progress in the field has been made steadily in recent years. The most comprehensive framework is provided by T. Vietorisz[4] which takes into account inter-temporal, inter-sectoral, and inter-regional relationships within a mathematical-programming context. At the same time, substantial progress has been made in developing less complete but more immediately-operational optimization models which take account of spatial relationships. These are represented by A. Manne,[5] D. Kendrick,[6] and J. Harris.[7] A promising model that simulates some aspects of change in a multi-region system is presented in H.R. Hamilton et al.[8] R. Eckaus and K. Parikh[9] provide guidance for the treatment of savings, investment, and sectoral-allocation decisions over time. These are the principal conceptual building blocks that are now available.

3.3 The Concept of Linked Submodels

We propose the construction of a dynamic simulation model consisting of several linked submodels. The main advantages of this approach are the potential flexibility to use the individual submodels independently for some planning purposes, as well as the ability to link together any group of submodels, or to examine the complete system. To be specific, let us consider three levels of spatial disaggregation: national, regional, and city (local). Separate submodels for each city within a region can be

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[4]"Locational Choices in Planning" in M. Millikan, ed., *National Economic Planning* (NBER, 1967).

[5]*Investment in Capacity Expansion: Size, Location and Time Phasing* (MIT, 1969).

[6]*Planning Investment in the Process Industries* (MIT, 1967).

[7]"Urban and Industrial Deconcentration in Developing Economies: An Analytical Framework," *Regional and Urban Economics* (July 1971).

[8]*Systems Simulation for Regional Analysis: An Application to River-Basin Planning* (MIT, 1969).

[9]*Planning for Growth: Multisectoral, Intertemporal Models Applied to India* (MIT, 1968).

constructed and they can then be linked together to form a regional model. Similarly, submodels for regions within a nation can be linked to form a national model. Figure 2 depicts such a system. Each region consists of a number of cities which are linked together in a regional system. Explicit linkages between the elements of the regional system are taken into account. The national economy is then viewed as a system of regions and linkages between these elements are indicated.

Depending on the detail included in each submodel and the total number of submodels (regions and cities) deemed appropriate for consideration in a particular country, it may be feasible to run the entire model thus depicted as a single system. However, because the computational cost of running such a model increases substantially with the number of submodels included, it will be appropriate for many purposes to examine the working of only parts of the system or of the entire system with several subparts appearing only in aggregated form. Figures 3-6 depict different possibilities. Figure 2 represents a national model including only aggregated regions. These regional models include no city detail and ignore interactions between cities within the region as well as the effects of different distributions of activity among cities on the levels of regional activity.

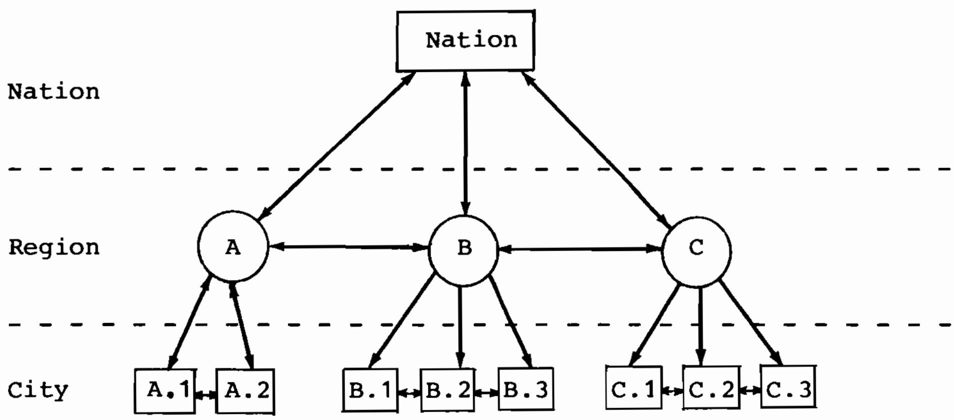
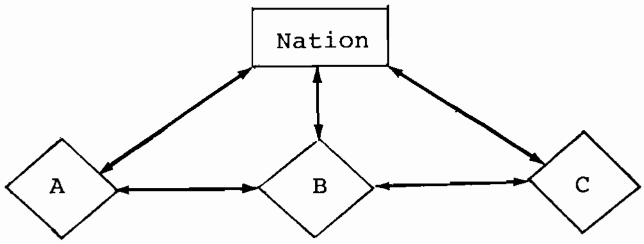


Figure 2.



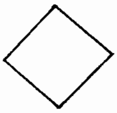
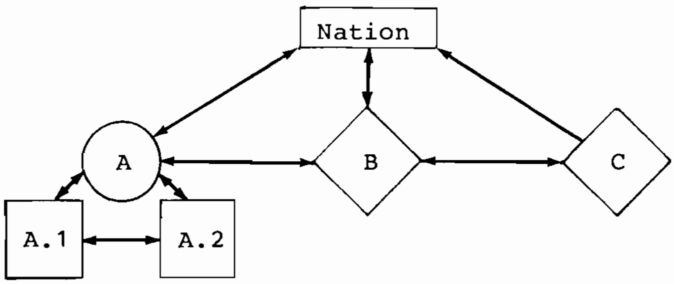
 represents an aggregative regional model.

Figure 3.



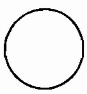
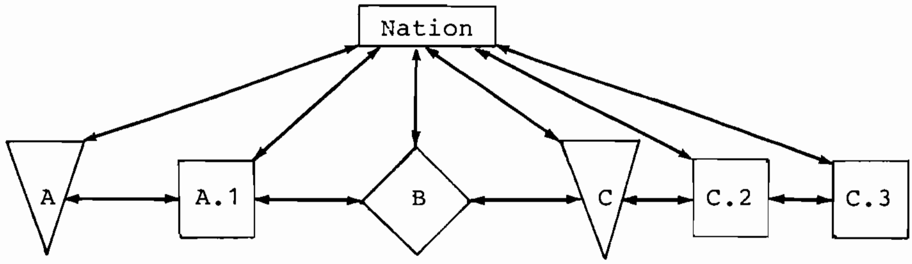
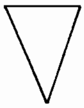
 represents a regional model consisting of a number of linked city or subregion models.

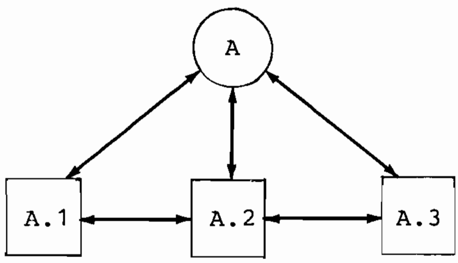
Figure 4.

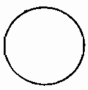




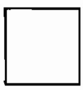
represents an aggregated model of region exclusive of those subparts which are modelled as separate submodels.

Figure 5.





is a region



is a city or subregion

Figure 6.

In Figure 4 the possibility of retaining subregional detail for some regions while aggregating relationships for other regions is introduced. Treatment of certain cities as separate subnational regions with corresponding definition of regions to exclude those cities treated separately is introduced in Figure 5, while Figure 6 demonstrates the possibility of modelling an articulated region alone. Traditional regional models are represented by the elements A, B, C, and metropolitan models by elements A.1, A.2, etc. Clearly, the corresponding submodels can be used in these conventional contexts and existing regional and city plans can, with appropriate adjustments, be incorporated into the larger model as submodels.

Thus national models corresponding to Figures 2-5 can be implemented to examine the consequences of alternative national policies (such as those outlined in the previous section) on output, fiscal balance, and balance of trade as well as on the regional distribution of employment and income. Similarly, a regional model such as that of Figure 6 can be used to examine the likely effects of alternative policies with respect to the distribution of city sizes on total regional output and fiscal balance as well as on the distribution of employment and income among cities given total resources available to the region.

In addition to evaluation of policy options, this approach may shed light on the nature and extent of central guidance needed for regional and city planning to be consistent with national planning. In particular, it should be possible to determine the minimum amount of common information required by regional and city planners to make independent plans that in total achieve certain national goals and require no more resources than are available to the entire national system. Which sets of regional decision objectives are mutually consistent and which goals need be specified by central authorities can also be explored in this context. Progress can thereby be made towards identifying appropriate patterns of decentralization of planning and decision making for achievement of various goals.[10]

3.4 Definition of Regions and Cities

The particular choice of regions or cities to be included and the way in which boundaries are to be defined will be determined by two of the criteria of model construction set forth at the beginning of this section. For instance, if inequalities of income between regions are a policy concern because of political pressures arising from disadvantaged areas and political organization rests on ethnic bases, then regions should be defined

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[10] This approach is similar in spirit to recent work by Prof. Alan Manne for the IBRD on multi-level planning models with sectoral, but not spatial, submodels.

according to ethnic areas. The model could then generate the distribution of benefits accruing from a particular policy among the various politically-relevant areas. In another society with a different set of political goals or political structures, a different method of defining regions would be appropriate. Secondly, the definition of region must also reflect the area over which a particular policy instrument will be exercised. If one wants to evaluate the effects of concentrating investment in certain growth poles, then regions (or cities) must be defined to be congruent with the proposed growth poles since the individual submodels do not contain spatial detail. That is, the choice of policies to be considered dictates and is dictated by the definition of regions and cities. The proposed strategy of building a model from a set of linked submodels allows great potential flexibility in considering rather different evaluative criteria and different types of policies.

However, another factor is particularly important in determining definitions of regions and cities. That is data availability or cost of generating appropriate data. One must be able to obtain appropriate data in order to estimate the various relationships for each separate submodel. Therefore, data must be collected and aggregated or disaggregated to correspond to the geographic divisions represented by the various submodels. Unfortunately, in most countries the data required for the model are collected and published only for the national level. It is possible in many cases, however, to have recourse to the raw statistical data and regoup it to obtain regional and metropolitan detail. However, several countries have begun to collect and publish regionalized national accounts in recent years. If data are not presently available for subnational regions or cities they may be obtainable by mounting special surveys. Obviously, compromises will have to be made between ideal levels of detail and cost of obtaining the requisite data. One cannot make general statements in advance outlining the ways in which these decisions will be made but certainly data availability will be an important determinant of which country the model should be initially implemented in.

We believe, however, that the strategy outlined is potentially viable under a wide range of circumstances. Standard practices for national, regional, and city planning have been shown to be special cases in which a single submodel is employed. Within this framework we can incorporate a great deal of existing work and build upon it. Depending on the particular circumstances there can be many or few submodels linked together. As will be outlined in the next section of this report, the submodels can be composed of a few highly-aggregated sectors or many detailed sectors. Choices about degrees of sectoral and geographical detail must be made on the basis of particular circumstances in the country in which the model is developed.

It should also be made clear that this kind of model makes no presupposition about institutional structures: political centralization or decentralization, public or private enterprise, market or guided allocation processes. However, a framework is provided within which particular institutions and realities can be modelled and the consequences of policy changes within given institutions or of changing institutions can be analyzed systematically. Perhaps these points can be clarified further by examining in some detail proposed structures for the submodels.

IV. Model Structure

4.1 Structure of the Basic Submodel--Single Period

It is impossible to write the detailed set of equations that constitute the structure of the model in the absence of specific information regarding the actual economic structure, institutions, and data availability for a particular country in which the model is to be implemented. However, in this section we will indicate our thinking concerning the major sectors and relationships that should be considered and suggest the ways in which these might be structured in the model.

We will describe the basic submodel as pertaining to a region. In fact, we believe that this submodel will have the same general structure whether the actual region is large or small, industrial or resource based, developed or backward. The city-level submodels will also have the same general structure. But the submodels for different regions or cities will use different degrees of disaggregation, specify different institutional constraints, and may have very different parameter values.

The basic submodel, regional or city, will contain three principal sectors: demographic, production, and public. The rest of the national system and the rest of the world can be viewed as sectors of the model with which the principal sectors interact.

In any single period a regional economy finds itself with a given population that can be described in terms of age, sex, education, and ethnic group composition. Furthermore, there are existing stocks of capital in specific forms such as equipment, buildings, inventories, public facilities, and transportation nets. Government will have specific expenditure plans determined in previous periods, and the rest of the nation and rest of the world have particular demands for regional outputs. We must specifiy processes which determine how these predetermined factors give rise to a number of specific outcomes. Figure 7 provides a schematic diagram of the way in which the single-period problem will be modelled.

It seems natural to consider two principal processes through which resources are matched with demands. This matching may take place through administrative processes guided by planning agencies or through the operation of impersonal markets. It will be convenient to describe the principal matching processes as a

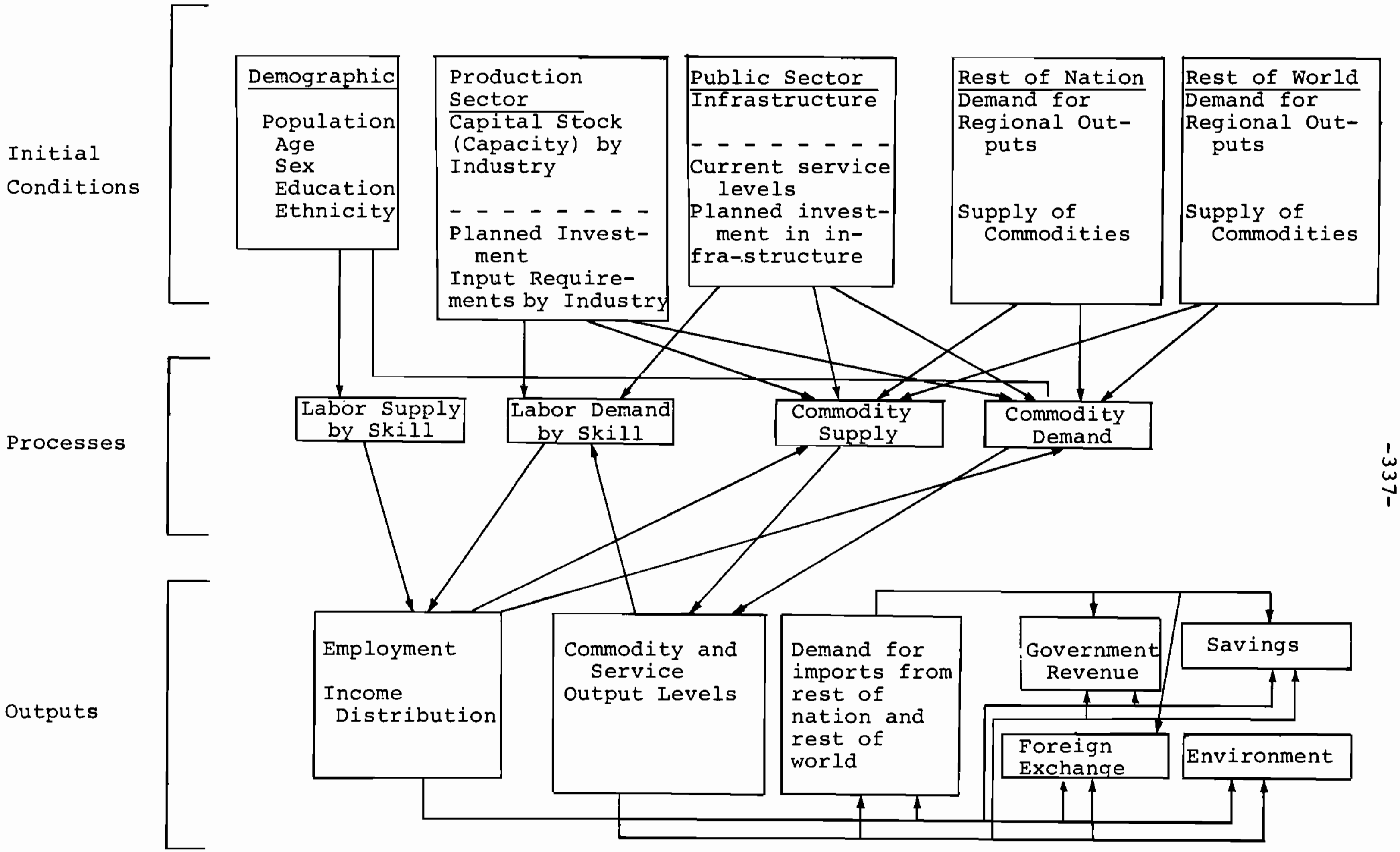

Figure 7. Single region--single period.

labor market and commodity market respectively but these labels do not indicate presupposition of the precise nature of the matching operations. In most economies a combination of administrative and market forces with a variety of imperfections operate and the model will be valuable to the extent that it is able to project the actual matching and resulting outputs that will take place under specified circumstances.

Demographic conditions together with social and institutional relationships governing labor force participation determine the available labor force classified by skill (educational?) level. The inherited plant, equipment, and inventories along with intermediate input requirements by industry are specified within the production sector (note that such capital may be owned by private local, private foreign, or public organizations). Inherited levels of infrastructure are accounted for within the public sector. Taken together, the labor supply, production-sector capital, and infrastructure, given the technological relationship between inputs and outputs, determine the potential levels of outputs of commodities and services within the region.

Demand for this potential output arises from local consumer demand which is determined by demographic conditions, preferences, cultural norms and income; need for intermediate goods and from planned investment in the production sectors; from public sector planned service levels and planned infrastructure investment; and from demands for exports to the rest of the world and rest of the nation. Two possible processes can be specified for matching these demands with potential supplies of goods and services. Prices may adjust so as to equate demands and supplies or there may be methods of rationing when demands and potential supplies are not consistent. One cannot specify the precise mechanism without examining the actual processes operative in a specific economy. One plausible specification that will be explored is to make actual output the smaller of effective demand or potential supply in any period. Prices adjust only with delays. With such a mechanism some demands will not be met by regional output if the capital stock or labor of particular skill level are already fully employed, although some of these demands can be met by imports from other regions or the rest of the world. If demand is less than potential output in a period, then some capacity will not be fully utilized, or certain types of labor will remain unemployed. Delayed price adjustments may lead towards equilibrium over time or there may be institutional constraints that prevent such equilibrating tendencies.

Actual output levels determine the effective demand for labor. Again, it is possible that demand and supply for labor be equated through variations in wage levels or that actual employment will be the smaller if demand or supply and wages adjust, if at all, and then only with delay. In the latter case, unavailability of labor of a particular skill constrains output while insufficient demand gives rise to unemployment. The actual level of employment and the wage levels then determine the level and distribution of income within the region. Institutional constraints such as wages and hours legislation or trade unions agreements must be taken into account explicitly.

It is obvious that these two markets are intimately interconnected since wage incomes are important components of demand for output which in turn affects output levels and demand for labor. A consistent solution must be found. Most likely, this part of the model will be set up as a simultaneous-equation system. The degree of complexity and the attendant computational problems depend on the specification of the production relationships, sectoral detail, and adjustment mechanisms. Production relationships may take the form of production functions which allow for substitution between factors (e.g. Cogg-Douglas or CES) or may be of the fixed-coefficient type used in input-output analysis. It is likely that the latter will be used if many sectors are specified while the former is more appropriate with a more aggregated approach. Data availability will be a strong factor in influencing the final forms of the equations. Less satisfactory data will force greater aggregation and less complex specifications. We certainly expect to be able to do better than rely on aggregate capital-output relationships which are widely used and justifiably criticized. Special effort will be devoted to identifying and estimating infrastructure-direct-production relationships and to intersectoral linkages. Methods of taking into account scale economies and indivisibilities will be explored in detail. (See Section 4.3 below.)

Once output, employment, and an income distribution are determined, it will be possible to determine government revenues; savings; imports from and exports to other regions; imports from and exports to abroad, thereby determining foreign exchange impacts; and perhaps effects on the environment. This assumes that identifiable stable relationships exist that connect these latter phenomena with regional output, population and employment.

4.2 Linking Submodels to Form A National System

When a number of these submodels are linked together to form a national or regional system there will be four principal sources of interaction between the components. First, interregional exports of one region are the interregional imports of another region. These flows must be mutually consistent. Secondly, the total of planned production-sector investment in all regions cannot exceed the total savings generated in all regions. (Additional constraints may be placed on interregional transfers of savings.) Third, total public-sector expenditure for services and infrastructure-investment across regions is constrained by total government revenue across regions. (Actually, some government expenditure can compete with investment for savings but total constraints remain on the system as a whole which forces regions to compete for limited resources.) Finally, the sum of regional imports from abroad cannot exceed total foreign exchange availability which is the sum of regional exports in addition to net foreign capital inflows, aid, and running down of reserves.

So far, we have outlined a static model for predicting regional output, employment and income distribution in a single period of time for which the labor force and capital stock is inherited from the past. Even so, making the total of regional (city) solutions consistent with national (regional) constraints is no trivial task and would represent a major improvement over regional planning efforts to date. We hope to make significant progress on incorporating the special features mentioned above (scale economies, etc.). Within this framework, evaluation of a limited number of policy alternatives is feasible and merits consideration. In particular, the consequences of alternative fiscal programs, allocations of foreign exchange, or composition of demand can be traced. Furthermore, parametric changes of infrastructure or productive capacity across regions can be postulated within this framework to simulate alternative investment location options.

For instance, national projections of resource availability, population, foreign exchange, etc. in some future period, such as five or ten years from the present, can be taken as a starting point. The model can be used to insure that alternative projections of regional and metropolitan population, output, employment, etc. are consistent with the national constraints. Some strategic policies such as infrastructure location can be tested in the framework. From such an exercise, national planners would be able to evaluate alternative strategies for development and regional and metropolitan planners would be provided with consistent projections of population, economic activity, and resource availability with which they could begin to prepare detailed physical plans.

4.3 Dynamic Relationships

However, we intend to make the model dynamic--that is to make explicit the processes of change over time. Figure 8 contains a schematic view of the processes that give rise to change. These processes are demographic transitions and investment in the production sector and in infrastructure.

While total population growth for the nation will be taken as exogenous to the model (population and health policies can be simulated by parametric changes in population growth and aging parameters), aging will depend on the initial age structure of the population and particular estimated transition parameters. Educational change will also be taken as determined exogenously to the model and alternative education policies can be simulated through changing these levels. Interregional migration flows will be modelled as dependent on demographic structure, income and unemployment levels for each skill group in each of the regions and may also reflect particular institutional and ethnic factors.[11]

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[11]See J.R. Harris and M.P. Todaro, "A Two-Sector Model of Migration and Unemployment in Developing Countries," *American Economic Review* (March 1970).

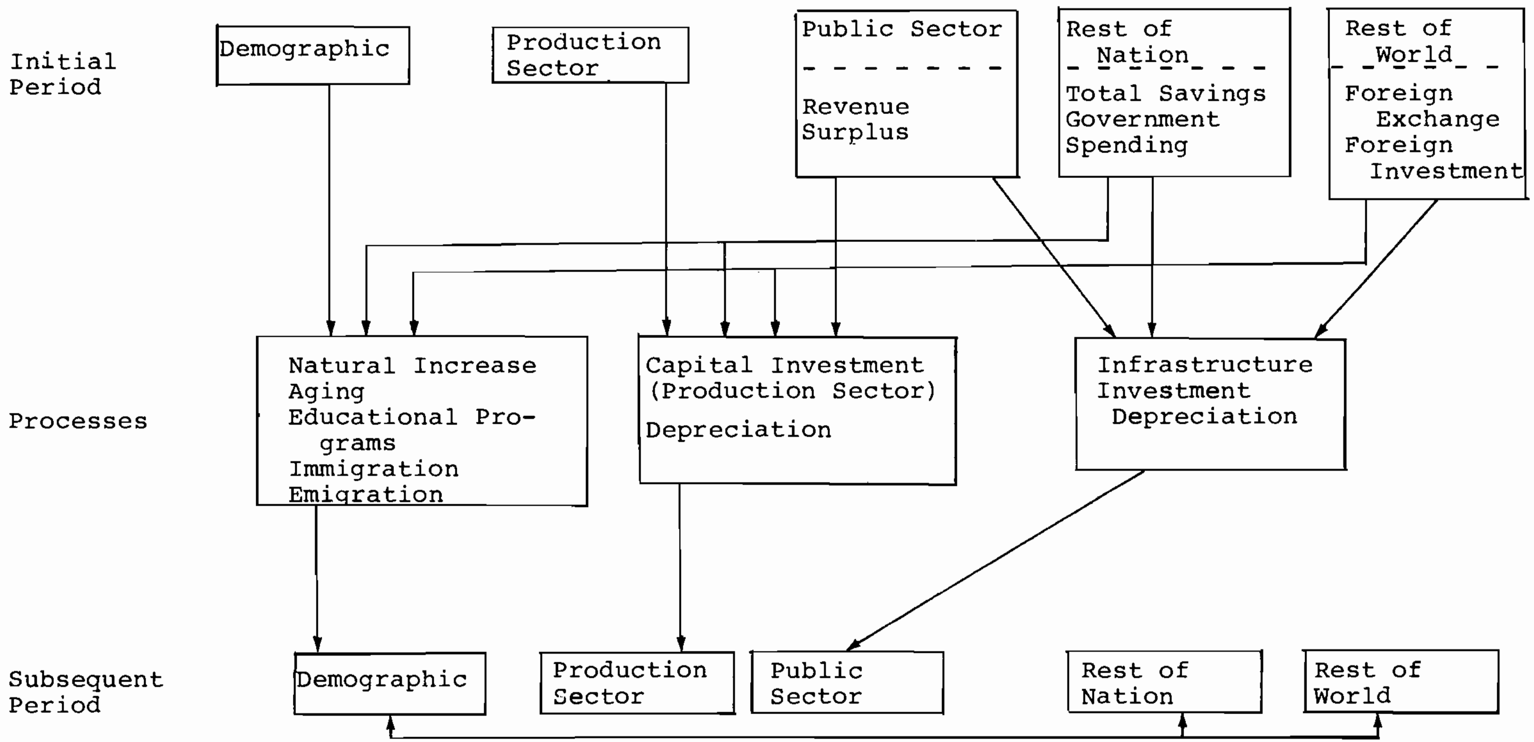

Figure 8. Single region--multi-period.

Thus, change in the demographic sector of each region (city) is determined over time. Note that these changes depend not only on what happens within the particular region but also on what happens in other regions, in the rest of the world (to allow for international immigration or emigration), and the public sector (education policy). Also, the specification of wage-adjustment processes and changes in output levels will affect this sector to the extent that interregional migration is influenced by relative wage levels and levels of unemployment.

Levels of capital stock in the production sector and infrastructure in the public sector are changed over time through new investment less depreciation. The total amount of such investment within the nation is constrained by total private saving, government saving, and foreign capital inflow. However, the amount of investment that takes place in each region depends on governmental allocation policies and on private decisions. Infrastructure and production-sector investment undertaken by regional governments depends partly on regional government revenue which is determined endogenously or on allocation decisions which will be modelled as exogenously-determined parameters. Central government investment allocation between regions will also be modelled as determined exogenously to the regional submodels although the total of such investment is constrained by central government revenues and sources of borrowing. Private investment in the production sector will be modelled to depend on total savings. Allocation between regions will be determined partly by regional savings, prospective returns to investment indicated by prices, wage levels, demands in each of the regions as well as on institutional constraints and policies.

We shall devote considerable attention to problems posed by economies of scale and economies of agglomeration. The former can be attacked by requiring investment to take place only in plants or units of specified minimum size,[12] while the latter can be handled in part by making productivity a function of the total level of activity in a particular region (city). Furthermore, investment in certain sectors can be specified to take place only if a minimum level of excess demand exists, which prevents the model from predicting construction of a number of small-scale plants.

4.4 Linking of Dynamic Submodels

Once a set of these dynamic regional (city) submodels are linked, the interactions between regions become evident. Demographic sectors are linked since immigration into one region corresponds to emigration from another region. Investment in one region reduces the investment available to another region

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[12] See Kendrick, *Planning Investment in the Process Industries.*

since total savings, government revenue, and foreign exchange are fixed in any one period. However, different allocations of resources among regions will have different effects over time on total output, total available savings, and foreign exchange availability.

A dynamic model of this sort exhibits feedback loops. For instance, a unit of production-sector investment in a region will increase the potential output of the region. Assuming that there is demand for the additional output of the region, the level of output and employment will increase in the initial period. An increase in employment will cause some immigration of labor. Depending on the magnitude of this immigration and the way in which the labor market adjusts, additional demand for output will be generated and there may be a net increase in labor availability or a reduction in wages (if immigration exceeds the initial increase in labor demand). In turn, the higher level of demand coupled with increased labor availability will encourage additional investment. Similarly the reinforcing effects of rising government revenue caused by increased output and income can be traced. Such a feedback loop causes an initial change to be reinforced. It can also be seen that a reinforced decline will be induced in a region that loses out-migrants as a result of the investment that took place in the other region. However, there also may be feedback loops that dampen rather than reinforce an initial change. For instance, if the loss of out-migrants results in a contraction of demand for imports from the region in which the initial investment took place, expansion in that region will be lessened and could offset the initial impulse for growth. The purpose of this discussion is not to trace out particular feedback loops but merely to indicate the kinds of indirect relationships that arise in a model of this sort. Indeed, it is because of these indirect consequences that a formal model is needed.

4.5 Modelling Urban Growth Strategies

It is now possible to see how such a model can be used for the evaluation of alternative urban growth strategies. A set of policies can be introduced which correspond to a particular strategy. The most obvious type of policy is a set of allocations of infrastructure investment among regions and cities over time in a predetermined fashion. Such an allocation may consist either of a scheduled path of investment levels or a path in which varying proportions of government revenue are allocated among regions for infrastructure investment. Starting then with the same initial conditions the model is run for some number of periods first with one allocation of infrastructure and then for the same periods with another allocation of infrastructure. Assuming that the model structure and parameter estimates are "true," differences in the time paths of employment, output, income distributions, etc. are attributable to the different infrastructure allocation. *This particular example suggests how physical planning of the spatial distribution of infrastructure can be* *facilitated by the use of such a model. A wide range of alternative physical plans can be tested and evaluated in a common framework.*

Other policies such as migration restriction, or special incentives for investment in particular regions can also be simulated. In these two cases, the policies would be simulated by exogenous alteration of certain parameters of the interregional migration and production-sector investment functions and changes in time paths of output variables then observed. Similarly, alternative patterns of regional specialization can be simulated by exogenous alternation of the particular sectoral investment functions in the production sector.

4.6 Sequential Methods of Model Building

Several words of caution are in order at this point. It is easy to complicate the model only to find that necessary data are not available. Data acquisition and computation of a complicated model are expensive. Furthermore, as the model becomes more complicated it becomes increasingly difficult to understand which relationships are giving rise to particular results and errors in specification or estimating of particular equations may become magnified as a result of reinforcing feedback mechanisms. There is a danger of the model becoming a "black box," the contents of which are poorly understood and difficult to validate empirically.

We have been aware of these problems and, in fact, the modelling strategy outlined above is dictated in part by these considerations. The flexibility of working with linked submodels allows careful experimentation with manageable subparts. Where particular problems require only part of the model, computational expense is reduced. Also, the submodel structure indicated is consistent with either highly aggregated or finely disaggregated sectoral specification. Linkages between submodels have been designed so that the overall model can contain few or many geographical divisions.

It will be sensible to begin any actual modelling effort employing only a few regions and a few industries within each submodel. The exact specification will depend on the particular country and data availability. In the process of operating a fairly simple model, one is able to determine which parts of the model policy results are most sensitive to. This then will stimulate further refinement of specification, disaggregation of sectors, collection of data, and estimating of parameters. It is crucial to the research design that the model be constructed in a way that allows further articulation without complete reconstruction. We believe that the structure outlined provides such a framework.

V. Computational Problems, Computer Software

Section IV of our initial outline "Work Plan and Data

Requirements for Computer Simulations" lists the categories of problems that would be encountered in the making of the model. The comments that follow provide details concerning possible computer software.

5.1 Computational Problems

Since the model we are proposing will stretch existing computational and programming capabilities to the limit, the initial stages of computer application must be performed in a setting providing large high-speed computers, a wide range of existing software, and access to a variety of specialized experts. It would be wasteful and grossly inefficient to do otherwise. As the model becomes operational, it can be adapted to locally-available machines and transferred to the field for continuous use and updating.

Making the model will require obtaining and analyzing data, formulating relations, fitting the parameters of the equations to the observed behavior of the economy, validating the formal structures and operating the model. For almost all the software required for these procedures we believe that a system such as TROLL 1 can be used to begin with. It appears to be sufficient to meet at least the needs for getting underway.

5.1.a Data Problems

The model will have to do for the most part with the information available. Additional measurements might be gathered, but these are likely to constitute a small increment to the larger body of data already collected. What would comprise a sufficient set of data is not a matter for a priori choice. That depends on the structure and intent of the model. The model, on the other hand, would take account of the information that could be collected.

The data will have to be collected, corrected and filed in a way which makes them most accessible. Some of the software for collecting and cleaning may have to be made locally. TROLL 1 can do much of the remainder. A bad datum can be eliminated and missing data can be labelled or replaced by interpolation. The base of a time series can be changed from one time period to another and smoothed according to specified rules. Standard statistics can be reported and multi-variate correlations and component analyses obtained. A table or graph can be the format of the output.

5.1.b Specification and Calibration

Fitting the parameters of the model to these observations is a most important step in the process, and is likely to be especially delicate because the formal structure will probably be made of simultaneous nonlinear equations, both in the single period analysis and when the model is operated over time. The TROLL system provides a rather elaborate repertory of facilities to meet these problems. The repertory includes, for example, a basic least squares algorithm for both linear and nonlinear equations, two- and three-stage estimators for sets of equations, lag operators, auto-regressive corrections, and estimating routines for constraining some of the coefficients. The system also provides for the possibility of testing the significance of the differences between sets of regression estimates. It is unlikely that very much more would be required.

5.1.c Validation

Validation occurs at two levels. Before any property of the model can be tested, one ought to be certain that the numerical structure of the model is correct, that the algorithms perform as intended, that they are directed to the proper data and that they are correctly linked. This is essentially the debugging problem. It is complicated but not profound. Comparing the behavior of the model with realities is both complicated and profound.

Validations require running the model, in the whole and in various combinations of its separate parts. Comparisons are made with the behavior that would follow from economic theory, and on a more detailed scale, with replications of past behavior. Operating the model requires the solutions of simultaneous sets of equations, linear and nonlinear, for both fixed and flowing time. TROLL has such facilities and provides convenient means for changing assumptions, equations, and parameters, and monitoring the course of the operation of the model, thereby making it easier to experiement with the components of the model separately or in combination.

5.1.d Output Format

It is easy to be smothered in computer paper. During the making of the model one might well wish to look at everything that would reveal the characteristics of the thing being made. But in the use the output should be clear, terse, eloquent, and sensitive to local conventions. TROLL provides some graphics. However, some local programming may be required. This is not an immediate problem.

5.1.e Optimizations

TROLL provides no software for solving optimizing problems either at a fixed point in time (linear or nonlinear programming), or as control policy over time (dynamic programming). It is not clear now whether such capabilities will be necessary or if they are, what varieties will be needed. If they are, then other software systems will have to be looked for. A number of such programs have been written in Standard Fortran and are available.

5.1.f The Availability of TROLL

TROLL was written for the IBM 360/67 and runs under an operating system known as CP. It can run on a stand-alone basis on other IBM 360's of comparable size. The designers of TROLL have said that it would also run with some modification under another operating system, OS/360. OS/360 is a more widely available operating system than CP. However, since the extent of the modifications required is vague, it would be better to count on the use of an IBM/360/67 running under CP.

The documentation of TROLL is relatively good, and the organization behind TROLL, a special division of the National Bureau of Economic Research located in Cambridge, Massachusetts, appears to be able to provide a high level of service. The system is easy to learn and requires no exceptional competence in programming.

Analysis of the Contemporary Urban Ecosystem: An Appraisal of Hong Kong's Future

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Explanation of Method

New approaches are needed for creating simple models of a metropolitan community which at the same time promise to provide a more comprehensive description. Models achieve simplicity by pushing complexity back to a field of study that has been rather thoroughly pursued and elegantly condensed so that newcomers can quickly find their way to the frontier where new findings are discovered and reported. Thus the urban economy can only be understood in terms of the general principles of micro- and macro-economic theory as previously elaborated; urban geography is comprehended according to techniques for observing phenomena, such as transport and location, strongly determined by spatial relations; urban sociology is forced to refer to holistic principles elucidated in demography, social structure, social organization, and social pathology; and urban politics depends upon prior generalizations regarding the use of power in human relationships. An executive, a planner or a doctor responsible for welfare in a city finds that each approach excludes so many significant phenomena from consideration that a corrective is sought.

A living systems model promises just such an overview. From the time of Aristotle until the 1920's an organismic analogy for a society, or a city with its dependent territory, was a favorite for those who endeavored to be wise advice-givers. The organismic model failed when the component populations of an urban society exhibited many wills simultaneously, so that action was rarely coordinated--although it was often interrelated.[1] Thus, for a suitable framework, a contemporary living

[1] The Chicago School of urban sociology emphasized what almost every city dweller who tock pains to observe his milieu already knew--a rapidly growing metropolis fostered a disjointed, pluralistic society. Louis Wirth is often given credit for expounding this argument systematically, but a careful reading of his selected works edited by A.J. Reiss, *On Cities and Social Life* (Chicago, Phoenix, 1964), yields no succinct definition that remains valid today. Concepts of order and organization applicable to cities are still undergoing rapid change, perhaps because the sources of the problems that are faced collectively are also shifting. Also see S.S. Guterman, "In Defense of Wirth's Urbanism as a Way of Life," *American Journal of Sociology, 74* (1969), 492-499.

systems model must fall back upon outside-of-the-skin biology with its greater indeterminacy.

Indeed, it can be argued that a city is organized in a manner that is not merely similar to the ecological community; it is a true member of that class of phenomena--albeit in an advanced, highly elaborated form. Therefore the generalizations and laws applying to community as a level of organization in ecological theory must also apply to cities.[2] It follows that studies of natural communities, or synthesized communities (as in agriculture and animal husbandry), will generate useful predictions (hypotheses) regarding communities in which the biomass is predominantly human. Such predictions could not otherwise be achieved without conducting experiments that were risky for member populations within the community itself. Thus ecological models are most useful because they permit the acquisition and organization of information for positive improvement of viability in much the same way it is accumulated in medicine--systematic observation backed by controlled experiments, most often on simple homologues, dealing with a few variables at a time. However, the rigor of this analysis would fail to be communicated were it not for the fact that the teaching of ecology, formal and informal, has recently become as common as that of economics, sociology, or political science. The ideas can be transmitted to advisors and decision makers in ecological language now, whereas even a half decade ago this would have been possible in only one or two departments of government.[3]

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[2]Theory building in biological systems rarely depends upon analogy; it strives to reach generalizations about living systems that are homologous--in practice this means that they should apply to all members of a class emerging at a specific stage of evolution. That argument is best summarized by the formulation assembled by James G. Miller, *Behavioral Science*, *10* (1965), 193-237 (basic concepts); ibid., *16* (1971), 287-307 (structure and process). A subsequent formulation of methodology directly applicable to the social sciences was published later by C.A. Laszlo, M.D. Levine, and L.H. Milsum, "A General Systems Framework for Social Systems," ibid., *19* (1974), 79-92. It succinctly defines the intellectual frame within which this paper is conceived, but not its style. The transition from natural to urban systems is very elegantly treated by Amos H. Hawley, "Ecology and Population," *Science*, *179* (1973), 1198-1201.

[3]The developmental policy consequences of ecological arguments are rarely taken up in a holistic fashion, but a good beginning is found in Eugene P. Odum, "The Strategy of Eco-system Development," *Science*, *164* (1969), 262-270.

Some appropriate definitions are in order at the start of an attempt to conform the systematic presentation: A *community* is made up of a cluster of interdependent populations interacting and exchanging with a physical environment. The *boundary* of a community--the semi-permeable barrier that separates it from others and makes it possible to assign membership of individuals with minimal disagreement among observers--is an edge or the line (physically identifiable or abstract, as in law) that accommodates a much lower intensity of transactions and continuing relationships. The *environment* is composed of materials and resources necessary for the survival of the constituent populations as well as the forms and signs imposed upon it that serve to guide the behavior of the individuals and groups. The effective *observer* of a human community becomes a participant in it, whether he likes it or not. In order to acquire information rapidly he must place himself in busy sites and play an interactive role, thereby taking a risk of modifying some of the relationships likely to be of greatest interest. Naturalists and anthropologists are investigators of communities who are particularly alert to the care that must be taken; an urbanist must take similar precautions when contacting the elite of a city.

There are *dimensions* to a community which are correlated with the appearance of organizational level observed within it. Population sizes, territorial limits, energy consumption, and materials processing also explain a great deal. Perhaps the most important feature of living systems analysis is the quantitative description of the internal dynamics or life *processes*. These include births, deaths, fate of migrants, formation of households and larger organizations, imports, exports, the accumulation of internal stocks, energy flows, and all the cyclical relationships that develop between them. Finally there is a *history* which traces the introduction and evolutionary course of the respective species (genotypes), the initiation and transformation of organizations, the redistribution of life spaces, the irreparable damage left from catastrophes, the depletion of essential resources, and so on.

A city records a huge amount of information about all of these matters. The problem of achieving a manageable overview is that of filling in the gaps and condensing the data. Even that is not enough, however, so the system description must take advantage of the fact that an educated reader has had experience with cities and would not be surprised by most of the assertions. What is most valuable for the policy formulator and the decision maker, as well as the scholar, is to have a knowledgeable person pick out those features that may be expected to have repercussions for the urban community in the future. They prefer specific forecasts of the local systemic trends that could lead to pollution, famine, epidemic, energy crisis, or other grave injuries on one hand and the kind of intervention that increases the capacity to cope with the stresses imposed by the environment and by competitors.

If there is evidence that the forecast may be faulty (usually contra-indications appear months or years before an urban ecosystem experiences a severe change) it becomes necessary to scrutinize the relevant details. Until then it is necessary to pick out the highlights and the surprises. The obsolescence of much of the data drawn upon by the study can be overcome by using informed current estimates and short range projections. Any marked change in the dimensions from what had been expected quickly alerts the user to the fact that an error has been made in measurement, in estimation, in inference, or in the construction of the model.

Dimensions

In *Planning for an Urban World*, when endeavoring to envisage a world population at steady state, with a predominant share of people finding it necessary to reside in cities in order to live at a level above subsistence, I was forced to consider the city as a habitat for machines as well as for living things.[4] Machines are continuously filling niches previously occupied by humans, animals, and even plants; this process needs to accelerate as human population expands and natural resources become depleted.[5] Thus the urban ecosystem fits the following paradigm:

Physical
Environment

Stationary Machines	Plants
Mobile Machines & Vehicles	Animals
Automata	Humans

Organic
Environment

[4]Richard L. Meier, *Planning for an Urban World: The Design of Resource-Conserving Cities* (Cambridge, Mass., M.I.T. Press, 1974).

[5]The initial insight occurred when Ikumi Hoshino and I were enquiring into the loss of population from the most densely settled ward in Tokyo. All indicators suggested that it remained as crowded as ever. Then we discovered that the minimum parking space on private property, as required by a law that was strictly enforced, equalled the average living space of a resident human being, and that for every person who had moved out a vehicle had been moved in. R.L. Meier and Ikumi Hoshino, "Adjustments to Metropolitan Growth in an Inner Tokyo Ward," *Journal of American Institute of Planning, 34* (July 1968), 219-222.

Among all existing metropolises in the world, Hong Kong allows one to obtain more exact counts of the respective populations and fair estimates of the current rates of change. The reason is that the political boundary drawn around the Crown Colony encloses very little rural hinterland and allows exceedingly little overspill into adjacent territories. Hong Kong's population is 98-99 percent pure metropolitan. It is not distributed over suburbs, exurbs, and satellites in an undefinable manner, as is the case for most other metropolises.

Macao, for example, has an identity of its own, gaining no more sustenance from and being no more a satellite to Hong Kong than would a small city several hours distant from a true metropolis anywhere else in the world. The Kwangtung province of China has a common language, but it also has a political system that is utterly alien; China is quite strict about maintaining control over flows at the boundary. Thus Hong Kong operates very much like a self-sustaining city state.

Most of the Hong Kong's statistics-collecting apparatus was set up by British civil servants, so the data are as reliable as any available for cities. It represents a better case for ecosystem assessment than Singapore, partly because it is twice as large but also because it has a history with fewer discontinuities, so one is allowed to press inferences from ecological relationships a bit further in Hong Kong than elsewhere.

The notable populations introduced in the paradigm have been estimated for Hong Kong and are presented in Table 1. Attempts were made also to estimate annual rates of change for the mid-decade period, but these trends are often more uncertain or variable. Inspection of Table 1 shows that, although a great deal of publicity is given to the rate of increase of human population, there should be a great deal more concern for the growth in numbers of vehicles (each of which requires as much concrete platform for its "habitat" as twenty to thirty persons in a resettlement unit). Crowding caused by the growth of vehicle numbers is much more imminent.[6] The even more rapid growth in electric motors

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[6]Vehicular population growth in Hong Kong already seems to be slackening--a trend that is attributed more to administrative measures due to increases in the costs of fuel. The cost of the operating license was doubled, and the queue for obtaining a driver's license was allowed to lengthen to six months. Parking charges are brought up to a level that is felt, even though they are still less than the charges that would meet the current land rent. Traffic law enforcement has been noticeably tightened. An excise tax on passenger cars exists, but until now has not been high enough to act as a serious deterrent.

Table 1. Population estimates: Hong Kong ecosystem (1974).

Component	Population	Trend	Component	Population	Trend
Stationary Machines			Plants		
Electric Motors	700,000	+11%/yr[1]	Trees	2-3 millions[5]	+5%/yr
(air conditioners, pumps, clocks, industrial)			Brush and Grass		?
			Vegetables and Rice[6]		-2%
Engines	30,000	+ 5%			
Electric Generators	100	+10%			
Mobile Machines and Vehicles			Animals		
Watches	500,000	+20%[2]	Pigs	400,000	[7]
Vehicles	295,000	+ 9%	Poultry	6,000,000	
Autos	135,000	+ 7%	Cattle	10,000	
Trucks & Buses	40,000	+ 5%	Fin Fish	10,000,000	+10% in biomass
Bicycles	150,000	?[2]	Shellfish	10,000,000	
Motorcycles	25,000	+18%	Dogs	100,000	
Ships	10,000	+ 5%	Cats	50,000	
			Birds	50,000	
			Wildlife (mostly fish and birds)		
Automata			Humans		
Minicomputers[3]	100	+30%	Census	4,250,000	+ 1.4%
Computer Centers[4]	1-200		Refugees[8]	100,000	+15 %
			Tourists	15,000	+10 %

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1) Electric power use was increasing 12 percent per year up to the energy crisis.

2) Estimate from observations on the street and in the field, possibly low.

3) Estimates obtained from the University Joint Computer Centre.

4) Automata are sophisticated circuits controlling the machines; computer centers have much greater capacity, but their jobs are still mostly routine.

5) Assumes forest averages seventy trees per acre, with more in banana and fruit orchards, a few in residential zones. A tree is at least twenty feet high or one foot girth.

6) Increase in output due to faster rotation: acreage has been reduced recently.

7) Listed in approximate order of contribution to biomass.

8) Many are illegal, so perhaps underestimated; a new wave has appeared since 1972.

requires the kind of attention to energy supply that has been accorded the subject only since the "energy shock" of 1973-1974.

An overall judgement of this community of humans and their artifacts arising from the population magnitudes and their trends is that Hong Kong is being stimulated to undertake extraordinary development. The growth of the respective populations could hardly be expected to stay in balance. Stated still another way, the human population is very busy constructing and arranging a habitat convenient to itself, but in so doing it must draw increasingly heavily from the rest of the world for nourishment in the form of energy (food and fuel) and materials of construction. This developmental pattern is typical of a speeded up process of modernization in the twentieth century. However, with all the competing cities following much the same pattern as they move toward the twenty-first century, the physically limited supplies will not allow such a strategy to persist. The same kind of accelerated growth would occur in the natural world if, say, a forest were to be given much more fertilizer and a steadier supply of water, so that it became greener, supporting more insects. The latter, combined with more seeds and fruits, support more birds. More leafy materials permit a greater population of mammals, and the presence of both birds and animals allows a much larger population of predators, such as man, to survive. If that extra fertilizer and water were to be shared with other forests the overall growth of biomass would be diminished, but not necessarily totally halted.

One consequence of this agglomeration of human habitat is the increase in the number of associations. Meta-stable groups are formed from the interdependence of individuals drawn from the respective populations; these groups have an address in the city; they respond to inquiries and transmit messages; they transact in many ways as would individuals. Households are groups of human beings but they frequently have a pet, several electric motors, a clock and a watch or two, several plants and sometimes a tree or two. Enterprises and voluntary associations are, of course, legally recognized as corporate units, substituting in many instances for persons. Those engaged in market-related activities are, characteristically enough for Hong Kong, more completely enumerated and recorded than the religious, cultural, sport, and friendship groups. Nevertheless, due to a history of trouble with secret societies, the listing is more comprehensive than in most Western countries. At their present rate of growth it appears that human associations will require a larger share of the living space in the future. That means more office blocks and neighborhood meeting space (restaurants, cafes, tea shops, church parlors, temple grounds, playgrounds, community centers, resorts) than dwelling space (see Table 2).

Table 2. Households and organizations.

	Number (1974 estimate)	Annual Change
Domestic Units[1)]	740,000	+ 3%/yr
Companies[2)]	37,000	+13%
Manufacturing Employers[3)]	31,000	+10%
Voluntary Organizations[4)]	30,000	+10-15%

[1)] The growth in domestic units seems to be at the rate of 4-5 percent per year, but the rate of withdrawal from use appears to be 1-2 percent. After 1976, with the accelerated building of the new towns, both figures are expected to increase.

[2)] The disappearance rate for companies is extremely irregular, reflecting levels of stress in the business environment. Most firms disappear through amalgamation (a kind of predation?), with the survivor firm gradually integrating the activities of the separate predecessors.

[3)] The method of collecting statistics for the annual report of the Government has changed recently so that unregistered employers are now also counted, therefore the rate of growth units is currently quite uncertain.

[4)] The number of registered societies is obviously an underestimate. The Chinese, as an ethnic group, are known to create many associations; increasing ease of contact in Hong Kong city life is expected to increase the number and the variety of these organizations.

The Search for Competitive Advantage

It is difficult to determine whether Hong Kong is moving into a basic imbalance with respect to the ecosystem as a whole. The metropolis of Hong Kong floats on a system of worldwide exchanges rather than a resource base in a hinterland, as is most common for other metropolises. Over the last several decades, and in prospect for at least one more, world trade has been expedited by improved transport technologies and new multinational institutions. Hong Kong is no longer merely an entrepôt for China; its residents are able to trade their services for goods at a rate much closer to that obtained by Japan, Europe, and the United States. This is accomplished by extending the diversity of its skills, and incorporating new activities into the community that connects with others elsewhere so as to result in enhanced rewards for both parties; each change represents an adaption to new opportunities and an investment in internal reserves and buffer stocks or repertoires. The stepwise acquisition of new activities by the city curing its relatively brief history illustrates this process.

Hong Kong was created by the British as a locale for expediting the flow of trade with China--households and firms specializing in tea, opium, silver, shipbuilding, and banking settled there from 1840 onward. Trade moved irregularly, taking advantage of intermittent booms to establish a broader base, until the 1930's, when textile and garment manufacturing were introduced by Japanese and Chinese entrepreneurial groups to circumvent the Imperial Preference Agreement (they intended to capture some of the markets supplied by Lancashire mills). Before World War II a rubber shoe industry was superimposed upon them and electric flashlight production had also become established, but little else.

Many of these original activities have now been displaced, while a few have been transformed.[7] Opium traffickers are vigorously hunted but still are present; the silver trade has been replaced with gold, and shipbuilding and repair have advanced to shipbreaking and rolling the salvaged steel into plates, bars, and rods. Tea blending is giving way to coffee,

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[7]See S.G. Davis, *Hong Kong in Its Geographical Setting* (London, Collins, 1949); C.B. Endacott, *Government and People in Hong Kong* (Hong Kong, Hong Kong University Press, 1964) which describes government actions; T.W. Chiu, *The Port of Hong Kong* (Hong Kong, Hong Kong University Press, 1973) which emphasizes the responses in port development and administration that made continued industrial growth possible.

but quite grudgingly. Banking and brokering have found rich new opportunities for gathering financial resources; one result is an expansion of the surface and volume of the reconstructed environment. The textile weavers and the shoemakers reached a plateau in the early 1960's, but the garment makers have fitted their wares to the world fashions so well that they continue to prosper.

Artisans who were fabricating colored paper for Chinese festivities took on sheet plastics and found a world market for plastic flowers, so that in the 1950's they farmed out the orders to a cottage industry for the population floating in the small harbors and the women in peripheral settlements. Upon this base a much larger plastic toy industry was built in the 1960's; by adding clockwork, electric, and electronic mechanisms it became a world leader in the 1970's. Manufacture of cheap transistor radios was taken up about 1960, and in 1965 the production of high precision microcircuits was solved for Hong Kong conditions. These sub-assemblies for instruments and computers were produced so well and so cheaply they became a principal Hong Kong industry within a few years; soon they became equally well established in Seoul, Taipei, and Kaoshiung and the interchange of these products between these areas has become a striking phenomenon in the air freight industry. The fabrication of knitted goods in the early 1960's led Hong Kong enterprisers into wigs--a supergrowth industry that collapsed in 1970--and then into high style knitted gowns that were more profitable for both the enterpreneurs and the workers.[8]

Printing is an industry that has been around to some degree for a long time, but high quality printing for export has now been added, and magazines and books are produced in ever larger quantities. Other precision industries, such as watchmaking and camera manufacture have also been showing some remarkable increases. Soon to come are oil refining, the systhesis of plastics raw materials, fiber manufacture and desalinated water; in each of them the production is carried out by stationary machinery supervised by automata which in turn are managed by a few technical workers and executives. The accession of these major facilities was in

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[8]Much of this information needed to be gleaned from issues of the *Far East Economic Review*, but they rarely rise above the news and comment upon it. The business news sections in the newspapers sometimes contain more comprehensive reports. A useful partial summary with time series was produced by the Hong Kong Trade Development Council, *Industrial Investment, Hong Kong 1973-4* (1973).

each instance demonstrated to fit a niche that had been created by the establishment of the predecessor activities.[9]

Note that in this discussion the successive rise and fall of activities has been reported. Activities that are not contributing to the survival and maintenance of the populations in the community are soon abandoned in favor of others that appear more promising. In general, Hong Kong is installing activities that require more energy, more machines, and better trained people to take the place of the waning activities. An approach to some kind of climax condition will depend not only upon the discovery of a balanced integrated set of activities, but also upon the achievement of relative stability in the rest of the world. Therefore those people in the community who watch over the boundaries and pick up the influences (information) transmitted across them must be very alert and must communicate much more. It is not surprising that a steadily increasing part of the human effort is being spent upon communications. Paper work is the creeping disease of an established organization, whether in the manufacturing sector or in government, even in a community ostensibly dedicated to laissez-faire.[10]

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[9]The principles of ecological succession are very much discussed in America, but are virtually ignored in Europe, perhaps because intervention by man over the course of recent natural history has been so common in Europe that few instances exist where successional changes can be clearly identified (a complaint heard here in Hong Kong as well). The *activities* referred to here are represented by a category of machines, identifiable by name and function, around which human and vehicular movements are organized. The successor industries may not have more numerous machines than those they displaced but they do tend to organize more people, vehicles, and other stationary machines. Thus activities have been emphasized, rather than the populations of the respective "species" of machines. Most of the specific information on activity has been winnowed from the annual reports of the colony, the latest of which was *Hong Kong 1974, Report for the Year 1973* (Hong Kong Government Press, 1974). Although the government is quite secretive about its operations, particularly when judged by the top civil servants to be relevant to policy considerations, they are quite fulsome when claiming credit for progress. Since the additions of new activities are normally defined as progress, they are quite comprehensively reported.

[10]The extent to which laissez-faire ideology affects administration and policy is striking. It comes out most clearly in Keith Hopkins, Ed., *Hong Kong, The Industrial Colony* (Hong Kong, Oxford University Press, 1971).

The statistics for clearly separating the white collar communications-based jobs from the production labor are not available, since manufacturing employment reflects the total jobs reported by a firm if its predominant activity was a secondary form of production. Hong Kong has a long way to go to catch up with Western societies, but it, too, is becoming a white collar, service-oriented community. Thus far only the dullest work of the clerks and accountants has been replaced by electronic data processing--the next stage in the normal succession of activities in a modern community. Software utilized up to the present in Hong Kong cannot be regarded as having achieved the status of automata, with the few exceptions noted in Table 1. Recently, however, an increasing number of reasonably sophisticated automatic reservations and inventory-management systems have been instituted. The next stage in the succession will appear shortly when automata are assigned the operation of equipment in office buildings and the control of trains and buses in the mass transit system Interestingly, the important criterion for automation in Hong Kong, as elsewhere, is not to save labor (unless human specialists are exceedingly scarce) but for the minimization of errors, accidents, and some kinds of negligence and crime within the metropolitan community. Automation will reduce fatigue, which often also means a work week reduced from the present forty-six to sixty hours to the more typical thirty-three to forty hours practiced elsewhere. But the advanced automatic control systems also require huge quantities of information in order to assure stability over the long run, therefore many more humans are put to work obtaining the data, editing it, and coding it for the machine. Altogether these are more interesting and varied jobs than routine paper shuffling, because most of the data are obtained from other human beings, and much of the remainder requires non-routine inspection of the environment.

An urban community is assured of survival at its present standards of existence if it can export products and services of continuously increasing quality. In the future quality no longer depends upon the richness of the materials employed or the luxuriousness of the features displayed, but mostly upon the precision (i.e. absence of error) with which it fits the requirements.

The Stresses of Growth and Change

Whenever a community undergoes rapid growth it should expect that some kind of price must be paid. Different components grow at their own rates, and some of the apparent imbalances that result have already been highlighted. The identification of these differentials is a worthwhile enterprise. The respective growth rates have been estimated by making deductions from various annual reports of Hong Kong agencies.

The official physical dimensions for Hong Kong have remained constant since 1861, yet the land surface is increasing about 0.2 percent per year due to reclamation from the sea. The human population is growing about 1.8 percent per year (counting refugees), and the number of vehicular trips by about 3 percent. The number of dwelling units is expanding by about 3 percent, as are the number of school places and the number of jobs. The amount of roadway is lengthening by about 4 percent, the amount of income available for consumption (in real terms) 5-8 percent, the amount of water consumed 8-9 percent, vehicles licensed 8-9 percent, solid waste produced 10-12 percent, and electric power generated about the same. The number of telephones installed advanced 13-15 percent, but the number of telephone calls placed is going up at a rate of 15-17 percent. The value of checks cleared is multiplying at a rate of 20-30 percent per year, while the additions to capital stock are more variable at 10-35 percent per year.

Each of these represents a different way of looking at internal growth, those mentioned earlier being of a more primitive and structural nature, the intermediate ones involving transfers of consumer goods with a marked style, quality, or informational component, while the last measure transactions which have purely symbolic value with minimal demands upon space, so that they exhibit little friction with the environment.

A few indicators of the localized ill effects imposed by the milieu upon its resident populations can be found within the current reports. Tuberculosis is still a big killer in Hong Kong, but the rates are dropping by 3-5 percent per year. Measles and chicken pox are episodic, but also show a major long term decline. Traffic casualty rates are falling 1-2 percent per year based upon potential victims, about 9 percent based upon the population of vehicles. Overall crime reported showed a marked jump in 1973 (16 percent) but this indicated much more a willingness to record crimes that could not be traced to perpetrators as well as a redefinition of crimes against public order, such as littering public places. A noticeable increase in violent crime, particularly on the part of the growing population of juveniles, led to a special campaign with the slogan "Fight Violent Crime!" An increase in the number of crimes against property and the processes of exchange (e.g. theft, fraud, forgery, corruption) reflects not only the vast increase in opportunity due to the extraordinary growth in securities transactions, but also increasing attention by the authorities concerning the corruption issue.

Data like these demonstrate rather uniformly that the individual and the family are becoming more secure against private disaster despite the increasing intensity of public interactions and an enhanced temptation for criminals. In part this improvement may be due to cooperation taking the form of public associations which allow people to defend themselves against sources of insecurity.

Thus the Hong Kong of 1974 had significantly fewer bad things happening than the Hong Kong of 1973, and the trend promises to continue. Such a conclusion goes against the perceptions of the people themselves, even the educated stratum, because the mass media, particularly television, have taken up crusades against crime, accidents, and pollution, so the number of incidents reaching the attention of the public exaggerates their prevalence. Very likely this increase in concern, which often changes to cynicism, is one of the necessary prices people must pay for enhanced communication.

Hong Kong's population densities set the world's record (still up to 400,000 persons per square mile, or 1,600 per acre, with hundreds of thousands of households limited to twenty-five square feet per capita--2.5 square meters--or less). They have caused architects and town planners to search for ill effects due to crowding. Studies on mammals had long ago demonstrated that crowding caused serious disorders leading to neglect of infants, resorption of the fetus, infertility, cannibalism, and related phenomena. The health and activity reports already reviewed give no confirmation of these expectations. However, one argument commonly made is that the stresses may have been internalized, so that they may later release into the urban ecosystem some kind of collective frenzy that could gravely injure, perhaps destroy, the community. Historic examples of self-destruction in cities have been cited, starting from the days of imperial Rome and continuing into the mid-twentieth century.

It is not surprising then that in the social scientist's attempts to get at levels of emotional strain conditions in Hong Kong have been studied more intensively than those of any other metropolis.[11] Moreover, smaller comparative studies were conducted in metropolises which contained Chinese along with other ethnic groups (Thai, Malay, Indian) in crowded districts. Mitchell started his major investigation by identifying indicators of strain--worry, personal unhappiness, low self-esteem, ill health, emotional instability, hostility, withdrawal from family roles, withdrawal from work roles, and deprivation of access to social services. Although almost

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[11] Robert Edward Mitchell, *Levels of Emotional Strain in Southeast Asian Cities*, 2 vols. (Taipei, Orient Cultural Service, 1972).

all of these reports (taken by interviewers proficient in the same dialect over an extended visit with adults) intercorrelated at the individual and the household level, none of the metropolitan areas studied could be shown to be clearly superior or inferior to Hong Kong. The latter contained a greater proportion of unhappy people and those that complained of ill health, but the hypochondriac character (recall that morbidity rates, except for tuberculosis, are low, and all are declining) is explained by the fact that at that time (1968) it also contained the greatest downward intergenerational mobility (subjectively interpreted) among all the comparable Asian cities. The wide-scale loss of status may be attributed to the very high proportion of refugees together with the frequency of being employed in a "dead end" job. However, few Hong Kong people felt "exploited" then, despite 60 percent of them being hired for a seven day week, usually with a ten hour work day. Conditions like these also explain why Hong Kong people were most likely to feel tired at work. They were also often disturbed at work by things that happened at home, but not vice versa.

Extraordinarily dense, Hong Kong housing is not statistically associated with unusual levels of emotional strain, even down to a median floor space in resettlement housing of twenty-three to twenty-six square feet per person. Analysis of the separate breakdowns provided by the survey persuade one to believe that government policies for the construction and management of subsidized housing were consonant with user preferences. Although these major programs were aimed at preventing destructive fires and epidemics, as well as opening up accessible land for more intensive use, they have not measurably enhanced levels of mental strain.

Despite the immediate relevance to ecological arguments of this attempt to elucidate the earliest possible traces of stress, few specific forecasts of those who knew the subject best have been borne out. For example, without investigating the public data Mitchell speculated that strains might appear on the crowded streets if they did not show up in tightly organized workplaces or households.[12] That possibility has obviously not been borne out, because delinquency and crime rates on the streets are low. Nor was the intuitive guess that the transition to a six day week would result in malaise confirmed.[13] Further-

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[12]Robert Edward Mitchell, "Some Special Implications of High Density Housing," *American Social Review, 36* (February 1971), 18-29.

[13]Robert Edward Mitchell, personal communication, December 1968.

more it must be noted that indicators of mental strain are very sensitive to security of employment and to the threat of political instability. When the business and political climates are rosy, as during the first three quarters of 1973, there should be a noticeable improvement in happiness as reflected by interview techniques.[14] These qualifiers about social surveys of mental health are introduced primarily to discourage their use of social program development; their outstanding value in this instance was a strong disconfirmation of the "worst case hypothesis" which, until the work was done, sounded only too credible.

The conclusions to be derived from the sum of evidence is that the Hong Kong habitat is presently favorable for man, animals, and some plants, more so than almost anywhere else in Asia. These conditions are encouraging a proliferation of growth together with the emergence of higher levels of organization. Local residents resist such conclusions; professional opinions voiced elsewhere also do not agree. Therefore I have sought a number of corroboratory tests.

Migrants change their home environment for a better one. A local example is the moving of the water people from their boats and isolated houses-on-posts in tidewater villages. Jobs in factories and apartments in a tightly packed settlement have brought more than half of them into the metropolis over the past fifteen years. Apparently they prefer that life to the uncertainties of fishing and the ties to a folk community with a long tradition. Almost all have the opportunity to move back again, but they are sticking it out in the heart of Hong Kong or its high density appendages. The fisherman's life is much better now that dieselization allows him to go out in all seasons and prices are up. But the number of local fishermen continues to dwindle while the number of Korean and Tai-

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[14]These deductions follow from the studies upon happiness, particularly those which demonstrate a close relationship between the degree of social participation and happiness. During periods of improving employment prospects participation and opportunity obviously increase and are, on the whole, more rewarding. Derek J. Phillips, "Social Participation and Happiness," *American Journal of Sociology, 72* (March 1967), 479-488. Although the original studies were carried out on an American sample, parallel investigations undertaken elsewhere in the world indicate that the relationship is quite general.

wanese fishermen expands.[15]

Similarly an increasing new flow is observed from China into Hong Kong, much of it moderately well-informed because relatives outside provided contacts both before and after migration. Moreover, the flow to the United States, Canada, and the United Kingdom tends to select the locales in those countries that most resemble Hong Kong, even though jobs for bilingual Chinese are readily available in more thinly populated locations. Hundreds of thousands of individual choices of residence have been made over the past decade, and the great majority show a clear preference for Hong Kong-like communities, as compared to a variety of others.

These are personal and small-group decisions made by people who are marginal to communities, and presumably more sensitive to the stresses than the mass, because it is the over-stressed (or under-stimulated--a stress of another sort) who seek to escape. The totality of evidence, therefore, seems to argue that the quality of life in Hong Kong grades from average to good as compared to all the real alternatives open to human members of the community, even though it may be seriously flawed as compared to an ideal version of city life.

Alternative Pathways into the Future

The fundamental environmental issue facing Hong Kong as a community is not the relative goodness or badness at present, or even the threatened levels of pollution. It is the need to find a relatively painless path to a climax condition that exhibits zero population growth and zero energy utilization growth, together with flexible water usage and raw materials requirements. Because it is only a speck on the shoreline of China, it has little control

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[15]The best current indicators are obtained from the annual reports on fisheries in which estimates of those actively engaged in fishing occur periodically. The total has dropped from 70,000 in 1965 to 46,000 in 1973. Moreover, an important share of the water people still fishing have moved into flats in harbor towns, some of them involuntarily as a result of shoreline cleanup programs. The number of vessels has been reduced to 5,600, not all of which are used as residences. This represents a huge reduction from the 150,000 to 200,000 estimated to live on more than 10,000 vessels after World War II. The hurdles that they needed to overcome are described by E.N. Anderson in his monograph *The Floating World of Castle Peak Bay* (Washington, American Anthropological Association, 1970). Crowding was the least of their worries.

over its destiny; therefore pathways that offer least resistance to outside forces must be considered. Three very different kinds of alternatives will be explored here, but a review of parallels in recent history will suggest a number of others.[16]

First the important nonfuture should be noted. The recent remarkable growth cannot continue very long in the path it has taken. Curiously, most people in Hong Kong are acting as if it will. The commentary in the newspapers tends to confirm them in this habit. The fallacies in this way of thinking have already been reviewed.

1) Goal-Directed Projection into the Future

This is the kind of future that a society can plan for and then proceed to implement. For many societies, if they can construct a realistic plan, this would be the most likely pathway; however, Hong Kong's political situation reduces the capacity to plan effectively. Yet, at the moment, this future can be better defined than any other because it is continuous from the present and the recent past.

The simplest, most ecologically sound program for the community of Hong Kong presumes that the boundaries (which virtually are undefended) will remain stable and that the lease for the New Territories can be renegotiated on much the same terms as at present. Immigration would be balanced by emigration.

The continuing investments in education make it likely that another 40 percent of the population will accept birth control as rapidly as the last 40 percent (requiring perhaps twelve years). Thus the one to two child family becomes the norm and only unusual households bring the reproduction of the human population up to or somewhat beyond replacement levels. Under these circumstances the population will grow older, with the average age shifting from less than twenty at the present time to about thirty-five a generation from

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[16] An admirable paper analyzing the possible political futures for Hong Kong was published by Prof. P.B. Harris, "The International Future of Hong Kong," *International Affairs, 48* (January 1972), 60-71. It is unusual that the conclusions should remain valid after the cessation of the American participation in the Vietnam war, the Nixon shock, and the Kissinger miracles. The passage of time has allowed only a slight sharpening of the alternatives which he was able to perceive.

now. The total population of Hong Kong would level off at a figure close to six million.

As a part of this projection it is judged that the dependent pig and poultry populations would by then have reached a somewhat higher level than at present, mainly because they can be fed on the wastes of the city and the byproducts of the food processing industries, with supplements drawn from the cheapest rough grains on the world market.

The major population expansion is to be expected in fish, as an outgrowth of the borrowing of mariculture techniques from Japan and Hawaii. Floating ponds allow the recycling of human and animal wastes back to the pigs and the domesticated fish, instead of the present disposal into the tidal currents. These innovations are proceeding in nearby Taiwan.[17]

Under climax conditions rice growing should virtually disappear, but Hong Kong would be almost entirely self-sufficient in vegetables. The steep hill and mountain sides would be largely reforested, and a human generation hence some of it will already be quite dense and parklike. The mountain tops would support new and more digestible grasses, fertilized to increase the rate of production. Thus much more grazing would be carried out, but in a way that seldom detracts from the enjoyment of people on holiday, since the same peak areas are very precious for recreational uses.

The big stationary machines--oil refineries, petrochemicals, plastics, fiber production, steel mills, and shipyards--are due to be installed in Hong Kong. Then its industry will become far more vertically integrated than now, but still less so than Japan, Korea, or Taiwan. Many intermediate products will still be shipped out, and others quite similar will be imported. In this future Hong Kong must remain a very open system with worldwide relationships. The big machines require energy, but that energy is already spent elsewhere

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[17] The Taiwanese are said to combine night soil from Taichung with pig wastes to produce by means of a sequence of three ponds a continuous crop of proteinaceous green algae, mainly *chlorella*. This product can be added to the swill, supplying some of the calories and a large share of the protein required for raising pigs. (Private communication from Michael G. McGarry, September 1971, supplemented by Taiwanese descriptions at the International Seminar on Land Reform in Relation to Industrial Development, Taipei, December 1973.)

on the globe for intermediates now used by Hong Kong, so their energy demand represents merely a displacement of "dirty industries" from Japan and the Common Market to outlying islands around Hong Kong. There the dirt is either prevented by more modern design or it is segregated so that the living populations are not much affected. The Japanese are even willing to design synthetic islands; they become ecomonic if land price continues to escalate. The expense of the fuel will assure that a high level of energy economy is practiced in manufacturing.

The automotive vehicle population must come under control well within a decade. As the annual increment dwindles to zero the diversity will increase, much as has already occurred in construction machines, vans, and in shipping. Private automobiles can be displaced by increasing the personalized transport services, such as dial-a-ride. Fortunately the era of the universality of the telephone is virtually upon Hong Kong. Its micro-electronics industry will soon be capable of producing a portable telephone that would allow one to quickly obtain a ride from any origin to any destination at a price less than is paid for the same trip by automobile.

Bicycle populations will vastly increase in the new towns and environs, being assigned in many instances a separate network of lanes, following upon precedents now being established elsewhere in the world. The cycle population will also become quite diverse in order to fit the needs of older people.

The automata in this future will be largely invisible and embedded in the newest industries and services. If half of the new equipment in America will incorporate sophisticated automatic control systems by 1975 (a *Business Week* estimate) then the same level of use should come to Hong Kong ten or fifteen years later. Their introduction could save 20 to 40 percent of the energy and materials required per unit of output. A large share of the saving would be due to the expediting of round-the-clock organization which allows Hong Kong to be continuously "on line" by means of communications satellite with America, Japan, and Europe.

The constructed physical environment must keep on growing much longer than the populations. In large part this is due to the unfulfilled demand backed up behind the construction activity in this metropolis, but it is also needed to add flexibility to the economy, allowing it to adjust quickly to exigencies and opportunities in world trade. Thus a population of six million is likely to demand living space for itself and its organizations at least three times the present floor and road area and perhaps four times the enclosed volume. One of the significant reasons for enhanced demand is the growing body size of the resident Chinese that is attributed to improved diet. A variety of water borne structures is likely to be added a decade or two hence. All new structures must be designed for minimal air conditioning and maximal natural ventilation in order to save energy and gain flexibility of use under widely varying conditions of world supply.

Everywhere henceforth the emphasis must be on improved fit between the respective populations and the constructed physical environment. The engine and chassis of a vehicle may be quite standard, but the body and the auxiliary equipment will be increasingly adapted to the function it serves. Thus, in very little time, the body may change to fit a completely new function. Containerization starts with a standard exterior and introduces new liners and internal supports to handle many different cargoes. These approaches complement each other.

Similarly the price structure for services, such as water and power supply, must be made still more variable so that real economies can be achieved during periods of regional or world scarcity that inevitably mean scarcity for Hong Kong. Thus if the world food situation becomes serious (less likely than presently publicized in the newspapers, but still a very real possibility) the pig and poultry populations of Hong Kong will suffer; the banquets will depend upon tofu and textured protein substitute materials. Rice would give place to bread, noodles, and cornmeal. In general it is much more economical for a harbor metropolis to invest in flexibility than in large buffer stocks.

2) Rupture of the Boundary with China

This is an apocalyptic future that presumes temporary breakdowns of public order in China equal to or more severe than the Cultural Revolution. Then poor refugees will come crowding into Hong Kong. At the same time a large share of the cosmopolitan population and the financial resources controlled by the tiny minority holding passports would be fleeing to safer cities. The population could very easily double, and the standard of living fall back to subsistence for a while.

Population pressures are already so great in Kwangtung, Fukien, and the provinces to the west that, once economic development was resumed, the conurbation of Canton would grow to a size larger than greater Tokyo. The number would be at least in the range of 30,000,000 - 50,000,000 people, and probably even larger.

The land forms in Hong Kong require it to be polycentric, so that an enlarged Hong Kong might play a very significant role in initiating the enterprises and managing the technology as well as offering an opening to the world. Hong Kong might play the same role for the new Canton that Yokohama-Kawasaki did for Tokyo, because Canton would almost certainly remain the center of political administration and be backed with the military police power. The small scale manufacturing that still employs much of the labor force of Hong Kong would move onto new industrial estates not yet occupied.

The risks of further breakdowns along this pathway are very high. There may be repeated famines and revolutions in China until population distributions again come into rough balance with food production and with the capacity to distribute imports from the outside world. (The transport system of China does not allow it to depend upon food surpluses in America and Australia the way that India and Java can.) However, due to its high quality harbor and docking facilities, and the great distance from the famine belt, the Canton conurbation should be better off than any other part of China.

During a period of hard times and disorganization in China the conurbation of Canton should remain a center of relative stability and become a base from which political power over a large hinterland could be exercised. Whatever institutions would be left of contemporary Hong Kong would become important participants in that renaissance.

3) <u>A Quasi-Independent City State</u>

The accelerated decline of the United Kingdom's share of international trade makes it possible that it might divest the last traces of Empire in the foreseeable future. Then Hong Kong would be forced to pursue a course somewhere between that of Singapore and the future Taiwan. Like Macao, it would have to take orders from Peking, but as long as the yield in foreign exchange is high there may be very little interference. Nevertheless, the demands upon its ecosystem would be much more dependent upon Marxist philosophies expounded in Peking than the Western ideas increasingly propagated in Hong Kong now. Short run interests of an aggressively developing economy, separated by a more permeable boundary, would predominate over the progressive evolution toward a steady state propounded here.

As a result the carrying capacity for the biomass would be significantly reduced for a long time to come. The ability to adjust to shocks arising from political and environmental shifts would be judged from the point of view of the survival of the collective unit, and much less that of individual welfare. A biologist would recognize that such a policy is analogous to a concern with the survival of the subspecies, or the gene complexes, rather than the size of the respective cohorts. Both emphases are common, and neither can be claimed to be superior to the other.

Conclusions

Hong Kong's urban ecosystem is unique in that it produces better data about the functioning of the complete metropolis. The information clearly shows a community in the midst of exponential growth. A continuation of present differential growth will soon exert intolerable stresses. Already in 1974 some of the forces that should cause this growth to level off and integrate were noticeable, but most of the essential policies have yet to be formulated and put into effect.

Three very different kinds of futures were explored. The one that can be planned by present leaders could lead to a steady state in population, energy use, and water consumption in perhaps a dozen years, although the growth in the constructed physical environment would continue for decades. Rupture of the boundary with China would probably be accompanied by major disasters, from which Hong Kong would recover as an integral part of a Greater Canton conurbation. The third involves increased permeability of the boundary. Then Hong Kong's environmental philosophy must more closely approximate the Marxist-Leninist viewpoint held in Peking at the time. It is expected that this thinking will place less emphasis on maximizing the carrying capacity of the environment, and more on the survival of the collective.

International Urban Systems: Outline of a Research Project

Peter Hall

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University of Reading, England

Introduction

1. This short paper attempts to outline a proposed comparative international study of urban systems in evolution. The idea arose from a seminar on the International Comparative Study of Megalopolises held in Tokyo, Japan, in June 1973. Papers by Hall [II] and Berry [I] presented the advance results of urban systems studies in Britain and the United States respectively, and Hall also summarised attempts in recent years by workers in the Netherlands and the Federal Republic of Germany to produce a consistent framework for urban systems analysis. Since then, both authors have produced the full results of their studies (Hall et al [12]; Berry [2]) and these suggest directions which the proposed international study might usefully follow.

2. Since the Tokyo conference, not much substantial progress has been made. A proposed meeting of the participants was postponed due to logistical difficulties. Hopefully, the Laxenburg conference will mark a renewal of the active attack on the problem. Meanwhile in Britain, Drewett et al [9] have nearly completed a follow-up analysis of urban system changes in Britain during the intercensal decade 1961-71; and Hall has applied to the British Centre for Environmental Studies for a grant to make a preliminary analysis of the geographical framework for a European urban systems analysis, on the understanding that a fuller study based on this framework could be conducted by the International Institute for Applied Systems Analysis (IIASA) at Laxenburg from late 1975 onward.

The Nature of the Problem

3. The problem essentially is to define *Daily Urban Systems* (DUS's): a term first used by C.A. Doxiadis in 1967 and adopted by Berry [2] in his exhaustive analysis of 1960-70 changes in

the American urban system. In the United States the DUS's, based on actual observations of commuter flows around major economic centres, cover very wide areas. The DUS's are in many cases based on the familiar Standard Metropolitan Statistical Areas (SMSA's) used in much official statistical presentation but in some cases a number of SMSA's have been aggregated into one DUS because of the high degree of interconnectivity among them, and in rural parts of the country non-metropolitan cities have been used, provided that they served an area of at least 200,000 people and served as a wholesale trade centre for that area. As finally delineated, Berry's 171 Daily Urban Systems completely exhaust the territory of the co-terminous continental United States and each has a high degree of closure with regard to its job and housing markets. In many rural parts of the country they extend beyond the existing commuting fields, and so include the most likely prospective commuting areas within their limits (Berry [2], I, p. 15); see Figure 1.

4. The definitions of DUS's made by Hall et al [12] had two alternative forms. One, the *Standard Metropolitan Labour Area* (SMLA), was a direct attempt to adapt the Americal SMSA concept to British experience, with some refinement in the definition of the central city. Earlier attempts in this direction had been made by International Urban Research [14] not merely for Britain but also for the whole of Europe and indeed the world; but close analysis showed that the definitions were to some extent inconsistent and also were overtaken by events, while later work by the same team (Davis [8]) has largely forsaken the Daily Urban System concept in favour of a physical definition of urban areas. Goddard et al have used the SMLA as their basic building block for their follow-up analysis. The other definition, the *Metropolitan Economic Labour Area* (MELA), was a conscious attempt to produce a unit broadly comparable with Berry's original definitions of DUS (Berry [3]). It used in each case the same central city definition as the SMLA, but also included the whole of the commuter field around that centre; thus it nearly exhausted the territory of England and Wales save for a few peripheral rural areas, as a comparison of Figures 2 and 3 shows. Even the MELA's are, however, not fully comparable with Berry's current definition of Daily Urban Systems.

5. So far as can be established, the work on Daily Urban Systems so far done in Western Europe is based on concepts close to the traditional American SMSA. This is certainly true of the Netherlands' agglomerations based on socio-economic criteria (Schmitz [16]) and for the city regions *(Stadtregionen)* in the Federal Republic of Germany (Boustedt [5;6], the first of which uses a 15 percent commuting level (as a percentage of the resident work force of an area commuting to a central city or cities) and the second a 20 percent level. Nor has the most recent work (Bundesforschungsanstalt [7]) made any breach in this principle.

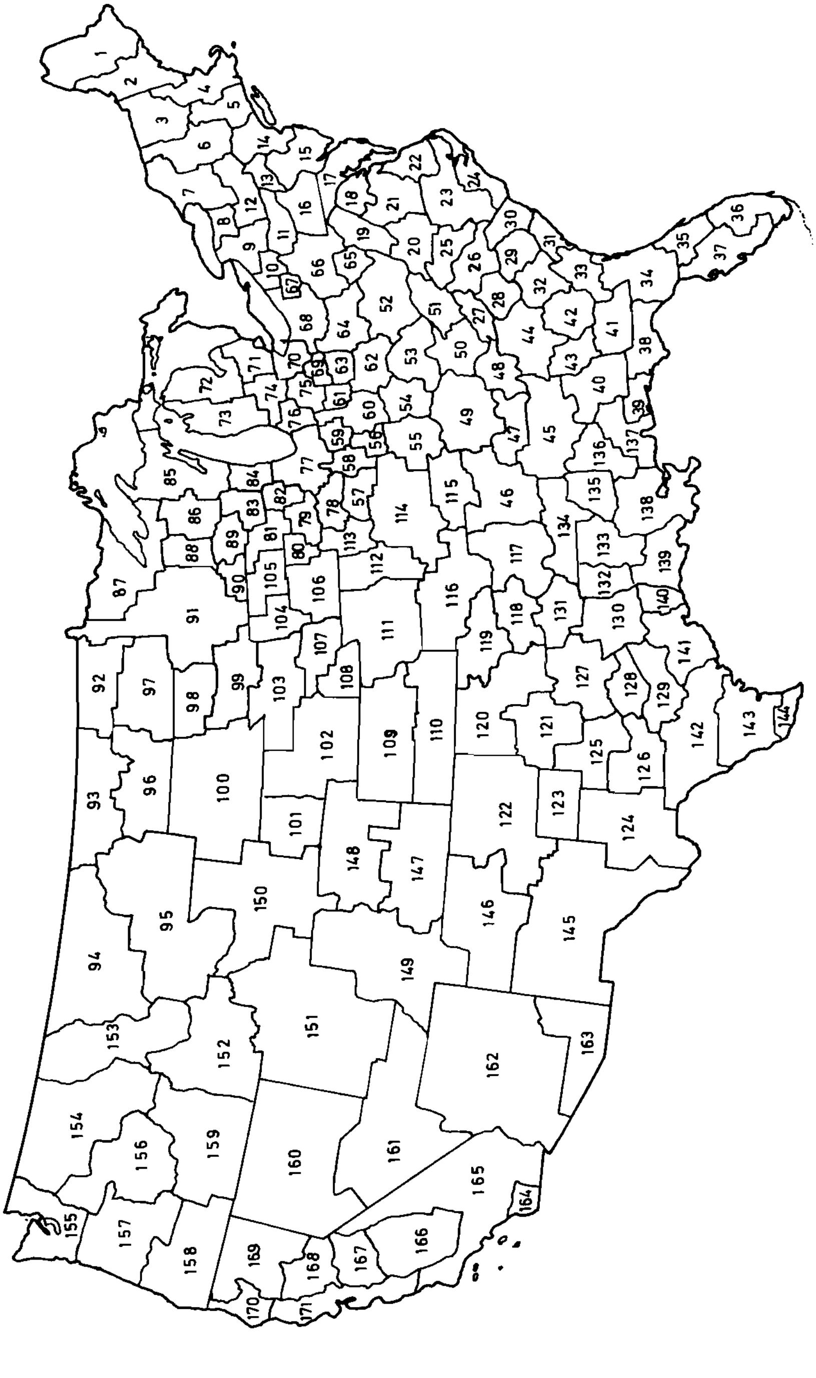
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Figure 1.

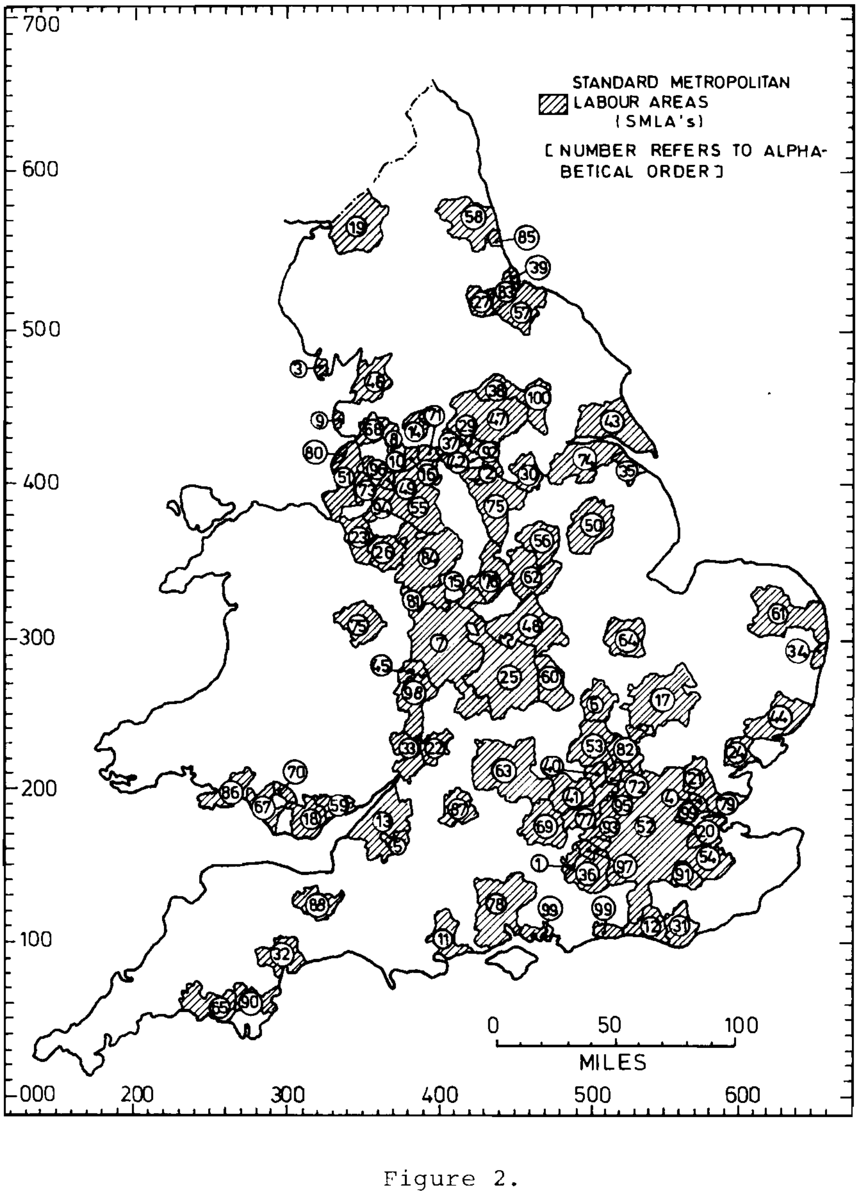
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Figure 2.

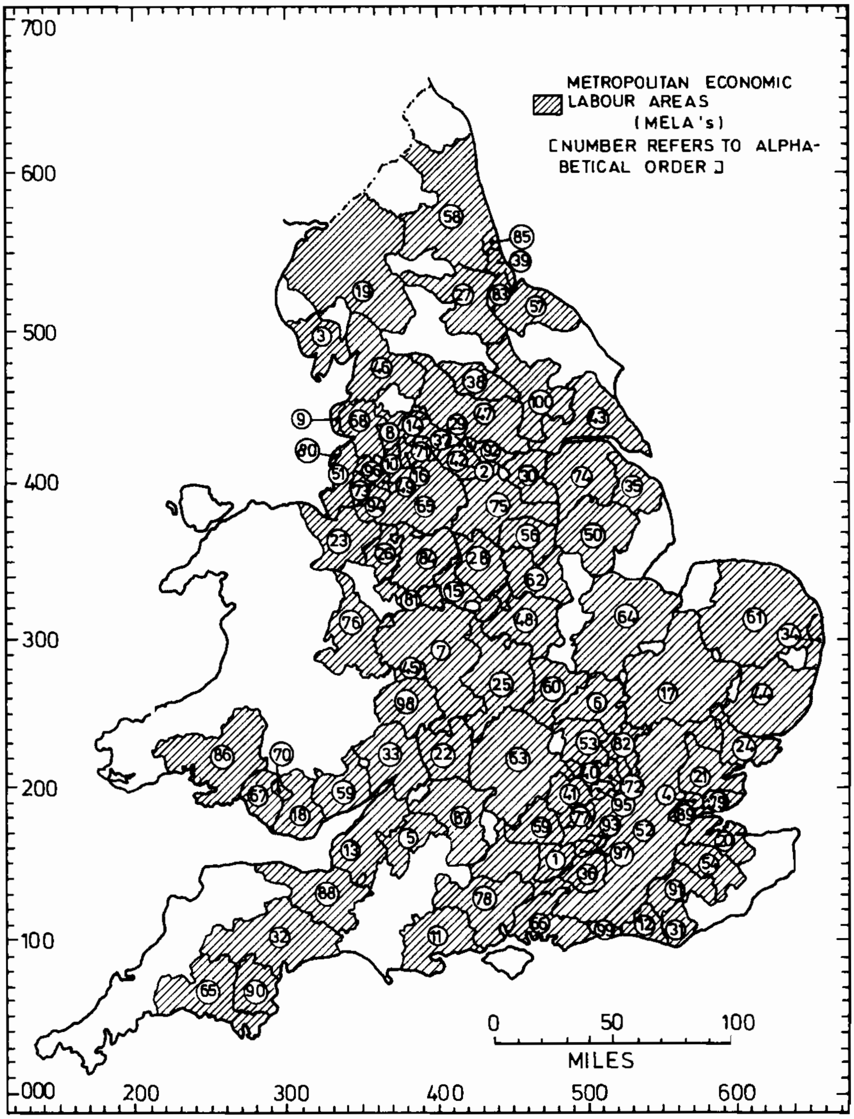
METROPOLITAN ECONOMIC LABOUR AREAS (MELA's)
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Figure 3.

Uses of the DUS Concept in Analysis

6. Basically, the DUS concept is valuable in two ways: first, in providing a rigorous comparable set of units for analysing differential *growth* and its possible causes; second, in providing a framework for analysing *internal change*. The British study of urban systems was able to show that the differential growth of different SMLA's was the product of both a regional differential--with growth in the south and midlands, and stagnation or decline in the north--and a size effect, with the most rapid growth tending to occur in the smaller DUS's, having less than about half a million people. It was also able to demonstrate that rapid decentralization of population and (slower and more belatedly) employment was occurring within the SMLA's during the 1950's and 1960's. Since 1961 indeed this trend appears to have become accelerated: the major cities of Britain have lost up to one-fifth of their populations, and a substantial share of employment (this last not yet documented by the census as of November 1974) in a single decade. The British researchers used this evidence to produce a simple model of urban development, in which outward diffusion of population is followed by outward diffusion of employment and then--in the largest DUS's--by overall loss of both people and jobs to separate, smaller peripheral commuting systems (Hall [10], p. 397). It could well be argued that by using the SMLA framework for this purpose, the British researchers were too restrictive; Berry argues for his DUS's that they catch the rich complexity of internal organisation, in which increasingly suburban and exurban centres challenge the primacy of the old central city. What is certain is that at any rate in the largest British urban regions, such as London and Manchester, a very complex polycentric form has developed in which commuter flows to a whole series of centres overlap and merge. And among these, most strikingly in the ring twenty to forty miles (thirty-five to seventy km) around London, it is the more distant centres that are gaining in relation to the big central employment magnet.

7. Berry's own analysis is in many ways fuller. First, he is able to show that relative growth is systematically related to the major source of income of the DUS. The greater the dependence on the primary sector, the lower the growth rate. As earnings from secondary sources increase, growth rates stabilize round the national average; while the greater the share of earnings from the tertiary sector, including residentiary activities, the greater the growth rate (Berry [2], I, p. 17). Many of the bigger DUS's are growing because of their reliance on governmental expenditures. Secondly, Berry demonstrates the full impact of suburbanization: new growth of all kinds--residential, industrial, commercial--has shifted to the suburban and even the exurban segments of the DUS's, and in particular the interurban peripheries in the major megalopolitan regions, where the centres of the DUS's approach each other

more closely than elsewhere. The mainsprings of this process are more social than economic: families move out in search of the best neighbourhoods they can afford, leaving behind older homes in less environmentally desirable neighbourhoods. So far has this process of outward movement gone, Berry asserts, that the traditional core-periphery distinction is fast losing its meaning: what does matter is the multiplicity of nodes and of connections. Within such megalopolitan areas, the old spatial order--consisting of the metropolis and its gradients of influence which decline gradually away from the centre--is replaced by a new order whereby the periphery may actually grow faster. These "megalopolitan confluence zones" are now the most dynamic areas of the contemporary United States, combining tertiary and quarternary employment growth with high-income residential developments in amenity-rich environments. Beyond these are other fast-growing areas, based on high levels of amenity for vacationers, for the most rich and mobile members of the metropolitan communities and for the retired. And even outside these zones, manufacturing industries are rapidly filtering into small towns and rural areas on the intermetropolitan periphery, in such regions as the Carolinas, Georgia, the mid-South (Kentucky-Tennessee) and Arkansas. Thus a new manufacturing belt is emerging in the South. In this pattern, the peripheral areas with the greatest growth of real incomes in the 1960's were those from which the migration from the cities had been the greatest. And the ghetto areas of the central cities were left as areas of decline, together with the black and hillbilly South, the Indian reservations, and the most remote rural areas.

8. There are many points of resemblance between the emerging trends in the United States and in Western Europe. In both regions, the forces of dispersal have worked powerfully in the last two decades, reducing the importance of central cities and enhancing the role of small and medium-sized cities on the metropolitan peripheries; nowhere is this clearer than in southern England. In both, though the detailed evidence for Europe is so far lacking, the most dynamic areas tend to have been those dependent on tertiary and quarternary industry, such as professional and business services and higher education; R and D growth, generated by these dynamic sectors of the economy, tends to be synonymous with high income. In both, growth and coalescence of metropolitan areas is leading to the emergence of megalopolitan regions representing a new order of complexity in the organisation of space. At least three such zones can be firmly distinguished in the United States, based on the east cost (Boston-Washington), the southern shores of the Great Lakes (Chicago-Pittsburgh) and the coastal zone of California (San Francisco-San Diego); several others seem to be emerging, including Florida, the Gulf Coast, the Piedmont zone from North Carolina to Georgia, and the Willamette-Puget Sound zone of the Pacific Northwest. In Britain, the hourglass-shaped zone extending from the south coast up to Lancashire and Yorkshire is another clear Megalopolis, closely

comparable with the American eastern seaboard in its general man-land relationships. Continental Europe seems to possess a linear Megalopolis extending up the Rhine from the Dutch Randstad through the Rhine-Ruhr area to Rhine-Main and Rhine-Neckar (see Figures 4 and 5).

9. There are, however, probably differences--though rigorous comparison is not possible in the present state of the art. In continental Europe, above all, decentralisation almost certainly set in later and so far has been less profound than in Britain and above all than the United States. There are still substantial areas of rural loss in Europe, and the extension of the metropolitan regions has not yet proceeded fast or far enough as to reverse this trend. Manufacturing industry has proved less apt in moving to the rural peripheries, though there are signs of this in parts of southern Germany and in East Anglia. The role of tertiary and quarternary industry, and above all R and D and the science-based industries, is almost certainly less pronounced in Europe (with local exceptions, such as Sweden) than so far in the United States.

Objectives of A Research Project

10. Against this background, it can be argued that the time is now ripe for an *international urban systems study* that would systematically analyse statistical trends in the most important major urban areas of the world. The obvious focus for such a study would be:

1) *North America*: the extension of Berry's work to take in Canada, incorporating, hopefully, the work of Bourne [4] and others;

2) *Western and Central Europe*: a new study based on the existing British work by Hall and others, as extended by Goddard, Drewett and Spence, and drawing as far as possible on related work in other countries;

3) *Japan*: a comparable study of the linear development of the main Japanese DUS's, as outlined in the papers by Ito [15] and Watanabe and Morito [18] presented to the 1973 Tokyo conference.

11. Some of the most important questions to be answered in such a study have been raised--and partially answered--in the studies so far made:

a) *Comparative growth*: What is the pattern of growth (and, perhaps, in a few cases, decline) of DUS's? Do they have a systematic geographical pattern? How far are growth trends systematically related to size, and if so, how? Is growth "transmitted" over space? How far is growth to be explained in terms of the chief economic support(s) of the DUS? Does high income, generated by one or more leading industrial sector, attract high growth?

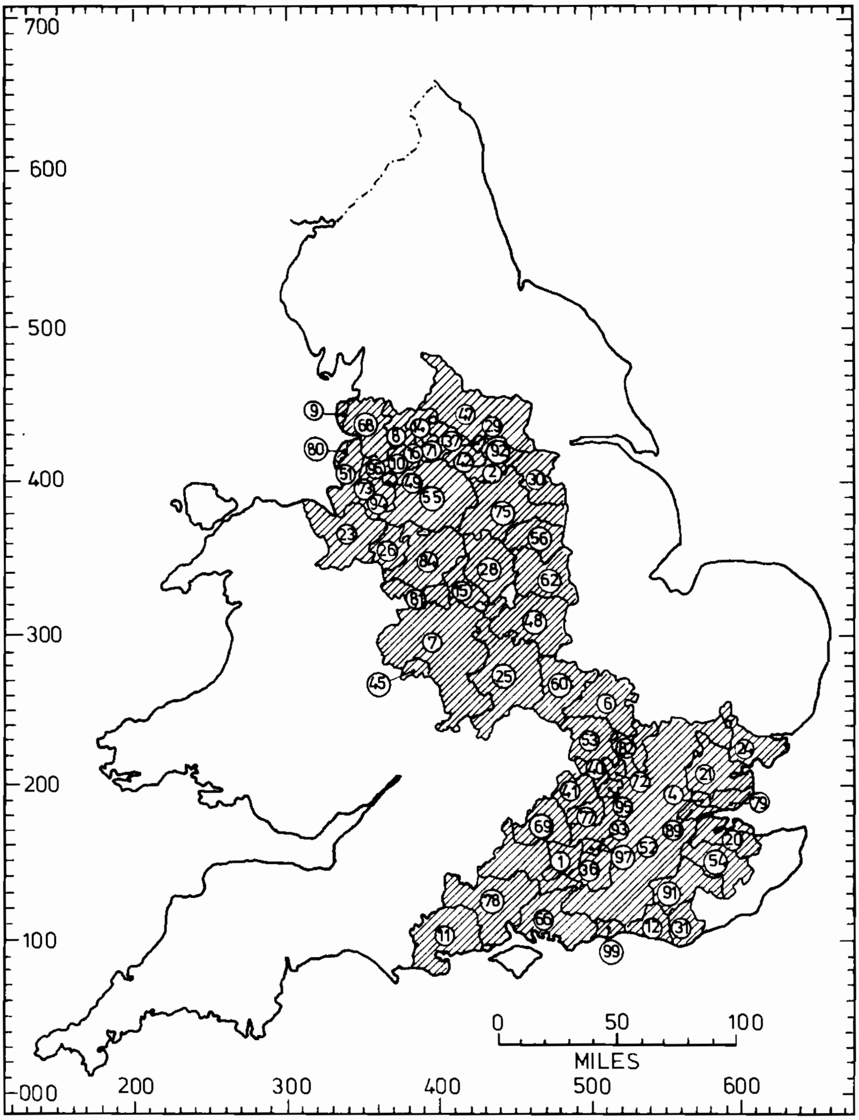
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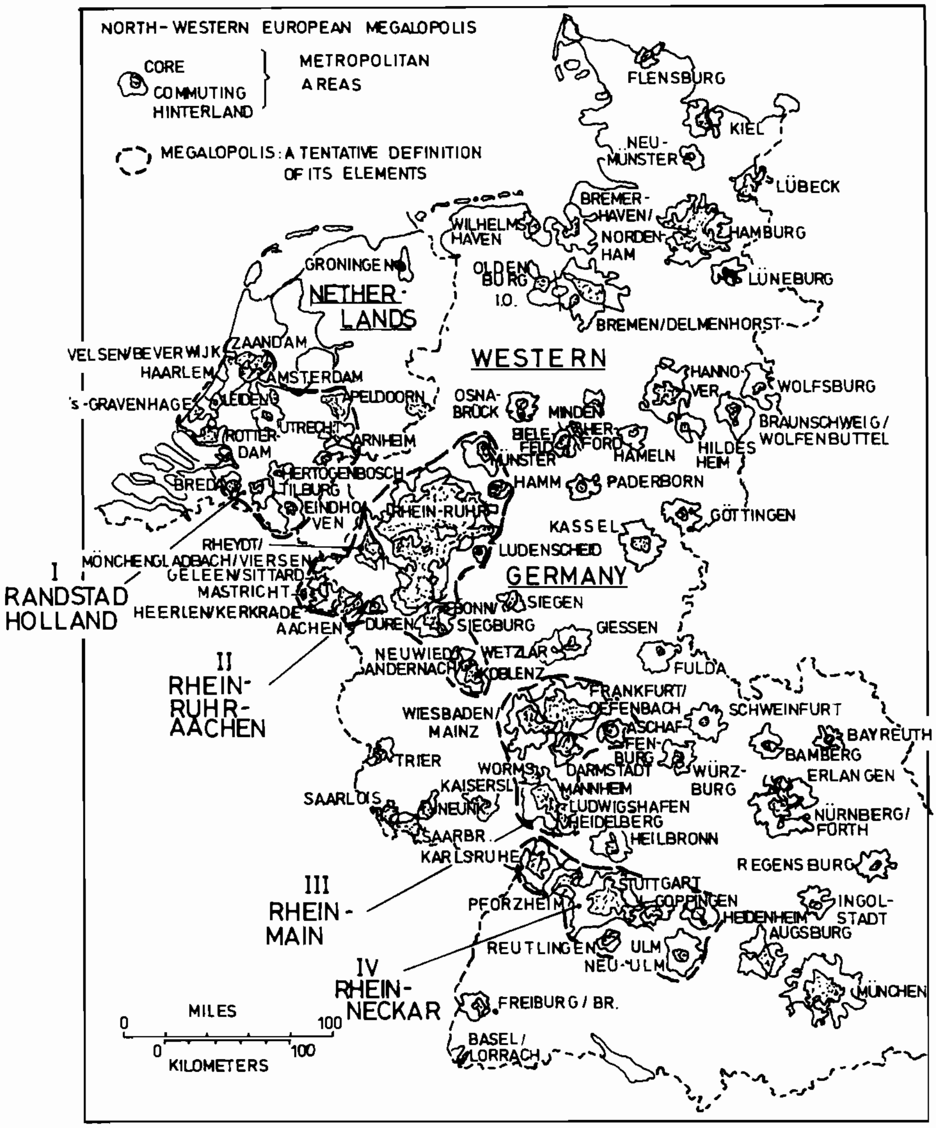
Figure 4.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CORE
COMMUTING HINTERLAND
METROPOLITAN AREAS
MEGALOPOLIS: A TENTATIVE DEFINITION OF ITS ELEMENTS
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WILHELMSHAVEN
NORDENHAM
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OLDENBURG I.O.
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BREMEN/DELMENHORST
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BASEL/LÖRRACH

Figure 5.

b) *Internal change*: How far is decentralization of residential population and jobs taking place? Does it appear that the traditional pattern (whereby new jobs attract new people) still hold good? (Conversely, is there evidence of attraction of people to amenity-rich areas, with industry in turn attracted to labour supplies?) Are economic activities dispersing to multiple nuclei, leading to a weakening and even a destruction of the old core-periphery relations? What are the resulting patterns of travel for work and for other purposes? How far is dispersal leading to lower densities of occupation of the land (bearing in mind that this requires analysis at different geographical scales)?

c) *Social indicators*: A further extension of the work could develop social indicators for urban areas in different countries and continents. Up to now work has been done on this subject either at a coarse national aggregate level or for metropolitan areas *within* one country (see Hoch [13], Smith [17]). There is increasing interest in the subject of what is loosely called the "quality of life" in different urban areas, but the comparison is vitiated most of the time by the lack of precise comparable areal definitions; for instance, comparisons between Paris, London, New York City and Tokyo would be greatly affected by the precise geographical units chosen for comparison. Once comparable units are determined, the statistics in this area are fairly plentiful though unfortunately they present difficult problems of comparability.

d) *Resource and energy stocks and flows*: Models have been developed in recent years for systems that are reasonably closed, but to develop these for urban areas clearly presents great difficulties of data capture. Much of the information may not be areally disaggregated in the right way, and the flows in particular might be difficult to monitor. But the study would hold out particular interest in its focus on the comparative efficiency of different urban systems in terms of resource use. One particular part of the study, that on land use, would relate closely to the themes on population growth and shift discussed earlier.

The Value of the Research

12. For a group of urban researchers, the proposed research will probably justify itself. But to attract support, it should be possible to demonstrate that it would have positive value for practical decision makers.

13. The most important single outcome would be to *give better understanding of the capacity and the limitations of national public policies.* During the thirty years since World War II, virtually every advanced nation has initiated schemes of regional development. Not a few have embarked on attempts at a national urban development strategy. Most have aided the establishment or relocation of industry in regions deemed worthy of development. Some have deliberately restricted the new location of industry in more prosperous areas to this end. Further, most countries have introduced more or less restrictive policies of urban land use planning. These policies, which have differed in their emphasis and in their force from one country to another, seem to have operated against a back cloth which is to some degree common: a back cloth of increasing concentration of industry and people into super-urban megalopolitan regions and of growing dispersion within those regions. A comparative urban systems study would permit a series of verdicts on just how effective these policies have been at different scales, in particular:

1) macro- or national-regional: the attempt to steer development into backward or depressed regions and to re-make the national urban settlement hierarchy;

2) micro- or regional-local: the attempt to steer development in certain directions, through land use planning and associated measures in housing and transportation policy.

14. It might seem anomalous that answers were still required to such questions. A great deal of comparative urban public policy analysis has taken place in recent years, and much is still underway. But without a rigorous study of the type proposed here, reasonably definite answers will not be possible.

15. As well as this, the study will have an indirect *prospective* value. In its present form, it is not planned to build predictive models. But the data base assembled for the study could indeed be used for such purposes. Thus decision makers could be supplied with a picture of the likely trends in major urban areas over the next decade. This would be of great value not only to governmental planners but to decision makers in the fields of industry, housing, transportation and communications, and wholesale and retail distribution.

16. The later and more speculative parts of the study--those dealing with social indicators and resources--similarly would have great value for decision makers, particularly those (in the EEC, OECD and elsewhere) concerned with the development of policies on an international scale.

Technical Problems

17. The research would present considerable technical problems of comparison. Indeed, the first stage would involve discovering just how serious these are:

a) *Geographical building blocks*: Even without one country, these vary in scale. (Compare the township units of New England with the giant county units of the American deserts.) In an international comparison these variations are apt to be even greater. Thus within Europe, local government in Britain and Sweden is now reorganized on the basis of rather large units while some countries (Netherlands, Spain, Portugal) still retain a system based on small municipalities. Different countries will have data available only for certain larger scale units, not for smaller-scale units. This particularly applies to data on industrial structure, incomes and other economic data. Aggregation upwards, so as to obtain the "lowest common multiple," may be the only answer.

b) *Availability of data*: Some very important basic data vary in availability from country to country, though probably this is not as serious as heretofore. Commuting data for small areas will be absolutely basic to the exercise. (Its availability would be examined in the research project for which application has been made to the British CES.) Basic population data will almost certainly be available everywhere, but migration data may not. Employment data for small areas, preferably classified at least by major sectors, would be a very important basic input and may not be available for all countries. Some social indicators should be readily available, but there will be difficult problems of comparability. Data on incomes, production and energy may be the most elusive of all.

c) *Time series*: The minimal objective would be to make an analysis for the intercensal decade 1960/1-1970/1, with, hopefully, a backward extension to 1950/1 in order to obtain a picture of changing trends over two decades. Here, the chief difficulty will probably be the octennial censuses taken in France, the results of which would need to be interpolated for comparison with other countries.

18. The first step in overcoming these difficulties would be an exhaustive inventory of data availability for small zones in each country, coupled with a comparison of sizes of small zone. This would almost certainly require a small research unit equipped with all the necessary statistical materials, backed by

a network of expert correspondents in each country concerned. The team and the correspondents should meet at one or more working conferences to consider working papers produced by the team and to resolve the differences that will certainly emerge.

19. If the British proposal for a preliminary survey received support, it would start early in 1975 on a twelve-month study in close cooperation with the research team at Laxenburg. The intention would then be to convene a conference of expert cooperating members at Laxenburg towards the end of 1975, at which draft working papers from the British study would be discussed. Thereafter the intention is that the research project proper should start at Laxenburg during the winter of 1975-6.

Organisation of the Research

20. Logically, the research programme would seem to fall into three (or four) well-defined stages:

1) the preliminary stage of data examination and development of the geographical units of analysis, as described above (January 1975-December 1975);

2) the detailed analysis of population, employment and income trends within the daily urban systems, involving any necessary reconciliation of work already done in North America and the completely new analysis of data for Europe (and possibly Japan). It is suggested that this would realistically take two to three years: say, January 1976-July 1978;

3) follow-up studies on social indicators and (perhaps as a separate stage) resource and energy stocks and flows: these need not wait the completion of stage 2), but should begin when work is already well advanced on that stage, so that they can draw on experience and hopefully on results; they would again take about two to three years each, say from July 1977-December 1979.

21. It is an open point whether all the main studies should be conducted at Laxenburg. If the Japanese component is to be included, it might demand a separate input from a cooperating Japanese agency. In any event, a panel of international experts would need to be consulted regularly during the study. Some of them might agree to be seconded to work in Laxenburg for periods of time.

22. The scale of the inquiry is such that it would involve the continuous full-time equivalent cooperation of three or four

research workers over the entire period. Some of these might be relatively junior since a great deal of routine work will be involved; the problem will be that it will involve the continuous exercise of discretion and cannot, therefore, easily be given to data clerks. The exact scale of the staffing requirement will be clearer as and when the preliminary study is under way. Geography and/or economics, plus linguistic ability in at least one major European language group, will be the basic skills needed.

23. If previous experience on similar projects is any guide, quite soon the publication of the first results would awaken enthusiasm among researchers for other work using a common agreed statistical framework. Indeed, one of the attractive advantages of the project is that it could establish IIASA as a centre for international activity in this field.

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