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Nested Dynamics of Metropolitan Processes and Policies: Turin

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NESTED DYNAMICS OF METROPOLITAN PROCESSES AND POLICIES: *TURIN*

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Contribution to the Metropolitan Study: 19

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CONTRIBUTIONS TO THE METROPOLITAN STUDY:

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2. Casti, J. (1983) Emergent Novelty and the Modeling of Spatial Processes. Research Report, RR-83-27. IIASA, Laxenburg, Austria.

3. Lesse, P.F. (1983) The Statistical Dynamics of Socio-Economic Systems. Collaborative Paper, CP-83-51. IIASA, Laxenburg, Austria.

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8. Andersson, A.E. and B. Johansson (1984) Knowledge Intensity and Product Cycles in Metropolitan Regions. Working Paper, WP-84-13. IIASA, Laxenburg, Austria.

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17. Tornqvist, G. (1984) Contact Potentials in the European System. Collaborative Paper, CP-84-55. IIASA, Laxenburg, Austria.

18. Rima, Annemarie, Leo van Wissen and Peter Nijkamp (1985) Towards an Integrated Dynamic Model for Amsterdam. Collaborative Paper, CP-85-5. IIASA, Laxenburg, Austria.

19. Bertuglia, C.S., S. Occelli, G.A. Rabino, C. Salmone and R. Tadei (1985) Nested Dynamics of Metropolitan Processes and Policies: Turin. Collaborative Paper, CP-85-6. IIASA, Laxenburg, Austria.

FOREWORD

BACKGROUND PAPERS FOR THE METROPOLITAN STUDY: 3

The project "Nested Dynamics of Metropolitan Processes and Policies" was initiated by the Regional and Urban Development Group at IIASA in 1983 and work on this collaborative study started the same year. This Series of contributions represents "entry tickets" to the Project, i.e., initial statements by authors from individual metropolitan regions that are participating in the Project's network.

The aim of these papers is threefold. First, to provide some background information describing the processes of change within four principal subsystems: population, housing, economy and transportation. Second, to identify major trends and crucial policy issues which are to constitute a focus for the subsequent analytical and modeling work. Third, to facilitate comparative studies of development paths among these regions and the dynamic interdependencies between the above subsystems.

The background information contained in this paper pertains to the Turin metropolitan region.

Åke E. Andersson
Professor of Economics
Leader
Regional Issues Project

March, 1985

CONTENTS

1. INTRODUCTION

This paper consists of a descriptive part referring to the processes of growth in the Turin urban system in the last three decades and a theoretical part in which we present a general methodological approach to the analysis of an urban system.

It is a first contribution to the IIASA research project, "Nested dynamics of metropolitan processes and policies" and offers a basis for comparison with the other studies involved in the project.

The Turin urban system represents an example of metropolitan development resulting from the growth and concentration of industry. It is a case which is remarkable for the speed of growth and mono-sectorial nature of the economic system.

Turin is the home of FIAT and manufacturing industry still dominates the economic life of the city (almost 50% of total number of jobs).

Our study period covers the principal phase of development when the population, boosted by massive immigration, increased from 1,230,000 to 2,130,000.

In Part I we analyse in social, economic and spatial terms the consequences of this process of growth.

In Part II we present a general methodological framework for the analysis of the dynamics of an urban system.

Derived from this framework is a simulation model which is being applied to the Turin urban system (cf.: Bertuglia, Occelli, Rabino, Tadei, 1980; Bertuglia, Gallino, Gualco, Occelli, Rabino, Salomone, Tadei, 1982).

The model derives from past modeling experience at IRES (cf.: Bertuglia, Rabino, 1975, 1983, IRES, 1976b) as well as from the detailed analysis of the processes described in this paper.

PART 1

2. THE TURIN URBAN SYSTEM

2.1. Geographical characteristics of the study area

The study area is in the Region of Piedmont and has a total area of 4,924 sq. kilometres. It is centred on Turin but includes part of the Alpine chain, a section of the Po Valley and adjacent hill areas (50% of the study area is mountainous, 20% hills and 30% plain) (1).

The most important industries and population are concentrated in the lowland part.

Piedmont is situated geographically in a highly fav-

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(1) For the sake of clarity we should define certain terms used in this study: "urban system" and "study area".
By urban system we mean the socio-economic and spatial system (socio-demographic pole) consisting of:
1. a basic productive subsystem (exporting firms);
2. a demographic subsystem;
3. a service subsystem (producers of goods or services offered, almost exclusively, to the resident population).

This system coincides spatially with the "gravitational area" defined by the geographical limit of permanent journeys to work (cf.: Socco, 1976).
The urban system so defined forms an area within which the resident population has the possibility of access to work opportunities and services at urban level.
The Study Area is in fact the Turin "Comprensorio" in Italian, an area which has been adopted for planning purposes by the Piedmont Regional Authority and is less extensive than the polarised area. (Cf.: Bertuglia, Rabino, 1975; FORMEZ, 1983).
For further discussion of the implications of this definition at different planning levels, cf.: Regione Piemonte (1978).

oured position both in European terms and in relation to the rest of Italy. It is located between the two great natural corridors which converge on the Mediterranean: Le Havre - Paris - Lyon - Marseilles and Rotterdam - Frankfurt - Strasbourg - and with the trans-Alpine tunnels has direct connections with the Lyon area, among the so called "strong areas" of Europe (cf.: fig. 1) (cf.: Regione Piemonte, Comprensorio di Torino, 1982a).

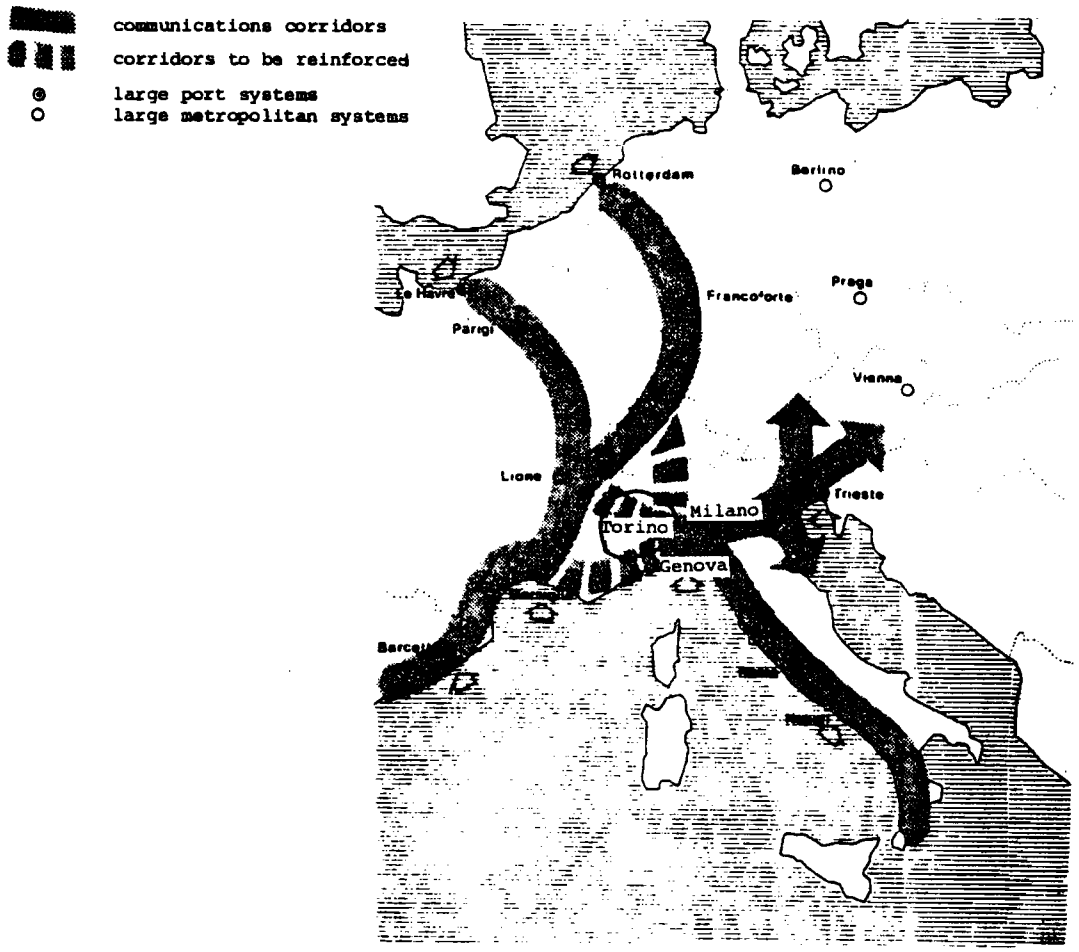

Figure 1. - The study area in the European system

The strong industrial and commercial links with the other principal cities of Northern Italy (especially Milan and Genoa) have meant that a strong infrastructure of communications of regional and inter-regional importance has been built up. The main routes Turin - Milan, Turin - Genoa, Turin - Aosta and Turin - Susa (the first three also being motorway routes) have had important implications on the spatial development of the Turin urban system (cf.: fig. 2).

The study area consists of 206 communes, these being administrative sub-division within the Province of Turin, and corresponding to the basic unit of census information.

The most important of these in socio-economic terms is obviously the Commune of Turin, which we shall in the text call the City of Turin.

For the sake of convenience the communes outside the city of Turin have been grouped together into "zones" which serve as (statistical) units for the purpose of our analysis.

As a further simplification we have referred in the study to the city and to three surrounding "rings" (cf.: fig. 3). The first two are roughly concentric. The first consisting of those zones immediately adjacent to the city itself (i.e. those closest from a physical and socio-economic point of view) and correspond to the main present-day suburbs (cf.: Detragiache, 1976).

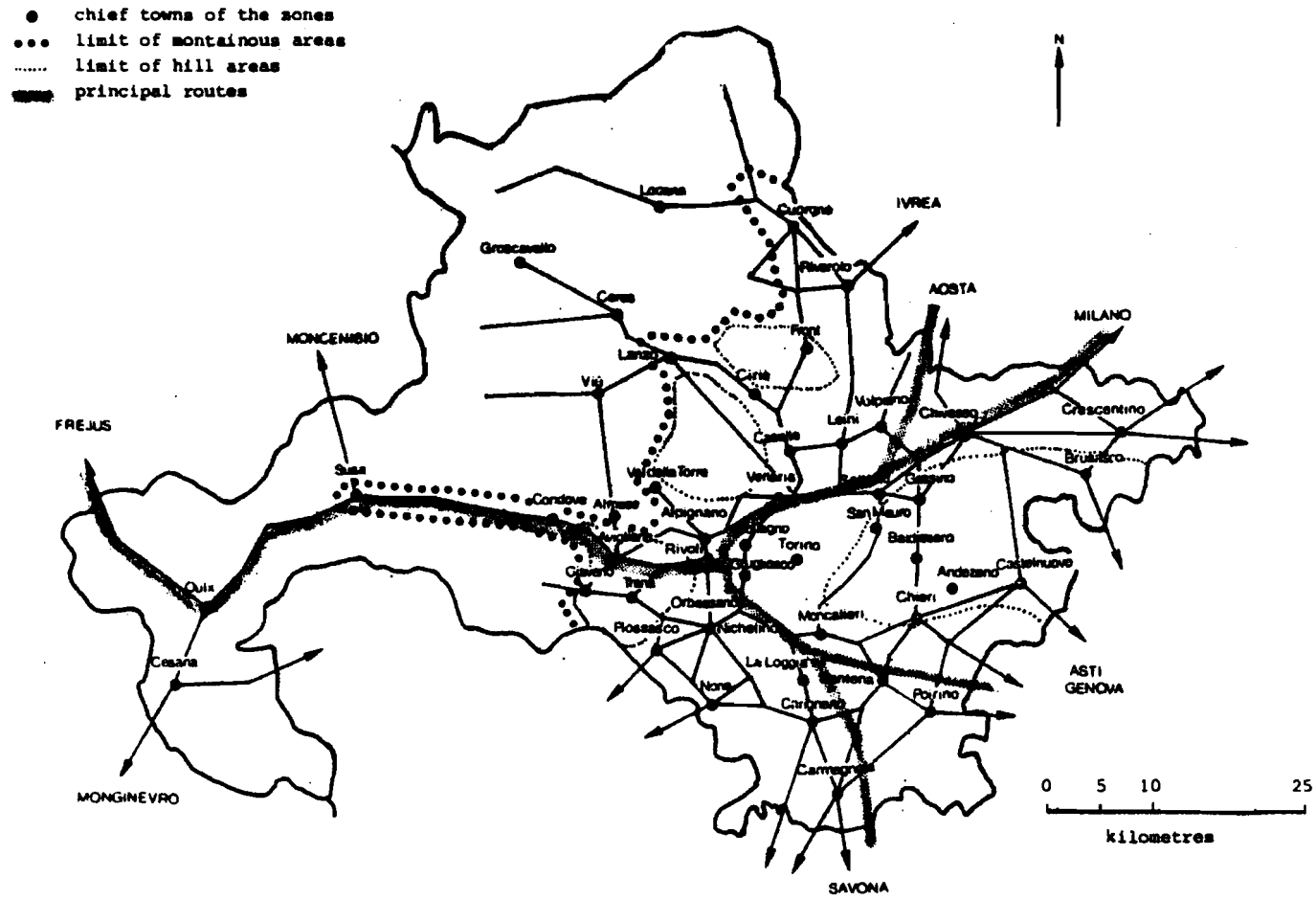

Figure 2. - The study area

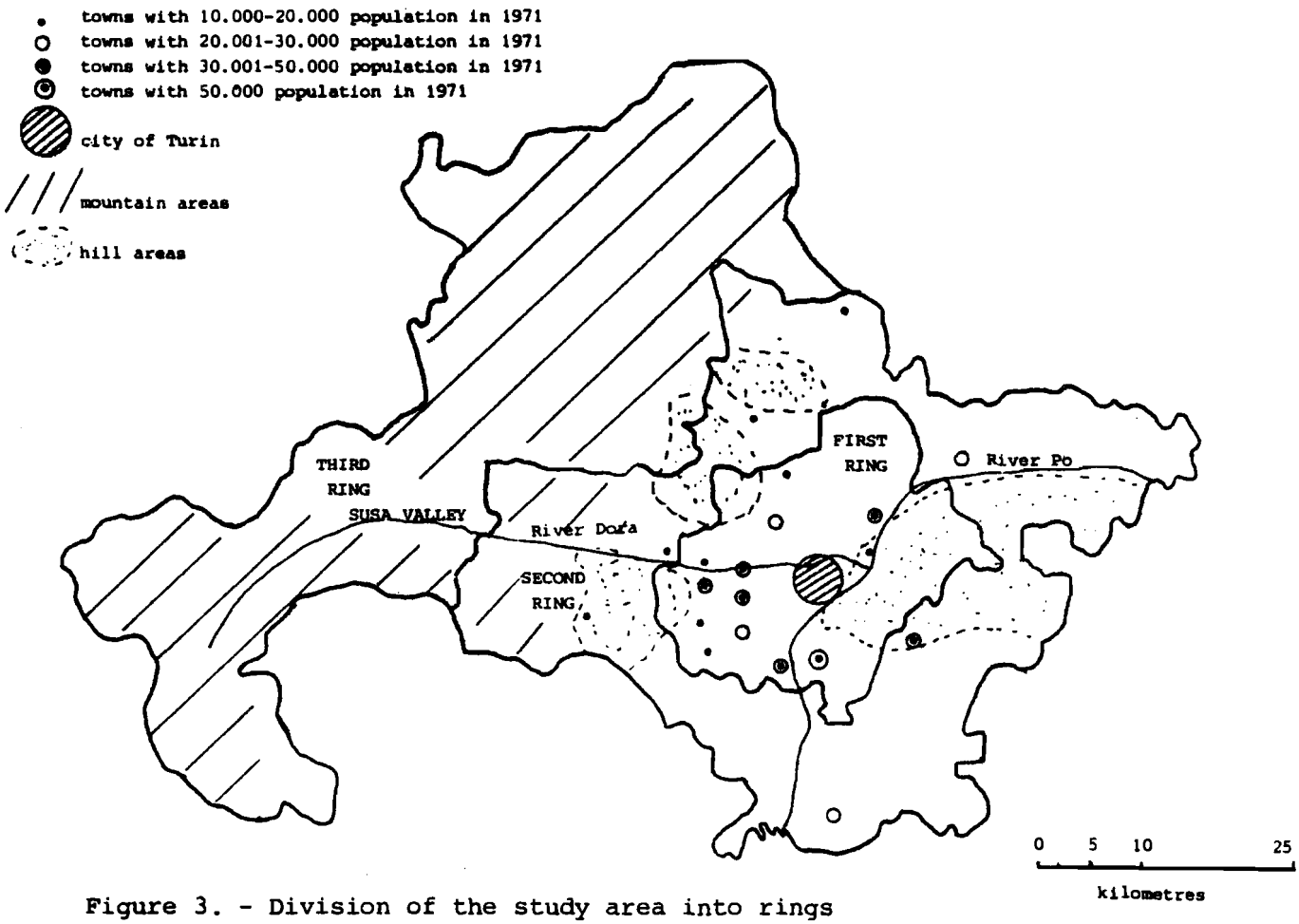

Figure 3. - Division of the study area into rings

The second ring consists of those zones adjacent to the first ring but further out and includes areas of open countryside and farmland as well as small towns and villages.

The third is not in fact a complete ring but consists of zones in the north and west which are contiguous to the second ring and are principally mountainous.

2.2. The growth of the system 1951-1980

The fundamental factors which have characterised the socio-economic and spatial evolution of the Turin urban system since the Second World War are the following (2):

a. a political factor, consisting of decisions taken at a national level which had the effect of contributing to the concentration of post-war industrial development in areas which already offered a certain level of externalities;

b. an economic factor linked to:

b.1 the presence in the Turin area of a well-established

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(2) These fundamental factors have influenced, although to different degrees, the development of practically all Italian cities and can therefore be considered typical factors of urban development in Italy.

metal-working industry and above all the car industry, which, taking advantage of the relatively low cost of Italian labour and advanced technology, acted as a base sector for economic development (cf.: IRES, 1966, 1976a, 1976b; IRES, ITALCONSULT, SEMA, 1962; Gabrielli, 1974; Borlenghi, 1982);

b.2 the role of the building industry, which in the period of urban growth following the industrial development, offered a first employment opportunity for immigrants, who often then moved on to other sectors (cf.: Secchi, 1972; Roscelli, Bedrone, 1975);

c. a demographic factor, closely inter-linked with the two preceding factors, which meant that as a result of a high level of migration, from the south of Italy to the North and from the country to the city, the Turin area received a large number of immigrants. This caused a rate of population growth far faster than the natural trend and resulted in significant modifications in the structure and characteristics of the total population (cf.: IRES, 1965a, 1965b).

Based on these three factors, the underlying mechanism which has moved and guided the socio-economic and spatial evolution of the Turin urban system since the second world war is, as we have said, the relationship which has linked population and spatial growth in the area and the process of industrial growth and concentration.

The process of growth in the Turin urban system can be outlined as follows (Bertuglia, Rabino, 1976, p. 193):

a. socio-economic growth of the city of Turin;

b. subsequent socio-economic growth affecting the surrounding areas (in particular the inner ring) along with the transfer of industrial jobs from Turin city to the inner rings;

c. relative socio-economic decline of the marginal (outer) zones.

The result of this process can be synthesized in the two following contrasting effects (Bertuglia,Rabino, 1976, p. 194):

a. expansion of the Turin conurbation in the form of an "oil spot" effect i.e. first of all ribbon development along the principle communication routes and then infilling of the intervening spaces;

b. rarefaction, in terms of population and jobs of outer marginal areas.

The subsystems with which we are primanly concerned in our analysis are:

1. the economic activity subsystem;

2. the housing subsystem (population and housing stock);

3. the transportation subsystem.

The analysis covers altogether a time period which

goes from 1950 to 1980 and is therefore fundamentally a long-term analysis.

Naturally, given the "macro" nature of the present analysis and the characteristics and limits of the information used, the level of depth will differ according to the subsystem (for those where the information was more fragmentary we have proceeded with a qualitative analysis).

2.3. Socio-economic and spatial processes of development in the Turin Urban System: dynamics and functional inter-relationships between subsystems

2.3.1. Introduction

In this section we outline a framework for the description of these processes.

Emphasis has been placed principally on the way in which spatial expansion of the system has resulted from the process of socio-economic development.

The framework of the analysis was inspired by the interpretation of the urbanisation process by Papageorgiou (1982). In his work he refers to an ideal urban system consisting of a city and its hinterland. He considers how variations in socio-economic conditions (such as income and technology) affect utility levels and spatial exten-

sion of the city and consequently its form, dimension, land values and urban density.

He defines the urbanisation process in terms of 'open city', 'transient city' and 'closed city', concepts which are applied in this study.

Naturally, it should be born in mind that, although we provide the essential elements, the framework is inevitably simplified and may seem excessively schematic in relation to the phenomena being analysed. Given however the aims of the present analysis, we maintain that it is sufficiently explanatory.

The evolution of the Turin urban system can be considered in terms of the following phases of development.

2.3.2. First phase: open system (1951-1960) (3)

This is the period of the "take-off" of the Turin urban system and together with this a more rapid socio-eco

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(3) As the principal source of information was the census data it was convenient to divide the study period into ten-year phases. This was done to give a general time reference and does not imply that these dates have any special significance.
The basic information used for analysis purposes are the census of 1951, 1961 and 1971. Data for the intervening years and post -1971 come, when available, from ISTAT (National Institute of Statistics). We should add that the 1981 census data when available will make it possible to increase the accuracy of certain aspects of the analysis relative to the last ten year period considered.

nomic development with the consequent triggering of the process of spatial growth of the system.

The rapid economic growth generates a strong immigration dynamic which brings to the urban system a very high level of immigrant population (both from outside the study area and from the marginal areas of the system itself) (cf.: fig. 4) creating profound modifications in the socio-economic structure of the system (cf.: IRES, 1965a, 1965b). In this period the population and number of jobs rise respectively by about 400,000 and 140,000 (cf.: fig. 5, fig. 6 and fig. 7) (4).

In the city of Turin, where the major increase, in absolute terms, of jobs and population is concentrated, the socio-economic growth gives rise to a process of spatial expansion, pushing outwards and extending into certain zones of the first ring.

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(4) The statistics on employees from the Census of Industry 1951, 1961 and 1971 are slightly lower than their real values as data on those employed in agriculture and the service sector were underestimated. Given, however, the relatively limited importance of agricultural employment in the study area this sector has not been specificly analysed here. (cf.: IRES, 1969, 1982). In addition the number of agricultural workers in the study area was in continuous decline from 1951 to 1971 [cf.: IRES, 1966; SITECO (Ed.), 1976].
As far as the service sector is concerned, we maintain that the underestimated data do not affect the qualitative analysis of the dynamic.

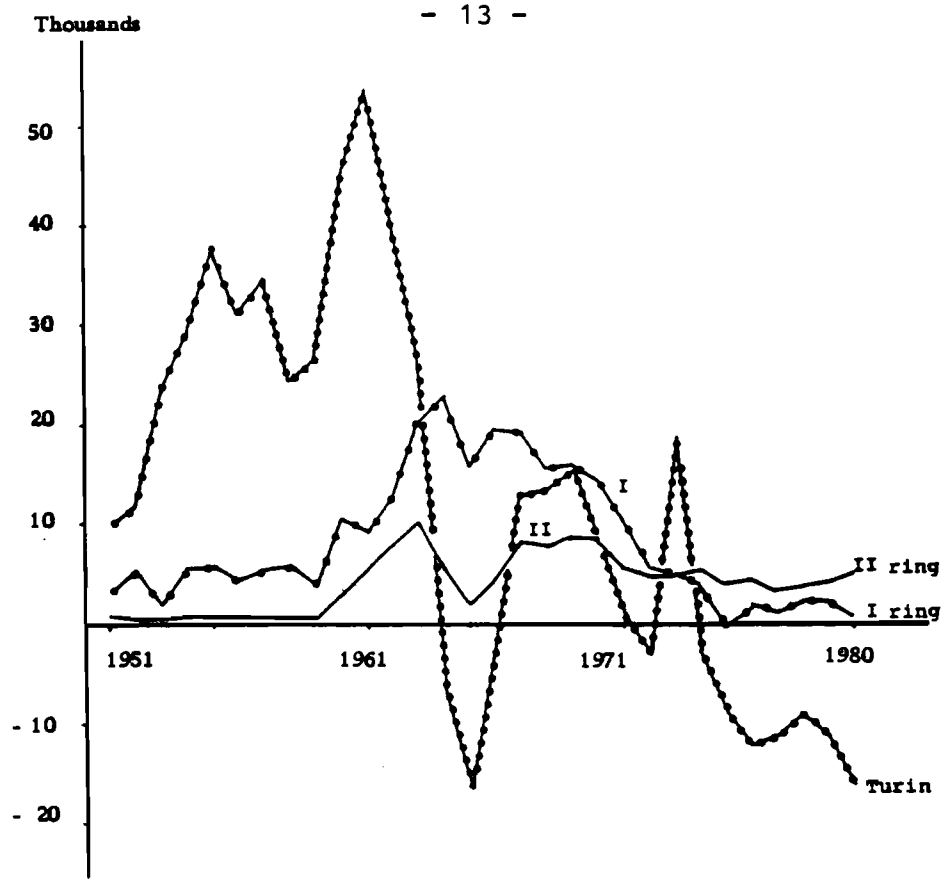

Figure 4. - Dynamic of the net migration in the city of Turin and in the first two rings (absolute values). (The third ring has net migration of approximately zero and is not shown)

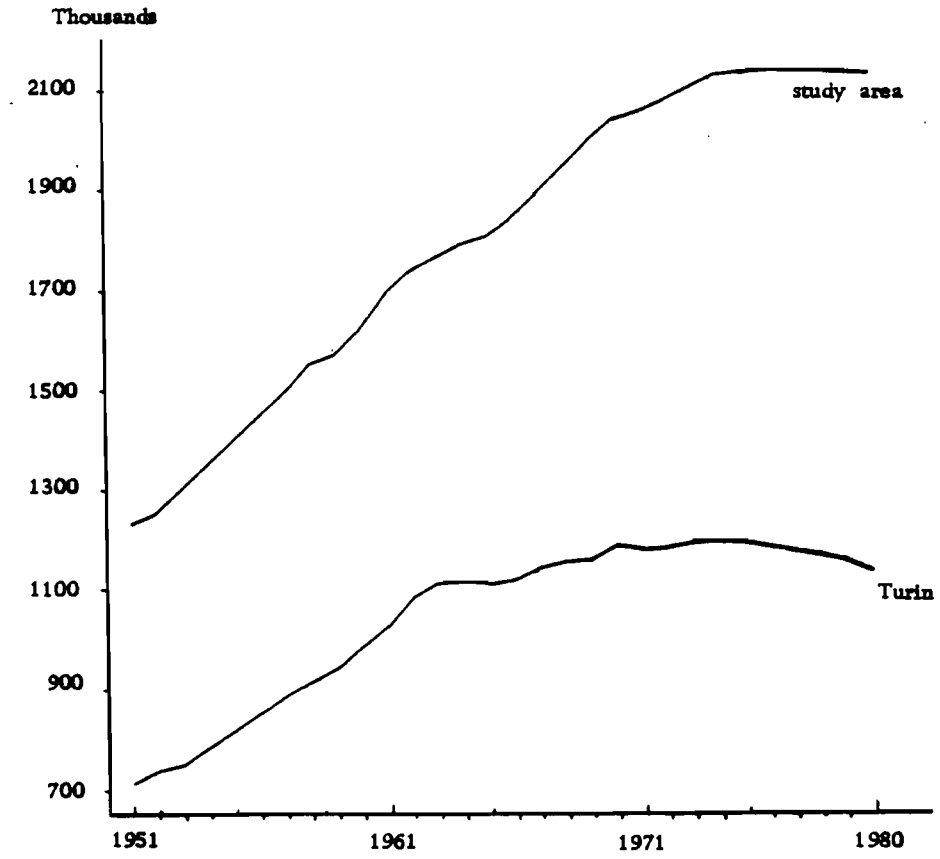

Figure 5. - Dynamic of the population in the study area and in the city of Turin

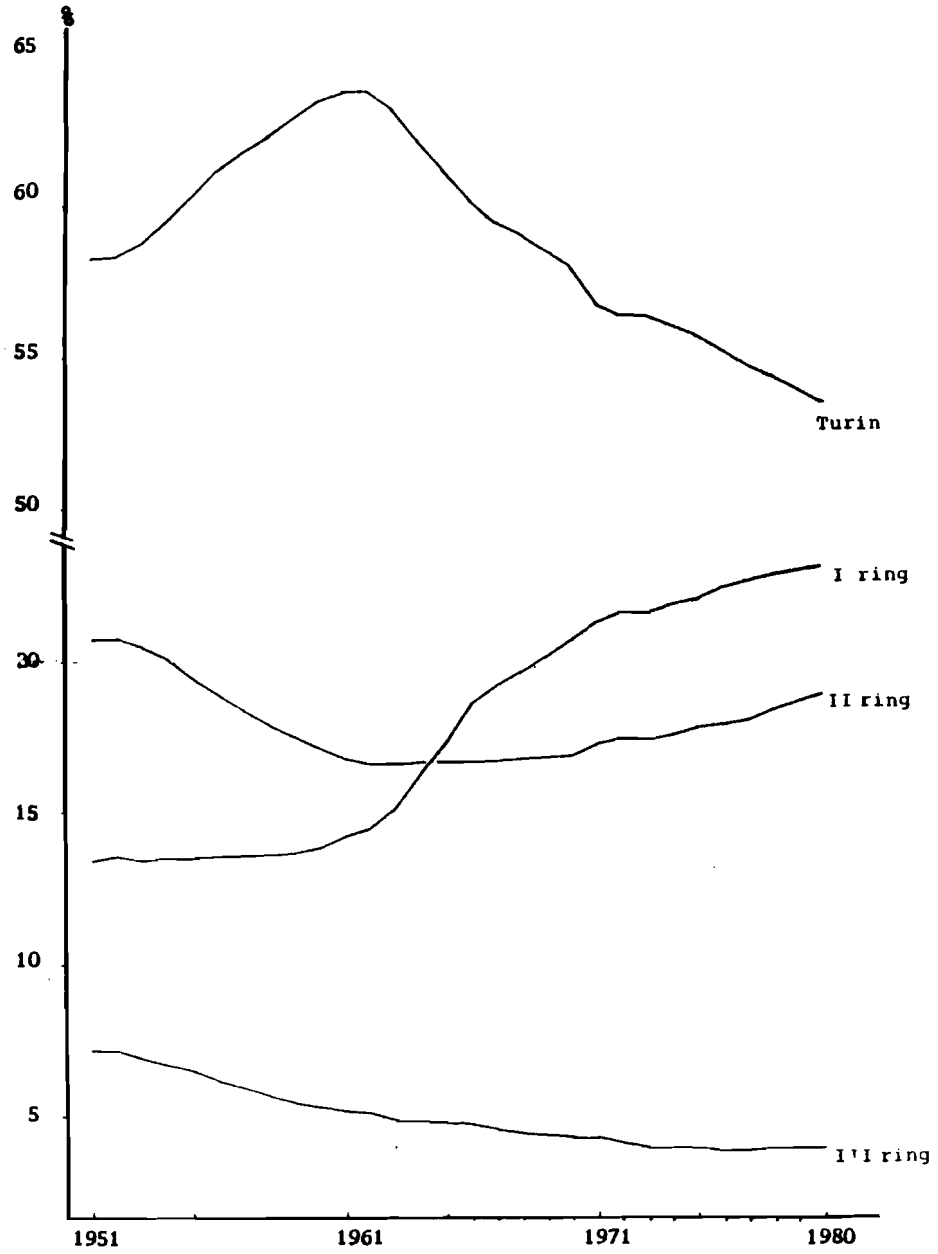

Figure 6. - Dynamic of the population in the city of Turin and in the three rings as a percentage of the total population in the study area (percentage values)

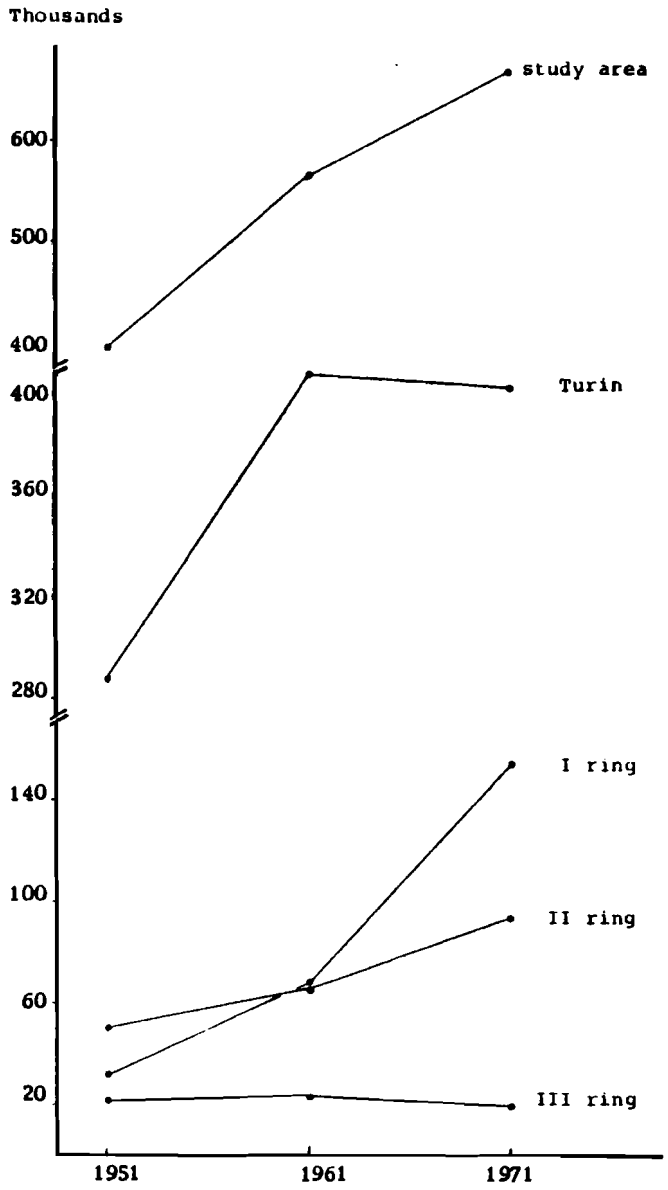

Figure 7. - Number of jobs in the study area, in the city of Turin and in the three rings in 1951, 1961 and 1971 (absolute values)

In this phase it is possible to recognise a time delay in the demographic dynamic with respect to the economic dynamic (or, more precisely, two different speeds). The spatial expansion due to economic growth (already spreading outwards from the city towards the first ring) seems to precede or be faster than that due to population growth which is still concentrated mainly in the city (cf.: fig. 6 and fig. 8).

The spatial expansion initially occurs in the direction of the two main exit routes from Turin, that is, towards the south-west and, to a lesser extent, the north-east. Although the choice of these two directions may appear to be simply explained by the fact that this corresponds to the siting of the two great new industrial complexes there are other underlying factors:

1. an economic factor, connected with the strong inter-industrial links in the industrial sector, and reinforced by the "mono-sectorial" character of industry in the Turin urban system.
   For a breakdown of the economic structure of the system, cf.: fig. 9.
   In this phase the manufacturing industries (in particular metal-working) act as the basic agents of economic development in the study area and are also the dominant activities in terms of the spatial structuring of land-use;

2. a spatial factor, resulting from the radial structure

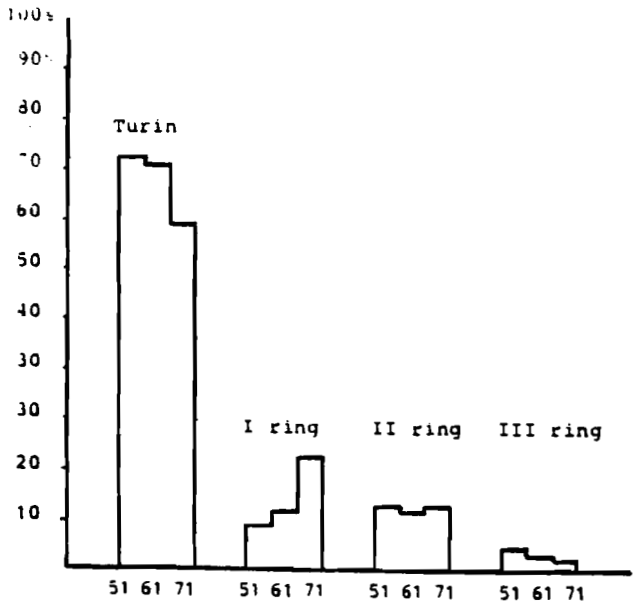

Figure 8. - Number of jobs in the city of Turin and in the three rings as a percentage of the total number of jobs in the study area in 1951, 1961 and 1971

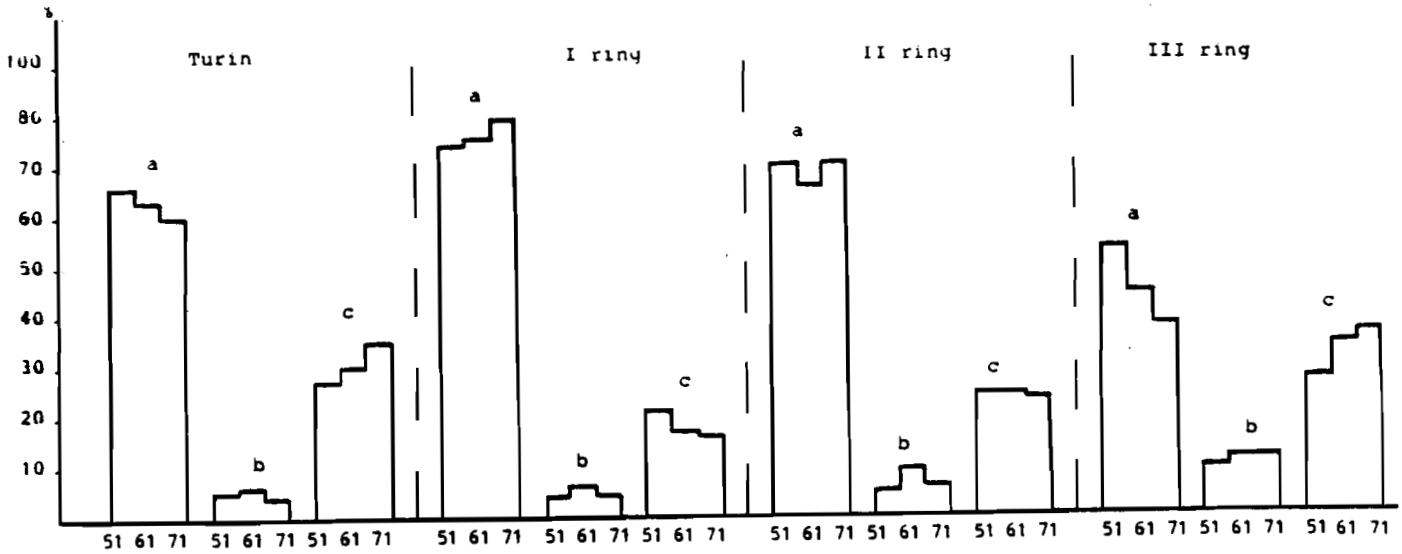

Figure 9. - Number of jobs in the non agricultural sectors in the city of Turin and in the three rings as a percentage of the total number of jobs in Turin and in each ring in 1951, 1961 and 1971

a. quarrying and manufacturing industries
b. building industry
c. service sector (energy, commerce, transport, banking, services)

of the communication network, which means that activities located in peripheral areas can benefit from the existing urban infrastructure, as they have direct access to the centre (and therefore can take advantage of the high level of urban externalities).

It may also be observed that the location of residential development, with the time delay referred to above, basically follows the location of industrial activity, i.e. occuring prevalently in the south-west and north-east of the first ring (cf.: fig. 10 and fig. 11).The process of residential development is sustained in addition by a strong dynamic of building activity concentrated in this period in the city of Turin (of the total of 160,000 new dwellings built 78% are in the city). A further indicator of the rate of building activity is the increase in number of jobs in the building industry (cf.: fig. 9).

2.3.3. Second phase: transient system (1961-1970)

This is the phase in which we see the spatial "diffusion" of the socio-economic development of the Turin urban system reach its highest levels.

From the city of Turin (and from certain zones of the first ring) the socio-economic growth, which, although it is now less rapid than previously, invades the first and then the second ring leading to a fast and chaotic

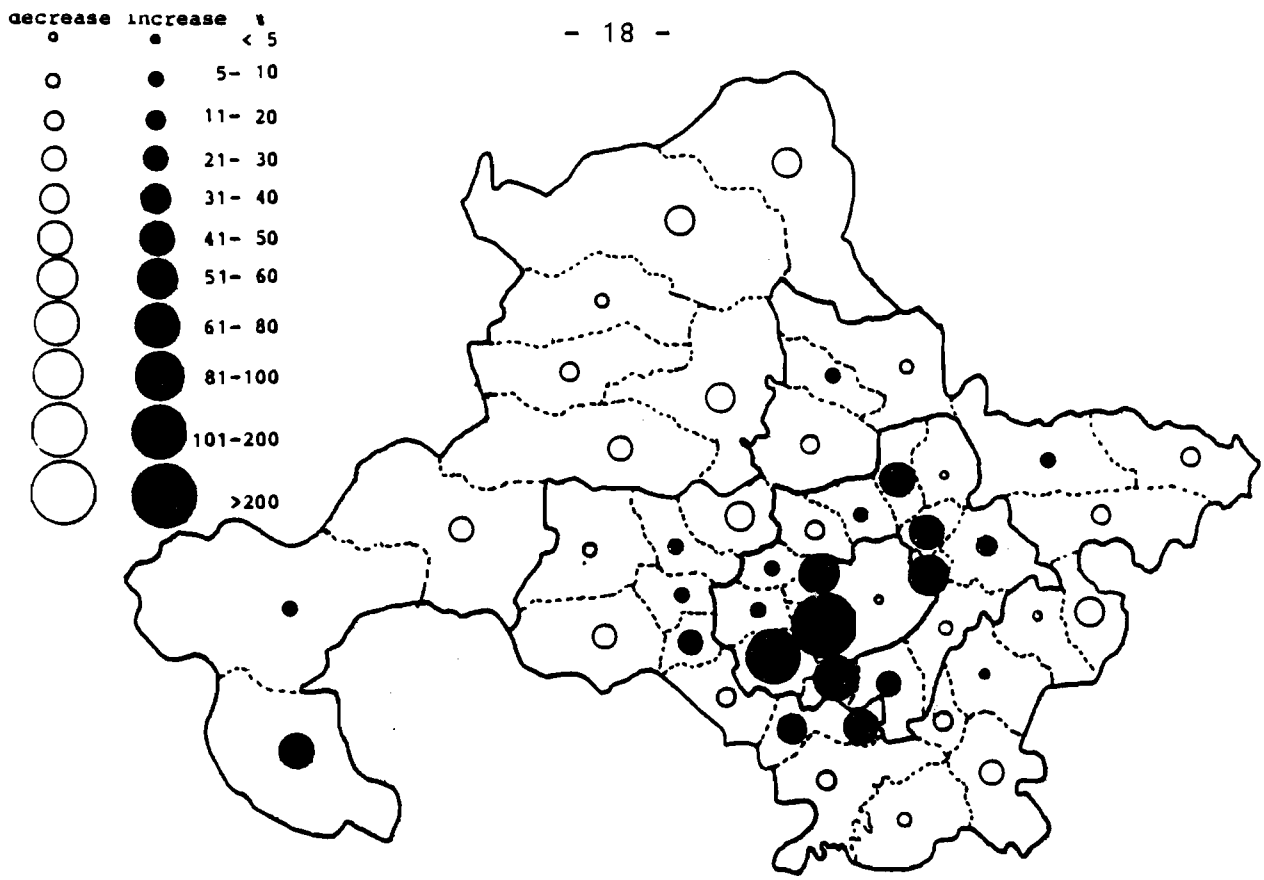

Figure 10. - Percentage variation 1961/1951 of the number of jobs in the zones (This variation bas been calculated from the percentage values of the total number of jobs in the study area)

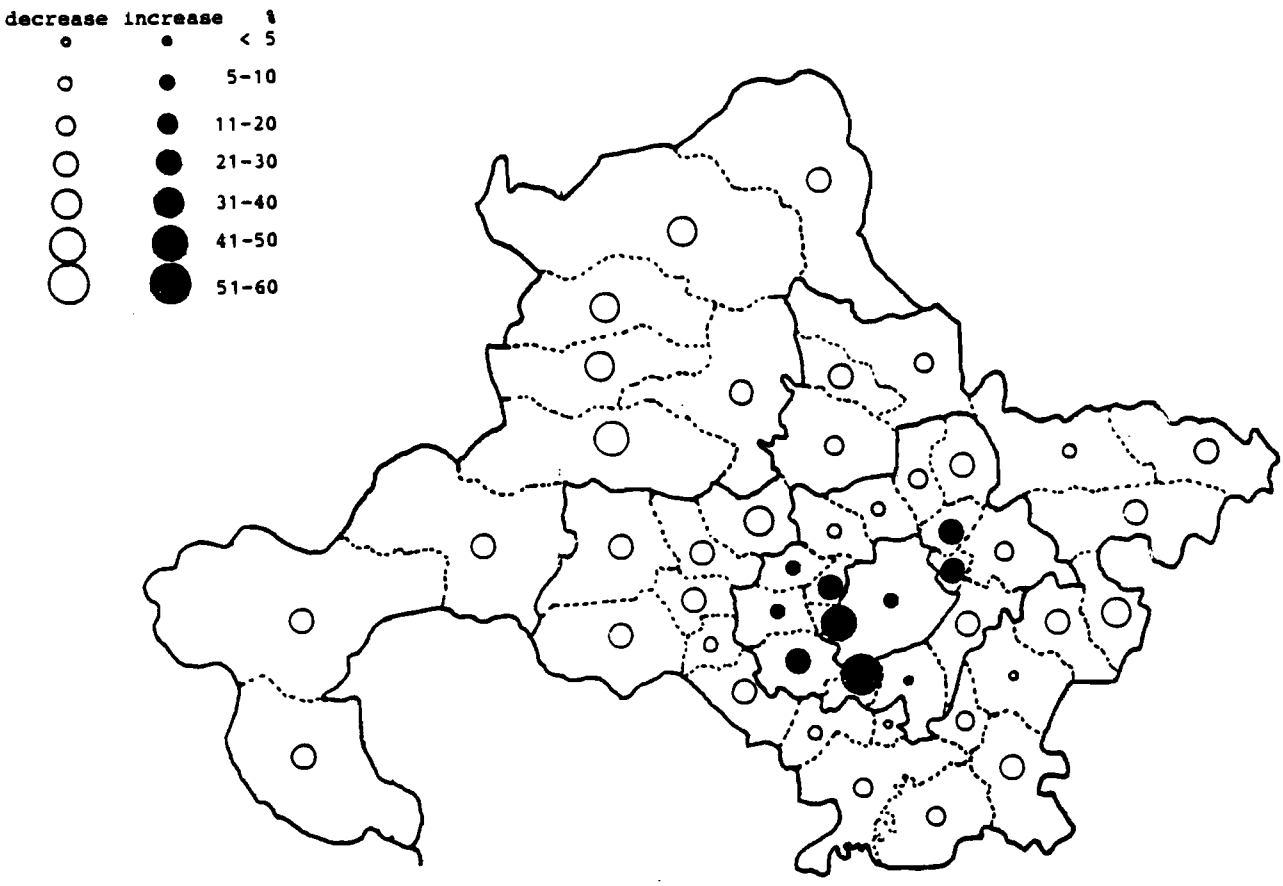

Figure 11. - Percentage variation 1961/1951 of the population density in the zones (This variation has been calculated from weighted values of the population densities)

process of urbanisation of these areas.

Relative to the whole study area, the socio-economic weight of the city of Turin is diminished (in terms of jobs and population), that of the first ring increases and, to a more limited extent, also that of the second. The decline of the third ring continues (even though,for certain zones we begin to see a "take - off" as areas of tourist attraction) (cf.: fig. 6 and fig. 8).

The locational dynamic of industry has in this period the predominant role in determining the characteristics of spatial development which occurs. It acts both directly, through the siting of new industry and the consequent residential growth (i.e. the housing necessary for workers) and indirectly, orientating locational behaviour in general (cf.: fig. 12 and fig. 13).

We describe here the workings of this dynamic in more detail with reference also to its time sequence (cf.: IRES, 1966):

1. industrial concentration in the major towns of the first ring (and later in the second). (This is due to the emergence of new locational factors: economies of scale and economies of agglomeration).
   As well as new activities, we see the relocation of jobs from the city of Turin, the latter occuring as a result of the progressive saturation of available space within the city and the increase in land rents. An additional factors is the growing importance of road as opposed to rail-based transport which allows mo

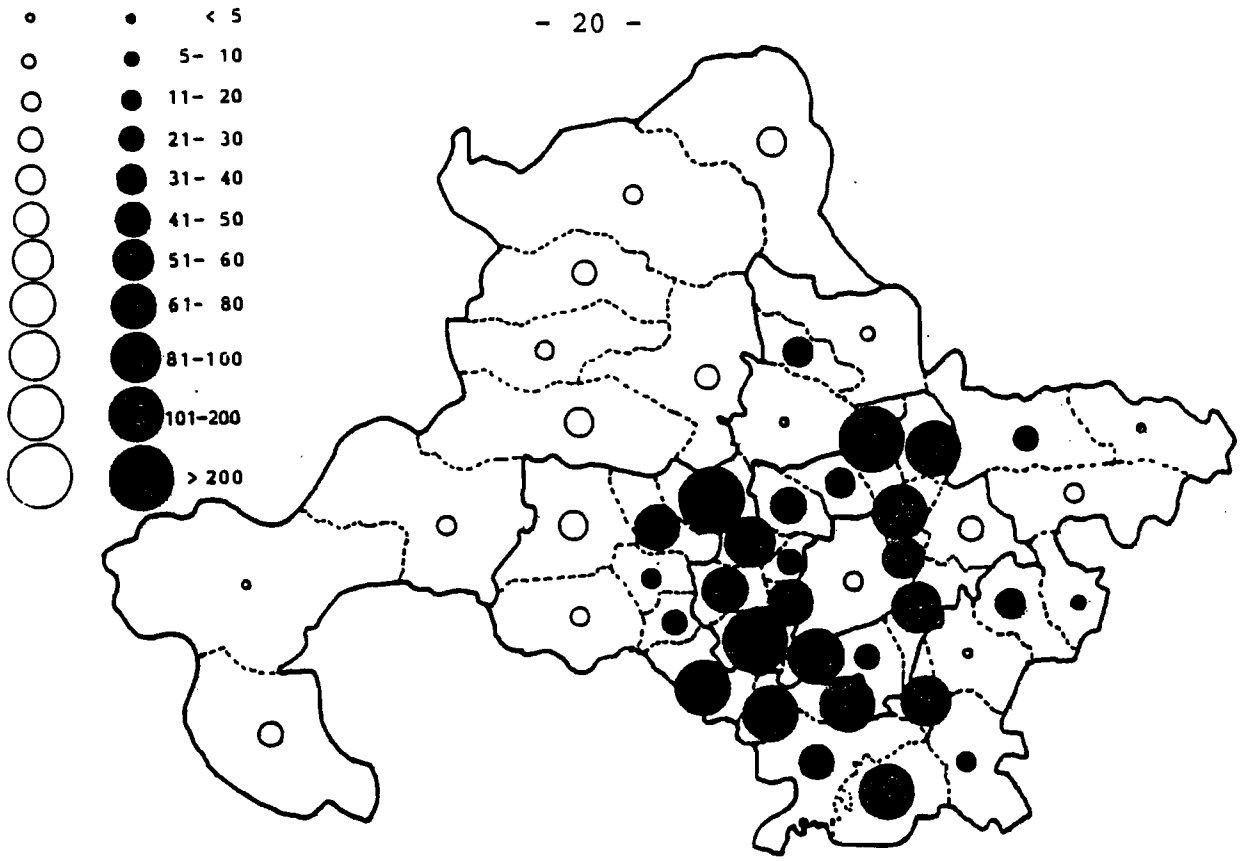

Figure 12. - Percentage variation 1971/1961 of the number of jobs in the zones. (This variation has been calculated from the percentage values of the total number of jobs in the study area).

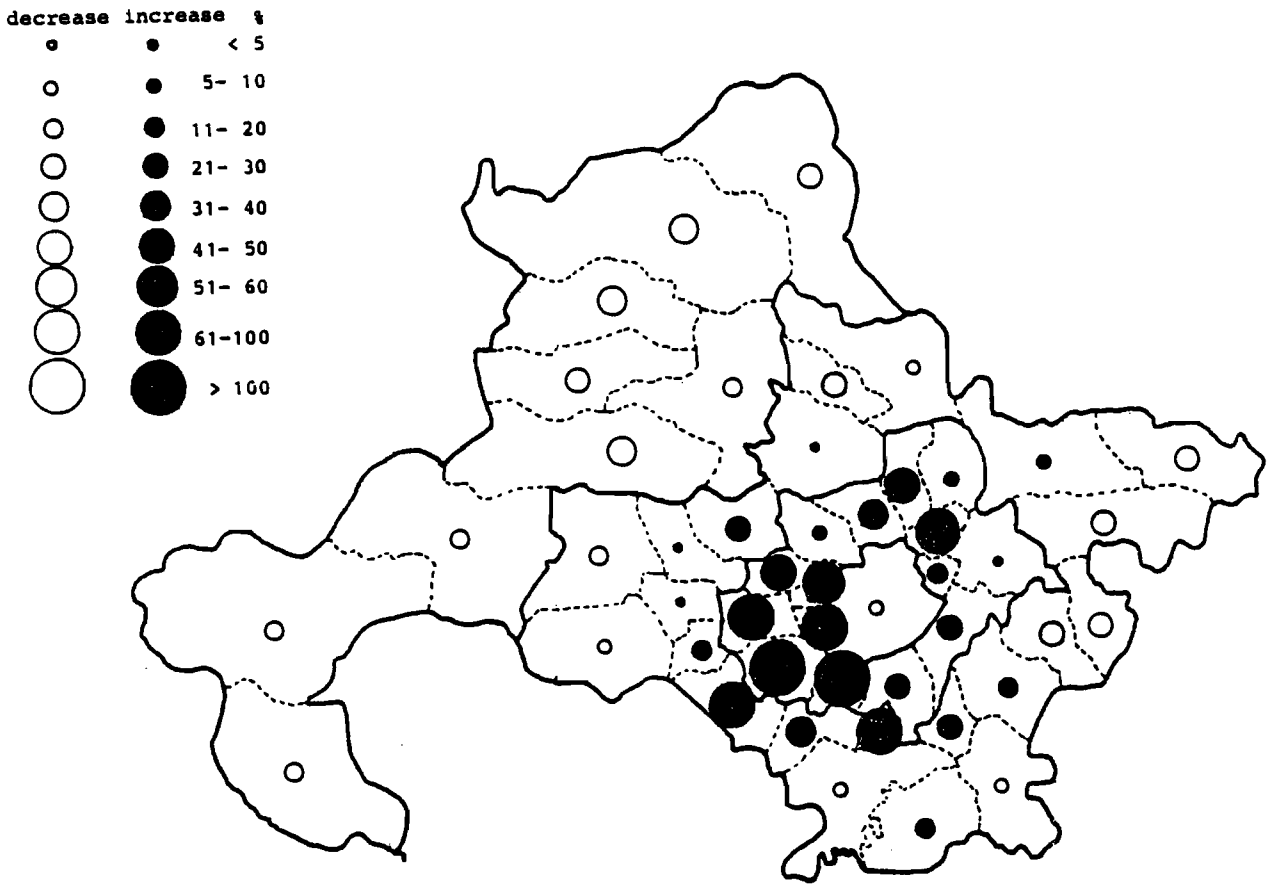

Figure 13. - Percentage variation 1971/1961 of the population density in the zone. (This variation has been calculated from weighted values of the population densities)

re freedom in location of industry (5);

2. economic development and consequent growth of population and need for housing in the towns of the first ring (which occurs later also in the second ring). We see a "radiation" of development around these towns, as a process of growth and internal reorganisation follows their socio-economic expansion;

3. diffusion of the socio-economic growth of these towns along the main communications routes with the formation of "axes" of development connecting them firstly to the city of Turin and then to the towns of the second ring. This is followed by the gradual infilling of the remaining free space contained between these a

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(5) To the factors cited in the text we can add the following reasons for the relocation of industry.
To explain why firms should move at this particular time we must take into account that it was a time of economic and social stability (with an absence of union conflict) which gave certainty to the forecasts and expectations of the entrepreneurs and a time when there were few controls affecting land-use and land rents (cf.: Ortona, Santagata, 1982).
In general the movement tended to be radial i.e. firms tended to relocate along the same axis on which they were previously sited. This certainly seems to apply to smaller and medium-sized firms. Larger firms, which if necessary could afford to construct or have the necessary infrastructure built, were freer in their choice of location.
Most relocation occurred, however, within a radius of 20 kilometres from the centre of Turin, indicating a relative inertia.
The explanation is not simple but it seems to be motivated by a desire to retain the original workforce (cf.: Mazzucca, Vito, 1982).

xes.

As can be seen in figs. 12 and 13 all the main exit routes from the city were affected by both economic and residential development practically concurrently.

The modifications brought about in this period to the communications network - the building of new routes out of the city in the north and east - contributed significantly in influencing industrial location (in particular along the northern route) and residential location (in particular along the eastern route).

Although in all the zones we have in fact a mixture of residential and economic development (which is mostly industrial), we can delineate the following spatial typologies (6) (cf.: fig. 14):

a. prevalently industrial zones, in which the index of occupational concentration (expressed as a ratio of jobs to population) has a value considerably above the average for the ring in which it is located. This happens in particular in the western zones and to a lesser extent in those in the north of the first ring (cf.: fig. 14b);

b. mixed zones, in which the index of occupational concentration is close to the average. This is the case for the north-western zones of the first ring and the eastern zones of the second (cf.: fig. 14b);

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(6) Here we refer only to the first two rings because they are the areas mostly affected by socio-economic and spatial development and because the index of job concentration for the third ring could be distorted because of the loss of jobs and or population.

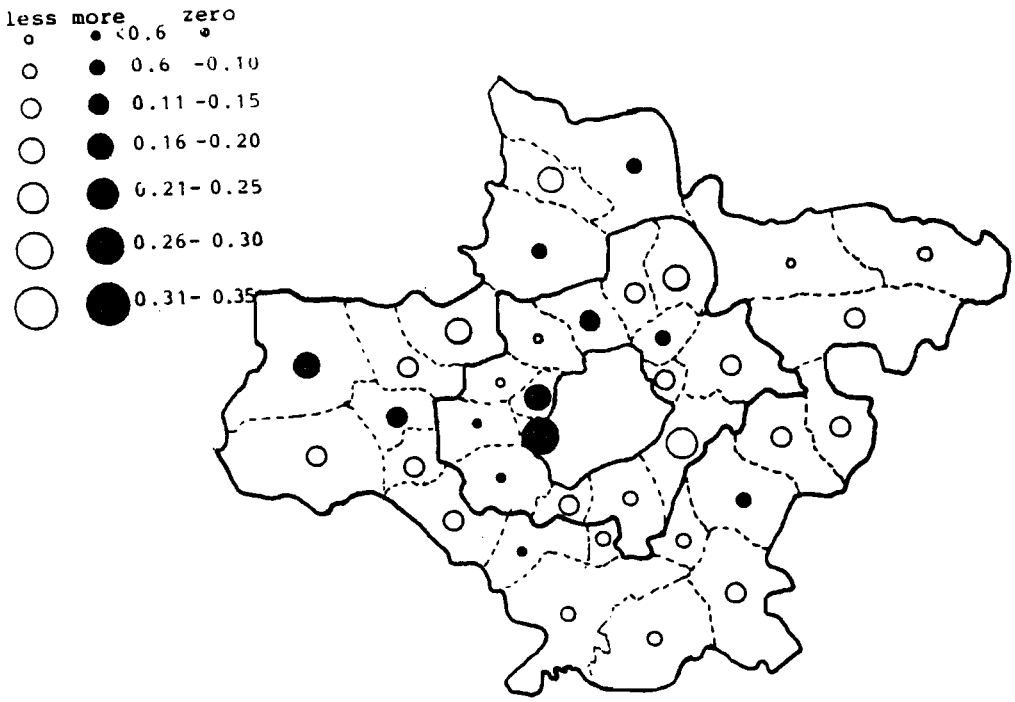

Figure 14a. - Situation in 1961. Mean value of the concentration index: I ring 0.30
II ring 0.25

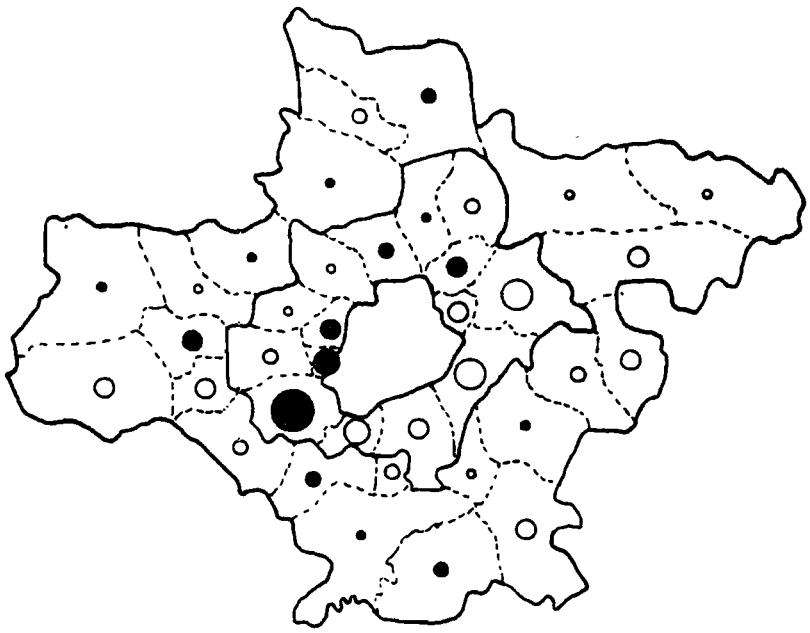

Figure 14b. - Situation in 1971. Mean value of the concentration index: I ring 0.35
II ring 0.26

Figure 14. - Zone distribution in the first and second ring of the jobs concentration index (jobs/population ratio) expressed as a difference from the value in each ring

c. prevalently residential zones, in which the index of occupational concentration is appreciably lower than the average.

Comparing the situation in 1961 and 1971 we observe that certain zones in the first ring, especially those in the east and south-east of the city (and in the hill area), emerge as predominantly residential areas (cf.: fig. 14a and 14b) (7).

The process of spatial spread in general was sustained by a strong building dynamic, which was favoured by the lack of incisive control over land-use. In this period a total of about 200 thousand dwellings were built (about 24% more than in the second phase) and of these more than 60% in the first two rings (8).

The distribution of housing in the study area in 1971

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(7) Comparing figs. 14a and 14b we see that a certain number of zones which in 1961 had a low index of concentration, in 1971 have a value much nearer the mean, indicating a relatively strong locational dynamic for industry in this period. (This is the case for certain zones in the nord-west and south-west of the second ring). For these zones residential development had to some extent a functional relationship with industrial development in that it provided the necessary accomodation for the workers.

In addition, some of the zones with a low index in 1961 and 1972 are areas particularly favoured for housing of upper income groups.

(8) The weight of the building dynamic also diminishes in this period in the city of Turin where only 37% of new dwellings are located compared with 78% in the previous phase.

is illustrated in fig. 15. We can observe that the city of Turin and the first two rings have a rate of vacancy very close to zero, whereas the zones in the third ring have a significantly higher value. This is due to the phenomenon of depopulation of these zones as well as to the construction in certain of them of a large number of second homes in and near the winter sports resorts.

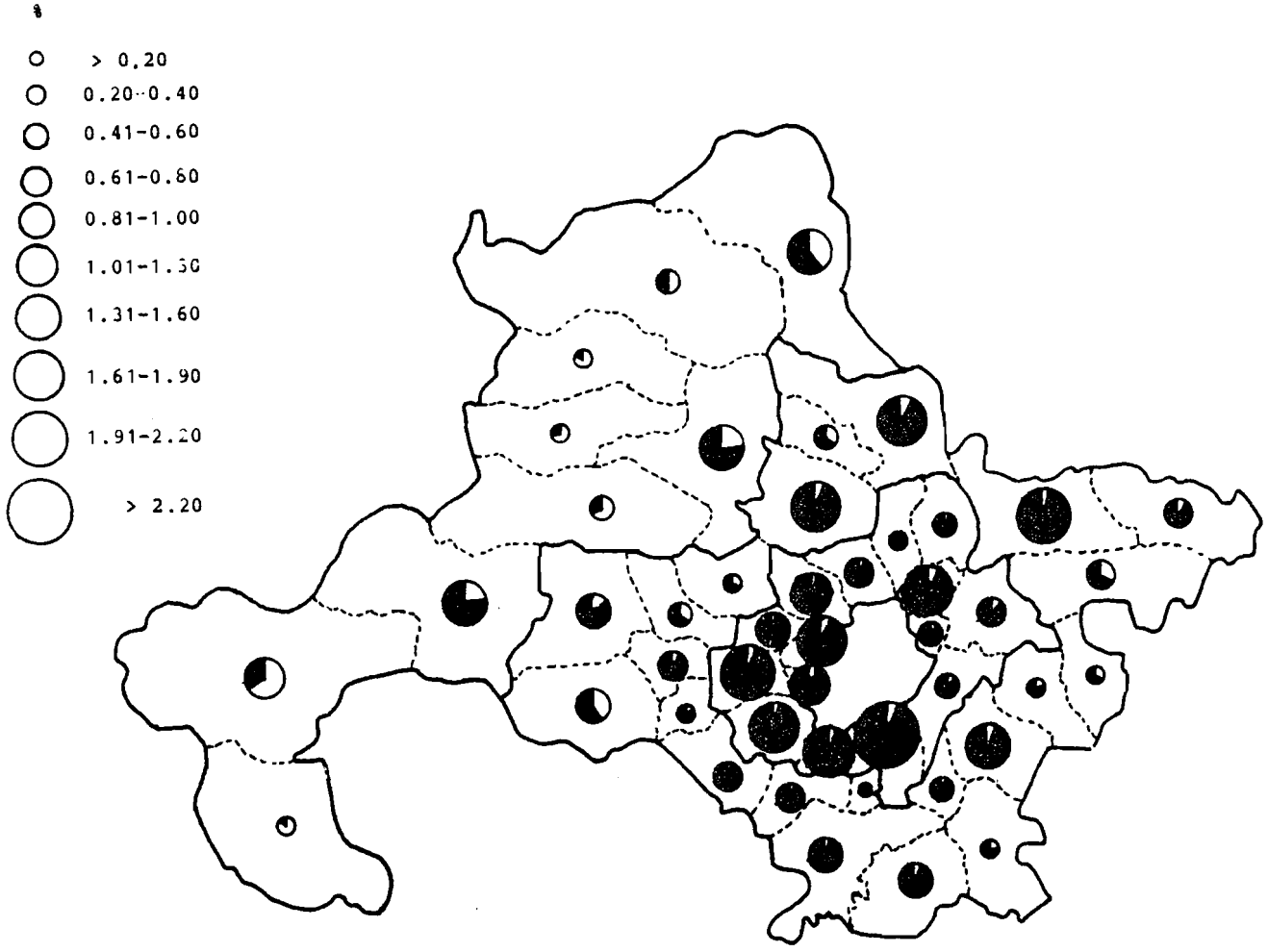

Figure 15. - Zone distribution of the housing stock in 1971 as a percentage of the total housing stock in the study area (the white part shows the vacant stock).

2.3.4. Third phase: closed system (1971-1980) (9)

This is the phase in which socio-economic development progressively slows down while spatial expansion, although slower than previously, continues.

The immigration dynamic disappears (cf.: fig. 4) and at the same time the birthrate begins to fall (cf.: Regione Piemonte, 1979b, 1980) (10). The trend of 'diffusion' continues, affecting the first ring and, more than previously, also the second ring. The decline in the third ring now seems to have ceased, some zones having socio-economic development, while the decline of the socio-economic weight of the city of Turin continues (cf.: figs. 6, 7 and figs. 16, 17).

Economic development prevalently affects the zones outside the city, i.e. the first ring and, more than previously, the second (11) (cf.: fig. 17).

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(9) The information relating to this phase has been based on the results of model simulation.

(10) In this period the Turin urban system and, in particular, the city of Turin, entered into a situation of economic crisis (which was felt also at regional and national level).
This helps to explain the reverse in the migration dynamic and to a certain extent that of the natural population. The fall in birth rate which accounts for the latter can be attributed to the general climate of uncertainty resulting from this situation.

(11) From the first experiments with the model it appears that the percentage variation 1979/1971 of total numbers of employed is +12 in the city of Turin, +13 in the first ring, +13 in the se-

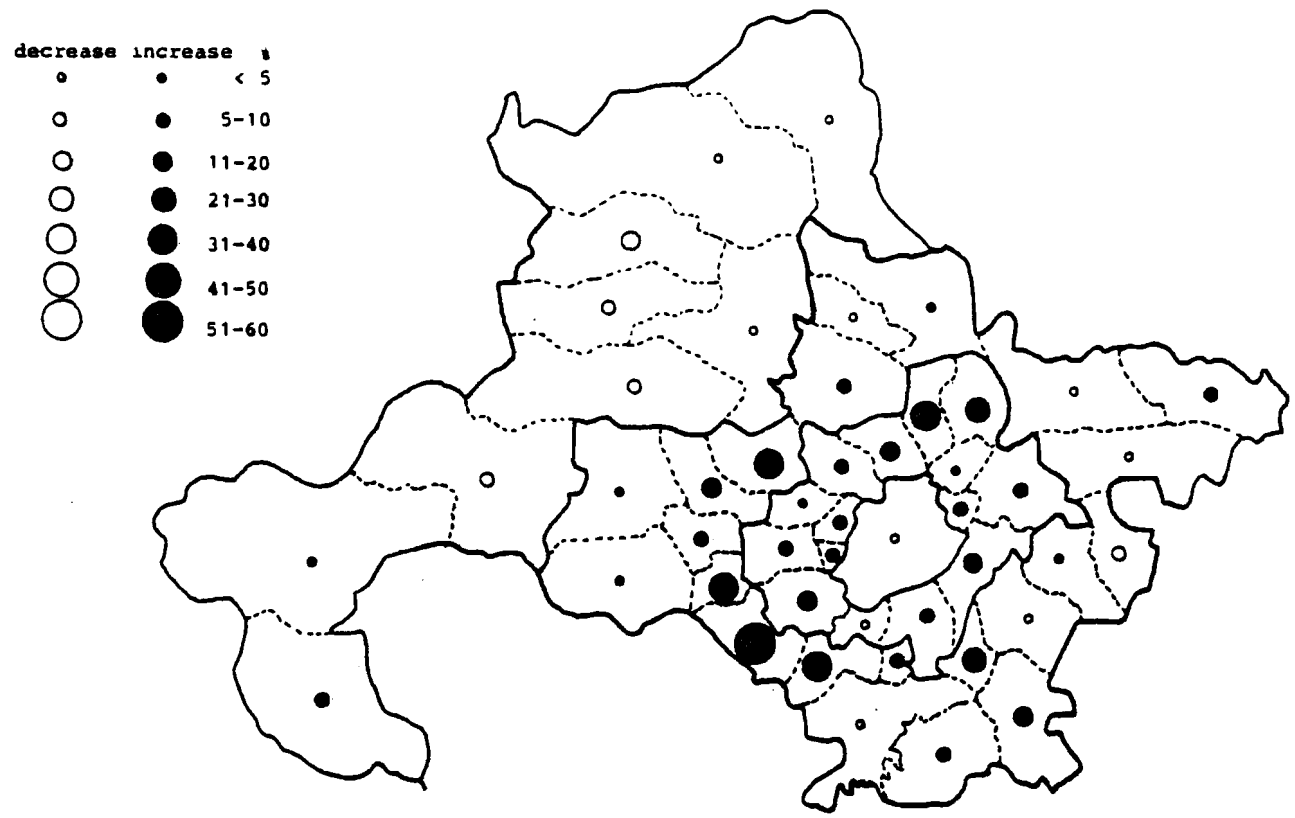

Figure 16. - Percentage variation 1980/1971 of the population density in the zones. (This variation has been calculated from weighted values of population densities)

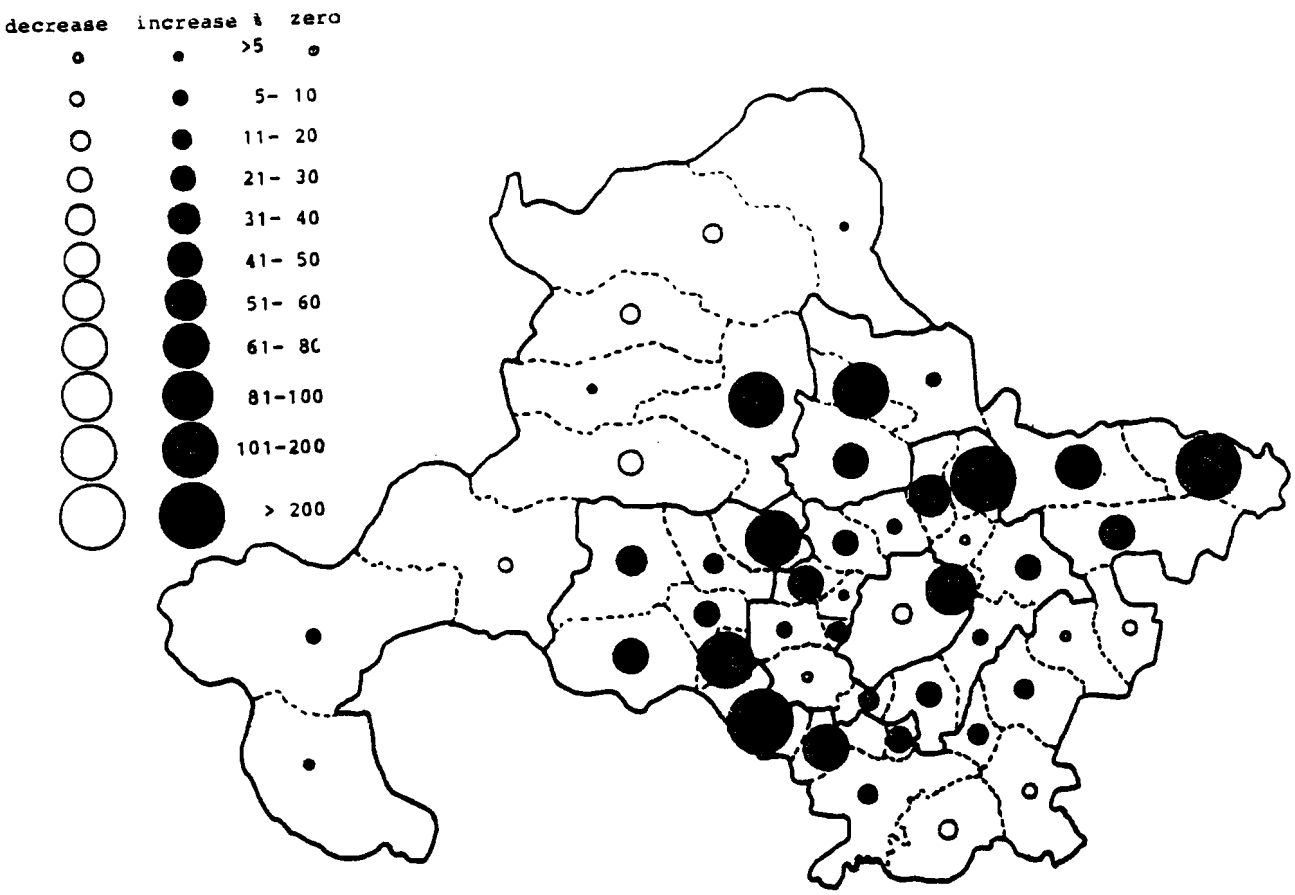

Figure 17. - Percentage variation 1979/1971 of the number of jobs in the zones. (This variation has been calculated from the percentage values of the total number of jobs in the study area. The computation is based on the simulation outputs)

The most important feature, however, is that economic growth occurs in different sectors than previously, no longer affecting manufacturing industry, being prevalently in the service sector (cf.: fig. 18) (12) (cf.: Regione Piemonte, 1979b, 1980; Regione Piemonte, Comprensorio di Torino, 1982b; IRES, 1980; Federazioni delle Associazioni Industriali del Piemonte, 1979). It appears, however, that the negative aspects of the previous phases of economic growth conditioned the development of the service sector which did not benefit as much as might be expected from the scale of industrial growth (cf.: Sanlorenzo, 1976). Considering the size of Turin compared with other urban areas, the services, especially the so-called high-level services are relatively little de-

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(11) contd.

cond and +18 in the third.
In addition the variation of the percentage weight of the city of Turin and the three rings (relatively to the total number of jobs in the study area) is -0.50 in the city of Turin, -0.02 in the first ring, +0.65 in the second and -0.15 in the third.

(12) The structure of the service sector in the study area is very similar to that in the region as a whole. It has been important in relieving the unemployment problem. Unlike in the rest of the region, however, there is a development of high level services in the city and inner ring due to the more intense growth process.
We see, in fact, in early years of industrial development in Piedmont, that the support function of services to the economic growth was greater than its function in absorbing surplus labour (cf.: Sanlorenzo, 1976).

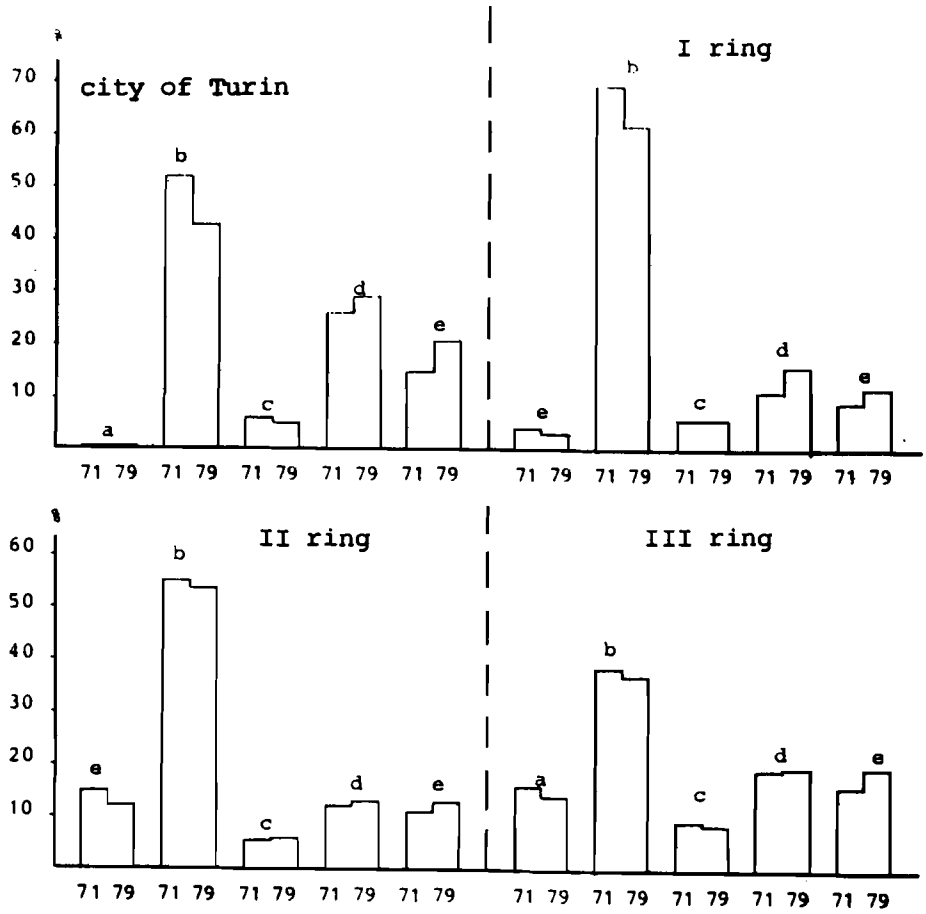

Figure 18. - Number of jobs in the economic sectors in the city of Turin and the three rings in 1971 and 1979, as a percentage of the total number of jobs in the study area. (Distribution calculated from model simulation)

Articulation of the economic sectors:

a - agriculture;
b - quarrying, manufacturing;
c - building;
d - high-level services: commerce (wholesale, intermediary services, hiring services), transport and comunications, banking, services (leisure, health, education, legal and commercial institutions, professional institutions), public administration;
e - low-level services: commerce (retail, market stalls, hotels), services (cleaning, religious institutions).

veloped (13).

In the city of Turin, the number of jobs in the service sector, in this period, increases by 76,000 of which 34,000 are in the high-level services (14).

At the same time, despite the increase in jobs, the growth in terms of land use (area) in this sector appears to have slowed down (cf.: Dematteis, Di Meglio, Emanuel, 1978). This apparent contradiction can be explained by:

a. the tendency for high-level service activities (especially those requiring greater floorspace) to relocate, moving out of the city of Turin usually into the first ring (15);

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(13) The "take-off" of the high-level service sector in the Turin urban area seems to have been hindered by the proximity of the city of Milan. In other words Turin appears to be located within the area of influence of the high-level service system centred on Milan (cf.: Regione Piemonte, 1979a).
For a comparison of the level of service employment in certain Italian cities, cf.: SITECO (Ed.) (1976).

(14) The text refers to the distinction between 'high' and 'low' level services, as used in the model. This definition attempts to distinghish those services which serve as a 'base sector' for the economy (high level services) involving 'export' of services outside the study area, and those more traditional services for the resident population.
A list of the kind of services included in each of the categories is found on fig. 18.

(15) According to experiments conducted with the model we found that the number of people employed in high-level services goes in 1971-1979, from 78% to 76% in the city of Turin and 10% to 13%

b. a great increase of jobs in this sector in the so-called "advanced industrial services" i.e. those involving administrative and technical assistance for industrial firms. Information on the size and location of these offices is extremely difficult to obtain and the scale of the development is consequently hard to quantify as the offices are frequently small and often located in residential premises, therefore not appearing in the statistics.

The full implications of this process of transformation in the economic structure in terms of population and socio-economic changes are at present difficult to assess, because of the lack of accurate information.

In this phase the urban area suffers from the negative effects of over-rapid and chaotic growth. The principal problems being:

a. lack of social services and shortage of housing (aggravated by deterioration of condition of existing housing) especially in the city of Turin and the first ring;

b. traffic congestion and consequent reduction in the

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(15) contd.

in the first ring (expressed as a percentage of total employed in this sector in the study area).
The above values are naturally approximate and should be interpreted with care. The tendency for this sector to relocate and decentralise emerges also in the study already quoted, cf.: De matteis, Di Meglio, Emanuel (1978).

ease of accessibility from the outer areas (especially the second ring) to the services located in the city;

c. a disorganised pattern of land-use in the urban areas especially in zones affected by the "oil-spot" effect previously referred to.

As far as the service system is concerned a situation of general disequilibrium emerges, both in terms of the kind of services provided and their spatial distribution in the study area. Despite the presence of a considerable number of services (above all high level) in the city and in certain peripheral zones, there is a noteable shortage of the low level services (cf.: Regione Piemonte, 1981).

An indication of the level of services was obtained by using an index which represents the percentage of population employed in local (low-level) services i.e. those serving the resident population. This index is shown for each zone in relation to the mean for the ring in which it is located, cf.: fig. 19.

In the residential subsystem we find a shortage of housing (represented by the gap between demand and supply) (16) and a deterioration in the condition of existing

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(16) It should be added that this discrepancy between supply and demand for housing has been a problem for many years, not only in the study area but all over Italy. For a more detailed study at national level, cf.: Dandri (1977) and IRES (1977) for the regional situation.

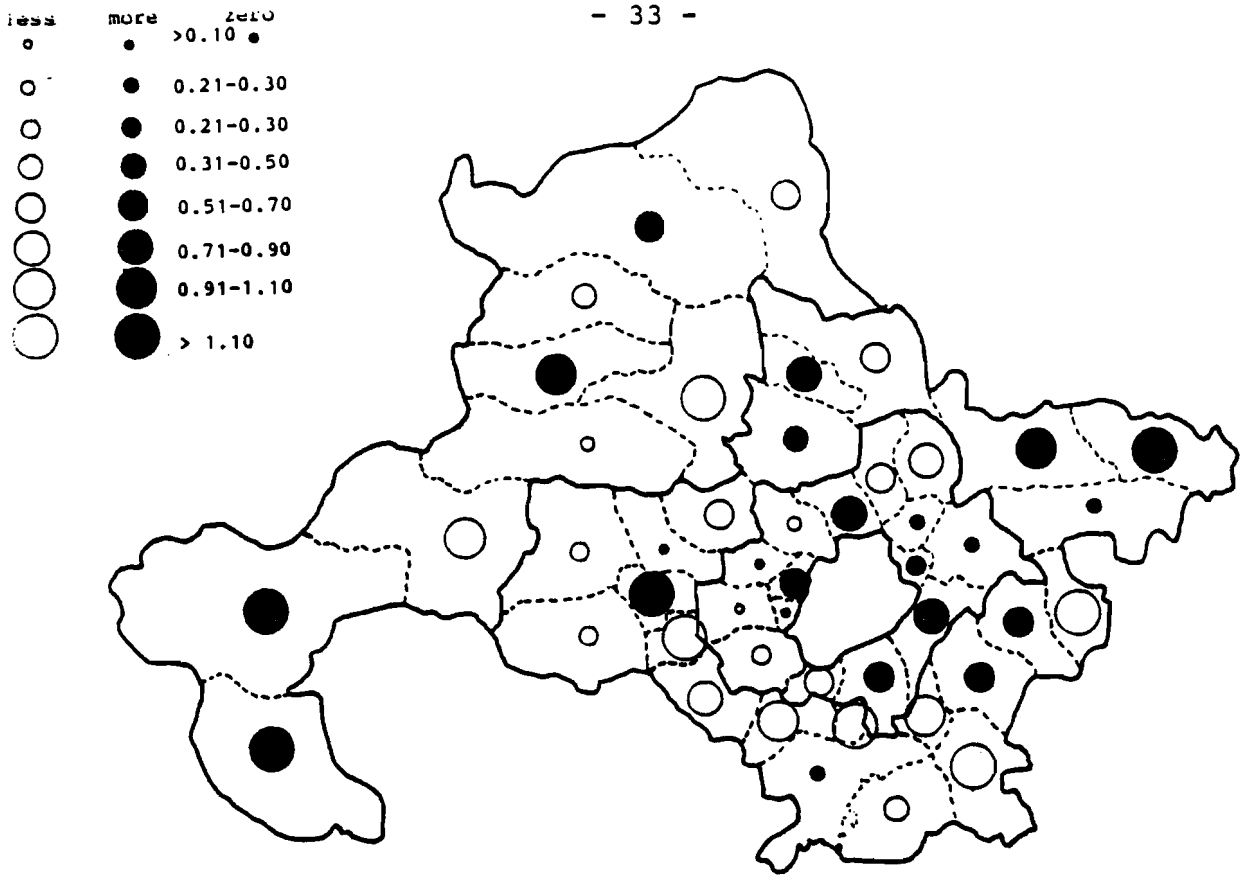

Figure 19. - Zone distribution in 1971 of the service jobs population ratio expressed as the difference from the mean value in the first ring (3.36), in the second ring (3.59) and in the third ring (5.23)

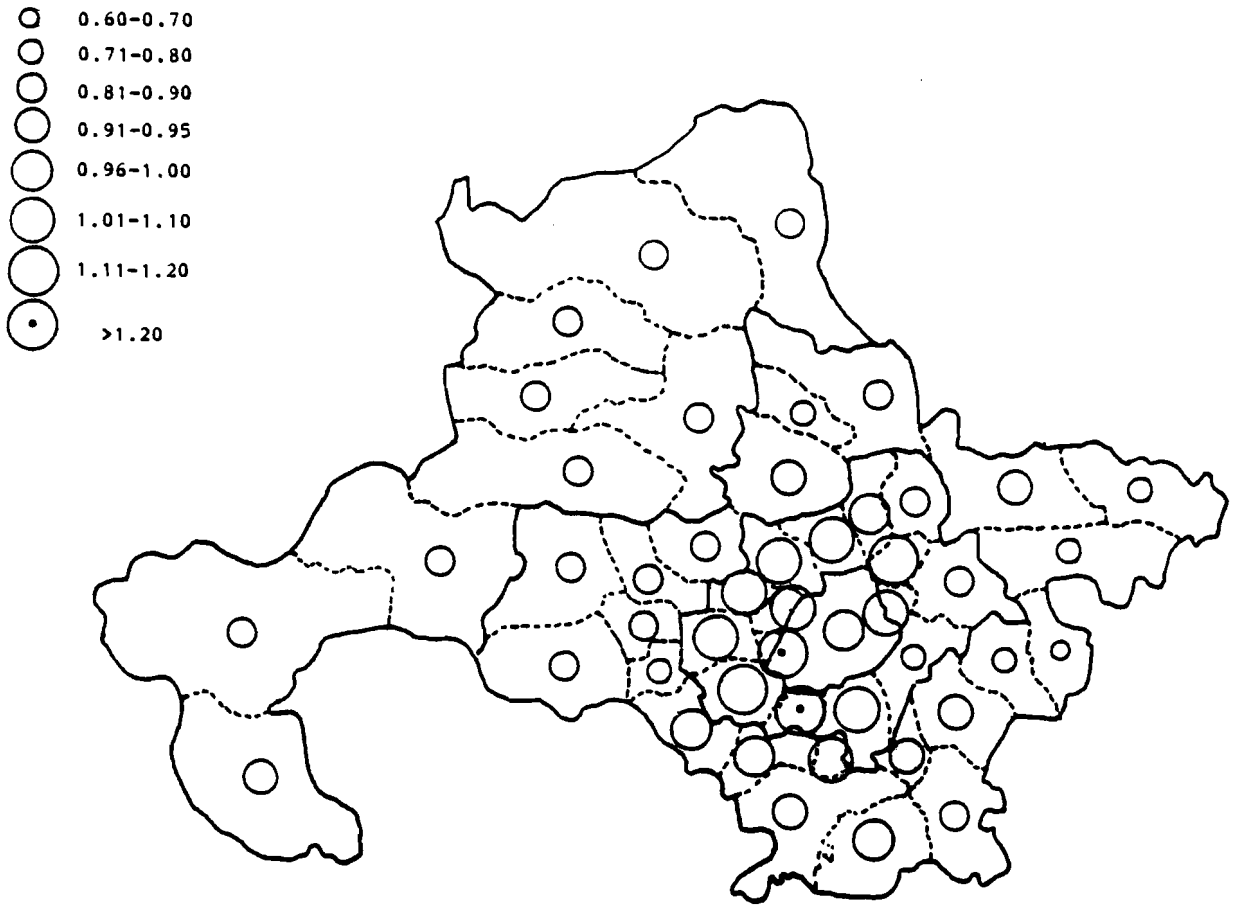

Figure 20. - Distribution in 1971 of the residential crowding index (population/room occupied ratio) in the zones

housing (physical and functional obsolescence) (cf.: Bertuglia, Mela, Preto, Reale, Socco, 1974).

The size and spatial distribution of this shortage can be partly measured by the 'crowding' index (ratio of population to rooms occupied) (cf.: fig. 20). Practically all the zones of the first ring show a value of more than unity (17).

It seems that despite the high rate of building in the previous phase the supply of new housing has not been sufficient to provide adequately, either in terms of quantity or distribution, for the demand generated, and that public housing has been too sporadic and insufficient to remedy this problem (18).

An additional problem arose as the consequence of new legislation passed in this period. It was designed to regulate the letting conditions and control the price of rented property but it had the effect of freezing the supply and creating the formation of a 'black market'

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(17) In fig. 20 the crowding index for the city of Turin is less than unity because of the way in which it was calculated i.e. as a ratio of the population to the total number of rooms occupied in the city. In fact in another study where a similar index was calculated taking each individual dwelling occupied it emerged that in the city of Turin in 1971, the 'shortage' of rooms was 201,000 (cf.: Bertuglia, 1976).

(18) To give an idea of the level of building in this sector, the figure for 1972 for Turin and the first two rings (for public authority housing and company housing for employees), amounted to only 7% of the total, practically all of which was in the city of Turin (cf.: EISS, 1972).

(cf.: Bertuglia, Occelli, Rabino, 1979).

For this reason and because of the introduction of land-use controls, building activity was considerably reduced. From 1971-1979 only 43,000 new dwellings were built compared with 200,000 in the previous decade. The new building occurred mainly outside the city, especially in the second ring, whereas in the city itself we see a process of infilling and building towards the hill area (cf.: fig. 21).

The tendency to spatial specialisation referred to in 2.3.3. continues and we find (especially in and near industrial areas and working-class residential areas), poor environmental quality, a high level of crowding, lack of services and other problems resulting from an unsuitable mixture of land-use.

In the hill area where the development is mainly residential (for the upper income bracket) and relatively 'exclusive' we find an urgent need to safeguard the landscape and protect agricultural resources (cf.: Regione Piemonte 1979a).

The problem of housing decay and obsolescence is represented in fig. 22 where we show the distribution of obsolescent dwellings (19). It appears to be less severe

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(19) Fig. 22 is based on the housing data used in the simulation model which are from the 1971 census. This defined two categories: housing in decay or sub-standard (i.e. with outside toilet), and obsolescent housing (i.e. that built before 1946, but excluding housing in the former category).

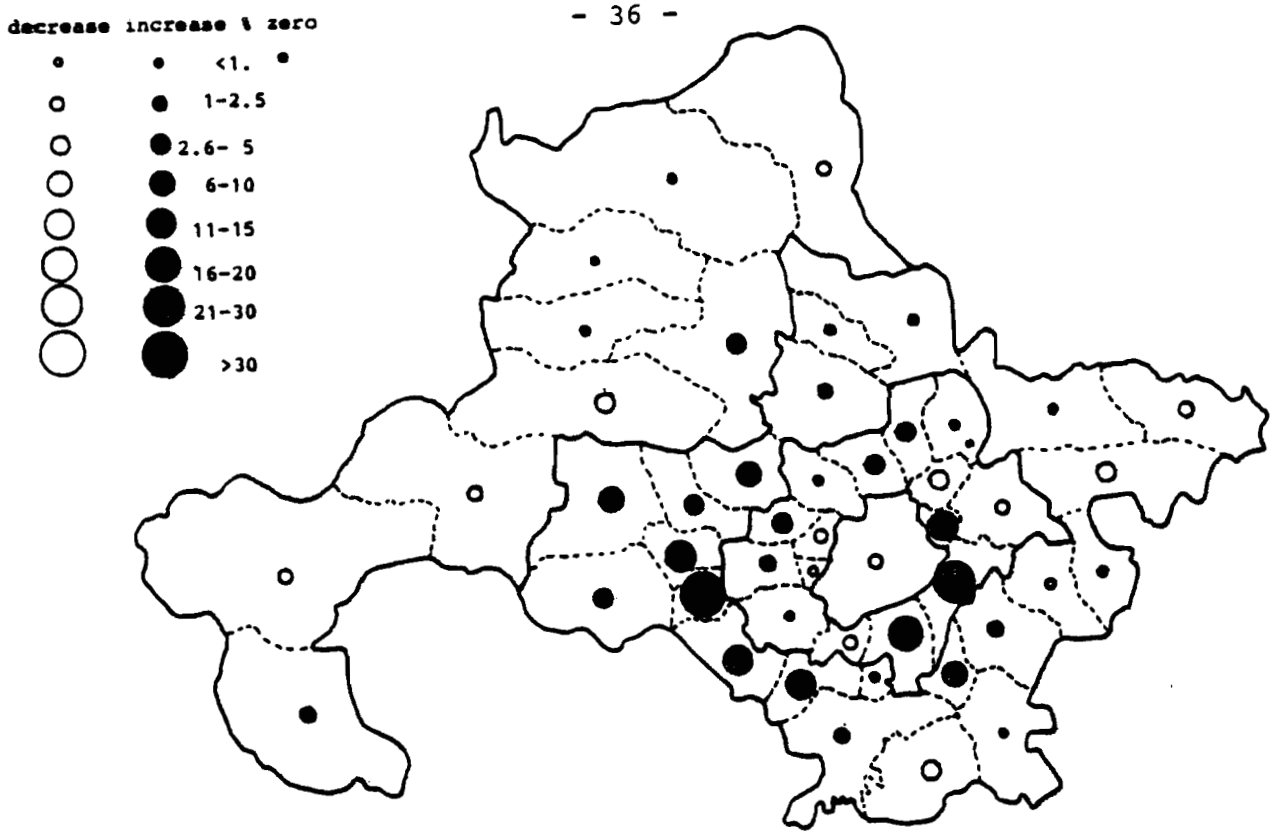

Figure 21. - Percentage variation 1979/1971 of the housing stock in the zones. (This variation has been calculated from the percentage values of the total houses in the study area. The calculation results from the model simulation)

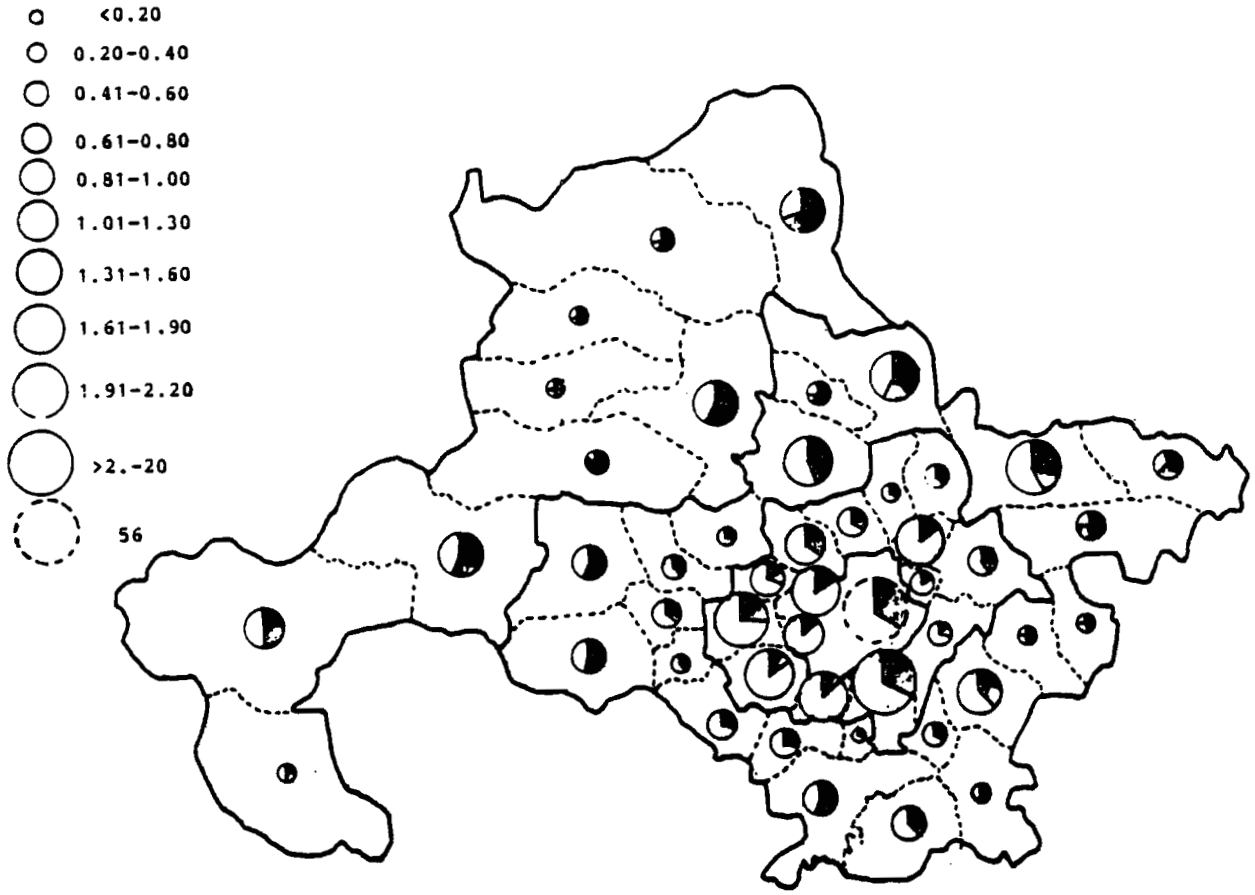

Figure 22. - Zone distribution of the housing stock in 1971 as a percentage of the total housing stock in the study area, of the decaying stock (black part) and of the obsolete stock (grey part)

in the city of Turin and the first ring when expressed as a percentage per zone (as this is the area of densest residential development) but in this main urban area we find the highest number of rooms in absolute terms defined as obsolete (cf.: Bertuglia, 1976; IRES, 1977; Comune di Torino - IRES, 1980).

In relation to the transportation subsystem the problem of congestion arising from the inefficiency of the radial system of communications reaches a serious level. Continued development outside the city increases the distances necessary to travel into and out of the urban area and also increases volumes of traffic.

The commuting problem (journeys to work) has been met principally by the private sector i.e. the private car. At area level, very little has been done to improve public transport, and where improvements have been made they have principally affected the bus service and not railways [cf.: Regione Piemonte, 1975; SITECO (Ed.), 1976].

However, we should note that although the public transport system appears not to have adapted adequately to the spatial development of the city, it caters nevertheless for a significant proportion of the population (about the 35%).

An idea of the practical implications of the transportation system is given by fig. 23 which shows travel times from the city of Turin (central area) to the va-

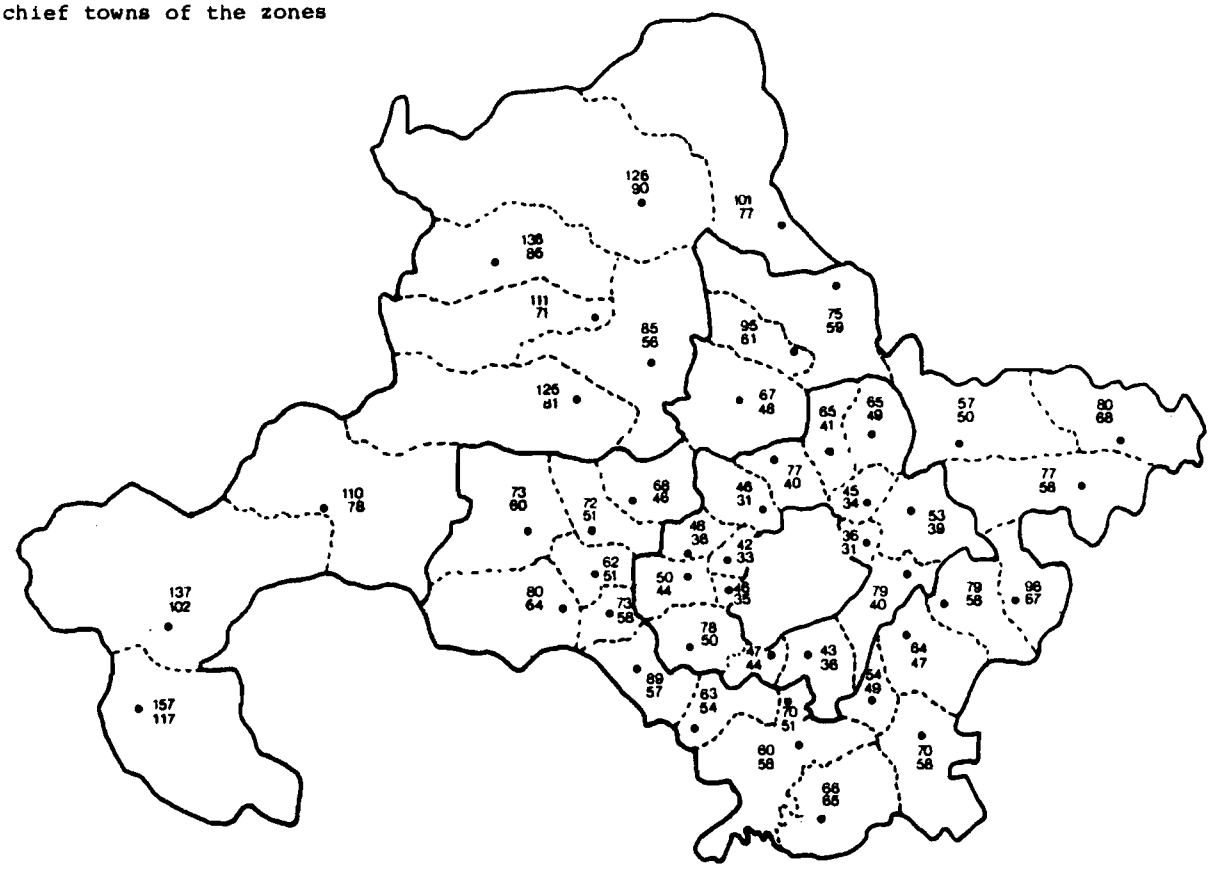

Figure 23. - Travel times (minutes) from the city centre of Turin to the zones (the upper value being the public travel time)

rious zones for public and private transport (20).

As far as journeys to work and school or University are concerned we can distinguish three kinds of movement [cf.: SITECO (Ed.), 1976]:

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(20) Travel times shown in fig. 23 have been take from the matrices used in the simulation model. These matrices are not symmetrical therefore travel times from the zones to the city centre are different from those in fig. 23.

a. radial movements - i.e. between the zones and the city. The radial flow generated by those living in outer zones but working or studying in the city is greater (72% of the total radial movement), but in any case both directions of flow involve use of the principal road axes; journeys to work to the city are shown in fig. 24, and journeys to work to the zones in fig. 25 (21);

b. tangential movements - i.e. movements between zones, without involving the city of Turin. (The number of these journeys is becoming increasing significant due to the decentralisation process and creates certain problems in terms of organisation of transport in view of the basically radial communications pattern);

c. urban movements - i.e. those prevalently within the city, which account in fact for the largest percentage (67%) of the total movement in the study area (cf.: Città di Torino, Assessorato ai trasporti, viabilità e polizia urbana, 1980; Città di Torino, Assessorato ai Trasporti e Viabilità, Consorzio Trasporti Torinesi, 1981).

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(21) The figures have been based on the data concerning families with family-head employed, according to their zone of residence and place of work.
The information used for calculation of this input comes from a 20% sample of the population taken in 1971. As this data is based only on the family-head it obviously does not represent the total number of journeys.

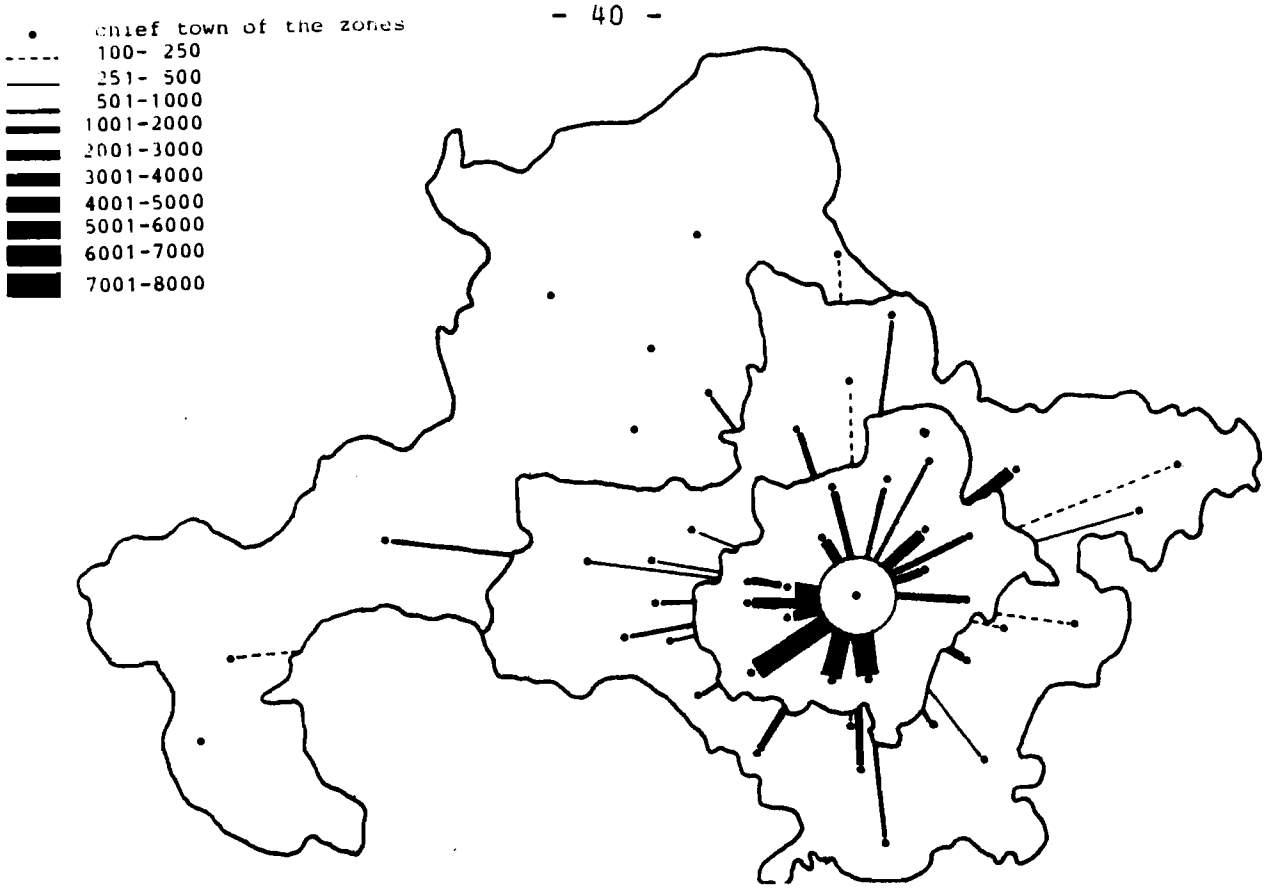

Figure 24. - Journeys to work in 1971 of employed family-heads from the zones to the city of Turin

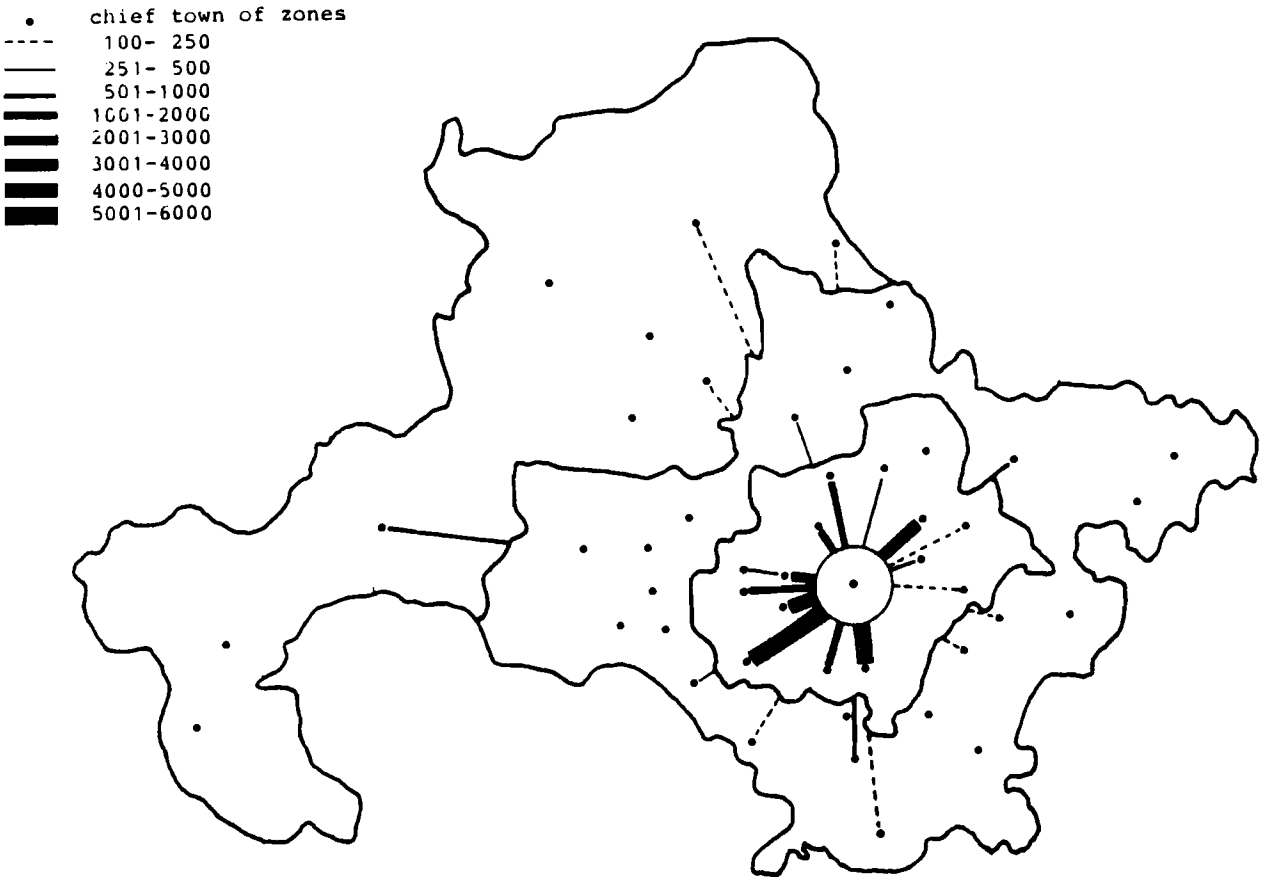

Figure 25. - Journeys to work in 1971 of employed family-heads from the city of Turin to the zones

2.3.5. Which system?

It is not within the aims of this present phase of the study to put forward hypotheses about the possible future socio-economic and spatial structure of the Turin urban system, although this would undoubtedly be an interesting exercise. We consider it ambitious at the present stage, requiring as it would a theoretical and practical effort along with a study of the process of formation of urban policies. It is intended, however, that this challenge should be taken up in a successive phase of study.

Nevertheless, on the basis of the present analysis it is possible to make certain observations which could be useful in this future phase.

These observations concern firstly the refinements which would be necessary in the methodological and theoretical aspects of the analysis and secondly an assessment of the possible alternative forms the system could take in the future.

It is clear that to undertake this kind of exercise requires an approach which goes beyond a mere description of the processes being observed. It should provide, on the basis of this description, the necessary elements for an interpretation of the processes being studied and permit reasonable forecasts of their future evolution.

In fact, while it is relatively simple to recognise the effects that the socio-economic dynamics have produ-

ced on the spatial pattern of the system (as we have attempted to do in this analysis), it is of course a far more difficult exercise to determine how far the present spatial structure is likely to affect the future socio-economic processes. Take for example the problem of determining the role which land-use constraints (in terms of destination and capacity) play on the settlement dynamic of economic activities or the implications that housing supply have on the locational behaviour of the population.

An analytical approach of this kind is illustrated in section 3 (part 2).

As far as the future 'shape' of the Turin urban system is concerned, it is possible to make the following observations.

As explained in 2.3.4., it emerges quite clearly that the system is undergoing deep changes in its economic structures, with a contraction in the number of jobs in the industrial sector and progressive growth in the tertiary sector accompanied by a fall in the population.

At the same time the spatial diffusion of the system is continuing (decentralisation of productive activities and suburbanisation of the population, which is reflected also in a relative decline in the socio-economic importance of the city of Turin).

On the basis of these characteristics (closed system) we must hypothesise the different spatial patterns which

are likely to occur in the future. Some clue to the future situation may be supplied by the answers to the following questions. To what extent is the current process of spread determined:

a. by the socio-economic changes referred to above. If we suppose that the diffusion process is occuring as a result of a 'crisis' situation, which once the crisis resolved, we may well see a reversat of the process, causing once again a socio-economic concentration in the metropolitan area (the city and the first ring) (open system);

b. by a spontaneous "natural" process of development linked to the growing importance of certain peripheral towns (especially in the second and third rings). Thus even if the socio-economic changes settled down, this tendency to spread outwards would continue (closed system).

These two alternatives are represented in fig.26.

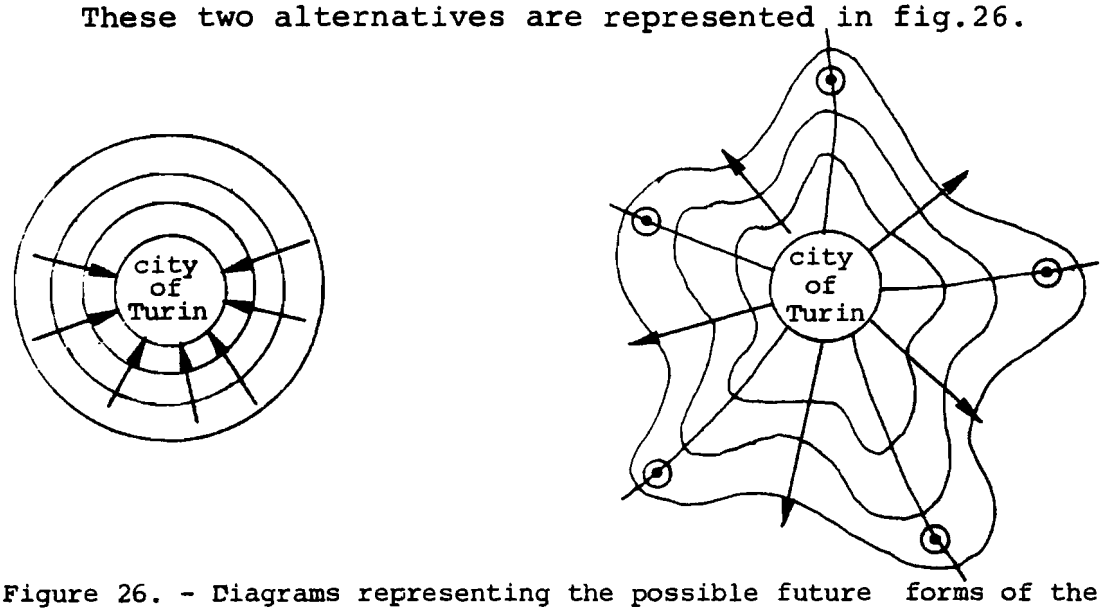

Figure 26. - Diagrams representing the possible future forms of the Turin urban system

There is a third possibility. This is a situation in which the city of Turin regaines a new importance (in particular for certain service sector activities and certain socio-economic groups of the population) while a number of towns of the external rings continue to grow (cf.: fig. 27).

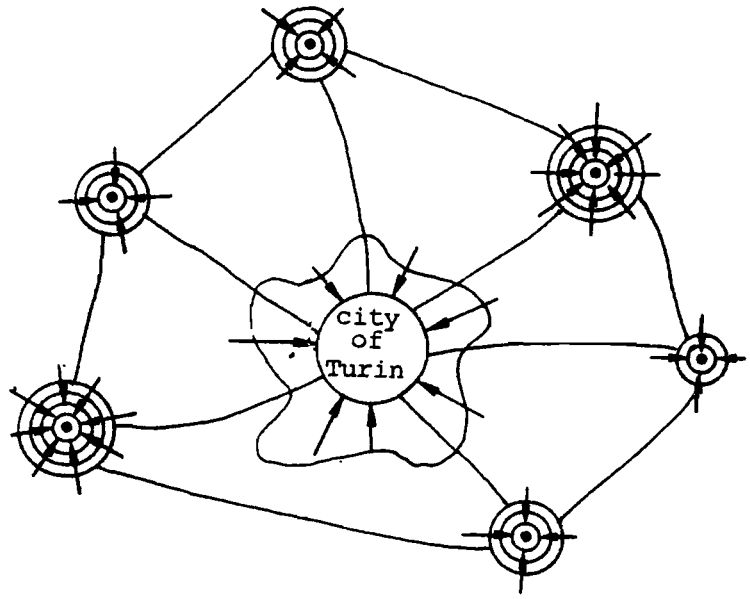

Figure 27. - Diagram of a possible desiderable 'shape' of the Turin urban system

If the pattern of fig. 27 could represent the desirable future shape, it remains to be established to what extent the system is evolving spontaneously in this direction or would be susceptible to do so as a result of socio-economic and planning policies.

The three patterns shown above are schematic representations of the various alternatives which are to be assessed in the next phase of the study.

PART 2

3. DYNAMICS OF AN URBAN SYSTEM

3.1. The structure of an urban system

An urban system consists of three main subsystems (cf.: fig. 28):

a. production activities [block (1)];

b. housing [block (2)];

c. transportation [block (3)].

Each of these subsystems shows a dynamic process which interacts with the others through certain capacity tensions [block (4)].

The main actors involved in the dynamics of an urban system are:

a. producers;

b. customers (i.e. households);

c. public decision makers.

These actors are involved in an evaluation and choice process [blocks (5), (6), (7)] . The evaluation process generates a new preference structure, described by a distribution of expected utilities, while the choice process produces effects like (i) changes in production tecniques and/or spatial distribution of the units of production [block (8)] , (ii) population redistribution

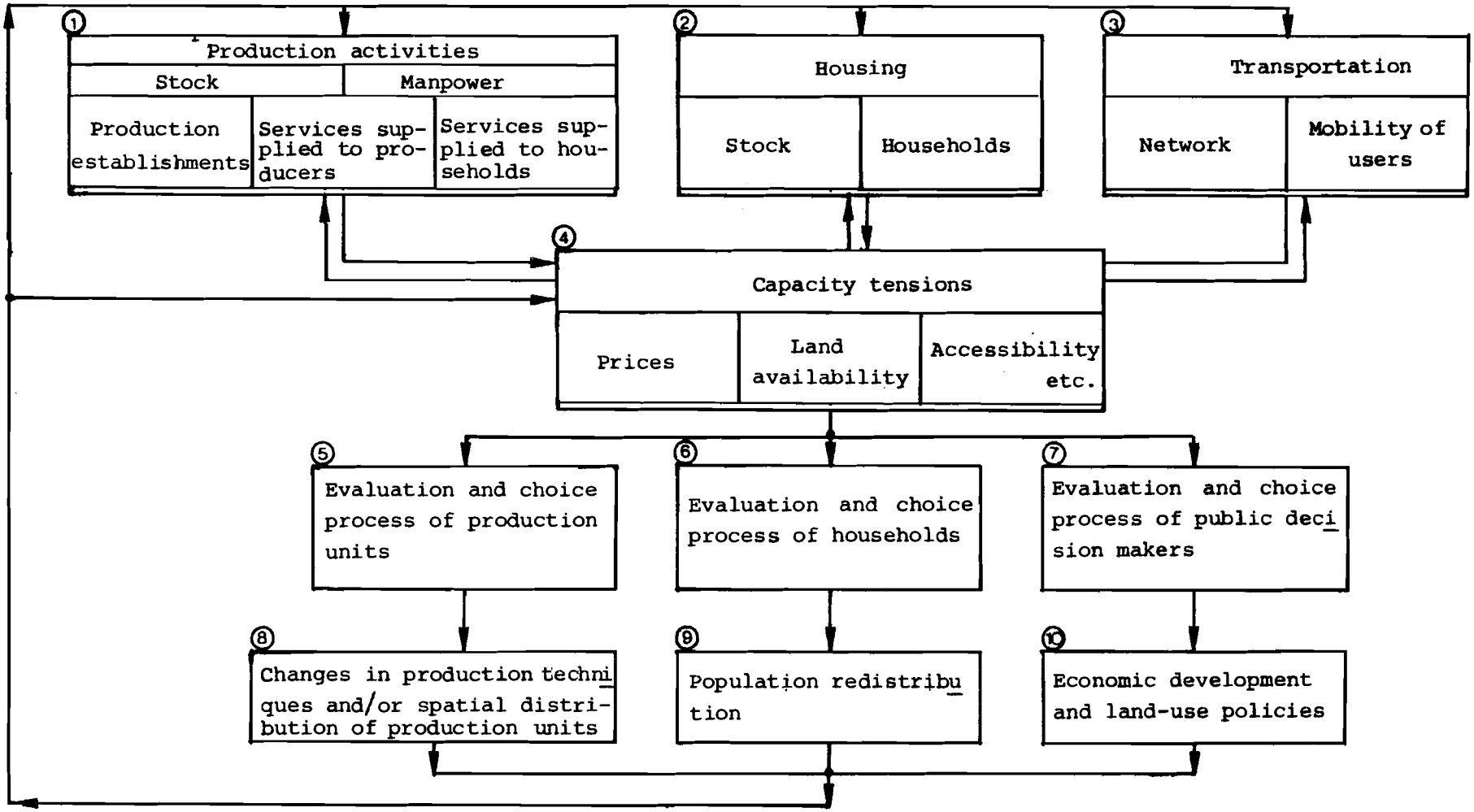

Figure 28. - A simplified structure of an urban system

[block (9)] , (iii) economic development and land-use policies [block (10)]. These phenomena feed back both to the subsystem [block (1), (2), (3)] and to the capacity tensions [block (4)]. The subsystems react showing different dynamic behaviour due to lags in reaction times, inertia,oscillations, different speeds of reaction. Of course, also the capacity tensions [block (4)] are modified by the effects of the choice and show oscillations and lags in behaviour analogous to the behaviour of the subsystems. In addition, the capacity tensions feed back to the three subsystems.

Before discussing the blocks of fig. 28 in more detail, we must make a further comment concerning the structure of the subsystems. Each subsystem consists of two main components: stock and flows. The major difference between the stock dynamics and the flow dynamics is their different speeds. Let us take, for instance, the transportation subsystem. The stock is the transportation network and the flow is the mobility of users on the network. Change in the network is a very slow process compared to that of user mobility.

The network is usually relatively static and changes only over periods of many years. On the contrary, the mobility of users can change much faster, being governed by household and labour mobility (which can vary over a period of a few years)and shopping mobility and network congestion effects (daily changes).

A useful simplification when studying a slow dynamic process is to take the faster process in its steady state and nest it into the slow process. As shown in Leonardi (1983) this is possible only when the stability of the steady state of the fast process is independent of the state variables of the slow process, otherwise the fast process could not achieve its steady state because of instability and bifurcations.

Let us now analyse some of the possible interactions occurring between the subsystems. As mentioned, the subsystems interact in their dynamic processes through the capacity tensions. These may be expressed in terms of prices, land availability, accessibility etc. Following on from Johansson, Korcelli, Leonardi and Snickars (1983) a good, although static, example of interaction among production activities (in particular, services supplied to households), housing (in particular households) and transportation (in particular the network) is the expression of the local potential of a production unit:

$$F(x) = \int \frac{H(x,y)}{G(y)} \qquad (1)$$

where:

$$H(x,y) = h(y)\ e^{-\alpha\, d(x,y)}$$

$h(y)$: density of households at y, weighted by purchasing power;

$d(x,y)$: distance between supply location x and household location y;

$G(y) = \int k(x)\ e^{-\alpha d(x,y)} dx$: competition due to the other suppliers;

$k(x)$: density of suppliers at location x;

$\alpha > o$: distance decay parameter.

Equation (1) can be represented by the block diagram of fig. 29.

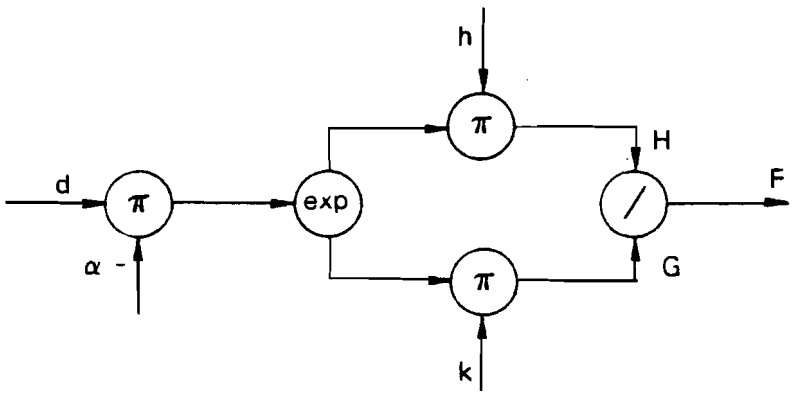

Figure 29. - The local potential of a production unit

The capacity signals involved in eq. (1) are:

a. prices, through h which is price dependent;

b. land availability, because k, and also h, is a function of the available land, measured in terms of floor space cost and land values;

c. accessibility, measured in terms of the distance d.

Studying the dynamic behaviour of the local potential we should pay attention to the different speeds of the dynamics of h, k and d.

Another example of interaction, this time dynamic, between subsystems is the interaction between household mobility and labour mobility. The dynamic process of these two phenomena have speeds of the same order of magnitude and, therefore, should be treated jointly. Leonardi proposed a way of doing this (Leonardi, 1983). He defines:

$P_{ij}(t)$ number of people living in zone i and working in zone j at time t;

W_k number of job opportunities available in zone k, assumed constant and such that $\sum_k W_k > P_{ij}(t)$;

c_{ij} cost per unit time of commuting between zone i and zone j;

$r_{ij,k}(t)$ flow rate for residential changes made by people living in zone i and working in zone j at time t, and moving to zone k in the time interval $(t,t+\Delta)$;

$s_{ij,k}(t)$ flow rate for work-place changes made by people living in zone i and working in zone j at time t, and moving to a new job in zone k in the time interval $(t,t+\Delta)$;

λ intensity parameter for housing search, scaling the speed of the moving process;

θ intensity parameter for job search (playing

for labour mobility the same role as λ for housing mobility);

a exogenous utility gain per unit time, it will be assumed that $a > 0$;

$V_{ij}(t)$ the expected utilty for an individual living in zone i and working in zone j at time t.

At each time instant a simultaneous change of resi — dence and job can occur. It is shown that the following differential equations for the population sizes and for the expected utilities hold:

$$\dot{P}_{ij} = \sum_k P_{kj}\, r_{kj,i} - P_{ij} \sum_k r_{ij,k} + \sum_k P_{ik}\, s_{ik,j} - P_{ij} \sum_k s_{ij,k} \qquad (2)$$

$$\alpha V_{ij} - \dot{V}_{ij} = a - c_{ij} + \frac{\lambda}{\beta}(\Phi_{ij} - \Psi_i) + \frac{\theta}{\beta}(\Omega_{ij} - \Gamma_j) \qquad (3)$$

where:

$\Phi_{ij} = \sum_k (Q_k - \sum_j P_{kj})\, e^{\beta(V_{kj} - V_{ij})}$ is the accessibility to the vacant housing stock for people living in zone i and working in zone j;

$\Omega_{ij} = \sum_k (W_k - \sum_i P_{ik})\, e^{\beta(V_{ik} - V_{ij})}$ is the accessibility to vacant work-places for people living in zone i and working in zone j;

$\Psi_i = \sum_{kj} P_{kj} e^{\beta(V_{ij}-V_{kj})}$ is the population potential in zone i for the housing market;

$\Gamma_j = \sum_{ki} P_{ik} e^{\beta(V_{ij}-V_{ik})}$ is the population potential in zone j for the labour market;

$r_{ij,k} = \lambda (Q_k - \sum_j P_{kj}) e^{\beta(V_{kj}-V_{ij})}$ are the flow rates for residential mobility;

$s_{ij,k} = (W_k - \sum_i P_{ik}) e^{\beta(V_{ik}-V_{ij})}$ are the flow rates for labour mobility;

α is a real parameter which might be of either sign.

For the discussion of eqs. (2), (3), cf.: Leonardi (1983). Here, we simply wish to comment that the model (2) - (3) constitutes a very good basis for modeling the dynamic interactions between subsystems and will be the object of empirical investigation in our future research.

Eqs. (2) - (3) can be given a systemic interpretation. To simplify let us drop the indices i,j,k. We can define the operators R and S in such a way that:

$$PR = \Sigma Pr - P \Sigma r$$

$$PS = \Sigma Ps - P \Sigma s$$

Eq. (2) becomes

$$\dot{P} = PR + PS$$

or, in block diagram form

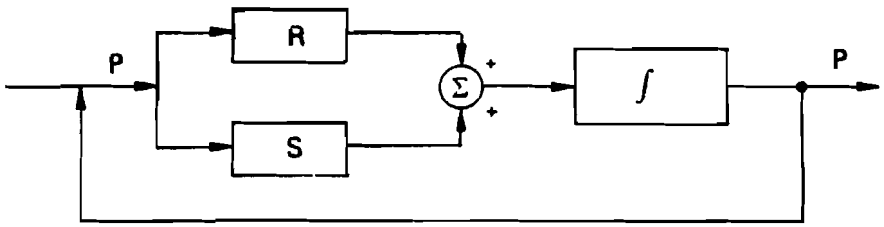

Figure 30. - The dynamic process of population in the household and labour mobility system

Let us define h as the rate of change in utility

$$h = a + c - \frac{\lambda}{\beta}(\Phi - \Psi) - \frac{\theta}{\beta}(\Omega - \Gamma) \qquad (4)$$

eq. (3) becomes

$$\dot{V} = V + h$$

or, in block diagram

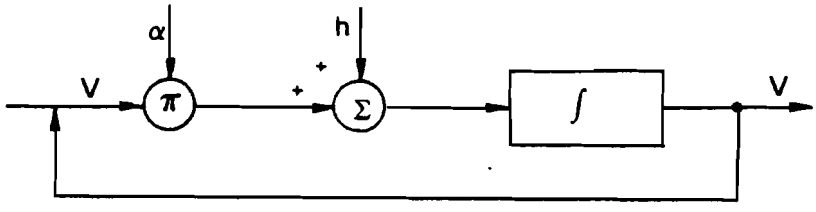

Figure 31. - The dynamic evaluation process in the household and labour mobility system

A block diagram form of the eq. (4) is the following

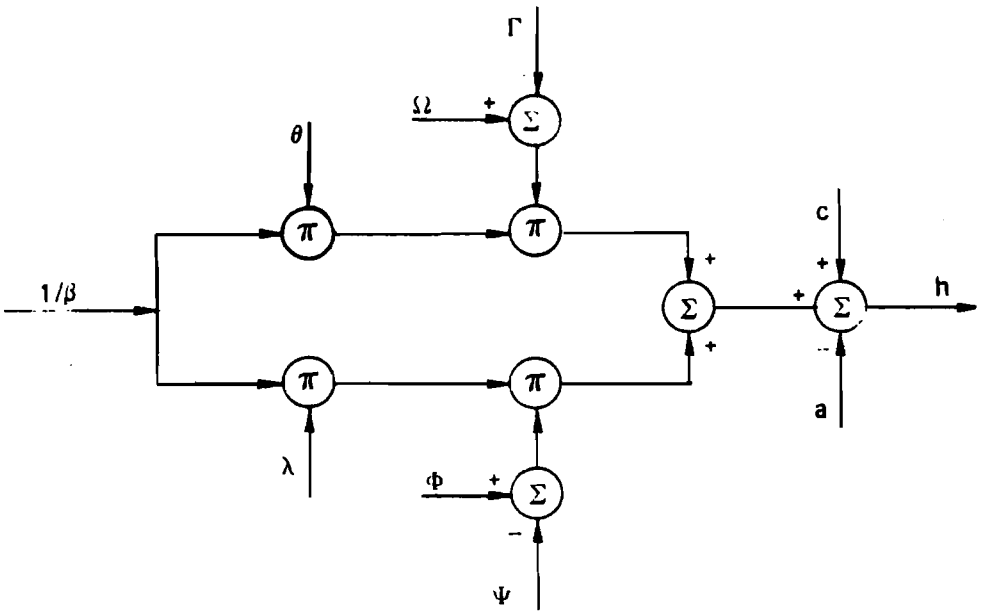

Figure 32. - The rate of change in utility

3.2. The Turin case study

To model the structure of the Turin urban system an approach similar to that outlined in fig.28 has been used (Bertuglia, Occelli, Rabino, Tadei, 1980).

In the model three main subsystems can be recognized: production activities, housing and transportation.

The internal dynamics and the interactions of both

the production activities and housing subsystems have been investigated as well as their interactions with the transportation subsystem. At present, the internal dynamics of the transportation subsystem has not been fully developed, and its interactions with the other subsystems have been assumed exogenously.

For the production activities subsystem the following phenomena have been studied: the building of new production plants, the closing and relocation of the existing ones, as well as the variation of jobs in the production plants already in existence.

For the housing subsystem both the stock dynamics and residential mobility have been investigated.

As far as the stock is concerned, the building activity, together with the renewal and demolition of obsolete buldings have been analysed.

Residential mobility has been simulated taking into account population changes, the availability of houses and the amount and location of the variables representing the production activities and the transportation subsystems.

Thus, the housing subsystem constitutes the heart of our simulation model and for this reason, will be dealt with in more detail later on.

In the model some capacity tensions have also been taken into account, particularly land availability and

accessibility. However, the role of prices has not been fully developed and will be given more attention in future research.

As far as the evaluation and choice process is concerned, it is assumed that the production activity changes occur according to exogenous increasing and decreasing rates as well as to land availability constraints.

Further developments should involve endogenous changes in production techniques and spatial relocation dependent on the accessibility to the other producers and to households.

The evaluation and choice process of the households is more complex and needs mathematical formulation.

Let us define the following variables (to simplify the notation the indices referring to zones, household types, production sectors etc. will be dropped):

O : number of workplaces;
KO : inverse of mean rate of employment;
Q = O/KO : households;
TPROB : probability of using different transport mode;
T : travel costs;
AB : houses;
SLAO : land in residential use;
K,H,N : weight factors;
TETA,CSI : parameters;

$A = \Sigma\ Q \cdot TPROB \cdot e^{-TETA \cdot T}$: residential accessibility.

The utility of households from the choice of the residential location is given by:

$$U = K \cdot \bar{A} + H \cdot \overline{AB} + N \cdot \overline{SLAO} \qquad (5)$$

(where $\bar{x}$ represents the normalized value of x).

The expected value for the utility U is

$$\bar{U} = \Sigma U \frac{\Sigma DPOTO}{Q} , \qquad (6)$$

where

$$DPOTO = Q \frac{WT}{\Sigma WT} , \qquad (7)$$

and

$$WT = \Sigma TPROB \cdot e^{-TETA \cdot T} \cdot \Sigma e^{-CSI(\bar{U}-U)} . \qquad (8)$$

The variable DPOTO represents the residential and labour location of the household. From (6), (7), and (8) we can see that the variable DPOTO and U are interdependent. Their values can be found using an iterative search method starting with a given value of DPOTO (cf.: Bertuglia, Gallino, Gualco, Occelli, Rabino, Salomone, Tadei, 1982).

The model (5) - (8) is based on the hypothesis that not all the households find the optimal residential location; some attain a utility level higher than the expec-

ted one while others remain below it. The model tries to describe a real market using a measure of disequilibrium based on the difference between the expected utility and the real utility for the residential location of the households.

The model proposed is not a dynamic model. In fact, it has basically been built following a comparative statics approach. Nevertheless this model reproduces adequately the dynamics of the Turin urban system during the seventies as described in section 2.3.4..

The last point which deserves attention is the evaluation and choice process of public decision makers. In our opinion, it is a very important point which must be taken into account both in the analysis of past dynamics and for forecasting future developments and assessments.

The evaluation and choice process of public decision makers involves the three subsystems and the capacity tensions. Let us take, for example, public intervention affecting the housing stock and the transportation network, as well as land availability and prices (introducing controlled prices for public services and housing rents, control over the latter being particularly strong in Italy). In our model we began to take into account these phenomena introducing exogenous public policies and programmes into the dynamics of the subsystems. This is just a first step. Further research needs to deal with endogenous public policies and programmes subject to both the capacity

signals coming from the subsystems and financial con — straints, imposed on the public administration, which are particularly strong in Italy at present.

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APPENDIX

WORKING PAPERS

*1 "Un modello urbano a larga scala per l'area metropolitana di Torino", *gennaio 1981*

*2 "Metodologie per la pianificazione dei parchi regionali", *gennaio 1981*

*3 "A Large Scale Model for Turin Metropolitan Area", *maggio 1981*

4 "An Application to the Ticino Valley Park of a Mathematical Model to Analyse the Visitors Behaviour", *luglio 1981*

5 "Applicazione al parco naturale della Valle del Ticino di un modello per l'analisi del comportamento degli utenti: la calibrazione del modello", *settembre 1981*

6 "Applicazione al parco naturale della Valle del Ticino di un modello per l'analisi del comportamento degli utenti: l'uso del modello", *settembre 1981*

*7 "Un'analisi delle relazioni esistenti tra superficie agricola utilizzata ed alcune principali grandezze economiche in un gruppo di aziende agricole piemontesi al 1963 e al 1979", *settembre 1981*

8 "Localizzazione ottimale dei servizi pubblici, con esperimenti sulle scuole dell'area torinese", *settembre 1981*

9 "La calibrazione di un modello a larga scala per l'area metropolitana di Torino", *ottobre 1981*

10 "Applicazione al parco naturale della Valle del Ticino di un modello per l'analisi del comportamento degli utenti: l'individuazione di un indicatore di beneficio per gli utenti ed una analisi di sensitività su alcuni parametri fondamentali", *ottobre 1981*

11 "La pianificazione dell'uso ricreativo di aree naturali: il caso del parco della Valle del Ticino", *novembre 1981*

*12 "The Recreational Planning of Country Parks: the Case Study of the Ticino Valley Park", *marzo 1982*

13 "Alcuni aspetti della calibrazione di un modello dinamico spazializzato: il caso del modello dell'area metropolitana torinese", *settembre 1982*

*14 "L'applicazione di un modello dinamico a larga scala per l'area metropolitana di Torino: la calibrazione", *novembre 1982*

15 "Modello commerciale Piemonte", *novembre 1982*

16 "Resource allocation in multi-level spatial health care systems: benefit maximisation", *dicembre 1982*

17 "Relazione sulla struttura e sulla dinamica del settore elettromeccanico piemontese", *dicembre 1982*

18 "Evoluzione della finanza locale in Piemonte e in Italia 1977 - 1981", *febbraio 1983*

19 "Un metodo per l'analisi di scenari multidimensionali in ordine alle relazioni tra domanda di trasporto e variabili strutturali dei sistemi economici e territoriali", *febbraio 1983*

20 "Modello commerciale Piemonte", *marzo 1983*

21 "Calibrating the residential location submodel of the simulation moder for the Turin metropolitan area", *giugno 1983*

22 "Dinamiche spaziali dell'area metropolitana di Torino negli ultimi tre decenni", *giugno 1983*

23 "Struttura economica delle imprese del dettaglio alimentare in Piemonte — prime valutazioni", *luglio 1983*

24 "The dynamics of Turin metropolitan area: a model for the analysis of the processes and for the policy evaluation", *agosto 1983*

25 "Un'analisi, con il modello RAMOS, della struttura spaziale del servizio sanitario regionale: il caso del Piemonte", *settembre 1983*

26 "Manuale per l'uso del modello RAMOS (Resource Allocation Model Over Space)", *ottobre 1983*

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