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URBAN CHANGE AND SPATIAL INTERACTION

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FOREWORD

Declining rates of national population growth, continuing differential levels of regional economic activity, and shifts in the migration patterns of people and jobs are characteristic empirical aspects of many developed countries. In some regions they have combined to bring about relative (and in some cases absolute) population decline of highly urbanized areas; in others they have brought about rapid metropolitan growth.

The objective of the Urban Change Task in IIASA's Human Settlements and Services Area is to bring together and synthesize available empirical and theoretical information on the principal determinants and consequences of such urban growth and decline.

In this paper, Piotr Korcelli deals with interrelationships between urban form, spatial interaction, and the inter-urban patterns of population and employment change. Several conditions are identified for the improvement of the planning relevancy of urban models.

A list of publications in the Urban Change Series appears at the end of this paper.

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ABSTRACT

Changing intra-urban structure and spatial interaction patterns represent a major aspect of recent urban trends. A framework is outlined in this paper for the study of interaction patterns over time by taking into account changing urban forms. The paper also attempts to trace the impact of interaction costs on the overall level of population and employment change in a city. Several conditions are discussed for the development of dynamic urban models. These conditions refer to population composition, land-use conversion, residential relocation, and the evolution of the changing function of distance in urban areas.

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URBAN CHANGE AND SPATIAL INTERACTION

1. FACTORS OF URBAN CHANGE

While disputes concerning conceptual deficiencies and virtues of urban models will soon acquire a decade-long tradition (see Goldner 1971; Lee 1973; Sayer 1976; Batty 1979), the need for further development of such models becomes ever greater. The demand is strengthened in view of recent trends of population decline encountered in some of the large urban agglomerations of highly urbanized countries and of the continuing population concentration in the primate cities of many less-developed countries. As a consequence of these trends, planners are now facing the necessity of reformulating settlement policies carried out at the national and urban levels, since the present-day policies have either supported trends no longer deemed favorable (as has been the case for many European countries that promoted large city-growth limitation measures), or have failed to produce more balanced settlement patterns (a goal aspired to by a number of Third World countries in their spatial policies).

Existing urban policy-oriented models, such as spatial interaction models, however, represent a limited aid in such endeavors. In particular, these models say little if anything about how and why economic activities originate within, or migrate to or out of a given urban area, and what the likely consequences such moves may have on other urban areas. For example, the allocation of public facilities with respect to population distribution (disaggregated by age, education, income, etc.) presents in itself a problem of considerable planning interest. This problem, however, still remains to be translated into aggregate performance measures if questions concerning the attracting and discouraging mechanisms with respect to in- and outflows of population and facilities are to be considered.

If such basic questions cannot be treated within the available spatial interaction modeling frameworks, why should the expansion of these models be emphasized? It is because the internal functioning of urban areas represents one of the substantial facets as well as determinants of urban change, both in the case of contraction and of rapid growth. In his discussion of "metropolitan maturity" Leven (1978) identified three groups of factors underlying recent urban trends in highly urbanized countries. These factors include: (a) changing intersectoral proportions and locational requirements within individual economic sectors, as well as evolving spatial patterns of generation and diffusion of technical and organizational innovations, (b) demographic and mobility transitions characterized by declining rates of natural population growth and replacement of rural-urban migrations by inter-urban flows, and (c) spatial policies, both explicit and implicit, which influence the shifts in the distribution of population and economic activity at the inter-urban and intra-urban scale. Thus, out-migration from some large urban agglomerations is seen as being determined, among other factors, by features of internal organization in these areas which make them less attractive compared to other (for example, smaller) cities. Once the outmigration pattern begins to prevail, it may in turn bring about new rounds of spatial adjustments within urban areas conducive to further increased population outflow.

In the case of rapid urban growth, the interest in spatial interaction patterns lies not so much in their perceived impact on overall rates of population expansion (since these primarily rely on the demographic momentum and the continuing dominance of scale economies), as on questions of social and engineering systems management. The major cities in many less-developed countries are now approaching the size of the largest cities of the highly urbanized countries; at least two of them (Mexico City and São Paulo) have reached the ten million population mark. It is safe to predict that over the next several decades these urban areas will continue to expand beyond the size so far experienced elsewhere. Consequently, existing rules concerning the integration of transportation systems, work trips, and facility location patterns within urban areas may be rendered inapplicable under such growth conditions.

Hence, the relevance of spatial interaction studies for the understanding of urban growth and contraction may be justified not so much by the merits of the available spatial interaction models, as by the role played by population flows and land-use interdependence in the processes under consideration. The development of submodels which would allow one to trace adjustments of urban spatial structure to changing intersectoral proportions, technological change, and household-size and composition, seem of particular relevance in this context. Spatial adjustments occurring within urban areas may be expressed in a number of metrics, such as population and employment distribution, degree of internal specialization (homogeneity), and intensity of interactions among city subareas. In a temporal framework such metrics may define individual stages of the transformation of urban regions, such as the city-hinterland (the concentration phase), metropolitan dominance (the specialization phase) and urban field (the dispersion phase) (Korcelli 1980). Each state of this sequence is characterized by specific patterns of interaction and future patterns can, in fact, be predicted with the help of the trajectory described, using more specific alternative assumptions concerning economic, technological, and social change, as well as spatial policy.*

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*The impact of one such policy, namely, transportation pricing, has been modeled recently by Cordey-Hayes and Varaprasad (1980) who used somewhat similar assumptions concerning alternative patterns of population concentration and deconcentration within an urban region.

2. A MODELING FRAMEWORK

The foregoing discussions suggest three sets of interrelations on which future urban models may focus. One of these pertains to location trends of what is now usually considered as exogenous sector employment. Another area of interest relates to the impact of population trends on the internal structure of urban areas. The third domain may be defined as the interdependence between intra-urban structure and the structure of settlement systems on a national and regional scale.

Some of these interrelations are shown in Figure 1. The scheme attempts to account for the changing nature of spatial interaction--its dependence on socio-economic conditions--as well as to illustrate possible feedback relations between the endogenous and exogenous sectors in spatial interaction models. The ruling paradigm in such models is the generation of trip distributions on the basis of the knowledge of location of trip origins and destinations or the generation of residential, workplace, and service locations while using the information pertaining to travel cost and attractiveness of individual zones for trip origins and destinations. To be able to reproduce past and predict future interaction patterns, however, it is necessary to introduce rules that will allow for those measures to vary systematically over time.

General rules of this type are contained within the existing theory of urban growth and structure, notably in the concept of urban transition. According to that concept the distribution

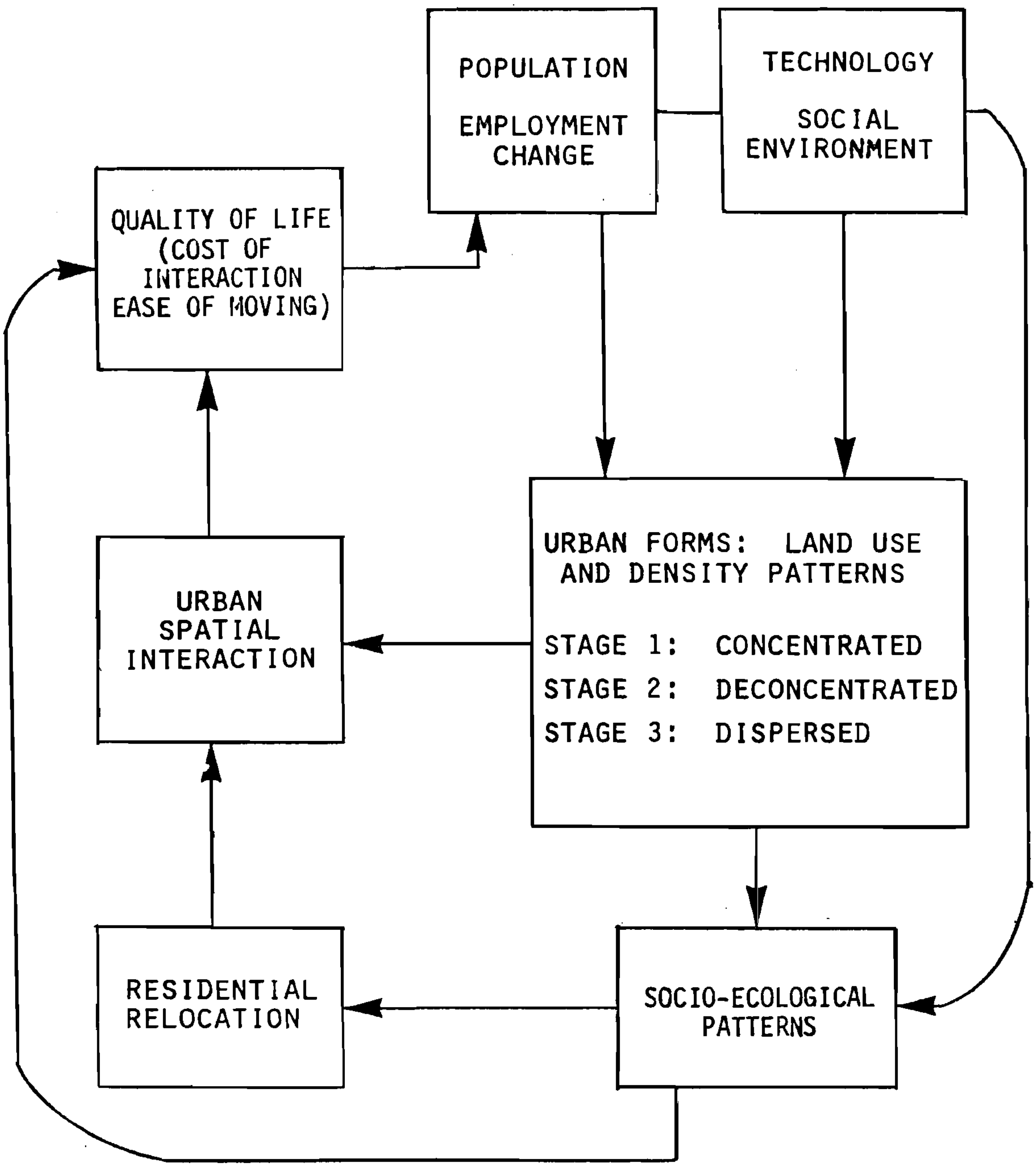


Figure 1. Spatial interaction and the changing urban structure.

and density of residences, as well as spatial employment patterns within an urban region, evolve in a predictable manner, while being shaped mainly by two factors, i.e., the changing transportation cost and the increase of urban size. Following Klaassen and Paelinck (1979), urban transition may be portrayed as a sequence of six phases (see Figure 2). Phase One of this sequence refers to a situation when advantages of spatial concentration are still predominant and growth occurs in the urban core at the expense of the surrounding territory (conventionally called the ring) which becomes increasingly depopulated. This latter trend is reversed in Phase Two when the growing population size of an urban area causes its territorial expansion. Phase Three marks the increasing competition among land uses within the core, resulting in the transfer of some jobs to the ring. By the end of this phase, which may be identified as the spillover stage, the growth of an urban area in terms of population size is entirely due to the expansion of its external zone. Subsequent growth, however, results in agglomeration disadvantages (Phase Four), such as a decreasing ease of movement and incompatibility of land uses, that are strongly felt. This, in turn, results in the transfer of growth to smaller urban areas which at that time may experience Phase Two of their transition. If extended, the sequence leads to negative growth for both an urban core and the region as a whole (Phase Five) and, ultimately, to the decline of the urban ring as well (Phase Six). New growth impulses, however, typically generated or located at the core (such as the development of new functions and major infrastructural improvements) may prevent the cycle from being completed and may

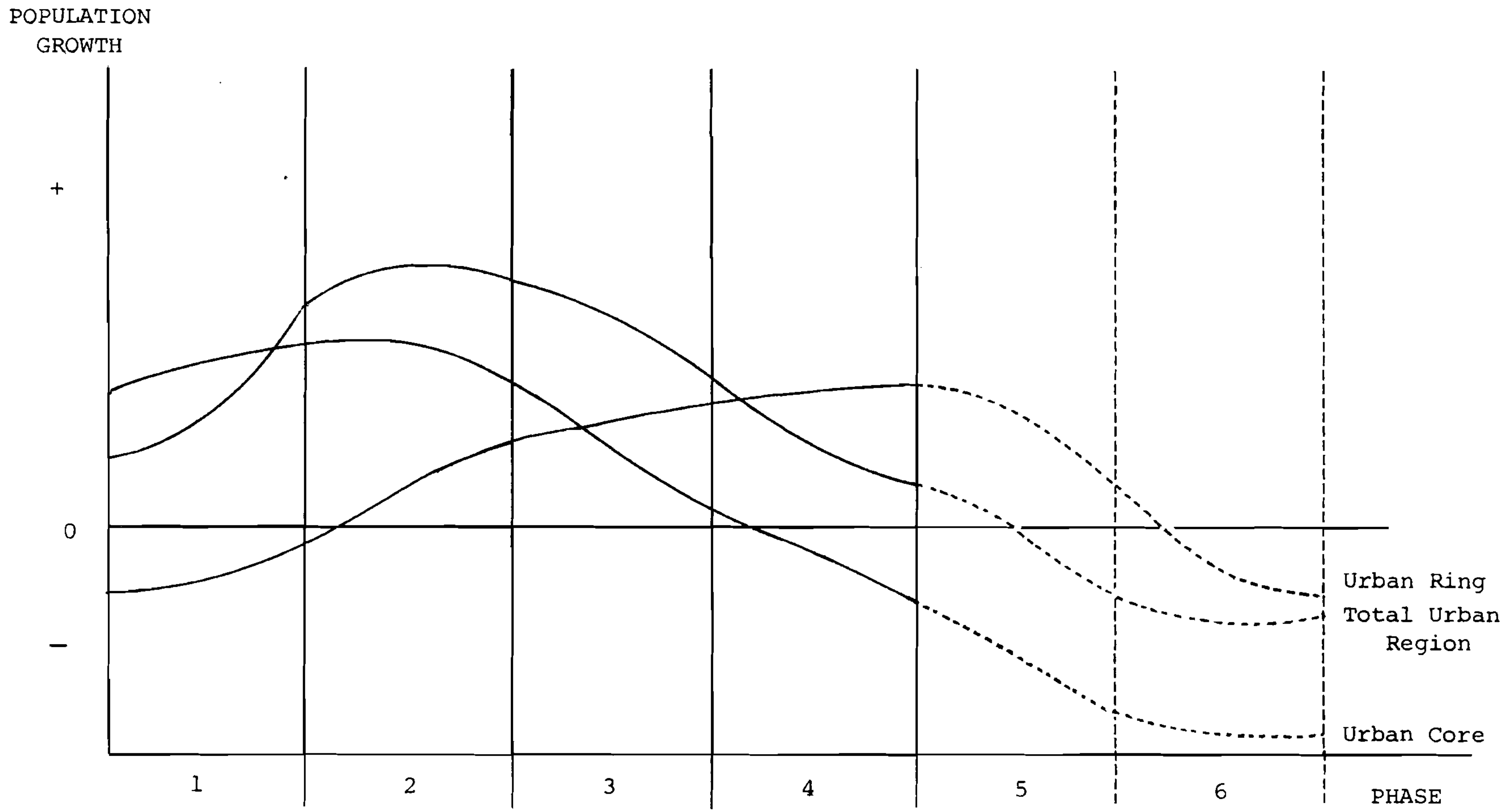


Figure 2. The concept of urban transition. (Source: Klaassen and Paelinck, 1979:1096.)

move the urban area in question back to Phase Two or Three. Indeed, with respect to contemporary large agglomerations, the empirical evidence hardly extends beyond Phase Four of the sequence.

While the evolving spatial profile of a large city, in terms of population distribution and the allocation of activities, is seen as a function of its growth over time, a decline in the momentum may not be directly attributable to the emergence of deconcentrated urban forms. Major correlates of metropolitan contraction, as indicated earlier, include a high urbanization level at or close to the saturation point (75-85 percent population urban), declining relative transportation costs, and small overall rates of population change.

The usefulness of the urban transition concept in the present context is that despite its very general nature it offers a logical picture of temporal evolution of locational patterns of residences, jobs, and service functions within a large urban area--the type of variation which should be accounted for in the modeling of spatial interaction over time. It is understood that morphological changes attributable to just two variables, i.e., overall transportation costs (a proxy for which can be automobile ownership) and urban size, can only be estimated in gross terms. Demographic factors, inter-sectoral proportions within an urban economy, social environment and urban policies may be seen as intervening variables, responsible for modifications of the general sequence outlined (see the upper-right part of Figure 1). In particular, socio-economic conditions may be considered as filters producing alternative socio-ecological patterns within urban areas. The latter in turn should determine the way and detail by which a spatial interaction model needs to be disaggregated (by occupational groups and housing types, for example); they can also provide constraints on residential location. The stability of socio-ecological patterns, measured in terms of residential relocation, indicates directions in which such constraints may evolve.

Evaluation of alternative spatial interaction patterns, established for individual urban areas and time periods, enables one to introduce feedback relations between endogenous and exogenous sectors of an urban economy. That is, while the allocation of basic employment within the city follows its morphological rules of development, the size of new employment also becomes determined by such variables as the per capita cost of spatial interaction (energy cost) and related quality-of-life indicators. Similarly, alternative socio-ecological patterns can be compared with respect to their efficiency in terms of daily travel within a city.

3. PROBLEMS OF IMPLEMENTATION

The nature of interdependencies shown in Figure 1 puts forth a number of prerequisites with respect to the structure and specification of individual submodels. These requirements should be presented against the background of available modeling approaches. However, rather than attempting a comprehensive review of modeling efforts corresponding to each segment in the diagram, it seems justifiable to state a priori that the fusion of existing models would not likely result in an orderly overall structure.

Consequently, the discussion can be focused on postulated linkages between the models and lead towards the identification of conditions and assumptions to be followed at each stage of the modeling sequence. A surrogate list of such conditions includes the consideration of population dynamics, land-use conversion, substitution among various types of spatial interaction (such as migration and daily travel), evolution of distance functions, and evaluation and intervention processes. Although reference will be made below to individual types of models as proposed by a number of authors, the evaluation criteria are restricted according to the scope and purpose of the scheme presented in the previous section.

3.1 Population Dynamics

The impact of changing population growth on urban forms has not been studied so far in a systematic way. Empirical evidence for the highly urbanized countries suggests that a rapid expansion of the urban population can be associated with the development of either concentrated or deconcentrated urban patterns, while dispersed urban development is typical of periods with declining rates of population growth (see, for example, Bourne and Korcelli 1980). This generalization may allow one to extend the concept of mobility transition (Zelinsky 1971) into the domain of urban spatial structure. It also points out the correspondence between the development of urban structure and the changing patterns and hierarchy within settlement systems at both a national and regional level.* Nevertheless, general empirical observations of this kind allow one to say little about the underlying relationships between population size, its composition, and the location of economic activity.

Interrelations of the latter type have been extensively treated in the studies of inter-urban migration (see for example: Alperovich et al. 1975; Cordey-Hayes 1975) which attempt to explain the observed and derive projected population flows on the basis of configurations of labor market characteristics (employment, unemployment, and vacancy rates) and of demographic characteristics (such as labor formation and participation rates). What generally has not been answered by these studies is whether the intensity, composition, and spatial patterns of population flows can be translated into the changes of urban hierarchy and evolution of physical forms of urban development. This type of knowledge is necessary if one attempts to predict urban spatial interaction patterns over time by taking into account the instability of relations between origins and destinations: the kind of instability that stems from changing locational factors with respect to households and enterprises. Recent developments of spatial interaction theory allow one to capture, for example, the effect of age structure on employment and

*One can note that concentrated urban patterns tend to be associated with a stable settlement hierarchy at an interregional level; the emergence of urban regions is accompanied by interregional concentration trends; finally, dispersed urban forms (urban fields) and metropolitan contraction are translated into interregional population and settlement deconcentrations. Similarly, the expanding role of circulatory movements which replace a part of migration movements during the later stages of the mobility transition is clearly associated with progressive urban dispersion.

population allocations within urban areas (Schinnar 1978), but the impact of shifts in locational requirements within individual sectors, including the household sector, must still be accounted for.

3.2 Land-Use Conversion

As is true in the case of population change, the explicit consideration of compatibility and competition among land uses represents another essential precondition for developing dynamic models of urban spatial interaction. The urban land-use theory on which such considerations should be based is not quite able to offer relevant rules. For an empirically minded researcher, this theory, for example: (a) disregards interdependencies underlying the land-use structure, (b) fails to take account of land-use adjustment and succession processes, and (c) neglects land-use supply (Bourne 1978). Similarly, for a general urban theoretician, urban land-use theory and applied urban analysis (as represented by spatial interaction models in our case) are seen to advance in parallel rather than converge in the near future (Richardson 1977, p. 243).

No matter how justified these statements may be, they underestimate the potential of existing theory to generate dynamic urban land-use patterns. One can refer here to possible extensions based on attempts to vary the shape of curves representing the spatial structure of transportation costs. Following observed regularities, the spatial variations in aggregate accessibility levels and the share of the individual's budget allocated to costs of movement may be allowed to diminish over time. A decrease in the spatial accessibility gradient results in the flattening of individual bid-rent curves. When the amenity gradient is kept constant over time (with amenity values rising towards the urban periphery), a flattening of the population density gradient and a spatial extension of the city occurs.

A problem to be encountered is the increasing weight of the amenity component in the total value of site rents, since spatial variations of this factor may not follow uniform patterns among cities. A decrease of the accessibility gradients favors some sites over others within the city independently of their location with respect to the city center; this phenomenon is conducive to the emergence of polycentric urban forms (Ullman 1962). As a consequence, the homogeneous character of individual distance-zones, as portrayed by static land-use models, can no longer be retained.

In order to reproduce a land-use transition process within an alternative model, however, it would be necessary to account for such factors as differential inertia and congruency among land uses which explain typical observed land-use sequences. These sequences include the socio-ecological succession and the redevelopment cycle (see Hoover and Vernon 1959; Schnore 1965; Davies 1968; Birch 1971). Their inclusion, in turn, suggests that greater sectoral disaggregation and introduction of time lags are among the necessary conditions for the development of temporal models of urban land use.

3.3 Residential Relocation and Journey to Work

Conventional migration theory asserts that at an advanced urbanization level the bulk of labor-oriented migrations take place between individual labor market areas, or functional urban regions, while within such regions the corresponding role is assumed by daily journeys to work (see, for example, Boudeville 1978). An urban modeler (and an urban planner), on the other hand, tends to view intra-urban migrations as manifestations of a spatial adjustment process of (a) bringing residences closer to jobs once a better knowledge concerning the local housing market is obtained or once proper housing becomes available and (b) responding to the changing location of jobs. Under those assumptions intra-metropolitan migration can be approximated by gravity-type formulas similar to those employed in journey-to-work models.

Empirical data are not quite consistent with the latter approach (see, for example, Simmons 1968; Dzieciuchowicz 1979). Typically, for a fair majority of intra-metropolitan residential moves the mean time (as well as metric) distance between home and place of work is greater after migration than before. Alternative interpretations of this phenomenon may be sought, based on the following factors:

(a) Urban deconcentration and the expansion of urban size. In a growing metropolitan area, new housing, as well as new job opportunities, tend to be situated on the metropolitan fringe, and due to site requirements of individual users, not necessarily in the same city sector. Longer after-migration distances may also result from diminishing overall urban densities and from higher inertia on the part of fixed assets in the industrial sectors as compared to the housing stock within urban areas.

(b) The household activity space factor. Residential relocation may be attributed to daily journey patterns of household members other than the main breadwinner. Also, a change in distance traveled to work may be caused by new entries to, or withdrawals from, the labor market.

(c) Dissociation between spatial allocation of employment and residences. In this case it is postulated that residential relocation within a metropolitan area is attributed to factors other than the place-of-work location. These factors include housing needs (subject to constraints of the housing market), environmental preferences, location of specialized services, as well as such purely push-factors as urban redevelopment. As one author concludes, intra-urban mobility is primarily a manifestation of the process by which families adjust their housing to the needs generated by shifts in family composition that accompany life-cycle changes (Simmons 1968). Proximity to work places, on the other hand, does not represent an independent factor of residential relocation within a city. Relocation costs and the relative distances must also be considered.

The above interpretations may prove to be complementary rather than mutually exclusive, but they all point to a necessity of accounting for intra-urban migration in a dynamic modeling of daily journey patterns. Such suggestions are supported by empirical work. Miron (1978), for example, has found that residential relocation from place-of-work area i to area j during the time interval t to t+1 had a significant effect on the subsequent level of commuting from j back to i. This effect was found to be remarkably constant over time and independent of the choice of distance variable, i.e., time-distance or intervening opportunities.

If life-cycle migration is found to correspond to housing-dependent migration and thus to represent the major component of intra-urban residential relocation, then the migration data to be introduced to the attractiveness (mass) terms of a spatial interaction model may be endogenously generated. This would require an *a priori* generation of the housing stock (in a way analogous to procedures followed by Echenique, Crowther and Lindsay 1969) or, alternatively, an application of a cohort-survival framework in a multi-zonal case (Rogers 1975; see also Termote 1980, for an extended discussion of migration-commuting interdependence in a demographic perspective).

Such an attempt would be justifiable if systematic variations were identified within an urban space in terms of demographic characteristics. Indeed, studies on factoral urban ecology (see Berry 1971, for a concise review) show that such variables add up to a major spatial dimension, conventionally defined as family status. This appears to be true under diverse socio-economic conditions, particularly in planned economies where demographic characteristics tend to be highly intercorrelated with both the age of housing and its location with respect to the city center (Jagielski 1977).

3.4 Evolution of Distance Functions

The gravity assumptions used in most urban spatial interaction models have come under mounting criticism (for a comprehensive review, see Chang-I-Hua and Porell 1979). This criticism pertains to both the theoretical derivations and the structural properties of the models. The explanation of the occurrence and distribution of flows and their relation to the overall urban fabric has not progressed very far, and more recent studies (for example, Sheppard 1978; Griffith and Jones 1980) confirm the weaknesses exposed earlier by Curry (1972), which include the spatial autocorrelation effect, i.e, the impact of the arrangement of urban land used on interaction patterns. Even more basic and still open questions are those of the perception of distance and direction of causality with respect to the interdependence between interactions, accessibility, and land use. A relatively simple but partial solution of the latter problem is to assume the existence of a feedback relation to be modeled by a simultaneous equations system (Fortheringham and Webber 1980).

In addition to such general problems, there are certain characteristics of individual approaches to the modeling of urban interaction patterns that are unsuitable for the framework under discussion. For example, an analysis of the scale of settlement systems rules out the assumption of the fixed total cost of travel used in the entropy maximization approach. The choice of elastic, as opposed to inelastic travel demand functions (see Sheppard 1980) should depend on evaluation criteria of aggregate urban performance.

Conceptual deficiencies of the gravity approach may prompt one to suggest that the allocation of places of residence and places of work within an urban region should be modeled separately. Studies which have followed this track include those by Karlquist (1975) and Wegener (1980). The hypothesis of mutual independence of the spatial processes referred to can be based on the following simple rationale:

(a) With the increasing specialization of skills and occupations, the range of available and acceptable jobs for a given employee becomes smaller rather than broader with the passage of time. This aspect of place-of-work/place-of-residence relations was studied extensively in the case of inter-urban migrations (Gleave and Palmer 1975). It generally supports the intervening opportunities notion and suggests the use of highly disaggregate sectoral data.

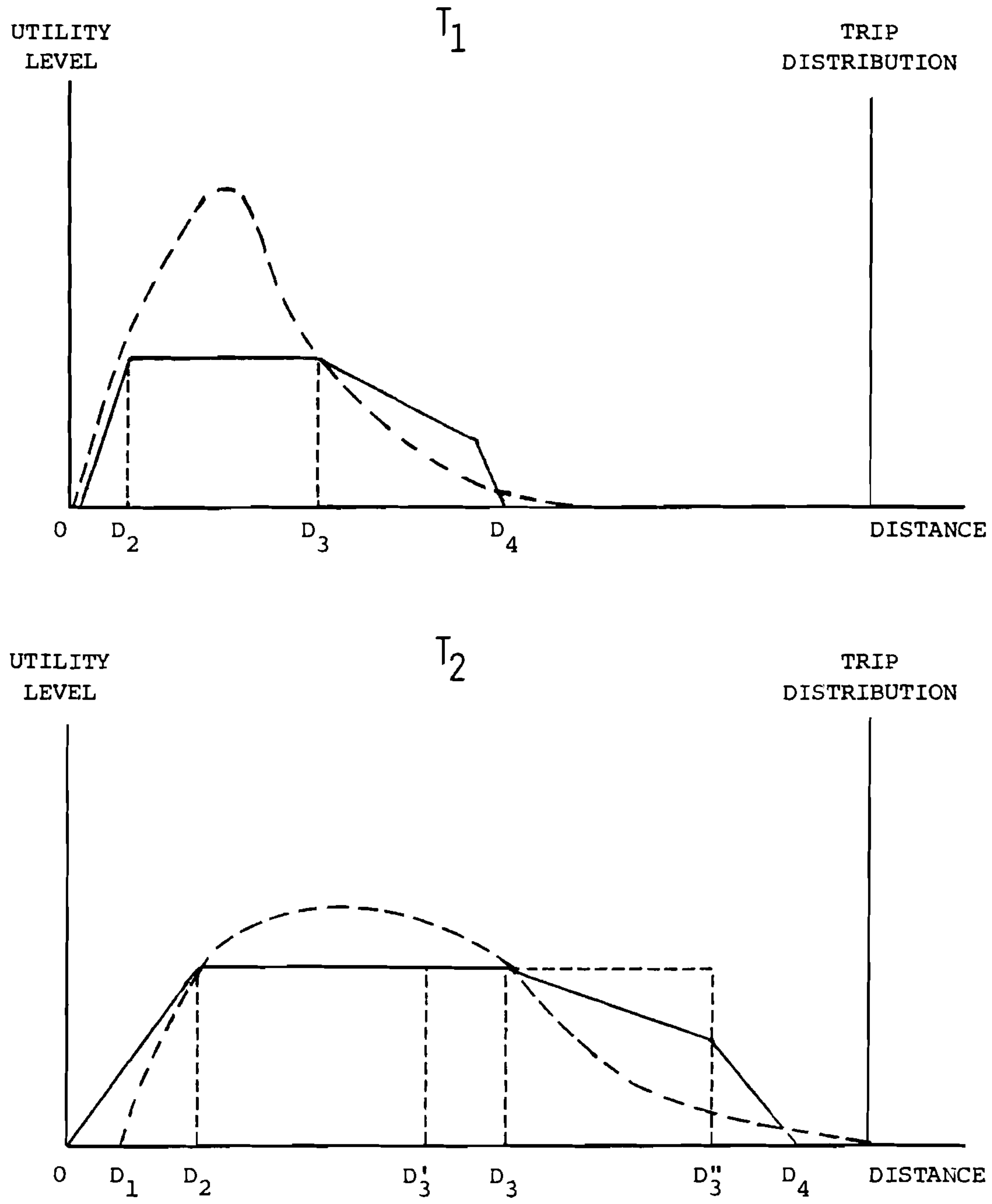
(b) Due to the inertia factor, the formation of new origins and destinations within an urban region is not likely to bring about spatial adjustments which are implied in the gravity-based comparative-statics interaction models, i.e., the reorientation of established linkages. This problem was addressed by Wilson (1974) in his two-by-two matrix describing the mover/stayer behavior with respect to changes of jobs and residences, but few attempts are known which measure the relative magnitude of those mover/stayer groups and the respective determinants of their behavior.

(c) The location of residence is of a multipurpose character. As suggested in the previous section, the housing needs, environmental characteristics of the site, accessibility to specialized service facilities and alternative activity patterns of individual household members counterbalance the spatial interdependence between residential and employment locations. Studies on activity space formation and change represent an established field of research (Hagerstrand 1970) but their impact on urban spatial interaction modeling has been mainly restricted to the question of multipurpose trips which is of secondary importance in this context.

(d) The choice of residence and place of work is subject to a number of constraints. Some of them have been alluded to before but it is useful at this point to enumerate them: (1) land-use structure, (2) incremental nature of urban development (i.e., aggregate supply constraints), and (3) segmentation of housing and labor markets (specific supply constraints).

(e) Only a part of employees perceive a spatial separation between home and place of work as a disutility. This does not only imply the satisficing behavior, suggested by Sheppard (1978) but also the perception of costs and benefits that are different from the ones postulated by spatial interaction theory (see Isard 1974) and that are also different from observed behavior, which is influenced by spatial configurations of origins and destinations (i.e., urban forms).

A possible representation of the perceptions listed above is given in Figure 3 (solid lines). Versions T_1 and T_2 refer to subsequent points in time. In both cases the concentration of destinations in the city center and the exponentially declining residential densities produce the given pattern of trip-length distribution, not necessarily congruent with the



OD_1 - the land-use homogeneity constraint

$OD_3 - OD_2$ - indifference zone

OD_4 - time-budget constraint

Figure 3. An alternative representation of the cost of distance function in journeys to work.

perceived friction of distance. As the budget constraint on travel cost becomes less pronounced over time and the factor of uniqueness of employment opportunities and residential characteristics sought increases (T_2), the indifference-distance zone becomes extended, and observed linkage patterns are deconcentrated. Even when the aggregate trip distribution remains stable, given the supply and demand constraints referred to earlier, the indifference zone may become extended (D_3') or contracted (D_3'') as a consequence of alternative transportation and land-use policies.

Thus, one can claim, the employment market and the housing market coexist in space, although each is governed by mechanisms of its own. The degree of their spatial coincidence influences the level of aggregate urban life quality (and the aggregate utility) with its effects on differential performance of urban areas in terms of population flows and shifts in economic activity.

3.5 Evaluation

The methodology for evaluating spatial interaction patterns originated in the period of rapid expansion of model applications in urban planning. The study by Echenique, Growther, and Lindsay (1969) who proposed a set of performance indicators to be used in the construction of alternative plans for the development of New Towns in Britain, is perhaps the best known effort in this area. The indicators referred to the ease of social interaction, accessibility to employment opportunities, services and open space, the work place, service and residential clustering, as well as the actual mean distance traveled. These concepts were further developed by Brethany (1974).

More recently the evaluation of urban spatial interaction has become a more popular topic again. Due to growing energy concerns the performance criteria have mainly focused on energy efficiency and transportation pricing policies. Conclusions reached so far are by no means uniform. In one case increased energy-cost scenarios are shown to produce higher urban densities and a decrease in the number and average length of work trips (Sharpe 1980). According to another study (Cordey-Hayes and Varaprasad 1980), increased travel costs are not able to influence substantially the decrease of commuting flows. These differences reflect the range of assumptions concerning price elasticities of travel and, implicitly, assumptions relating to the adaptability of existing urban stocks to changing price structures. Nevertheless, the approaches referred to can be further developed. Their extension to an inter-urban scale represents a relatively straightforward task.

Some insights into the evaluation criteria may be derived from the concept of an indifference zone (see Figure 3). Since the length of this zone is sensitive to energy costs, a substantial increase in transportation costs would no doubt cause its contraction. What many policy-impact studies assume, however, is that such a change would also bring about an adjustment of trip distribution patterns. This may indeed be a long-term result (provided the cost increase is big enough to have a pronounced impact on the budget equation), in a short- and middle-term perspective, however, the increase of total interaction costs and a decline of life-quality indicators are inevitable outcomes as is their impact on the comparative performance of cities of various size categories and internal organization patterns.

A more attractive alternative than the one described above would be to allow an expansion of the indifference zone while restricting the parallel increase of the mean trip length. Such an approach would require both extensive transportation improvements and the application of detailed land-use development controls.

Moving over to the settlement systems scale, a differential urban performance in terms of spatial interaction patterns may be seen as a factor contributing to shifts in population and economic activity among urban places. The spatial interaction should of course be measured relative to other factors of urban change, which include the distribution of economic opportunities, housing, specialized services, and environmental quality characteristics.

4. CONCLUSIONS

It follows from the approach suggested in this paper that an improvement of planning relevancy of urban models is strongly dependent on their ability to incorporate some basic postulates of urban growth and structure theory. Development costs of the modeling framework outlined may be high, since it not only calls for the establishment of linkages so far missing but also requires reformulations of the existing partial models. However, the growing interest in comprehensive and dynamic urban models (see, for example, Wilson and Macgill 1979; Gordon and Ledent 1980) is founded on their expected role in integrating urban theory and providing improved tools for urban and settlement policy.

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