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COMPREHENSIVE HOUSING PLANNING

Some Issues of Theoretical and Empirical Investigation for Detroit

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INTRODUCTION

Housing as an activity is linked with many aspects of economy (urban land, industry, business, finance, etc.). As for the urban and land economy, housing dominates the spatial pattern, and consequently determines its advantages or disadvantages. The construction industry depends directly on housing activity as well as indirectly on many other industrial branches which produce different material goods, and business and finance are greatly stimulated by housing activities, too. In a social sense, a bad housing situation has specific results. Poverty is correlated with poor housing and good housing conditions are the basis of social welfare. Housing functions are linked or integrated with other functions: working, services, commerce, education, and particularly transportation because of several causal relationships with them. Thus, it is understandable that housing should be planned so as to maintain and stimulate other functions and activities that substantially influence the urban pattern, magnitude, and structure of a city.

A schematic relationship among basic city elements, presented in diagram 1, indicates that the city should be planned in an integral way for the achievement of full efficiency. This relationship is very complex, however, and changeable in space and time.

Past and present urban development, which has been more chaotic than planned, has not featured a balance among urban functions--particularly between housing and working. Housing has usually been developed as a consequence of transportation system and its structure. It is also the reason for some important phenomena today: unstable urban growth, i.e., rapid urban sprawl, difficulties of land development because of increasing costs, the extension and complication of transportation and other infrastructure networks, etc. In order to avoid such phenomena, housing should be planned as an integral part of city planning, and the city should be planned as a process, i.e., as a dynamic structure.

What kind of analysis does comprehensive city planning imply, in which housing planning is one of the most important sequences?

In order to clarify these problems, we are going to present three parts of the research, conducted in both a theoretical and empirical sense. The first part represents a short argument of basic problems making up urban models as well as some ideas related to planning theory. It will explain some basic urban phenomena important for understanding urban system analysis and synthesis.

The second part represents a demonstration of the model of urban optimization, which is an attempted synthesis of dynamic urban systems. This model deals with the relationship between housing and working in the context of transportation and land use.

The third part represents an empirical investigation of space and temporal dynamic changes of some basic urban phenomena in the Detroit Region, changes which are relevant for many aspects of urban development, particularly for housing, transportation and working.

Investigations to date in urban planning were primarily individual, partial, conducted in a divergent sense, mainly static instead of dynamic. There have not yet been many attempts at synthesis of urban systems developed in a dynamic sense. The target of this research was a contribution to the better understanding of complex urban growth. The aim was to proceed several steps toward the synthesis of urban systems. This research represents a continuation of the author's previous studies, particularly with one which will be mentioned in a later section.[1]

Part I: URBAN SYSTEM MODELS - SOME BASIC PROBLEMS OF CONSTRUCTION

There are many urban models which have appeared in the last fifteen years and have been classified in several ways according to character: descriptive, causal, behavioral, empirical, probabilistic, statistic, stochastic, normative, etc. They have also been classified according to topic: transportation, housing, industry, retail, etc. We shall keep the basic classification: descriptive and causal quantitative models, as they include other models.

These two kinds of models were formulated by scientists of the Westinghouse Research Laboratory[2] in the following way:

A descriptive model is one that provides an adequate description of the phenomenon being studied, but does not attempt description of the causative background of it. The most important descriptive models are those that evolve from the theory of probability.

A causal model is one which attempts to duplicate, within our understanding, the physical influences that cause the phenomenon we are interested in studying. Once these influences are represented in our Model we can then use it to predict the outcome.

The understanding of modeling problems in the urban domain involves the clarification of four basic questions:

1. What processes take place in the city?
2. Why do some processes take place in the city, what factors influence and generate a particular process?

3. Where would existing urban processes trends lead, and where should they be redirected, i.e. what results can be expected and how should they be avoided?
4. How are planned processes implemented, and how is more efficiency in the planning process achieved?

These four questions are not separate sequences in the city planning process. Conversely, they should be linked and integrated, but today planning often implies part of the 1st, 3rd, and 4th questions, but serious analytical investigations in the 2nd and particularly the 3rd questions are insufficient to provide adequate answers. Nevertheless these questions, according to character and topic, can be interpreted or at least better understood by some urban system models, either descriptive or causal, or by their combination. We should not imagine that such models can ideally imitate behaviors in Nature, but anyway they can help to better understand urban phenomena. Of course, without any action in this field one cannot expect any improvement: quantity is the basis for the quality.

1. What processes take place in the City

The City is an aggregation of multivariate processes, which have different characteristics, shapes, intensities and speeds. These processes take place independently or are mutually linked in a convergent or divergent sense. The discovery and understanding of these phenomena is difficult because their mutual relationships and influences have both a visible and invisible character. Anyhow, we have at least to recognize

symptoms of an urban phenomenon, by its two basic characteristics: 1) cyclic periodicity* and 2) speed of change. It would be the least number of necessary elements for the description of a phenomenon.

The first element should be observed in three stages: long, middle, and short range.

Long range periodicity is a characteristic for phenomena such as:

-- total population growth of city (one cycle can be extended 80 - 150 years);

-- housing stock completion and its maintenance (50 - 100 years);

-- other urban physical structures have a similar pattern, although each should be investigated more thoroughly.

The pattern of population and housing stock development has the shape of the integral probability (figure 2). Such a shape, particularly for population, is characteristic and today visible for many industrial cities (central city) implying growth, saturation and the threshold of declining. Decreasing values and the maintenance of housing stock have reverse shapes from the integral probability, indicated in figure 3.

Middle range periodicity is characteristic for the following phenomena:

-- industry, business, education and other activities, having approximately 20-40 years as a one-cycle periodicity.[3]

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* It means, the time or the distance between two characteristic points of function, determined by the maximum or cross section with other function, meaning the correlation axis.

The long-range physical planning orientation of urban development in terms of land use, by present theories (20-25 years),[4] coincides with the middle range periodicity of urban growth, which has a particular socio-economic importance.

Short-range periodicity is characteristic for phenomena such as: services, commerce, business, etc., having full economic meaning. It may be assigned as 5-10-15 years.[5] In a mathematical sense, these changes have a partial or fully harmonious shape, irregularly or regularly patterned. Such shape for short cycles of changes (5-7 years) is also characteristic for residential construction.[6] Exchanges of housing shortage (demand) and its elimination also have an oscillating character, but with somewhat larger, middle range periodicity (10-20-30 years).[7] Graphic patterns of such changes can have a similar shape as that in figure 4.

This characteristic (development periodicity) of industrial cities varies with local conditions. But the acceleration of general technological progress, and consequently more rapid changes in human customs and behavior, influence changes of periodicity of observed phenomena in the sense of shortening and consequently the acceleration of these processes.

The second characteristic, speed of processes, depends on the changes in the shape of the function and the point of observation on this function. External as well as internal influences (technology progress or human behavior) may be important for changes of the pattern of function shifts. Such transformations are more considerable for short range than for middle or particularly long-range periodicity changes. City reconstruction, the

rebuilding or rehabilitation of existing deteriorated urban areas can alter the shape of functional changes in the domain of living conditions, prices, social values, influencing functional changes of population growth, housing conditions, activities, transportations, etc. too. Such classification of urban phenomena by the range periodicity has been done in order that they be easily reorganized. It is obvious that they are mutually correlated and conditioned.

The next question is what kind of analysis and models can and should be undertaken? Considering topics, such analysis might be classified in the following four groups:

-- Population and its social characteristics -- composition, income, education, ethnic appropriation, activities, employment, cultural level, etc.;

-- Housing stock and its town planning, architectural and building characteristics, including ecological and sociological conditions;

-- Work places and characteristics according to the kind of activities, as well as town planning, ecological and other characteristics too;

-- Transportation by purpose, mode, car ownership, communication behaviors, etc.

Observed phenomena have a probabilistic character and determinable stochastic pattern. Such trends could be found by regression analysis. Such analysis represents descriptive models, which can describe growth patterns of a phenomenon. Two kinds of analysis can be done:

1.1. Total growth trends related to a defined area (central city, metropolitan region), are more or less deviating from administrative boundaries. This problem implies twofold related problems: periodicity and total growth. Figure 5 shows the characteristic growth for population in the central city, metropolitan area and region. Such an S shape pattern is common for other observed phenomena: housing stock, work places, and transportation. Considering different areas (central city, metropolitan area, region) we can recognize three different periodicities. The solution of this problem, the correlation between periodicity and total growth, may be done by a relatively complicated mathematical procedure--an iterative method. With respect to population growth, for instance, it may be solved in the terms of housing development, on a probabilistic basic base, as is shown in figure 6. Applying reality of such method is based on the fact that the site of turning points on functions are known.[3]

The solution to the observed problem requires two kinds of analysis: 1) total growth, which has absolutive sense, and 2) relative (probabilistic) growth. The mathematical form of the first problem is shown by the following defined integral (see figure 2):

$$Y = \int_0^t y(x)\,dx = \int_0^t ax \cdot e^{-bx}\,dx \qquad (1)$$

where y(x) is the function of time changes (per year, for instance) (t) is time periodicity.

The probabilistic pattern of total growth (distribution function) is:

$$Y_1 = \int_0^t p(x)\,dx = 1 \qquad (2)$$

where p(x) is the probability density function.

location of residences and work places in the urban area. Such a method had a probabilistic character and was sufficiently crude and imprecise. In fact, this observation of work trips by rings and sectors was conducted according to the 1953 traffic study for Detroit.[12]

Our suggestion has this logic: the observation of one urban phenomenon (population, housing, work places and transportation or others) by rings (circles) and sectors implies a tool for the identification of changes in urban space. It is particularly related to ring division. Sector division provides higher homogeneity of an area, being based on main transportation lines (corridors) which usually correlate with geographical conditions. In fact, every sector should be observed by rings in the defined time period. Changes should be identified: first, in space by rings, for each sector and afterwards in the characteristic time periodicity and adopted to census cycles. Consequently, the observation of a density distribution in an absolute or relative sense, has a three dimensional meaning. This fact should be distinguished in terms of preceding theories, which abstracted the third dimension of urban phenomenons.

What are the differences between absolute and relative density distribution? Absolute density distribution means absolute concentration (charge of one surface unit (acre for instance) by one particular phenomenon, expressed in units (number of people, or housing units, trips, working places, or floor space of housing units, etc.). Its importance is the distinction between living, working or communication conditions in different urban areas. Rings and sectors relative (probable) density distribution means the distribution of the total mass of the particular

phenomenon. Considering that a split pattern is a function of rings (two dimensional units), this relative distribution is concerned with the characteristic shape of the city, developed concentrically. This kind of function can help in the following of developing processes much more easily and effectively and it is very useful in the analytic optimization of processes, demonstrated in part 2.

Let's now consider the shape and characteristics of these two functions.

1.2.1 Absolute density distribution

This problem with respect to population was dealt with by C. Clark.[13] Investigating the problem of population distribution in terms of land use, he established a mathematical form of population density as a function of distance:

$$y = Ae^{-Bx} \qquad (3)$$

or generally, the total population of city as the integral of the preceding relation in a simplified form (1):

$$P = 2 \int Ab^{-2} \qquad (4)$$

Function (3) has a shape as in the figure 8 and its symbols mean:

A - maximum density in the central city

x - distance (radius)

B - factor of correlation

e - basis of the natural logarithm

Function (3) and particularly (4) should be corrected, because they represent a particular situation, i.e. population development until its culmination, but the present situation of a mature industrial city has the shape of population density which changes as in figure 9. The function 0 in figure 9 assigns the culmination population density in the center, and function 1, a later phase, declining of the central city and growth of the suburb. In fact, this shape represents the beginning of the next cycle of urban growth (the end of the preceding cycle of the total population growth in a particular area - central city, for instance, see the preceding figure 5).

In the figure 10, the function (1) represents the culminative density in the center city and function (2) represents the decline of the center and the growth of the suburb. The mathematical form of the total density of the function (3) is shown by the following formula:

$$y = Ae^{-Bx} + e^{\frac{a}{b+x}} - 2e^{\frac{a}{b}} \qquad (5)$$

where the symbols mean:

A, B as in preceding equations (3) and (4), and

a, b positive regression parameters of auxiliary function (figure 11) which shows the redistribution of population density from the central city towards suburb.

Total population function has the following form:

$$Y = \varphi\pi \int_0^d \left(Ae^{-Bx} + e^{\frac{a}{b+x}} - 2e^{\frac{a}{b}}\right) dx \qquad (6)$$

where:

φ - circumference multiplier (part of the full circle), and

d - radius of urban area

1.22 Relative probable density distribution

The mathematical form is:

$$Y_o = \int_o^d \frac{y(x)}{Y(x)}\, dx = 1 \qquad (7)$$

The relation (7) is a continuous function (differentiable at every point). If the division by rings are used, that can be expected in the practice, relation (7) should be given as the discrete function:

$$Y_1 = \sum_{i=1}^{r} \cdot \frac{Y_i}{\sum_{i=1}^{r} Y_i} = 1 \qquad (8)$$

where:

y - absolute density in i-ring,

i - ring index,

r - total number of rings.

Relations (7) and (8) show the probabilistic character of density distribution, which may be represented by the Binomial probability or Poisson mass function probability (figures 12, 13).[14]

The mathematical form of the Binomial probability has the pattern:

$$P(x) = \frac{n!}{x!\,(n-x)!}\, p^x\, (1-p)^{n-x} \qquad (9)$$

where:

P(x) - probability in any x ring,

p - probability that x ring is really dense,

n - number of rings,

x - ring.

For practical purposes, Poisson's probability is more convenient.

Its form is:

$$P(x) = \frac{n^x \cdot e^{-n}}{x!} \qquad (10)$$

where:

n - degree of freedom (corresponds to p·n of the Binomial probability),

x - total number of rings,

e - Natural logarithmic base.

1.3. Conclusion. The analysis of questions on urban processes encompasses two descriptive models: 1) total growth changes of the particular phenomenon of urban development (population, housing stock, working places, transportation, etc.) through time, and 2) a spatial density distribution of the particular phenomenon in time which corresponds to the observing time points of the first one. In both cases the analysis should be absolute and relative, indicating total changes (entire conditions) and relative changes which characterize the development process of the particular phenomenon. These analyses serve for following and forecasting of trends of the particular phenomenon of urban growth, operating with its spatial characteristics. Such methods enable comparison between cities of different magnitude and characteristics that previously were very limited or impossible. Observation of cities with different characteristics may help to establish general stochastic rules of urban growth. Synthetical observation of urban phenomena in space and time can be presented by three dimensional diagram (see figure 14), meaning the development trajectory of an urban phenomenon.

2. Why and How Something Happens in a City

This group of questions implies two kinds of analysis: global for the city in the entirety, and partial for particular areas. These questions should be dealt by causal models representing very complex and complicated problems, because there are many difficulties to discover all factors, influencing on one particular phenomenon. There are also two kinds of factors, which influence separately or linked. If we observe the city as a dynamic process, each of these factors should be discovered as the function of time. Such factors indicate the multivariant character of these processes.[15] Let us try to explain these problems by total population growth of a city.

The question is why and how the population grows in a city? Between many influencing factors we can recognize three groups of factors:

1. Growth of economic activities,
2. Living condition changes,
3. Social-cultural advantages.

Progressive changes of activities are the first and probably the most important factor for the population growth of a city. As J. Forester explained,[16] this process is not linear, but a complex non-linear function, which implies development, saturation and decline, corresponding to three characteristic phases of one cycle: developing, maturation and aging.[17] So the total product as synthesis of activity growth correlates with changes of the following factors:

-- employment demands, which should be growing,

-- personal income which should be increasing,

-- production and marginal costs which can be oscillating,

but should be decreasing.

In mathematic sense the total product may be expressed as the growth ratio:

$$\Lambda(t) = e \cdot E(t) \dot{+} i \cdot I(\dot{+}) \dot{+} c \cdot C(t) \qquad (11)$$

where:

E, I, C -- employment demand, income and costs growth ratio, as time functions,

e, i, c -- factors of correlation.

Considering these functions have different characteristics, periodicity and speed, as results of other external and internal influences (technology, human behaviors, general social-economic situation, etc.), these functions may produce complex oscillating function of product growth ratio which can have disparative characteristics, periodicity and speed, in terms of componental functions. This problem may be very difficult when such functions represent complex non-linear changes, but it would be possible to develop such non-linear problems.

The second group of factors surrounds more factors:

-- housing demands,

-- residential density,

-- amortization of housing stock,

-- building costs,

-- rental cost.

-- production and marginal costs which can be oscillating,

but should be decreasing.

In mathematic sense the total product may be expressed as the growth ratio:

$$\Lambda(t) = e \cdot E(t) \dotplus i \cdot I(\dotplus) \dotplus c \cdot C(t) \qquad (11)$$

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Each of these functions has different patterns. As like in the first case, it would be necessary to observe their growth ratio. Housing (quantitative) demands have oscillating shape, building costs and rental too, but with other patterns. Residential density has the shape of the integral probability (increasing), amortization of housing stock decreasing, linear or unlinear pattern. Mathematical equation of such correlation can be as follows:

$$LC(t) = aHD(t) \div bRD_{(t)} \div cAH_{(t)} \div dBC_{(t)} \div eRC_{(t)} \qquad (12)$$

where:

LC(t) = Living conditions

HD(t) = Housing demands

RD = Residential density

AH = Amortization of housing stock

BC = Building cost

RC = Rental cost

t = time variable

a,...e = regressional parameters

The third group of factors -- social-cultural advantages -- is more complicated and less determinable because of difficulties of measurement and quantification. Anyway it surrounds at least three subgroups of factors: education, cultural levels and behaviors mutually interrelated. The mathematical form may be expressed:

$$SCA_{(t)} = e \cdot E_{(t)} \div c \cdot C_{(t)} \div b \cdot B_{(t)} \qquad (13)$$

Basic problems in this case are the identification of observed phenomena, or their deabstraction, expressing by specific indicators. Such problem has to imply certain simplification. As for education, it might be expressed as growth ratio of the indicator: highly educated people per 1000 inhabitants. The second indicator would be number of cultural institutions per 1000 inhabitants and the third: crime cases per 1000 inhabitants. At the end, the total population growth should be expressed in the following way:

$$P_{(t)} = q \cdot AG_{(t)} + r \cdot LC_{(t)} + s \cdot SCA_{(t)} \qquad (14)$$

where:

q, r, s -- are factors of correlations,

AG, LC, SCA -- time functions.

Partial analysis of population growth in the particular area needs the correlation analysis on similar way as preceding ones, but aggregation of other variables, such as:

-- vacant land for building,

-- residential density,

-- land price,

-- social-ethnic consistence,

-- behaviors of inhabitants, etc.

Development of such models, particularly for marketing purposes (differential or integral) needs very attentive analysis of important factors and its mutual influences. Such analyses are very sensitive, particularly for housing market purposes because of the large number of factories with complex influences.

Conclusion

Foregoing analysis, although general, without possibility to develop practically useful mathematical models indicates two things: (1) System analysis of complex urban phenomena is an extremely complex job, as for discovering of influencing factors and its relationships, and (2) Mathematical modeling of causal type, which should be developed in this case, also is a very complex job, because it has to imply development of non-linear multivariance correlations. Such models should be experimentally tested, and of course, computers should be used.

This field of urban planning, which is extremely important for succeeding of practical problems, it can be said, is considerably undeveloped in a theoretical and also empirical sense.

3. Where to Direct Urban Processes

This group of questions is probably the most important in the point of view of human responsibilities because it means to take the role of determining of the city's fate. There are a lot of questions, philosophical and practical, which should be answered. The entity of analysis in this field should be determination of urban planning as preventing rather than treating of existing problems. In this sense, urban planning should imply the way to avoid many possible impacts because of perpetual urban growth, overcrowding by people and structures. This field of urban planning, which is extremely important for succeeding of practical problems, it can be said is considerably undeveloped, in a theoretical and also empirical sense.

This field has to imply making up such synthetic models which can enable understanding and prediction of urban phenomena changes, as well as consequences of urban planning actions (partially and in the entirety) for many years in advance. It would be necessary to understand the relative character of such comprehensive models, because their value may depend more or less on goals and tasks formulated in advance.

Thus, we can mention several such important tasks, which should be solved in this field although it is difficult to imagine that one universal synthetic model could deal with all of them (probably not in the very near future):

1. traffic congestion, because of inadequate relationship between housing, working places, and transportation;
2. losses in time and money because of disparative urban development;
3. losses in energy because of irrational land use;
4. protection of air, water and earth caused by foregoing factors;
5. more choices for housing living conditions because of growing need for material goods, cultural demands, and attitudes.

Having in mind such problems, particularly those of numbers 1, 2, and 3, we developed one theoretical model of urban optimization (see the 2nd part) in order to demonstrate the techniques of dynamic programming of complex urban phenomena, such as transportation, housing, work and their mutual correlations. This model has potential character, meaning rather suggestions than solutions.

There is no prejudice that this model can simulate the urban dynamics and comprehensiveness in the entirety. It may be and should be developed and perfected, but our belief is that such model can help to better understand the city in reality and also simulate changes of the future. It can help the image of the future and hope to stimulate undertaking of some planning actions which purpose would be avoiding of impacts in social, economic and technical sense.

Although there are some more or less successful attempts in the developing of such kinds of models in transportation, housing, activities, etc. (by the way, more partial, not enough comprehensive, and mainly static), we can say that this field needs more experimenting and better applying of mathematics and computer techniques.

4. How to Implement Urban Planning Process

In this chapter we shall explain some technical problems of planning process procedure, which could represent analytic and scientific background for policy decision makings. In fact, this is only an exposition of some ideas which propose to clarify and understand the complexity of urban planning in contemporary conditions.

Considering the very close connections and interrelations of housing and other city functions, it is necessary to observe city planning procedure as the integral process in which housing planning represents only one of the non-dividable sequences.

The starting base of the concept exposed here was the attitude that planning as well as planner activities should be maximately objective, based on scientific analysis of dynamic urban processes. Intuitive methods

should be changed by analytic ones. Planning proposals should be based on complete and valid information and data. Planners should be scientists rather than politicians and without possibility to decide directly about the particular project. Conversely, political systems should be established to be obliged to decide about proposed projects, to accept them or refuse them, and also to suggest corrections, but never to ignore and avoid analytic planning proposals. Thus, this is, at the same time, a critique of planner attitude who consider the planning as decision-making power. Consequently, our understanding of planning implies some corrections and adoptions in existing system of establishment, particularly in the planning domain in terms of information system. Being extremely important for analytic planning, information systems, data processing, census, survey and other actions, with the same purpose, should be based and organized on analytic methods, and so to enable easier and more precise planning procedure.

4.1. City as a complex supersystem. Through the history of man, the city has appeared and developed as the result of man's struggle and competition with nature, as well as mutually between themselves. The city has passed through many transformations. Many times it has changed in character, functions, structure, etc., but always kept the purpose: to be a scope of human development, human-being, and the nucleus for making up of human ideas.

The present time has the particular importance for city development in the future. Being developed spontaneously in the past, city development should be planned scientifically and analytically in the future, and so to help better and faster development of man himself.

Thus, having in mind man's relationships with the nature as well as their inter-relations, city as the scope of these inter and intra-relations should be planned in a systematic way, as a complex structure, which will provide some balances, stability, choices and stimuli for development of man. Presented next, several diagrams purpose to explain the approach for system design of urban planning process.

Figure 1 has the purpose to explain the city as a twofold integrated system. In the first general sense, the city should be integrated with nature on the basis of ecology and technology inputs. In the second sense, the city should be the integration of physical and social-economic structures. Both senses have to be connected and mutually conditioned. The explanation below emphasizes the second sense.

The scheme 15 symbolically represents the complex structure of the city where people live, consisting of physical and social-economic structures, on the higher stage: 1) functions, more close to physical structures and 2) activities, more close to social-economic structure, but mutually connected and interrelated. Both structures are symbolically represented by two manpower in the social-economic domain, and material in the physical structure domain. The first nucleus encompasses social-economic establishment, intellectual and scientific experiences, decision-making procedure, etc., which are reflected by social and economic influences from wider levels: the national and the world-wide.

The second nucleus represents material riches, its organization and distribution, including establishment (tools, its ownerships and usage).

Both nuclei should be mutually connected and integrated. We would say, by the urban planning system.

Substructures are further developed on the basis of existing experiences: city functions as aggregation of work, housing, communication, education, supplying, recreation, etc., which are mutually connected too. City activities are divided in a classic way: primary, secondary, tertiary, etc.

The figure 16 represents the scheme of the city planning process as mutual connections between manpower and material riches nuclei and urban planning system. The manpower nucleus is represented, in this case, by planning relevant activities (science, research and experiences). The material riches are represented by integrated subsystems: (housing, transportation, facilities, etc.). Connections between these two nucleuses and planning systems should be on the information basis. The connection between the planning system and city government system should be closed. The planning system need as input goals, materials, finance, control and other connections, and as output it should provide proposals and analysi background for decision making education.

The scheme 17, 18 represent units and their connections inside the integrated urban system (which encompasses planning, design and information).

The scheme 19 represents phases and stages of planning procedure, emphasizing housing, developed according to scheme 16, 17, 18.

4.2. Conclusion. City and urban planning should be understood rather as the prevention against possible social, economic and technical impacts in the future than the treatment of present social and economic poverties and weaknesses. It has to be obvious that hesitating with systematic and integral planning must imply guides to the treatment of appearing crises; poverty, crimes, etc. stimulated by people and structure overcrowding of cities. Planning, we suggest, can be understood as the protection of people, nature, resources, rather than limitation of properties, choices, freedoms. Understanding of city planning and planning generally today is a relative thing, depending on attitudes, goals, wishes, but also on establishment, scientific background and information communication. It is true that planning is not developed enough and is misunderstood. But everybody--citizen, businessman, or scientist--can understand relatively simple logical things. It would be a paradox of our time if the technological progress from which so much is expected, does not go with planning, and probably the reason for slowing down total progress. Today is also the paradox that every supermarket can use advantages of technology as for organization, efficiency, but city planning offices cannot or at least are very limited. A million things used by individuals are the result of technology progress, as for planning, technology is yet out of the door. Of course, planning cannot be developed automatically without manpower and conditions. There are at least five basic conditions in order for a utilitarian planning to be developed:

-- right democratic values of a society,

-- scientific background,

-- economic base,

-- understanding and well informed people,

-- establishment of planning mechanism.

All five conditions, as well as many others, are linked and connected mutually. Weakness of any of them must generate bad or wrong, and normally unpopular planning. From my point of view, I can suggest faster and better organized scientific research, better informed people and faster and larger introduction of computers in all aspects of research, planning and information generally, but scientifically rather than intuitively. Mathematical models, simulation techniques and quantification methods, in general are tools for the intercommunication between the real world and the world of computers.

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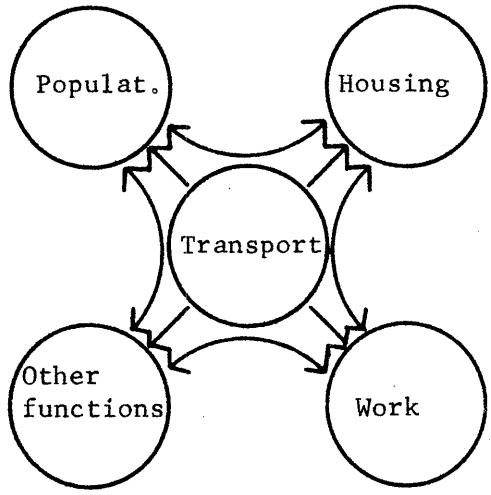


Fig.1.1 The Scheme of the Basic Functiona Relation in a City

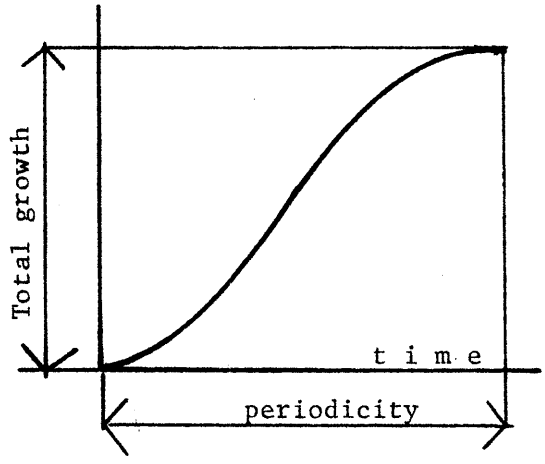


Fig.1.2 The Probability Pattern of Population and Housing growth

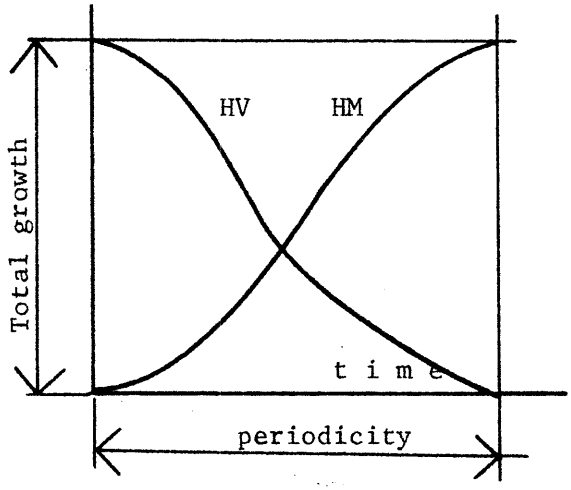


Fig.1.3 Housing Decrasing Value and Maintaning Cost Patterns

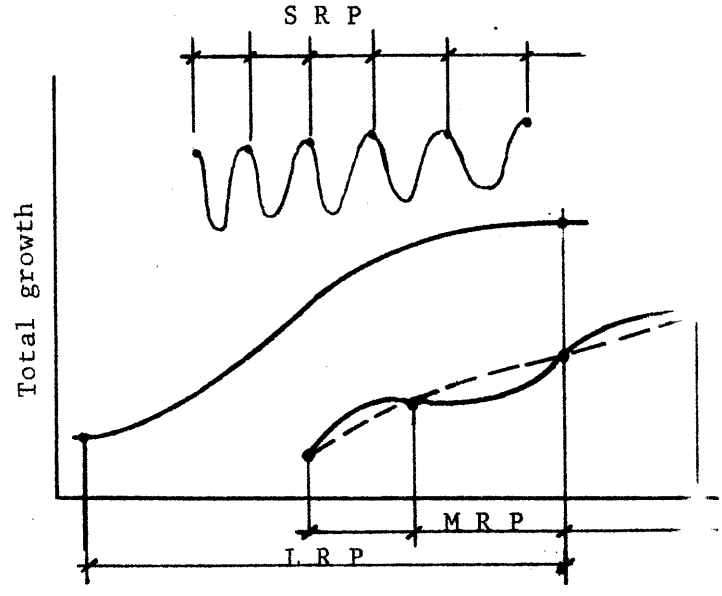


Fig.1.4 Cyclic Periodicy of Urban Phenomenons:
Long
Middle
Short Range

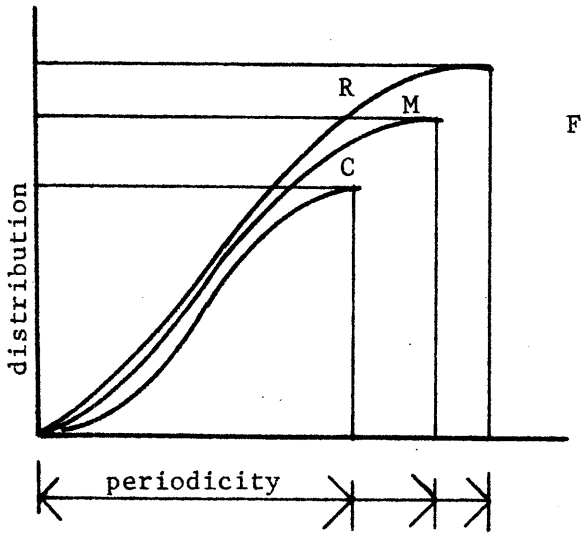


Fig. 1.5 The probability growth in city, metropolitan and regional urban areas

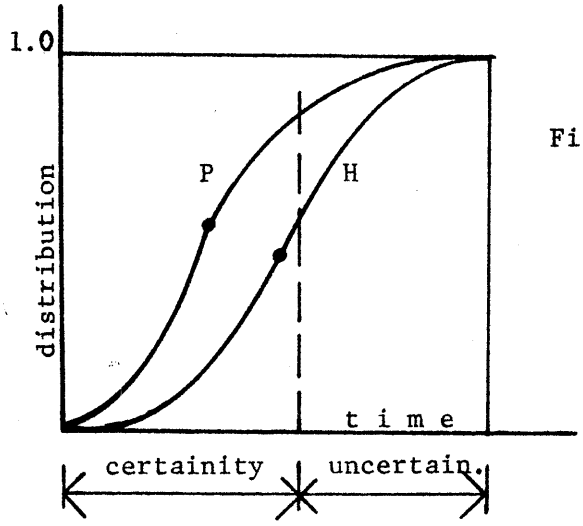


Fig. 1.6 The probability pattern of lation and housing growth

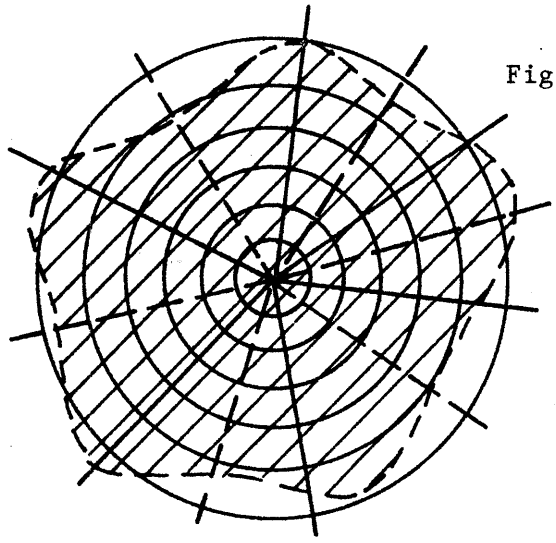


Fig. 1.7 The spatial division of urba by circles and sectors.

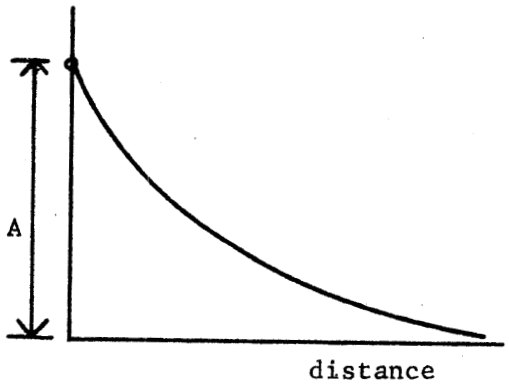


Fig. 1.8 The Colin Clark's exponential function of population density

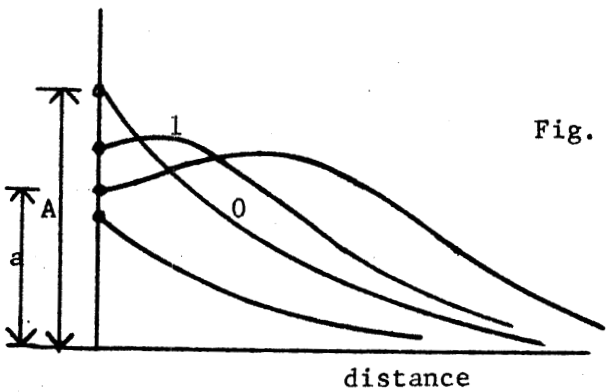


Fig. 1.9 Time changes of population density

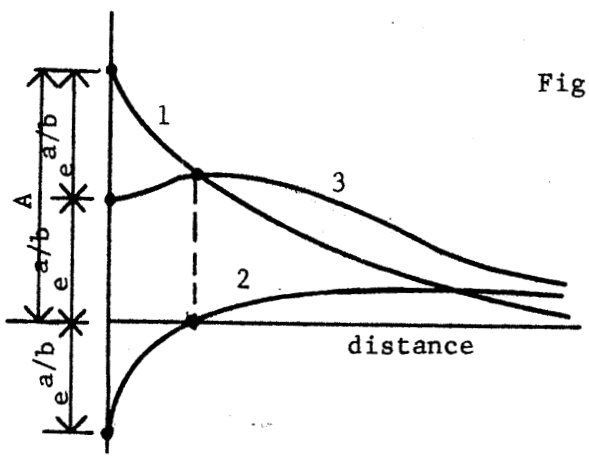


Fig. 1.10 Changes of population density after its culminated growth in the

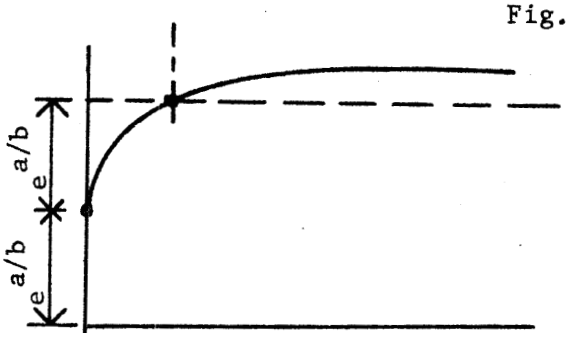


Fig. 1.11 The auxiliar function of the population density redistribution

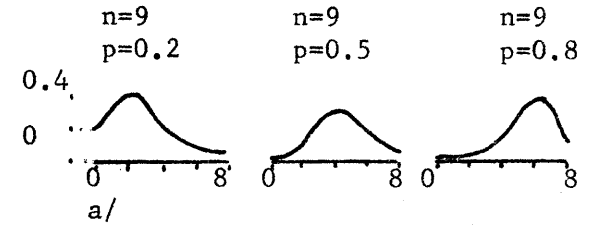
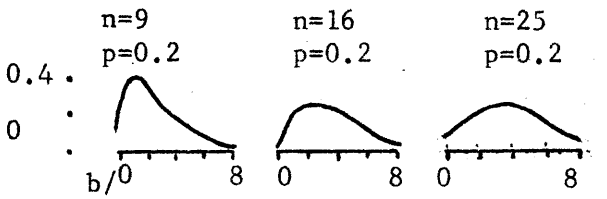


Fig. 1.12 The Binomial probability mass function for various pand n
a/ fixed n
b/ fixed p



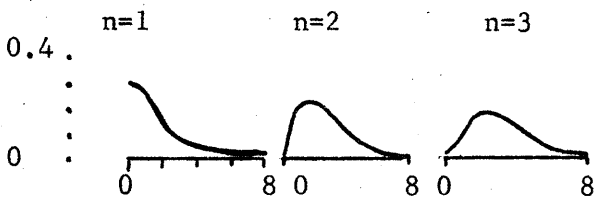
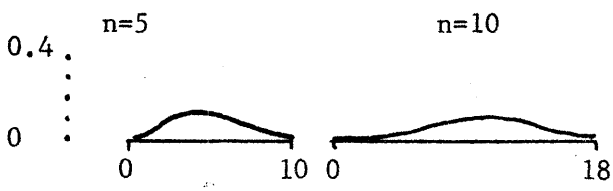


Fig. 1.13 The Poisson probability mass function for variuos values of



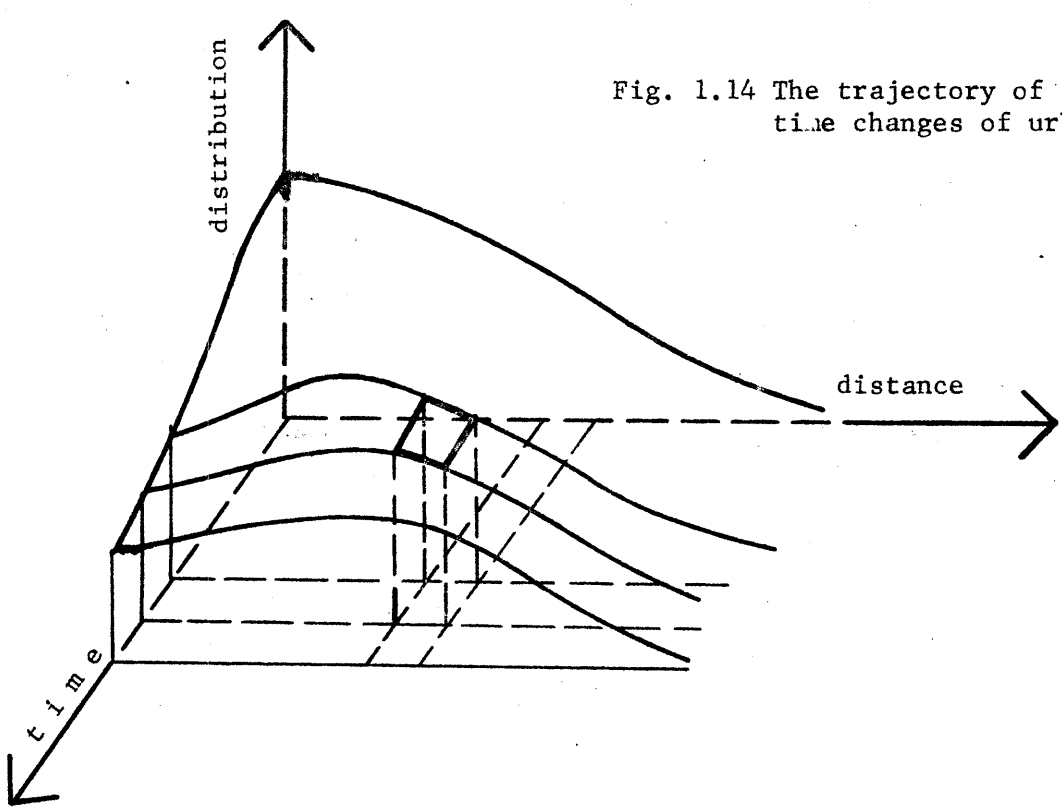


Fig. 1.14 The trajectory of spatial and time changes of urban r

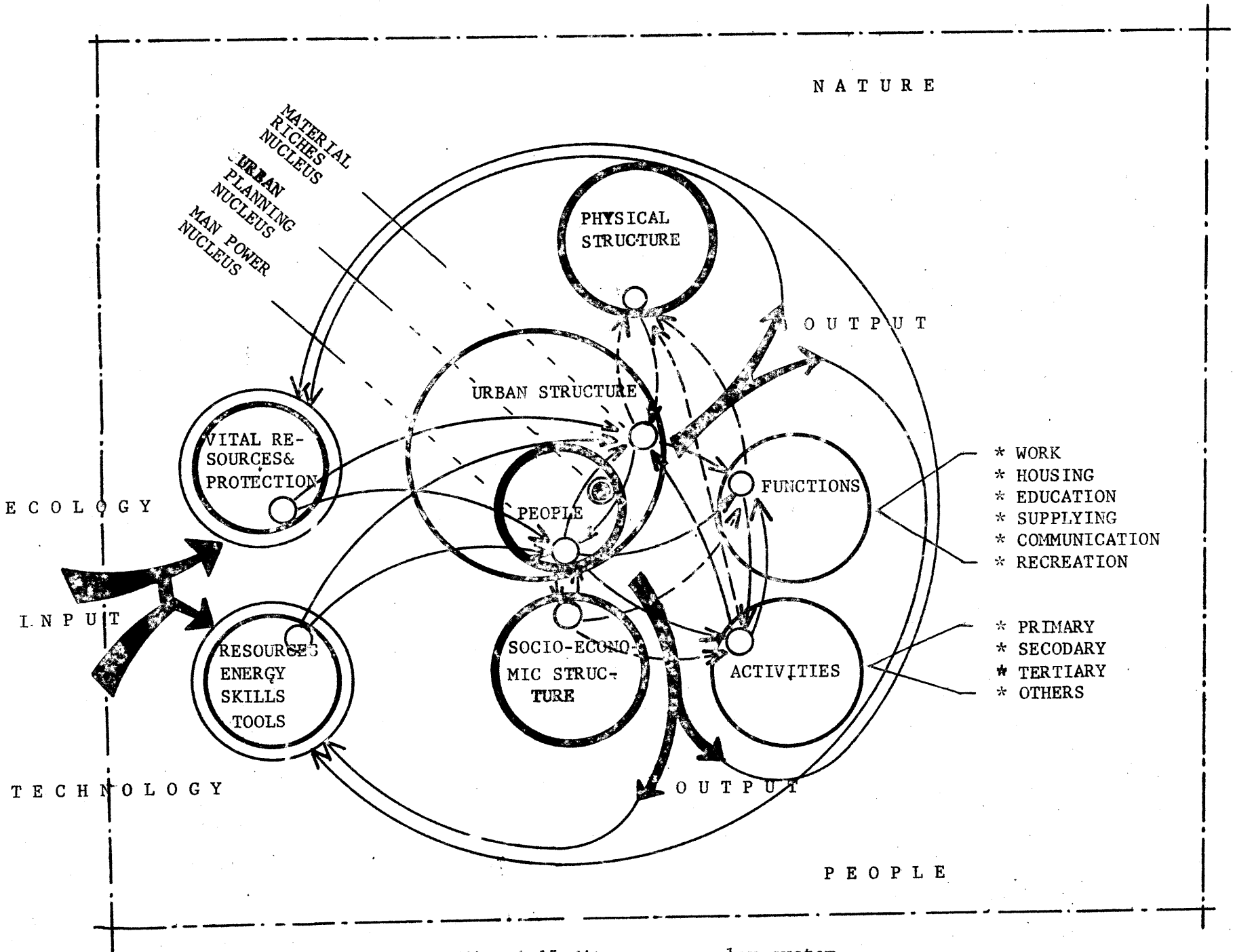


Fig. 1.15 City as a complex system

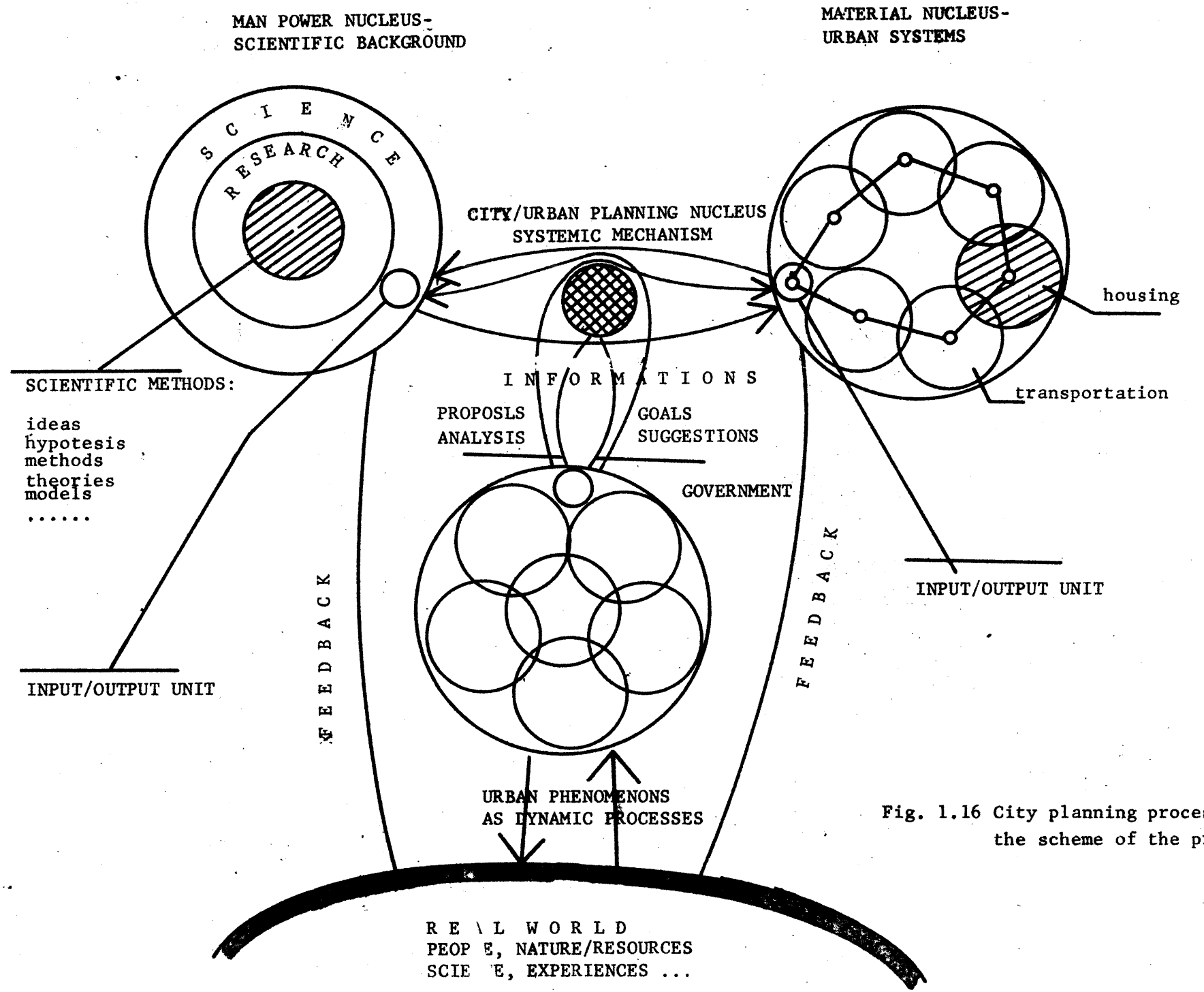


Fig. 1.16 City planning process - the scheme of the procedure

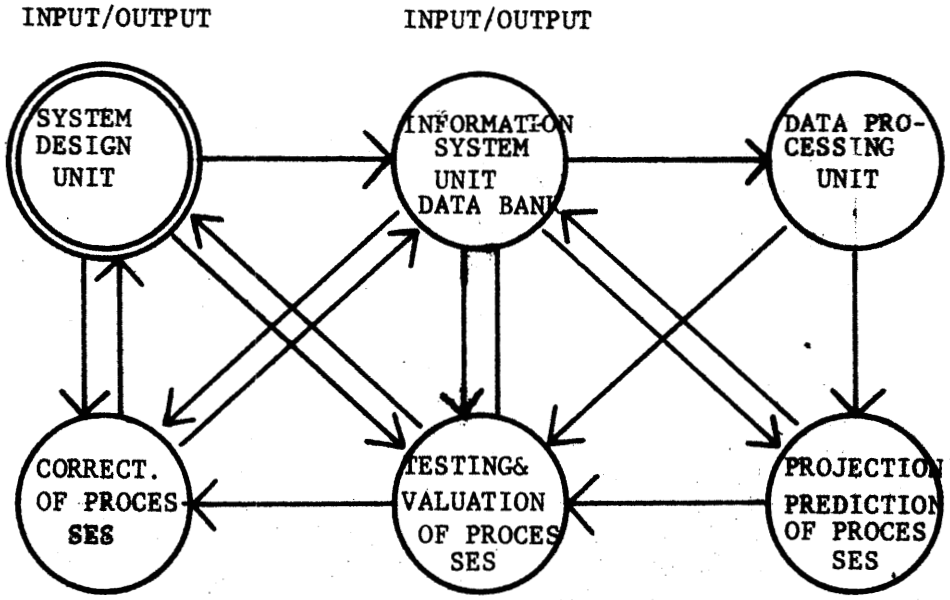


Fig. 1.17 The scheme of the city planning integrated system

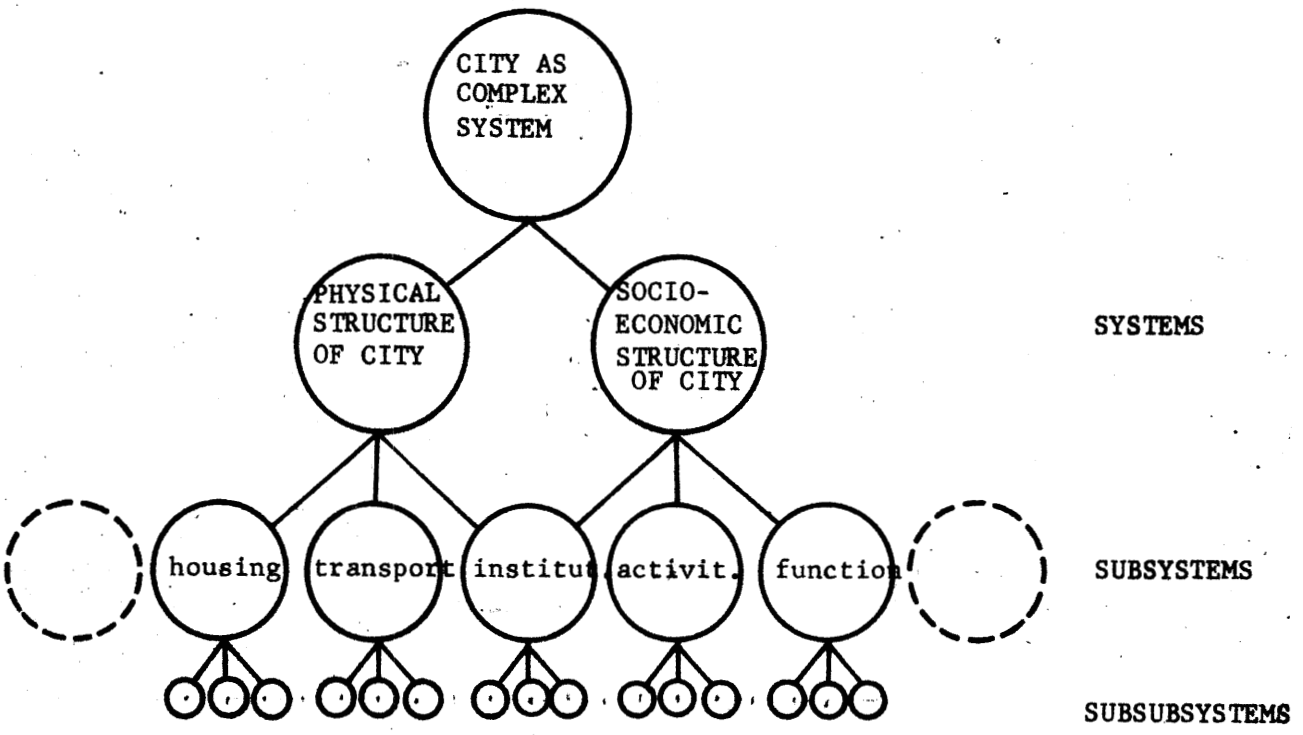
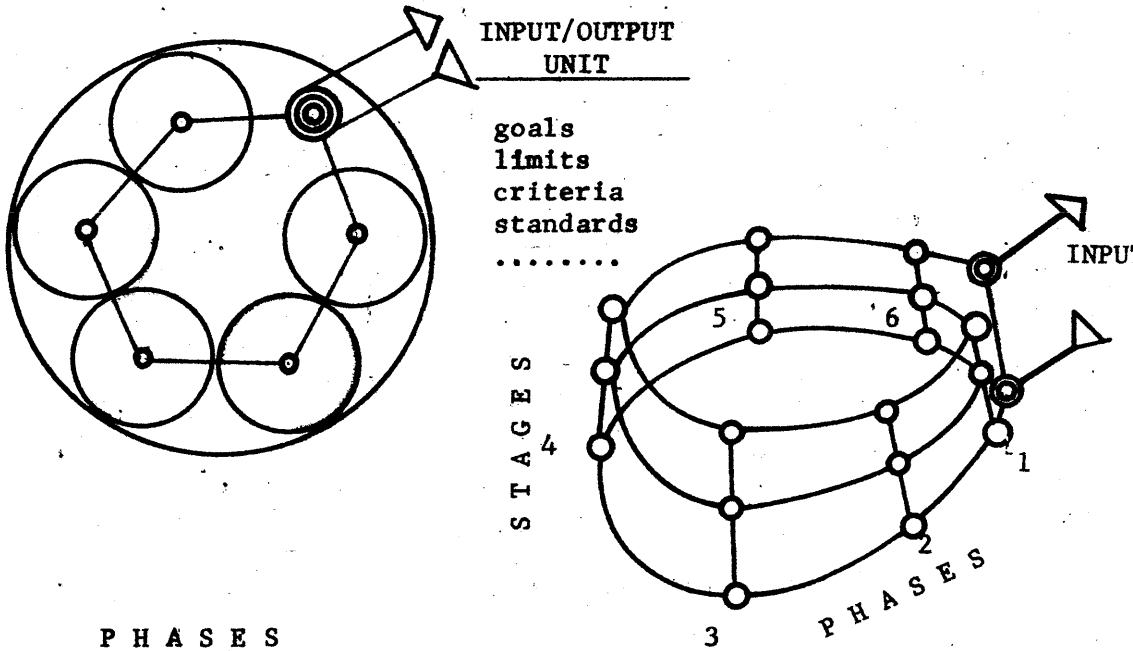


Fig. 1.18 The scheme of the planning system levels

Fig. 1.19 Housing planning process integrated in the city planning process - phases and stages

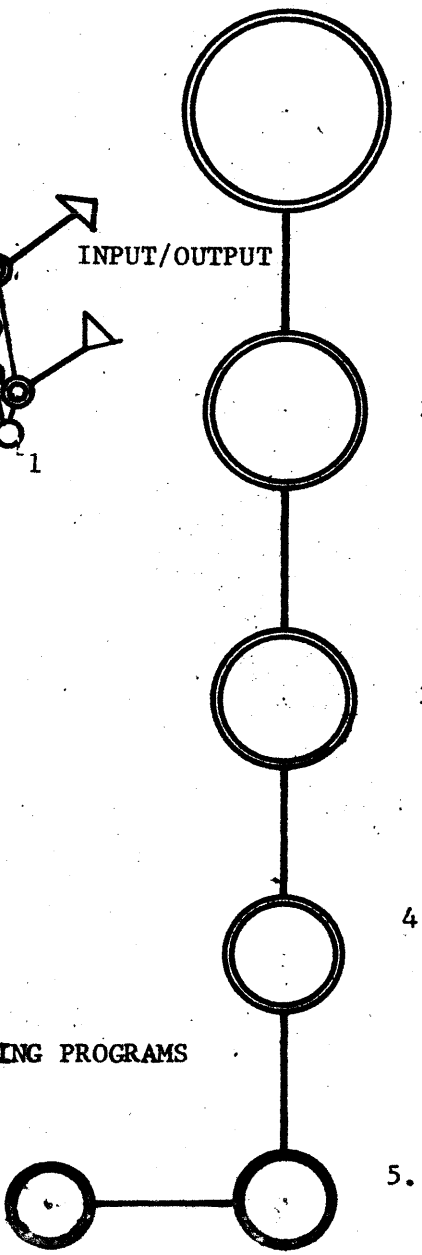
PHASES OF URBAN PLANNING PROCEDURE



P H A S E S

1. INPUT - TASKS, VERIFICATION (System design unit)
2. INDENTIFICATION OF PROCESSES (Data bank)
3. DATA PROCESSING, QUANTIFICATION AND ESTIMATION
4. PROJECTION&PROGNOSIS OF PROCESSES
5. TESTING AND EVALUATION OF PROGNOSIS
6. CORRECTION OF PROCESSES
1. FORMULATION OF PROPOSALS, SYSTEM DESIGN

S T A G E S



1. URBANIZATION PROCESS ANALYSIS
2. MACRO REDISTRIBUTION OF POPULATION IN THE METRO AREA OPTIMIZATION ANALYSIS
3. BALANCING OF PFYSICAL URBO SYSTEMS .EQUILIBRIUM THEORIES
4. QUANTIFICATION OF HOUSING NEEDS AND DEMANDS
6. HOUSING PROGRAMS
5. MICRO REDISTRIBUTION OF POPULATION - COMMUNES

Part 2 - POTENTIAL MODEL OF RESIDENTIAL URBAN AREA OPTIMIZATION

1. The Task

The purpose of this model is to analyze some consequences of dynamic processes of urban growth and to investigate the optimal relation between work places and housing, operating with the constraint of the minimization of distances and costs of transportation and land use. The task was formulated in the following sense: Functions of population (or employment) and work places distribution in urban space should be changed in order to get minimal transportation and land use costs (operating with distance and time changes too).

Such a formulation can be simply expressed in a mathematical way:

$$C = T_c\ (d,t) + L_{uc}(d,t) \qquad (1)$$

where:

C - total cost in the urban area

T_c - transportation costs with work purpose

L_{uc} - land use costs, including land costs and land development

d - distance variable observed from the center towards the periphery

t - time variable, observed in terms of the basic time

2. The Concept

The concept was based on the following postulates and principles:

-- Employees wish to shorten trip time and driving distances from home to work place, although these depend on traffic conditions and the transportation network. Thus, it is not simply a question of random choice but of objective conditions.

-- Work places might be concentrated to take advantage of common services and to have proximity to institutions and activities of general city importance

(business, administration, education, recreation, etc.). This concentration may be in the city core (CBD) or on the periphery or outside the urban area. Other activities, particularly retail services, should be decentralized and dispersed through the residential area in order to minimize distances between home to these work places.

These postulates and principles are based on the premise that people wish to save time in everyday communication and journey to work. Also, a metropolitan area has at least one point of gravitation (CBD) which attracts labor force although work places are presently mixed by general and specific purposes.

Movement is not only characteristic of traveling and communication. Activities and building structures also move in space and time, although slower and in a specific way. Manufacturing, services and shopping centers may move from or towards the CBD. This is a dynamic process, not plainly visible but existing never-the-less. What are the consequences of such movement? This question can be answered by the model presented here, or at least can be better understood.

The diagram in Figure 1 illustrates the principal relation between employment* work places and trip distribution functions which are mutually inter-dependent. Curves W, T, E represent probabilistic functions of mass distribution. The surface ABC represents the surplus of work places in the central business district (CBD) having general importance. Theoretically, it might be divided, partially in the suburb or out of the compact urban area. The surface BD indicates the net shortage of work places in the inner city and in the suburb. Consequently, trip distribution is between the W and E functions, because the imbalance between work places and labor force generates more movement in a residential area of work place shortages than in residential areas with work place surpluses. Theoretically, if W and E functions are identical ones, the relation between T and E(W) would be as Figure 2 shows.

---

* meaning employees living in urban residential area.

The small surface between T and E/W functions means that trips are generated more in the suburb because the central city traditionally attracts more employees. Such unified E and W function also generates more pedestrian traffic.

Thus, our task was formulated as the development of a model which can help in finding the optimal relation between functions of work places and employment distribution, considering that they are historically in transition, changeable in space and time.

3. Structure and Components of the Model

The applied method implies the division of the urban area by rings and sectors, as explained previously (1st part, 1st chapter). The presumption is that employees go from one urban unit area (in a particular ring and sector) to all other units of work places in accordance with certain probabilistic rules (see Figure 3). This case involved two kinds of probability:

1) that employees go from one ring (residential-origin) to all the the others (working-destination).

2) that employees go from one residential sector to all other working sectors.

These probabilities should be corrected by a work place coefficient, meaning that employees will get jobs in a particular urban area depending on available work places.

This movement probability is developed on the basis of probabilities which should be calibrated and tested for every city situation.* The equation (1) represents two added functions of many variables:

---

* Theoretically it would be possible to develop such a model as the function of the gravitation power (one or more focal urban structure) which does not need calibration, only estimation of such attractiveness power (expressed by the surplus of work places, for instance).

$$T_c = \Theta\ (P_d,\ E, \varphi,\ t_e,\ P_r,\ P_s,\ P_w,\ F_d,\ S,\ t_c) \quad \ldots\ldots (1.1)$$

$$L_{uc} = (S,\ l_v,\ l_d) \quad \ldots\ldots (1.2)$$

The symbols have the following meaning:

P_d - population density/acre

E_d - employment density/acre

W_d - work place density/acre

φ - employment multiplier (dimensionless)

t_e - generated daily trips per employee

F_d - factor distance between origin and destination (in miles)

S - surface or origin urban area (in acres)

t_c - average unit traffic costs (per mile)

l_v - unit land value/acre

l_d - unit land development costs/acre

P_r - ring probability of movement (dimensionless measure: $0<x<100$)

P_s - sector probability of movement (dimensionless measure: $0<$

P_w - work place coefficient (dimensionless $X_1<1<X_2$)

The equation (1), including preceeding variables, has been developed in the following mathematical formula for the particular time:

$$C = t_c \sum_{j=1}^{s} \sum_{i=1}^{r} F_d \left(\prod_{m=1}^{3} \prod_{n=1}^{4} P_m T_n \right)_{ij} + \sum_{j=1}^{s} \sum_{i=1}^{r} S_{ij}\ (l_v + l_d)_{ij} \qquad (2)$$

where the symbols have the following meaning:

C - total costs of urban area, expressed by rings and sectors

Pm - total probability (ring and sector and corrected by the P_w coefficient) in ij-urban area

T_n - total generated trips in ij-origin urban area

F_d - factor distance from origin to destination

t_c - average unit transportation costs

l_v - land value of ij-origin urban area

l_d - land development cost of ij-origin urban area

S - surface of ij-origin urban area

i - index of rings

j - index of sectors

r - total number of rings

s - total number of sectors

The partial equations of the equation (2) are:

$$P_m = P_r \cdot P_s \cdot P_w \qquad (2.1)$$

$$T_n = P_d \cdot S \cdot \varphi \cdot t_e \qquad (2.2)$$

$$S_{ij} = (s_i + s_{i-1}) \cdot d_{i/2} \qquad (2.3)$$

$$l_v = \xi\left[(d),t\right] \qquad (2.4)$$

$$l_d = \phi\left[\eta(P_d)\right] \qquad (2.5)$$

$$F_d = \sum_r r_i + \sum_s s_{mi} \qquad (2.6)$$

where the symbols have the same meaning as previously, including the following ones:

$\xi\left[(d,t)\right]$ - land value as the function of distance and time

$\phi\left[\eta(fd)\right]$ - land development as the function of the population density function

$s_{i,i-1}$ - sector (curve) lines for the i ring (boundaries i, i-1)

r_i - length difference between two rings i-1, i+1

s_{mi} - middle sector line in the i ring

The meaning and mathematical formula of preceding relations are explained below.

3.1 The movement probability function (P_m)

This is a twofold probability: rings and sectors corrected by the work place coefficient. This means that employment from origin to destination can be expressed as percentages, depending on distances and work-place locations.

The rings probability represents typical binomial probability, given by the next formula: (figure 4)

$$P_{(r_i)} = \frac{r!}{i!\,(r-i)!} \cdot p^i \cdot (1-p)^{r-i} \quad 1^*$$

where:

r - total distance (number of rings)

i - sequence in r (ring)

p - probability that employee goes to the i ring

In this case the pattern of probability is a nonsymmetric with a surplus of work places in the central city. Theoretically, if workplaces are proportionally distributed (E and W functions being identical) the pattern of probability would be symmetric. Also, it would be possible to determine the probability pattern for two or more urban focal points (more CBD).

1* See the reference 1.

Sector probability can be expressed by the standardized normal distribution[2*] (figures 5,6):

$$P_{(sj)} = \frac{1}{\sqrt{2\pi}} \cdot e^{\frac{-j^2}{2}} \qquad (2.1.2)$$

where:

j - distance (sector)

e - base of the Natural Logarithm

The multiplied ring and sector probability represents the total location probability, which means that work journeys depend only upon the location factor, not on the available job in a particular area. The location probability should be corrected by the coefficient of work places.

This is the coefficient of available jobs and depends upon the relation between work places and employment functions in the area destination (for i-ring, in every j-sector). The mathematical formula for this coefficient is (see figure 7):

$$Pw = \frac{W}{\sum_r W} - \frac{E}{\sum_r E} \qquad (2.1.3)$$

The value Pw represents the difference (percentage) between work places and employment distribution. This coefficient depends upon the actual situation, on the distribution of work places, as

---

2* See reference 1. In another case, the urban pattern can represent a part of a full circle, and the probability should be the Binomial, with a symetric shape. (see figure 6)

well as on employment or population distribution. If the relationship between work places and employment is changeable, the probability to obtain a job in a particular area should also be changeable. Therefore, the total movement probability variable (Pm) includes the location probability, which is supposed to be a stable statical system, and the reality to set work place, that is a dynamic system, representing changes of activities and population redistribution in the urban structure.

3.2 Total Trips Function (Tn)

This function (equation 2.2) implies the multiplication of four parameters: population density, the employment multiplier, generated daily trips per employee, and the surface of origin area.

3.3 Population Density Function (Pd)

This was explained in the first chapter. Observing by rings or distance, population density represents a complex exponential function (see Chapter 1, equation 3). This function is changeable through time and is, in fact, the base for simulation of possible situations. Changing the shape (parameters) of the population density function, one can estimate consequences (time and money losses) in terms of the work place distribution function which exists in reality (it is fixed) or to find the optimal relationship changing both population and work places.

3.4 Employment Multiplier ($\mathcal{S}$)

Generated by population and employment distribution density, this multiplier is a function of distance, as was Pd, but it may oscillate depending upon the relation between the Pd and Ed functions. Theoretically, it might be constant if the distribution of population is proportional (in sectors) and if the population

composition is homogeneous (the employment ratio constant) meaning that the number of employees per inhabitant is the same in all urban areas.

3.5 Daily Trips Generated Per Employee (t_e)

These were observed only in terms of private transportation (automobile). Although such transportation is the predominant mode for work journeys, the degree of which depends on the local development of public transportation, the reason for an emphasis was more related to time constraints than to theoretic difficulties. It is true that consideration of public transportation would complicate the probability model of work journeys, but it would be possible to develop it in a similar way as was done for private transportation. It might also be more simple to do so considering that public transportation has much less variation in terms of lines and directions of movement. The modal split should be estimated in order that the model of movement in a city would be more nearly correct and objective. Our understanding of problems, however, allows us to assume that public modes are not very considerable and can be neglected in this analysis.

Trips per employee is a function of distance which, in turn, reflects socio-economic characteristics (income and car ownership patterns) of population distribution. It can be changeable from area to area or constant through space. It can also be changeable through time. So the introduced method, with observation by ring and sector, can help to reflect such variations.

3.6 Surface of Observed Urban Area (S_{ij})

This depends upon the location and parameters of ring and sector division of the urban area, and it may have a different shape: a part of a circle, trapezoid, or simply a rectangle.

3.7 Factor Distance

This factor represents the real distance from the origin area to the destination area, counting distances between centroids, by rings and sectors. This factor is, in fact, changeable depending upon ring and sectoral division of an urban area, particularly the former. Rings in the division scheme can influence distance changes but this deviation cannot be considerable because the total deviation is related to the total urban area, and in the consideration of the total area may be disregarded. Also, the different choices of the route can influence the distance, although the probability of the choice of the shorter distance should be high. It should distinguish two cases: analysis of potentialities (independently of existing transportation network) and analysis of existing situations, including the existing network of roads and habitual movement routes. Figure 3 shows different possibilities of route choices. Figure 8 shows the maximum possibilities from one origin to all destination areas.

3.8 Unit Traffic Costs

This factor involves several issues which depend on parameters observed and analysis undertaken. Two basic possibilities exist. The observation of a potential situation, such as new construction or reconstruction of the transportation system network, implies building, operating and transportation costs. The observation of the existing situation can imply operating and transportation costs. In both cases there is a problem of determining unit costs as constant or variable. Constant costs are average costs, resulting from the integral character of the transportation network in terms of initial investment, taxation, and also if there are no variations in the intensity of use. Operating costs can vary with driving speed (see the following Part 3), intensity of use, etc.*

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* See Colin Clark, Population Growth and Land Use, MacMillan, London, 1967

The field of observation can encompass a highway or freeway system, but it can also include the rest of the system of roads and streets, although this would depend on the specific tasks of the analysis. If public transportation is included, costs should be observed separately by system, for precise analysis of the advantages of different transportation systems or averaged for approximate analysis of the population and work place distribution, as is likely in this study. Considering other variables included in the equation (2), most traffic costs, constant or variable, should be expressed by distance.

3.9 Land Use Costs

This function implies two superimposed functions: unit land values (per acre) which are changeable in time and space (having a stochastic character), and land development costs which depend on the intensity of land use (residential or population density). The second one can also be changeable in time, depending upon current prices. Land values are capable of being statistically determined, and judging from the Detroit situation total land value shows that it is presently stagnating (according to current prices) with changes in its spatial distribution, decreasing in the inner city and increasing in the suburbs (see Figure 9). Land development costs (per acre), i.e., infrastructure, facilities and other development (without residential houses) depend on population or residential density. Lower density generates higher unit costs and vice-versa. The shape of these changes (exponential function) is shown in Figure 10.

The determination of unit development costs as well as the total land costs in the distance function are shown in Figure 11.

4. Extension of the Model by a Housing Variable

Land use costs should be extended to include housing costs in the following way:

$$L_{uc/i_j} = S(l_v + l_d + H_c)_{ij} \qquad (2.1)$$

where the variables and parameters have the same meaning as before including housing costs which are the production of building density and housing unit costs:

$$H_c = B_d \cdot h_c$$

where:

B_d - building density (sq. foot of dwelling floor surface per acre)

h_c - unit housing costs per unit dwelling surface (sq. feet)

4.1 Building Density Function

This function may be changeable in space and time. It can be transformed and exposed by population density in the following way:

$$B_d = P_d \cdot d_s \quad (2.12)$$

where:

P_d - population density (population per acre)

d_s - average dwelling surface per inhabitant

The P_d function is changeable in time, shaped in a particular way (see foregoing chapters). The d_s function depends on location and correlates with population density. Higher population density generates a lower d_s, and vice-versa, but it also increases with distance. In other words, the d_s function increases with distance (from the center towards the periphery), according to the exponential function:

$$y = ae^{bx} \quad (2.13)$$

Therefore, the total building density function can be derived as the population density function multiplied by unit dwelling surface, as shown in Figure 12.

4.2 Housing Costs

There are two basic situations: 1) rental apartments and 2) owned apartments. The function h_c represents rental housing costs, composed of three variables:

amortization, maintenance costs and profit. Figure 13 represents a typical relationship between basic rental components. This relationship can vary, e.g., showing higher profit and lower operating costs indicating symptoms of physical or moral deterioration of the housing stock. Low amortization also indicates a slower reproduction of housing stock. Housing costs (Figure 14) (h_c) include mortgage, which is usually for a shorter period than the house's life (30 years for instance) and operating costs, which depend on the type of building, materials used and building standards where they exist. The shape of operating costs function is usually "S." with total value depending on the house age. For the 60-year period it should be something more than 100 percent of the initial value of the house.* Figures 13a and b represent the total combined rental housing costs in one period, and differential ones (per month for instance). Figures 14 a and b represent total and differential housing costs for apartments under ownerships. Between these two basic cases various alternatives are possible, representing more or less profit, slower and insufficient maintenance, different mortgage periods, etc. which can generate different conditions in the housing stock, various living conditions for the same house and sometimes even for the same investment.

5. The Demonstration of the Model - An Hypothetical Example

The task is to find the total urban costs (traffic, land and housing) for one particular urban area (unit in the Ring 4, the Sector 1) in which trips are generated and distributed in all other urban areas (see Annex 1, Figure 1) and to demonstrate the behavior of the established dynamic system in terms of 30- and 60- year periods.

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* According to results of a UN study about different aspects of housing costs.

The reasons for the observation of behavior of the dynamic systems in these two periods include some of the characteristics of urban and human life such as those given below.

The thirty year period roughly represents:

1) the employment period in the life of a man

2) the long-range orientation of the city master plan

3) the usual housing mortgate period

4) a period in which changes in urban structure and the results of planning actions appear as visible realities.

The sixty year period represents:

1) the mature life of an individual

2) the typical housing age, although today this is tending to be less than the 60-year period

3) this is at least one half a cycle in city development

Such partial demonstration of the presented dynamic system can only be a rough simulation of reality but something more than intuitive guessing of changes of urban dynamics. It should help to understand urban development more completely, and may be encouraging for the demonstration (simulation) of the potential model in its entirety.

The basic parameters necessary for the demonstration of the model are given below, according to the situation shown in Annex 1, Figure 1.

S_{41} = 110 sq. mil

P_{d41} = 2500 inh/sq. mi. (4.5 inh/acre)

$\mathcal{G}_{41}$ = 40%

t_{e41} = 2 trips/employee

t_e = 0.1$/mile (average for operating and transport)

D = 100,000 dwelling units

Other transportation parameters are presented in the following matrix. The movement probability (for the origin UA_{41} to the all urban destination areas) is determined on the basis of ring and sector probabilities (roughly estimated, see Annex 1, figures 2, 3). The work place coefficient (for every destination area) is based on the data for Detroit (1953 survey, see part 3) and adjusted to this model (5 instead of 6 sectors).

The Matrix of Movement probability (Pr,Ps), work place coefficient (Pw) and the model split (Pm) are given below:

P_w / P_{r4} / P_{s1} / P_m	P_{wr} P_{4-1}	P_{wr} P_{4-2}	P_{wr} P_{4-3}	P_{wr} P_{4-4}	P_{wr} P_{4-5}
P_{ws} P_{1-1}	1.0078 13 40 5.23	1.0068 34.5 40 13.90	1.0026 34.5 40 13.80	0.9832 15 40 5.90	1.0495 3 40 1.26
P_{ws} P_{1-2}	1.0087 13 24 3.12	1.0106 34.5 24 8.40	1.0058 34.5 24 8.35	0.9990 15 24 3.60	1.0087 3 24 0.70
P_{ws} P_{1-3}	0.9971 13 6 0.80	0.9866 34.5 6 2.07	0.9847 34.5 6 2.06	0.9696 15 6 0.87	1.0102 3 6 0.22
P_{ws} P_{1-4}	1.0072 13 6 0.80	1.0048 34.5 6 2.10	0.9946 34.5 6 2.09	0.9836 15 6 0.88	1.0392 3 6 0.28
P_{ws} P_{1-5}	0.9981 13 24 3.10	0.9894 34.5 24 8.20	0.9774 34.5 24 8.10	0.9661 15 24 3.46	1.0119 3 24 0.71

The factor distance (principally the shortest possible is used) is presented in the following matrix: (in miles)

sectors \ rings	1	2	3	4	5
1	15.00	10.00	5.00	2.50	5.00
2	18.14	19.40	22.70	22.00	27.00
3	21.28	28.80	36.40	44.00	49.00
4	21.28	28.80	36.40	44.00	49.00
5	18.14	19.40	22.70	22.00	27.00

5.1 Traffic costs

The first part of the task (traffic costs as a function of trips generated in area 41) are computed by the formula:

$$T_c = F_d * \left(\prod_{m=1}^{3} \prod_{n=1}^{4} P_m * T_n\right)_{41}$$

The result of one part of this analysis (the total route in miles) traveled by employees every workday from urban area 41 to all others, are presented in the following matrix (in millions of miles):

rings

sectors \ rings	1	2	3	4	5	Σ/%
1	172	308	152	30	14	676 17.9
2	124	360	420	174	42	1120 29.9
3	38	132	166	78	24	438 11.4
4	38	134	170	78	28	448 11.9
5	122	348	404	168	42	1084 28.9
Σ/%	494 13.0	1282 34.0	1312 35.0	528 14.0	150 4.0	3,766 100.0

The total traffic costs (operating and transport) per day would be: trip-miles, multiplied by unit costs:

$$T_c = T_n^1 \times t_c = 3,760,000 \times 0.1 = 376,000$$

The costs per year are:

$$T_{c1} = 376,000 \times 200 = 75,200,000$$

After a 30 year period the total cost is:

$$T_{c30} = 75,200,000 \times 30 = 2,256,000,000$$

A comparison of the movement probability and the distribution of traveled miles from the origin area to all destination areas, by rings and sectors shows some interesting characteristics.

Observing both distributions by rings, there appears to be a close correlation (see Figure 15). The possible deviations are logical consequences of longer journeys from peripheral rings, and a larger number of trips gravitating to the CBD.

Observing both distribution by sectors (see Figure 16) there is considerable deviation, meaning a saving of distances as a consequence of main journeys located in the original urban area.

The observation of traffic costs through time shows dynamic changes as a linear function (see Figure 17). Computed costs per year will be 75 million dollars and after 30 years, 2.26 billion dollars. Expressed by dwelling unit, traffic costs will be $750 per year and $22,600 for 30 years. Of course, such linearity is the result of fixed parameters such as population density, trips per employee, transportation unit costs. As they change in time, the deviation of the total costs function can be expressed as increasing or decreasing.

5.2 Land Value and Development Costs

These two components should be determined in a deductive way. Supposing the total market price of a typical family residence in a Detroit suburb is presently about $30,000, and the land value, judging by Detroit also (situation in 1960 see Part 3) may be about $5,000 per dwelling unit, land development costs can be obtained by subtracting housing building costs (a known value) or tabulated below we have the situation:

Resid. House Market Price	$30,000
Land Value	5,000
Land Development Costs	5,000
Housing Building Costs	20,000

Observing in terms of a 30-year period, several possibilities of investment appear:

1 -- To buy open land and to mortgage land development costs

2 -- To buy open land and to pay land development costs immediately

Both situations are presented in Diagram 18.

5.3 Housing Costs

There are several possibilities for housing costs:

- To build new houses and mortgate them in a 30-year period and to invest in maintenance gradually.

- To inherit existing houses older than 30 years which should be maintained and possibly modernized depending on the real (building and usage) value.

- To destroy existing houses and to build new ones in which case the land development costs must include the costs of replacement units.

This dilemma, however, disappears after the 30 year period. In an economic sense, the situation is sufficiently obvious for houses in ownership as the total housing costs imply mortgate and maintaining costs, as is shown in Figure 19.

The first diagram represents the solution of building new houses: mortgate in the first 30 year period and continual maintenance through the first and the second period.

The second diagram shows the construction of new houses in the second 30 year period.

The third diagram represents the modernization of the existing housing stock, mortgaged until the end of the current 60 year period and, afterwards, the building of new housing stock.

In all three cases operating costs are determined approximately as 0.7 building value of new houses after 30 years and 1.2 after 60 years.*

5.4 Synthesis and Conclusions on the Costs Analysis

One may have two kinds of reservations about the analysis presented in such a hypothetical example: 1) because of the observation of the separate urban unit in one complete integral process (such as changes in urban structure in terms of population, work places and traffic distribution), 2) this analysis does not include construction costs of the transportation network because of the difficulty of finding any useful information concerning it. These costs can have a great influence on decision-making and the answering of relevant questions as when and how to undertake changes of urban structure after a characteristic period, e.g., 30 and 60 years.

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* This approximation is done on the basis of the UN Study of housing costs.

Parameters used in the hypothetical example, however, were real, and possible deviations could emphasize the importance of traffic costs and eventually housing costs, but such a fact probably would not change the conclusions to any great degree.

Total urban costs, observed as a function of time, grow roughly linearly until the end of housing mortgate period (30 years, see Figure 20). The most important component is traffic costs, (33%), and housing mortgate a little less (30%). If we observe housing mortgage and operating costs together, it may be more than 1/2 of the total costs.

Land costs do not represent an insurmountable economic barrier for urban development as they represent about 15% of total costs.

The relatively high traffic costs generated in the observed urban area are the result of relatively longer traveling distances from the CBD. In other words, traffic costs are rising with the distance from the CBD, in spite of a decreasing of its attractiveness (movement of population and activities to the suburb). Consequently, rising population density in the suburbs generates considerable losses in time and money in everyday transportation. The slower movement of activities than that of population in the suburbs emphasizes these losses.

The end of the 25 or 30 years is a time for important decisions with respect to changes in urban structure. Consequently, housing costs should be observed simultaneously with traffic costs. The next 30 year period may mean the maintenance of the existing housing stock, but a growth of traffic costs as in the preceding period should also be expected. In this case, traffic costs and total housing costs become roughly equal (each about 45%). Such

an increase in traffic costs through time indicates reconstruction possibilities for the residential area to build new housing stock and generate those urban structural changes which can bring about a decrease in traffic costs.

Temporal changes in total urban costs indicate one basic problem with respect to the character and quality of housing stock. That is, whether to build: 1) cheaper houses which require more maintenance and after the 30-year period to build new housing stock, 2) high quality houses which require minimal maintenance in the first 30 year period with a gradual increase in the second 30 year period, or 3) houses of medium quality with reasonable maintenance costs in the first 30 year period with a later need to build new housing stock. The answer to this problem depends on the location in the urban area. It seems reasonable to build the first type in the suburb which has usually meant one-family houses, with an effort to keep a relatively low population density. The inner city can be built with the third type which can allow for higher population density, but also allows for reconstruction and urban structural changes (e.g. increasing density) after one characteristic period (30 years). The dilemma is what type of house should be built in the CBD as a part of the inner city. If it is necessary to keep relatively high population density, because of the concentration of activities there, it would be reasonable to build the third type also, and to enable considerable reconstruction of the CBD after a 30-year period. This would be reasonable considering also the expected rapid technological progress. If it is necessary to achieve higher population density the first type would be more desirable. Of course, technological progress in the building domain can enable more rapid changes in urban structure, more rapid reconstruction of higher quality houses, but it might be necessary to develop prefabricated building systems.

As for the present situation of American central cities which are awaiting rehabilitation and being of a relatively low density, it would be useful to build new houses in the future and to expect changes of urban structure (middle quality and reasonable operating costs).

After each 30-year period (Master City Plan duration) the needs for the internal restructuring of urban area to change density and activities in the inner city and suburb should be very seriously investigated. Urban sprawl should be stopped because of the tremendous losses in driving time, traffic costs, and land development costs. The way to accomplish that is through the restructuring of the inner city if living and economic conditions of the Metropolis allow. In fact, hesitation to rebuild presently declined central cities must necessarily stimulate the extension of the suburb and the acceleration of urban sprawl. The restructuring of the suburb and re-building of the central city should be synchronized on the basis of typical time periods (e.g., 30 years).

When a more stable relationship between the suburb and the inner city (1-2 cycles) is established, it might be reasonable to form new urban centers in metropolitan or regional areas. Such a concept should also be developed through a kind of optimization analysis.

A concentrated structure of the inner city, as well as the contraction of the urban area in the whole have more technic-economic advantages in terms of traffic costs, transportation building costs and land costs. Although it is not possible to conclude anything more precisely according to this partial analysis, the model is directed to answering such questions which stimulate urban structural changes for the urban area in the whole (equation 2).

6. Advantages, Limits and Possibilities of the Model

The model deals with urban dynamics through five basic parameters: population and work place distribution, transportation, land use and housing. The city is observed as one dynamic system, as the integration of urban area units in which people live, work and communicate every day.

The first purpose of the model is simulate space and time changes of urban structure and to estimate their economic consequences. Such analysis enables us to understand what happens in the housing domain and why, observed in the context of urban growth and development. It also enables us to understand what and how some actions should be undertaken for the rehabilitation of the central city, as well as for the restructuring of the suburb. The preceding hypothetical example showed that building action in the suburb and central city should be synchronized, and only in such a way can regular urban growth succeed.

The second purpose of the model is to determine an optimal distribution of population and work places, which are the process in transition and to estimate the necessity of stimulating existing processes or of redirecting them. The housing market can also be planned in a more integrated manner because it is possible to estimate what quality of housing should be built where and when in the metropolitan area. Such a task implies not only better economic effects (saving of money) but also superior choice. Sub-populations of different social characteristics can have a better choice among different types of houses.

The possibility to predict interzonal work trips and to determine the modal split probability distribution of trips can enable better, cheaper and more precise transportation planning in terms of the system, kind of transport, etc. This field of planning has two requirements: 1) to prove

that the probability of the work trip modal split is a stable system, or at least little changeable over time, 2) to extend the model by a public transportation variable that would require the analysis of the actual situation in a city, or alternatively, examination of its future situation. As for the first requirement, there are indications that the presented modal split is stable, judging by empirical investigations for Detroit (see the third part).

As for the second requirement, it was previously explained that such a problem can be solved in the similar way as was done in this model.

The planning of land development and land use, in general, can be made easier and more successful. If such analysis enables the estimation of economic and technical consequences for existing trends of land value and land development costs, it would be easier to decide upon and to fix the policy of urban land sufficiently in advance to make it more effective, e.g., to discourage land use speculation.

The limit of the model is that only one focal point urban structure was considered, characteristic for a considerable number of metropolitan areas. The same principles can be used to develop a model for urban structures with two or three focal points. A poly-centric urban structure within a dispersed area, when new urban centers appear or are about to appear, is a problem, which implies the development of a regional urban system. Such a problem could be solved for ring structure (one focal metropolitan center and several satellite towns) as a kind of urban equilibrium (stable circumstance). It should include population, economic and functional equilibriums, determined so as to minimize time and money losses in everyday communication, as well as to provide the proportional development of a system in demographic, economic and functional sense.*

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* Some ideas and one attempt of such modeling was done in the author's study, "Housing in Urban Planning," but it should be developed.

Further improvement and development of this potential model of urban optimization should be addressed to the disaggregation of input data in 1) a socio-economic sense (households, activities, etc.) and 2) a technical-economic sense (quality of housing, characteristics of observed transportation systems, etc.).

If some standards or thresholds are to serve as input data, the presented model can be transformed into a normative model (e.g. with respect to population density, work place location, transportation characteristics, housing quality and quantity, etc.).

7. Simulation Technique

The model presented by equation 2 is the multivariant dynamic system, changeable in time and space. Let us assign it again (extended by the housing costs variable) in order to explain better the simulation technique.

$$C = t_c \sum_{j=1}^{s} \sum_{i=1}^{r} F_d \left(\prod_{m=1}^{3} \prod_{n=1}^{4} P_m T_n \right)_{ij} + \sum_{j=1}^{s} \sum_{i=1}^{r} S_{ij} \left(l_v + l_d + H_d \right)_{ij} \qquad (2)$$

where:

$$P_m = P_r \cdot P_s \cdot P_w \qquad (2')$$

$$T_n = P_d \cdot \mathcal{G} \cdot S \cdot t_c \qquad (2'')$$

Equations 2' and 2" represent two dynamic subsystems, the first in the P_w function, the second in the P_d function.

The second part of equation 2 includes two independent variables (l_v and H_c) and one dependent variable (l_d) in terms of the P_d

function. These two independent variables are, in fact, the function of distance (location). This fact indicates that the simulation of the model should be conducted in such a way as to fix one part of the model and to simulate changes of the others. The simulation of the model has to imply the limits of the variables. If a computer technique is used, changes in variable observations can be recorded on the basis of smaller intervals. If the simulation should be done manually it would be useful to fix the middle value between extremes and afterwards to interpolate the remaining values.

The basic problem of the simulation is to follow changes of population density (equation 2'') by work place distribution, which influences the determination of the work place coefficient (P_w, see equation 2').

Since equation 2'' includes one variable (P_d) it should be the starting base for the simulation. The first step, therefore, should be to determine the P_d function in certain limits, as the set of exponential functions (see the first part of study) and deriving for each of them the probability distribution density (see Figure 22). The second step would be to determine the set of work place functions, computing P_w functions for each population probability distribution density (see Figure 23).

When the simulation of the first part of the model is accomplished, another part should be undertaken in a similar way, although every change in population density should be in input for the l_d function. Functions l_d and H_c would be changed independently: moving first one, with the second one, fixed etc. When the simulation of changes is completed for both parts of the model these values should be superimposed, systematically. It would be useful to move up the matrix of variables and fixed values. The superimposed C (total costs) must appear as its minimum value but may vary in small increments resulting from different compositions of cost components.

8. Behavior of the Model

Simulating changes of population and work place distribution within certain limits (by intervals which correspond to time sequences) will generate changes of traffic, land use and housing costs. Such changes represent an oscillating behavior of component cost functions: transportation, land use and housing. The geometric interpretation of this statement is presented in Figures 24-28.

Figure 24 represents the time series of differential traffic costs for all sectors. Using preceding conclusions, minimal costs will result from the concentration of population in the inner city, and conversely, maximum costs will result from the dispersion of population in suburbs.

Figure 25 represents two superimposed functions of differential costs of land value as an independent variable and land development as a dependent variable (on population/building density).

Both should be synchronized in time, and time series in certain limits would be obtained also.

Figure 26 represents differential housing costs which, on one hand, depend on population density changes, (i.e., addition or subtraction of housing stock) and on the other hand, depend on the quality of the housing stock (hheaper or more expensive houses). These costs may be represented by two sets of curves, generated by the quantity and quality of housing stock.

Figure 27 represents superimposed differential costs for three components (traffic, land use, housing), corresponding to the particular time sequence, derived for all sectors of observed urban area. By observing these changes in particular time sequences, the urban differential costs will be obtained as will the trajectory, changeable in space and time, as shown in Figure 28.

As the total urban costs represent the summation of differential costs (for the all urban area), the minimal costs will be generated in one (maybe more) time sequence for particular component costs (traffic, land use, housing), which theoretically must not be all minimal ones.

If we follow time changes of the real situation of a city, simulating model can then estimate approximately the measure and time of the minimal urban costs.

If we simulate a theoretical case (a potential situation), we can estimate precisely the measure and the time when and what minimal urban costs will be achieved.

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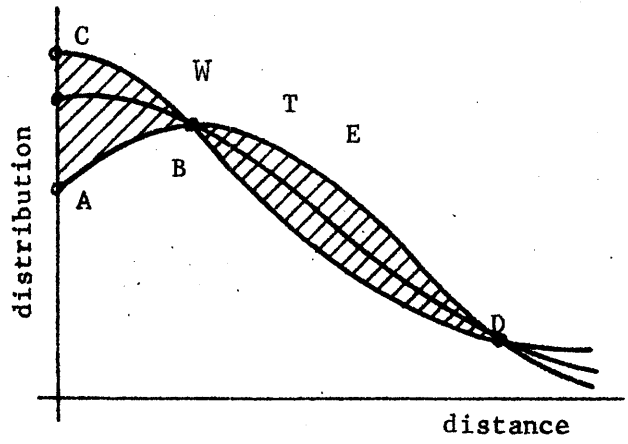

Fig. 2.1 Work place, employment and work trips distribution functio

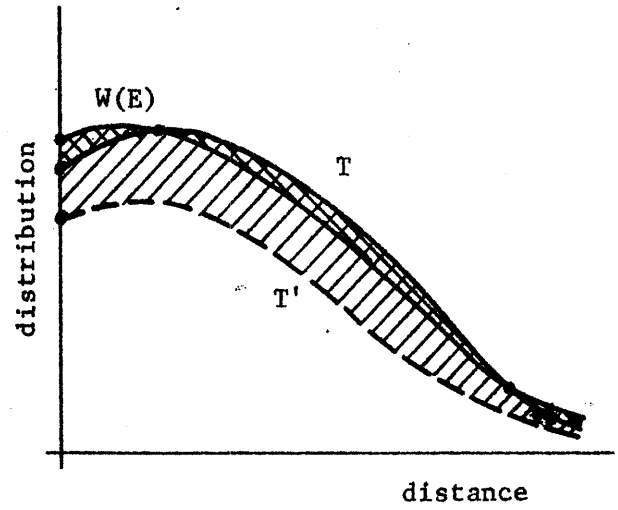

Fig. 2.2 Work place and trip distribution functions, when W and E functions are indentical. The T function is deviating slightly. The T' function indicates considerable pedestrian traffic.

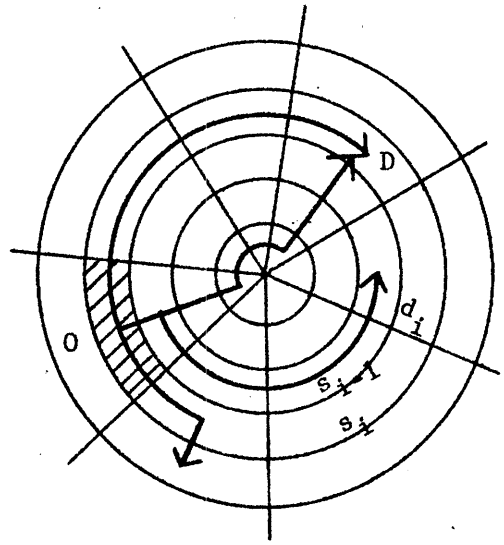

Fig. 2.3 The division of urban area by rings and sectors, and O-rigin, D-estination movements.

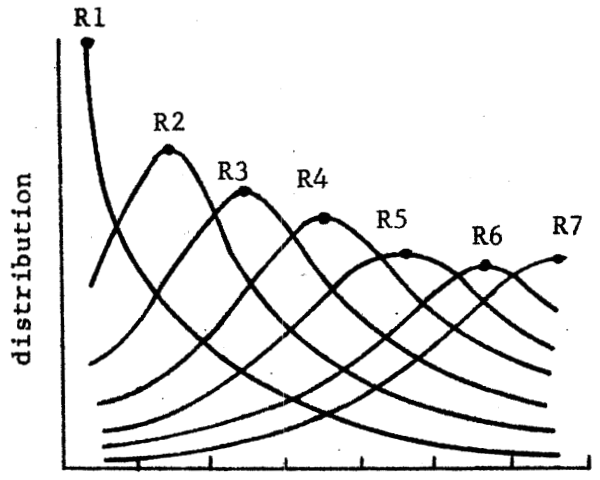

Fig. 2.4 The theoretical ring probability of movement. The Binomial distribu tion, an asymmetric pattern.

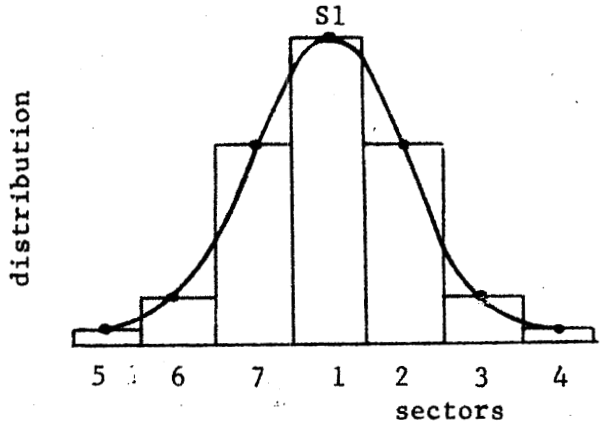

Fig. 2.5 The theoretical sector probability ov movement. The Standardized nor- mal distribution, a symmetric pat- tern, for the full circle urban are.

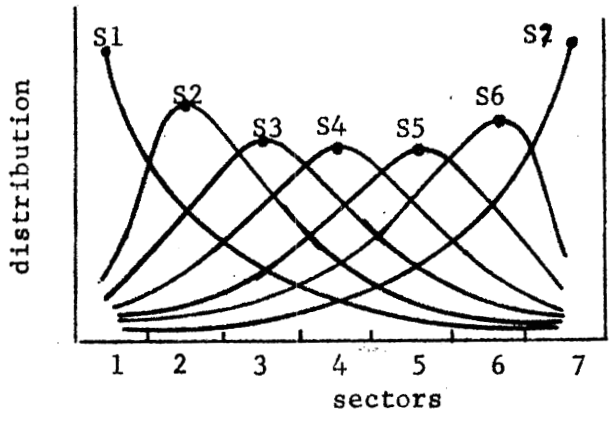

Fig. 2.6 The theoretical sector probability movement, for a part of circle urban area, a symmetric pattern.

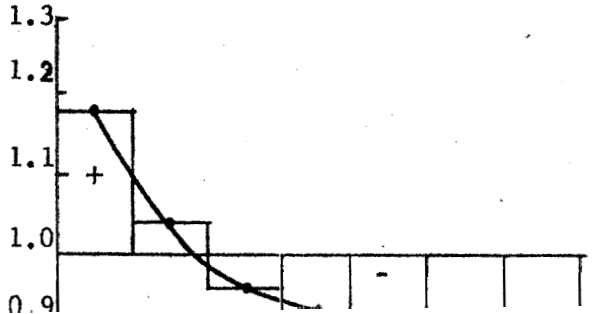

Fig. 2.7 The work place coeficient. The case coresponds to the situation shown on the fig. 2.1

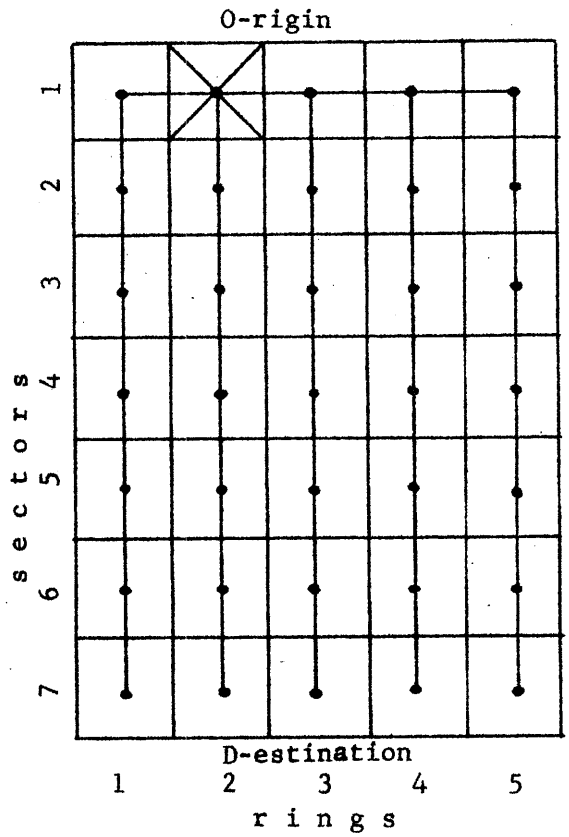

Fig. 2.8 Fig. The matrix of the factor distance, maximum possibility of movement

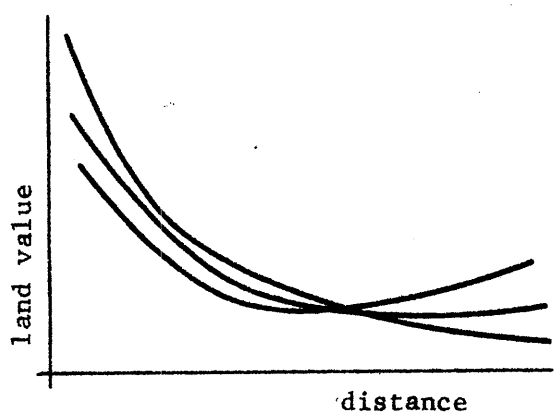

Fig. 2.9 Changes of land value. The time sery showing increasing in the suburb and decreasing in the central city. The situation is similar as likly in Detroit city in recent couple decades.

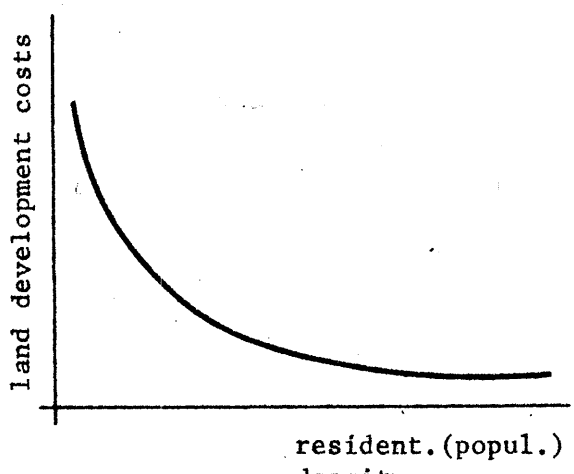

Fig. 2.10 Land development costs as the function of residential (population) demsity.

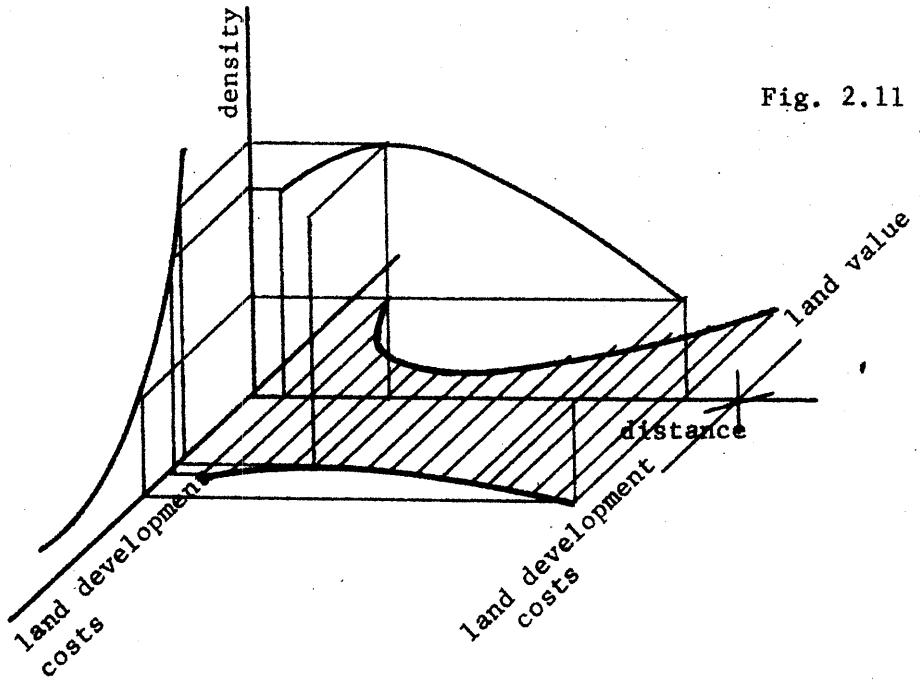

Fig. 2.11 The projected land development costs as the distance function and superimposed with land value.

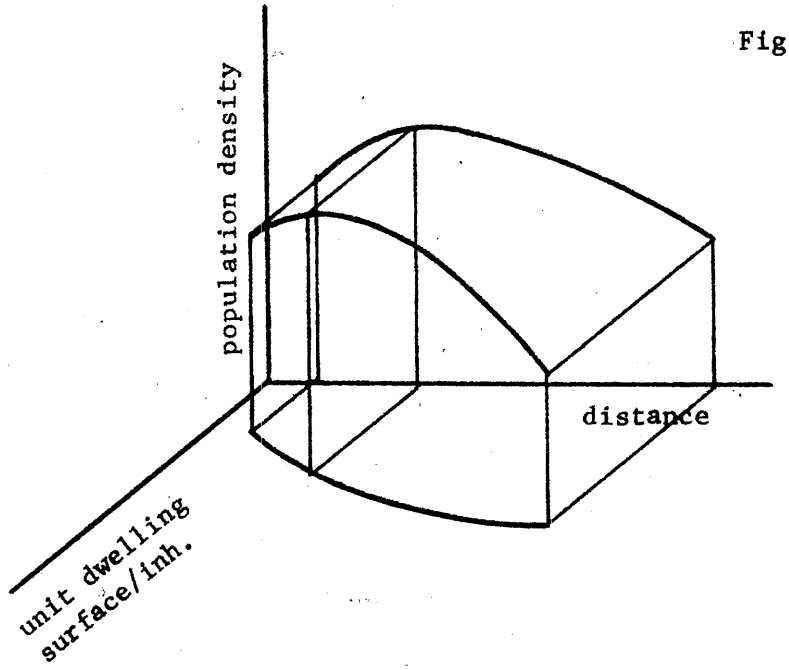

Fig. 2.12 The threedimensional diagram of the total building density.

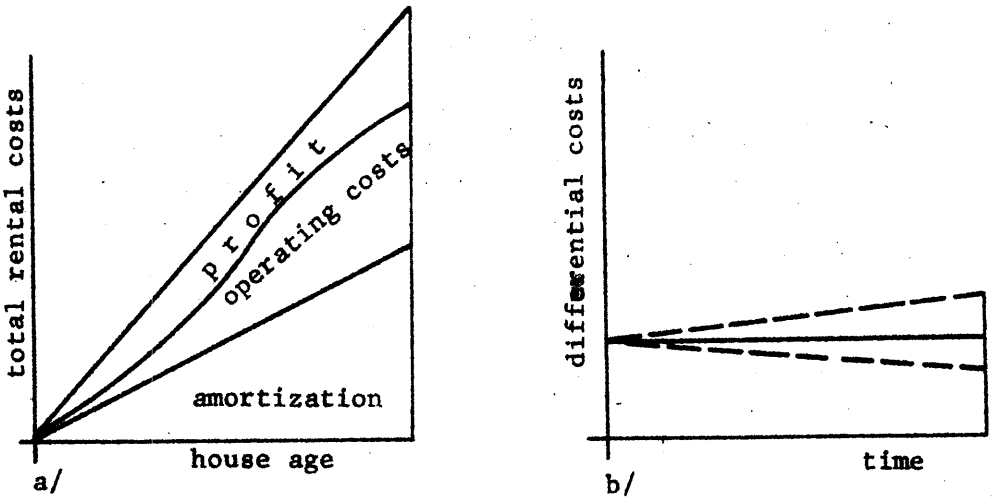

Fig. 2.13 Total (a) and differential (b) housing rental costs

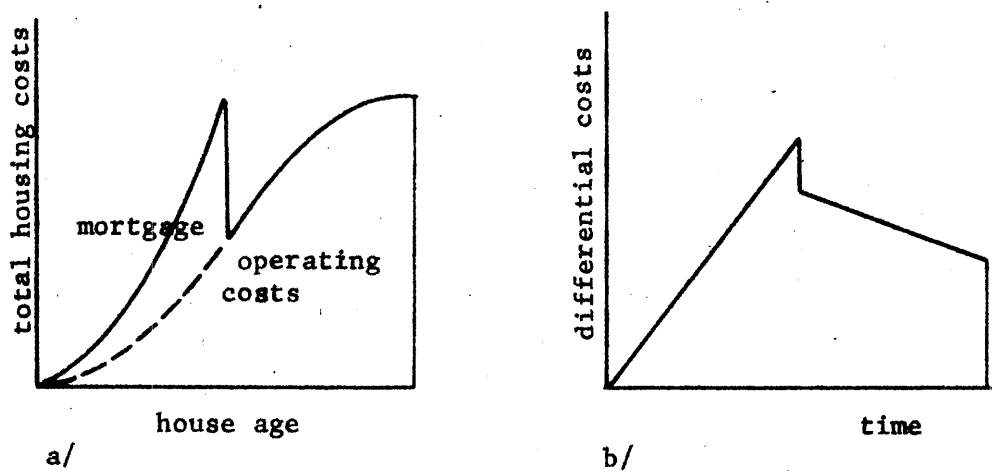

Fig. 2.14 Total (a) and differential (b) housing costs (ownership)

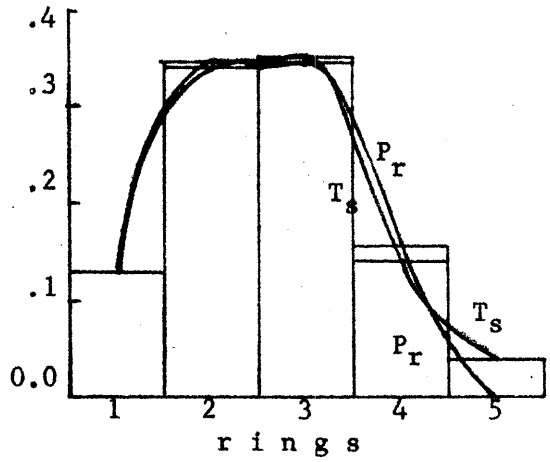

Fig. 2.15 Ring probability movement and trip/mile distribution

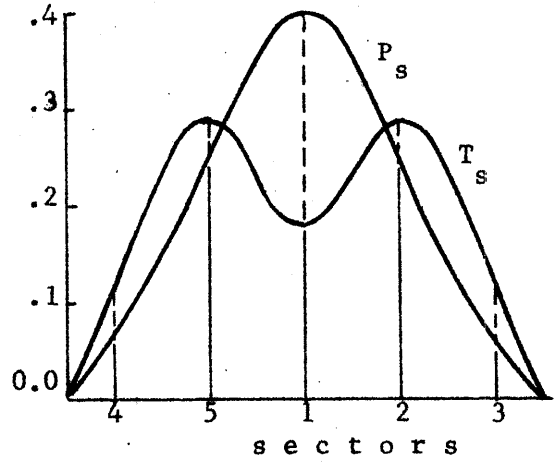

Fig. 2.16 Sector probability movement and trip/mile distribution

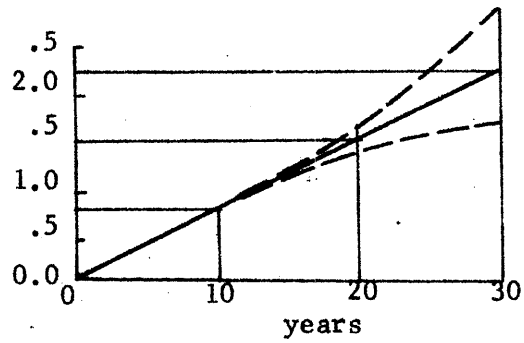

Fig. 2.17 Traffic costs

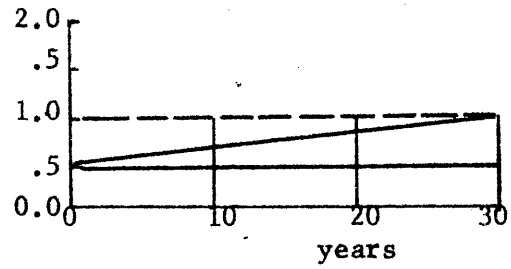

Fig. 2.18 Land value and land development costs

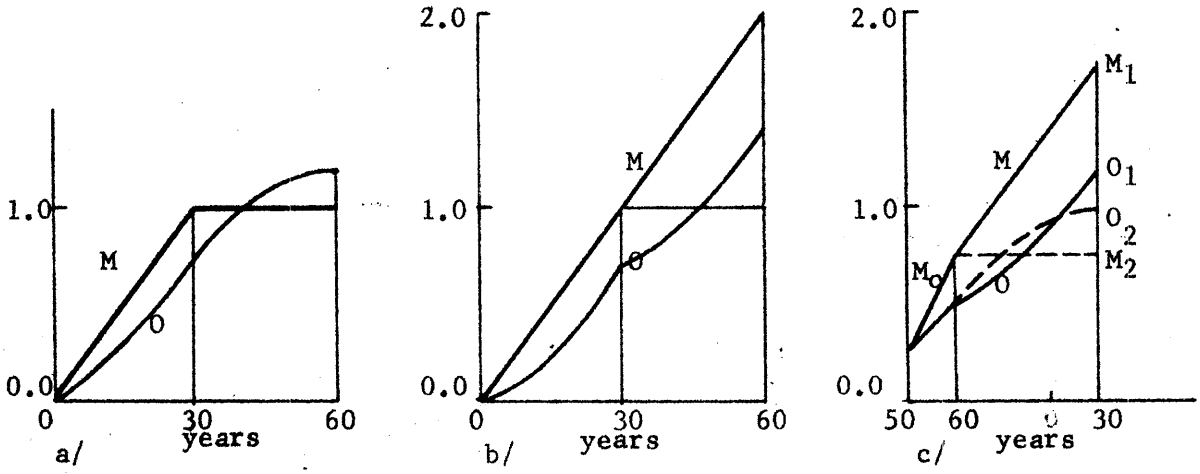

Fig. 2.19 Housing mortgage and operating costs
a/ maintaning after 30 years period
b/ new building after 30 years
c/ modernization (M_0) mortgage (M_1 and operating costs (O)

Fig. 2.20 Superimposed total urban costs (traffic, land and housing) for the observed urban unit UA_{41} after 30 and 60 years periods.

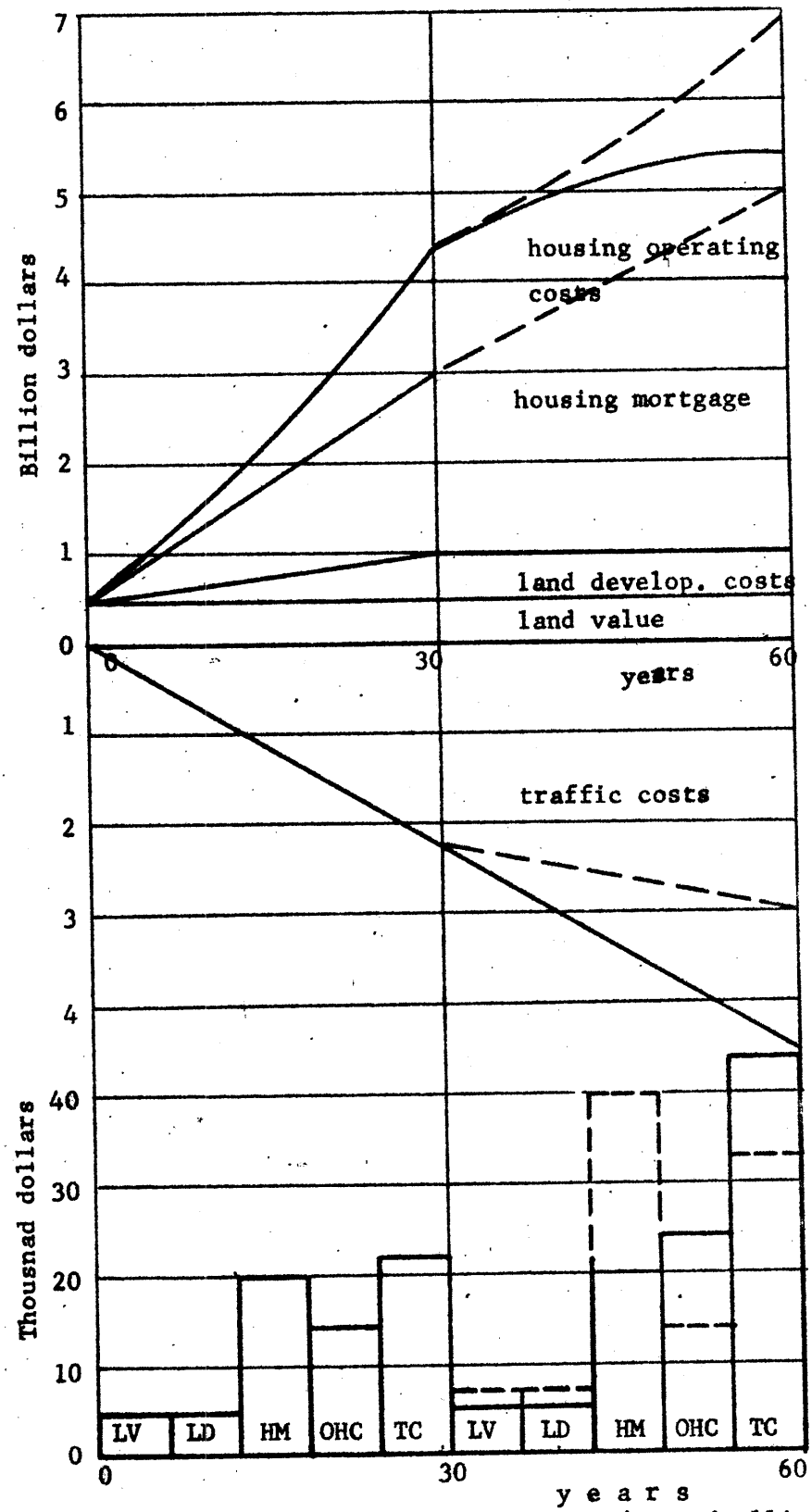

Fig. 2.21 Unit urban costs/ per dwelling

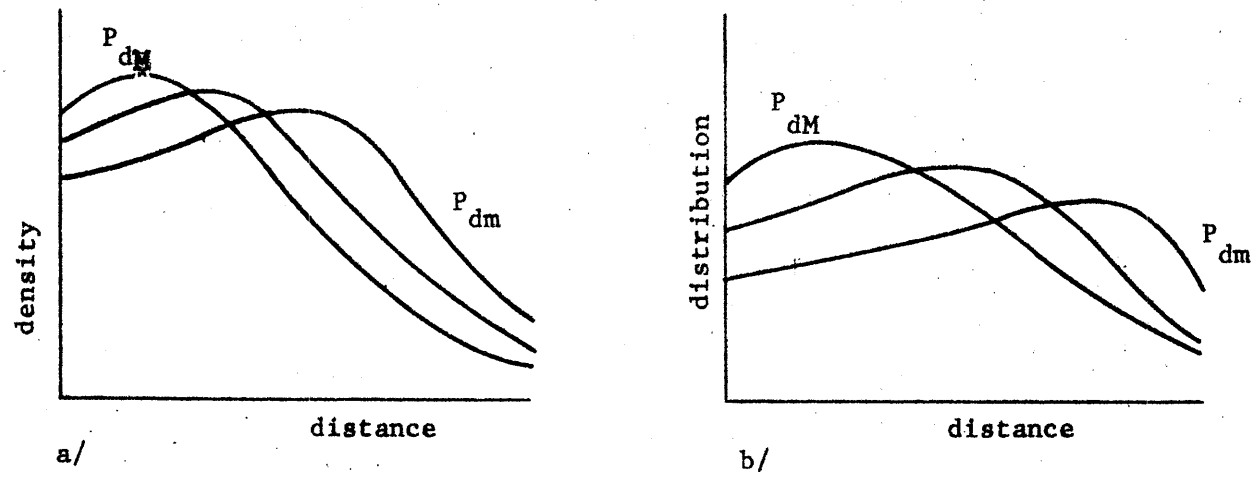

Fig. 2.22 The first step in simulation of the model of residential urban area optimazition
a/ population density changes
b/ population probability distribution

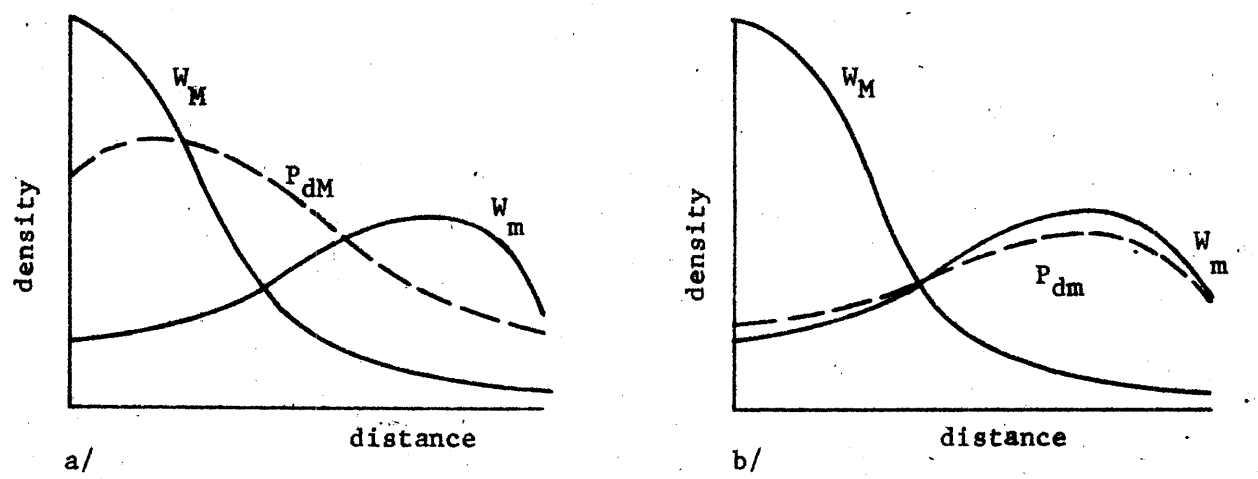

Fig. 2.23 The second step in the simulation of the model
a/ max. population density function and work places function changes in Max/min. limits
b/ Min. population density function and work place function changes in Max/min. limits

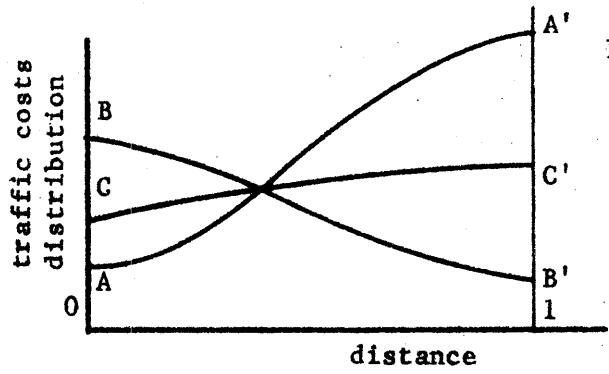

Fig. 2.24 Spatial distribution of traffic costs (differential). The surface AA'01 represents maximum costs, BB'01 minimal and CC'01 average costs.

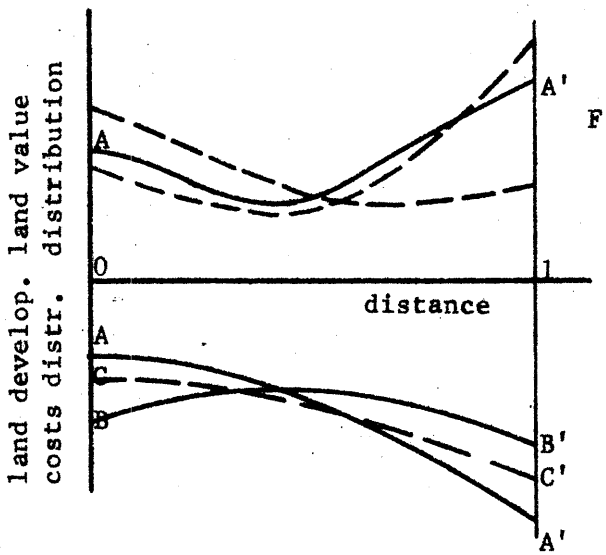

Fig. 2.25 Land use (differential) costs as superimposed land value and land development costs

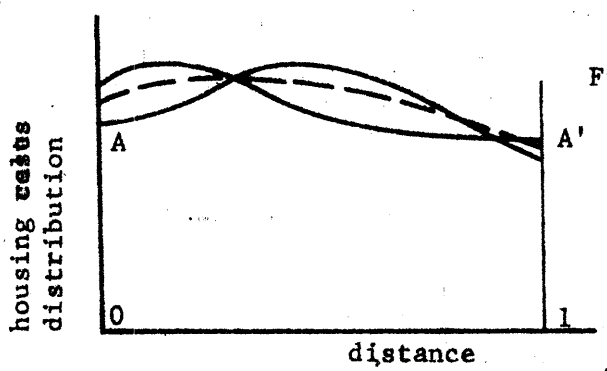

Fig. 2.26 Housing (differential) costs distributed in the space. Changes can vary depending on residential density and quality of added or subtracted stock.

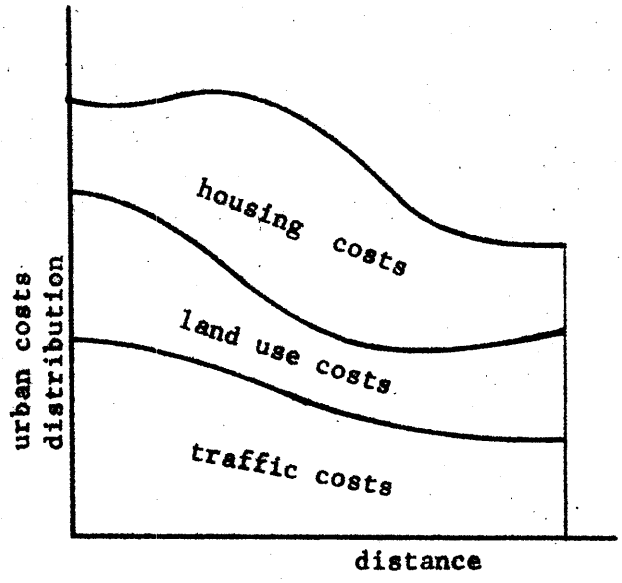

Fig. 2.27 Superimposed differential urban costs in the particular time

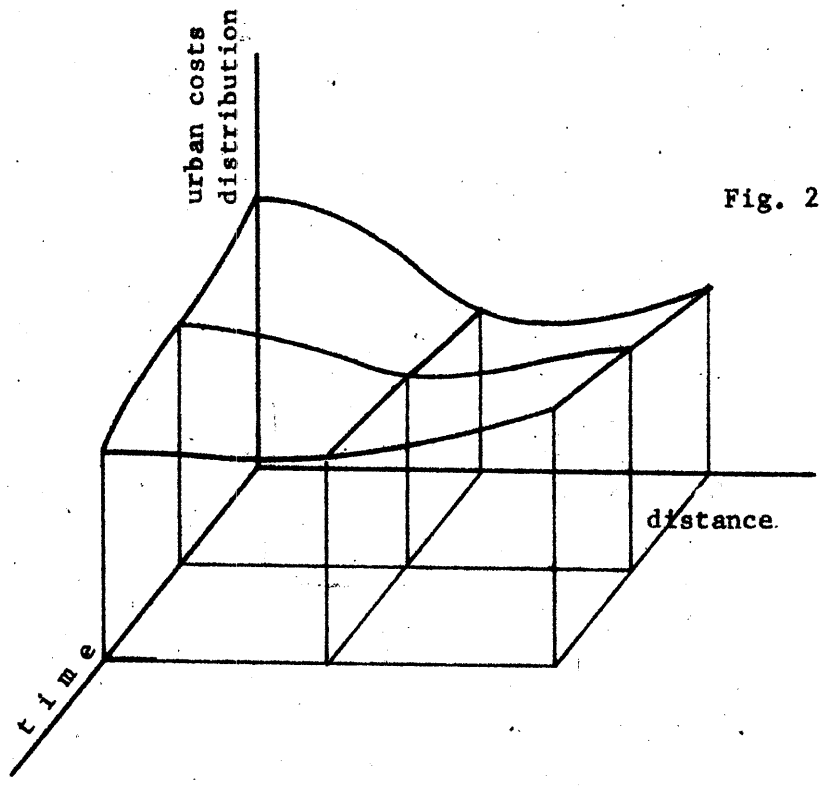

Fig. 2.28 Differential urban costs as the trajectory, changeable in space and time

Part 3 - EMPIRICAL INVESTIGATION OF URBAN AND HOUSING DEVELOPMENT OF DETROIT

This part of the study encompasses three chapters:

-- Trend analysis of basic urban phenomena,

-- Trend analysis of population and work place distribution,

-- Some comments on TALUS and UDA studies and conclusions of the empirical investigation.

The target of this investigation has been the analysis of housing development in the context of urban dynamics in the Detroit metropolitan area, using some methods exposed in the first two parts of this study. Although time was severely limited and in spite of many difficulties concerned with collection of not always available data, I managed to analyze trends of some basic phenomena relevant for comprehensive housing planning. I also managed, although not very precisely and not quite completely, to analyze and quantify the dynamic processes of redistribution of population, activities and consequently work trips, taking place between 1953 and 1965 from the central city to the suburbs. At the end I commented on some basic findings of two of the most important studies, TALUS and UDA, confronting them with our own findings and investigation results.

The basic problem of this investigation was inconsistent data for the same area at different times. Therefore, considering the dynamic character of the study, we analyzed available 1953 and 1965 survey data and statistical data. We also used some results and findings of two important studies, i.e., TALUS and UDA. Some statistical data and results of other studies were used, which are mentioned in the list of references.

Considering the imcomparability of some data in terms of space and time and because of their inconsistency, this investigationencompasses analysis of urban phenomena of Detroit in several scopes: SMSA (Standard Metropolitan Statistical Area) Detroit and three counties, TALUS (Traffic and Land Use Study)

of Detroit Metropolitan Area - DMA - including seven counties, Detroit Central City (DCA), and some very general observations related to Urban Detroit Regional Area (UDA) and the State of Michigan (see the map on figure 1).

1. Trend analysis of basic urban phenomena

Considering the foregoing theoretical background, it would be necessary to investigate at least five basic urban phenomena of Detroit in order to understand better the comprehensiveness of housing planning there: 1) population growth, 2) housing conditions, 3) land use and land value development, 4) transportation conditions changes, and 5) employment development.

These five phenomena are closely interrelated and correlated, and although each of them is caused by many different factors, they indicate positive or negative conditions of urban development of a city in the entirety. Consequently, they have to be developed synchronizedly in order for the urban development of the city to be progressive and regular. Reversely, their disparities and non-synchronization have to generate a lot of impacts in a socio-economic sense, losses in time and money, etc. Let us briefly review trends of these phenomena taking place in the Detroit metropolitan area.

1.1 Population growth

Population growth of Detroit Metropolitan Area (DMA) can be easier estimated comparing it with Michigan state and by population growth.[1*] In 1970, there were something more than 4 million people living in the DMA, which was about 50% of Michigan state population and 2% of U.S. population (see fig. 2). If we observe population in the past (in terms of 1970) approximatively estimating, U.S. population was doubled twice, after 50 and 35 years, and in the future it would be able to expect the same thing after 65 years. Population of Michigan

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1* See reference 1, Vol. 1, Fig. 11-A-1

state were twice doubled, both after 40 years, and it might be likewise in the next 40 years. As for Detroit Metropolitan Area, it was three times doubled after 30, 20, 10 and it would be expected to be the same in the next 40 years (see figure 2). This comparison indicates some important conclusions.

The growth of population of DMA has been accelerating in the past, but in the future it would be expected to slow down in terms of Michigan state level. In other words, the present time is the turning point of the urban growth character of DMA. Instead past concentration of population in DMA, dispersion in the state of Michigan would be expected. This fact indicates that DMA should be planned synchronizedly with the State of Michigan, because of the acceleration of movement from DMA to the outside as for population, activities and probably economic power. Also, it should be expected that faster development of centers in the state, outside of DMA which can negatively influence the DMA's further development. Although this is a relative slowing down of the population growth in DMA, observed in terms of the state, declining process for Detroit has been quite obvious since 1950.

This process is easier to observe by population density changes. Judging by the UDA study,[2] populatinn density has perpetual tendencies of decreasing in the central city and increasing in the suburb. From 1940 to 1960, population density declined from about 22,000 to 15,000 inh/sq. mi. in the ring between 0 and 5 miles, and considerably increasing in the ring between 10 and 15 miles, from 1,000 - 2,000 to 7,000 - 8,000 inh./sq./ mi. in the same period. In 1953 over 80% of the total population of the DMA (3 million) lived in the area between 0-12 miles. In 1965 70% of the total population lived in almost the same area, although in absolutive sense it is something more. However, these data

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2 See reference 8.

indicate the process of movement of population towards the suburb, which began taking place in early 1950, with the decline of the central city.

Such changes of population growth and its distribution show that some consequences should be expected in development of other urban phenomenoms.

1.2 Housing Conditions

There are a lot of components which should be observed in this field, but in this limited observation only quantity,quality, and ages of housing stock will be done.

By the 1965 Survey[3] there were 1,132,629 housing units in SMSA of Detroit. This housing stock was distributed by counties on the following way (in percent): Macomb 12.2, Oakland 19.0, Sub-Wayne 26.0, Detroit 42.8. Comparing with population distribution we can see considerable differences: Macomb 13.7, Oakland 19.3, Sub-Wayne 27.7, Detroit 23.3. Housing stock in Detroit City Area (DCA) was less occupied (4%), and also less persons occupied one housing unit 3.2,in terms of 3.6-3.9 in other areas. This data correlate with data of marital status of head. Comparably, more single persons (16.2), widowed (7.2) and divorced persons, 8.9, lived in the D.C.A., and there were female heads of the family in 22.8% of the homes. These data indicate specific and unusual social composition of population in DCA. It also coincides with the distribution of the quality of housing stock, which is considerably lower in the DCA.

The quality of housing stock in terms of the location closely correlates with the age of urban development. The map in Fig. 3 made by the UDA Research Project[4] shows the evolution of the developed area of the Central Region (SMSA, Detroit plus 3 counties). The DCA was developed mainly until 1920 with the downtown (the core developed until 1909) representing the critical areas in 1960. UDA defined this specific area in terms of low-income people living there and bad housing conditions. Very slow changes of housing conditions in DCA result

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3. See reference 2.

4. See reference 8.

from the low housing building activity in the central city, while in the all region is considerably higher. Judging by the building permit data for the DMA there were between 20,000 and 40,000 new building permits per year for dwelling units in the period 1955/1968, but very few in the DCA.[5]

The quality of housing conditions were studied for Michigan state and Detroit SMSA* on the basis of a 10 point scale. The first four points were from poor to extremely poor conditions and were considerably more expressed in Detroit SMSA than out-state, non-metro areas. Such data for poor and extremely poor conditions oscillated between 40 and 90 percent for Detroit SMSA and only 40 to 10 percent for the out-state, non-metro area. Better housing conditions correlate with type of houses, location and building time. One-family houses predominated. In the suburb, where the main building activities take place, there are 87-93% of one family houses, but in the DCA it is less than 60%.

The new housing is often light construction, relatively lower building quality (cheap building), which requires relatively higher maintenance costs and often they have a shorter life span than the similar type of houses built in preceding periods. Such a situation has to bring about the dilemma: what to do after 25-35 years--rebuild them or attempt to maintain them? Such questions must be answered very soon, for many of the urban areas in the suburbs.

The future housing situation (SMSA) will encompass two basic questions: 1) How to provide housing units for 2 million new people in the next three decades, and follow existing trends in terms of residential area development, house types, building techniques and, of course, life style? 2) What to do with existing housing stock, primarily in the central city where there have been great problems of rehabilitation and rebuilding since the last decade. Also the problem of the older houses in the suburbs which today are all right but because of the relatively lower building quality as well as increasing building

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5 See the reference , p.

* See the same reference 9

standards may soon become problem housing. Computing with present parameters of residential land use--proxy 340 square meters per 1 person (see the next chapter)--new land demands for 2 million people will mean providing 265 square miles of new residential area, that is 85% of the total residential area in 1965. It is not difficult to figure out that the residential area development will become a tremendous problem which has to bring some changes in the planning philosophy, attitude and judgment of people about life style, individualism, properties, etc.

1.3 Land Use and Land Value

The last 10-15 years have brought tremendous extensive land use, closely correlated with the building of highway structure and the extension of private car usage. Although the Detroit area SMSA has remained almost constant over the last 20 years, (1,908 sq. mi. in 1953 and 1,915 sq. mi. in 1965). An investigation on six components shows a rapid decrease of vacant area and increasing of use for different purposes. The following table shows considerable differences:[6]

	1953	1965	Difference
Residential area	14.0	21.0	+7.0
Commerce	1.3	2.2	+0.9
Industry	1.9	3.3	+1.4
Public Area	2.7	4.7	+2.0
Recreation	2.8	5.0	+3.2
Vacant	77.3	63.8	-13.5
	100.0	100.0	

In the same period residential developments (proportion of SMSA) increased from 70 to 80 percent of the total residential area. Computing the population of SMSA (1.446 million and 2.416 million) indicates a small decrease of the population density from 8,000 inh/sq. mi. to 7,800 inh/sq. mi. In terms of developed residential land and the slow increase of occupied land total land increased from 0.127 sq. mi. per 1,000 pop. in 1953 to 13. sq. mi. per 1,000

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6 See the reference 1, Vol. I.

pop. in 1965.

Considering the building activity orientation towards the distant points in the DMA it would be useful to observe these tendencies in terms of land value. Although we have no complete land value data, judging by the UDA research of the components for Detroit[7] we can say that the total land value has stagnating tendencies, in terms of current prices and constant 1957-59 prices too. Land value decreased from 10 million dollars (current prices) or 18 million dollars (constant prices) in 1930 to 5 million dollars (both prices).

Spatial distribution of land value has tendencies: concentration of high value in the narrowest CBD with stagnating prices over $1000 per foot, decreasing in the rest of the inner city $15-30 per ft. and slow increasing towards the suburb area $30-75 per ft. Although we have no data for the SMSA or DMA, judging by trends for CDA it seems that land value is not the discouraging factor of urban sprawl, and probably is encouraging.

The foregoing analysis indicates that urban development of the suburb has to be synchronized with rehabilitation of the central city. Only such unified action can bring slowing down of very irrational and unfunctional urban sprawl. Such goals, of course, must result from adequate changes of urban planning tools (primarily taxation) and the policy of land use in general.

1.4. Transportation Conditions

Observation of changes of transportation conditions between two recent

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7. See the reference 5 and 8

traffic surveys, 1953 and 1965, represents the important task of considering the effect of the completion of highway systems built in the 1950's[8]. However, the next survey will demonstrate the changes in the urban structure caused by the highways construction which may be summarized briefly by several characteristics.

Individual traffic is absolutely the dominant mode for all journey purposes, and particularly is important as for work destination. In 1965 only 6.1 percent of the bus passengers were going to work. This fact seems unusual, having in mind that for 26.8 percent of people in Detroit, cars were unavailable. The total trip volume increased in the period 1953/65 from 6.4 to 9.8 million trips (over 50% difference). In the same time work purpose trips decreased from 23.5 to 17.0 percent. Person trips per person increased from 2.15 to 2.46. The reason for such an increase can be found apart from the improvement of the transportation network in the increasing of personal car ownership from 0.285 to 0.374 per person.

Improvement of traffic conditions are indicated by data about auto driver trip length and travel time in 1953/65 period. The first one increased from an average of 6.6 to 7.75 miles. Travel time was shorter in the same period. The SMSA boundaries could be overtaken in about a 70 min. drive, and TALUS ones in a 90 minute drive. In other words, isochrones were closer to CBD in 1953 from 1 to 10 miles in outarterial and arterial lines. The prediction

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8. See the reference 1, 2, and 3.

in 1990 shows similar shape of isochrones as in 1965. Small deviation in sense of getting closer isochrones to the CBD means bigger traffic volume in the future.

Shortly summarized, transportation conditions are relatively good in a general sense, but as for work purpose, it should be kept in mind that there were over 15% of the people in SMSA and almost 27% of the people in Detroit with unavailable cars and the public transportation has to provide the service for them and probably for those who sometimes want to use it. Anyhow, further development of transportation has to be closely correlated with the development of urban structure patterns which can bring either further dispersion and more irrational traffic or the contraction of urban structure, which can provide better savings of time and money.

1.5 Employment

Studying of employment is relevant for housing planning from two basic points of view: 1) employment ratio, because of economic power growth, 2) employment structure according to activities because of urban structure changes in general, and housing development in particular, directly or indirectly depended upon, and also because of income growth.[9]

As for the first view, existing data for the past, and predictions for the future, show that employment ratio has been increased in the last decade from 38% in 1960 to 43 percent in 1970. For the next three decades it should be expected to be a slowly oscillating figure between 42 and 43 percent. This stagnation in the future has in fact another dimension. Observing in terms of technological progress, we would expect a diminishing need for direct personal engagement in a job and also a delivering of surplus of labor. A relatively high employment rate in the future can contribute to a rising of income. The

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9 See the reference 4

present prognosis[10] shows that median family income in 1965 ($7,700) will increase very considerably. In more than one-half of TALUS region income wil' oe almost doubled. Such tendencies should open much better prospectives for the comprehensive housing and urban planning.

As for another aspect, changes in the type of activities in the future show an interesting prospective of urban structuring and housing development. A couple basic things will take place in the next 30 years. The first is rapid decreasing of manufactures and similar rapid increasing of professional and related services. In the first case it means 40.5% in 1960 will be decreased to 24% in 1990. In the second case, services will increase from 12 to 27%. The second characteristic is stagnating or slow changes in the domain of retail trade and services. The third characteristic thing is a slow decreasing of employment in construction, transportation and communication utility, but reversely increasing of public administration. It is supposed that such characteristic changes will result from the expected technologic progress in the future. Activities which generated in the past the most movement from home to work have decreasing or stagnating tendencies (manufacture, retail trade). Considerable decreasing of manufacture will also diminish the impact of urban decentralization that occurred in the past.

Reversely, activities with general importance which should be concentrated (professional and related services, public administration) show rapid increasing tendencies. Consequently, there should be an expected stabilization of existing dispersion of workplaces in metropolitan area (meaning slowing down) and concentration of activities in CBD again. These tendencies do not go together with two other tendencies: decreasing of employment in the construction and public transportation domains. Dynamic changes of urban

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10 See the reference 1, Vol. 1, Summary and Ref. 8,

structure and particularly housing building demands would have to bring increasing of construction employment in spite of expected technologic progress because of large volume of building demands. Rehabilitation of the city core appears as the real necessity and the development of public transportation in it would create an increase in employment in spite of the possibility of high automatization of utilities.

Preceding analysis of basic trends oriented more to the future shows interesting possibilities and different chances of urban structure changes and housing development. Meanwhile, existing trends of urban structure and some phenomena of urban dynamics occurring in the last 15 years, are more or less disparative in terms of the prognosis of urban development, its structure and character. It will be analyzed in the following two chapters.

2. Trend Analysis of Population and Work Place Distributuion in Detroit

This analysis is quite relevant for housing planning, but also for urban planning in general, and it encompasses two groups of problems. The first group includes population distribution, workplace distribution and general work-trip distribution. The first two elements were observed by 1953 and 1965 surveys, the third one only the 1965 data, because only these data were available. The second group of questions imply an analysis of distribution of destinated work-journeys by 1953 survey (that was only possible to operate in a very limited time).

The first group of questions has importance for understanding the process of urban transition in terms of spatial and time changes. This phenomenum has been observed by methods depicted in parts one and two of this study, implying division of urban areas by concentric rings and sectors, and also probabilistic distribution density of population, workplaces and generated worktrips used.

The second group of questions was observed in order to prove the probabilistic character of the potential model of urban optimalization exposed in the part 2 considering that the transportation components were based on the movement probability.

The aim of this part investigation was to answer the question is the probability system of work journeys of this model a stable system or not, or what oscillating boundaries are and consequently, what its value is? Meanwhile, it was only partly carried out (1953 survey data were used) because of heavy time limits.

As for sources and validity of available data, we have to say that it was very difficult to make up the time dynamic analysis because of disparities of survey and census data time (changes of districts and zone boundaries, collection of different data, etc.). In this particular case we had not enough time to unify and verify available data, and sometimes we had to do some estimation and reoperation of previously operated data in order to do necessary comparisons. It is particularly related to 1953 data, because we could only use the data presented by Louis Loewenstein* to do a relatively complex analysis of distribution of population and workplaces, as well as distribution generated work trips. As for 1965 situation, we computed the survey data and this part of the analysis is quite reliable. So, the comparison of space changes in 1953/65 period is relatively valid because of small differences between ring and sector boundaries we had to establish for this analysis. Both divisions of the Metro urban area were adjusted to census zones and districts, and both were based on the highway system network. Sector divisions were almost identical for 1953 and 1965 data and bit rings differed little (figure 4.5). In fact, the division of urban area for 1953 was accepted from the 1953 traffic study[11] and the second one was adjusted in order that the comparison be done. In both cases,

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* See the reference 12.

11 See the reference 10.

almost identical sectors were recognized by six main traffic corridors in Detroit Metropolitan area: highway lines 1) 75/85, (towards Toledo), 2) 94/12 towards Ann Arbor and Jackson, 3) 96 towards Lansing, 4) 75 towards Flint, 5) 53 towards the North of the area, 6) 94/25 towards Port Huron (see the map of the Detroit Regional Area analyzed in the Doxiadis study[12]. Results of this analysis can be summarized by a couple of statements. (See diagrams on Figures 6, 7).

2.1 Population and Workplace Distribution Trends

Distribution of population (P) and workplaces (WP) in 1953, was considerably changed, both in the volume and in the pattern observed by sector (see Fig.6). Sectors 1, 4, and 5 have a similar shape of WP and P distributions, meaning WP shortage in the part of the inner city (Rings B,C) and WP surplus in rest rings A,D,E. The sector 4 differs in terms of volume having the largest number of work places and population, concentrated there. Conversely, sectors 1 and 5 have the smallest volume of workplaces and population. Sectors 3 and 6 have a similar distribution pattern and the almost identical volume of population and work places, meaning considerable WP shortage in rings B,C,D,E.

Observation of the urban area in the whole in 1953 (superimposed on 6 sectors) shows distribution of WP surplus in the CBD (Ring A) mainly and little in the suburb (Ring E) and concentration of WP shortage in the other part of the inner city (Rings B,C,D). If we neglect a small WP surplus in the suburb, we can conclude that Detroit urban structure had in the early 1950's a classic pattern of concentration of work in the CBD and population in the central part of the inner city. It was just the time of the beginning of urban sprawl and dispersion

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12 See the reference 3,

of activities. This process has been taking place during the last 15 yrs. very intensively and we would say dramatically. Diagrams in the Figure 7 show such dramatic changes of population and work place distribution in 1965. Observing either sectors or the whole area these changes were very considerable. Compared with 1953 situation, sectorial analysis shows changes which could be summarized in the following way. Population and work place distribution functions were reshaped by 1965 into a considerably larger metro area, meaning intensive movement towards the suburb, but much more expressed for population than activities. The general phenomenon is the WP shortage was particularly expressed in the suburb, mainly in the Ring D (8 to 12 miles). There were little deviations at sectors 3 and 5, and WP surplus in the further Ring F. The main WP surplus was concentrated in the CBD or wider in the Downtown, including Rings A,B,C. The comparison of the whole urban area shows that the process of population movement from the downtown to the suburb is quite obvious. This process has been followed by activities movement, but much less intensive and slower. These changes can be described by this statement:

- The maximum of the population distribution function in 30% (about in both time) were replaced from the central part of the inner city (Ring B) to the suburb (Ring D). At the same time, population distribution in the CBD was decreased from 17% to 5%.

- The maximum of the work place distribution function was replaced from the CBD, being over 30% in 1953, to the suburb (Ring D) but decreasing to 22% in 1965. At the same time, work place distribution in the CBD was decreased from 34,5 to 18%.

The process of metropolitanization has been taking place in the recent five years, and the question now is has it been finished or not, and what can be expected as a result of such space and time changes? This question is relevant

in the first hand for the transportation development. Presented diagrams show two important facts: 1) generated work trips distribution closely correlate with population distribution, that may be very important for approximate analysis of urban structures, 2) the shortage of work places in the particular area has to generate more work trips, that was one of the hypotheses important for the development of the potential model of urban optimization (see Part 2). The third fact, not visable on the presented diagrams, but deduced by the foregoing analysis (the Part 2) was that movement of population to the suburb and increasing work place shortage generating longer distances and losses of time and money in spite of increasing of driving speed. As for the foregoing finding that 1965 brought considerable decreasing of work trips distribution (5.5 percent less than in the 1953/65 period), it should be observed partly as the consequence of decentralization of work places, although unsufficient and slow, and partly as the consequence of inadequate following of population spatial redistribution and education, considering the increasing trips for shopping of 2.6 percent and to schools of 1.5 percent.

2.2 The split model of work journeys of Detroit in 1953

This problem was a very relevant one for proving the probability character of the potential model of urban optimization that was observed by 1953 data and it should be explained that it was done in a round about way. Disaggregated 1953 survey data of interzonal trips for eight activity groups, operated by L. Loewenstein[13] were reoperated and adjusted to the purpose of this study. So, the absolutive distribution of work journeys (see Fig. 8) implied different distribution of population proportions and some diagrams of sectorial and ring distribution of work trips which patterns are very close to the theoretic bi-

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13 See the reference 12

nomial distribution of trips explained in the Part 2 (see Figure 9). Although this analysis would have to include correction of present diagrams by the work place coefficient (it was not done because of the time limit). However, we can conclude that the foregoing theory of work trip model split has really probabilistic character (binomial type) and it would be possible to develop precisely such a theoretical mathematical model which would include the case that employees do not go from one urban area to all others. The analysis presented here is enough to indicate that the movement probability represents relatively stable system, only changeable by specific spatial changes (none work places in particular areas, etc.).

3. Some Comments Regarding TALUS and UDA Study[14] and the Conclusions of the Empirical Investigation

The next couple of pages do not propose to assess these two studies, considering they overpower our empirical investigation in terms of the scope and topics. But, as for housing planning dealt with in our study, there are some disparities between existing trends and proposals in terms of these studies. So, this target is to clarify some conceptual misunderstandings.

Although with different approaches and different scope and topics,* there are some basic common things relevant for the future urban planning of housing which are in opposition to our conclusions or controversial themselves. Let us summarize quite briefly common and disparative things of these studies.

The first common thing was the understanding of further very extensive land use as well as population distribution in metropolitan area by the classical urban pattern: high residential density in the CBD and gradual dispersion in the metropolitan area, following main traffic corridors.

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14 See the reference 1, 8.

* The UDA study was dealing with the Detroit urban region with the area of 23,000 square miles where 15 million people will live by the year 2000. TALUS was dealing with the Detroit metropolitan area of 4,500 square miles where 7 million people will live by the year 1990.

While the TALUS study would try to keep existing transportation system networks with little changes, conversely, physical urban structuring was different. The UDA study presented urban structure in a stronger, more systemic way, based on the rectangular traffic network. This system was composed by three east-west and one north-south regional axis of urban development with centers developed along them and their cross-sections, implying graduation of housing communities in several stages. The specifications of this proposal is the between center at St. Clair, balancing the growth mainly developed along the lake shore line from Toledo through Detroit to St. Clair.

The similar concept of distribution of activities was, too. Apart from some foreseen differences as for structures and volume of activities, both of the studies predicted on the one hand concentration of employment of some manufacturing and particularly services in the central city, and on the other hand, their dispersion in the regional metropolitan area.

A considerable difference, in spite of similar understanding of the public transport role, the UDA study predicted much more optimistically, improvement of the transportation system which would bring movement of isochromes at least three times, while the TALUS foresaw it quite slightly. In other words, in the first case the efficiency of transportation system would be a considerable jumping in terms of 1965 situations.

In both studies, the housing organization implies domination of one-family houses developed in the present more or less conventional way. Without going deeper into details and the entity of concepts, these few items confronting our understanding of housing planning and results of our research indicate some conceptual disagreements.

First, distribution of population by the negative exponential function, meaning decreasing from the CBD to the suburb is contrary to existing trends

as our findings showed. In fact, this concept means the return to an earlier phase of urban development. By our opinion, there are at least two arguments against it:

1) Concentration of residences and activities in the city core would bring the overcrowding of physical structures, people, traffic, which is already considerable and represents a problem, particularly as for parking space in both categories of residences and employees. Since the concentration of employment in the central city is real as for basic activities, servicing the complete and outlying area, it would not be reasonable to concentrate housing too, because of physical saturation and/or high land values.

2) The other extremely high dispersion in metropolitan area, has to bring considerable time and money losses in everyday work journeys. Although the proposed pattern of population distribution is relatively convenient in traffic cost point of view, it is not necessary that residential density increase with employment density by similar pattern distribution together. It would be reasonable to correct the 1965 population density (today it has probably moved further in the suburb) in the sense to remove the main population mass to Ring D (see Fig. 7), the space between the 8th and 12th mile on the north and between the Southfield Freeway and Telegraph Road on the west from Ring C, and B, or the space between the inside of the downtown boundary and outside the central city boundary. This action really rebuilding character would mean getting back population density which was in 1960 in the area 10-20,000 pop/ sq. mi. (15- 30) p/acre[15]) and today is lower, at least at 40,000 pop/sq.mi. (60 p/acre).

As for activities distribution, it seems to us that the reasonable concentration of basic employment is in the central city (servicing the whole urban area) and dispersion of services and retail through residential area. Such concept is reasonable although widely expected technologic progress in the

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15 See the reference 8.

domain of information systems will diminish demands for labors and direct contacts, implementation of such devices will not be, it seems to us, so fast a process in spite of very promising automization and computerization. The same reason is to be reserved with very optimistic development of transportation systems which would imply high automation and widely applied information systems in all subjects of urban life.

As for housing development, it seems to us only partly reasonable to keep the low density in the furthest points of the metropolitan area, but anyway not bellow 10 pop./acre, than at least 20 pop./acre (5-6 D.U./acre). Anyhow, the big volume of housing demands in the future 30-40 years, should bring considerable changes in the convential housing planning, design and building. Prefabricated building systems should be developed and applied for one family houses (middle-low density, 20-40 pop./acre as well as multi-family houses, middle-high density 40-60 pop./acre). Roughly computing for the next 30-40 years, it would be necessary to build at least 1,000,000 dwelling units more for 3-4,000,000 population who will live in the metro area and at least 300,000 dwelling units in the downtown; that means in the total 1,500,000 dwelling units, or 35-50,000 dwellings should be built every year in the Detroit Metropolitan area. Comparing with the present building volume, it means a doubling. It is obvious that the classic approaches in planning--ineffective, slow, hesitant--have to be disregarded. Individual comfort should not be paid for by the destruction of the whole city.

Let us allow ourselves to suggest something at the end of this consideration. Every proposal of urban development, long or short range, and particularly the long range, must analyze and estimate consequences particularly in an economic sense, but also in social, technical, ecological and others, etc. Intuitive methods

must be changed by quantitative methods. Our intention was to do this a few steps ahead. This is our modest contribution to the general treasure of knowledge about city and the city's complexity.

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13. Changes in Urban America, U.S. Department of Labor/ Bureau of Labor Statistics, BLS Report No. 353, April 1969.

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15. Population and Land-Use Data of 1965 Survey, SEMCOG (unpublished) data.

General Conclusions

Comprehensive urban planning and particularly housing comprehensive planning, being relatively new domains of scientific activity,intensively developed in the last 10-15 years, has resulted in a period of accumulation of research knowledge. This is mainly a result of individual investigation and analysis. There are many theories and hypotheses which have not yet been tested, proved or completed. The new field of quantitative models also represents a wide scope of present investigation. The accumulated research material first requires clarification in terms of better classification. A next step would be the completion and verification of two basic kinds of models: descriptive and causal, both of which involves the asking of at least four groups of questions in urban analysis: 1) What happens in a city which implies some descriptive models of urban phenomena taking place in a city and in wider areas; 2) why something happens in a city, implying the development of causal models of urban phenomena; 3) where to direct urban processes, implying development of causal-predictive models of the complexity of urban phenomena; and 4) how to implement urban processes, implying development of integral planning procedures, based on highly developed information systems. The hope is that this study contributes to a better understanding of problems of quantitative modeling, basically important for the development of urban systems. The focus of this study was in the third group of questions, i.e., where to direct urban processes, which implies an attempt at the development of an urban dynamic system.

The purpose of this system model was to analyze economic consequences of urban dynamics in the housing field as well as to determine the optimal relationship between housing and working with respect to transportation. This system dealt with problems of transportation, land use and housing in a dynamic sense,

operating with spatial and temporal changes. Although it should be further developed (polycentric urban structure, varied transportation system, etc.) this model basically differs in relation to others in the treatment of work journey modal split. Instead of the analogy with physical gravitation (dealt with in many other models) which is a stable system in Nature, but unstable and changeable in socio-economic phenomena, an attempt was made to compose a system which can be relatively stable, and correctable by known input data which reflect a variety of socio-economic processes. In this case it involved multiplying the so-called "movement probability" (as a stable system) by the work place coefficient as a variable system.

Although resources did not permit the simulation of the whole model by changes of input variables, a partial demonstration of the model highlighted some consequential conclusions. Urban sprawl, observed in a long-range period, involves economic and social costs. Present housing development primarily oriented to the suburb may bring new problems of urban development, expressed by the sophisticated question what to do at the end of a 30-year period with respect to new housing construction or old housing maintenance or rehabilitation? Neverthe less, urban development of the central city and the suburb must be synchronized in a cyclical process, a synchronization which should be occurring perpetually in order to maintain the vitality of the city in its entirety.

The metropolitan development of Detroit has been taking place in the last 10-15 years as an urban explosion. Tremendous urban sprawl has tended toward very extensive land uses which generate negative economic consequences for traffic and land use development costs. The orientation of housing building activities to the suburb has had two consequences: 1) discouraging reconstruction of the central city and 2) stimulation of urban sprawl in the form of one-family houses truly

comfortable but mainly of low building quality, which require relatively higher operating costs. The life of these houses will probably not be longer than their mortgage period and the question of their future must be asked now, not when problems will appear. The further orientation of the Detroit metropolitan development must bring changes in planning methods, but particularly in the implementation of rehabilitation of housing and utilities in the central city. A balance between the central city and the suburb should be established and a synchronizing of the development of both is necessary. This fact indicates a need for urban planning as a prevention against future impacts rather than as a treatment of apparent crisis. Urban planning must be an integrated process in terms of topics, tools and implementation. Nonsystemic planning cannot bring considerable success, but partial and nonsynchronized realization of plans also can be ineffective. Comprehensive planning has to become an important factor of urban development, but it must utilize those scientific methods which can help to understand better urban phenomena. Such methods can quantify consequences of existing or simulated processes, and can find answers on how to compromise disparities of diversified urban processes. The implementation of urban plans requires adequate mechanisms, based on democratic principles and widely applied modern technology, particularly in the domain of information systems.

ANNEX 1.

Fig. 1 Urban area divided by rings and sectors, and three basic lines of O-rigin-D-estination

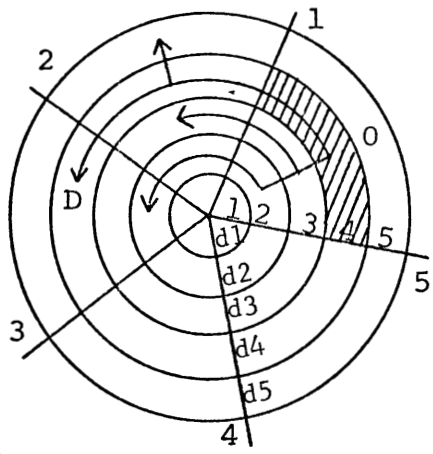
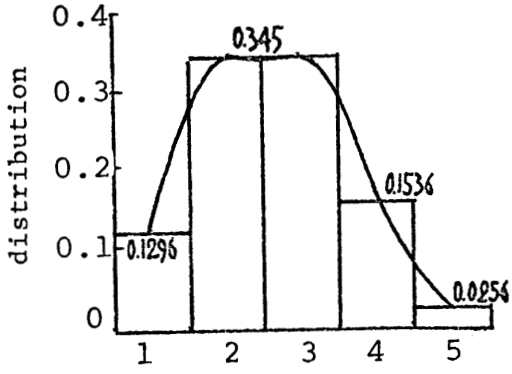


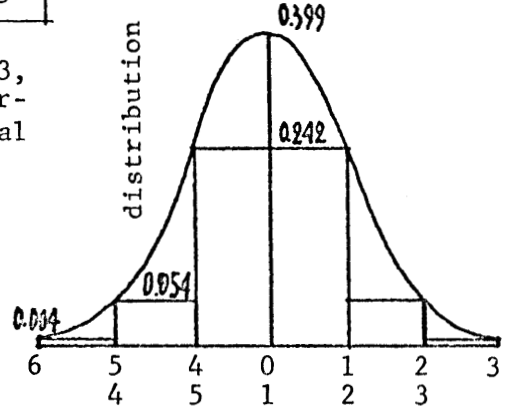
Fig. 2 The ring probability for the 4th ring, meaning movement to the 3rd ring.



The section of the Binomial Probability Table for X=0 . . . 4, p=0.1 . . . 0.5
(see Wohl & Martin, Traffic System Analysis, p. 69)

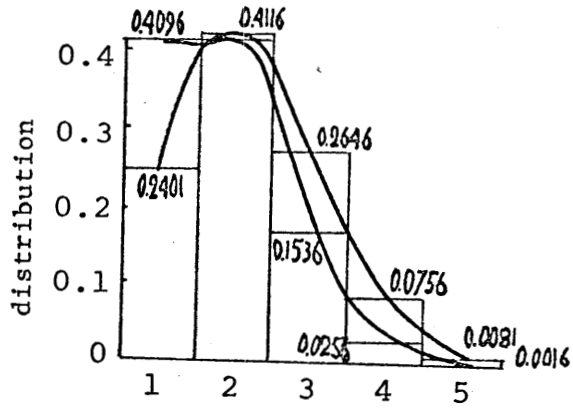
X \ p	0.10	0.20	0.30	0.40	0.50
0	0.6561	0.4096	0.2401	0.1296	0.0625
1	.2916	.4096	.4116	.3456	.2500
2	.0486	.1536	.2646	.3456	.3750
3	.0036	.0256	.0756	.1536	.2500
4	.0001	.0016	.0081	.0256	.0625

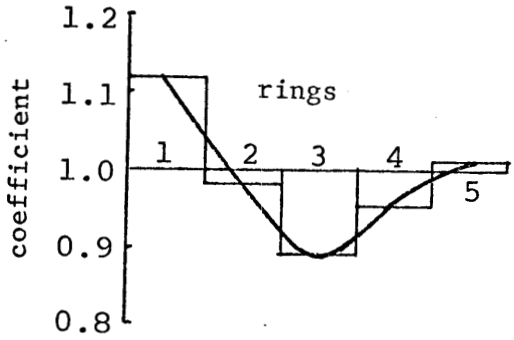
Fig. 3 The sector probability for the sector 3, given according to the Standardized Normal distribution (See Horn, Mathematical Handbook for Engineers and Scientists)



X	P
1.0	0.399
2.5	0.242
3.4	0.054

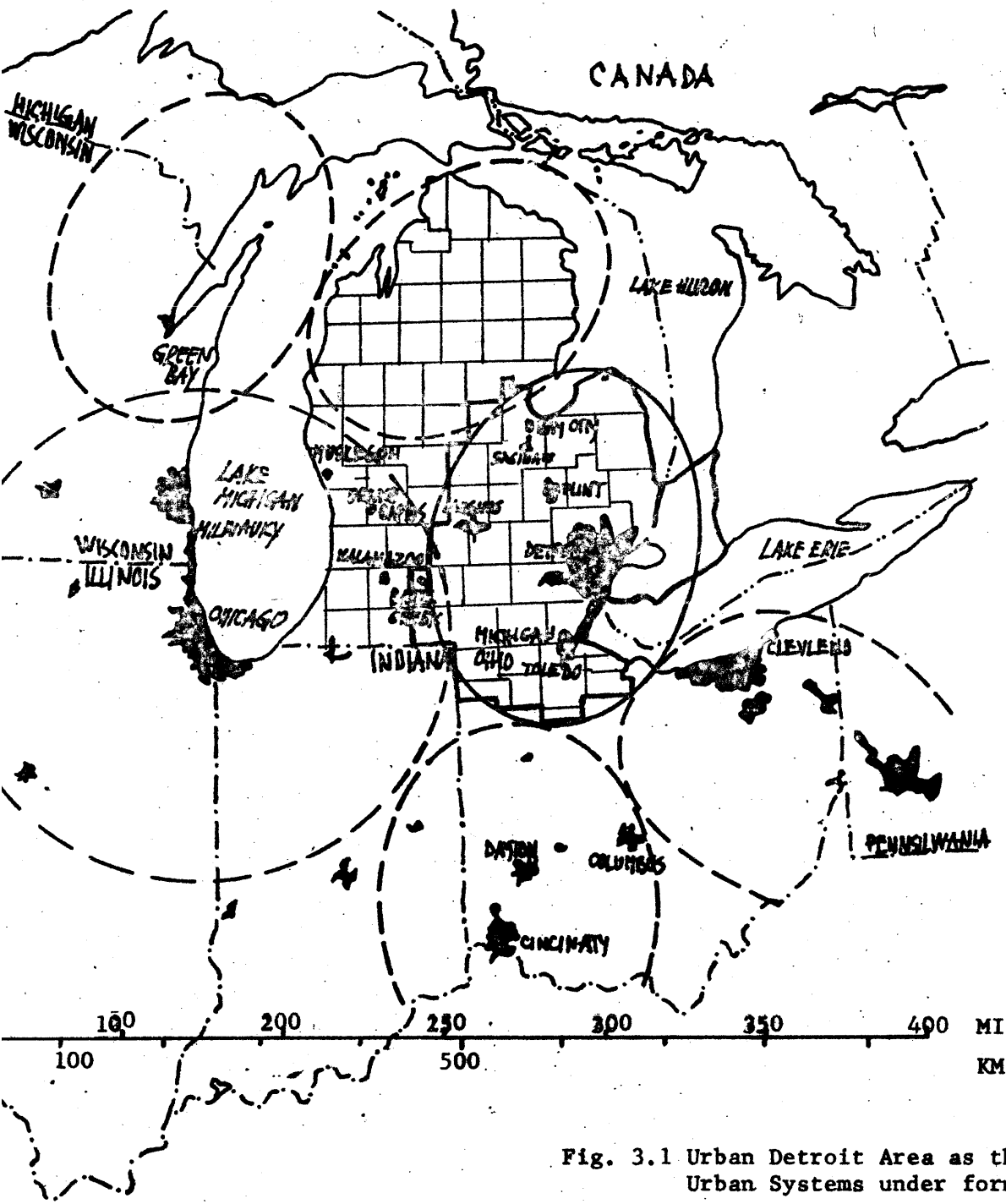
Fig. 4 Work Place Coefficient (a principle example) given by the population and the Work Place Distribution (the distance function)

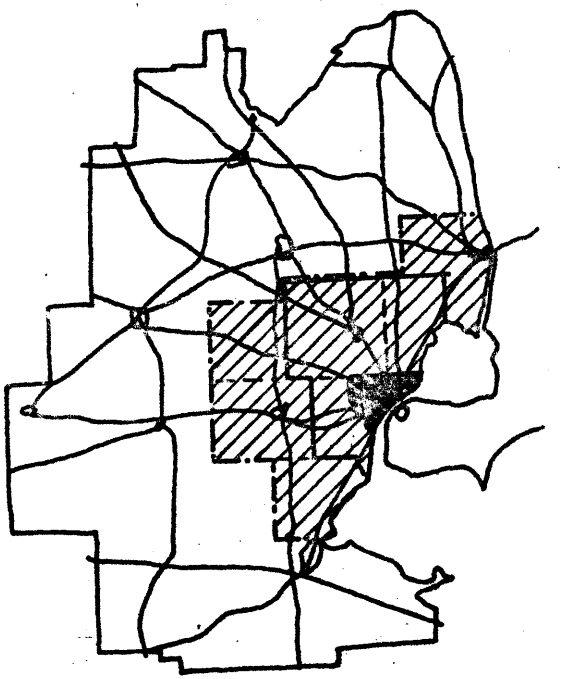




Function W/P is given by the following table:

Pw = 1.1695
Pw = 0.9800
0.8890
0.9500
1.0065
5.0





0 50 100 150 mi.
0 100 200 km.

Four scales of Detroit Area studies

UDA
TALUS
SMSA
DCA

Fig. 3.1 Urban Detroit Area as the fragment of Urban Systems under formation*USA*year 1970

Fig. 3.2 Past population and future projections for USA, Michigan, TALUS and Detroit city

(source: TALUS)

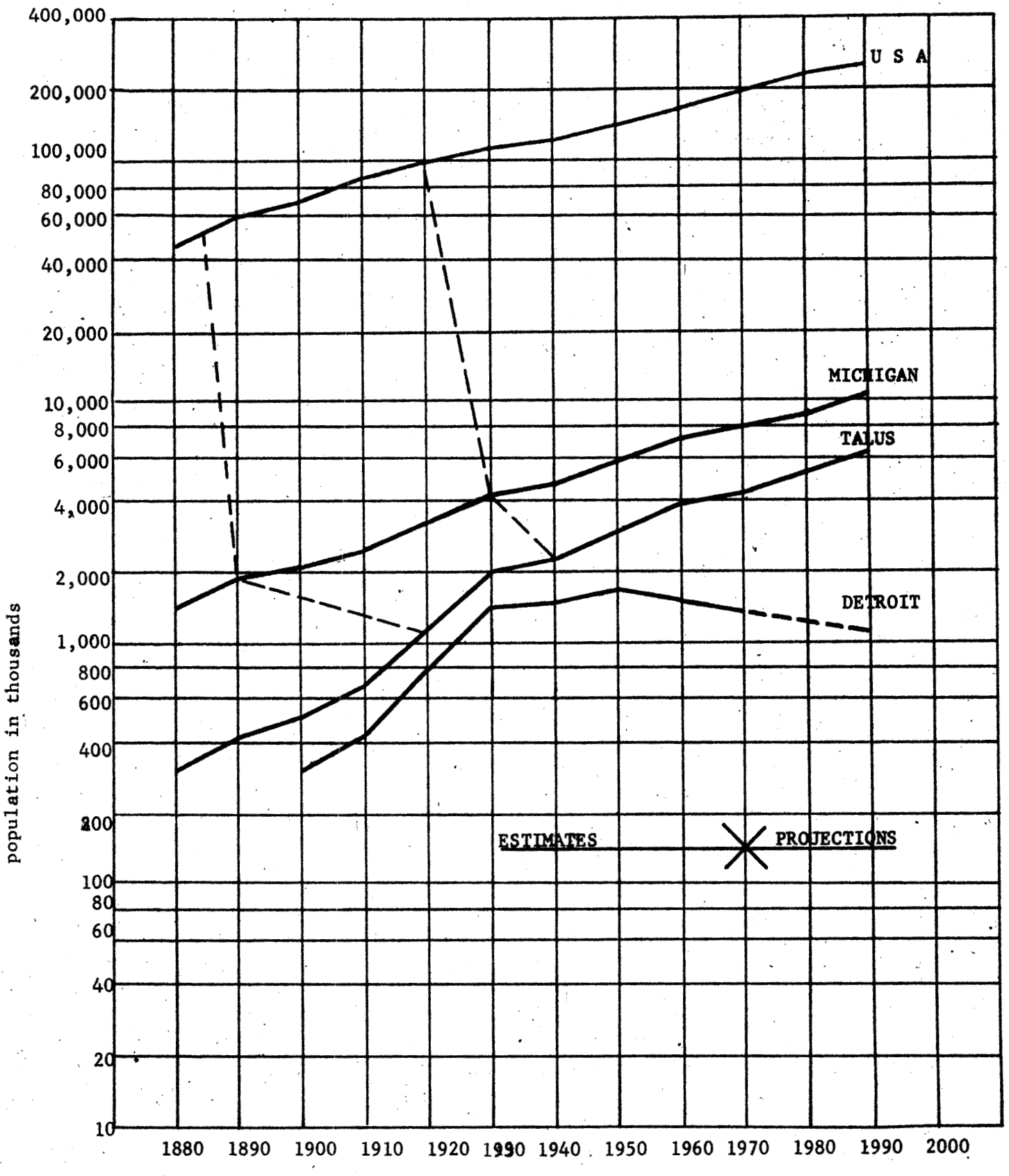
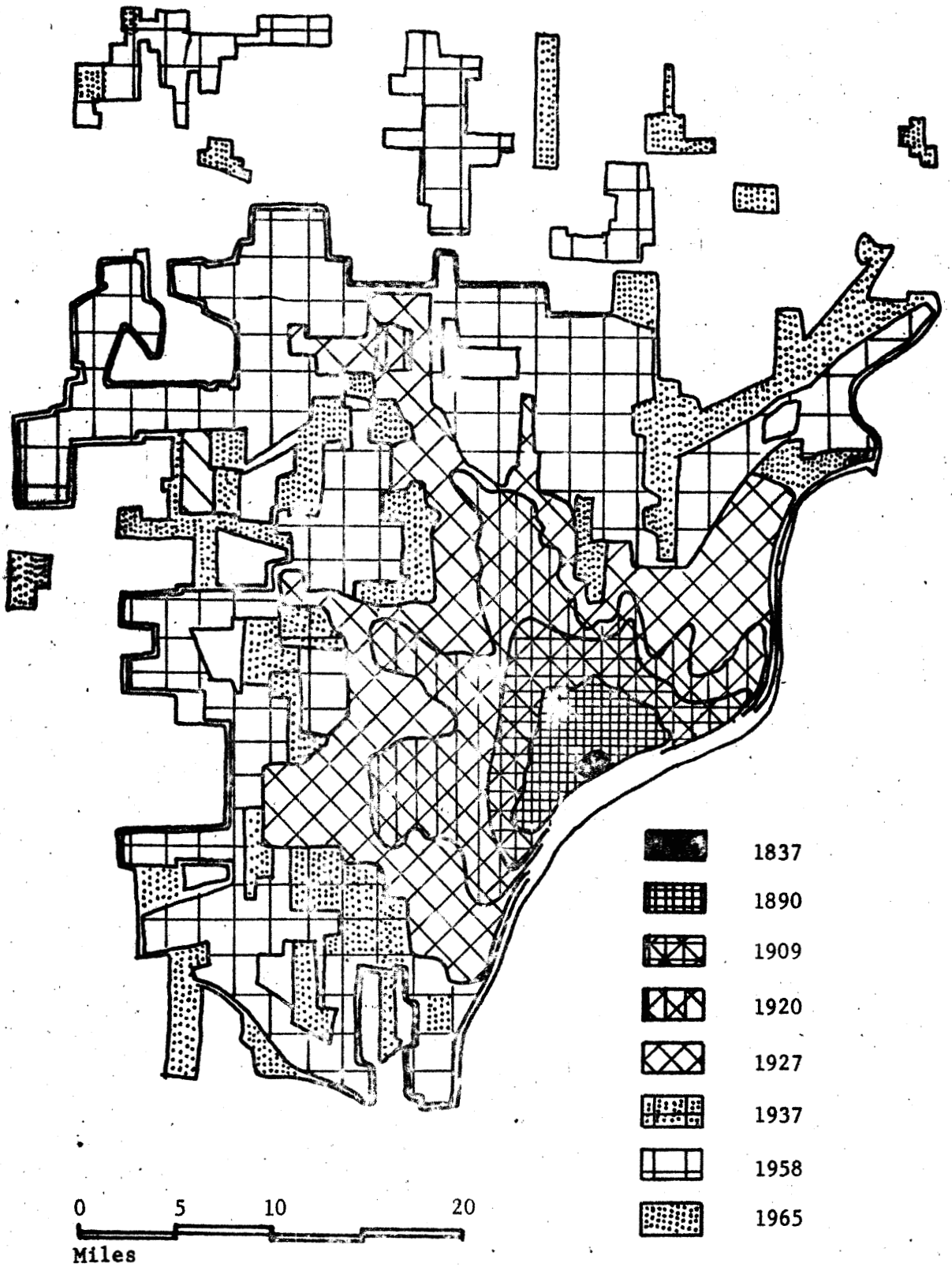


Fig. 3.3 Evolution of the developed urban area within the Central Region of Detroit (according to the UDA Research Project)



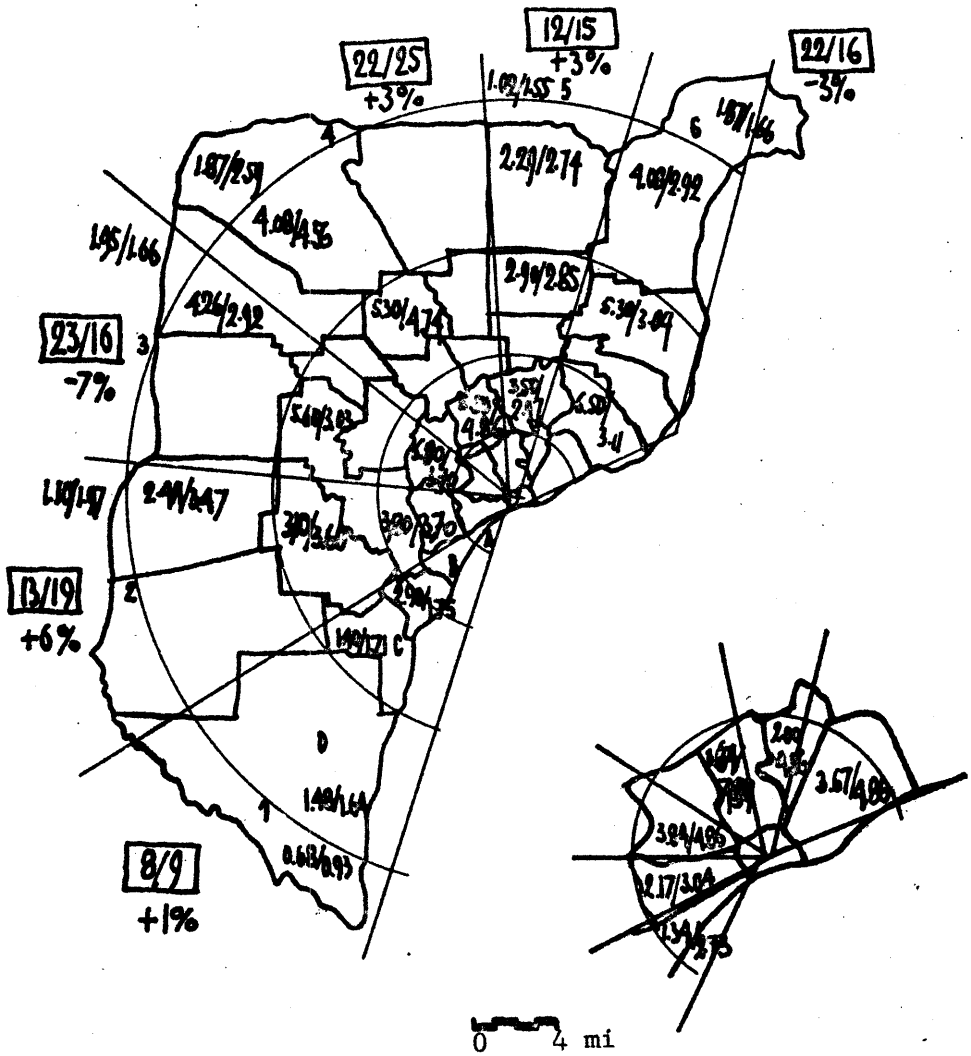


Fig. 3.4 Spatial distribution of residences and work places in Detroit (1953'Surwey) observed by ring and sectors. (Reoperated data from the L.Loewenstein' book "The Location of Residences and Work Places in Urban Area")

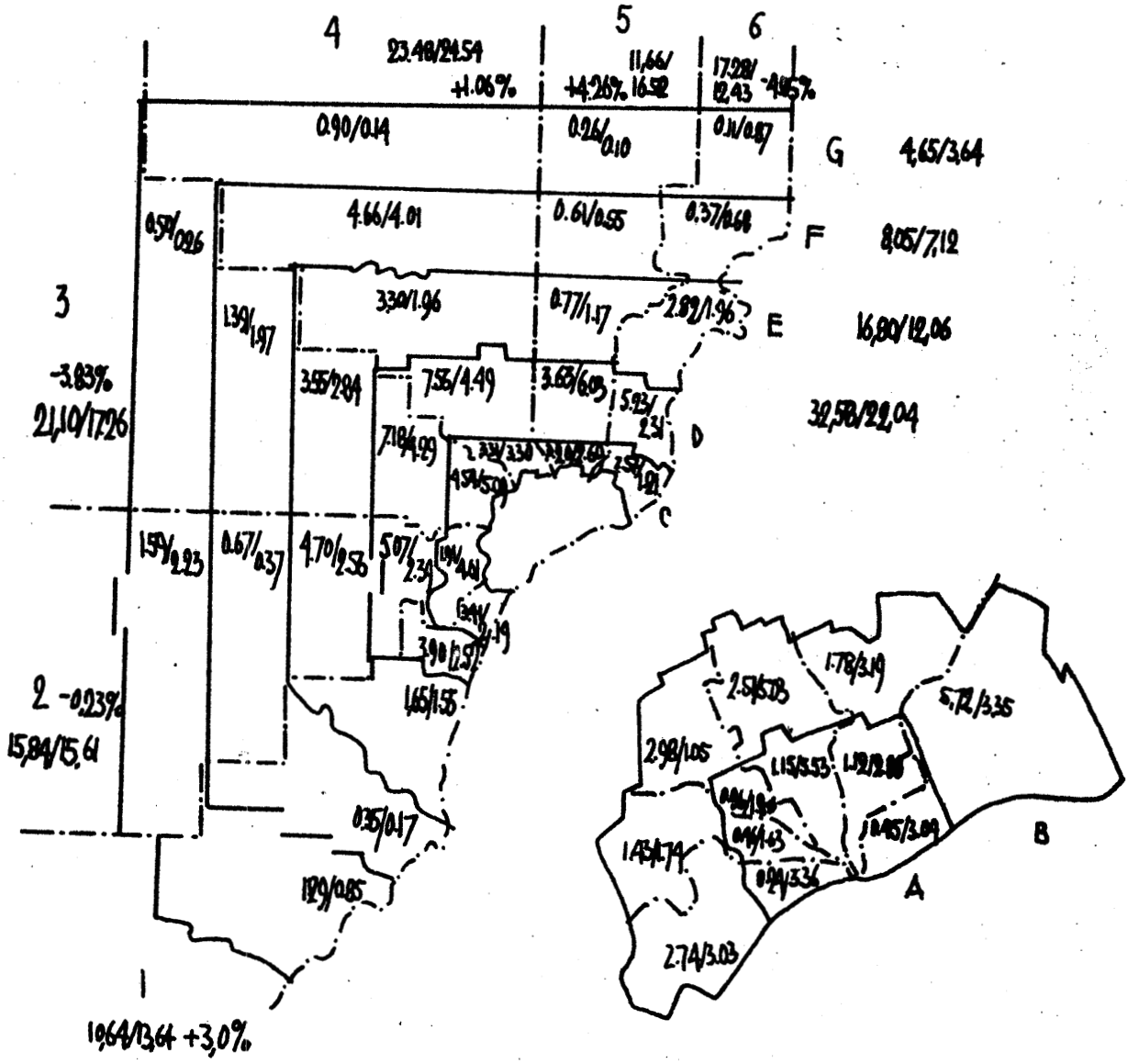
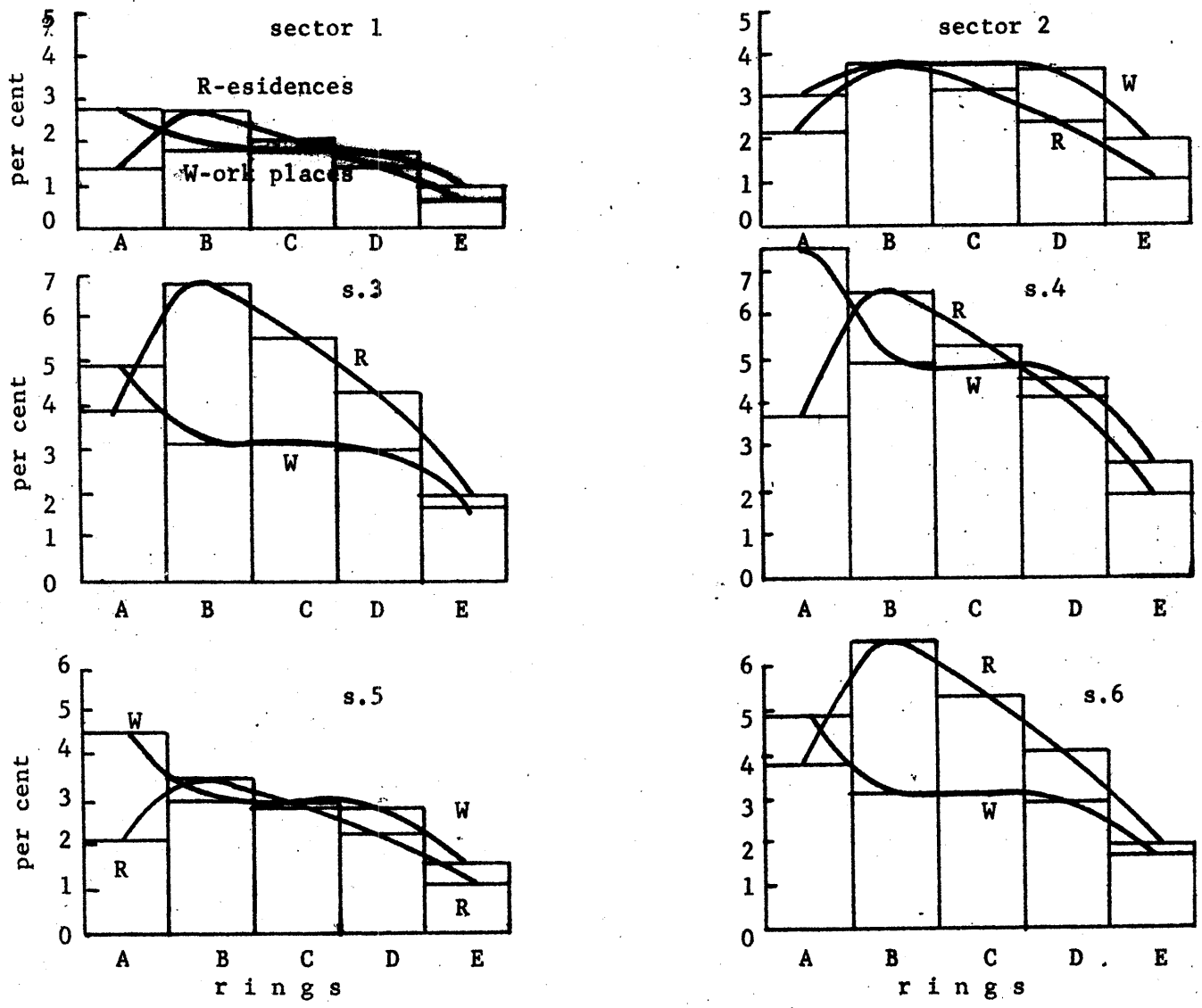
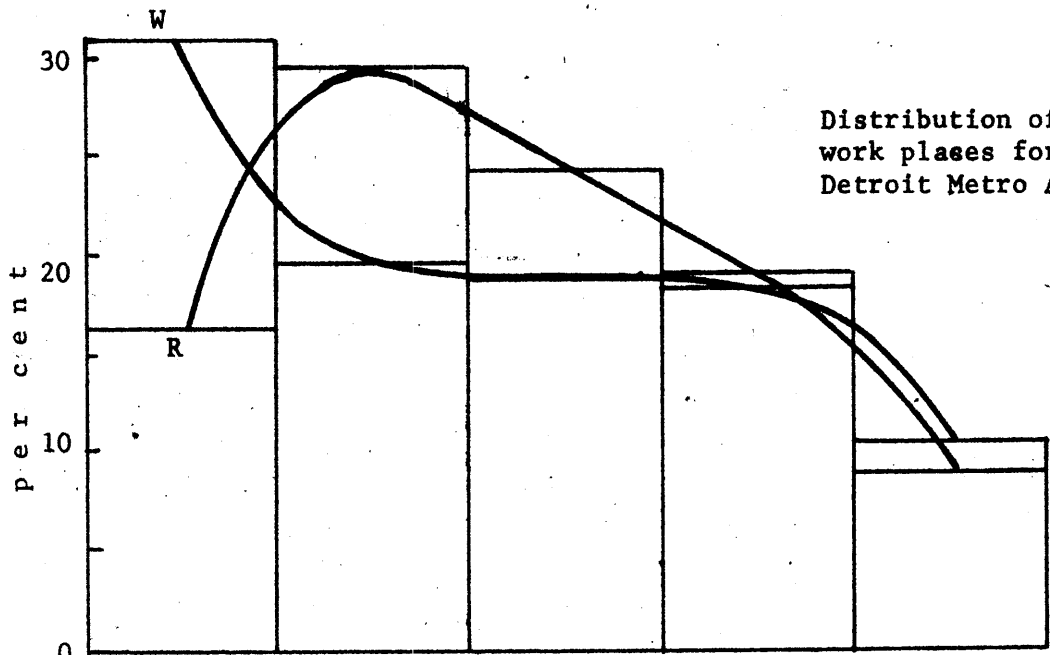


Fig. 3.5 Spatial distribution of residences and work places in Detroit (1965'Surwey)
Source: SEMCOG data

Fig. 3.6 Spatial distribution of residences and work places in Detroit (1953'Survey)





Distribution of residences and work places for the whole Detroit Metro Area (1953'Surwey)

Fig. 3.7 Spatial distribution of residences, work places and work trips in Detroit (1965' Survey)

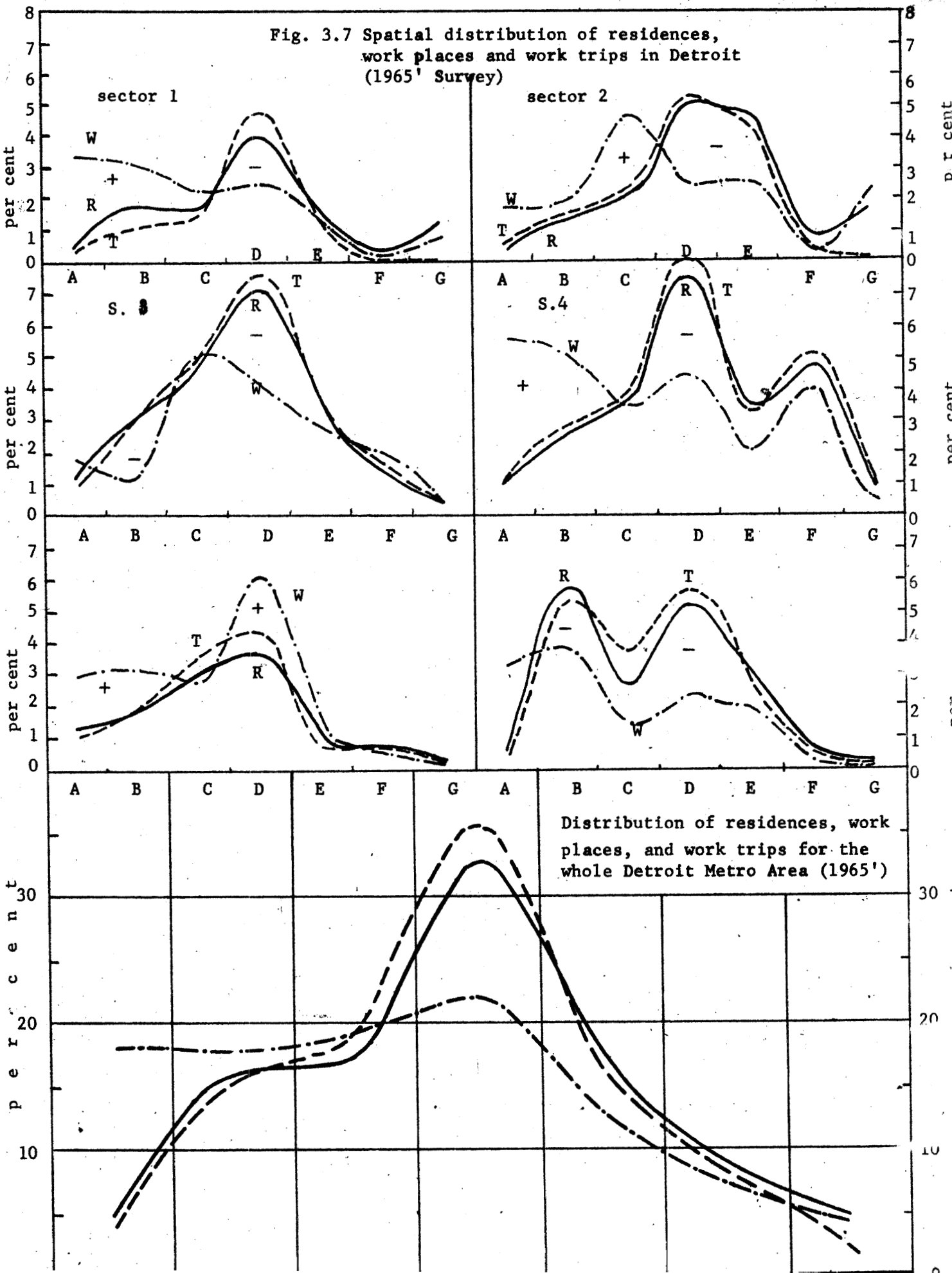
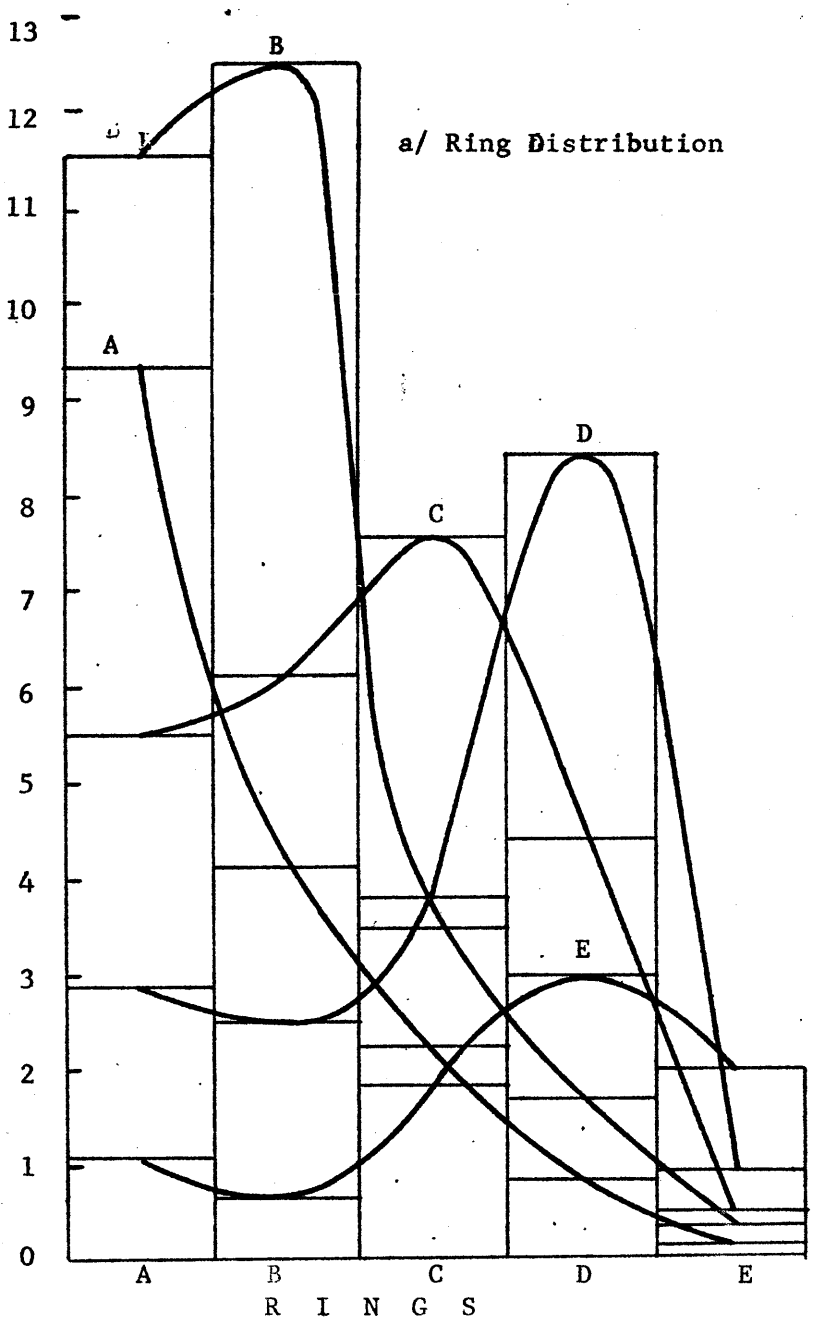
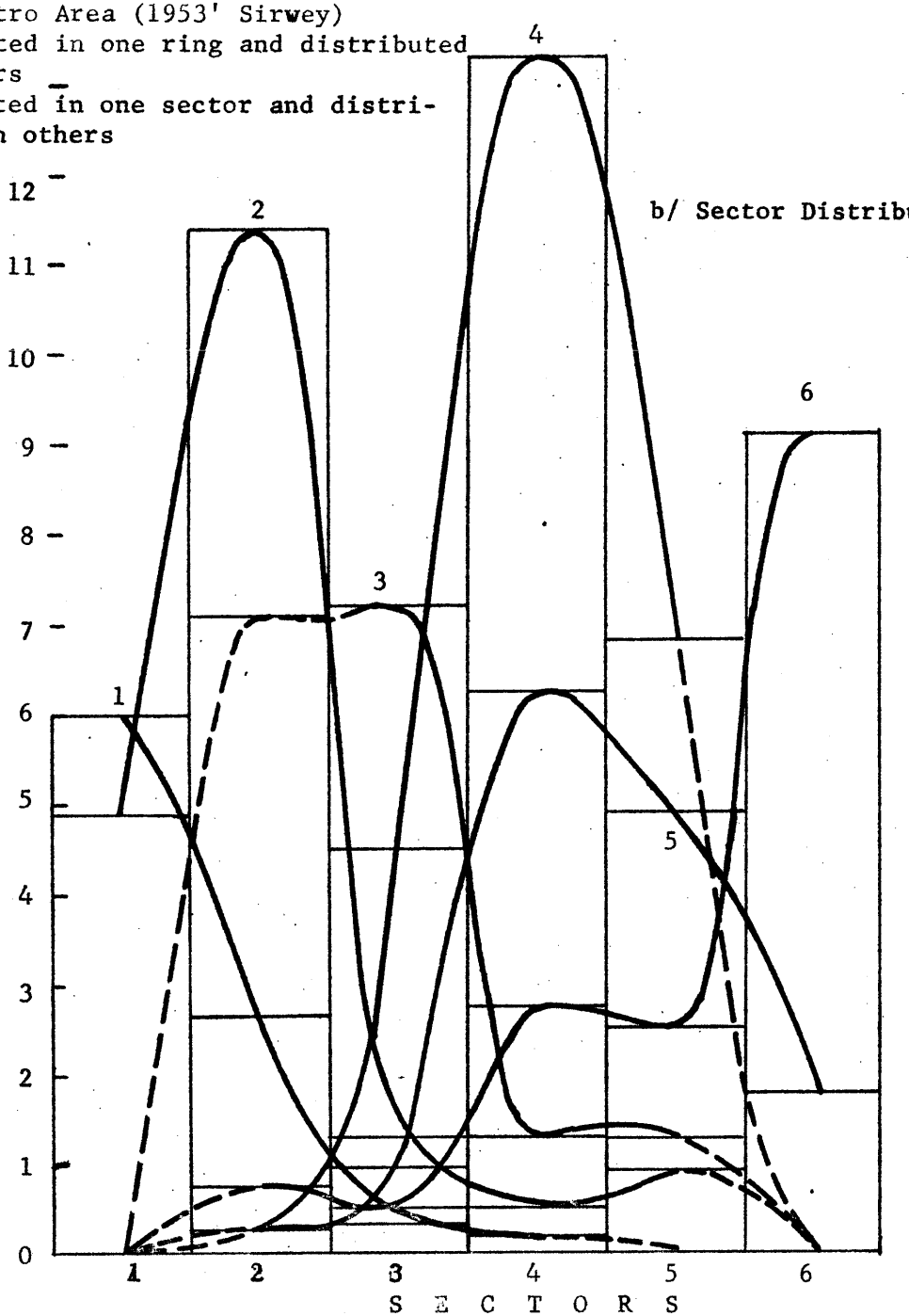


Fig. 3.8 Absolute distribution of work trips in Detroit Metro Area (1953' Sirwey)
a/ originated in one ring and distributed in others
b/ originated in one sector and distri-bited in others





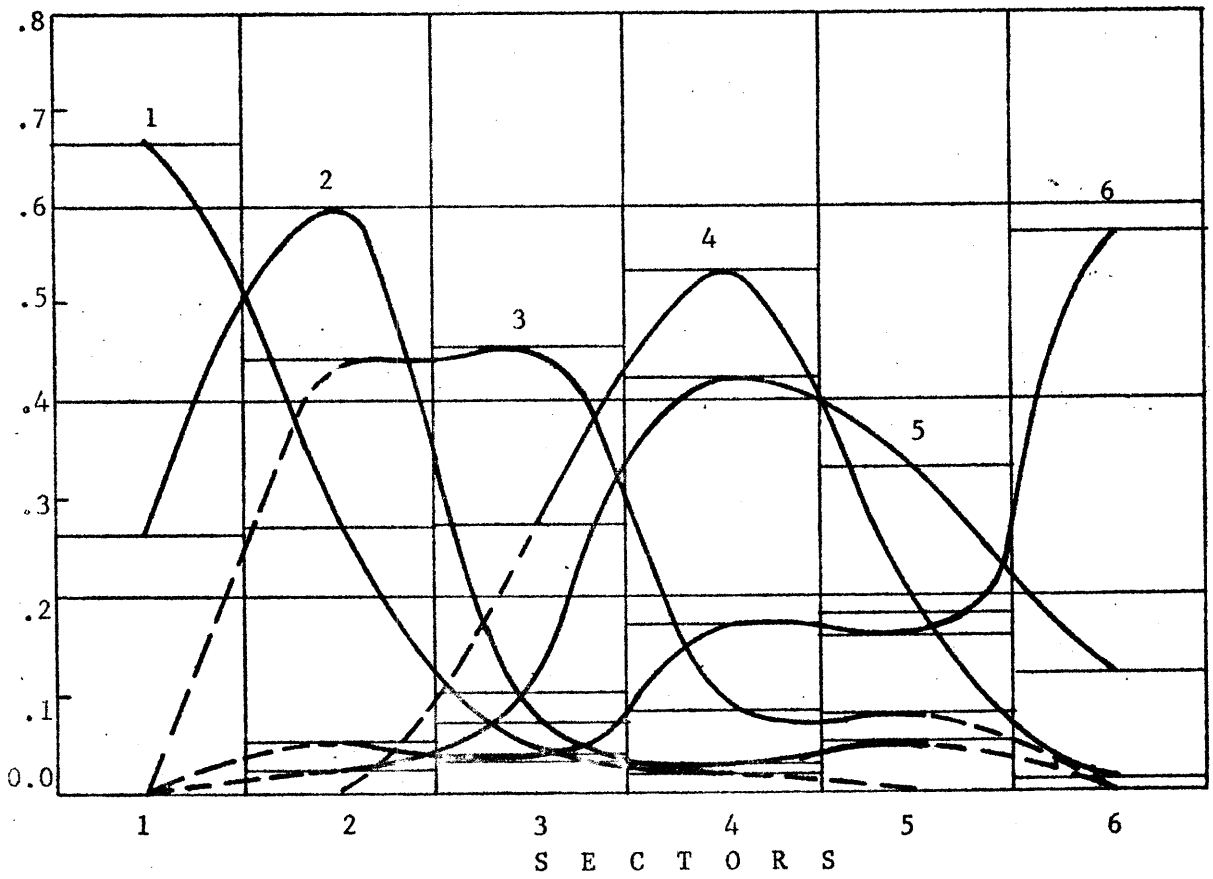


Fig. 3.9 Relative distribution of work trips
in Dteroit Metro Area (1953'Surwey)
a/ Sector Distribution

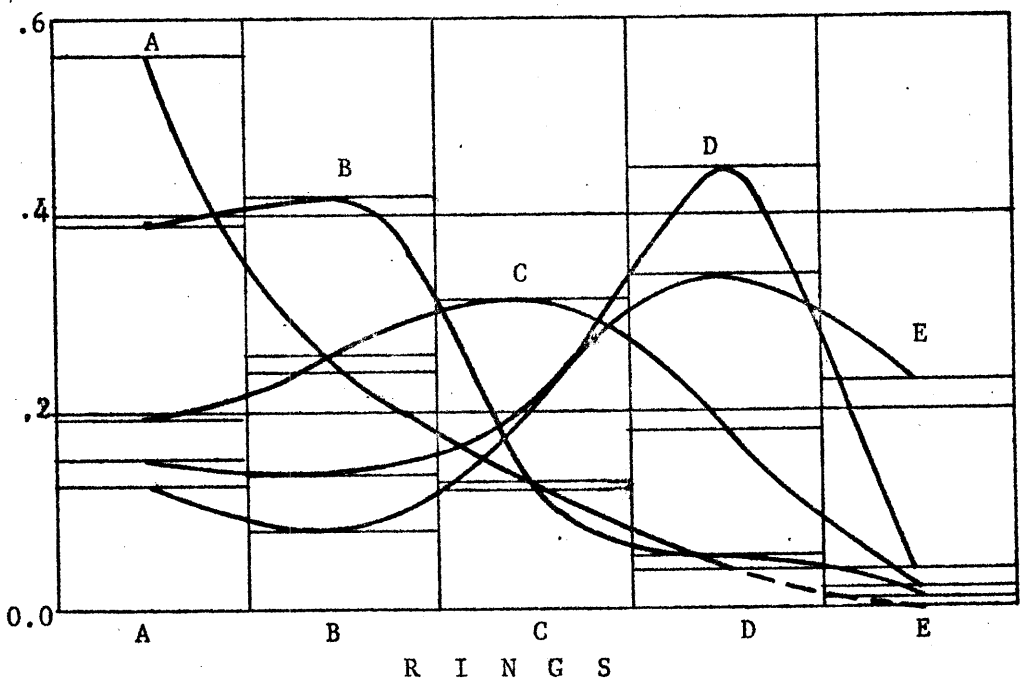


Fig. 3.9' Relative distribution of work trips
in Detroit Metro Area (1953'Surwey)
b/ Ring Distribution