Henderson

TOWARDS A METHODOLOGY FOR COMPREHENSIVE PLANNING IN ROMANIA

A Survey of the Urban Models and Associated Techniques and Their Applicability in the Romanian Context

Mircea Enache
Center for Metropolitan Planning and Research
The Johns Hopkins University
Baltimore, Maryland
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1. Romania: The Urban Scene.

1.1 Industrialization and Development of the Country.

Postwar Romania had to face all the problems of underdeveloped countries. These problems were mainly quantitative. In the period 1950-1970 Romania ranked second in the world (after Japan) with respect to average annual economic growth: 12-14%. The figures were very high, of course, partly because of the relatively low initial level of economic development of the country. The policy of rapid industrialization though was followed steadily in the next decades. One of the objectives to attain now is insuring an average rate of industrial growth of 9-10% in the period 1976-1990. At the end of this interval the global industrial output is expected to be 6-8 times higher than in 1970. On the basis of the development of material production, the national income will have to grow 5-6 times, reaching by 1990 the level of $2500-3000 per capita. At the same time, the present policy of allocating a high percentage of the national income for economic and social development will be continued: it is planned to allocate about 70-72% of the national income for consumption and 28-30% for investment. Following the same line of argument, the real income per capita in Romania between 1970-1990 is supposed to increase 3.5 times. (46, CEAUSESCU, 1972).

1.2 Urban and Regional Planning in Romania.

There are many similarities between urban and regional planning in Romania and in the other socialist countries. In order to avoid giving redundant information, I shall refer to Yugoslavia (78, DYCKMAN, 1972), pointing out several similarities as well as dissimilarities in the above-mentioned field. After that, a more detailed presentation will be devoted to two major problem-areas in Romania which are more likely to require a well defined methodology of comprehensive planning and quantitative analysis.

The development plans in Romania may be either regional spatial plans which are produced for a county or a district or urban plans for city areas and the urban zones of larger settlements. The more recent laws require a plan of development (which should be the synthesis of existent and proposed economic, demographic and spatial patterns of growth) for each locality above a certain size.

These plans are considered social instruments through which urban policies and the spatial pattern of development are realized. They guide the present and future development, the means of achieving the purposes being the physical layout of activities, the proposed infrastructure network, the proposed investments and their location as well as residential development.

Urban and regional spatial plans are to be coordinated with socio-economic plans. And problems have arisen as a result of increasing conflicts between planning objectives and the forces accompanying economic development and social change. It seems that, like in most East European countries, the physical infrastructure of urbanization is lagging behind that of overall socio-economic development (16, ANDORKA, 1972; 27, BEREND, 1972; 148, KONRAD, 1972). Also, the persistence of a large number of small settlements creates serious problems in providing a positive environment as well as commercial and public services necessary to the urban way of life. This is one of the reasons of the increasing importance of spatial considerations as a factor integral to general economic development.

Much like in Yugoslavia (102, FISHER, 1966; 103, FISHER, 1967; 78, DYCKMAN, 1972) the spatial aspects consist of increased quantitative requirements for urban space (especially in areas adjacent to important activities), increased complexity of the built structures in space (infrastructure, economic and urban) with consequences in the environmental quality and character.

The main task of the spatial planning turns out to be the maximization of the utilization of space, which is freely occupied but only partially utilized.

At the metropolitan level the main problems concern two dominant sectors of urban planning: housing and transportation. [This is, in the areas of housing and traffic.] The housing problem in my opinion is twofold: <u>the first aspect</u> of it is a purely economic and technical one: housing shortage. This issue will be discussed later. However, the decisions in this domain heavily influence <u>the second aspect</u> of the housing problem, which is the spatial one, which I described above. The problem here is to insure the best allocation of land use activities (out of which residential is overwhelming), the best use of space in a metropolitan area. By best I mean <u>optimum</u> as against a certain set of goals and criteria. Thus, the answer to the first question would be certain technical solutions (high rise or low rise construction) in a certain social context. Economically, individual construction (e.g. detached houses) provides the cheapest housing and it is encouraged in villages and small settlements. Unfortunately, a substantial part of one-family residential construction is in violation of the provisions of the urbanists' plans, but penalties for violation are minimal. Consequently, it results in spatial disorder and lack of coordination. On the other hand, in the range of social dwellings, built by the state, the cheapest housing is the high-rise apartment buildings, which, in their turn, affect heavily the spatial pattern of the urban structure. As 15 years of experimentation with this type of housing proved to be unsatisfactory, the trend now is both to encourage people to build their own dwellings (thus widening the housing market) and to promote a more diversified, better quality urban environment through a reevaluation of the concepts of density, rise, vicinity, etc.

The very recent orientation in planning is to consider urban and spatial planning and design as integral parts of social action. The unity of policy, planning, and action in this field is viewed as a condition for the development of a positive concept of spatial ordering. Urbanization and spatial ordering policies are an integral part of the development policies of our society. Scientific methods should be introduced in urban management and decision-making.

1.3 Major Problem Areas Requiring Quantitative Analysis.

In my opinion, there are two major areas of interest for the application of modern methods of urban management and decision-making in Romania: one is the regional policy and the network of settlements and the other is the reshaping and development of cities and urban areas.

1.3.1 The Regional Policy.

In general, the process of urbanization in Romania has three forms: the development of cities, the transportation of the villages and the building of new towns. Inherently, some of the older settlements will disappear. This process is both influenced by the industrialization of the country and the modernization of cooperative agriculture. Agriculture releases man power, while industry and the development of services absorb it, thus insuring a generally balanced character to the process of urbanization, in spite of its swift tempo.

Industrialization in Romania implies a new territorial distribution of the productive forces and implicity a new territorial distribution of the population, a "new" national network of localities, more or less different from the ones existing today.

The old network of localities was determined by the prevailing agricultural character of the Romanian economy,(a traditional kind of agriculture at that). As a consequence of this heritage, in 1970 the rural population was 59.2% of the total population, and was dispersed in 13,149 villages, two thirds of which had less than 1,000 inhabitants each.

On the other hand, industrialization implies the generalization of the social organization of production, advanced division of labor, high productivity. Such an organization of production is incompatible with a network of dispersed settlements, like the one existing in Romania; it calls for a concentrated one.

Under these circumstances, most of the basic concepts of regional science, such as migration and commuting, have a specific social and economic content in Romania.

Thus, in the developed countries commuting means daily pendulation, mainly by private means of transportation, from home to work place and back. The life style and comfort are comparable and the division of the employees into commuters and non-commuters is more or less conventional.

In the present conditions of Romania, namely those of a country in full process of industrialization, commuting is in general practiced by public transportation means which are other than the urban ones; that is, according to a specific time table. These means of conveyance are particularly important in the case of a network of dispersed, small localities, each of them being able to supply little manpower, the public vehicles are compelled either not to reach all localities (thus obliging some people to walk part of the way, to cover rather long distances under uncomfortable conditions and in bad weather), or to adopt complicated routes to reach several localities, which prolongs the commuting time.

Moreover, the existence of several industrial units in the same center, working according to different time tables, makes the correlation of all these time tables with those of public transportation practically impossible. Hence, there is a waste of time, much bigger than that which is strictly necessary to the commuting process itself, and which produces disequilibrium in the budget of time of the people. All this leads to increased fatigue, to a cut down in other activities (esp. those related to culture and reading), and a smaller opportunity for women to carry on industrial work, because it is virtually impossible to both commute and satisfy household requirements. The 1966 Census, indeed, pointed to the fact that while among the industrial workers living in towns, 30.5% were women, in the rural areas, their number only reached 8.3%.

At first sight, it would seem that the dispersion of industry over the territory could solve the problem, because the difference in time tables would disappear. It is, however, obvious that only a certain type of industry can be dispersed - a fact to be discussed in further detail later on. It would, moreover, be necessary for all workers in the zone of attraction of an enterprise to work in that enterprise itself, any territorial overlapping of the manpower hiring zones being undesirable.

We might consider characteristic the commuting from village to town, because of its overwhelming prevalence. In this process, the former peasant becomes the future worker, commuting from the rural type of housing and living conditions to urban type ones. This category of commuting is in general characterized by a multiple class position; through his place of work, the man is a worker; through the lot of land he owns, he still preserves powerful reminiscences of the individual peasant. Thus, his economic interest is not focused on the place of work in town, unless he breaks himself from the land that overwhelms him in the busy periods of agricultural work and increases his fatigue (reducing his productivity in industry). Also, this man's cultural and professional level shows a slower increase than that of a person in the city because he wastes so much time on commuting, because of the lack of facilities and opportunities in the village, etc.

Nevertheless, commuting also has certain advantages: it diminishes the demand for housing in the city, and is a specific form of gradual adaptation to urban industrial life, which thus avoids the psychological and social problems which appear when one is torn from one's usual surroundings.

The dispersion of industry is, however, impossible under the present conditions in the decisive branches of industry: engineering, electronics, machine building, chemistry, as technological efficiency first of all asks for comparatively big units. The same principle at a somewhat smaller scale goes for other branches, such as the textile industry, the power industry, and the wood processing industry. One should note here the indisputable advantage of the achievement, by cooperation, of the big industrial units where investments for access roads, power or water supply or other such things are sensibly reduced.

And yet, the expansion or rather the creation of some networks of smaller factories and workshops with a handicraft character, for the primary processing of agricultural products, etc. is nevertheless possible. But their importance as compared to the rest of the industry will never be decisive; it will only be auxilliary.

Such units could very well be located in the villages, but they need not exist in all localities. Their dispersion into 500-600 future towns could draw them sufficiently near the basis of agricultural production.

If we were to formulate some working hypothesis, they would be the following:

a) In the present situation of the network of settlements in Romania, the very great number of small villages is indisputably the key problem for the future development. The trend of reducing the number of villages is illustrated by a migration of the population, a fact which even leads in some cases to abandonment of some very small localities. It is reinforced by the territorial administrative reform, which implies a decrease in the number of villages from 4,259 to 2,706. This more than 40% reduction has a particular importance, as the village which is a residence of the commune becomes a gravitational center, a center of attraction for the rest of the villages constituting the sommune, which leads towards a rather important territorial regrouping.

One may thus suppose that part of the network of villages will concentrate into a small number of localities: the existing residences of the communes. Of course, part of them will continue to increase and will soon become actual towns. The state of these 200-300 polarising centers may already be a subject of study. However, what will happen with the rest of the villages? Do they all have conditions for being viable, for maintaining themselves, or does such an assumption oppose some objective laws or major requirements?

Research will be undertaken to determine the minimum reasonable limit to the future localities. The basic criterion will be that of the quality of services provided to the communities. For instance, for the education system, even in case of a high birth rate, a population of 1,500 inhabitants is required for providing the students necessary for one grade. This figure is enough in the case of the first four elementary grades, if we assume just one teacher for all the disciplines. But in the case of a different teacher required for each discipline, in the optional system (options for foreign languages or for workshop activity) as well as in the case of the diversification of education through theoretical high schools, vocational schools, or specialized high schools, education can no longer be ensured in such a small locality. The result would be either boarding schools, thus separating the children from their parents over long distances and period of time, or the home-school commuting of the child which is complicated and which would encourage the family to move to a bigger locality. A population of 3,000 is hoped to allow the existence, in general, of two parallel classes thus partially solving the problem. However, only about 5% of the villages including about 20% of the village population exceeded this limit in 1966.

b) Labor productivity increases much faster in bigger towns. The general validity, at least in the conditions of Romania, of this thesis, confirmed by figures and maintained by the Soviet researchers at the Seventh Congress of Sociology (Varna, 1970) calls for verification. At first sight, it seems possible, as many theories point out.

c) Hence, we find the implicit result of an economic disadvantage of the localities with a unilateral economic profile, or with an insufficiently complex one. And some social shortcomings may also be added to this economic disadvantage. The young people in a certain locality will choose a wide range of professions in most cases different from those existing in the respective localities, a fact which will speed up the division of the family, will increase migration and create additional problems in housing and integration.

d) What will be the tendency of development and what would be optimal dimensions for a locality? First comes the problem of village regrouping and concentration. Out of 2,706 existing communes (the suburban ones included) only 58.8% have more than 4,000 inhabitants. On the other hand, our present industrial development requires modern, high-productivity factories with highly qualified labor. Such big competitive production calls for big factories, for plants and aggregate works, which are incompatible with small localities. That is why the future development will probably be characterized mainly by a growth of the towns, especially of the existing ones. Their development must, however, be correlated. The role of the towns of various categories, in the economic coordination, in providing certain services and having certain functions on a zonal level should be taken into account. It is also to the same effect that the urban network must be analyzed, according to economic zones and in keeping with the characteristic features of the activities taking place there.

e) There are, obviously, many policies to control the process of urbanization. However, at present, the two main ones used in Romania are the generation of job opportunities and the building of houses. There are also others, of course, but even with these first two, we are still lagging behind as far as the exact knowledge of their effects is concerned, with regard to the qualitative and quantitative effects a decision in these fields might have in the development of the town, in particular, and the urbanization process in general. We need a great deal of research work, testing, experimenting in order to predict and control the effects of various policies.

This is necessary for achieving a pre-established territorial distribution. This desideratum which implies advanced decentralization calls for a narrowing of the gap existing between the capital of the country, with 1.5 million inhabitants, and the smaller cities which have seven or eight times smaller populations. This could lead to a variant of development comprising a few localities of 400,000 to 500,000 inhabitants to be taken into account.

From those localities to the minimum limit of 3,000 inhabitants there would be a whole range of localities of various sizes, the main stress probably being laid on the middle-sized one - those of 20,000 to 50,000. This hypothesis is still to be analyzed.

1.3.2 Reshaping and Development of the Cities.

A second major area of interest for the application of quantitative techniques is the inner city structure and the metropolitan area. As the complexity of urban problems occurs mostly in Bucharest and several second rank relatively big cities, they will constitute the main focus of this study. However, one of the basic questions to be answered with regard to the above statement is where and when sophisticated quantitative analysis (computer-aided) should not be applied. In other words, what are the circumstances under which the complex mathematical statistical approach to problem-s-lving ought to be replaced by some other kind of decision-making?

Bucharest provides the best example of complex urban problems requiring the aid of quantitative techniques in decision-making and policy evaluation. The second ranked cities are less complex in terms of scale and number of elements involved.

Bucharest is the most important economic, cultural and political city in Romania. The industry represents 17.6% of the total number of industrial units in the country. The population (1.468 million inhabitants) represents 7.5% of the population of Romania (20 million). However, the second ranked city, Cluj, has 7.3 times less population. 52.8% of Bucharest's population is employed (33.5% employed in basic activities, and 19.3% employed in the non-basic (service) sector.

The density varies from about 190 inhabitants/acre in the central city to 15-25 inhabitants/acre in the suburb areas or in the surrounding villages. The density gradient shows a decrease in density from center to periphery, excepting the new residential areas, built on the fringe of the city, where the density is close to 180 inhabitants/acre.

The total number of employees in Bucharest in 1968 was about 800,000 out of whom 40.7% work in industry, 12.2% in construction activities and 9.5% in the exchange of goods.

The working places are unequally distributed over the urban area; there are 1900 work places/1000 inhabitants in the central area, about 920 work places/1000 inhabitants within the inner ring and 355 work places/1000 inhabitants outside it. The industry tends to concentrate in industrial parks, at the fringe of the residential areas, or between the residential areas. However, many industrial units are scattered throughout the city. The density varies from 35 employees/acre in the exterior industrial parks to 115 employees/acre in the inner city. The area covered by the industrial developments is about 6,000 acres, representing 13.5% of the total built area of the city (42,000 acres).

The housing problem in Bucharest is still primarily a quantitative one, as the average number of families living in a housing unit is 1.07, and the number of persons per room is 1.34. Although 164,530 apartments have been built between 1948-1970, the housing problem remains an important one (if we take into account the increase in population as well as deterioration of housing stock). The general housing policy is to be judged against the economic background of the country, as well as in the light of the general social policy of the state. An individual dwelling or apartment was consequently treated as a social good rather than an economic good. This implied that it was the state's responsibility to supply the individual with an apartment of the necessary size and quality. Rent was not competitive; it was not intended to cover amortization, maintenance, services, etc. It varied between 2 to 4% of the average family budget.

The economic burden of such a policy of generalized social housing was apparent very soon. The state couldn't afford any longer to provide free housing for everybody. Consequently, the more recent policy is to encourage the building of personal property apartments, apartments built with the population's own funds. Very recently, a system of long term loans, combined with a special loan to cover the amount of money necessary to start construction, was perfected. It is interesting to witness the increase in awareness of the fact that the housing units are both social and economic goods, and that the socialist ideals and principles should be granted an economic feasibility.

Finally, some attempts have been made to differentiate the categories of comfort of the newly built apartments. As the idea was to make them financially less expensive (a kind of "diversity within scarcity") the attempt failed. This is, in my opinion, one of the fields in which intensive research and insights in developed countries' experience should be undertaken, in order to satisfy the imperatives of economic viability and efficiency of investments in the infrastructure. In other words, an optimization of the resources (limited although increasing) allocated to this sector of the national economy proves to be essential.

From the spatial point of view Bucharest presents a radial concentric pattern of streets. As a consequence, the traffic tends to be very heavy in the center, and although at present there are only about 50 vehicles/1000 inhabitants, there is a certain amount of congestion at peak hours. The public transportation (buses, trams and trolley buses) is heavily solicited, partly because of the very low car ownership rate. The average number of bus trips reached 739 trips.inhabitant/year. Increasingly serious parking problems occur in the central area.

Some of the main (recognized) problems which need to be solved as well as some of the directions of development of the city of Bucharest could be summarized as follows:

1) The approach to the city's growth and development problems within the territorial system (including the settlements in the metropolitan area) as well as in coordination with the other important urban

centers in the country.

2) Control and limitation of the territorial expansion of the built areas.

3) Controlled development and location of the new industries, manufacturing and servicing units.

4) Expansion of the public parks and recreation areas in the south and provision of new facilities in the lakes area to the north of the city.

5) Intensification of the activity of housing construction in order to meet the quantitative and qualitative requirements.

6) Reshaping and reconstruction of some of the central areas which have become obsolete and deteriorating.

7) Providing social-cultural facilities for the residential areas as well as a correct distribution of them throughout the city.

8) Traffic control and circulation improvement by widening arteries, constructing bridges, tunnels, etc. Studies and research for a mass transit system.

These principles and problems exposed above and which are part of the tasks set by the Planning Authorities in Bucharest reflect quite clearly some of the limitations of the current approach to urban planning. The criticism of it should not only refer to the underestimation of the magnitude of the future problems (as in the case of transportation) but should also point out the incompleteness and limited character of the analysis (relying heavily on just physical planning methods and on the spatial "appearance" of the social interactions and relationships).

However, several forecasting studies have been undertaken and three variants of development have been produced (trying to take into account the future population forecasts, criteria of functioning, economic efficiency, space distribution, etc.):

Variant I: City expansion by constructing in the peripheral areas; consequences: spatial expansion of the city, low densities in the central area and in the older areas.

Variant II: Development of the city by reshaping and reconstruction of the existing built areas; consequences: higher density, higher efficiency in the management of the city.

Variant III: A combination of variants I and II which would hopefully combine the advantages of both.

As regards the metropolitan area (including the network of surrounding settlements), the studies undertaken proposed also 3 variants of a future regional system:

- a system of towns located on the main roads intersecting in Bucharest;
- a concentric system of towns around the capital;
- a system of towns located on the main railroads.

As a general comment on these studies, the rather empiric and crude approach to problems which needs deep quantitative analysis as well as a complex, interdisciplinary approach should be noted. For instance, the three variants of city development are rather crude, two of them expressing two extremes, two entirely opposed policies (obviously, none of them resisting a careful analysis) and the third one proposing a compromise of the first two.

2. The Role and Uses of Quantitative Analysis In Urban Decision-Making.

2.1 Models. Structures. Systems. Theory.

It is not my intention to start the argument with any of the well-known and frequently quoted definitions of models and systems. However, in order to support my line of argument I shall note several references on this subject.

There are mixed feelings about the uses, misuses and abuses of models (especially mathematical models) in urban and problem-solving and decision-making. It is to be pointed out that the mathematical models are very powerful tools provided that they are properly used. Moreover, one could assert that they are a basic "ingredient" of human reasoning and judgments.

The concept of model is closely related to the concept of structure. The modern concept of mathematical structure is part of the theories of abstract algebras, which do not refer to particular numbers or geometric entities, but rather to "a set of abstract elements in which are defined certain laws of composition or certain relationships between the elements or between the subsets of the set itself, each of them being characterized by corresponding axioms" (97, FADINI, 1972). Although various mathematical structures can be defined, there are three fundamental structures which can be combined in innumerable variants: algebraic structure, structure of order, topological structure.

An algebraic structure S is a set of elements of unspecified nature, and of one or more laws of composition, also of unspecified nature, which satisfy certain formal properties. Interesting applications of the group theory (which is part of the algebraic structures) in architecture and urban planning have been derived by Yona Friedman in his "theory of comprehensive systems" (106, FRIEDMAN, 1968).

The <u>structure of order</u> S is the couple consisting of a set S of elements, of unspecified nature, and of a relationship, also of unspecified nature satisfying the reflexive, antisymmetric and transitive properties. This is, if the relationship is R, and the elements of S are s, y, and z, the result is:

$xRx \quad \forall x \in S$		(reflexive property)
xRy	and $yRx \Rightarrow x=y, \forall x, y \in S$	(antisymmetric property)
xRy	and $yRz \Rightarrow xRz, \forall x, y, z \in S$	(transitive property)

The <u>topological structure</u> S is the couple consisting of a set S of elements, which we shall call points, and of a relationship of correspondence which at any point x of S associates a system of subsets S_x of S, called the neighborhood of x, so that:

a) the intersection of two such neighborhood points is a neighborhood of x itself;

b) for any x' belonging to S_x there is a $S_{x'}$ entirely contained in S_x.

The set S in which a topological structure has been introduced is thus called <u>topological space</u>. The topological structures report themselves to the concepts of limit and continuity (thus to the fundamentals of calculus). More than that, they refer to concepts of convexity and set boundaries, which are fundamental questional of geometry. If any mathematical structure is built through overlapping and interconnection of simple structures (the three structures above-mentioned) linked by common concepts of correspondence or operation, order or neighborhood, adherence of contiguity, we can derive the conclusion that mathematics is essentially founded on these three concepts (97, FADINI, 1972). And since mathematics is the logical and operational basis underlying any rational and scientific activity, we could further argue that the three concepts of correspondence, order and contiguity constitute the basis of the rational organization of the human mind.

This has been confirmed by the experimental research of the psychological school of Piaget. The understanding of their findings is essential for the methodological approach, for building a valid system of hypotheses starting with a certain logical scheme, with certain axioms (90, ENACHE, 1972).

It can be further argued that within certain limits, architectural, social, and physical structures are models of particular abstract mathematical structures. However, in the case of social, economic, or urban sciences, the phenomena are so complex that the simple cause-effect relationships are unknown, and it happens many times that the orders of magnitude determine a high level of uncertitude about the future evolution of certain phenomena.

As regards the models, Chadwick presents the topic in a certain kind of hierarchy, the components of which are (48, CHADWICK, 1971):

Theories

Paradigms

Metaprocedures $\xrightarrow{\text{represented as}}$ Metalanguages

Models $\xrightarrow{\text{represented as}}$ Language and mathematics

Algorithms and heuristics $\xrightarrow{\text{represented as}}$ User and machine languages

Parameters and variables <u>represented as</u> → Symbols

A <u>theory</u> is considered a system of ideas or statements held to explain a group of facts or phenomena, a statement of general laws, a systematic statement of general principles. Thus, for instance, the English school of system approach to planning represented by McLoughlin and Chadwick (175, McLOUGHLIN, 1969; 176, McLOUGHLIN, 1970; 48, CHADWICK, 1971) attempts to set out a theory of planning, a system of ideas and of general principles based upon a yet broader system known as general systems theory.

A <u>paradigm</u> might be described as a theoretical pattern, a way of looking at the real world in the light of some theory.

By <u>metaprocedure</u> is meant a way of selecting procedures, a procedure for procedures, a method for methods: i.e., a progression from theoretical patterns towards particular application; similarly a <u>metalanguage</u> is used to discuss, and select particular languages: it is a "higher level" language.

As for <u>model</u>, there are several complex and subtle definitions which, as I stated above, I do not intend to discuss in the present paper. However, it is basically a <u>representation of a system</u>. Such representations may be in <u>languages</u> of various kinds (mathematics, graphics, etc.).

An <u>algorithm</u> is a precise method of computation related to a model: a step by step indication of actions to be taken in solving a problem.

A <u>heuristic</u> is opposed to an algorithm in that it does not cover every possibility: it is not wholly rational, but is capable of practical use in discovering a solution.

If algorithms are associated with computer use, a <u>user language</u>

(e.g., FORTRAN, ALGOL, etc.) will be used to translate the algorithm into precise instructions (in machine language) for the operation of the machine. The representation of models in mathematical language involves quantities, represented conventionally by symbols, known as parameters and variables. I will refer to these terms in the further discussion of models.

Leo Apostel in his paper presented at the Colloquim sponsored by the International Union of History and Philosophy of Sciences (Utrecht, 1960) has defined a number of reasons for using a model in science:

a) absence of a theory to explain a set of facts;

b) presence of a theory but one which is difficult t solve mathematically;

c) two theories with little seeming contact;

d) a well-confirmed but incomplete theory;

e) new information about an established theory;

f) a theory requiring information;

g) the need for a theory concerning an inaccessible object;

h) a theory which we wish to visualize in order to appreciate;

i) a theory and a set of observations which we hope to reconcile.

Maybe the most interesting of these reasons for planning is the situation of inaccessibility. Planning, by definition, is concerned with the future; the future, by definition, is inaccessible. However, a very important issue lies in theories and hypotheses concerning something which is now past is tested. The hypothesis takes the form of a model of some future state of the system concerned and we test this model in order to evaluate the hypothesis. Thus, instead of dealing with an inaccessible (future) system we substitute a readily-accessible (because in model form) present system and base our judgment upon the evaluation of the model.

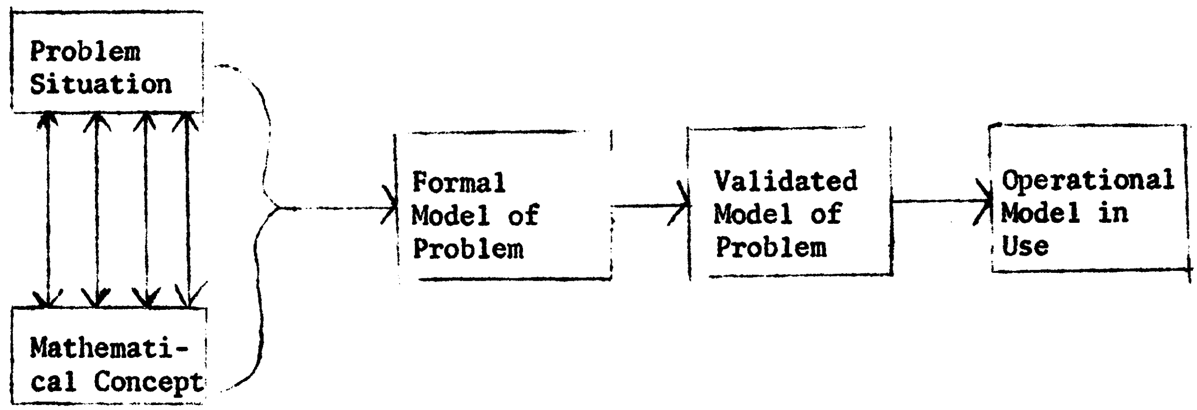
In Chadwick's view, a model of a system is a representation of that system by another system. There can be different kinds of similarity of systems: in form, complexity, universe, characteristic, or behavior. Klir and Valach, in "Cybernetic modelling" (1965), suggest two kinds of similarity:

a) Similarity in the behavior of two systems: thus one can be a model of behavior for the other.

b) Similarity in the universe (i.e. set of elements) together with similarity in the characteristic (i.e. set of elements plus environment) of the two systems: thus one system can be a model of the other system which is simultaneously a model of behavior.

Taking two systems of similar behavior, we can modify the inputs of one system by transformation or mapping, so that the system produces an output mapping in such a way that the behavior of this system is now equal to that of the other system: the first system thus becomes a modelling system of the other, having an identical modelled behavior. The relationship between S_1 and S_2 can be isomorphic or homomorphic, in the case of models of behavior: homorphy requires that one system possess more elements than the other. If the two systems are isomorphic, and the inputs and outputs are identical then one system is a model of the other.

Chadwick charts the process of modelling a problem in the following diagram (48, CHADWICK, 1971):



Mapping of problem situation on to mathematical concept. | Algebraic statement. | Input of problem data for validation. | Input of problem data for problem solution.

Similarly, Carlo Santi points out three fundamental levels of planning (219, SANTI, 1972):

a) At a very general level stands the <u>urban theory</u>. It can be defined as a general interpretation of urban phenomena, a reference frame, a logical structure capable of containing and explaining the observed processes. It contains the goals and objectives of the society with reference to the territorial patterns.

b) At a more particular level stand the <u>mathematical models</u>. This category includes the mathematical models of operational research, as for instance models of linear programming, models of multiple regression, analysis models of stochastic processes, etc. These models are built like simple mathematical structures, which only represent purely formal relationships. From the operational point of view these techniques are extremely useful because they enable quick judgments of the aspects of the real world, provided the causal hypotheses of urban change and the objectives to attain are clarified.

c) Between these two extremes there is an intermediate level, that of urban models. The urban model is a way of describing or representing a certain regularity observed in urban phenomena, using a language and logics universally comprehensive, in other words a semantic repertoire as precise as possible.

2.2 Economic Models and Management.

It is my strong belief that the quantitative analysis in urban sciences should be approached from the economic viewpoint. This approach would eventually insure that the models developed are operational and useful. The urban modeling should be a link between the general economic planning and the concrete social and spatial patterns of development. However, this link is seemingly more apparent and evident at the regional level, where the macro-economic planning is more likely to integrate harmoniously with the general spatial configuration, network of settlements and growth patterns. It is not such a simple and direct interaction at the metropolitan level, where the processes and phenomena involved are much more complex. (Social and behavioral, as well as political aspects play a very important role.) However, even in this case, the economic transactions and trade-offs are extremely important for the shape of the community and the city structure.

In emphasizing the economic aspects of development, my assertion is not free of value judgments. It relies on specific national goals, values, and priorities (90, ENACHE, 1972). And the rapid economic development of the country is one of the most important goals of the socialist society. This is not to deny the obvious fact that the urban development is more than just economic growth and efficiency. Nor does it argue against the complex system of specific values attached to the process of urban and regional planning and subordinated to the very general values. There are, of course, very important indicators and key concepts (belonging to several disciplines) such as: density, comfort, sociability, satisfaction in life, development of one's personality, adaptability, flexibility, mobility, safety, variety, privacy, environmental quality, etc. When defining such a concept like standard of living, its content and evolution should be studied from the point of view of a chosen set of values and objectives to attain.

However, although these values and aspirations (93, EUROPE 2000, 1970) should have a very important role in planning and decision-making, they have associated with them a great deal of subjectivity and uncertainty. Hence, they are or tend to be much out of control. And there is always economics which provides the means to attain the goals and objectives. It is the discipline which provides the ultimate answer with respect to the feasibility or the efficiency of a certain project undertaken.

And in the case of Romania, the obvious questions which are to be answered are: how can we avoid the planning mistakes of the more developed countries? How can we optimize the resources allocation to insure a rapid and harmonious development of the country?

This is why I shall refer in this section to the problems of planning and control in a socialist economy, as well as the theoretical bases for quantitative analysis in this field. The study also leans toward providing arguments supporting the use of certain urban development models developed in the United States. It tries to define and predict basic economic mechanisms, acting under the general economic laws of socialism which are supposed to determine the structure of the quantitative models and techniques.

2.2.1 Mathematical Models and Dialectics.

The use of models is based upon a fundamental dialectic contradiction, that is, they can describe a real system, while they represent an excessive simplification of reality. That is, they are isomorphous and not identical to the real systems. A mathematical model that would integrally reflect the structure and functionality of such a system - namely the entire series of variables and of interdependence relationships that exist between them - would be unsolvable. The model becomes more and more useful as it describes more exactly the relationship between the essential elements of the structure of the real system; but, in order to have the certitude of a correct description, the construction of the model must be preceded by a correct analysis of the modeled process.

Dialectical thinking helps in establishing the system of exogenous variables as an authentic axiomatic group characterized by the lack of contradictions, the independence and the completeness of the axioms. It makes sure that the exogenous variables do not lead to contradictions within the model, that none of these variables can be derived exclusively from the others and, finally, that the system of the exogenous variables is sufficient for the determination of the entire construction of the model.

Dialectical thinking helps in correctly deciding upon fundamental problems of modeling: the finding of an equilibrium between the rigidity of the model, a consequences of a small number of exogenous variables, and its elasticity, determined by a larger system of exogenous variables. The analysis beforehand, as finalized in the logical scheme of the model, constitutes a guarantee against arbitrariness owing to the large number of endogenous variables and to the nature of the interdependence relationships introduced in the model.

In interpreting the results obtained by the solution of the model, the understanding of the concept of isomorphism is important in order to avoid placing a priority on relation over existence, to substitute mathematical realism for reality and to reach a blind alley that would make us explain, as Laplace: all the worse for reality, if it does not integrate into the logic of the model.

Mathematical modeling can deepen the knowledge of the economic and social reality by creating a system of models more and more complex in structure and functionality. This possibility does not, however, exclude, at least not in the present state of our knowledge, the idea of <u>limited knowledge</u> on the basis of models. What was exaggeratedly called the crisis of econometrics (the denial of the usefulness of econometrical models) reflects, of course, an unjustifiable skepticism, in contradiction with the progress of this modern science. But just as untenable is the idea that mathematical modeling can by itself offer the solution to all the problems of economic and social development, because the mathematical model cannot operate in processes that cannot be quantified (viz, the case of the social sciences). Maybe the root of the misunderstanding of the models' uses, misuses, and abuses lies in the expectation from a powerful tool of something which is beyond its power: expecting qualitative outputs from quantitative inputs.

The fundamental idea is that the mathematical model represents a frame of reference for the evaluation of the tendencies and of the major proportions of development, an extremely useful instrument for the quantitative analysis of the planned processes, in other words that its value must be judged in terms of what it offers and not of what it does not. The correct interpretation of the results obtained by the solution of the model offers useful elements for a qualitative analysis; nevertheless the model independent of its value cannot impose a decision in economic policy. Such a decision requires the additional analysis of factors and relationships that are not contained in the model. It could only be made by a decision center which has a deep knowledge of the economic and social realities and problems.

2.2.2 Quantitative Analysis in Socialist Economies.

Economic laws in a socialist society have an objective character but they are realized under the conditions of a planned economy to a large extent by means of deliberate solution. Therefore, the successful application of the laws in the interest of society depends on how completely and deeply we master them. One naturally expects that in this kind of analysis mathematics will be especially useful. Owing to the complexity and interdependence of economic problems in modern production one cannot expect that it will be possible to succeed in the quantitative analysis of these problems with the most simple mathematical means. Here undoubtedly the latest achievements of modern mathematics will be required. At the same time, if a model of the economic mechanisms is built, its mathematical analysis may be used not only for obtaining certain quantitative data, but also to reveal new comformities with laws, to analyze causal relationships and dependencies, and to predict new phenomena.

Of prime significance for the effectiveness and applicability of a particular model is the correctness of the initial premises used in its construction; it is also necessary that the important factors are in fact included and that the lesser ones are discarded. According to Kantorovich (146, KANTOROVICH, 1972) the initial premises should be in agreement with the basic principles of the Marxist method of economic analysis, namely dialectical thinking, the objective character of research, social analysis of the relations of production, pre-eminence of production and recognition of labor as the sole source of value.

The fundamental criterion for estimating the significance and correctness of such research is the criterion of "check-reality". In other words, the greatest importance for its evaluation must lie in the agreement of the results obtained with reality and in their ability to explain and influence the phenomena of our economic reality, so that they may help in the development of more effective policies and solutions.

For each sector of socialist production and for socialist society as a whole, an optimal plan has a concrete reality, and the consistency of such a plan with economic laws corresponds to the real economic conformities with the laws of socialist society.

In the conditions of socialist society, a critical problem is that of raising the level of production. In the study of this problem and of the economics of socialist society it is known to be correct to separate the problem of production from the problem of distribution.

It is interesting that, besides the qualitative difference in principle in the laws of socialist and capitalistic society and in the meaning of the fundamental economic categories, manifest formal analogies are to be found in various quantitative indicators and relations - for example, in normal efficiency and normal profit, normal valuations and the price of production (146, KANTOROVICH, 1972).

Socialist economy is concerned with obtaining scientifically based magnitudes of costs for various types of products. It is essential to know these magnitudes for solving problems of labor distribution and of replacing one product, or certain inputs, by others. Such a manifestation of value relations in socialist society is fundamental.

One of the interesting recent trends in the application of quantitative analysis in socialist economies is that of passing from simulation models to optimization models of processes, including the macroeconomic ones - a trend that forcefully brings forward nor only the cognitive power of modeling, but also its efficiency in the rational organization of economic activity (171, MANESCU, 1972). The gnoseological functions of economic models are realized by the fact of bringing forward in a qualitative-quantitative form the interaction of various components of the economic mechanism, its organization and management, its optimal articulation in view of raising the efficiency of economic activity.

2.2.3 Socialist State Intervention in Economy: The Plan.

While operating with programs at the scale of the whole economy, socialism aims at a unitary management and direction in view of an optimal regulation of the whole national economy. In socialism the main instrument with which the state intervenes to regulate social life is the state plan. The plan is actually the predictive model of the general system of the economy. The continuous development of the economy ascribes a dynamic character to the plan as the model of the cybernatic economic system. This is why the plan is considered as a trajectory in the economic space which defines the main directions of the economic evolution, and that may be correlated on its way according to the demands of social development.

The plan as a model of economic growth is not static, but dynamic; the more rapid growth of some branches or sub-branches and the modification of certain proportions in the development of the economy may be corrected or completely eliminated with regard to the general line of the established program. This principle, originating in the general property of the models of economic growth, of having in their structure the regulating factors, has a particular importance for the economic and social management.

Under the conditions of socialism, management of the national economy, control over the development of production and distribution and consumption of goods are effectuated through planning. The elaboration of the balance of relationships between branches, with its two models - static and dynamic - as well the optimization by means of mathematical programming constitute a major objective of the Romanian economists. Mathematical models for planning by means of the balance of relationship between branches are of great practical importance in the analysis of consumption of socially necessary labor and, therefore, in the analysis of the formation process of value and prices. At the macro-economic level, for example, the decision-maker seeking an optimum evolution of the model over a period of years elaborates forecasts on the basis of available data and establishes the function of regulation and control. The solution adopted by law, to set a system of prices of the production prices type is supposed to allow a more correct measurement of values, economic processes and efficiency, and to stimulate the technological progress and the initiative of the basic production units.

The idea is to take into account the law of value in planning by the inclusion in the plan of the demands of the internal and external market, without admitting, however, that the relation between demand and supply is regulated spontaneously. The system of planning in Romania tries to respect the demands of the law of value through the construction of the plan according to the social needs of the means of production and consumer goods, through the adoption of a system of prices constructed in accordance with this law, through the permanent control of social labor expenses, through the continuous reduction of the cost price, through the insurance of equivalent exchange and the organization of an efficient economic activity.

The state plan embraces the major aspects of the entire social and economic life of the country and has the character of a directive. It must provide the national center of decision with the possibility of making decisions in setting the main rates and proportions of development, the repartition of the national income for investment and consumption, the dimensions and structure of investments, the orientation of the foreign trade policy, of prices and salaries, of the rising of the standard of living, briefly all major problems regarding the development of the national economy. A decisive problem for the entire activity of perfecting the planning and for the correct functioning of the economic mechanism is the harmonious combination of central management with the autonomy of the productive units. The plans are supposed to be stable and fixed as far as qualitative indicators are concerned, and mobile in the sense of a continuous adaption to the internal and external demands, as regards the variety of products.

2.2.4 Forecasting and Planning.

The forecasting studies recently undertaken in Romania are hoped to bring in two innovative elements. In the first place, they would lead to approach to the development aspects of the society not only from the economic point of view; sociology, psychology, and ethics must also supply elements for prognoses which are essential for the projection of development on a long-term prospective. It is basically a problem of values, goals, and needs.

In the second place, apart from the quantitative evaluations (affected by approximations that grow in size as the horizon grows further away and the investigated domain is narrower), special importance should be attached to the qualitative factors, to the appreciation of the directions in which significant mutations in economy and society will take place as well as transformations in structure capable of accelerating the socio-economic development of the country.

The essential requirement of prospective studies is their conclusion in the form of variants of socio-economic development, whose implementation should foster economic and social progress, and anticipate the general framework and some of the necessary conditions to ensure economic growth and social progress. This is why in prognoses we talk about alternatives of development of possible futures.

From this viewpoint, in socialist economy and society conditions are most favorable for the provisions of the plan have an emphatic normative character, and as such, may combine systematically with prognoses, with possible alternatives of development, extending the horizon of reflection for a period longer than the plan. This interweaving of planning with forecasting, of future projection with demands of planned construction in a socialist economy can be illustrated with the case of Romania.

The school of "normative thinking" in American long range planning (H. Ozbekhan, C.W. Churchman, E. Jantch, etc.) defines planning as an activity oriented toward the attainment of some future objectives, considering their characteristics and evolution. Planning can thus be performed at three levels: political planning (defining the basic objectives), strategical planning (describing various ways of attaining the mentioned objectives) and tactical or operational planning (studying the practical way in which the strategies may be implemented): 152, CIDSP, 1972.

It is interesting that the relationship between plan (or normative planning) and forecasting has been many times misunderstood, the two activities being either replaced by each other or totally opposed. Thus, while in the socialist countries the importance of forecasting was underestimated and any attempt to forecast was reduced to normative planning, in the capitalist countries the importance of normative planning was underestimated, and consequently, the forecasting had a rather low level of effectiveness and operativeness. The forecasting (implying a random, partially uncertain view) and the normative planning (considered strictly deterministic, rigid) seemed to be structurally incompatible. One proposed solution was to understand forecasting as pre-planning; the plan is thus supposed to select only one alternative from among the various possible forecast alternatives - the most fitted to the social goals - to make it normative and compulsory by law.

A careful analysis of the above-mentioned contradiction shows that while planning tends to be approached through statistical methods, decision-making is by its nature unique. That means that the contradiction is still there. The practical way to solve these problems must obviously appeal to the theory of the statistical decisions under the conditions of uncertainty - a very "fashionable" aspect of modern operations research. It is worth noting though that this requires the restructuring of the entire concept of plan, which is now supposed to deal with categories like risk, mean efficiency, probability of implementation, etc.

However, forecasting and normative planning are two distinct activities and the relationship between them could be compared to that between strategy and tactics. Long range forecasting activity tries to define the strategic objectives, the rather axiologic and political goals, while normative, "operational" planning is mainly oriented towards implementation.

In the activity of management and decision-making both these two activities are very important. There is also a great deal of feedback and iteration in this process.

2.2.5 Planning and Market.

The economy is in continuous movement: all external conditions are continually changing and decisions will, accordingly, have to be made continually. According to Kornai, a modern socialist economy can dispense neither with planning nor with the market mechanism. In a socialist economy, consumer preferences will assert themselves over a wide sphere of decisions (and, maybe it is desirable that they assert themselves over an even wider sphere, with less friction and shorter time lags). But the prevalence of consumer preferences is not unlimited, nor is it desirable for it to be so. It is only reasonable that certain economic decisions of fundamental importance should be made centrally and in accordance with the interests of society as a whole. Now, in the former sphere it is the market that should prevail, and in the latter sphere it is planning, if possible, planning based on exact mathematical methods.

It is primarily in the long-term decisions of the investment plans that deliberate social resolutions should be made to prevail. Decisions based on the survey of the national economy as a whole and on the simultaneous consideration of the development of all sectors will be much more reliable.

The role of mathematical planning consists in preparing rational decisions; that of the market is to check subsequently the rationality both of the decisions themselves and of their execution. The market will thus signal whether the plan was acceptable to the operative units within the economy; whether the estimates were realistic; whether disequilibria were manifesting themselves in divergences from the originally balanced plan, and so forth. We are able to survey only a few of the problems to which the appearance of mathematical planning methods in the socialist economy has given rise (150, KORNAI, 1972).

The market has certain merits. There are many aspects of reality which cannot be dealt with by computers, which have limited capacity. The old-fashioned market servo-mechanism has a much broader capacity (156, LANGE, 1972). Also, the market is institutionally embodied in the present socialist economy. In all socialist countries consumers' goods are distributed to the population by means of the market. Here, the market is an existing social institution and it is useless to apply an alternative accounting device. Even the computer's predictions have later to be confirmed by the actual working of the market.

An important limitation of the market is that it treats the accounting problem only in static terms, i.e., as a foundation for the solution of growth and development problems. In particular, it does not provide an adequate basis for long-term economic planning. For planning economic development, long-term investments have to be taken out of the market mechanism and based on judgment of developmental economic policy. Because investment changes the conditions of supply and demand which determine equilibrium prices. The market fails to reflect various interconnections of investment projects in both the short run and the long run. These "externalities" can be used to justify planning for <u>any</u> time period.

For the reasons indicated, planning of long-term economic development as a rule is based on overall considerations of economic policy rather than upon calculations based on current prices. However, the theory and practice of mathematical programming makes it possible to introduce strict economic accounting into this process. After setting up an "objective" function (for instance, maximize the increase of national income over a certain period) and certain constraints, future shadow prices can be calculated. These shadow prices serve as an instrument of economic accounting in long-term development plans. Actual market equilibrium prices do not suffice here. Knowledge of the programmed future shadow prices is needed.

2.3 Urban Models.

The urban model, as stated in a previous section, is a way of describing and representing a regularity observed in the urban phenomena, using a language and logics universally comprehensive.

The urban models would be broadly classified into: models of regional growth and stability, models of activities allocation, transportation models, and evaluation models.

Under determined political, social, economic and technological conditions in a certain region during a certain period, the models of regional growth are supposed to provide information on population and employment forecast (more or less disaggregated).

The models of activities allocation distribute the population and jobs in the territory defining the various land uses. They tend to shape the spatial pattern of industry, commercial activities, residential, etc.

The transportation models are intended to further provide, on the basis of a deduced activities pattern, the interchange between the various areas, and to identify the distributed and characteristics of the transportation demand. They generate information about the volume of origin and destination trips, distribution and model choice, and the volume of traffic generated between various zones.

The evaluation models try to establish the costs and benefits of the effects of various policies and help in choosing among certain alternative actions.

I defined in a previous section two major problem areas for urban studies and management: the regional policies and the reshaping and development of cities. A careful analysis would prove that all four categories of the above-mentioned models could and should be utilized in urban management at various levels. It is not the task of this paper to discuss the models of regional growth. They are closely related to the general and regional economic models and are suppose to help directly in decision-making concerning the first major problem-area identified. The transportation models on the other hand are obviously the first step to be taken in urban modelling, but they will also not constitute the task of this paper, as their "transplant" and implementation have but several minor difficulties. The transportation models are not based on economic or structure laws and theories. They are more or less a "pure technical question" (although the interpretation of, say, a simple gravity model can lead to very interesting conclusions about the social structure and the social impact of various policies adopted). The evaluation models can intervene in both problem areas identified. However, they will not be considered in this paper either.

The major task of the paper is to define, evaluate and question the applicability of the models of activity allocation (or urban spatial development models) in the Romanian context. However, some elements of the transportation models will intervene in the discussion, as transportation and land-use allocation are interdependent due to circular causality.

In 1965, Ira Lowry, in discussing the problems of model design, drew the vital conclusion that financing a large, urban-oriented model building effort is inevitably a risky enterprise. New models have been built, research has been conducted, money has been spent; but, unfortunately, Lowry's pessimism is still warranted today. These difficulties are seemingly due to the inability of model designers, in dealing with a complex system, to unearth and formulate accurate statements about the causal relationships between the variables describing the system being modeled. As Lowry himself points out, "the model builder's work begins with the identification of persistent relationships among relevant variables of causal sequences; of a logical framework for the model" (165, LOWRY, 1965). The many attempts to simulate all or part of the urban system have been generated by the whims of model builders claiming new insight into the proper method of capturing these relationships in an abstract model. Consequently, the efficient use of the urban development models within a general urban strategy will be a constant preoccupation while analyzing the various models and techniques.

2.4 Urban Spatial Development Models. Analysis.

2.4.1 The Dimensions of Urban Development Models.

In the following discussion of the dimensions describing the variety of available models, I rely on several summaries, like those of Britton Harris (121, HARRIS, 1965; 123, HARRIS, 1967; 124, HARRIS, 1968), Maurice Kilbridge, Robert P. O'Block, Paul V. Teplitz (147, KILBRIDGE, 1970), and Ira Lowry (166, LOWRY, 1972).

The first set of issues worth consideration deals with system definition - the assumptions about the structure of the system that establish tone, size, and form of the model. Two relevant dimensions for system definition are identified - holistic versus partial and macro versus micro. A holistic model contains more variables (and, consequently, more relationships among variables) than a partial model. To phrase this another way, we should refer to a definition helping to establish the boundaries of a system: "For a given system, the environment is the set of all objects a change in whose attributes are changed by the system". As a larger number of variables are termed endogenous and changed inside the model (the environment or number of exogenous variables is made smaller), the model becomes more comprehensive and it should come closer to approximating the system.

Because the environment represents all variables held constant or changed outside the model, all model predictions are conditional on that environment. Britton Harris makes two points about the appropriate degree of comprehensiveness (size of the system relative to the environment). First, a comprehensive model is nothing more than a well assembled set of partial models; therefore, comprehensive modelers are also partial system modelers. Second, policy makers must be holistic.

The second issue, that of aggregation level, is somewhat more complicated. Although urban change comes about in response to many decisions made by individuals, abstraction of reality in the form of models, in order to reduce the number of decision makers to some reasonable magnitude, must treat groups of people as homogeneous. Similarly, each location in a city has unique characteristics but analysis by parcel is virtually impossible; change must be measured for some larger areal tract. Very simply, the problem is what and how many groups of people and areas of analysis are appropriate.

First, let us consider the "how many" part of the question. Ease of data collection and hypothesis testing make the highly aggregated model appealing. Lowry mildly advocates highly aggregated models (165, LOWRY, 1965). Harris points out the problems encountered in aggregation in statistically predicting average behavior (124, HARRIS, 1968).

Michael Stegman argues that a greater understanding of individual decision-making processes is the key to making advances in urban modeling (229, STEGMAN, 1969). It is obvious, however, that work must be pushed on all fronts. It is interesting though that the demand of policy application for an extremely high level of disaggregation becomes a prime source of conflict between the development of models for such application and those for use in the development of theory, because it inhibits experimentation with the model. Thus, it seems that policy-makers, independent of relative predictive ability associated with degrees of aggregation, must use highly disaggregated models; only theoreticians can afford the luxury of aggregation.

Some theoretical principles have been developed to guide the model builder through this problem. Herbert Simon argues that systems are hierarchical and that components (aggregated groups) on any level of the hierarchy are determined by the level of interaction between elements in the components. Specifically, groups of elements whose within-group interactions are larger than the interactions with elements of other groups can be treated as a single component and the behavior of the component can be described in a single statement. At this time, implementation of this principle is virtually impossible for urban systems given the existing technology for measuring or even defining interactions. Unfortunately, the aggregation problem is most often resolved by whatever data exists; science of this type rarely plays a part.

A third dimension noted by Harris is the treatment of time. The time dimension is viewed in terms of statics versus dynamics. The use of comparative statics requires strong equilibrium conditions, and analytical dynamics requires complete closure (all changeable variables are endogenous and the environment is held constant); but as Lowry indicates, most builders use some form of compromise (165, LOWRY, 1965). The nature of this compromise does not appear to be crucial. Maybe the most relevant feature about the treatment of time is the time frame; that is, the length of time for which predictions can be made and the amount of time into the future for which predictions might remain accurate. It is obvious that the theoreticians often build models for the time frame dictated by their theory; the policy makers must fit their theories to the time frame dictated by the types of policy.

A fourth dimension has as its extremes descriptive, behavioral (Harris uses analytical) and normative models. Descriptive models deal with correlations on observed regularities. Analytic models attempt to get at cause and effect relationships. Normative models, given an objective and correct cause and effect relationships, indicate the best means to achieve the objectives. For theory building, the verification of cause and effect is, in fact, of primary concern; policy makers might, for certain types of prediction, accept descriptive relationships.

The predictive ability of the model is another issue to be discussed. Certain models are built as logical constructs for the purpose of clarifying or formalizing theoretical notions and are, consequently, not predictive. Other models contain certain weaknesses in theory and aim only toward reasonable forecasting ability. Still other overlook theoretical elegance and apply crude, but possibly accurate, correlation techniques.

Finally, two factors are purely pragmatic concerns. First, the relative ease of implementation depends on availability of date, computer limitations, and technical background of the users. A model using readily compiled data, not dependent on a particular computer and easily applied by a non-specialist, is easy to implement. Second, the operational status of the model - whether or not it is, in fact, used - must be considered. A great deal of time, money, and energy has often been wasted based on the promise that a given model works.

The urban spatial development models have been applied primarily as tools in the land use and transportation planning process. Although some models have been constructed as exercises in theory building in an effort to better understand the dynamics of physical growth in cities, most were designed to predict future land use and/or transportation patterns to be used in the planning process.

The prime concern of such models has been the detailed presentation of anticipated patterns of population, employment, housing, and transportation systems. Over-emphasis on the relationship between transportation and land use has preempted a comprehensive approach to urban modeling.

The long life of capital equipment (roads and buildings) and the long time required for major transportation system changes (two to ten years) have forced land-use model builders to deal mostly with long-run prediction. However, the data requirements and the need for skilled programming staff with access to the storage of a large computer make land-use models extremely difficult to develop. Once operational for a given city, they become relatively easy to use; however, updating the data base is still a difficult task.

The theoretical basis for these models is the gravity approach which has proved to be highly descriptive in nature.

2.4.2 The Model's Functions.

As Kilbridge, O'Block, and Teplitz point out, the urban models perform three basic functions:

a) projection: estimating the future of the subject;

b) allocation: dividing the subject into subsets;

c) derivation: transforming the subject by deriving another subject from it (147, KILBRIDGE, 1970).

A model's purpose is performance of one or more of these functions in varying combinations. For example, a model may project the subject into the future and then allocate it to activity subsets. Or a model may allocate a subject, project its subsets into the future, then use these projections to derive a new subject.

A pure allocation model serves only to divide the subject according to some theory of the relationship of the parts to the whole, and to each other; it neither projects nor predicts the future state of the whole or the parts. Such a model must, of course, have estimates of the total aggregate subject provided to it from an external source:

otherwise it has nothing to allocate.

Derivation is the process by which a model transforms its subject or derives another subject from it as, for example, land-use classes are derived from population data or traffic is derived from land use. The transformation equations, which convert one subject to another, contain the model's theory of the relationships between these subjects: this functional statement of causal relationship is the heart of most models. Thus, the Model of Metropolis (164, LOWRY, 1964) is an allocation-derivation model, while the Probabilistic Model for Residential Growth of Donnelly, Chapin and Weiss is a pure allocation model.

Ira Lowry classifies the urban models in three categories: descriptive models, predictive models, and planning models (165, LOWRY, 1965).

The descriptive models, if properly built, are of scientific value because they reveal much about the structure of the urban environment. They reduce the apparent complexity of the observed world to the coherent and vigorous language of mathematic relationships. However, they do not satisfy the planner's demand for information about the future.

For the predictive models the relation between form and process becomes crucial. Causal relationships must be established; simple co-variation does not suffice. In the case of predictive models, the prime variables (causes) must be plausibly evaluated as far into the future as may be necessary. However, this second condition is partly relaxed in the case of conditional predictions, which are in any case of greater interest to planners than the unconditional variety (if X occurs, then Y will follow). A special case of conditional prediction is called impact analysis, and it is focused on the consequence that should be expected to follow a specified exogenous impact (change in X) if the environment were otherwise undisturbed.

The planning models necessarily incorporate the method of conditional prediction but they go further in that outcomes are evaluated in terms of the planner's goals. The methodology here is very much like the steps to be taken in decision-making:

a) specification of alternative programs or actions that might be chosen by the planner;

b) prediction of the consequences of choosing each alternative;

c) scoring these consequences according to a metric of goal-achievement;

d) choosing the alternative which yields the highest score.

It is quite obvious that all these three categories of models could and should be used in urban management in Romania. However, as general urban and regional theory is at present rather poor, very sophisticated models, based on cause-effect relationships would be a risky enterprise. One more difficulty lies in the lack of skills and experience in modeling, and lack of data, especially time-series data. Consequently, it is to be expected that, at least in the first stages of experience, the planners should heavily rely on descriptive models.

The planning models seem to be extremely useful at a higher level of decision-making in urban problems for major decisions regarding the general policy to be followed and implemented. Very interesting and important applications at the same level will no doubt come from the impact analysis models and the conditional prediction models. It is to be noted that at a lower level of decision-making, in solving current, less complex planning problems, the same procedures are applied empirically and without sophisticated mathematical tools: specific objectives are identified; alternatives are generated; consequences for choosing a certain alternative are predicted; these consequences are empirically weighed and scored; and the alternative yielding the highest score is chosen.

The critical area in my opinion is the area of planning decisions at intermediate level. As asserted above, at the higher level of decision, the costly enterprise of research, modeling and experiment is technically and financially feasible. On the other hand, at the lower administrative levels, the decision may be taken empirically (to note that the field of decision at this level is narrower, and the number of possible alternatives is consequently smaller). At intermediate levels important decisions are to be taken, and skilled personnel, expertise, and technical assistance are very often lacking.

On the other hand, any problem of urban development is, by its nature, unique. This makes rash generalizations at this level out of the question. As a matter of fact, this is in my opinion, precisely the reason why excessive centralization in decision-making didn't work (90, ENACHE, 1972). The attempt to apply mathematical and statistical tools in aiding decision-making should be oriented towards rather simple models, repetitive, easy to manipulate and operationalize. The idea is to develop "modular" models, models which could be combined according to the complexity and specifics of the decision situation. It would be interesting to see if sequels or "bits" of experience, of "good" experience, can be used in different contexts. In other words, I guess that Chr. Alexander's approach to this problem (generalized from design to planning and policy-making, eg. a "language" of policy-making) could be a most valuable one.

To be more specific, a good example of such a model would be a gravity model for transportation planning to be used in a whole series of regional settlements, 200-300 polarising centers, which are supposed to develop as "new towns". The argument for using modular models lies in the similarity of goals in the development of these future urban centers: redistribution and concentration of population in territory; fast economic and social development. The model (or models) would have to cope with scarcity of data, technical skills, and expertise. They should rely many times on small samples of data, as the model developed by B. Smith: "Gravity Model Theory Applied to a Small City Using a Small Sample of Origin-Destination Data" (224, SMITH, 1965). At the same time, the methodology developed should take into account the differences and the specific characteristics of each particular settlement and decision problem. The models thus must be flexible and open enough to permit empirical inputs and contributions.

2.4.3 The Model's Underlying Theories.

The underlying theory of an urban planning model is that set of relationships, stated or implied, which is assumed to prevail between the model's subject and the larger environment. It is impossible to make a "theory-less" model, for the model either derives directly from theory as a symbolic statement of it or abstracts urban phenomena to symbolic form and relates these structurally, thus creating theory. According to Kilbridge, O'Block and Teplitz, "models are either theory-based or theory-laden" (147, KILBRIDGE, 1970).

Where theory exists, the model builder usually relies heavily on it, as his organizing principle, deducing the model from it. The result is a model in which the relationships between the subject and the environment are expressed by a series of precise - but often rather limiting - mathematical statements.

One measure of the development of a field of knowledge is the extent of its structured theoretical base which is partially equivalent to the extent to which it employs abstract models for analysis and prediction. These abstract models need not be fully mathematical in form. They may, for example, be block diagrams. Although the language of symbolism is not rich enough to allow translation of all propositions into precise notation, it is usually sufficiently subtle and varied to express the important elements of reality when these elements are precisely and logically formulated. The main advantages to symbolic representation of a theory are the conceptual clarity, the improved comparability with known theories, the simplified deduction, and the empirical framework (a framework for empirical investigation).

It is obvious that the goal is to formulate models which are subtle and rich enough to reflect reality adequately, yet simple enough to be operational. The model builder's dilemma lies in the choice he must make between a model which is theoretically "elegant" and one which is operationally "feasible".

Many complex urban situations, however, are not tractable by ordinary analytic techniques: the mathematics may become too difficult or the exact nature of the functional relationships may not be fully understood. Some of these difficulties can be overcome by using computer simulation which can handle problems beyond the effective grasp of mathematical analysis and which has considerable tolerance for unverified assumptions and unexplained relationships. Models too complex even for simulation can be broken into submodels and solved sequentially. Models that overrun the capacity of the largest computers can be handled by interrupted simulation, in which the model user stops the computer at decision or judgment points, chooses from among alternative courses and sets the computer on that course. Imperfect models containing relationships not sufficiently understood for reduction to mathematical form can be similarly handled.

The major theoretical building blocks used in the construction of any land use and activities allocation model are considered by the authors of Bay Area Simulation Study (BASS) to be the following:

a) economic base theory;

b) input-output analysis;

c) location theory;

d) urban land market;

e) growth theory;

f) transportation behavior (142, BASS, 1968).

The attempts to develop quantitative models of the spatial aspects of urban development for use as planning tools have encountered several difficulties. Lowry points at a basic weakness which all urban economic models must share in some degree, and which is the source of the model builder's greatest dilemma. This weakness lies in the difficulty of translating a highly complex theory of the urban land market into a feasible empirical operating model.

Kilbridge gives a classification of twenty urban planning models (147, KILBRIDGE, 1970) according to subject, function, theory and method (see page 60). He makes a clear distinction, as regards theory, between behavioral and growth forces. Input-output analysis is included in the general growth forces. The methods utilized (which are called algorithms and heuristics in Chadwick's classification; 48, CHADWICK, 1971) are econometric and stochastic (e.g. regression, input-output, Markov processes), mathematical programming (linear or other), and simulation (autonomous or with intervention).

It is obvious that the early stage of development of urban economics in Romania has a very important impact upon model building and quantitative analysis in urban management. It is more than a risky enterprise to attempt to build operational predictive models, based on cause-effect relationship without a sound theory of urban location, resources allocation, urban growth, economic efficiency of urban systems under socialism, etc.

Some of the theories underlying the model building in the U.S. are valid and could easily be extended to a socialist economy. This is the case with the economic base theory, input-output analysis, or some of the growth theory principles. However, the models of growth in a socialist economy take as their starting-point the problems of the dimensions of available factors of growth, and not the problems of aggregate effective demand, emphasizing thus, above all, "supply" as limiting the size and the growth rate of production. Factors concerning the "supply-side" can be dealt with in two major ways: first from the standpoint of current labor; viewed thus the gross national income (Y) is determined by the product of employment (Z) and productivity (W) defined as gross value added per employee:

$$Y = Z * W$$

Secondly, the problem can be approached from the point of view of stored-up labor; the gross national income can be presented as the product of the real productive fixed capital (M) by the effectiveness of this fixed capital (E) defined as gross value added per unit of capital, or

$$Y = M * E$$

However, in reality, the gross national income is the sum of both products:

$$Y = Z*W + M*E$$

The transition from abstract generalities of the theory of growth to the complex conglomerate of practical limitations and inter-dependencies would require both a study of methods and forms of disaggregation of different elements of economic structure in their dynamics and a study of the relation of decisions taken at the highest level to those made at lower levels in the process of practical application of the selected path of development.

As regards the location theory, there are about ten basic principles in the planned economies to guide the location of activities (location of industry, farm production, transportation facilities, trading establishments, tourist and recreational amenities, and residential areas). The activities should be located: (1) close to the resources or inputs they use (especially industry, agriculture, and tourism); (2) close to the markets they supply (finishing industries, trading, recreational, and housing facilities); (3) interregionally to develop maximum regional specialization of production where this is optimal; (4) between regions to achieve maximum regional self-sufficiency where this is optimal; (5) as evenly as possible to exploit regionally or locally underutilized resources and to assist in solving regional scarcities; (6) in a dispersed fashion throughout the countryside; (7) preferentially in backward or underdeveloped regions to achieve greater interregional equality; (8) to eliminate cultural, economic, and social differences between city and country; (9) as strategically as possible; (10) to achieve optimal international trade flows. As Ian Hamilton points out in "Aspects of spatial behavior in planned economies" (Regional Sciences Association Papers, vol. 25, 1970) laws 1, 2, 3, and 10 appear to be Weberian or Löschian, but they assume their identity with planned socialist economies in their ranking as <u>laws</u> of location in their own right, and not merely as expressions of factors which location cost accountants consider in deciding locations with their minor concern for transportation inputs, their major concern (especially laws 5-9) for sociocultural values alongside economic values of environment and their quintessential aim at achieving the maximum dispersion and

Maurice D. Killbridge, Robert P. O'Block, and Paul V. Teplitz: <u>Urban Analysis</u>, Harvard University Press, Boston, 1970 (Ref. 147).

CLASSIFICATION OF TWENTY URBAN PLANNING MODELS*

	Model Name	Author(s)	City	Approx. Date	LAND USE a. Residential	b. Industrial (Mfg.)	c. Commercial	d. Govt. or Institutions	e. Roads, Streets, Alleys	f. Public Open Space	POPULATION	TRANSPORTATION a. Interzonal Trips	b. Other Transp.	ECONOMIC ACTIVITY a. Employment 1. Retail Trade	2. Manufacturing	3. Service	b. Trade 1. Retail	2. Other	c. Personal Income	PROJECTION	ALLOCATION	DERIVATION	BEHAVIORAL a. Economic (Market)	b. Preference	GROWTH FORCES a. Gravity	b. Trend	c. Growth Index	d. Input-Output	ECONOMETRIC AND STOCHASTIC a. Regression	b. Input-Output	c. Markov Process	MATHEMATICAL PROGRAMMING a. Linear Programming	b. Other Analytic Forms	SIMULATION a. Autonomous	b. With Intervention	
					Subject																Function			Theory						Method						
1.	How Accessibility Shapes Land Use	Hansen	(Hypothetical)	1959	x						x										x					x								x			1.
2.	Activities Allocation Model	Seidman	Philadelphia	1964	x	x	x		x		x			x		x				x		x	x		x			x		x					x		2.
3.	Chicago Area Transportation Model	C.A.T.S. Group	Chicago	1960	x	x	x	x	x	x		x				x					x		x				x									x	3.
4.	Connecticut Land Use Model	Voorhees	State of Conn.	1966	x						x				x	x	x			x	x		x			x		x		x					x		4.
5.	Econometric Model of Metro. Employment and Pop. Growth	Niedercorn	(Hypothetical)	1963							x		x		x	x	x				x		x					x		x							5.
6.	EMPIRIC Land Use Model	Brand, Barber, Jacobs	Boston	1966							x				x	x	x			x	x		x			x		x		x							6.
7.	Land Use Plan Design Model	Schlager	S. E. Wisconsin	1965	x		x	x	x	x	x											x	x	x	x								x		x	x	7.
8.	Model of Metropolis	Lowry	Pittsburgh	1964	x	x	x				x				x	x						x	x			x								x		x	8.
9.	A Model for Predicting Traffic Patterns	Bevis	Chicago	1959								x	x								x		x			x							x				9.
10.	Opportunity-Accessibility Model for Alloc. Reg. Growth	Lathrop	Buffalo	1965	x						x	x										x	x			x									x		10.
11.	Penn-Jersey Regional Growth Model	Herbert	Philadelphia	1960	x																x	x	x	x									x		x		11.
12.	Pittsburgh Urban Renewal Simulation Model	Steger -	Pittsburgh	1964	x	x	x				x				x	x			x	x		x	x		x	x		x	x		x				x		12.
13.	POLIMETRIC Land Use Forecasting Model	Hill	Boston	1965							x				x	x	x			x	x	x	x			x		x						x	x		13.
14.	Probabilistic Model for Residential Growth	Donnelly, Chapin, Weiss	Greensboro	1964	x																	x						x		x						x	14.
15.	Projection of a Metropolis—New York City	Berman, Chinitz, Hoover	New York City	1960							x				x	x	x	x	x	x		x	x						x		x						15.
16.	RAND Model	RAND Corp.	(Hypothetical)	1962	x						x			x								x	x	x	x			x							x		16.
17.	Retail Market Potential Model	Lakshmanan, Hansen	Baltimore	1964								x						x				x	x			x								x			17.
18.	San Francisco CRP Model	A. D. Little, Inc.	San Francisco	1965	x						x										x	x	x	x	x							x			x		18.
19.	Simulation Model for Residential Development	Graybeal	(Hypothetical)	1966	x									x							x	x	x	x	x			x						x	x		19.
20.	Urban Detroit Area Model	Doxiadis	Detroit Area	1967							x	x									x	x	x			x				x				x			20.

* Some of the larger simulation models are general systems containing particular submodels of different types, and thus their presentation here may seem to contain contradictions in classification. The apparent contradictions arise from including both general and particular models under one title.

From: "Urban Analysis": M. Killbridge, R. O'Block, and P. Teplitz; Harvard University Press, 1970.

spatial equality of development possible. It is also to be noted that the laws blend cultural, economic, military, political, and social motives which sometimes complement but more often conflict with each other. Neither theoreticians nor planners have conceptualized or defined the laws adequately; interpretation and application are thus flexible.

This is why, in the case of location theory or transportation behavior, one would expect a strong resistance to any attempt to "transplant", as their "raison d'etre" itself is rooted in the market mechanism, not to mention the urban land market theory and the whole range of urban models based on it. As stated in a previous section, there is a market mechanism in the socialist economy as well. Some economists (e.g. 150, KORNAI, 1972) assign an even bigger role to this market section of the economy. However, its content and functions in a socialist economy are different. The market mechanism and the planning are supposed to be complementary. The role of the market thus is to check subsequently the rationality both of the planning decisions themselves and of their execution.

However, the market mechanism is supposed to cover only a segment of the economy. Moreover, the demand is only to a certain extent matched by the supply, which results in saying that the market forces do not act freely in that they are partially controlled by the state. It should be emphasized though that the recent trends of decentralization of the economy granted the economic units a much higher degree of autonomy (although there is no private investment in the economy) and they have gotten incentives for acting freely. This particular type of competition is hoped to help supply match demand.

Apart from this, the recognition of the importance of a strict economic accounting (through the prices system) may lead to a future development of a theory of urban land value under the conditions of socialism. Consequently, it is expected that a theory of urban economics (including location theory, urban growth theory, urban land value theory, transportation behavior) can be derived from the general socialist economic theory.

The points made here above will be used in discussing and evaluating the model chosen for analysis: the Lowry type model (164, LOWRY, 1964).

2.5 Conclusion: A Unitary Approach to Urban Management in Romania. The Role and Uses of Quantitative Techniques.

The planned economies are supposed to satisfy the following conditions: (a) State representatives (usually in, or appointed by, the government) make most decisions concerning current and future developments in most administrative, economic, political, and social activities at all levels of the spatial administrative hierarchy - from national to commune or city space. (b) Decisions are made within a framework of collective ownership and management of most capital, infrastructure, production, resources, and services, which (c) permits substantial, if not rigorous, control over prices, profits, rents, wages, and, in some instances, even structural and spatial labor mobility. Decisions (d) embody coordination between economic sectors and regions, (e) are incorporated in medium-and long-term plans which are (f) executed through state control allocation of fixed capital investment and circulating cash. (g) Decisions are intended to fulfill socialist ideals-fundamentally, the deliberate maximum and equalized benefit of every member of society.

Decisions made in planned economies emerge from a complex interaction of people representing and cooperating with complementary, as well as bargaining over conflicting, interests. Broadly pyramidic decision-making structures characterize planned economies. The power of the individual (or group) to make or to influence locational decisions decreases from the top to the bottom (local government authorities), a decrease which is directly related to the size of spatial responsibility and inversely related to the number of people (or groups of people) at each level of the spatial management hierarchy (national, provincial, district, city, enterprise) who seek to influence decisions.

In arriving at finalized development plans, whole series of interactions occur between the planners on the one hand who, as experts, formulate developmental goals and the projects best able to attain those goals, and second, other participants who supply information concerning development needs and potentials in the plan period, who express opinions accepting, rejecting, or modifying the planners' proposals and who pressurize the planners to satisfy their particular vested interests in the plan.

I do not intend to go into describing the decision-making behavior. This short presentation of the decision-making process is intended to help draw conclusions about the role and place of quantitative techniques in urban and regional management.

As stated in a previous section, these quantitative techniques should be a link between general economic planning and concrete social and spatial patterns of development. At the strict economic level, the idea for the management of the economy consists in solving two main problems:

1. definition of the structure of the economic system;
2. prediction of its development in a certain given period.

Solving the first problem implies the processing of the information received from the system itself and building models of its structure. The second problem, more complex in its content, requires supplementary information exterior to the system (goals, objectives, social command, etc.), information which allows us to analyze the real system and build the predictive model.

Thus, through combining these two categories of models with the real economic system on the basis of the feed-back principle, a cybernetic model of economic management is defined. This concept considers the balance sheets as structural models and the plan as a predictive model. The information system in economy is the instrument used to correlate the two categories of models with the concrete economic phenomena (171, MANESCU, 1972).

Through the information system, information from the economic system itself is compared to exogenous information as well as the predictive model. Decisions are taken and transmitted to the economy, thus forming a feed-back loop. Any time it is required, the predictive model is revised and corrected. The elaboration of an economic plan is supposed to contain three cycles: from the general goals to the plan draft, from the plan draft to the plan project, and from the plan project to the plan (the final decision).

Similarly, at the regional level, the regional management should accept two inputs: the analysis of the developmental problem (performed at the central level) and the input from the participatory level. In certain cases this participatory input would affect directly the development plans. In other cases, it is confronted with the analysis using both empirical and quantitative methods (structural models and predictive models) and the decisions are made in accordance with very broad social and political goals.

The role of regional science is to constitute the theoretical basis for model building. As the structural models play an important part in theory-building, there should be a feed-back loop between the general regional theory and the structural models. Both structural and predictive models should accept inputs and modifications from the social and environmental planning, as described in a previous section. The social and environmental inputs, however, are present both at the central decision level (in the form of general theory) and at the participatory level, in the form of public opinion and people's individual intervention in the process.

While regional management is somehow a more general, overall approach, urban management tends to be rather problem-oriented. The two major areas of concern here are housing and transportation. The plans and policies from these two areas are synthesized in general master plans. Consequently, the quantitative analysis should be present at both these levels, making use of specific models and techniques. It is evident that a large variety of structural and predictive models should be used. However, at the level of synthesis, a very important role will be held by the evaluation techniques and the policy models.

Here again, the inputs of social and environmental planning should be present at both the analytic level and the participatory one. And a final check of the more general objectives and goals should intervene in the working of the master plans.

3. ANNEX: The Lowry Type Models; Analysis.

The Lowry Model enjoys a rich heritage due to its very appealing characteristics: the promise of meaningful operationality, the simplicity of the causal structure, and the opportunity to enlarge and embellish the framework.

In my opinion, there are two viable ways of adapting existing urban models and techniques to a different situation (by "different" in this case I mean economically, socially and politically dissimilar): either by using rather simple, crude models, basically descriptive, which can be "fitted" to describe a different urban structure, or by going very far into the analysis of cause-effect relationship models, sophisticated behavioral models which have a very complex causal motivation and therefore are very specific to the given situation. In this second case, the particular techniques and procedures, the algorithms and heuristics (to use Chadwick's language) should be studied and borrowed and not the model itself. The degree to which the statistical tools succeed in "modeling" truthfully the given reality are of major interest here. And algorithms and heuristics could be subsequently built to model the various urban processes in the different context, and finally pulled together in a genuine and original model of the given reality. However, there are two major difficulties in carrying out this task: first, the inability of model designers, in dealing with a complex system, to formulate accurate statements about the causal relationships between the variables describing the system being modeled (a certain partial explanation of this fact resides in the weaknesses of urban and regional theory). Second, from the viewpoint of the counterpart interested in adapting existing statistical tools (e.g., in

Romania), the urban and regional theory itself is almost non-existent. As a matter of fact, one might note the relatively early stage of development of the economic theory in general. This wipes out entirely the second alternative, of going deeper in the analysis of cause-effect relationship.

Now to go back to the simple, descriptive models, there is a certain danger in adapting these models too, because although very simple, the causal structure has most of the time an underlying process, a built-in economic and social mechanism. There are always certain initial assumptions which are, or are not, made explicit by the model designer.

The Lowry Model is very appealing because it is phenomenological (the rules are derived empirically); it is not based either upon micro-analysis or macro-theory. This is the reason why it does not have, at least in its basic form, any predictive power.

As a static equilibrium model, it is very close to what our interests are - to derive rules and to experiment with models in order to achieve an optimal design.

Also the model proved to be adaptable in exploring the consequences of different policies, which is also very interesting in a planned economy. As I will discuss later, the pure predictive urban models are, in my opinion not applicable to Romania, simply because planning contains, or should contain, both the dimensions of cognitive and colitive power. The structure of the decision-making process in the economy as well as in urban and regional planning calls for impact analysis and conditional predictions (if X - then Y follows). The category of policy models is a potentially very useful tool in decision-making at certain levels. (The simulation quality of the Lowry Model is essential here.) The steps to be taken in this case would be: generating alternative programs or actions, deriving the consequences for each alternative program, scoring these consequences, and choosing the alternative yielding the highest score.

Again, the Lowry type models are very promising from this viewpoint, as they generate alternatives. As I shall discuss later, in many cases, the alternative spatial patterns proposed by the planners are wrong, and choosing one of them could prove to be highly unsatisfactory.

As an equilibrium model, the Lowry type model is of overwhelming interest to planners who are concerned with exploring long-term goals and bending development in some "best" direction (121, HARRIS, 1965).

Finally, the Lowry type model is hoped to give some articulate answers to the spatial allocation aspects of the two major problems of the urban development in Romania: residential location and urban transportation.

The Conceptual Elements of the Lowry Model:

The first conceptual element used by Lowry is the basic-retail dichotomy (116, GOLDNER, 1971). As Goldner points out: "Because of the resemblance of terms to the economic base concept, there has been some misunderstanding regarding the nature of the fundamental structural split in the Lowry model (164, LOWRY, 1964), a group of activities in the model are located in relationship to markets made up of households, thus being implicitly related to populations and purchasing power. The criterion used is locational, flowing from the existence of a local market or service area. Lowry himself states that the nomenclature of "basic" and "retail" is used for convenience, not for descriptive taxonomy, and implies that "site-oriented" and "residence-oriented" might be more exact labels. This situation is to be found in a planned economy as well.

The economic base theory is consequently eventually underlying a regional economic model, which would supply the region-wide inputs to the Lowry model.

This frequent misunderstanding of Lowry model is apparent in the Ljubljana model interpretation; thus R.L. Knight writes in "A Primer on Urban Development Modeling: The Ljubljana-Lowry Model" (Ljubljana, 1972, p. 5): "The model's structure derives from conventional economic base theory, in which employment in "export" activities is considered to be the engine which drives a region's economic growth". This distinction seems to be important in choosing the right scale of the modeled area, the scale of the tracts, etc. And seemingly the modeled area should not cover an entire urbanized region, at least in the case of countries like Yugoslavia and Romania.

The "site-oriented" and "residence-oriented" activity allocation is imbedded in equations nos. (2) and (7) of the model (164, LOWRY, 1964):

$$(2)\quad E^k = a^k N$$

Employment of k class is a function of the number of households in the region (or population N). In other words, the employment is factored by the dwelling unit/employment ratio, f.

$$(7)\quad N = f \sum_{j=1}^{n} E_j$$

Total population in region is a function of total employment in region (as a sum of total employment in each j tract). The total employment per tract is computed using equation (5), as a sum of "basic" and "retail" employment:

$$(5)\quad E_j = E_j^B + \sum_{k=1}^{m} E_j^k$$

The allocation of these quantities to individual zones is the particularly innovative contribution of Lowry. He used an ingenious <u>multiplier concept</u> to generate the spatial distribution of total employment from the exogenously provided location of basic employment.

Another important conceptual element of the Lowry model is constituted by the <u>allocation functions</u>. The model contains three groups that are subject to spatial allocation: employees to residences, households to services, and employees to services. For the first group (employees to residences), Lowry used a gravity function for the work-to-residence allocation, calibrated on the basis of trip indices calculated for residence-to-work relationships. The actual functional form is:

$$\frac{dp}{dr} = ar^{-x}$$

In the calibration of the model, the actual values used are:

$$\frac{dp}{dr} = r^{-1.33}$$

with dependence on normalization procedures to readjust the function for bypassing the coefficient a. What Lowry actually does is use equation (8):

$$(8)\quad N_j = 1 \sum_{i=1}^{n} \frac{E_i}{T_{ij}}$$

and a scale factor g, to make sure that the total population allocated does not exceed to total existing population:

$$g = \frac{N}{\sum_{j=1}^{n} {}^{1}N_j}$$

so N_j now becomes:

$${}^{2}N_j = g\,{}^{11}N_j$$

The residence-to-service allocation was fitted by reciprocals of quadratic functions of the form:

$$\frac{dp}{dr} = (a-br-cr^2)^{-1}$$

Thus, equation (3) is used to compute the retail employment potential:

$$(3)\quad {}^{1k}E_j = \sum_{i=1}^{n} \frac{c^k N_i}{(T^k_{ij})} + d^k E_j$$

Rescaled, to sum to E^k

$$E^k = a^k N$$

$${}^{2k}E_j = b^k\,{}^{1k}E_j$$

$$\text{where:}\quad b^k = \frac{E^k}{\sum_{j=1}^{n} {}^{1}E^k_j}$$

Finally, the allocation from workplace to shopping is assumed to take place within the zone in which the workplace is located, therefore no allocation function is required.

I do not intend to go into detail here about the zonal system, the aggregation and disaggregation and the treatment of time. The descendants of the Lowry model, although making certain fundamental additions to the initial framework, have the same basic structure. Their common characteristics are:

a) partitioning of employment into a market-oriented category called population-serving or "retail" and a residual termed "basic" or site-oriented;

b) the causal system leading from "basic" employment to residential population to population-serving employment;

c) the population-serving allocation growing out of a multiplier relationship applied to basic employment.

The task of this section is to prove that the Lowry model is more of a gravity model rather than a market model. More than that, even the identified underlying "market mechanisms" define a highly idealized situation which is quite far from the real functioning of the market system in the U.S. This is not to criticize the model for the lack of a virtue which it was not designed to have. The author himself points out (164, LOWRY, 1964, p. 23): "In planning the design of the Pittsburgh Model, I have followed the guidance of the social physicists more than that of the location theorists". This implies that the model is less likely to describe the urban spatial phenomena based on the principles of rational equilibrium, an equilibrium emerging from competition in the market for urban land. The social physics approach relies mostly on empirical laws of social interaction and mass behavior, rather than on reasoning from principles of individual behavior. They offer evidence of a number of interesting statistical regularities. Thus, the Lowry model deals in very broad aggregate of locators, distributing them over the urban space with the aid of mathematical probability-functions.

Maybe the most interesting further elaboration and application of social physics in urban and regional studies is the concept of entropy, developed by A.G. Wilson (243, WILSON, 1970). Wilson's entropy maximizing procedure proves to be useful not only in better understanding the gravity model, but also to develop hypotheses, or, in cases where hypotheses can be developed by more conventional means, it will often be useful to exhibit the constraint equation which would give rise to the same hypotheses in an entropy-maximizing procedure, as this will often facilitate interpretation.

Thus, a state of a system is an assignment of individuals to the origin-destination table which is in accord with any constraints. Wilson also defines a distribution which is the macro-property of the system to be estimated by statistical means. In this case, a distribution is a set of numbers, one for each origin-destination part, and one such number is the total number of people who travel from origin i to destination j (T_{ij}). It is obvious that there are many states which give rise to any particular distribution.

Wilson showed that three constraints are needed to generate a good estimate of T_{ij}:

$$\sum_j T_{ij} = O_i$$

$$\sum_i T_{ij} = D_j$$

$$\sum_i \sum_j T_{ij} \quad c_{ij} = C$$

where:

T_{ij} is the number of individuals living in i and working in j (to be estimated);

O_i is the total number of workers who live in i (given);

D_j is the total number of jobs in j (given);

c_{ij} is the cost of traveling from i to j (given);

C is the total expenditure on travel to work (given).

The idea is to find the matrix $\{T_{ij}\}$ which has the greatest number of states, say W $(\{T_{ij}\})$, associated with it, subject only to the constraints above mentioned. Wilson gives the procedure of obtaining the number of states which give rise to a matrix $\{T_{ij}\}$ (243, WILSON, 1970). Suppose T is the total number of workers (that is, T = $\sum_{ij} T_{ij}$). How many assignments of individual workers to the possible trips (combinations of i and j) give rise to $\{T_{ij}\}$? Firstly, we can select T_{11} from T, T_{12} from T-T_{11}, etc., and so the number of possible assignments, or states, is the number of ways of selecting T_{11} from T, ${}^{T}C_{T_{11}}$, multiplied by the number of ways of selecting T_{12} from T-T_{11}, ${}^{T-T_{11}}C_{T_{12}}$, etc. Thus:

$$W(\{T_{ij}\}) = {}^{T}C_{T_{11}} \quad {}^{T-T_{11}}C_{T_{12}} \quad {}^{T-T_{11}-T_{12}}C_{T_{13}} \ldots$$

So, explicitly,

$$W(\{T_{ij}\}) = \frac{T!}{T_{11}!\ (T-T_{11})!} \cdot \frac{(T-T_{11})!}{T_{12}!\,(T-T_{11}-T_{12})!} \cdots = \frac{T!}{\prod_{ij} T_{ij}!}$$

Interestingly, this result is independent of the order in which the specific trips are considered.

Then $W(\{T_{ij}\})$ is maximized subject to the given constraints in order to find the most probable (T_{ij}). We choose for maximization the function ln $W(\{T_{ij}\})$. Thus gives T_{ij} as:

$$T_{ij} = A_i B_j O_i D_j \exp(-\beta C_{ij}),$$

Where

$$A_i = \frac{\exp(-\lambda_i^{(1)})}{O_i} = \left[\sum_j B_j D_j \exp(-\beta c_{ij})\right]^{-1}$$

and

$$B_j = \frac{\exp(-\lambda_j^{(2)})}{D_j} = \left[\sum_i A_i O_i \exp(-\beta c_{ij})\right]^{-1}$$

Where β is the lagrangian multiplier associated with the third constraint, and $\lambda_i^{(1)}$ and $\lambda_j^{(2)}$ are the sets of lagrangian multipliers associated with the first and the second constraints.

This derivation parallels a technique in statistical mechanics known as the use of the microcanonical ensemble. In statistical mechanics, the equivalent of ln W above is <u>defined</u> to be the <u>entropy of the system</u>

We are interested in <u>distributions</u> only and the most probable distribution is that with the greatest number of microstates giving use to it. Thus, the distribution corresponds to the position where we are most uncertain about the microstate of the system, as there are the largest possible number of such states and we have no grounds for choosing between them.

The gravity model uses exactly the same notions and constraints.

The constraint equations can be satisfied if sets of constraints A_i and B_j associated with production zones and attraction zones respectively are introduced. They are sometines called balancing factors. Also, there is reason to think that distance plays its part in the general transport equation, as it does in the world of Newtonian physics:

$$F_{ij} = \gamma \frac{m_i m_j}{d_{ij}^2}$$

or, transposed into an analogous transport gravity model:

$$T_{ij} = k \frac{O_i O_j}{c_{ij}^2}$$

where k is a constant and where travel cost is interpreted as "distance".

Consequently, a general function of distance is introduced. The modified gravity model is then:

$$T_{ij} = A_i B_j O_i D_j \ f(c_{ij})$$

where

$$A_i = \left[\sum_j B_j D_j \ f(c_{ij}) \right]^{-1}$$

and

$$B_j = \left[\sum_i A_i O_i \ f(c_{ij}) \right]^{-1}$$

The equations for A_i and B_j are solved iteratively, and it can easily be checked that they insure that the T_{ij} given in the equation above satisfies the two constraint equations:

$$\sum_j T_{ij} = O_i$$

$$\sum_i T_{ij} = D_j$$

Also c_{ij} should be interpreted as a general measure of impedance between i and j, which may be measured as actual distance, as travel time, as cost, or more effectively as some weighted combination of such factors sometimes referred to as a "generalized cost".

Now let us go back to the Lowry model and try to discover the implications of using the mathematic probability-functions on the general spatial pattern of activity allocation and population servicing.

As stated before, the social physics basis of the model confers on it a highly idealistic character, certain "perfections" and regularities which make it a rather crude description of reality. This was reinforced by the using of the grid cell configuration and the air-distances. The grid cell configuration has the special advantage that simple geometric relationships define the interzonal centroid-to-centroid distances. Distances calculated in this way are much more economical to produce than the complex and elegant interzonal times (skim-trees) which are computed using minimum time-path procedures based on extensive definition and inventorying of transportation facilities.

Very important criteria in building the Lowry model were data available and required, internal coherence, and operationality.

Even the more sophisticated variants of Lowry model (24, BATTY, 1971; 13, AMERICAN-YUGOSLAV PROJECT, 1970; 82, ECHENIQUE, 1969, etc.) are rather idealized representations of reality and their predictive power is consequently low. One interesting contradiction in the "embellished" Lowry-type models is that <u>although the iterative allocation of activities built a metropolis out of scratch, given the "basic" or site-oriented</u>

activities, the allocation functions distribute the activities according to existent interzonal times (which are precisely determined by the existent spatial pattern of activities). All these considerations lead to the conclusion that the Lowry model should be used highly "experimentally", as a rough picture of the general equilibrium of activity in a metropolis.

Although the model is basically a gravity model, Lowry devotes a comparatively large section of his interpretation of the model to "reconciling at least the general structure of the model with the economic theory of choice, and offering interpretations of some of the more ambiguous results which emerge from this structure" (164, LOWRY, 1964, p. 23).

Thus, the model defines the production function as requiring fixed proportions of labor and site-space; above minimum efficient size, there are neither internal nor external economics of scale. Customers bear the burden of "delivery costs", which include all economic costs that vary with distance between seller and buyer. So far there are no radical differences among the spatial aspects of the economic mechanisms in a planned economy.

The locational choice-problem of the individual firm is fairly straightforward: Since profits vary directly with the volume of sales, the firm will seek to locate where it can attract the maximum patronage. As Lowry points out" "The number of customers attracted to any given tract j depends on the spatial distribution of residence and employment with respect to tract j, and also on this same distribution with respect to all other tracts containing retail outlets. The model thus incorporates both competition and distance as determinants of the probability that a particular buyer will do his shopping at j. The system is in equilibrium when establishments are so located that this competition reaches a stalemate".

Similarly, the consumer behavior market areas are analyzed as described by equation (3):

$$E_j^k = b^k \left[\sum_{i=1}^{n} \frac{c^k N_i}{T_{ij}^k} + d^k E_j \right]$$

Thus, the market areas are interpenetrating: the establishments at all locations are given some share, however small, of the patronage of customers located in tract i. It follows that the buyer does not choose between sellers simply to minimize the distance covered by his shopping trips.

The above interpretation is obviously a market and consumer behavior interpretation of the social physics probabilistic approach (particular case = gravity model) rather than a behavioral explanatory theory expressed in mathematical formulas. This is again the reason for the highly idealized character of the model. More than that, the market relationships, in this interpretation, appear to be of appealing but misleading simplicity. This simplicity is reinforced by the particular case of considering one and only one residential cluster located at a central point, i, within the region. The derived spatial interaction pattern is extremely simple and symmetrical.

Indeed, the allocation function expressed by equation (3) seemingly describes a perfect market system, a perfectly competitive market (218, SAMUELSON, 1970), leading to a perfect equilibrium, harmony and regularities.

The activities distribution follows the principles of least effort and efficiency maximization. The gravity model has built-in the principle of perfect competition, perfect supply and demand matching, continuous distribution, and market balance. Lowry states (164, LOWRY, 1964, p. 22): "These two traditions (market models and gravity models) are not necessarily antithetical in content, although they are in style".

What is interesting about the Lowry model in regards to applicability to a planned economy are the underlying principles of efficiency maximization and perfect population servicing. Indeed, in the market economy (in this ideal assumption of the perfectly competitive system), the firms competing for profit maximization end up with a balanced and efficient way of servicing the population. In a planned economy, on the other hand, although the main goal is not the same (this is, not profit-making but economic efficiency) it results in the same spatial desideratum (at the urban scale) of best servicing the population. And while in a market system the picture is that of a constant-sum game where the players strive for shares of the market allocated to that location, in a planned economy, the efficiency maximization is aimed through a better allocation of the limited resources.

The above arguments are in favor of the applicability of the Lowry model in a non-market urban context. However, there are some other difficulties in implementing the Lowry model in an East-European context. For instance, in the case of the Ljubljana model, it is not at all certain that accessibility to work plays such an important role in residential location in Ljubljana. Continuing shortages of housing and of residential area infrastructure act as powerful constraints on the function of accessibility. This is quite similar in Romania, where administrative difficulty in land acquisition for private home construction in many theoretically "developable" areas, combined with a heavy demand for the land that is available (driven by a high rate of inflation, under which many people are trying to build homes to avoid later higher costs) also acts as an artificial determinant of residential location. One similar feature of both Yugoslav and Romanian urban residential construction is represented by the construction in the form of high-rise apartments in large developments. These developments occur for the most part only in a few areas within the region, so the individual decision field is narrowed to a considerable extent. All these remarks make it questionable if an accessibility model of the Lowry type would be successfully subject to such a cultural transfer (Robert L. Knight, "A Primer on Urban Development Modeling - the Ljubljana-Lowry Model", Ljubljana, 1972). However, there are interesting arguments in favor of the Lowry model "transfer" in Yugoslavia. Thus, Jeffry Stubbs, in a letter to Robert L. Knight writes: "I believe that accessibility may have a higher explanatory power in Ljubljana than in the West, under the assumption that the time costs of travel are as important (or more important, than they are in the West, that the many costs of travel are higher (for private motor vehicles) and that other factors such as neighborhood are less important."

As I stated earlier in this section, in my opinion, it is out of the question to use the Lowry model as a predictive tool in a planned economy. The main two reasons are the following: 1) the Lowry model has a very poor predictive power (if any); it should be mentioned that even the Lowry model descendants have this weakness; 2) pure prediction in a planned economy is questionable. The individual decision field is thus narrowed by the societal overall decision in an attempt at balancing the individual and societal goals.

Suppose a Lowry-type model would succeed in describing accurately the urban structure of Bucharest (by including certain constraints of scale, density, land uses). The replica of the equilibrium state after ten years would not follow the actual changes in the city, as these changes do not occur according to a market mechanism. The changes occur in an incremented way, through a combination of decisions at various levels. This is why the Lowry-model should be used as a policy model, a real "model" of optimal design and perfect servicing of a population. Thus, a run of the model would depict the ideal activities pattern, the way it should be (of course, subject to certain constraints). It should be a tool to experiment with, to simulate roughly the interaction of activities in the urban scene.

To be more clear, let me take the case of Bucharest. Given: "basic", site-oriented activities, plus constraints of scale, density, land use, accessibility. Required: an ideal, optimal state of activities equilibrium (maximized accessibility, optimal service of population). Nota bene: I didn't mention maximization of freedom of choice for the population in terms of housing, work, etc., because this is a more complex goal and it requires a different set of policies like: housing construction, economic development, etc. (Note that it refers in principle to quantitative needs.).

After running the model, a confrontation of the optimal solution given by the computer with the reality would bring in interesting conclusions and policy issues. Thus, some of the differences between the reality and the model output would signal certain inefficiences in the aggregate functioning of the city. The consequent policies would take into consideration the "planning tools", such as housing construction, residential area expansion, density control, major transportation innovations, as well as population-serving activities location. All these planning tools are either given or act as constraints in the Lowry model. Moreover, locations of "basic" or site-oriented activities could be simulated, thus changing the exogenous input for the Lowry-type model.

However, many of the differences between the reality and the model output are due to behavioral, sociological, or political considerations, which can or cannot be imbedded in the equations of the model in the form of constraints.

The use of a Lowry-type model would consequently permit a very elastic interpretation of the urban phenomena and <u>should not</u> be regarded as a "frozen" tool of population and activities forecasting, rather than as a tool for simulating the consequences of various urban planning actions. There is a large scope for empirical consideration, weighing, and checking the accessibility model output with the more complex social and environmental criteria. There is, in my opinion, a very good chance for the intervention of economsts, sociologists and politicians, as well as people's participation at a certain level.

There is another question to be elucidated here: couldn't a simple gravity model perform the same functions of testing various policies and actions? The answer is no; because the Lowry model is not only useful in testing alternatives, but also in generating alternatives, and for certain assumptions and constraints, giving the optimal solution. This is, in my opinion, very important, as a simple evaluation of given alternatives could prove to be unsatisfactory.

Thus, in the case of Bucharest, none of the three variants of development is satisfactory. Two of them express entirely opposed policies, and are limited-cases, (obviously none of them resisting a careful analysis); and the third one proposes a compromise, more or less arbitrarily chosen, of the first two.

Finally, the model structure could easily be made more complex to better "fit" reality. Thus, as in the Ljubljana model, the interzonal distances could be carefully composed of combinations of transit and vehicle travel times instead of airline distances.

Also, certain population limits such as planning constraints on specific zones can be taken into consideration, as well as the problem of placing capacity constraints on selected zones.

For instance, the model can satisfy certain constraints or residential location, like constraints imposed on residential development due to physical factors or to institutional commitments. Thus, the zones can be divided into two subsets: Z_1 is the subset of zones which is affected by locational constraints (population being exogenously fixed by the planners) and Z_2 is the subset of zones not affected by constraints. Then,

$$Z = Z_1 \cup Z_2$$

is the total set of zones in the system. The constraints on residential location can be defined as (following Wilson's notation):

$$\sum_{j \in Z} T_{ij} = P_i \, , \quad i \in Z_1 \tag{1}$$

$$\sum_{i \in Z} T_{ij} = E_j \, , \quad j \in Z_1 \tag{2}$$

where T_{ij} is the number of people working in i and living in j

E_j is the total employment in j

P_i is the total population in i

If we add the xonstraint:

$$\sum_{\substack{i \in Z \\ j \in Z}} T_{ij} \, c_{ij} = C \tag{3}$$

It is possible to maximize log $T!/\prod_{ij} T_{ij}!$ to get the appropriate answer, subject to the constraint equations (1), (2) and (3).

The idea is to maximize a lagrangian, L, where

$$L = \log T! - \sum_{ij} \log T_{ij}! + \sum_{i \in Z_1} \lambda_i^{(1)} \Big(P_i - \sum_{j \in Z} T_{ij} \Big) + \sum_{j \in Z} \lambda_i^{(2)} \Big(E_j - \sum_{i \in Z} T_{ij} \Big) + \beta \Big(C - \sum_{\substack{i \in Z \\ j \in Z}} T_{ij} \, c_{ij} \Big) \tag{4}$$

where, as in Wilson's notation, T_i, T_j. and β are Lagrangian multipliers associated with equations (1), (2) and (3) respectively.

We have to solve:

$$\frac{\partial L}{\partial T_{ij}} = 0 \tag{5}$$

and constraint equations (1) through (3). (5) gives

$$-\log T_{ij} - \lambda_i^{(1)} - \lambda_j^{(2)} - \beta c_{ij} = 0 \qquad \text{for } i \in Z_1 \tag{6}$$

and

$$-\log T_{ij} - \lambda_j^{(2)} - \beta c_{ij} = 0 \qquad \text{for } i \in Z_2 \tag{7}$$

so

$$T_{ij} = e^{-\lambda_i^{(1)} - \lambda_j^{(2)} - \beta c_{ij}}, \qquad i \in Z_1 \tag{8}$$

and

$$T_{ij} = e^{-\lambda_j^{(2)} - \beta c_{ij}}, \qquad i \in Z_2 \tag{9}$$

In the usual way

$$e^{-\lambda_i^{(1)}} = A_i P_i \, , \quad i \in Z_1 \tag{10}$$

$$e^{-\lambda_j^{(2)}} = B_j E_j \, , \quad j \in Z \tag{11}$$

and the model, as represented in equations (8) and (9) can be written:

$$T_{ij} = A_i B_j P_i E_j e^{-\beta c_{ij}}, \quad i \in Z_1 \tag{12}$$

$$T_{ij} = B_j E_j e^{-\beta c_{ij}}, \qquad i \in Z_2 \tag{13}$$

where

$$A_i = 1/\sum_{j \in Z} B_j E_j e^{-\beta c_{ij}}, \quad i \in Z_1 \tag{14}$$

$$B_j = 1/\left[\sum_{i \in Z_1} A_i P_i e^{-\beta c_{ij}} + \sum_{i \in Z_2} e^{-\beta c_{ij}}\right], j \in Z \tag{15}$$

Finally, some of the very important conditions for applying a Lowry-type model in the Romanian context are: data availability and accuracy, the right number and dimensions of the zones, a correct calibration, etc.

Some of the difficulties encountered in the Ljubljana model were related precisely to these questions (see Robert L. Knight, "A Primer on Urban Development Modeling: The Ljubljana-Lowry Model.", Ljubljana, 1972).

However, these questions cannot be asked before experimenting with the model in the given context.

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