THE IMPACT OF RAPID TRANSIT STATIONS ON LAND USE CHANGES IN THEIR PROXIMITY; TOWARDS A MODEL

by

Paul P. Baross
B.A. L. Arch., University of Budapest, 1967
and
Robert R. Stüssi
B.Sc., Institute of Technology, Zürich, 1968

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Department of PLANNING

The University of British Columbia
Vancouver 8, Canada

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Department of Planning

The University of British Columbia
Vancouver 8, Canada

Date May 2, 72

abstract

For nearly one hundred years, from approximately the 1830s to the early decades of the twentieth century, the form of many North American cities was dominated by the pattern of mass transportation routes. Each successive form of transportation from the horse drawn omni-bus to the electric street railways, had visible effects upon the growth, shape and internal organization of urban agglomerations. After fifty years of almost sole reliance on private transportation, the last decade has witnessed a significantly increased interest in rail rapid transit with an often claimed, but rarely thoroughly analyzed expectation, that the revitalized and improved mass transportation routes will ultimately piece the fragmented environment of today's metropolises into a manageable whole again.

This study treats one aspect of the multi-dimensional interaction between the introdution/

operation of rapid transit lines and subsequent restructuring of the spatial distribution of activities in the urban field: the rate of development of areas in the proximity of rapid transit stations. Explanations for the aparent difference in the rate of new construction around various stations is sought not in terms of the traditional accessibility concept, but rather in the environmental context within which each station is placed. Drawing from a rather distinct subdivision of urban research and extensive data analysis, the components of the environmental context and their relative importance in exerting influence on the spatial distribution of new construction were identified. During the course of the study a simple simulation model was developed in order to capture the dynamics of changes within the environmental context and consequently to assist in anticipating the spatial distribution of new constructions or replacements of existing phyisical stock in the vicinity of rapid transit stations. The emphasis is placed on these specific structural changes because the consequences of locational and investment decisions that result in significant alteration or renewal of buildings represent a more substantial modification in the internal organization of the city than those resulting from the continuous shifting and filtering of activities within the standing stock.

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prologue

URBANIZATION PAST AND PERSPECTIVE

Clearly, one of the most outstanding phenomena of our time is the accelerating rate of urbanization. The gravitation of rural population toward large urban centers has occurred irrespective of national boundaries or political/ideological systems and has been manifested, with minor variations, in both the developed and modernizing countries. Since the turn of the nineteenth century the total number of metropolitan status cities in the world has grown from 25 to 90. Their population has increased from 11 to 173 million or about sixteenfold, while during the same period the world population increased only 2.4 times.[1] (Figure 1-1) The annual rate of horizontal expansion of these metropolises has been even more dramatic, often exceeding twice their population growth rate.

1. Papageorgion, (1971) p.4 -See also Davis(1955)

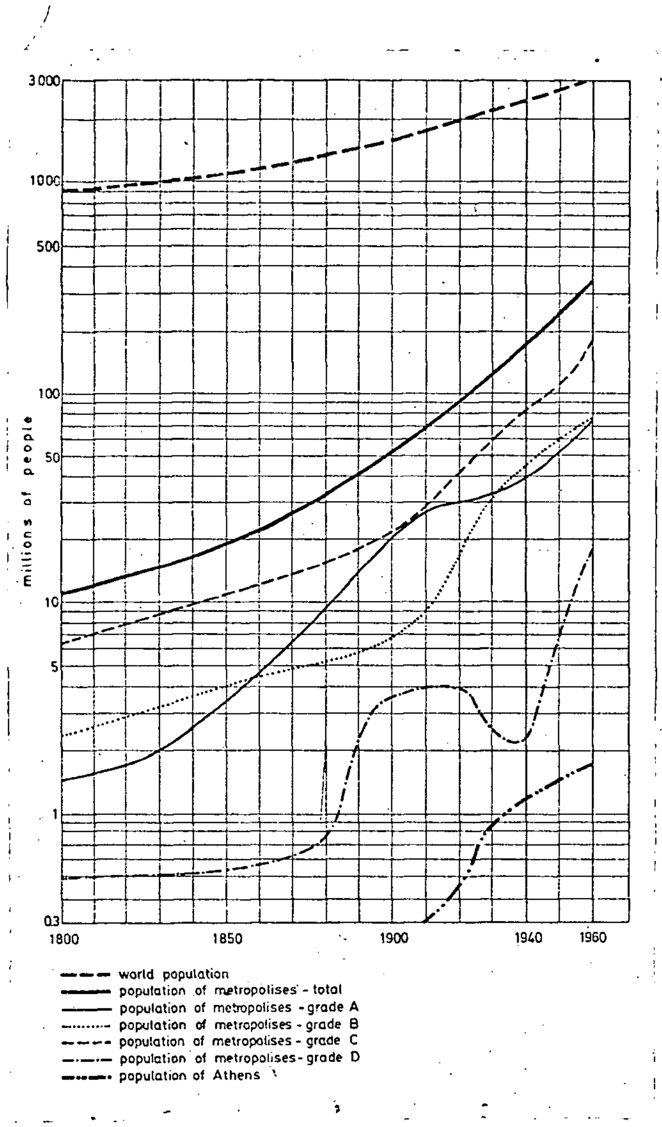

FIGURE 1-1
METROPOL-
ITAN POPU-
LATION
INCREASE
TRENDS
SINCE
1800 A.D.

<u>Source</u>: Papageorgion, "A Comparative Analysis of Fifteen Metropolises", <u>Ekistics</u>, Vol. 32, No. 188, p.4.

Current population projections for the United States and Canada predict further rapid expansion of urban agglomerations. Pickard[1] has estimated that by the year 2000 the American population

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1. in Manners, (1969) p.57.

will be 320 million and almost two-thirds of these people will be concentrated in the north-east (from the Atlantic to the Great Lakes), California, and Florida. The Lithwick report, analyzing present trends and projections in the Canadian urban development scene, foresees that 73% of the Canadian population will probably be living within 12 major urban centers at the beginning of the twenty-first century.[1] The notions of megalopolis and ecumenopolis, that is the urbanized world, may seem to have the futuristic overtone of the next century, yet their crowded, polluted nuclei already exist in North America, Japan, and Western Europe.[2]

STRUCTURAL GROWTH AND THE ROLE OF TRANSPORTATION

The spatial distribution, internal structure and growth of these future cities can not be divorced from the economic, social, technological, and political context within which individual decision-making units (firms, households) operate. These "context components" are increasingly regarded as parts of a "whole" exhibiting system characteristics. The whole is the spatial pattern arising from the accumulating result of

1. Lithwick, (1971) p.146.
2. Papaioannov, (1970).

large numbers of individual "firm" and "household" location decisions and transportation choices.

The role of <u>transportation choice</u> within this framework is of particular interest, for any inquiry into a phenomenon which has spatial dimensions necessitates the appraisal of the linkage system that facilitates flow among its discrete points.

Indeed the interrelationship between the available forms of communication/transportation and the location, distribution and forms of settlement growth has been extensively studied in the past from the points of view of a variety of disciplines.[1] Yet, partly because of the diversity and uncoordinated nature of the inquiry, and partly because of the complexities and the large number of variables involved, a systematic theory has been slow to evolve. It is pertinent at this point to quote Britton Harris' comment on the state of the art.[2]

"No general, quantitative laws emerged that are applicable to cities of large variety of sizes, functions and locations and over long periods

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1. Morrill, (1970)
2. Harris. (1961)

of time with shifting technological and economic conditions."

Although the profession still lacks powerful, reliable <u>predictive</u> techniques and models that would assist in forecasting the impact of large-scale transportation investments on the future growth pattern and spatial reorganization of a city in any significant detail, considerable literature is available that convincingly relates historical urban developments to contemporary transportation/communication forms.

REGIONAL SCALE

Morrill explored the profound effects of water features - rivers, lakes, estuaries - on the spatial distribution of settlements at the time when water transportation was the unifying element and principal means of communication.[1] The dynamic role of rail transportation in the regional development of the United States is well documented, and today increasingly more attention is directed toward assessing the impact of the rapidly-expanding air transportation.[2]

CITY SCALE

On the city scale, many scholars found explanations for the emergence of various settlement

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1. Morrill (1970) p. 10
2. Taafee (1959)

structures and their density gradients in the contemporary transportation technology. Halls' reasoning may be cited as the paradigm on which, with some variations, these speculation are based:

"At any point in the city's development, its form affected the available choice of transportation: but then, the available transportation affected the subsequent growth."[1]

TRANSPORTATION AND CHANGING URBAN FORM

Accordingly, the mutual relationship between transportation systems and the pattern of urban land use can be demonstrated in various stages of city development.[2] In the "pre-public transportation city" there was a dense concentration of people and activities within walking distance from the center. The early "public transportation city" depending upon the horse, buse and tram, exhibited tentacular growth along major arterial roads. By the 1930's the "mature transportation city" evolved, formed by the electric train and motor bus, with an overall spread of medium density housing, but employment was still concentrated at the center or in well-defined factory and warehouse areas. The erosion of the relative (and often absolute) importance of the central

1. Hall (1969) p. 409
2. Fagin (1962): Smerk (1967)

areas of most cities and the rapid expansion of the low-density urban fringe, marks the most recent tendency which is manifested in many North American metropolitan structures. The changing characteristics of central cities and suburbs may be attributed to a number of factors of varying importance: mass production, improved packing and handling techniques, innovations in communication and data processing technology, etc. However, the role that the automobile and its supporting facilities (roads, highways, parking) played seems to be of major importance.

"The lamentable consequences of the fragmentation of man-made environment - lack of focus, specificity and identity - are increasing .... The private motor vehicle makes provision for consumer facilities at random, because it has uninterrupted access everywhere. Location priority then becomes based on the automobile, and generates a spatial organization in an ever more chaotic mosaic."[1]

Many of those who believe that the indiscriminate accommodation of the automobile ultimately leads to an undesirable city advocate innovation and expansion of public transit facilities. They argue that rapid transit can be used as a "tool in reshaping urban areas towards a more orderly

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1. Chermayeff, et al., (1971) p.94

and better form of urban developments."[1]

Both statements quoted above reveal their bias - the former by giving a negative score to the urban structure which resulted from the influence of the private car, and the second by assuming that rapid transit can piece the "fragmented" environment into a manageable whole. There has been vehement discussion in recent years regarding the influence of the automobile and mass transit on urban life and form.

URBAN LIFE AND URBAN FORM

It is not the intention of the authors to take a stand on what <u>is</u> the desirable city and on the desirability of certain transportation modes per se. But it is our belief that urban life - and therefore the well-being of individuals and social groups - <u>is</u> influenced, for better or worse, by the form and structure of the urban setting. Form and structure are closely related to location and communication. To investigate the field of this problem, and to obtain an understanding of the interrelationship between the significant environment and human well-being, is therefore not merely a technocratic exercise.

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1. Meyer, et al., (1969) p.3

Knowledge of the significance of environment will provide people with the opportunity to change it according to their desires.

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introduction

2

INTERACTION BETWEEN URBAN DEVELOPMENT AND TRANSPORTATION

Much of the debate concerning the role and function of urban transportation originates from its dual character. On the one hand, transportation serves the metropolis as it evolves, by facilitating the flow of people and goods around its various areas. On the other hand, by the mere provision of facilities that handle the flow, the transportation network shapes the metropolis. Historically, this dichotomy has tended to polarize the approach taken by planners and engineers towards urban transportation problems. Practitioners, emphasizing the service aspect, have focused on trip generation, modal split, flow capacities, engineering efficiency, etc., and have paid little or no attention to the land-use changes that followed the introduction of new facilities or transportation policies. This view implies that land use changes autonomously in response to consumer demands, investment decisions and other, non-transportation factors, and that the transportation demand which is produced by the new configuration and density of land uses is balanced with the provision of new/improved transportation facilities.[1] Accordingly, transportation planning is seen as a process of forecasting land uses and designing a system that best serves the future land-use pattern.

> "Given a particular pattern of residential and non-residential uses, the transportation planner is to design the best possible transportation system. Ideally this could be accomplished if two conditions are met: (1) accurate information on the performance of any proposal could be obtained, (2) appropriate criteria to evaluate that information were agreed upon."[2]

However, as widened arterial roads and multi-lane urban freeways have become congested well before they were expected to reach their saturation point, the confidence in this narrowly technocratic transportation planning practice has gradually eroded. Almost ten years ago the Penn-Jersey Transportation Study set out to test the reciprocal proposition that the transportation linkage system plays a decisive role in the evolution of various urban land-use patterns.

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1. Mitchell and Parkins, (1954)
2. Caroll, (1962) p.3

Professor Fagin, one of the chief architects of the study, summarized the rationale behind the proposition in the following way:

"Let us assume that we could provide a transportation system so evenly spread and so speedy and efficient that urban complexes would remain permanently below the critical size beyond which time and cost do become significant factors in determining location. Let us further assume that the advantages of concentration and area specialization having been nullified, the various places of work, residence, recreation, education and like would become evenly spread. In short, let us assume the attainment of the very conditions just cited that tend to prevent any significant impact of the transportation system on changing patterns of land use. Have we, by these assumptions, proved that transportation decisions do not affect the evolving patterns of land use? Quite the contrary! We have merely shown that the deliberate development of one particular kind of transportation system is conducive to one particular type of urban pattern."[1]

INTERACTIVE URBAN MODELS

The gradual switch of emphasis, from land-use projection as a basis for transportation planning to transportation systems as a potential means of promoting a desired pattern of urban development, has resulted in an unprecedented wave of metropolitan transportation research. Hoping to expose the mutual interrelationship between traffic patterns and land-use patterns, researchers have attempted to draw their evidences

1. Fagin, p.3

from two, somewhat interrelated, sources:

i. Theoretical speculations on the relationship between transportation networks (accessibility) and land use (location rent).

ii. Empirical studies related to the impact of large-scale transportation investments (usually freeways) on the evolving configuration of urban land uses and densities.

The common element in both types of investigations is the concept of "featureless plain" ("all land is of equal quality, ready for use without further improvements, surrounding the centrally located, single 'market-place' ") that discounts any intrinsic or gained quantitative differences which may exist among the various points on the possible location surface. This concept is explicit in most theoretical models where the property of location A differs from the property of location B if, and only if, their accessibility from area C (or areas C_1, C_2, ... C_n), to which their connections have been agreed to be of some importance, is different.

Since most of the empirical impact studies were conducted during the era when the main mass of urban development occurred outside the city core, consuming large amounts of virtually flat, undifferentiated fringe land, the featureless plain concept was implicitly incorporated into their research methodology.

The usefulness of this concept, however, is severely limited when a new transportation network (rapid transit, for example) is superimposed on an existing and well-developed urban area. Here, physical structures sheltering existing activities, legal subdivision of land, sentiments attached to specific areas and other, non-transportation components reflect the "optimal" distribution of land uses based on the former accessibility surface, and can be expected to play a role of varying importance in the change and evolution of new land use and density configurations. The incorporation of the influence of past developments on future locational choice calls for a new dimension that would endow locations A and B with additional properties. These properties should not be derived <u>only</u> from the new network, <u>but also from the past commitments which were made to utilize their position in previous transportation networks</u>. In short, the authors propose the replacement of the sterile notion of featureless plain with a more differentiated and realistic notion of "environment" in transportation impact research.

CONTENT OF THE THESIS

Thus this thesis is an attempt to elaborate on the proposed new dimension, and its relevance to the planning of rapid transit lines and their station location. The thesis is organized into six major parts. Chapter three gives a brief review of relevant literature on the theory of location of activities in an urban setting. This literature review is supplemented with an appraisal of empirical impact studies related to both urban freeways and to rapid transit lines. These findings are evaluated as to the extent the observations can be rationalized in terms of the location theories previously discussed. At the end of the chapter some conclusions are drawn regarding the similarities and differences between the two types of transportation systems, and the extent and importance of the "environmental context" within which their operations should be analyzed.

Chapter four exposes the concept of "environment" and it hypothesizes on the impact its various aspects may have on the locational choice of different activities. Special attention is paid to the difference between activities (land use) and the physical stock necessary to accommodate these activities. Based on this conceptual departure, the research methodology is outlined in chapter five.

In chapter six the Toronto rapid transit system as a case study is analyzed. The results of the empirical research explain how the identified environmental components seem to influence the transformation of various areas after the rapid transit lines were introduced. On the basis of empirically defined parameters and some 'intelligent' speculations, where no adequate data was available, the formal structure of a simulation model is presented in chapter seven. The model is tested under several different assumptions and policy interventions, and the results are then compared and analyzed. The thesis concludes with some observations pertaining to what the previous analysis suggested in terms of station location and planning implications of rapid transit projects. Finally, directions for further research on the subject are indicated.

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3

concptual background

3.1

LOCATION THEORY

Location theories are usually understood as conceptual tools explaining the spatial distribution of land development in urban/regional areas. Most activity-distribution/growth/planning models, policy programs for development, etc., incorporate some aspects of location theory into their theoretical basis. A brief review of location theories is therefore fundamental for the construction and evaluation of the growth allocation model developed in this thesis.

REVIEW OF LOCATION THEORY

To the extent that space (area) is a factor in location, it must have a price (or cost) and vary with location. To the extent that space is not a factor in location of activities, they can be arranged and rearranged in space without consequence.[1] The cost of space arises from the transactions necessary to overcome the distance between

1. Ratcliff, (1957), Goldberg, (1970).

spatially separated activities (cost of friction or transportation cost). Usually these transactions are thought of as transportation of goods and people, although communication in general should be considered in the theory of urban location.[1] Thus transportation - the movement of people and goods - has usually been taken as the quantifiable manifestation of the cost of friction in the abstract structure of location theory. A firm or household that requires transportation inputs can obtain them either by purchasing transportation services or by purchasing location,[2] or a combination of the two, for they are substitutable.[3]

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1. Means of communication other than moving people, i.e., telecommunications are only to a certain degree a substitute for all transactions as is shown, e.g., in Meier's attempt to explain urban growth with communication theory (Meier, 1962).

2. There is a negative good (distance) with a positive costs (commuting costs); or, conversely, a positive good (accessibility) with negative costs (saving in commuting), (Alonso, 1960, p.149).

3. "When a purchaser acquires land, he acquires two goods (land and location) in only one transaction, and only one payment is made for the combination." (Alonso, 1960, p.150).

The competition for location is handled through the theory of rent.[1] Under the assumptions of:

i) single market place;
ii) infinite, homogeneous plain;
iii) production per unit of output are everywhere equal in the plain;
iv) transportation cost per unit is a linear function of distance;

a rent cone is derived which expresses the value of each location resulting from its accessibility to the market. Because sites closer to the market are more profitable, owners of these sites can charge more for their use up to the producers' surplus at each location. The diameter of the cone is determined by the distance at which transportation costs equal possible profit. This means that near the center the price paid for accessibility (site rent) is higher and decreases with distance from the center. (Figure 3.1-1)

As the efficiency of the transportation networks increas, rents likely would decrease (because profits decrease as more land is opened and competition increases).[2]

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1. The roots of this theory are to be found in Von Thunen's classic work. His theory of agricultural land was later expanded and applied to urban land use by Hurd and Haig. Von Thunen, (1825); Hurd, (1903); Haig, (1926).
2. Goldberg, (1970), p.160.

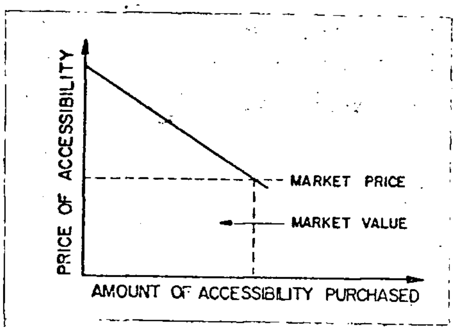

FIGURE 3.1-1 ACCESSIBILITY CONE

Source: Hutchinson, B.G., "An Approach to the Economic Evaluation of Urban Transportation Investments", <u>Highway Research Record</u>, No. 316, 1970, p.78.

Von Thunen[1] showed how different agricultural production activities would form into rings around the market, depending on which type of production could afford to pay higher rent in a particular location. A similar extension of the above model is to allow output per unit of land to vary (intensity of land use, non-land inputs of productivity increase, similar to density increase in housing) which also gives the rent curve a concave shape.

Wingo[2] uses the same concept, isolating the transportation function as shown in the following figure as a key feature of an urban transportation system that influences the distribution of house-

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1. Von Thunen's theory on agricultural land use in Hall, (1966).
2. Wingo, (1961); also Alonso, (1964).

holds in an urban region. The travel time or cost increases with distance from the center, as depicted in Figure 3.1.-2. However, an improved transportation system lowers this cost.

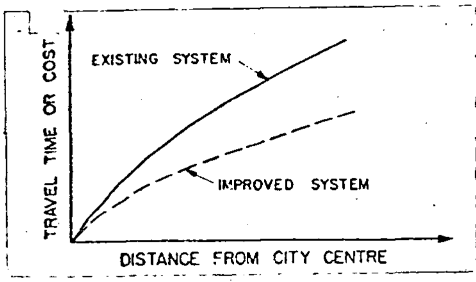

FIGURE 3.1.-2
TRANSPORTATION FUNCTION

Source: Wingo, L., Transportation and Urban Land, Baltimore, The John Hopkins Press, 1961.

From the transportation function shown in the last figure, Wingo derived a spatial structure of position rents, as shown in Figure 3.1.-3.

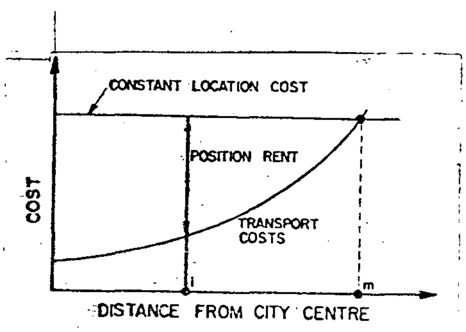

FIGURE 3.1.-3
SPATIAL STRUCTURE OF POSITION RENTS

Source: Wingo, L., Transportation and Urban Land, Baltimore, The John Hopkins Press, 1961.

The notion embodied in the above figure is that the householder located at "i" enjoys a premium in transportation costs with respect to a household located at the margin "m". This location premium invites competition from all householders located at a greater distance than "i", because a household at the margin can offer a position rent for "i" equal to the difference in transportation costs, R_i. In this way a locational equilibrium is established where each household's locational costs are constant.

Wingo has then demonstrated how density and unit rent profiles of the type shown in Figure 3.1.-4 may be derived from certain assumptions about space consumption and the rent relation of Figure 3.1.-3. Changes in the density and unit rent profiles resulting from changes in the transportation function are shown in the broken lines in Figure 3.1.-4.

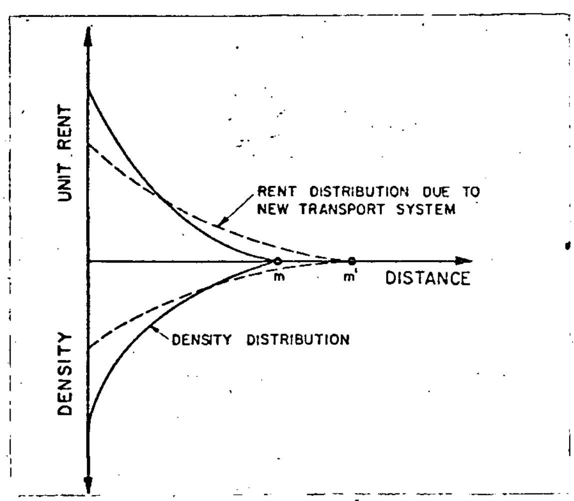

FIGURE 3.1.-4
UNIT RENT AND DENSITY PROFILES WITH DISTANCE

Source: Wingo, L., Transportation and Urban Land, Baltimore, The John Hopkins Press, 1961.

The theory as formulated so far assumes not only that transportation cost and rent are substitutable, but that their relationship is known. However, little empirical evidence is available at present to allow the rent surface to be defined. Most earlier attempts to explain the relationship between land values and distance from the city have failed to link them to a reasonable measurement of accessibility. The major studies undertaken to determine the rent surface as a function of accessibility were made by Kain[1] in Detroit and Chicago, where he found a linear land value/distance relationship, and by Berry[2], who derived a negative exponential function. Related works have been completed by Harris[3] and by Robinson.[4]

LOT SIZE

Alonso modified the site-rent/transportation cost model by introducing two additional concepts. First, the trade-off a household or a firm makes in seeking a location farther from the center depends on the amount of land it consumes.[5] Second, in the case of a residential location decision, the cost function of the firm is replaced by a utility function.

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1. Kain, (1962) and (1965)
2. Berry, et al., (1963
3. Harris, (1966)
4. Robinson, et al., (1965)
5. See also Goldberg, (1970), p.159-160

RESIDENTIAL LOCATION

"The household differs from the farmer and the urban firm in that satisfaction rather than profits is the relevant criterion of optional location. A consumer, given his income and his pattern of tastes, will seek to balance the costs and bother of commuting against the advantages of cheaper land with increasing distance from the center of the city and the satisfaction of more space for living."[1]

ACCESSIBILITY AND LAND USE

The notions of location theory discussed so far are commonly referred to as concept of accessibility, i.e., the relationship between transportation cost and site rent or land value. However, a further link between land uses and accessibility has now to be established. The question to be answered is: what land uses seek a given location with a given accessibility, i.e., a location with a particular combination of site rent/transportation cost. There are two alternative ways to formulate these interrelationships:

i. Access is the major determinant of land value, or rent, and the amount of rent that each type of firm or household could pay at each site could be determined. This would suggest that firms and households would be classified according to the amount of rent they can pay and this classification could be called land use. (Such a land-use

1. Alonso, (1960), p.154.

classification obviously would differ from the conventional one, in that it would be more dis-aggregated and different in rank, i.e., a commercial use could rank before single family use, but after high density or luxury apartment use in ability to pay, etc.). This approach, however, has some difficulties because the rent paid is not the site or access rent but the aggregate rent which in addition values implicitly all those locational factors which are access independent.

ii. Another formulation of the interrelationship between land use and accessibility directly uses the access-using characteristics of firms and households. A measurement for that is the trip generation of a certain land use. However, trips should be weighted. Household trips to work, shopping and recreation might be of varying importance to the individual. Also accessibility to the labour pool has a different significance to the firm than its access to the market or the raw materials. Therefore, again, the conventional land-use classification would have to be refined.[1] It is likely that such a breakdown would follow closely the ability-to-pay categories.

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1. Evidence for this is given - e.g., in a Chicago study, where the same land uses at different distances from CBD generate vastly different trip numbers.(Creighton, 1970).

EVALUATION OF LOCATION THEORY

In summary, the location theory seeks to explain the distribution of activities or land uses as a function of accessibility, that is as a trade-off between transportation cost and position rent. A prerequisite for the assignment of land uses corresponding to a given rent or accessibility surface is the knowledge of the relationship betweên land use and accessibility which can be expressed by the ability-to-pay rent, or by the trip generation of land uses, or by any other substitute measurement. Adjustments must be made for varying densities, i.e., for the land consumption per person or activity. This concept of location theory using the accessibility determinant results in a twofold stratification of land uses. First, activities requiring high accessibility and able to pay for it will be located closer to centers of high accessibility (CBD or sub-centers). Second, cost of high cost land close to the center may be balanced by high density uses. Therefore, the density gradient declines from centers of high accessibility towards the fringe area.

This concept of explaining land-use distribution is rather mechanistic and does not allow for many irregularities and local deviations from the predicted pattern. This follows necessarily from the fact that locational choice is not only a function of accessibility. Bourne concludes, for example, from his studies in Toronto:

> "...it must also be concluded, from the factor loadings as well as the correlation matrices, that distance to either the commercial or geographic center does not offer nearly as substantial explanatory power in understanding the relative dimensions of urban land use as might be expected. Variations among land-use types, between these types and the indices of density of activity and accessibility are too complex to isolate by two distance-decay functions alone."[1]

Swerdloff, who investigated the residential density structure of smaller sized urban areas in North Carolina, arrives at similar conclusions.

> "The utility of distance gradients as effective representations of the density surface quite likely diminishes as geographic analysis becomes finer. At gross levels of analysis, residential density patterns are apparently well correlated with distance outward from the city's centers; however, there exists an underlying pattern of small area heterogeneity superimposed on this growth pattern of exponential decay."[2]

Then, Swerdloff makes a very significant statement.

> "...distance gradients are quite useless in reproducing the likely fluctuations in residential development compactness resulting from

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1. Bourne, (1970), p.20.
2. Swerdloff, (1967), p.20.

alternations in one or a number in the socioeconomic character of the population. Only through the development of sound and logical models which simulate these interrelationships can such planning flexibility be established."[1]

This means that even though in the past transportation projects may have played a major role in shaping the cities, combined with much less control of land development by government, in the future the incremental improvement of the transportation network in a highly evolved city will cause less disequilibrium in the accessibility - land-use interaction. In addition, it was commonly assumed that the location of the workplace is a major determinant of residential location (and vice verse, the labour-intensive firm locates close to the labour shed). Present studies also indicate a change in locational behaviour towards a higher emphasis on environmental qualities trading off lower accessibility (longer commuting).[2,3,4]

Kain explained part of the deviation from the theoretical prediction of residential distribu-

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1. Swerdloff, (1967), p.20.
2. Clawson, (1965).
3. Lowenstein, (1969).
4. Shapiro, (1959).

tion by his empirical work done in Chicago and Detroit.

"It seems probable that a surface of location would be very complex and location rent surfaces might differ for various types of accommodations (those of varying quality, density, age, etc.). The quasi-rents obtainable in one sub-market defined by, say, quality differences, might differ substantially from those obtainable in another. Market disequilibrium may well be the rule rather than the exception."[1]

Kain documents with his findings the effects of racial discrimination, of trade-offs between transportation cost to work and housing cost as a function of high density work places and the housing cost savings as a function of the amount of residential land consumed.[2] He also demonstrated that these trade-offs are a function of city size. In small cities, where within a given time travel distance a higher percentage of all residential places are located; furthermore, transportation costs are on the average smaller, hence they play a less significant role in the location decision.

This finding, although it does not contradict the location theory, is very important, since this limitation of the theory is disregarded in numer-

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1. Kain, (1965), p.248.
2. Kain, (1965), p.256, pp.262-274.

ous cases. The gravity model, for instance, is applied often for cities in which the transportation cost differentials are too small to yield significant results. If time cost is used, an additional uncertainty is introduced through the valuation of work and leisure time.

EXTERNALITIES

The location theory, since it assumes that the rent paid consists of site rent and transportation cost and therefore for a user with a particular ability-to-pay is constant over the city, is in its nature economic. Harris provides an economic explanation for deviations from the theoretical prediction.

"Externalities take the form that certain types of land uses, for example, are either mutually supporting or mutually repelling. These externalities lead to economics of scale and economics of agglomeration, and they have extremely important consequences for analysis and model building."[1]

SOCIAL CRITERIA

However, other authors[2] question the predominantly economic approach to location theory and expect a better explanation of locational choice if additional variables are included in

1. Harris, (1961), p.711.
2. See, for example: Chapin, (1968); Berman, (1961).

the model.

"These theories (of location) all place almost exclusive emphasis on economic variables, like relevant prices and costs or proxies for costs such as 'elapsed travel time' for access to places of work or other centers. It would seem highly probable that a number of sociological variables, like those commonly encountered in cross-section consumer budget studies, are required for a really adequate empirical explanation of locational choices."[1]

CONSUMER AND PRODUCER OF LOCATION

It is of importance to appreciate that whatever conscious or subconscious criteria of locational choice individuals or firms have; be they access, economic, social, or whatever, their effective selection of a location is dependent upon two factors. First the decision is not made by the consumer (demand) or the producer (supply) alone. The market mechanism, operating within the constraints set by public policy, is the medium in which location behaviour responds to the given conditions and selects among available locations.[2]

IMPERFECT MARKET KNOWLEDGE

Secondly neither the consumer nor the producer have perfect knowledge of this market situation.

1. Meyer, (1963), p.46.
2. See also Manual for Market Analysis: Criteria for the Evaluation of Location Choices of Firms and Households, Miller, (1971).

"From the beginning of the process, when land must be released by willing sellers in different sections of the metropolitan community, through the entire development process involving differing behaviors of real estate men, developers, mortgage financiers, and builders, the combination of possible outcomes multiplies rapidly. Next, according to the opportunities emerging from this part of the development process, households make their locational decisions, some taking up rental accommodations, some acquiring lots and negotiating for a house through an architect or building contractor, and some buying the complete shelter package. Because of imperfect knowledge that both producers and consumers have of this process and the possible variability entering into decisions along the way, the outcomes are not easy to forecast."[1]

THE ROLE OF LOCATION THEORY

It is evident from the criticism of the quoted authors and their suggestions, that location theory is very much in a state of development and expansion. There is also a trend from merely trying to predict with location theory the spatial distribution of land use to an attempt to rationalize why land development takes place. Although it is only a matter of drawing the border line between the two aspects, the distinction is important if we are to relate the role of location theory in explaining the structure of cities. Chapin offers an excellent conceptualization of this problem.[2,3] He proposed three steps of

1. Chapin, (1965a), p.121.
2. Chapin, (1965b), p.4.
3. Chapin and Thomas, (1969).

analysis necessary to capture and explain existing and changing land-use pattern. He calls them first, second and third-order areas of concern in an analytical framework. The first-order concern refers to the (i) value system derived from man's experience with his environment. The second-order of analysis focuses on (ii) behaviour patterns which Chapin defines as "the various kinds of human actions involved in city life which have become sufficiently routinized to take the form of definite patterns". Chapin distinguishes two major patterns - patterns of spatial distribution of activities, and patterns of time allocation to activities. The study of these patterns requires the investigation of antecedent values associated with them, the values with respect to "environmental qualities" of a location and the values placed on "accessibility as it inhibits or facilitates the capability of an individual to engage in activities". Value systems and activity patterns of people generate (iii) location decisions, the third-order area of concern in the study framework.

The important conclusion to be drawn from Chapin's proposed framework is that location theory will never allow for more than the description of the land use patterns and for the formulation of some "laws" to predict future land uses as long as the first and second-order phenomena are not fully understood. In other words, most location models are able to predict, rather than to explain. However, the ultimate objective of this important branch of urban research is certainly to understand the influence that changed land-use patterns will have on people's behaviour and values for it is the responsibility of the agent of change - the planner or politician, or whoever - to be aware of the consequences his decisions will bear. Hamburg, Creighton and Scott formulate this concern clearly:

"Evaluating alternative land-use patterns must be based on the impact that differences in city form and composition have on the goal structure of society. To attack the problem of evaluation therefore requires (a) a definition and a means of measuring land-use patterns (form and composition), (b) a compilation and measurement of relevant goals, and (c) the identification and measurement of the impact of differences in land-use patterns on societal goals."[1]

1/ Hamburg, Creighton, Scott, (1967), p.231.

3.2

HIGHWAY IMPACT STUDIES

It is often suggested that the impact of freeways and rapid transit is comparable - to a certain extent. First, both systems have similar characteristics insofar as they are limited access transportation channels. The system can only be entered/departed at specific points. This channelizes the transportation flow and concentrates the impact of the facility in the area of access points.[1,2] Following the "freeway boom" of the last two decades, a great number of impact studies were undertaken to evaluate the consequences of freeways.[3] The early impact studies concentrated on economic aspects (land values),[4,5,6,7,8] and on

1. Thiel, (1965).
2. Bardwell, (1960).
3. See Highway Research Report No. 16, (1963), No. 75, (1965), No. 149, (1966), and Highway Research Bulletin No. 268, (1960).
4. Cribbins, (1965).
5. Ryan, (1959).
6. Adkins, (1959).
7. Pendleton, (1963).
8. Miller, (1971).

the changes in land uses.[1,2,3] More recently, social consequences to communities passed or crossed by freeways are being studied,[4] since the negative reaction of neighborhoods and whole cities towards freeways increasingly influenced the political decision-makers concerned with transportation investment decisions. This is evidenced, for example, in Toronto, Vancouver and numerous United States cities. Mass transit, which had been very slow to evolve in the same time span and only in recent years obtained increased attention, has not yet produced a similar amount of empirical research on its impact on people and activities.

Since the object of this thesis is the evaluation of the impact of rapid transit lines on land use, highway impact studies will not be reviewed in detail. However, because the authors do not accept the conclusion that substantial inferences can be made from the freeway experience to explain and forecast the influence rapid transit is likely to have on urban life and urban structure, highway impact studies are discussed only briefly to the

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1. Lemly, (1959).
2. Campbell, (1969).
3. Davis, (1963).
4. Thiel, (1965).

extent necessary to demonstrate the difference of impacts. The basic differences of the two transportation systems and their impacts are considered to be in

i. the spatial extent of impact,
ii. the state (environmental conditions) of the impact area at the time the system is introduced, and
iii. the type of land uses changed or generated.

SPATIAL EXTENT OF IMPACT

Spatially, three areas of impact may be distinguished. First, the area physically affected, which includes not merely the right-of-way, but more important, the barrier-effect dividing existing communities and communications (crossroads) and the environmental consequences (noise/air/visual pollution, etc.). If we compare a subway line (the concern of this study) with a freeway, the differences of impact and impact area are self-evident.

Second, we can delineate an area of "user benefits" - the area defined by the residence of the user of the transportation system ("user shed"). In the case of transit, this area can be stratified by users who walk to the station (collection point),[1] and by users who use the feeder system or car to reach the transfer point. The user shed in the case of a freeway corresponds to the latter and is substantially larger then for a transit system, as evidenced by the lower residential densities.[2]

Finally, we can distinguish a third area of concern, which is directly affected by the system. This area includes the non-users of the system. The impacts are mainly shifts in land values, land uses, tax base, job opportunities, acquaintances, etc. This area is adjacent to the access-points and differs for the two transportation systems considerably in its qualities.

ENVIRONMENTAL CONDITIONS OF IMPACT AREA

The most significant difference in impacts of the two transportation systems results from the state and type of development of the land at the time of introduction of the new system. The mass transit line, because of its nature as a high performance transportation system, requires great ridership

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1. Collection point is defined as a station in which more people are entering than leaving the station in the morning rush hour.
2. Compare residential densities around freeway interchanges as reported by Thiel, (1965), with those adjacent to the subway stations in Toronto, presented in Chapter 5.

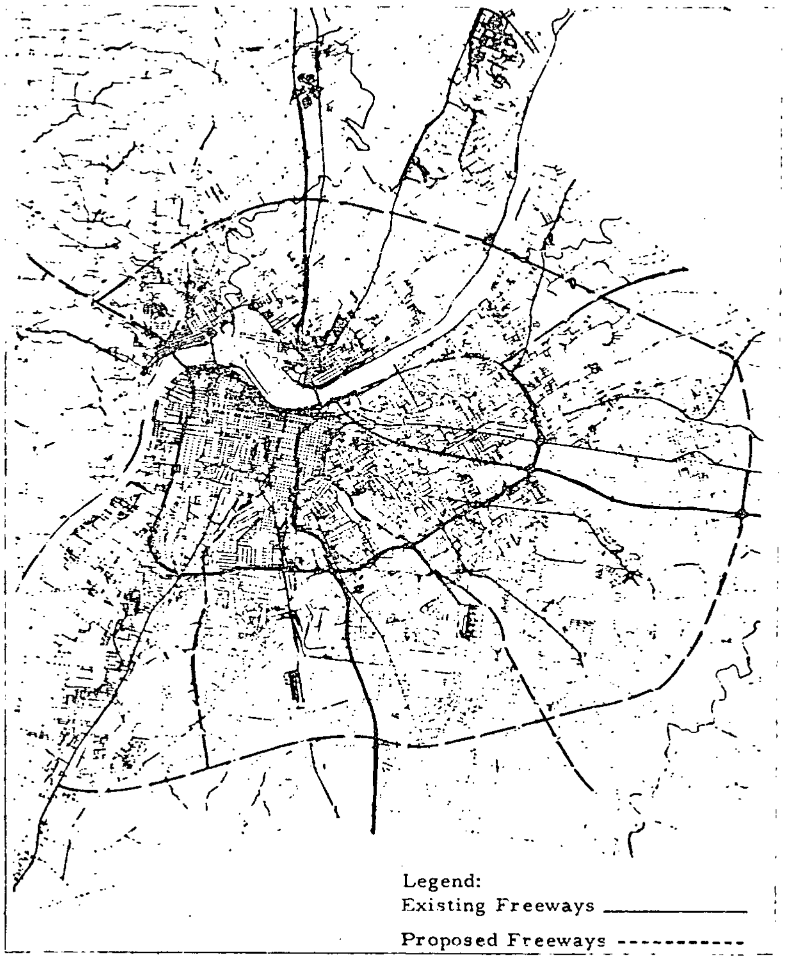
numbers to justify the investment. These passenger frequencies in turn can only be achieved in relatively high density areas. That is to say, rapid transit lines are usually introduced in already built-up areas and predominantly in higher density, residential areas. Freeways, on the other hand, are often designed to open up new areas of mostly undeveloped and vacant land, as Figure 3.2.-1 demonstrates.

Of course, the costs of producing new housing vary considerably from one location to another. The greatest differences are due to variations in land costs, and the greatest of these are between the costs of vacant and nonvacant land. Site costs of developed sites are equal to the discounted value of the income streams of existing properties plus demolition costs. Thus it is hardly surprising that demolition is seldom carried out by the private market except to provide sites for very high-density and high-quality apartment developments in areas where there is substantial excess demand for them, or to provide sites for industrial or commercial use.[1]

A further difference is found in the type of land use generated by the new transportation system. Figure 3.2.-2 shows land-use changes as a function of land values and amount of new land supplied by the transportation improvement. Curve "A" resembles the effect of the introduction of a transit line, which opens up less land and attracts mostly

1. Kain, (1965), p.254.

FIGURE 3.2-1
FREEWAY
NETWORK,
LOUISVILLE,
KENTUCKY,
U.S.A.



Source: Schimpeler, C.C., Grecco, W.L., "The Community Systems Evaluation: An Approach Based on Community Structures and Values", Highway Research Report, No. 238, 1968, p.150.

medium and high-density residential land uses. Curve "B" demonstrates the impact of a freeway, which opens up more land with higher portions of low-density and industrial land uses generated.

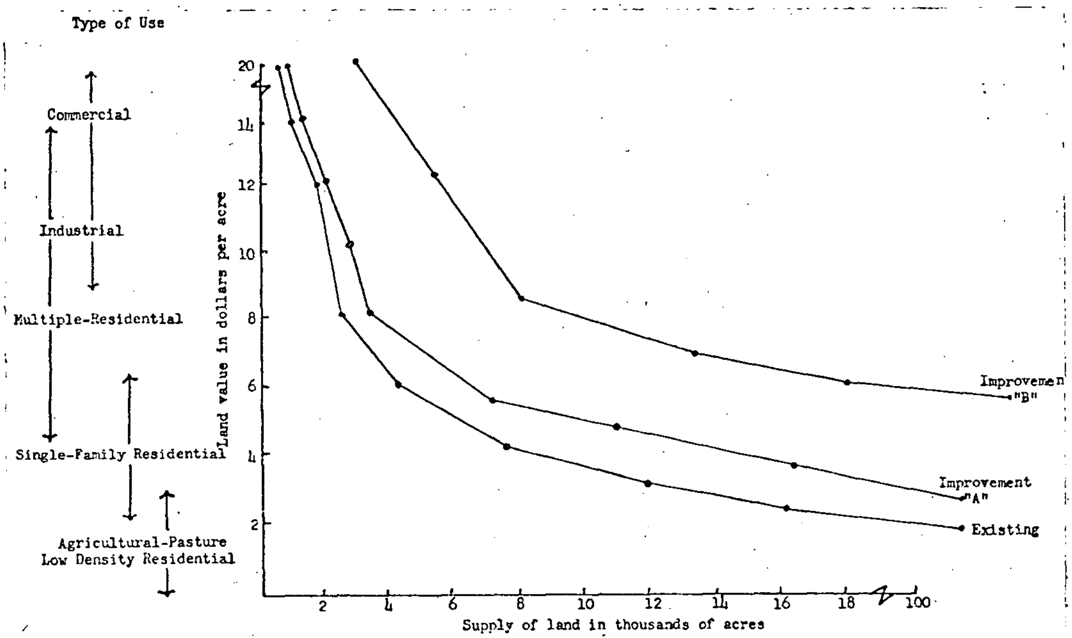


FIGURE 3.2-2 LAND USE AS A FUNCTION OF LAND VALUE AND ACCESSIBILITY

Source: Wendt, P.F. "Influence of Transportation Changes on Urban Land Uses and Values", Highway Research Bulletin No. 268, (1960), p.100.

TIME LAG OF TRANSPORTATION IMPACT

Finally, the development processes and changes of land display a typical pattern over time. The changes are initiated already in the planning stage of a facility and definitely when a project is authorized. The rate of change increases thereafter over time, decreasing usually some time after the project is implemented. Herr made detailed studies on this subject and Figure 3.2-3 gives a sample of his findings.[1]

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1. See also: Goldberg, (1971).

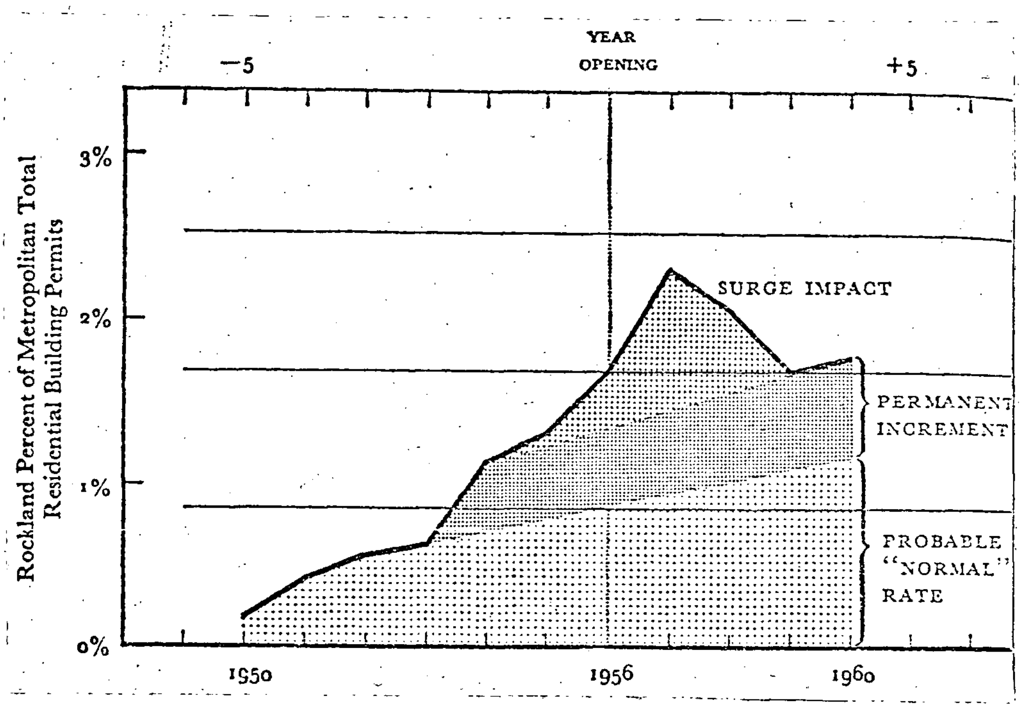

FIGURE 3.2-3 TIMING OF TRANSPORTATION IMPACT (Tappan Zee Bridge, Hudson River, Rockland County, N.Y.)

Source: Herr, P.B., "The Timing of Highway Impact", Traffic Quarterly, 1964, p.284.

GENERATED AND CHANGED LAND USES

As a consequence of the different spatial expansion of the impact area, the nature of the transportation facility (public transport/car) and the environmental conditions of the impact area, significantly different land developments are observed around access points of freeways and rapid transit lines. In the case of the freeway, a considerable part of the land is undeveloped. As found by Cribbins,[1] and by Raup,[2] an accelerated process of "ripening" for development can be observed in newly opened areas. However,

1. Cribbins, (1965).
2. Raup, (1959), p.84.

Goldberg[1] notes, "that freeways do not usually lead to immediate land development, especially in the urban-rural fringe." However, he states that land in this state shows normally the highest percentage appreciation in value.[2,3] In the case of transit lines, land is developed to a great extent, representing a commitment, which will not, for economic reasons, easily change. If it changes, the vacant and the more depreciated land will be used first.

Most of the studies on the timing of land development were made for freeways and on a rather aggregated level. This is justified by the relative uniformity of land opened by a freeway. Development priorities in this case are mainly determined by accessibility rather than by the qualities of the land. This does not hold for rapid transit lines. The accessibility differential along the line is usually much smaller, but the variance in environmental quality is much larger because of the development stage (filtering) of the land. Therefore, changes in land use over

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1. Goldberg, (1971), p.135.
2. Goldberg, (1971), p.175.
3. Bardwell, (1960).

time are expected not to be uniform for transit stations. In order to capture and explain the differences in time lags and at what point an individual station is "ripe" for development, the analysis must take place on a much more disaggregated level and must differentiate among environmental factors. Both these points are taken care of in the model presented in this thesis.

SUMMARY

In summary, both transportation improvements - new freeways and rapid transit lines - cause changes in the scale of land use. However, the nature, extent and timing of their impact is different. Whereas in the case of freeways considerable empirical evidence exists on these impacts, the experience derived from rapid transit developments is rather scarce. Knowledge on the consequences of investments in mass transit can not be gained by indiscriminantly transferring the findings of freeway impact studies. A separate framework of analysis needs to be developed.

3.3

RAPID TRANSIT IMPACT STUDIES

Rapid transit is a particular type of mass transit system, generally defined as a method of transporting large numbers of people and their incidental baggage in vehicles operating on exclusive rights of way within an urban area. Although great variation exists among present rapid transit services regarding vehicle and roadbed configuration,[1] capacity,[2] network layout[3] and level of automation, etc., a relatively simple way of classification is adopted for the purpose of this study:

(i) Rapid transit systems employing vehicles capable of leaving their designated rights of way and operating on city streets (bus rapid transit),

(ii) Rapid transit systems employing vehicles operating on, and incapable of leaving,

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1. Ferreri, (1970)
2. Young et al., (1969)
3. Tass, (1971)

specialized tracks (rail rapid transit).

In the past, the differences between these two types of transit systems have been considered generally in terms of their relative capital/operating expenses and flexibility. The construction costs of a grade separated rail transit track often greatly exceed the cost of constructing an additional freeway or redesigning an existing freeway lane to accommodate bus transit.[1] Similar cost relationship exists in general between the rolling stock of the two systems. On the other hand, rail rapid transit systems are more readily adaptable to automation. The prospect of reducing operational expenses - of which often more than 60% is labour cost - is less promising for bus rapid transit systems.

Capital and operating cost considerations are vital points in the selection of mass transportation hardware, for planners are inevitably confronted with the problem of how to finance any transportation improvement. Yet these considerations reveal little about the interactions between the transportation system and the environment within which it is placed. The above class-

1. Robinson, (1970), p.10

ification, however, is sufficiently flexible to take into account other differences between the two types of rapid transit systems. Thus it can yield operational advantages pertinent to this study when another inherent characteristic of rapid transit systems is considered - that is the 'level of commitment.'

THE ROLE OF COMMITMENT

Earlier in this chapter when impact studies in general were discussed, an important relationship was noted between the information available and/or the level of commitment to a particular transportation investment and real estate speculations, leading to change in land value patterns along the corridor. Miller has demonstrated that as uncertainty decreases through the steps of: (i) announcing the intentions of the authorities to construct a freeway, (ii) acquisition of land along the proposed rights of way, (iii) beginning and (iv) completion of construction, the rate of land value/use/density change increased accordingly.[1]

Interpreting Miller's observation in a more generalized manner, the interchangeable notions of decreasing uncertainty and increasing commitment

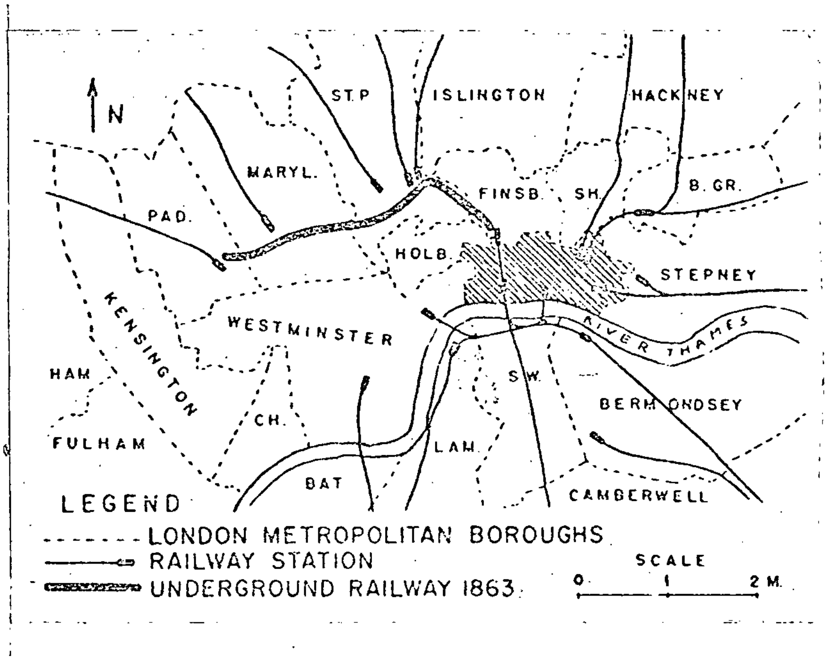
1. Miller, (1971)

seems to be a useful concept to predict the impact of the two types of rapid transit systems on land value/use/density changes. In the case of the bus rapid transit system, both the vehicle and the reserved land can be 're-used'; the commitment to a particular route is reversible. If demand for the service drops drastically or shifts spatially, the service can be abandoned or re-routed without much difficulty. In the case of the rail rapid transit system, neither can the vehicle leave the track it was designed for, nor can the track be used to accommodate other, non-rail, rapid transit carriers. The commitment to both the vehicle and the track is irreversible. Consequently, if rapid transit systems do have any impact on the evolution of land use/value/density along their route, this impact can be expected to be more evident along rail rapid transit corridors than along bus rapid transit corridors. Hence in the following discussion the focus is placed on rail rapid transit impact studies and the general conclusions drawn at the end of this chapter should not be interpreted as having either explicit or implicit reference to bus rapid transit systems.

HISTORICAL DEVELOPMENT

The first underground railway service was inaugurated in London in 1863. Although the original function of the three and a half-mile service was to facilitate the transportation of goods, it soon became the railway carrying almost exclusively passengers.[1] Probably the only comparable features of the 'underground' that are exhibited by present transit systems are those of grade separation, and the fact that it was fully underground. (Figure 3.3-1). The success of these features, however, led to the construction of new sections

FIGURE 3.3.-1
LONDON
'UNDERGROUND'
1863



Source: Tass, L., Modern Rapid Transit, Carleton Press, Inc., New York, 1971, p.180.

1. Tass, (1970).

and extensions in the following years. This marked the beginning of major developments in continually improving rapid transit services, which are now operating in a number of metropolises. (Figure 3.3-2).

On the North American continent, rail rapid transit systems are in operation in seven cities: New York, Chicago, Philadelphia, Boston, Cleveland, Toronto and Montreal. A rail system is soon to be opened in the San Francisco region (BART) and in Washington, D.C. construction has already begun on the first stage of the proposed 28 mile rapid transit network. Rail transit proposals were recently approved in Atlanta and Baltimore, while several other cities are examining their mass transit systems and studying rail transit as a potential means of alleviating transportation problems. These include Buffalo, Detroit, Houston, Kansas City, Louisville, Miami, Minneapolis-St. Paul, New Orleans and Pittsburg in the U.S.[1] and Edmonton and Vancouver in Canada.

IMPACT STUDIES IN GENERAL

It was noted earlier that central to the recent interest in rapid transit has been the increasing

1. Wermers, (1970) p.49.

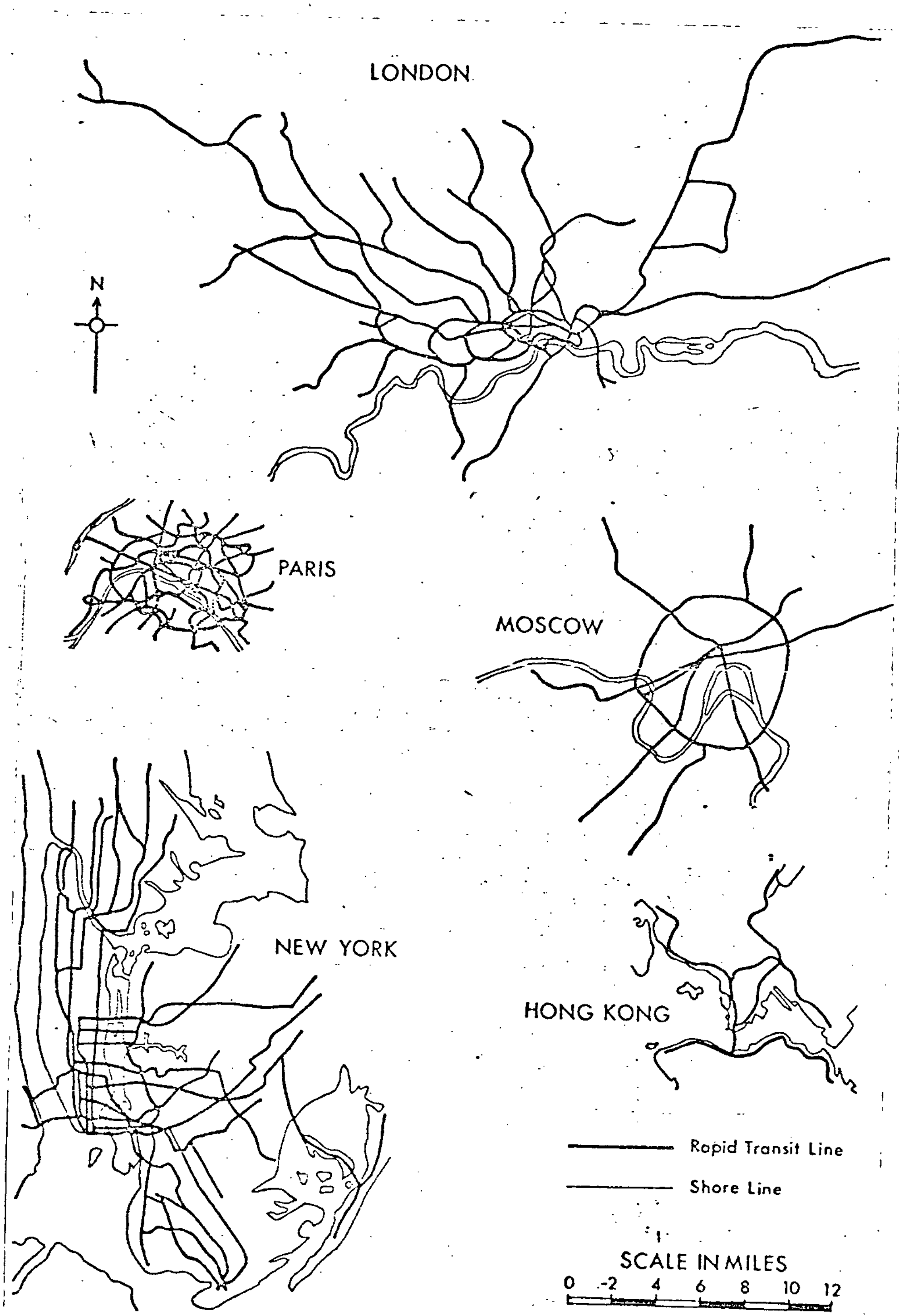


FIGURE 3.3-2
RAPID TRANSIT NETWORKS OF LONDON, PARIS, MOSCOW, NEW YORK, AND HONG KONG

Source: Taylor, S.F., "Urban Transport - A World-Wide Problem", Institute of Transport Journal, July, 1970, p.497.

recognition of the need to shape urban and regional growth. Credible literature on the actual impact of lines, which have been or are to be constructed, on the growth/redevelopment process along their route is rather limited. To be sure, transit trade associations and large corporations with a vested interest in urban transit hardware do produce volumes of testimony on the impact rapid transit has on the nature of subsequent land use, but the examination of this material often reveals more rhetoric than fact.[1] Commenting on the apparent difference between Toronto, where clustering of high density development is observable around specific stations, and Cleveland, where relatively little such development has occurred in association with the system, Thomas Deen warns against instantaneous generalizations:

> It appears there are times and conditions when transit can have an impact and others when it has relatively little impact. Research needs to be conducted that will help confirm the conditions that are required to bring about desirable urban land-use development goals.[2]

Since no paradigm has yet evolved that relates land value/use/density structure to rapid transit

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1. Jernstedt, (1970) p.3-7.
2. Deen, (1970), p.11

systems in a systematic and comprehensive framework, the writers drew the literature review from a variety of sources. These have included scholarly works, professional opinions, and appraisals conducted by various city planning departments and consultants. As a result, two aspects of these studies need to be treated with some caution - the academic rigour with which the conclusions were formulated, and the scale of spatial aggregation employed to derive the findings.

CITY SCALE

The effect of a rapid transit system on the city's growth pattern is probably the most debated issue in the literature. To illustrate the range within which professional opinions differ, the opposing propositions of Lash and Heenan may be cited.

> "By the time a metropolitan area begins seriously to consider adding a rapid transit system, much of its transportation system, in the form of an extensive network of roads and streets, is well established. ..... Thus the new network may be less of a controlling influence in determining the form of urban development than is sometimes imagined ..."[1]

On the other hand, Heenan claims that the first leg of Toronto's rapid transit line has attracted so much new real estate development to the city

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1. Lash, (1967) p.193.

that,

"... if urban rapid transit system never earned a dime, it would pay for itself many times over through its beneficial impact on real estate values and increased assessments."[1]

Whether the new rapid transit system leads to greater population growth and attracts additional investment is highly debatable. Theoretically, assuming unitary price elasticity demand for land, improvements in the transportation system result in decline of land prices and rents, for with the increase in the supply of land the competition among land and land service sellers becomes greater. However, as Goldberg demonstrated, the price elasticity of demand for land does not appear to be unitary, and in growing urban regions with expanding transportation networks the overall impact, at its best, would be only a slower rate of increase in land prices than without the transportation improvements.[2] To interpret the slower rate of land price increase on the aggregate level as a major factor for attracting additional growth to the city, as Heenan's statement seems to imply, is to assign a decisive role to the marginal differences of aggregated land prices among various urban regions for <u>interurban locational</u>

1. Heenan, (1968) p.213
2. Goldberg, (1970).

decisions. This proposition, in the light of the theoretical and empirical research on interregional locational behaviour, is rather ambitious, if not misleading.

Indeed, Conway's analysis of four metropolises with extensive and well developed rapid transit networks-- Boston, Chicago, Philadelphia, New York - finds no apparent pattern in the population growth rate or shifts in population density distribution which would distinguish these cities from those with no rapid transit lines.[1]

In summarizing the findings of the extensive urban transportation research study carried out by the RAND Corporation, Meyer arrived in more general terms at similar conclusions.

"An array of technological, economic and social forces has altered the structure and character of American cities in recent decades. The particular form, mode or even presence or absence of public transit is only one of these factors and apparently one of limited importance. In fact, the patterns of land use, population growth, employment locations and residential choices recorded in recent years by the most transit oriented American cities have essentially mirrored those of other cities with very strong highway orientation."[2]

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1. Conway, (1968)
2. Meyer, (1969) p.360.

However, both Conway's and Meyer's arguments are based on highly aggregated data and on the spatial distribution of growth in cities where the rapid transit system was built before the second World War and not radically modernized or expanded since. As in all of these cities - similar to most other North American cities - attempts to improve the quality of urban transportation were almost exclusively limited to highway and road improvements in the last two decades, Conway's and Meyer's conclusions are neither surprising, nor, for that matter, conclusive.

Stockholm is probably the most commonly used example where a deliberate attempt has been made to use the density generating effect of rapid transit systems to channel "predesigned" growth. To avoid disorganized sprawl after essentially all land in the central city was used, some 18 satellite cities were created, each centering around a rapid transit station. Tass uses the examples of Madrid and Hamburg to demonstrate the same point.

"One line in Hamburg was built for the sole purpose of developing the adjacent area. Consequently, the population of Hamburg's northern districts tripled while no other district showed similar results."[1]

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1. Tass, (1971) p.81

On the North American continent the only explicit attempt to use rapid transit to encourage and direct the orderly growth of a city, and in the process "to contribute to an improved way of life for its residents", is the Radial Corridor Plan of Washington, D.C. It proposes 5 corridors of urban growth, based on transportation spines radiating from downtown Washington.[1] The plan clearly resembles the structure of Stockholm and its satellite cities. (Figure 3.3-3).

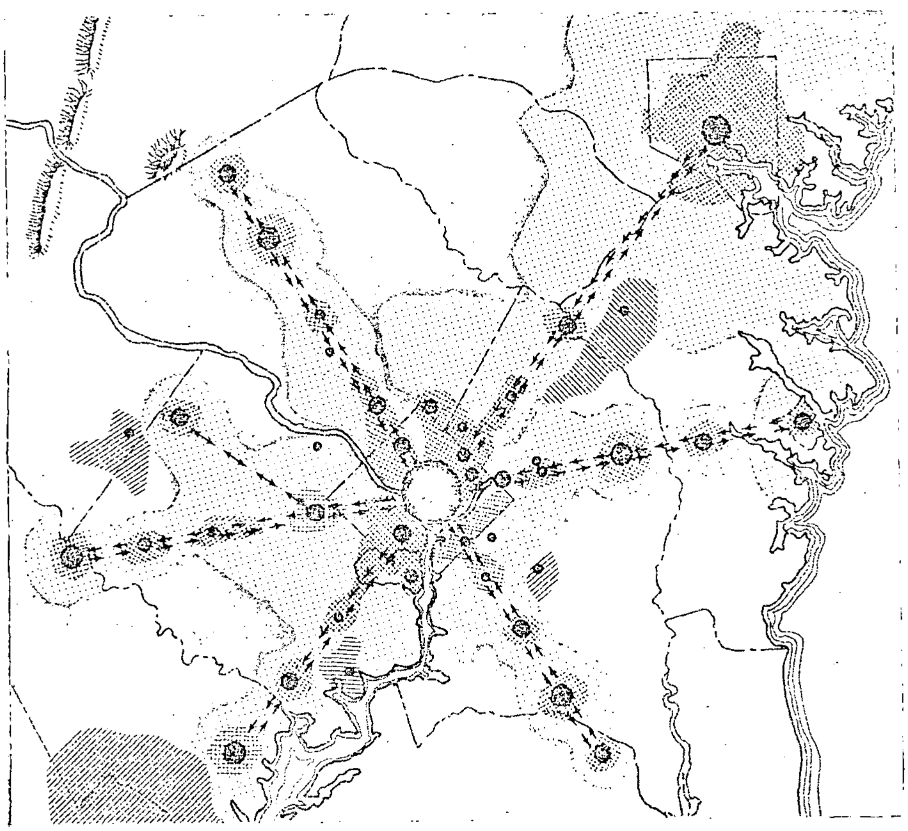

FIGURE 3.3-3 THE RADIAL CORRIDOR PLAN FOR THE METROPOLITAN WASHINGTON

Source: Metropolitan Washington, Council of Governments, Vol.12, No. 5, 1971, p.1.

1. C.O.G., (1971).

It may be argued, however, that the examples presented in the previous paragraph cannot be interpreted as evidence which contradicts the conclusions of Lash, Conway and Meyer. In the first place, these examples represent experiences in a non-North American context (different life style, lower car ownership, etc.). In the second place, the specific growth patterns recorded in these cities were brought about by the presence of a rapid transit system, in conjunction with a deliberate planning effort such as zoning, taxation, public land assembly, and bonus. This dichotomy leaves ample opportunities to speculate on the magnitude of influence attributable to the deliberate planning rather than to the presence of a rapid transit system. To this end, the crucial role that meticulous planning and public assistance can play in the development of high density nodes around rapid transit stations was specifically stressed at a recent conference on urban transportation sponsored by the U.S. Department of Housing and Urban Development.

"Most respondents believed that high concentration of facilities around transit nodes would occur only if zoning, taxation, and other public powers were used to reinforce the transportation advantages of the nodes ... William Wheaton noted that the scale and density of development foreseen was realistic and even conservative for a 30-40 year period, but financial incentives such as public underwriting of private nodal development risk, would be necessary."[1]

Favourable policy devices can undeniably enhance the attractiveness of rapid transit corridors for specific activities. However, examples from North American cities have indicated that even where rapid transit was intended to be nothing more than a means to relieve congestion, changes in land values and the rate of development have occurred along the transit corridors which are quite different from those in other parts of these cities. In Toronto, for example, a study was undertaken by the Toronto Transit Commission in 1959 to isolate properties considered to be within the sphere of influence of the Yonge Street subway line and to compare land value increases (as measured by realty tax assessment) recorded within these selected areas with land value changes elsewhere in the city. For taxation purposes the City of Toronto is divided into 40 ward subdivisions, 14 of which are adjacent to the Yonge Street rapid transit line. From the following figures taken from the study it is evident that property values adjacent to the line increased at a greater rate

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1. U.S. Department of Housing and Urban Development (1968) p.158.

than elsewhere in the city.[1,2] (Table 3.3-I).

TABLE 3.3-I
CHANGES IN REALTY TAX ASSESSMENTS, CITY OF TORONTO, 1950-1959

(all figures in thousands)

Year	Total City		Adjacent to Yonge Subway*	
	Increase	%	Increase	%
1950-53	$101,426	7.5	$ 48,557	9.2
1954-56	127,721	8.5	69,846	12.1
1957-59	212,523	13.5	121,521	18.8
	$441,670	32.8	$239,924	45.4

* Opened 1954.

Source: Kearns, J.H., The Economic Impact of Yonge Subway, (T.T.C. Toronto, 1964, p.6)

According to Heenan's estimates in the five year period between 1959-63, 48.5% of all highrise apartment development and 90%[3] of all new office

1. Kearns, (1964).
2. Unfortunately, the study has two significant shortcomings: first, the increase of land values adjacent to the line was compared to the total city increase which obviously included the former one, and second, no provision was made to discount the fact that Yonge Street has always been one of the main business districts of Toronto, thus land prices along the street might have been historically rising more rapidly than elsewhere.
3. This number may look less impressive if it is noted that Heenan generously included in this figure all the CBD office development in this time period. The total Toronto Downtown area lies within 5 minutes walking distance from the Yonge-University subway line.

construction in Toronto had occurred within 5 minutes walking distance from the Yonge Street subway line.[1]

Larry Bourne's analysis of the private redevelopment process that has taken place between 1959-63 essentially confirmed Heenan's findings. The spatial pattern of new construction activities in Toronto was largely limited to five areas - the central business district, a limited sector of the north of the CBD, and three outlying concentrations of office and apartment development. These five concentrations accounted for over 40% of all floor areas added by new construction, 83% of all new offices and 51% of all apartments.[2] All but one of these areas are adjacent to the Yonge Street rapid transit line. (Table 3.3-II).

Anderson documented similar tendencies in downtown San Francisco, Oakland, Berkley and the suburban areas of Contra Costa and Allamando Counties, through which the BART rapid transit line, expected to be in full operation by 1972, passes.[3] The 'office boom' in the Bay area is limited spatially almost entirely to the proximity of the subway.

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1. Heenan, (1968) p.217
2. Bourne, (1970)
3. Anderson, (1970)

TABLE 3.3-II DISTRIBUTION OF REDEVELOPMENT CONSTRUCTION, CITY OF TORONTO, 1959-63

Area (Districts)	% of Floor Area Added Total	Offices	Apartments	General Commercial	% Land Area Affected Total
Downtown (C.B.D.)	16.0	44.0	. . .	15.3	5.5
Uptown (Bloor)	11.1	19.8	10.4	17.5	10.2
Eglinton-Yonge	9.7	13.0	11.4	7.4	8.0
St. Clair-Yonge	8.6	6.6	18.9	0.2	2.6
Parkdale	5.9	. . .	16.0	3.6	0.2
Totals	51.3	83.4	56.7	44.0	26.5

Source: Bourne, L.S., "Trends in Urban Development - the Implication for Urban Form", The Appraisal Journal, January, 1970, p. 30.

Furthermore, private developers are often willing to pay the cost of the construction of direct access from their building to the rapid transit system's station mezzanines.[1] There are no comparative analyses available which relate, in any detail, the growth pattern of the cities of Cleveland and Montreal to the land value changes and development process that has taken place along their respective rapid transit lines. However, some descriptive investigations do confirm the hypothesis that developers of new office and high

1. Metropolitan, (1971).

density apartment construction tend to seek locations in proximity to rapid transit lines.[1,2,3]

Based on the previous discussion and the evidence published in the reviewed literature, it is difficult to be conclusive about whether rapid transit lines significantly increase or decrease land values, growth or rate of redevelopment of cities at the aggregate level, or whether their presence merely redistributes the changes that would have taken place in the city, irrespective of the presence or absence of the system. Yet it is evident that rapid transit lines do tend to create well defined corridors of intensive commercial and real estate development. This phenomenon cannot be captured adequately by the scale of aggregation used by Meyer and Conway. Similarly, studies that confirmed the existence of relatively higher rates of development growth along the transit corridors have done so by employing data aggregated to the whole corridor. However, these studies fail to recognize and to inquire into the apparent heterogeneity of growth that exists among specific sections of a line.

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1. Hyde, (1967) p.171
2. Herbert (1969) p.47
3. Mathias (1965).

LOCAL SCALE

One of the specific operational characteristics of rapid transit is that, while it is physically linear, often extending over many miles, access to the system is restricted to specific points (stations). Thus the notion of a corridor, frequently related to the spatial pattern of development along the line, is somewhat misleading. While the impact of rapid transit may to some lesser extent reverberate throughout the entire urban region, it originates from and can be expected to be the most dramatic around the stations.[1]

During the analysis of the impact of Toronto's Yonge Street line on new real-estate developments, Dawson noticed that construction was sharply focused around stations. The heights of buildings (density) and the range of commercial development

1. In the case of surface or elevated lines such factors as noise, pollution, visual and physical barriers can have a blightening influence on adjacent properties as has been the case in Boston, New York and more recently in Montreal. The adverse affects of the exposed rights of way, however, will not be considered in this thesis, partly because they are poorly documented, and partly because it is assumed that in the future deliberate efforts will be made to avoid such consequences by building the line below surface when severe impact is expected.

declined rapidly as the distance from stations increased. The main development appeared to have taken place within 5 minutes walking radius, and he observed not only the absence of dynamic changes of land uses in sections between stations, but even the vacating of some premises as their trade was attracted to the station.[1]

Davis has attempted to establish the station's range of influence by analyzing land value changes around it. Taking the BART's Glen Park Station site (situated within a residential area characterized by private homes and small apartment buildings), he documented real estate price trends to four distinct rings: one block radius and adjacent properties to the station site, two block, six block and the remainder of the area encompassed by an approximately sixteen block radius. Comparing the average annual percentage increases of real estate sales within the four rings, Davis found that the first two rings experienced an increase significantly above the average of the other two rings and concluded "that the price trend is substantially the direct result of the Bay Area Rapid Transit System's Glen Park Station Location."[2]

1. Dawson, (1968) pp.91-100.
2. Davis, (1970) p.568.

No comparative study has yet analyzed whether factors such as the station's position within the urban field, variation in the station size, nature and quality of the feeder system, or the difference in spacing of stations modify the station's range of influence. As a result, for practical purposes one to three blocks, or the five minute walking distance, has generally been accepted as the area where the accessibility advantage can be regarded as being homogeneous. Numerous reports prepared by local planning agencies and private consultants on the anticipated impact of BART (Bay area)[1] and Metro (Washington)[2,3] stations based their investigation on this radius.

New development tends to locate near the activity points served by transit. The most immediate area of impact is represented by a circle around the entrance. This distance constitutes a four to five minutes walk. Land values can be expected to increase in this zone, since regional accessibility combined with increased exposure to riders improves development potential for commercial, office and residential uses.[4]

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1. Liskamm, (1968), Okamoto, (1966), Development Research Associates, (1967), Oakland Planning Department, (1969), Stratford Research Institute, (1970).
2. Washington, D.C.
3. Alexandria Department of Planning, (1969).
4. District of Columbia, (1971) p.11.

In Washington, D.C. a specific plea has been made to reduce the extensive area originally assigned for parking around outlying stations so "the opportunities to relate development directly to the stations would not be lost."[1]

1. Transit Development Team, (1971) p.8.

3.4 SUMMARY

In this chapter an attempt was made to expose and synthesize the relevant theoretical and empirical literature on which this thesis is built. It was also intended to provide a point of conceptual departure toward a more realistic framework within which the impact of a specific transportation system - rail rapid transit - on the spatial pattern of growth and development of urban areas may be understood.

It was noted that traditional location theories tend to explain the spatial distribution of urban activities through the interrelated concepts of transportation costs, accessibility, land rent and land use. One of the essential assumptions that enabled scholars to compose their theoretical speculations into elegant mathematical models was the proposition that all land to be allocated for various activities is of equal quality. Since in the last three decades most urban transportation investments have been limited to the construction of freeways of various sizes, this assumption has not been seriously challenged; for freeways often open up vast areas of fringe land - land that for practical purposes could indeed be regarded from the point of view of urban use as being homogeneous. But even if some heterogeneity did exist among parcels of land (slope, vegetation, coverage, etc.), the fact that highways tended to attract the whole spectrum of urban land uses with extensive land consumption, this heterogeneity could be absorbed with minor shifts in the configuration of land uses. It was also established from the reviewed impact studies that freeways tend to induce new growth - that is, the conversion of agricultural or vacant land to urban uses - rather than redevelopment.

Since the middle of the fifties a number of North American cities have built and many others are actively considering building rapid transit lines. Proponents of the system use many reasons to justify this rather expensive transportation investment, not the least being the proposition that it can be used as a tool to create a more desirable pattern of urban land uses than that resulting from the sole reliance on the automobile.

However, empirical or theoretical research that would substantiate this assumption is rather limited. Furthermore, studies that are available on specific aspects of this phenomenon document the interrelationship on particular levels of spatial aggregation which may be inappropriate or non-existent at any other level. Despite these difficulties, a number of 'tendencies' have been traced in the literature on rapid transit impact which can provide a base to challenge the suggestions of some authors that meaningful inferences can be drawn from highway impact studies to anticipate the impact of rapid transit,[1] and to provide a rationale for the need to relax the assumption of the featureless plain in transportation research.

CHARACTERISTICS OF RAPID TRANSIT LINES

1. Historically rapid transit lines were built within the cities' most densely developed areas. Consequently, the economic utilization of the improved access around stations involves <u>land redevelopment</u> rather than the simple rural to urban conversion process.

2. Rapid transit lines tend to attract <u>specific</u>

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1. Thiel, (1970).

rather than the whole range of urban activities. These activities include medium and high density residential, retail, office, institutional and service industry uses, all of which can be characterized by their intensive land utilization and their strong orientation toward people (labour, or consumer) rather than goods.

3. Most existing and proposed rapid transit lines expand radially from the CBD. Consequently, there are a number of stations which are situated at approximately equal time distance from the center.

4. Past experience indicates that the most dramatic impact of rapid transit in terms of land value changes and intensified redevelopment occurred within the area of four to five minutes walking distance around stations. This evidence substantiates the assumption that increased accessibility is spatially limited to relatively small areas within which accessibility advantages can be regarded as being homogeneous.

The last two observations imply that there are a number of locational choices available for activities seeking location in the proximity of rapid transit lines - choices that offer similar advantages both in terms of CBD related accessibility and within the stations' sphere of influence. However, experience in Toronto, as will be demonstrated in a later part of this thesis, indicates that impressive developments occur around <u>some</u> stations while the area around others, located at a similar distance from the CBD, remains virtually unchanged. Furthermore, the spatial pattern of growth in the proximity of stations which do attract growth is <u>sectorial</u> rather than concentric. In the following chapter some hypotheses will be put forward which attempt to offer explanations for this phenomenon.

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4

environment as an input

4.1

THE CONCEPT OF ENVIRONMENT

In general, models derived from research in urban spatial structure are built upon three basic components:

(i) the two-dimensional land-surface;

(ii) urban activities, utilizing some areas of the surface; and

(iii) linkage systems, facilitating the flow of interaction among associated activities.

However, it is evident in the literature discussed in the previous chapter that, in practice, often only <u>two</u> of these components have been treated as variables in explaining how the spatial structure of an urban setting evolves - the activities and the linkage systems. The third element - the featurless, two-dimensional plain - has served merely to represent the total supply of possible location sites to be assigned to activities bidding for space, and to provide a series of reference points from which the cost of interaction can be measured. The points chosen, and the amount of area consumed on this two-dimensional surface, are determined by the bidding power of alternative activities and the cost of overcoming 'the friction of space' as defined by the available communication/transportation linkage systems.

In a more formal presentation the components may be characterized by the following expressions:

(i) $P^t_{A_i}$ (C) — Bidding Power for the composite cost of site rent and transportation cost - of activity A_i in time period t.

t = Time Period $(t=1,2,...,p)$

A_i = Activity i (land use) $(i=1,2,...,q)$

(ii) $C^t_{T_i}$ (d) — Cost of overcoming distance d using the communication/transportation system T_i in time period t.

T_i = Transportation/Communication system i $(i=1,2,...,r)$

(iii) $Q^t=\sum_{ij} q^t_{ij}$ — Total Supply of Land in time period t.

q^t_{ij} = Sites at location i,j in time period t. $(i=1,2,...,n$ and $j=1,2,...,m)$

The fact that these models fail to incorporate the processes by which various activities adopt sites for their successful operation and thus discount the impact that past commitments may have on locational behaviour, has been one of the principal criticisms levelled against such models. Bourne notes that one of the critical differences between rural and urban land economics is that

...to earn income from urban land, it is usually necessary to construct a building.[1]

Pendelton, in his generally favorable critique of Alonso's "Location and Land Use", argues that he can put little faith in a theory of urban residential spatial structure which completely ignores the standing stock of buildings.[2] In more general terms, Margolis expresses similar concern:

One of the major impediments of site adjustment is the long life of buildings, streets, utilities, parks, etc....It is difficult to visualize a reasonable approximation model for an urban area which does not concede the long continuing influence of old technologies and past allocation of capital, land and population to previous forms.[3]

The formulation of the general concept of <u>environment</u>, on which this thesis is built, represents an outgrowth of the above criticism. It is argued that urban activities do not merely occupy sites on the two-dimensional, featureless surface, but through the process of adjusting to the

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1. Bourne, (1967) p.39.
2. Pendelton, (1965)
3. Margolis, (1967) p.235.

specific needs of their operation, they significantly alter these sites. Through the process of adjustment and use, sites '<u>acquire</u>' a number of characteristics - characteristics which can be expected to play roles of varying importance on their transformation to other uses. Further, because of its fixed location, every piece of land occupies a unique position among other parcels.[1] Thus, the prospects for transformation of a particular area are modified not only by the acquired characteristics, but also by the general make-up of the surrounding area.[2] As it is implied in the above proposition, land surface utilized by various activities is no longer treated as a homogeneous plain, but rather, incorporated into the model as a multifacetted <u>environment</u>, representing a quantifiable input for the explanation of locational behaviour. In this model, the <u>attraction</u> of any site for a particular activity is defined in terms of the relative difference of cost/inconvenience (monetary and intangible) involved in altering its environmental characteristics to suit the operational needs of that activity, as compared to all other sites.

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1. Weimer and Hoyt, (1960)p.10.
2. Bourne, (1967) p.26.

To contrast the variables composing the proposed model with those criticized earlier, a formal description is presented below:

(i) $P^{*t}_{A_i}$ (C) — Bidding Power of Activity A_i for the total cost of site rent, transportation cost and the cost of alteration of the Environmental Characteristics of the site.

(ii) $C^{t}_{T_i}$ (d) — Cost of overcoming distance d using the communication/transportation system T_i in time period t.

T_i = Transportation/Communication system i ($i = 1,2,\ldots,r$)

(iii) $Q^t = \sum_{ijk} E_k q^t_{ij}$ — Total Supply of Land in time period t.

$E_k q^t_{ij}$ = Sites with Environmental Characteristics E_k at location i,j in time period t.

In the following, a general hypothesis is put forward which, upon verification, is intended to establish the existence of the influence that environmental characteristics have on the change in spatial distribution of urban activities. This general hypothesis is supplemented with a number of sub-hypotheses, each suggesting a separate element of the environment and speculating on the magnitude of impact various elements may exhibit. It was noted earlier that both the magnitude of impact and the relative importance that is attributable to each element is expected to vary with regard to different activities, and over time. Thus in the formulation of sub-hypotheses, the shape of graphs, showing the relationship between site attraction and quantitative change in the environmental element, represents a general approximation of the phenomenon, and it is subject to modification when related to specific activities.

4.2

GENERAL HYPOTHESIS

When a new rapid transit network is introduced into an urban setting, the spatial distribution of redevelopment taking place along the line and in the proximity of rapid transit stations cannot be accounted for solely in terms of the shifting accessibility surface. The explanation must be sought in the additional influence exerted by the environmental context within which each station is placed.

4.3

ELEMENTS OF THE ENVIRONMENTAL CONTEXT

There are a number of ways in which the environmental context may be described and its components grouped. The following classification system adopted for the presentation of sub-hypotheses is suggested partly because it clearly expresses the character of various environmental elements and hence they can easily be related to the type of action needed to be taken to alter them; and partly because this classification yields some operational advantages for the simulation model presented later.

PHYSICAL

The intrinsic physical features of an area play a central role in agricultural and regional location theories. The distribution of natural resources, land fertility, topographic and climatic characteristics explain the spatial distribution of a substantial amount of economic activity, either because the activity is technologically tied to the resource input, or because costs are minimized by a location in the resource area.[1] Although, as Hoover pointed out, for some urban activities (airport, recreation) the presence of certain topographical or other natural site features are essential,[2] the impact that slope, soil conditions, bedrock, water table level, vegetation coverage and the like may have on the spatial distribution of activities <u>in an urban area</u> is generally assumed to be less significant.[3] It is argued that within the scale of an urban agglomeration the difference in physical characteristics among sites is negligible as compared wit the variance that occurs on a regional scale, and further, that advanced engineering and building construction technology makes it possible to overcome the difference that does exist with relatively little additional cost. (The mutilated natural environment within and around our cities presents ample evidence to verify at least the second part of that statement.) However, as public awareness increases and techniques like those developed by McHarg,[4] Hills,[5] and Lewis [6] gain professional acceptance in planning, more emphasis can be

1. Stabler, (1968)
2. Hoover, (1968) p.239
3. Hoch, (1969)
4. McHarg, (1969)
5. Hills, (1966)
6. Lewis, (1965)

expected to be placed in the future on the preservation and sympathetic incorporation of the physical characteristics of the land when sites are developed. This process will tend to reduce the amount of available land for development within a fixed geographic area.

The concept of available land as opposed to the homogeneous plain has already been incorporated into Lowry's urban growth model for the Pittsburg Metropolitan Area.[1] In his approach, however, all available land could be assigned for suitable activities and the amount of available land left for the successive year in the simulation process represented no additional input.

It is proposed in sub-hypothesis #1 that the attraction of an area for suitable activities changes considerably when available land (as derived from the physical constraints) assumes values between the minimum and average amounts needed as site requirements for these activities. (Figure 4.3-1). This proposition is derived from the observation that when a city block or an entire neighborhood is redeveloped, the process rarely involves all the properties in that area.

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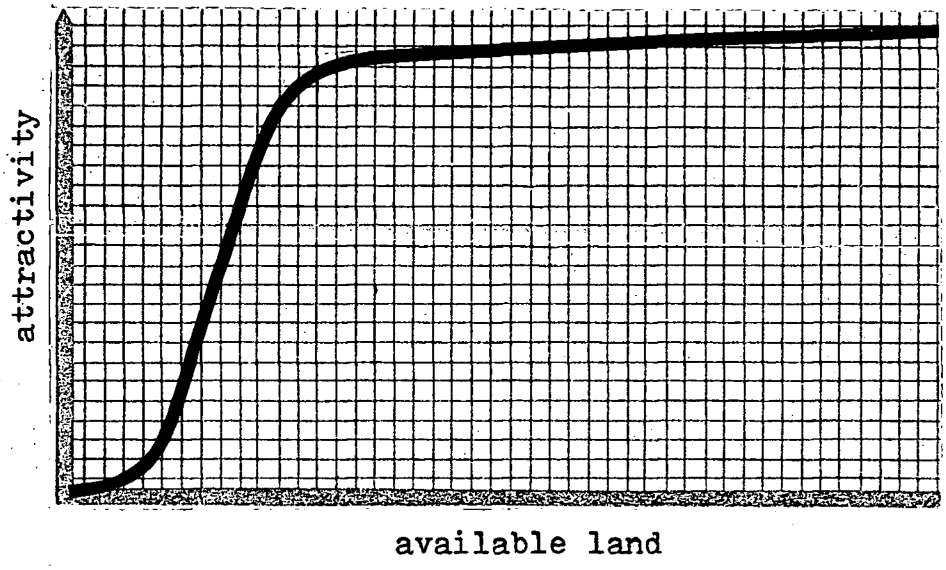
1. Lowry, (1964).

FIGURE 4.3-1
SUB-
HYPOTHESIS
#1



This phenomenon can be rationalized either by speculating that during the land assembly process some undesirable fragmentation occurred and the configuration of 'left-over' properties cannot be economically utilized, or by suggesting that drastic increases in land prices following the initial stages of redevelopment forced prospective developers to seek alternative locations.

TECHNOL-
OGICAL

The successful operation, and indeed existence, of most urban activities depend on the existence, quality and quantity of a number of technological supporting systems.

The powerful role played by the communication/ transportation linkage system in facilitating the flow of interaction among associated activities plays on the evolution of urban spatial structure is well researched, documented and fairly well understood. However, it was not until the Polish and successively the English economic school had developed the threshold theory of urban development that the significance of other supporting systems (water, sewer, gas, electricity) was widely recognized,[1] although the writers are not aware of any urban simulation model that incorporates as inputs the influence of these factors. For the purpose of this study, it is proposed to include among the technological components of the environmental context such 'non-technological' elements as school capacity, available recreational space, and other social services, in addition to the traditional public utility systems. There are three characteristics of the technological components that invite special attention:

i. Variables of this type exhibit <u>threshold behaviour</u> and the option to shift the threshold value often lies outside the power of the individual decision-making units (firms, households) utilizing locations served by the facilities.

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1. Koslowski, (1971).

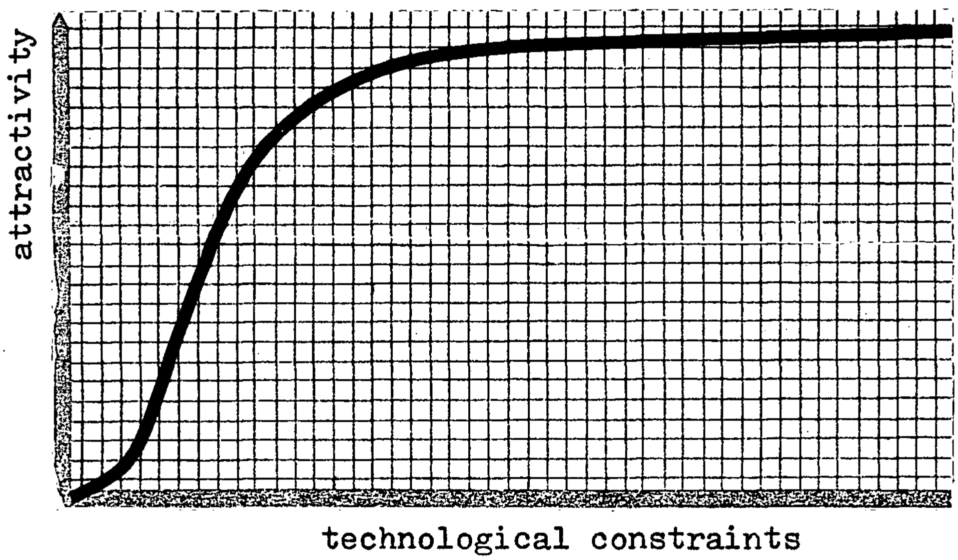
ii. These variables are not area but <u>density sensitive</u> (number of people times consumption/ production multiplier); thus, while serving a general area, their capacity can be exhausted by utilizing <u>any amount</u> of land within this area.

iii. The cost of alteration (capacity increase) in these variables are generally <u>not directly</u> levied against activities utilizing locations in the general area which is served by the facilities, but is rather carried by the urban region as a whole.

Sub-hypothesis #2 implies that technological elements exert a changing influence on the attractivity of an area when their value exceeds the optimum capacity level and reaches the maximum capacity load. (Figure 4.3-2). This proposition is based on the observation that authorities responsible for the supporting systems are reluctant to permit further development or density increases unless the load that the new development produces can be accommodated within the system's existing capacity, or comparable new capacity construction occurs simultaneously.

It should be noted that while various activities depend upon a number of different supporting systems, it is the critical rather than the composite values of the technological component which are measured. This proposition is the logical extension of Leibnitz's minimum nourishment analogy for plant growth which states that when the growth of an entity E depends upon factors a,b,c, ...n, its growth will be restricted by that factor which has the minimum value.

FIGURE 4.3-2
SUB-HYPOTHESIS #2



ECONOMIC

It is generally agreed that all the monetary and intangible costs which can be specifically related to particular locations, land values, building and land assembly costs are the most visible ones when transportation expenditures are held constant. Of course, within the framework of the traditional location theories, none of these factors can be treated as additional inputs in location choice; assuming similar transportation costs, no difference in land values would occur since the composite of the two is assumed to be constant, and neither the physical stock nor the fragmentation of land has been explicitly incorporated into these models.

PHYSICAL STOCK

In an earlier part of the thesis, some reference has already been made to critics of the traditional location theories who suggested that land in urban use should be treated as a three-dimensional resource. Their argument is based on the observation that in reality the majority of urban activities are accommodated within some kind of physical shelter; hence the presence, quality and suitability of the building stock in alternative, otherwise favourable locations can be expected to play an important role in the decision process as to which location will ultimately be chosen.

Two often interrelated and reinforcing processes characterize the building stock: aging, and technological obsolescence.[1] Aging implies physical deterioration, increasing maintenance costs and ultimately demolition and replacement. Tech-

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1. Ratcliff, (1949) p.356.

nological obsolescence results from changes in the activities' requirements for the internal organization of buildings and building complexes in the 'firm' sector, or changes in life style or taste in the 'household' sector.[1] Because of the durability of buildings and the often available option of flexibility that accommodates minor alterations, a large segment of activities seeking and changing locations in the already built-up areas in the city is accommodated within the existing stock. Thus the rate of change and replacement in the physical stock of the city is considerably slower than that of the activities that use these structures.

However, when a new transportation investment or policy significantly alters the accessibility potential of various areas, the economic utilization of the new potential often cannot be accommodated within the existing building stock. In sub-hypothesis #3 the building age as a proxy variable for the economic life of the existing physical stock (value remaining in the properties) is related to the attractivity of an area for potential redevelopment. (Figure 4.3-3).

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1. Lowry, (1960).

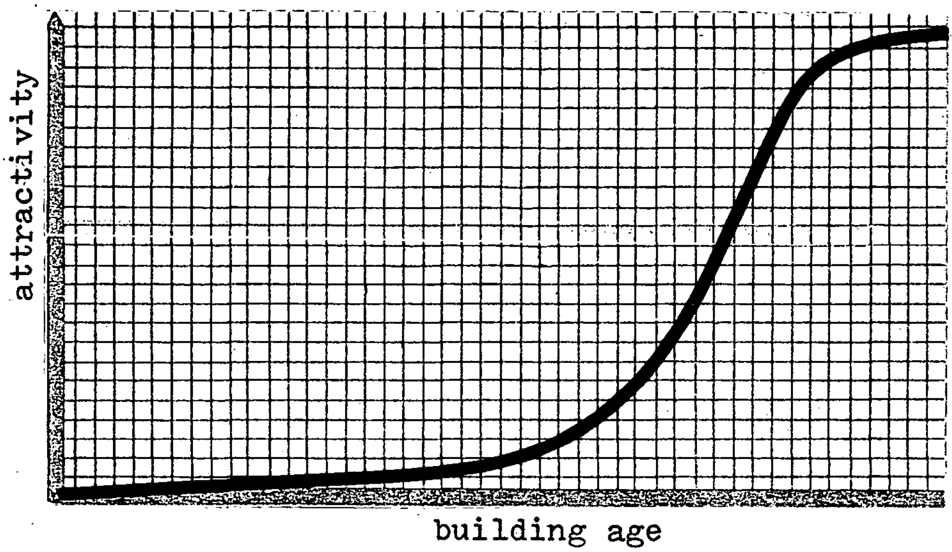

FIGURE 4.3-3 SUB-HYPOTHESIS #3

LAND FRAGMENTATION

In addition to the existing stock of buildings, another inherence from the past allocation of activities is the legal subdivision of land into various sizes of parcels. The size of these parcels, as Alonso postulated, is the direct result of previous transportation networks as activities, to substitute for the cost of access, alter not only their location but also the amount of space consumed at any location.[1] Consequently the site size requirement of activities seeking location in areas where the accessibility potential resulting from the new transportation investment increases, can be expected to be different from that provided

1. Alonso, (1964).

by existing subdivision of properties. In fact, Bourne observed that, although the ratio of land unit per floor space decreases as high density/ intensity activities replace lower ones through the redevelopment process, the total site requirement of new developments, nevertheless, exceeds the previous one because of shifts in the economics of scale.[1]

In sub-hypothesis #4 the existing fragmentation of land as measured by a proxy variable of lot size and the attractivity of area for redevelopment, is postulated. (Figure 4.3-4). As the number of continuous parcels needed to be consolidated increases, the assembly process becomes increasingly cumbersome, slow and costly. The last parcels obtained are often more expensive per unit than the first ones as owners 'hold out' for higher prices.[2] It is expected that developers would be inclined to seek out those areas among all otherwise suitable ones where either large individual lots are dominant or where consolidation has already taken place for some other purposes.

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1. Bourne, (1967) p.90.
2. Davis and Whinston, (1966).

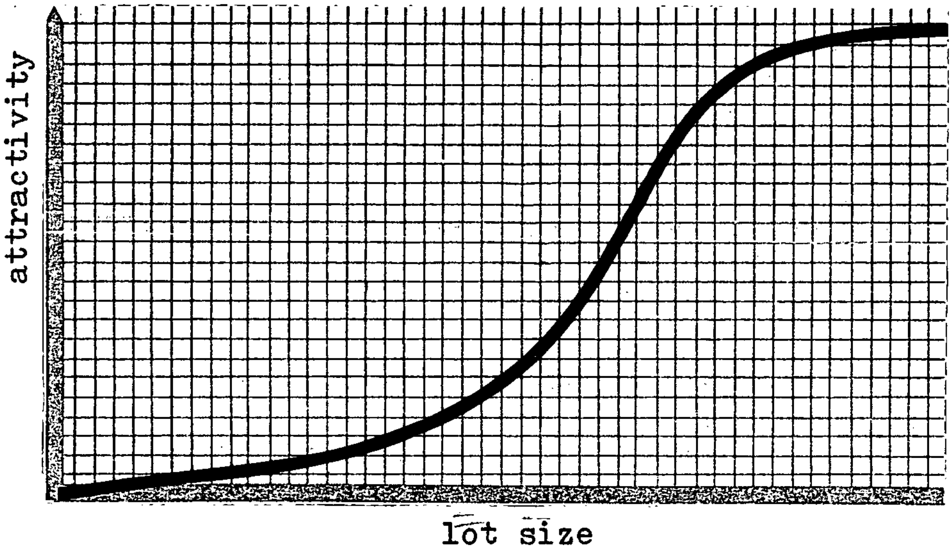

FIGURE 4.3-4
SUB-
HYPOTHESIS
#4

AGGREGATIVE

The 'like seeks like' theory - that is, the tendency toward area specialization and segregation through the clustering of identical or similar activities - has gained support from the empirical works of both urban economists and geographers.[1] This apparent cohesion of various establishments is generally initiated by the opportunity to share some common advantages - an especially suitable labour pool, a variety of specialized business services, or the concentration of potential customers seeking to compare a variety of offerings. The most often cited illustrations related the urban scale include restaurant and entertainment centers, financial and office districts,

1. Harris and Ullman, (1967)

specialized wholesale aggregations, or apartment complexes. Thorngern argued that one of the reasons for the slower rate of office decentralization from the CBD may be the absence of supporting activities in the suburban environment.[1] By the same token, Bourne observed that the agglomerative effect of existing concentrations of activities is a relatively powerful indicator in anticipating the spatial distribution of future apartment growth.[2]

Sub-hypothesis #5 relates the attractivity of an area for a particular activity to the amount of similar or supporting land uses existing in that area. The quadratic type of graph implies that some critical mass of existing clustering is needed to influence favourable further agglomeration, and when the size of clusters exceeds an optimum level, little additional attractivity difference exists among alternative clusters. (Figure 4.3-5). This proposition is essentially the logical extension of Perroux's concept of 'development poles' in the regional context.[3]

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1. Thorngern, (1967)
2. Bourne, (1968)
3. Perroux, (1970).

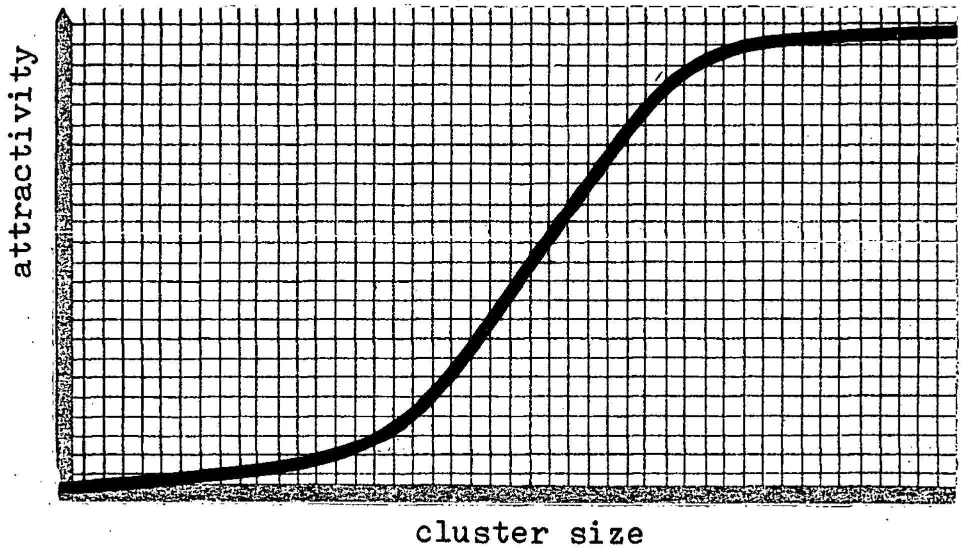

FIGURE 4.3-5
SUB-HYPOTHESIS #5

INSTITUTIONAL

One of the major 'externalities' in the operation of the private land market is the institutionalized aspect of the environment which facilitates public control over the allocation, use and profitability of land. In general, there are two areas within which this influence is exercised:

i. public construction and investment
ii. zoning.[1]

The impact that the provision of public utilities and social services may have on altering the locational preferences of various activities has already been accounted for in sub-hypothesis #2. Similarly, it is argued that the effect <u>building</u>

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1. Tiebout, (1971)

construction activity of public agencies (government offices, low cost housing, etc.) may have on the locational choices of other land users will be manifested through the spatial distribution of public construction - that is, the creation or reinforcement of clusters - and this influence has essentially been incorporated in sub-hypothesis #5.

ZONING

Probably the most comprehensive and the most widely used institutionalized public control over the spatial distribution of activities is exercised through zoning. Historically, the concept of zoning grew out of the concern for protecting the enjoyment of private property from anti-social use by neighbouring parcels - that is, separating 'incompatible' activities - but more recently this power has been increasingly applied either to protect and stabilize property values, or to spatially channel future development.[1] Despite the long history and increasing sophistication of zoning practices, their effectiveness on changes in land-use pattern and urban development/redevelopment is not very well understood.[2]

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1. Marcus and Groves, (1970)
2. Probably the critical variable, and most likely the least readily measurable one, is the degree of enforcement exercised on the part of the municipalities.

The great number of 'spot zoning' cases evident in most large cities seems to indicate that when the economic pressure is high enough to replace one type of activity with another or to increase density, this pressure ultimately receives the blessing of the zoning authorities. Alonso argues that in the long run zoning exerts little influence on the price of individual properties[1] and Yeates' empirical analysis on the effect of zoning on the spatial variations in land values essentially confirms Alonso's proposition.[2] On the other hand, Fisher argues at great length that the obsolete, rigid zoning practices contributed significantly to the inner city blight and he proposes a new zoning concept which would be

"...less stringent as far as the use to which individual properties may be put but more strict in regulating the collateral effects upon the neighborhood."[3]

The only aspect of zoning that has produced some consensus in the literature is its tendency to restrain the metamorphosis of areas when there is a pressure for change. Sub-hypothesis #6 is built upon this consensus. It is proposed that the time

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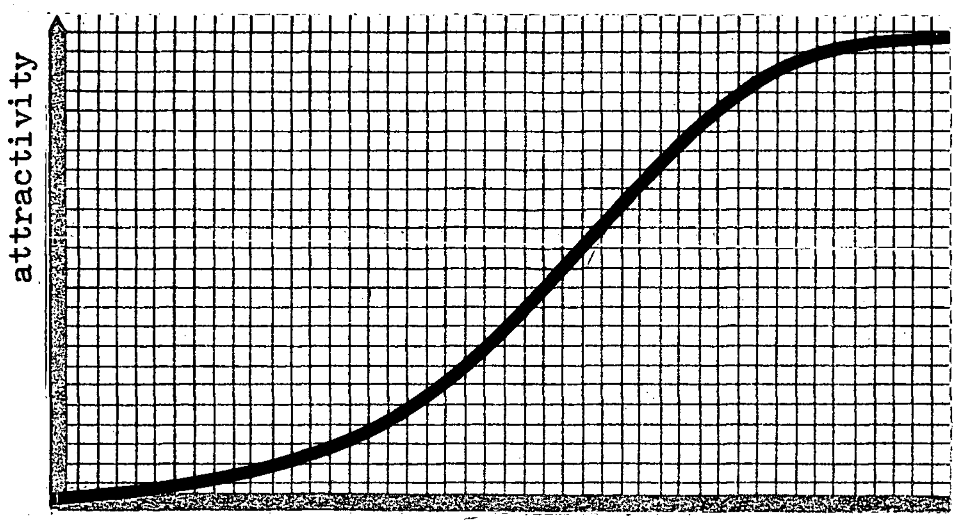
1. Alonso, (1964), p.117
2. Yeates, (1964)
3. Fisher, (1963) p. 18.

delay and the cost of legal procedure involved when changes in zoning are needed to accommodate the new or the same activity at a significantly higher density level, will tend to force developers to seek out those areas where permissive zoning already exists, or the necessary changes are minimal. (Figure 4.3-6).

FIGURE 4.3-6
SUB-HYPOTHESIS #6



SOCIAL

The interrelationship between the socio-demographic character of an area (number, age, family size, income, ethnic origin of its population) and its propensity to change (transformation) has traditionally been in the focus of urban sociological research. Many of the early studies were essentially limited to the variation of Burgess'[1] and

1. Burgess, (1925).

Hoyt's[1] classical works and it was only after Hoover and Vernon's empirical research in New York that a new concept - "The Stage Theory of Urban Growth" - evolved.[2] Hoover and Vernon's theory, and the subsequent research which attempted to verify their proposition in other urban areas,[3] related the evolutionary process of physical development experienced by particular 'neighborhoods' to their socio-demographic character. The central theme of the stage theory is that, as neighborhoods undergo transformation from the initial development to the final stage of renewal, corresponding changes occur in the income, family size, ethnic composition, etc., in their population.

Sub-hypothesis #7 sets out the reciprocal proposition. It is suggested that not only the physical characteristics of an area - building type, density, use, age - define its population, but the population in turn has an impact on the rate by which the corresponding area passes through the various development stages. It is argued that the rate of transformation becomes slower in poor and high income neighborhoods relative to 'average' lower income

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1. Hoyt, (1939)
2. Hoover and Vernon, (1959) p. 190-209
3. Birch, (1971).

neighborhoods. (Figure 4.3-7). Because of the generally unattractive physical and social environment in poor neighborhoods, new activities are often forced to create their own 'environment', necessitating a greater scale in the project, which in turn increases the risk factor. On the other hand, in prestige neighborhoods, individual and community power that exists among its residents can effectively block changes that would alter the character of the area. To substantiate the above argument, Bourne's analysis of the spatial distribution of land-use changes in Toronto may be cited:

"...interesting are those types of areas which have not changed. These are 1) certain high income inner city residential areas which are generally low density ...3) older working class residential neighborhoods ....In many instances the latter are densely occupied by recent immigrant groups and thus tend to be unattractive to developers for either office or apartment constructions....Zoning restrictions particularly in apartment development have been considerably more rigid in higher income neighborhoods than in other residential areas within the central city."[1]

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1. Bourne, (1970) p.7-8.

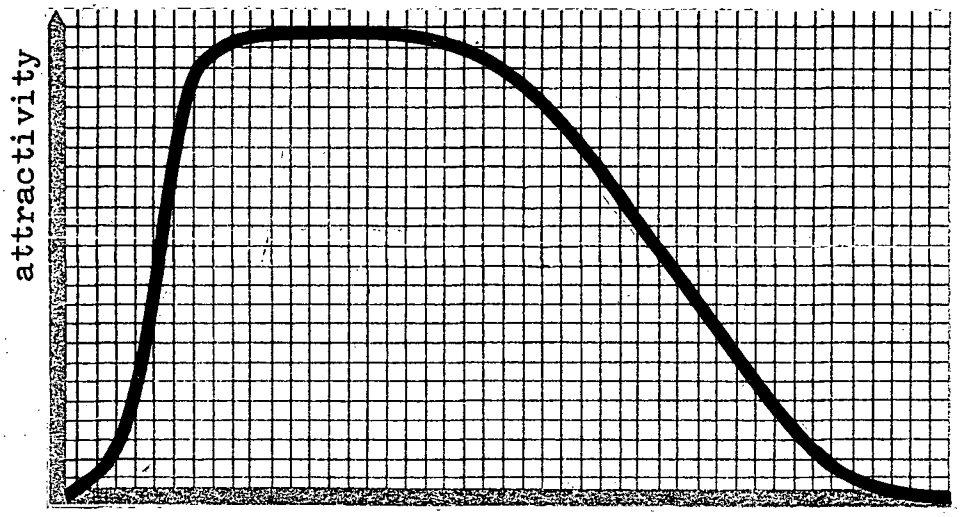

FIGURE 4.3-7
SUB-HYPOTHESIS #7

THE DYNAMICS OF THE ENVIRONMENT

The main concern of the previous discussion was to <u>isolate</u> the various components of the proposed environmental surface, and when one attempts to divorce parts from a complex phenomenon, this endeavour inevitably introduces some static features into the analysis. To some extent, all sub-hypotheses reflect these shortcomings, for their formulations were based on the permissible, but rarely adequate, proposition of 'everything else being constant'. Thus sub-hypothesis #4, for example, is interpreted as: if it is possible to find two locations where all other environmental factors are identical, then it is expected that the area where the average lot size is larger will be chosen by a particular activity requiring a minimum lot size greater than the largest individual lot available in either location.

However, since the multitude of forces that create, alter and formulate the various components of the environment are dynamic processes, the resulting environmental surface exhibits changing complexities. The picture is further complicated when various activities are matched with the environmental surface. Here the importance that different activity types attach to individual environmental components is not the only factor expected to vary - (a 10% slope may represent an inhibiting expense for large scale industrial land development, whereas the sloping terrain may be conceived as an additional benefit for single family housing location) - but also the way activities interpret the significance of various components as compared to one another. Neighborhood quality or prestige location may become the most important locational factors for some apartment or office development, while other activities may place little importance upon these.

To analyze the dynamics of this complexity in any detail is clearly beyond the scope of this thesis as well as the intellectual resources of the authors at this point. However, as a first attempt to make some inference from the separated environmental components to the complexity of their totality, three observations are offered.

i. While the totality of the environmental components impinge upon any individual site, not all environmental components necessarily originate from the site. The physical characteristics, zoning, the existing physical structure, or the actual size, can specifically be related to individual lots; neighborhood quality or the capacity of the supporting technological services are environmental components which can only be derived from the general area within which the site is located.

ii. Activities have an option to alter only a limited number of environmental components. For example, developers can change some physical characteristics or have the option to increase the size of a site through land consolidation processes, but to modify zoning or the capacity of the supporting utilities often lies outside the realm of their power. This division of opportunities in the alteration of undesirable or limiting elements also implies that although all changes represent some measure of 'penalty' (cost, time delay, etc.) for the activity, this penalty does not necessarily equal the actual cost involved in changing a particular environmental component. Time delay and legal costs involved in changing zoning regulations carried by the developer are often greater than the cost of actually changing the zoning ordinance which requires one public hearing. Alternatively, as it was noted in sub-hypothesis #2, the full cost of modifying the technological limiting factors is rarely passed on to the developers.

iii. There is a great time variance within which various components of the environment change, or can be changed. The neighborhood character often remains stable over 20-50 years and strong sentiments attached to particular areas could prevail long after its original character has changed. Other elements of the environment can be modified within a relatively short period of time (demolition of buildings, land assembly, etc.), while some components can be changed instantly (zoning).

The above observations still fall short in capturing a significant part of the dynamic interrelationship between the locational choices and activities and the environmental surface. However, it was felt that by incorporating these observations into a model which attempts to simulate the attractivity of areas around rapid transit stations for various developments, some progress may be achieved in anticipating the impact rapid transit has on a local scale.

CHAPTER IV
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study design

5

5.1

METHODOLOGY

To test the validity of the conceptual expectations formulated in the previously presented sub-hypotheses, a two-step analysis was pursued. First, some variables were selected to approximate the components of the proposed environmental context and by using a 'broad-brush' statistical analysis the intuitively defined and generalized 'table functions' - interrelationships between site attractivity and components of the environmental context - were modified. This analysis also provided some insight as to how a particular activity - new apartment construction - assigned relative importance to the various environmental components in site selection. Second, based on the adjusted table functions and weighting-scale, a simulation model was constructed. With the model, the spatial distribution of new apartment construction in the proximity of rapid transit stations was simulated for the period of 1959-1970 and compared with the actual development which had taken place over the same time period. When a reasonable 'fit' was achieved, the distribution of future apartment development along the rapid transit line was simulated and the effectiveness of options currently available to planning authorities for channeling development was tested.

For those who are accustomed to the rigorous statistical procedures designed to analyze interrelationships among phenomena, model building may be a questionable tool for verifying hypotheses. In a simulation model a large number of factors and complex interrelationships are formulated. While these models explicitly reveal both the logical structure of the postulated interrelationships among factors and the value range within which factors are assumed to operate, the empirical validity of <u>isolated interrelationships</u> between two factors, or the value range of any <u>individual</u> factor within the model cannot be tested. That is, when system 'A' is constructed with properties $p_1, p_2, \ldots p_n$ to model system 'B', the latter not necessarily consists of properties $p_1, p_2 \ldots p_n$, but rather of some other properties - $q_1, q_2 \ldots q_n$, which, however, exhibit a relationship with one another similar to the relationship that exists among the properties of model 'A'.

> ...models are isomorphs of one another. Both systems have the same structure, in the sense that whenever a relation holds between elements of one system, corresponding relation holds between the corresponding elements of the other system. The systems need not stand in any causal connection, for what is required is only that the relations correspond.[1]

Thus the verification of theoretical proposals (hypotheses) through a simulation model is quite simple; the pattern or order of the phenomen being simulated must resemble the pattern or order of the phenomenon in reality, within limits established by the academic and professional community.[2] As to whether the so verified model can be used as a forecasting tool, and if so, for how long a time period, solely depends upon the stability of interrelationships which were thought to be explanatory in the system's behaviour.

There are two reasons why the writers took the simulation approach to explain the spatial distribution of developments along rapid transit lines: one is methodological, the other strategical. It was noted earlier that the factors underlying the spatial patterns and relationships in locational choices were expected to be complex and dynamic, involving non-linearities, time lags and feedbacks. In this situation the statistical analysis of pro-

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1. Kaplan, (1964) p.263
2. Harris, (1968) p.407.

cesses is extremely difficult, if not impossible. Substantial sets of data are needed which are comparable over a fairly long time period and in order to capture both the feedback and time lag elements, the statistical analysis must be performed repeatedly. In a simulation model most of these problems can be dealt with in a very efficient way and the trade-off between the mathematical refinement of most statistical/analytical tools and the 'improficiency' of a simulation model ultimately pays off.

Since the scope of this study goes beyond a purely descriptive analysis, indeed it was hoped that insight would be gained from the understanding of past patterns as to how future developments will be spatially distributed along rapid transit lines, strategically the simulation model appears to be a more meaningful predicting tool than any other technique currently available. The model can easily handle changes in the importance that various activities may place on the components of the environmental context over time and vice-versa. Further, since there are a number of manipulative policy variables built into the model, it enables the user to select and evaluate the actions needed if one is to influence the spatial distribution of future growth.

5.2

LIMITATIONS OF THE STUDY

Before the selection of the variables, description of data collection and analysis and a formal description of the model are presented, it is appropriate to consider the range of limitations within which the following discussion should be interpreted. These limitations are grouped and elaborated on under the three headings of: spatial, dimensional and theoretical limitations.

SPATIAL LIMITATIONS

i. Due to the complexity of information necessary to analyze the spatial distribution of changes along rapid transit lines over a considerable period of time, the data used to construct and test the simulation model is limited to one city - Toronto. (Figure 5.2-1). This city was selected for the case study for several reasons.

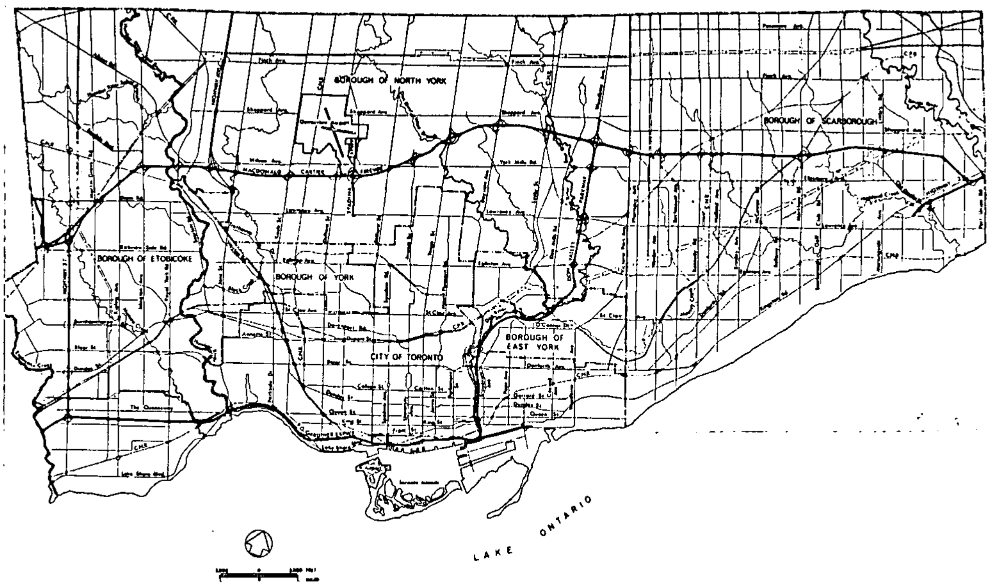

FIGURE 5.2-1 THE STREET MAP OF METROPOLITAN TORONTO

Source: Bain, R.P., and McMurray, A.L., Toronto: An Urban Study, Clarke Irwin, 1970, p.22.

a. Metropolitan Toronto currently has 20 miles of subway in service, with 45 stations.[1] Because this system has been built in three stages since 1954, it offers a unique opportunity to observe the time lag that may exist between the construction of a line and the new development around its stations.

b. In recent years a number of large scale studies have been undertaken on transportation, land use, population changes in

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1. Toronto Transit Commission, (1971), p.21.

both the city and the metropolitan area of Toronto. The wealth of this research provided a broad empirical background from which ample data could be drawn.

c. The writers had an intimate knowledge of the city. This personal experience was extremely helpful for general orientation and in the interpretation of the data when there was some inconsistency in the level of aggregation.

ii. Both the model and the data analysis were limited to stations situated <u>outside</u> Toronto CBD. The exclusion of the core area, however, was only partly due to data and time limitations. It is argued that while the CBD in general undoubtedly benefits from the rapid transit line, neither the growth nor its spatial distribution can be derived solely from the system. For most activities locating in the CBD, the attraction of the core area is attributable either to its maximum overall accessibility within the urban agglomeration, or to the external economics of clusters.[1]

DIMENSIONAL LIMITATIONS

It was noted in the summary of the literature review that there is ample empirical evidence

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1. Hoover, (1969) p.240.

suggesting that rapid transit stations tend to attract high density land uses, such as apartments, offices and some types of institutional and specific retail uses. As the mixture of locational determinants is quite different for each of these categories, the incorporation of all of these activities into the simulation model was impossible within the time and budgetary constraints of this thesis. Thus, for the purpose of the detailed analysis, the spatial distribution of only one land use category - apartment - was selected. There were two reasons for the choice of this particular land use category. First, detailed data on the location and the amount of new apartment construction were readily available for the period of 1959-1970. Second, 60% of the total floor area added by new construction along the Yonge subway line between 1952-1962 was apartment.[1] Although no comparable analysis was available for a later period, a visual survey indicated that the apartment share of the total growth had remained fairly stable, or possibly even increased. Further, because new office constructions - the other major land use category - were limited to two specific locations outside the CBD, in the

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1. Bourne, (1970) p.36.

St. Clair and Eglington station areas, their possible influence on the locations of apartment developments could be easily and accurately generated exogeneously to the model.

THEORETICAL LIMITATIONS

i. The model is essentially a <u>growth distribution</u> model. The focus of this study was <u>not</u> to determine the amount of growth rapid transit corridors capture from the total new development in the city, but rather to evaluate the <u>propensity</u> of individual stations to attract part of the growth assigned to the line. Thus the amount of new apartment construction anticipated to be attracted to the corridors is provided exogeneously to the model and is derived from historical trends in the city.

This approach represents some over-simplification of the phenomenon. Clearly, some mutual interrelationships exist between the attractivity of sites adjacent to rapid transit stations as compared to other sites in the city, and the amount of growth channeled to the corridor. It is suggested, however, that the principal attractivity of the corridor for apartment development lies in its high accessibility potential to the CBD, and the total number of apartment units located in the proximity of rapid transit stations reflects the aggregate locational choices of households, which for some reasons (work, shopping, etc.) place high priority on the ease of access to the core area. The number of these households in turn will be some function of jobs and shopping opportunities available in the CBD, and change in the latter can be expected to result in corresponding changes in the former.

ii. It is assumed that the locational choice of all new apartment construction in the proximity of rapid transit stations can be attributed to the presence of the system. To empirically substantiate this proposition, a large scale study would be required to analyze the travel patterns of households dwelling in these apartment developments and particularly their reliance on the rapid transit system. However, this assumption can be supported with an indirect argument. A developer, by choosing a site for the location of his project, performs a collective decision on behalf of all prospective households of his building and the total cost of his locational choice will ultimately be passed on to the tenants. It was demonstrated earlier that land prices in the vicinity of rapid transit stations (one to three blocks) tend to be relatively higher than for sites farther away. Thus, if only the location of the <u>general</u> area within the city was assessed to be valuable, the developer would secure sites outside of the higher price range, assuming some rational behaviour on his part. When development takes place within the stations' range of influence, the premium paid for sites can only be rationalized in terms of some additional benefits to be gained by building within walking distance from the station.

iii. It is assumed that all stations enjoy similar accessibility to the CBD - that is, no appreciable additional benefit can be derived from locating around one station as opposed to another one with regard to the ease of access to the core area. Conceptually accessibility, as it is commonly used in urban research, refers to some measure of distance and spatial association.[1] Although there is some variation in how it is measured, the concept generally includes two components: points of interest and their relative importance, and the 'cost' of overcoming the friction of space between these points. This 'cost' element in turn is measured either by physical distance, time distance, the actual money cost paid by the user of the transportation/communication system, or by some combination of all these elements.[2]

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1. Wilson, (1970)
2. Ingram, (1971).

In Toronto, the 'point of interest' has been assumed to be the CBD for all subway stations. Of course, there are a great number of people located along the line who pursue activities in areas other than the CBD served by the transit network. However, the 1966 analysis of passenger flow indicated that their number accounted for less than 25% during the peak period, and this proportion is not expected to change until 1980.[1] The other two elements that tend to equalize the CBD related accessibility from station-points are the similarities in the level of service to all directions and the cost of using the system (fares). Thus, in fact, the only variable held constant despite empirical evidence of its variation is the travel time needed to reach the CBD from various stations. This varies between 2 and 14 minutes along the lines. However, the lack of research on how the importance of travel time is perceived in trips on subways and the fact that the changing waiting time during the day further modifies the actual travel time, necessitated the exclusion of this variable from the analysis.

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1. Vorhees and Associates, (1968), p.21.

Harris, B., (1968), "Quantitative Models of Urban Development: Their Role in Metropolitan Policy Making", in Perloff, H.S., and Wingo, L. (ed.) Issues in Urban Economics, The Johns Hopkins Press, Baltimore, pp. 363-412.

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Kaplan, A., (1964), The Conduct of Inquiry, Chandler Publishing Company, Scranton, Pennsylvania.

Toronto Transit Commission, (1971), Transit in Toronto, Toronto.

Voorhees and Associates, (1968), Central Area Transportation Study, Toronto.

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6

empirical background

6.1

METROPOLITAN TORONTO

In urban research the unique characteristics of individual cities often play an important role when general theories and propositions are tested on special urban aggomerations. Even in the North American context, where a number of common denominators characterizing the spatial patterns and processes of urban growth in many metropolitan areas have been identified, the geographical location and historical evolution of various cities often act to modify the operation of general forces.[1] To place the following data and analysis in perspective, a brief history of Toronto's urbanization and transportation development is presented.[2]

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1. Kain, J.F. (1962).
2. For a more comprehensive discussion of Toronto's growth and the factors manipulating it, see Kerr and Spelt, (1965); Brain and McMurray, (1970); and Kirkup, (1969).

POPULATION, AREA AND DEVELOPMENT GROWTH

Since the incorporation of the City of Toronto in 1839 with a total population of 9000 persons, the provincial capital of Ontario has been one of the most vigorously growing con-urbations in North America. The first era of rapid development began in the early 1850s. With the construction of several railway lines, Toronto became the commercial distribution-centre for the rich farm lands of the province and a jumping-off point for northern development. By 1890 its population had risen to 180,000, partly through the annexation of several suburban communities, but mainly as a result of tremendous growth; in 1891 its 2400 industries employed 26,000 workers. Toronto reached metropolitan status in the early decades of the twentieth century. Its area doubled between 1900 and 1920, and by the time of the First World War, nearly all the nearby small villages and towns had been incorporated into the city. By that time its population had passed the half-million mark and its downtown skyscrapers had begun to appear. Manufacturing continued to prosper and the built-up area began to expand from the downtown core along the main arterial roads. The great influx of people to the cities following the end of the Second World War changed the face of Toronto profoundly. As the extensive suburbanization represented an increasing burden to the 12 suburban municipalities, a need for close cooperation between the City of Toronto and the adjacent municipalities arose. As a result, in 1954 a new political unit - the Municipality of Metropolitan Toronto - was formed. There are many indeces to illustrate the magnitude of the recent growth that turned Toronto into the premier trade, industrial and financial capital of Canada. However, probably none would be as powerful and representative of the 'Torontonian' attitude as the introductory paragraph of Kirkup's book.

"Toronto, the capital of the province of Ontario, is the most dynamic city on the earth. Metropolitan Toronto is boomtown. Metro's per capita value of construction is greater than that of any major city on this earth. Building permits in the metro area now total well over one billion dollars - second only to New York which has four times Toronto's population."[1]

To approximate graphically some dimensions of the emergence of Toronto from a small military fort to a metropolis, the following illustrations are offered.

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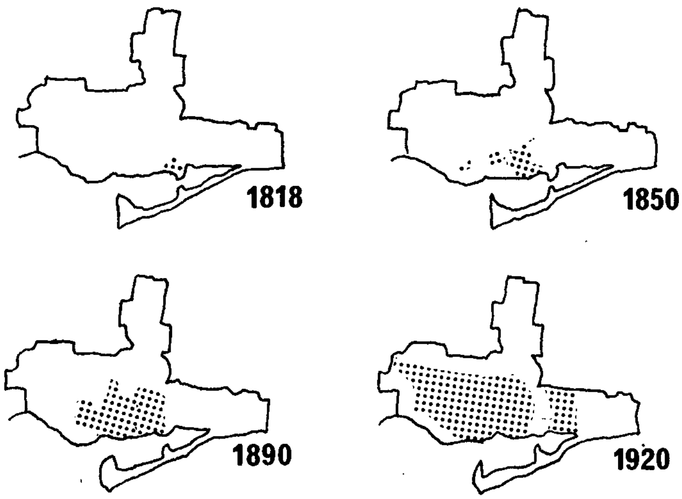
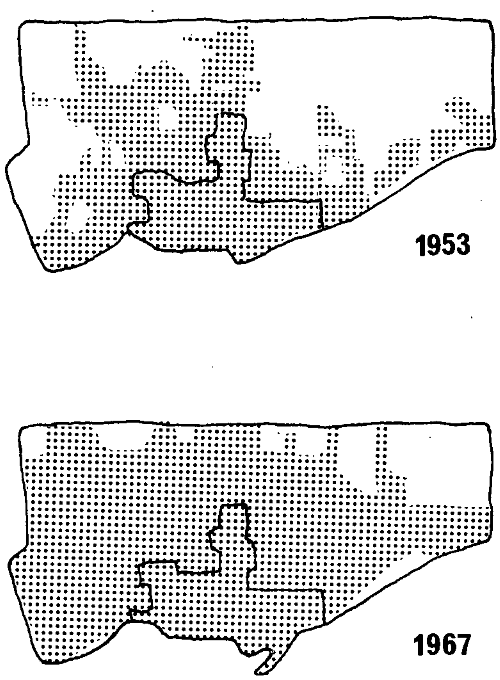
1. Kirkup, (1969), p.1.

FIGURE 6.1-1
THE GROWTH
OF THE CITY
OF TORONTO



Source: *The Changing City*, The City of Toronto Planning Board, 1959, p.10.

FIGURE 6.1-2
GROWTH OF
THE BUILT-UP
AREA,
METROPOLITAN
TORONTO
1953-1967



Source: *Metropolitan Toronto*, 1970, Metropolitan Toronto Council, p.6.

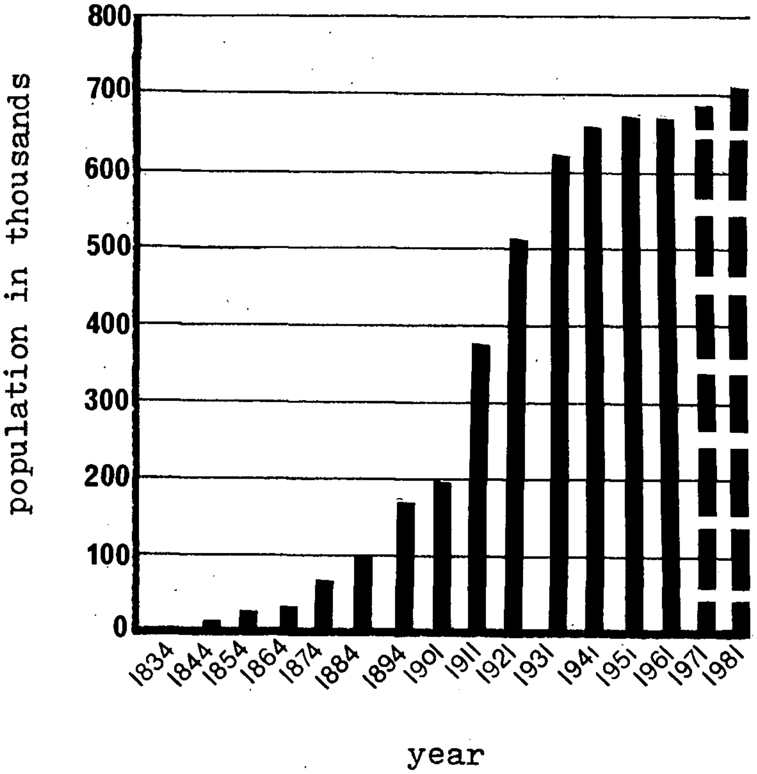


FIGURE 6.1-3
POPULATION
GROWTH OF
THE CITY OF
TORONTO
1834-1981

Source: Proposed Plan for Toronto, City of Toronto Planning Board, 1967, p.22.

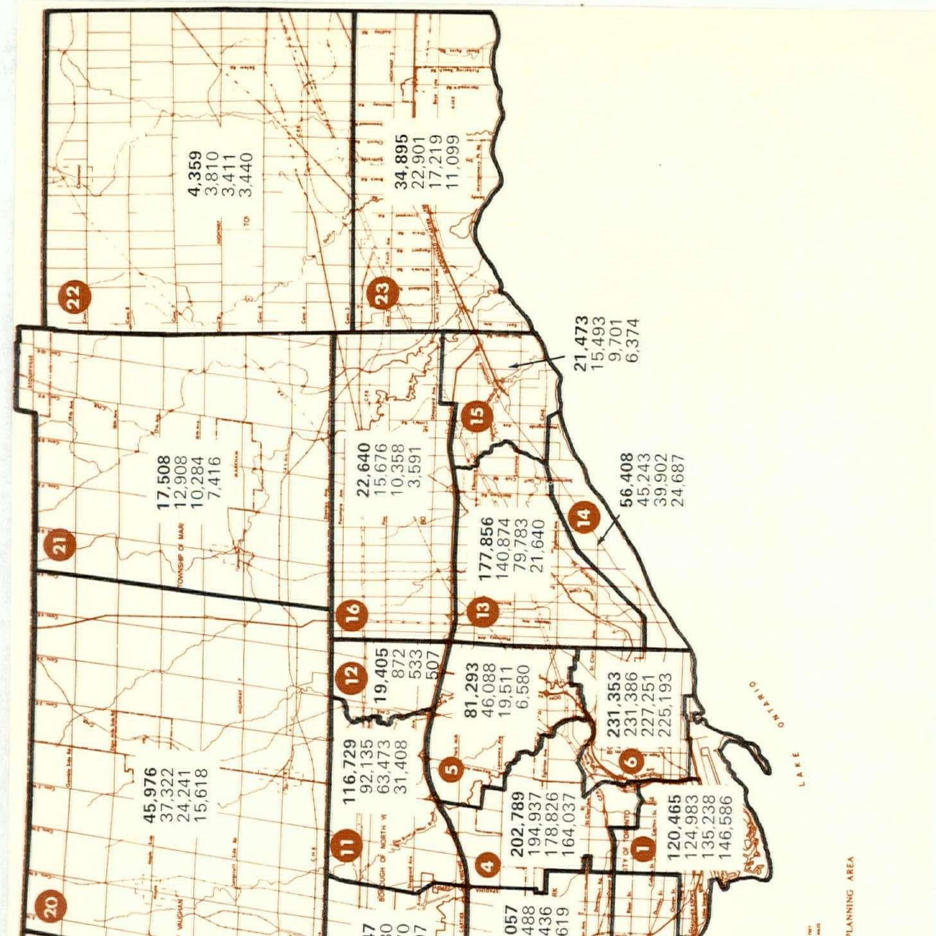
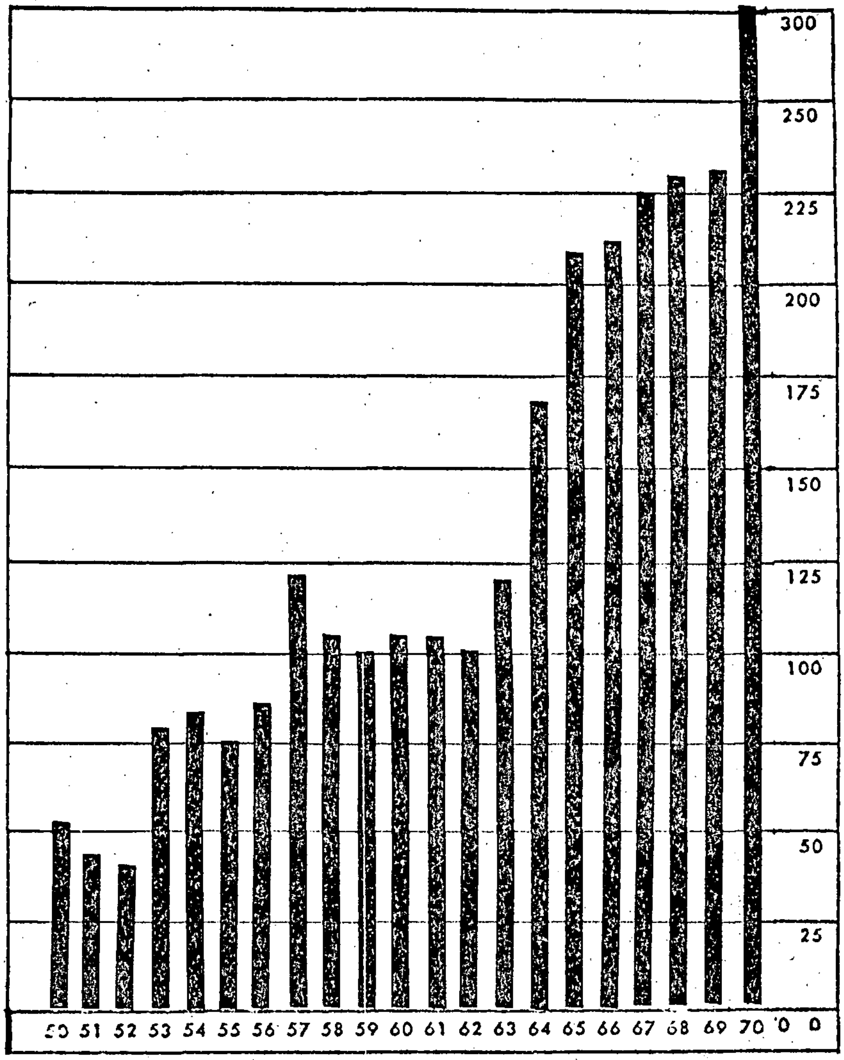


FIGURE 6.1-4
CHANGES IN THE POPULATION OF METROPOLITAN TORONTO PLANNING AREAS

Source: *Toronto: An Urban Study*, R.P. Baine and A.L. McMurray, 1970, p.66.

FIGURE 6.1-5
VALUE OF BUILDING PERMITS 1950-1970
- in millions of dollars.



Source: Annual Report 1970, Department of Buildings, City of Toronto, p.9.

RAIL RAPID TRANSIT [1]

Despite a number of reports dating back to 1910, studying the feasibility of introducing rapid transit lines to alleviate the severe traffic congestion that accompanied Toronto's rapid rate of

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1. The discussion in this chapter is based upon the following data sources: Boorse, (1968); Tass, (1970); T.T.C., (1971).

urbanization, it was not until 1947 that the citizens of Toronto voted 9 to 1 in favour of the public referendum authorizing the Toronto Transit Commission (T.T.C.) to build the first rapid transit line in Canada. One of the primary design objectives was that

> the subway would go where the need was greatest, despite the obvious high cost of building a line through the heart of the downtown area.[1]

The need was the greatest along Yonge Street and the first 4.6 miles of Toronto's rapid transit opened in 1954.[2] The Yonge Street line connects Union Station to Eglington and has twelve stations.

The need for an east-west route was apparent even before the Yonge subway was opened, but instead of constructing the Queen Street subway line which was originally conceived to be the first extension, an alternative route was decided upon, adjacent to Bloor Street and Danforth Avenue - the city's major East-West traffic artery. Further, to provide additional service to the downtown business district, the extension of the Yonge subway line under University Avenue was proposed. The ten-mile

1. T.T.C. (1971), p.21.
2. For reference on the technical description of the route alignment, track, rolling stock, etc., of the system, see Boorse, (1968), T.T.C., (1971).

system has been constructed in three stages: the University section from Union Station to St. George Street, 5 stations - completed in 1963; the eastern section from St. George to Woodbine, 9 stations; and the western section from St. George to Keel, 10 stations. The entire Bloor-Danforth line was opened for passenger traffic in 1966. In 1969, almost two years before the scheduled completion date of the Bloor subway, the extension of the line both eastward and westward was approved. Thus, in 1968 nine additional stations were opened - three to east and six to west. (Figure 6.1-6).

This subway system carried over 400,000 people per day, or approximately 50% of all transit trips, in 1968, and still continues to attract new riders. (Figure 6.1-7).

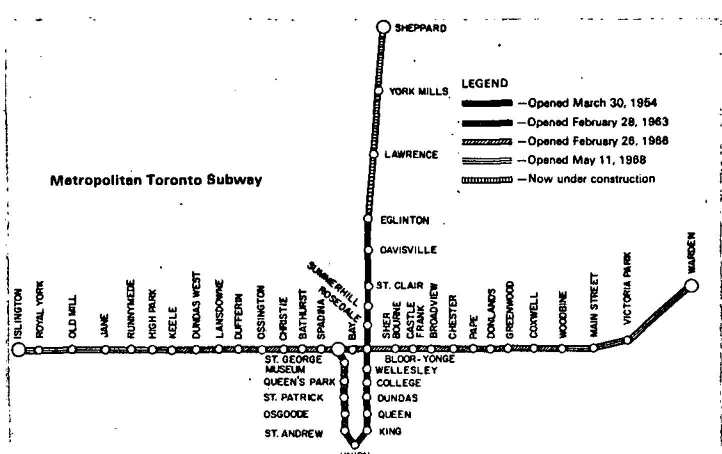
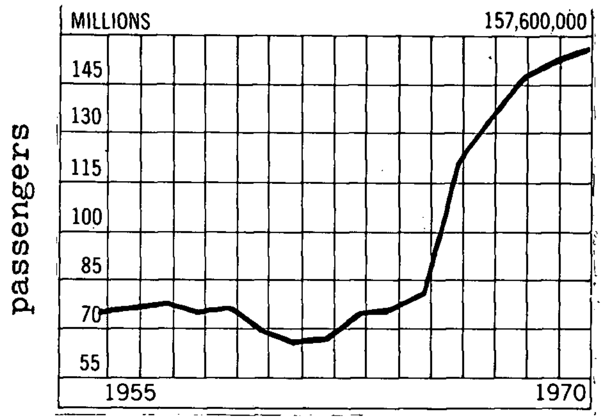


FIGURE 6.1-6
METROPOLITAN TORONTO SUBWAY, NEW LINE STAGES OF CONSTRUCTION

<u>Source</u>: <u>Development Follows Toronto Subway</u>, Toronto Transit Commission, 1969.

FIGURE 6.1-7
SUBWAY
PASSENGERS
CARRIED



Source: TTC 50 Years!, Toronto Transit Commission, 1971.

6.2

DATA DESCRIPTION

To construct and evaluate the simulation model two basic sets of data were required: the amount and spatial distribution of land use to be simulated in the model, and the description of variables needed to approximate various components of the environmental context. Although the Metropolitan Toronto Planning Board had already assembled a large amount of information on variables pertinent to this thesis for the years 1963, 1966, 1968, the use of this computerized information was not feasible.[1] Thus for the study the major data source was the review of all zoning change applications for the area within six blocks of the corridor containing three 'legs' of the Toronto subway system, from 1960-1970. This data was supplemented by infor-

1. This data was related to individual lots and the Planning Board insisted that the writers had no 'authority' to obtain information on individual properties. The transformation of this data to the next level of aggregation - city block - represented inhibiting expenses.

mation obtained from various planning district reports, studies and personal interviews.

APARTMENT REDEVELOPMENT

One of the most recent features of the North American urban landscape is the upsurge of highrise apartment developments. While in the United States only 17% of all dwelling units were apartments in 1950, by 1965 this portion was increased to 40%.[1] The trend has been similar in Canada - the share of apartment dwelling units from the total new residential construction increased from 16% to 52% by 1969.[2] As is expected, the tendency for apartment dwellings to dominate the provision of new residential units is even more pronounced in metropolitan areas; in 1967 in Toronto, for example, 73% of all residential units added to the existing stock of buildings were apartments.[3]

Extensive research has revealed a complexity of factors both on the supply and the demand side of the housing market leading to the accelerating trend towards apartment construction. Although there is some dispute over the future behaviour of this trend, the Toronto Planning Department forecasts a large amount of new apartment constructions

1. Neutze, (1968) p.9.
2. Nader, (1971) p.308.
3. Bourne, (1968) p.12.

for the next fifteen years within the metropolitan region.[1]

For the construction and calibration of the simulation model, the following 'apartment' data was required:

i. Number and spatial distribution of apartment units built before 1970.

ii. Land consumption rate of an average apartment unit.

iii. The amount of future apartment construction that could be assigned to the transit corridor for 1970-1985.

Information for the first input was gathered from the Toronto Planning Board's 1966 apartment survey, which is updated yearly. This survey contains information on the number of buildings, their location, and the units and storeys of all apartment developments since 1958 on a yearly basis. While the study gives similar information on the apartment construction which took place before 1958, it does not indicate in which year they were built.

From the survey information, the following data

1. Metropolitan Toronto Planning Board, (1967)

inputs were compiled:

i. The total number of apartment units built within two-year periods along each 'leg' of the subway line between 1959 and 1970 (Appendix A.B.-2,3,4), For the initial simulation process this data was externally provided for the model as 'the number of units to be distributed for each time period'.

ii. Total number of apartment units built in each station sub-area within two-year time periods.[1] These data were used for two purposes: first, as a proxi-variable for the agglomerative component of the environmental context - the influence of the spatial distribution of past developments - and second, as a base for comparing the amount and spatial distribution of simulated growth with that which actually took place.

iii. The analysis of average apartment building size was necessary to learn how the economics of scale of apartment construction changes over time. (Appendix A.B.-1). The cumulative distribution of apartment building and development size were compiled for various time periods. For those years within which the scale economics shifted consider-

1. Reasons for subdividing the network into three sub-sections, each station into four substation areas and the simulation time into two-year time periods will be given in the next chapter.

ably, different distribution curves were used in the apartment assignment process. (Figures 6.2-1 and 6.2-2).

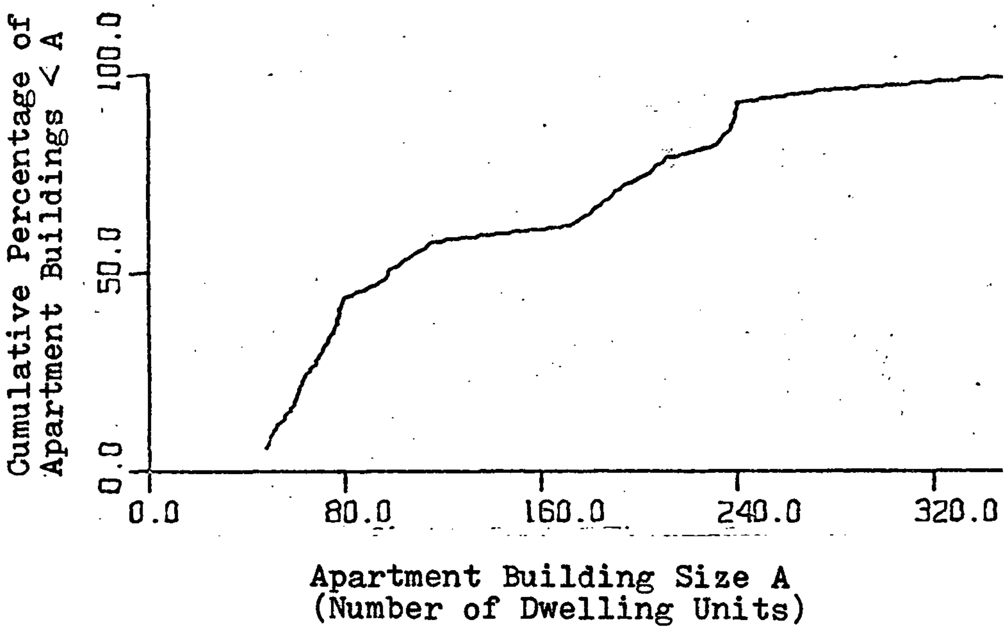


FIGURE 6.2-1 CUMULATIVE DISTRIBUTION OF APARTMENT BUILDING SIZE - 1959-1964.

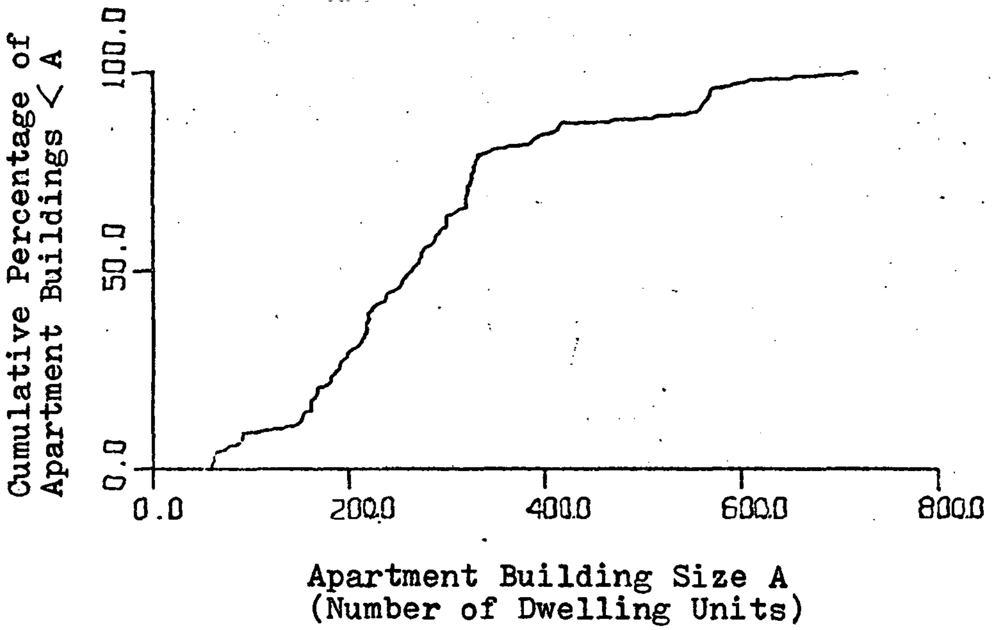


FIGURE 6.2-2 CUMULATIVE DISTRIBUTION OF APARTMENT BUILDING SIZE - 1965-1970.

In order to be able to deplete the available land for new apartment construction when, through the model, additional units are assigned to the area, some measure of land consumption rate had to be established. This rate essentially depends upon two factors: the size of average apartment units (square feet) and the permitted density.

Apartment sizes vary from 850 square feet in the core area where most buildings are composed of one or two bedroom units, to approximately 1100-1200 square feet in suburban locations where, catering to a different family size structure, most buildings have two, three and four bedroom dwelling units.[1] However, for reasons of simplicity an average apartment unit size of 1000 square feet was used uniformly in the model.[2] The other land consumption rate modifying factor also varies in the city.[3] However, it was evident from the reviewed zoning application approvals that for most apartment developments located near rapid transit stations some density 'bonus' was given so the average

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1. Neutze, (1968), p.24.
2. The 1000 square feet size was derived from averaging the actual apartment unit sizes of three large scale development projects located near the core (St. James Town), in midtown (Davisville), and in suburbia (Warden.
3. Metropolitan Toronto Planning Board, (1967).

density could be treated as stable (2.5 times the land area) throughout the city. From these two figures, the average land consumption rate of apartment units was calculated to be .01 acres.

The amount of future apartment growth to be distributed along the line was derived by employing a relatively simple formula.[1] First, the total amount of apartment growth in those individual planning districts which were adjacent to the rapid transit line were compared to the relative growth that had been attracted to the vicinity of subway stations. Then, the Metropolitan Planning Board's apartment construction forecast for each of these planning districts[2] were related to the line, assuming that the relative attractivity of the system remains constant throughout the simulation period (Figure 6.2-3).

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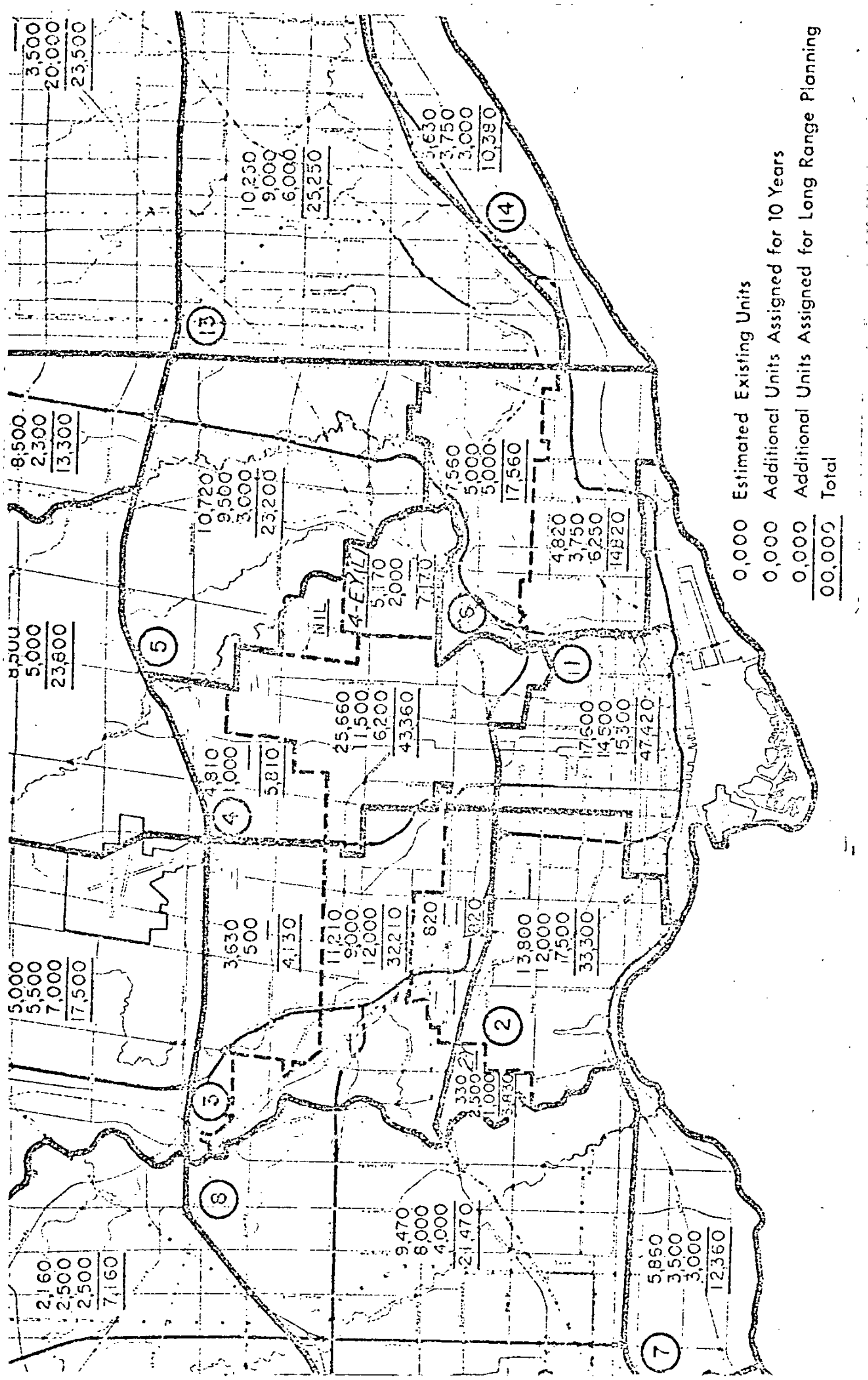
1. The shortcoming of this process has already been discussed and acknowledged.
2. Metropolitan Toronto Planning Board, (1967).

FIGURE 6.2-3
FUTURE DISTRIBUTION OF APARTMENT UNITS BY PLANNING DISTRICTS



Source: Metropolitan Apartment Development Control Policy, Metropolitan Toronto Planning Board, 1967.

DATA BASE FOR ENVIRONMENTAL VARIABLES

To approximate the role of the environmental context in site selection for apartment development, thirteen variables have been incorporated in the model. Data for these variables were selected from a variety of sources and levels of aggregation. The following section gives a brief account of how the various proxi-variables were measured and expressed in operational terms for the simulation model. This general discussion is supplemented by tables in which the value and the frequency distribution of each variable is tabulated, both for those station sub-areas that had attracted some apartment growth, and for those that had not, between 1959-1970. When maps were available to illustrate the occurrence of various variables on the city or metropolitan scale, these figures are also presented.

PHYSICAL

In sub-hypothesis #1 it was suggested that the influence physical constraints exert on site location should be measured through their role in reducing the total geographical surface theoretically available for development to a smaller area where the development costs are tolerable. In Toronto topographic characteristics - the harbour, lake front, ravines, the Lake Plain, the shoreline of the Lake Iroquois and the Scarborough Bluffs - had played a very important role in the development of the city. (Figure 6.2-4). However, since the rapid transit line passes through mostly already built-up areas, where the replacement of one

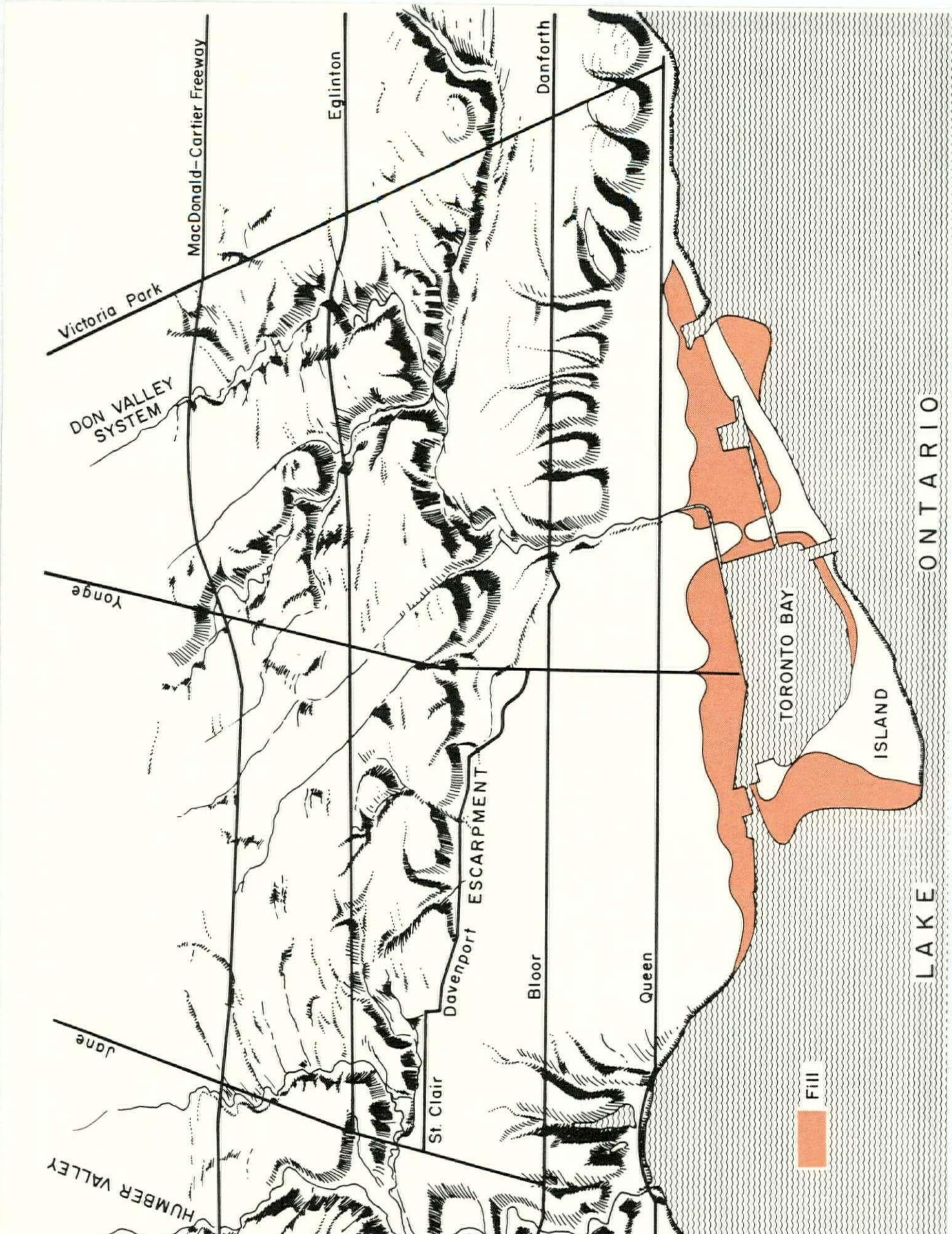


FIGURE 6.2-4
TOPOGRAPHY OF THE METROPOLITAN TORONTO SITE

Source: Proposed Plan for Toronto, City of Toronto Planning Department, 1967, p.103.

structure with another is not expected to involve major difficulties, the role of physical constraints is rather negligible. Thus, for all station sub-areas where no other obvious constraints existed (cemetery, public open space, flood plain, school playground, church, etc.), the whole sub-area (20 acres of land) was assigned as input. However, since the model does not generate indigenously the land comsumption of competing land uses with a higher ability to pay for sites, all areas which had been zoned for high-density commercial or specific institutional uses (university, hospital, for example) were deducted. (Table 6.2-I)[1] The name of the variable was abbreviated as LANDAV in the model. Its dimension is "acres".

TECHNOLOGICAL

To thoroughly assess and measure the value of all public utilities and social services covering the area in the vicinity of the rapid transit lines was clearly beyond the available resources of the

1. For all the following tables (Table 6.2-I to 6.2-XI) the figures in the upper portion are representative for those station sub-areas which attracted growth (25), whereas in the lower part those station sub-areas are grouped which have not (103), between 1959-1970. Under the column-heading of "absolute frequency" the number of station sub-areas exhibiting the value of the environmental variable is given in the column of adjusted frequency (the absolute frequency is converted into percentage).

TABLE 6.2-I

VLAND AVAILABLE (IN ACRES)	VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
NO LAND AVAILABLE	0	1	4.0	4.0
1- 5	5	2	8.0	12.0
6-10	10	3	12.0	24.0
11-15	15	2	8.0	32.0
16-20	20	14	56.0	88.0
21-25	25	1	4.0	92.0
MORE THAN 25	26	2	8.0	100.0
	TO	25	100.0	100.0
NO LAND AVAILABLE	0	12	11.7	11.7
1- 5	5	12	11.7	23.3
6-10	10	11	10.7	34.0
11-15	15	10	9.7	43.7
16-20	20	58	56.3	100.0
	TO	103	100.0	100.0

writers. However, two sources provided information on areas where shortages restricting further growth existed: the reviewed zoning applications, where the rejection was justified by the lack of service in the general area (school. open space, sewer), and the appraisals of various planning districts. Consequently, unlimited supply was assigned to those station sub-areas where no apparent limitation existed, or where no information was available; and restrictions were maintained for those sub-areas where it was documented. In these latter cases, some indication was often given as to when new services were expected to be installed (Davisville, Spadina, Main). (Figure

6.2-5). Thus during the simulation period these restrictions were relaxed at the appropriate time. The name of the variable was abbreviated to TECHNC in the model. Its dimension is: apartment unit.

ECONOMIC

To approximate the influence of land fragmentation on apartment site selection, the average size of individual properties was measured. In station sub-areas where lot sizes were not uniform, some adjustments were made: when the difference among lot sizes was small, simply the average was calculated; in areas where one lot size was dominant, but a relatively small area was comprised of considerably different lot sizes, this difference was ignored. In cases where a larger area had already been assembled for some other purposes, the amount of this land was classified as 'assembled'. However, an area, to be classified as 'assembled', had to be greater than or equal to the minimum lot size needed for average apartment site development. (Table 6.2-II and Figure 6.2-6).

The problem that individual lots are often further fragmented through the legal division of ownership is acknowledged here. However, for the purpose of this study, this complication was ignored. The name of the variable was abbreviated as LOTSIZ in the model. Its dimension is "square feet".

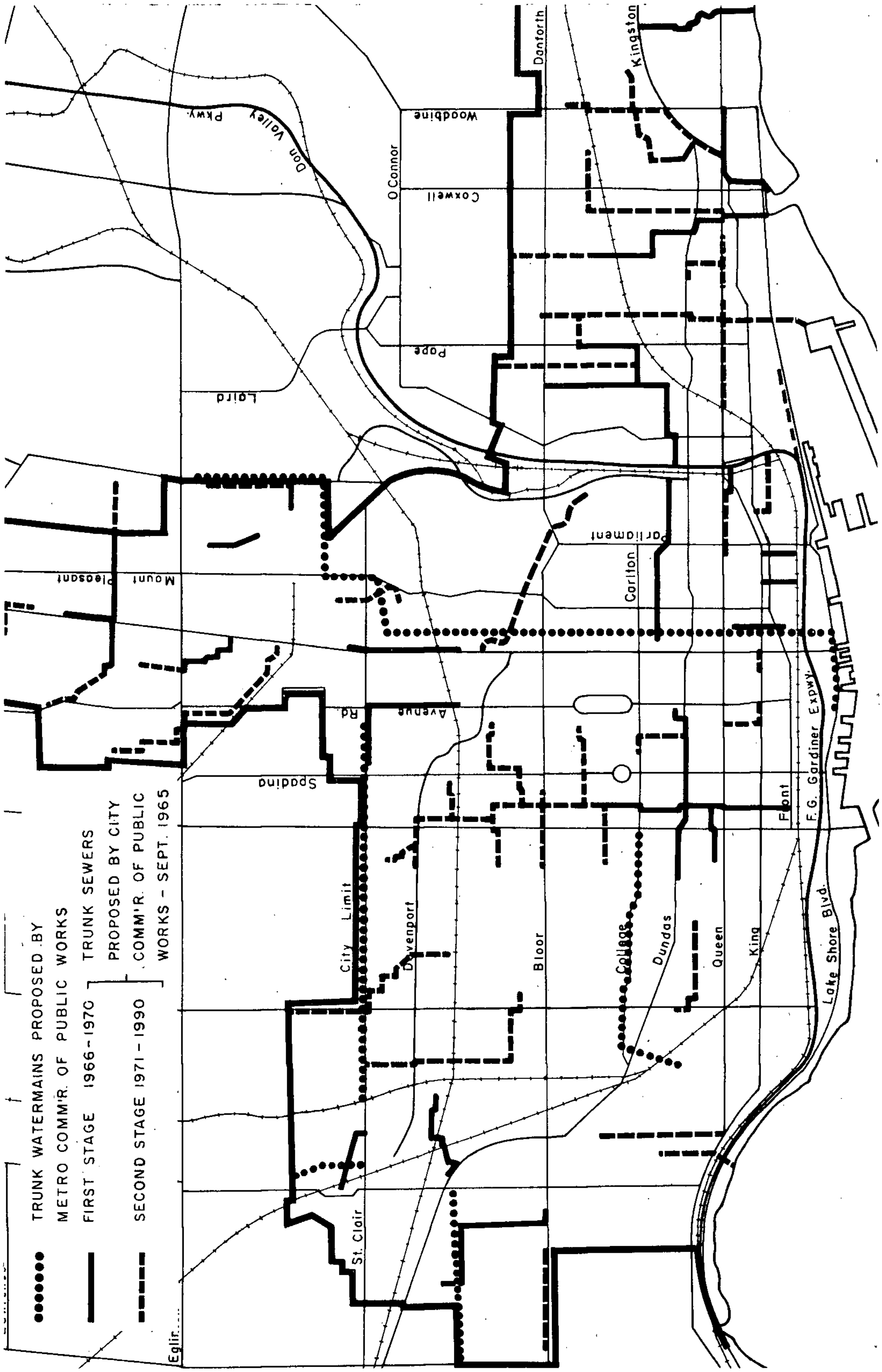


FIGURE 6.2-5
PROPOSED
WATER SUPPLY,
AND SEWERS

Source: Towards a New Plan for Toronto, City of Toronto Planning Board, 1965, p.24.

TABLE 6.2-II
AVERAGE
LOT SIZE

AVERAGE LOT SIZE (IN SQUAREFOOTS)	VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
LESS T. 2500	1	2	8.0	8.0
2500- 3000	2	2	8.0	16.0
3000- 3500	3	5	20.0	36.0
3500- 4500	4	1	4.0	40.0
4500- 6000	5	6	24.0	64.0
MORE T. 6000	6	3	12.0	76.0
LAND ASSEMBLED	7	6	24.0	100.0
	TO	25	100.0	100.0
LESS T. 2500	1	21	20.4	20.4
2500- 3000	2	53	51.5	71.8
3000- 3500	3	7	6.8	78.6
3500- 4500	4	5	4.9	83.5
4500- 6000	5	2	1.9	85.4
MORE T. 6000	6	4	3.9	89.3
LAND ASSEMBLED	7	11	10.7	100.0
	TO	103	100.0	100.0

To account for the cost that occurs when one or a number of buildings are replaced with another, two proxi-variables were introduced: the age mixture of the existing stock, and the vacant land.

During the preliminary investigation stage, it was observed that apartments tended to replace low-density residential structures. Since the economic life of these buildings is generally estimated to be approximately fifty years, the building age proxi-variable was expressed in terms of the average percentage of the physical stock in the sub-area built before 1920. (Table 6.2-III).

TABLE 6.2-III
BUILDING AGE MIXTURE

NUMBER OF HOUSES BUILT BEFORE 1920	VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
NONE	0	2	8.0	8.0
11-20 %	2	10	40.0	48.0
21-30 %	3	3	12.0	60.0
31-40 %	4	3	12.0	72.0
51-60 %	6	5	20.0	92.0
61-70 %	7	2	8.0	100.0
	TO	25	100.0	100.0
NONE	0	12	11.7	11.7
0-10 %	1	3	2.9	14.6
11-20 %	2	23	22.3	36.9
21-30 %	3	6	5.8	42.7
31-40 %	4	12	11.7	54.4
41-50 %	5	1	1.0	55.3
51-60 %	6	5	4.9	60.2
61-70 %	7	41	39.8	100.0
	TO	103	100.0	100.0

Data for the variable were inferred from maps illustrating the historic development of Toronto. The name of the variable was abbreviated as BUILDAG in the model. Its dimension is: percentage.

The variable of vacant land was additionally introduced to represent the economic benfit to be gained when no building demolition cost occurs. Similarly to the variable of assembled land, the variable of vacant land was assigned to a station sub-area only if its size was greater than the site requirement of the minimum, economically feasible development size. (Table 6.2-IV). The name of the variable was abbreviated as LANDVC in the model. Its dimension is: acres.

TABLE 6.2-IV
VACANT LAND

VACANT LAND (IN ACRES)	VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
NO LAND VACANT	0	18	72.0	72.0
1- 5	5	4	16.0	88.0
6-10	10	3	12.0	100.0
	TO	25	100.0	100.0
NO LAND VACANT	0	101	98.1	98.1
1- 5	5	1	1.0	99.0
6-10	10	1	1.0	100.0
	TO	103	100.0	100.0

AGGREGATIVE

The effect of clustering, the presence of supporting or the absence of incompatible land uses were measured by four variables: new construction, commercial development, proximity to major open space and lack of undesirable conditions. The influence of past apartment concentration on the spatial distribution of future construction has already been discussed in the previous section.

Here only the variable abbreviation and its dimension is presented: NEWCON; apartment units.

The amount, quality and viability of commercial development is not generated within the model; thus, their influence on apartment site selection was assessed through the provision of an external variable. In most urban structure models commercial and retail development is treated as a dependent variable, assuming that their location gravitates towards existing or future concentration of the population they serve. The somewhat reciprocal proposition implied here was based on the constant recurrence of reasonings, evident in most reviewed zoning applications, claiming that existing or planned shopping facilities could adequately serve the additional population increment resulting from new apartment development. To scale the quality of the commercial strength of individual station subareas, three levels of commercial development were used: local, district and office center. (Figure 6.2-6; Table 6.2-V). The name of the variable was abbreviated as COMDEV in the model. Its dimension is: dimensionless.

TABLE 6.2-V
COMMERCIAL
DEVELOPMENT

CLASSIFICATION OF COMMERCIAL DEVELOPM.	VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
LOCAL	1	15	60.0	60.0
DISTRICT	2	5	20.0	80.0
OFFICE	3	5	20.0	100.0
	TO	25	100.0	100.0
LOCAL	1	85	82.5	82.5
DISTRICT	2	17	16.5	99.0
OFFICE	3	1	1.0	100.0
	TO	103	100.0	100.0

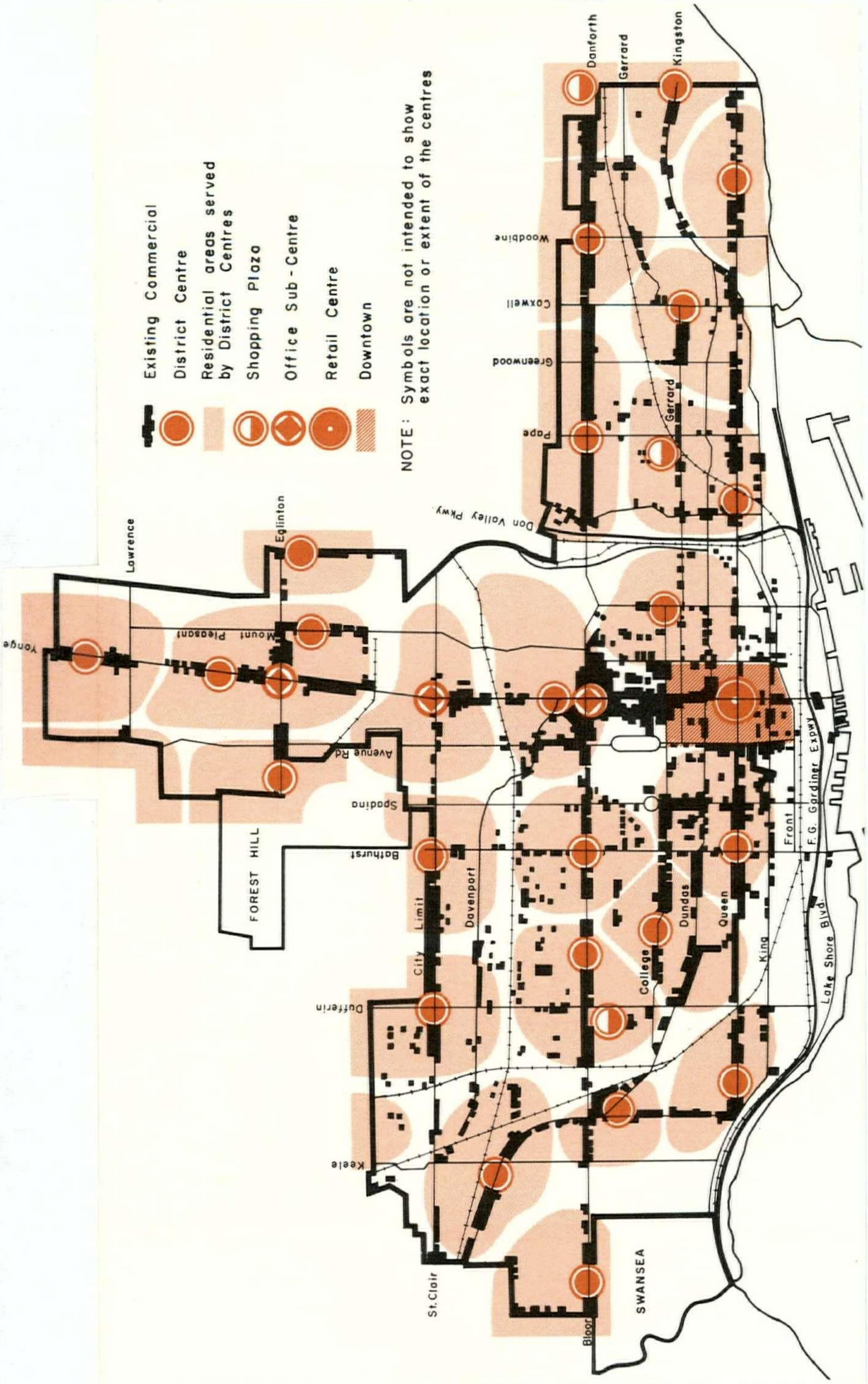


FIGURE 6.2-6
COMMERCIAL
AREAS OF
TORONTO,
1966

The availability of public open space within or adjacent to the sub-areas of individual stations was assessed to be important for two reasons: it provides a valuable recreational service and acts as a physical, visual buffer between low density areas and highrise apartments. The variable was treated as a binary choice, and assigned to the sub-areas only if the size of the public open space was greater than five acres. (Figure 6.2-7; Table 6.2-VI).

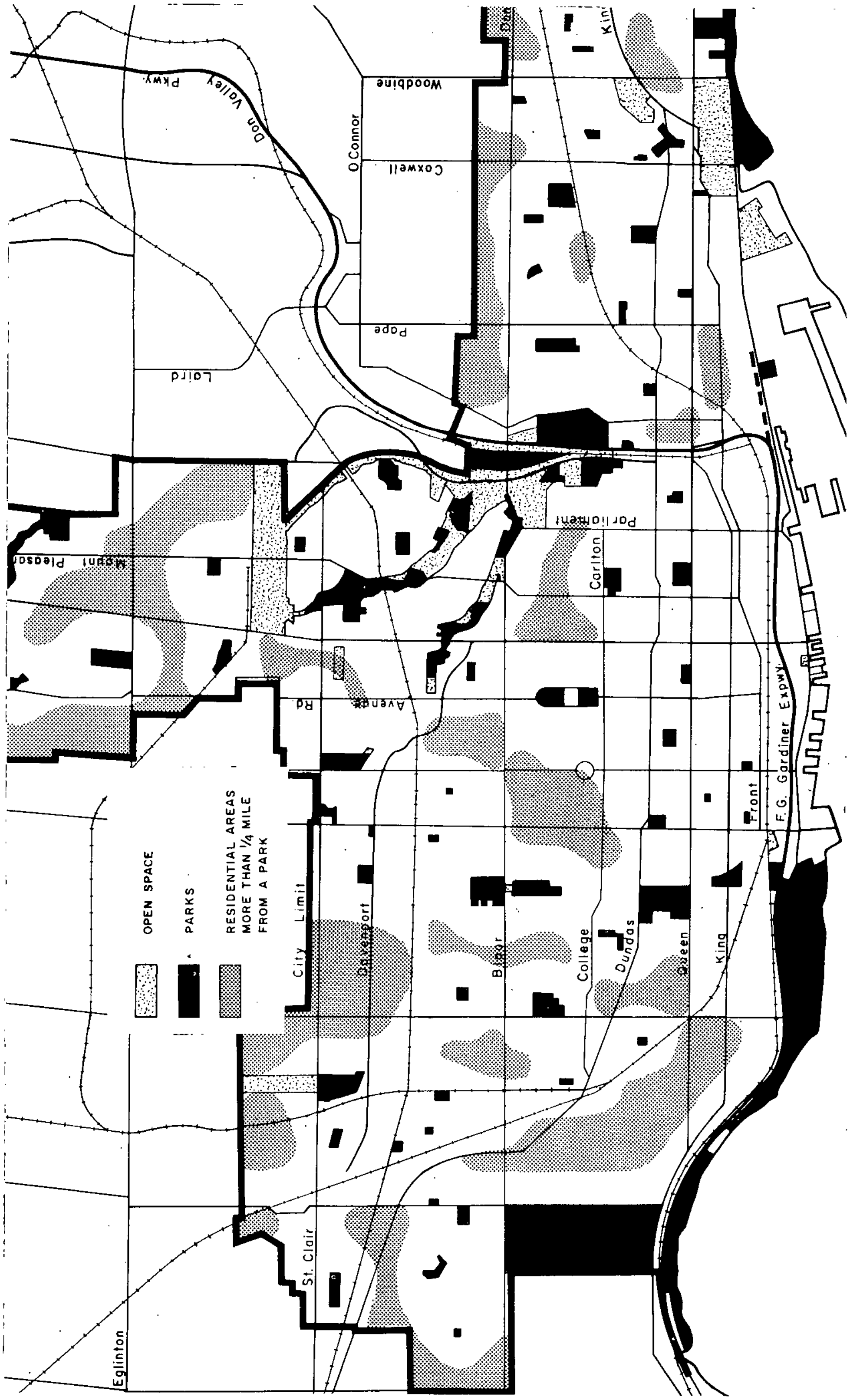
The name of the variable was abbreviated as PARKLD in the model. Its dimension is: dimensionless.

TABLE 6.2-VI
OPEN SPACE

PROXIMITY TO MAJOR OPEN SPACE	VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
NO PARKLAND	0	12	48.0	48.0
PARKLAND	1	13	52.0	100.0
	TO	25	100.0	100.0
NO PARKLAND	0	77	74.8	74.8
PARKLAND	1	26	25.2	100.0
	TO	103	100.0	100.0

Similarly, the presence of land uses generally considered as incompatible with residential development was also measured as a binary choice. Industrial and some transportation land uses were classified as incompatible. (Table 6.2-VII). The name of the variable was abbreviated as UNDCON

FIGURE 6.2-7
DISTRIBUTION
OF PUBLIC
OPEN SPACE



Source: Towards a New Plan for Toronto, City of Toronto Planning Board, 1965, p.23.

in the model. Its dimension is: dimensionless.

TABLE 6.2-VII UNDESIRABLE CONDITIONS

UNDESIRABLE CONDITIONS	VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
NON	0	21	84.0	84.0
SOME	1	4	16.0	100.0
	TO	25	100.0	100.0
NON	0	89	86.4	86.4
SOME	1	14	13.6	100.0
	TO	103	100.0	100.0

INSTITUTIONAL

To assess the importance that zoning exerts on apartment site selection, the existing zoning in station sub-areas was mapped.[1] Since the model is concerned mainly with apartment development, only the residential zoning was differentiated according to the permissible density, and all other non-residential zoning (commercial, institutional, industrial) was treated under one zoning category. (Table 6.2-VIII).

The name of the variable was abbreviated as ZON in the model. Its dimension is: dimensionless.

1. Figure 6.2-8 gives a generalized indication of the kinds of uses permitted in each zoning.

FIGURE 6.2-8
ZONING
SYSTEM,
TORONTO

Permissible Uses

Residential Districts

	G	R.1	R.1A	R.1F	R.2	R.3	R.4	R.4A
Park—Playground	●	●	●	●	●	●	●	●
Community Centre	●	○	○	○	○	●	●	●
Church		○	○	○	●	●	●	●
Detached Dwelling		●	●	●	●	●	●	●
Doctor, Dentist		○	○	○	○	○	○	●
Semi-Detached Dwelling				●	●	●	●	●
Duplex			○	○	●	●	●	●
Double Duplex			○	○	●	●	●	●
Triplex					●	●	●	●
Double Triplex					●	●	●	●
Row House					●	●	●	●
Apartment House			○		○	○	●	●
Converted Dwelling			○	○	●	●	●	●
Boarding House					○	○	●	●
Parking Station					○	○	○	○
Nursing Home						○	●	●
Day Nursery					○	○	●	●
Children's Home						○	●	●
Boys' Home						○	●	●
Public School		○	○	○	○	○	●	●
Private School					○	○	●	●
Public Hospital							●	●
Private Club							●	●
Fraternity House							●	●
Public Library							●	●
YMCA, etc.							●	●
Institutional Office								●
Professional Office								●
Administrative Office								●
Office Building for above Offices								●

Commercial Districts
which allow residential uses

	C.1A	C.1S	C.1	AC
All Residential Buildings			○	○
Some Residential Buildings	●	●		○
Public Buildings	○	○	●	○
Institutions	●		●	○
Office Building	●	●	●	○
Hospital	●		●	○
Bank		●	●	○
Hotel			●	○
Restaurant	○	●	●	○
Theatre, Hall		●	●	○
Commercial Club		●	●	○
Place of Amusement			●	○
Retail Store		●	●	○
Personal Service Shop		○	●	○
Bake-Shop		●	●	○
Repair and Service Shop		○	●	○
Studio, Custom Workshop		○	●	○
Commercial School	●		●	○
Supermarket		●	●	○
Animal Hospital			○	○
Private Parking Garage	●	●		○
Public Parking Garage			●	○
Service Station			●	●
Used Car Lot			●	○

● Permitted ○ Permitted subject to restrictions in By-Law

Not all uses are necessarily permitted in all locations with designations as shown above; for specific exclusions reference should be made to sections 16 and 17 of the Zoning By-Law.

Permissible Densities

Zone Designations

Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
0.35	0.6	1.0†	2.0†	2.5†

L 1	L 2	L 3	L 4 (through)	L 9
1.0	2.0	3.0	4.0	9.0

V 1	V 2	V 3	V 4
3.0	5.0	7.0	12.0

† Bonuses up to a maximum of 1.35 in Zone 3, 2.5 in Zone 4 and 4.375 in Zone 5 under special circumstances have been recommended by the Planning Board.

Source: Metropolitan Toronto Planning Board.

TABLE 6.2-VIII
ZONING

ZONING	VA	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
LOW DENSITY, DUPLEX	2	16	64.0	64.0
MED DENSITY,LOW RISE	3	4	16.0	80.0
HIGH DENSITY,HIGH RIS	4	3	12.0	92.0
NON RESIDENTIAL	5	2	8.0	100.0
	TO	25	100.0	100.0
LOW DENSITY,SING FAM	1	20	19.4	19.4
LOW DENSITY,DUPLEX	2	60	58.3	77.7
MEDIUM DENS,LOW RISE	3	8	7.8	85.4
HIGH DENS,HIGH RISE	4	1	1.0	86.4
NON RESIDENTIAL	5	14	13.6	100.0
	TO	103	100.0	100.0

SOCIAL

Since it was expected that the influence of neighborhood quality and cohesion on apartment site selection would be most apparent in extremely low and high income neighborhoods, a relatively crude process was followed to estimate the neighborhood quality variable. By compiling the average income, the percentage of blue-collar workers and dominance of ethnic concentration, three generalized values were derived: poor, average and high. (Table 6.2-IX).

The name of the variable was abbreviated as NEIGHQ in the model. Its dimension is: dimensionless.

TABLE 6.2-IX
NEIGHBORHOOD QUALITY

NEIGHBORHOOD QUALITY	VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
PREDOMINATLY NON RES.	0	1	4.0	4.0
LOW QUALITY	1	5	20.0	24.0
AVERAGE QUALITY	2	18	72.0	96.0
HIGH QUALITY	3	1	4.0	100.0
	TO	25	100.0	100.0
PREDOMINANTLY NON RES.	0	12	11.7	11.7
LOW QUALITY	1	62	60.2	71.8
AVERAGE QUALITY	2	8	7.8	79.6
HIGH QUALITY	3	21	20.4	100.0
	TO	103	100.0	100.0

NON-CBD ACCESSIBILITY

It was previously discussed that the CBD accessibility of all stations could be assumed to be constant. To account for each station sub-area's general location within the larger urban setting, two 'accessibility' variables were introduced: nodality and surface accessibility.

The former was derived from the number of feeder lines converging to each subway station (Table 6.2-X). Although some forms of additional weighting, such as the length of the line, or the total acreage of user shed, would undoubtedly have been beneficial, time and data limitations necessitated the omission of this further refinement.
The name of the variable was abbreviated as NODAL in the model. Its dimension is: dimensionless.

TABLE 6.2-X NODALITY

NUMBER OF FEEDER LINES (SURFACE)		ABSOL FREQUENCY	ADJU FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
1	1	5	20.0	20.0
2	2	2	8.0	28.0
4	4	8	32.0	60.0
5	5	1	4.0	64.0
6	6	5	20.0	84.0
9	9	4	16.0	100.0
	TO	25	100.0	100.0
0	0	20	19.4	19.4
1	1	23	22.3	41.7
2	2	26	25.2	67.0
3	3	8	7.8	74.8
4	4	16	15.5	90.3
5	5	3	2.9	93.2
6	6	3	2.9	96.1
9	9	4	3.9	100.0
	TO	103	100.0	100.0

The surface accessibility variable approximates the ease of access from stations to the general metropolitan area via non-rapid transit. This proxi-variable was designed to account for the large number of shopping, social and recreational trips which, because of their dispersed destinations, are made by car. It is assumed that all stations have an average surface accessibility and the 'above average' value was assigned only to those stations which were located on major arterial roads having direct access to the city's freeway system. (Table 6.2-XI).

The name of the variable was abbreviated as SURACC in the model. Its dimension is: dimensionless.

TABLE 6.2-XI
SURFACE
ACCESSIBILITY

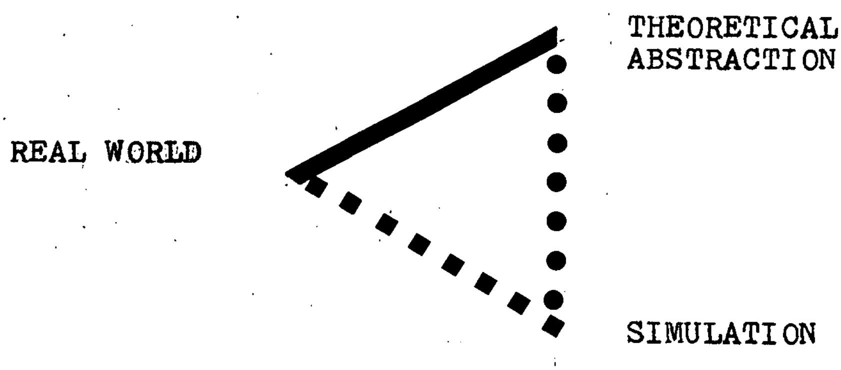
SURFACE ACCESSIBILITY		ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
AVERAGE	0	5	20.0	20.0
ABOVE AVERAGE	1	20	80.0	100.0
	TO	25	100.0	100.0
AVERAGE	0	75	72.8	72.8
ABOVE AVERAGE	1	28	27.2	100.0
	TO	103	100.0	100.0

6.3

PREPARATION OF INPUT FOR SIMULATION

In chapter five, arguments were presented as to why the writers choose to construct a simulation model rather than to use standard statistical techniques for prediction of land uses along subway lines. However, it was decided to include certain statistical methods in the analysis, because it was felt that the two methods can be complementary even though their concepts and objectives differ from each other. Figures 6.3-1 and 6.3-2 demonstrate the two approaches of analysis. A deductive method, as for example simulation, utilizes

FIGURE 6.3.-1
DEDUCTIVE ANALYSIS



theoretical abstrations from the reality. Based on the logical argument, the simulation model is constructed and its results are compared with the real world. The resulting contradiction or 'error' (dashed edge of triangle in Figure 6.3-1) is minimized by calibration of the model (dotted edge).

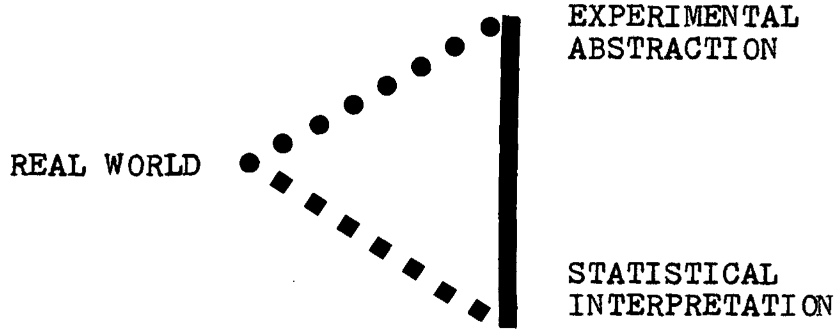


FIGURE 6.3-2
INDUCTIVE
ANALYSIS

The inductive method employs experimental abstraction from the real world. The "experiments" are the various statistical standard analyses available. The results of the analysis are compared with the real world. In this case, the resulting tension (dashed edge, Figure 6.3-2) from the comparison can be reduced by selection of statistically different methods (dotted edge) because the statistical inference itself allows for no modifications once the method and criteria for validity (level of significance) is chosen.

The approach adopted by the writers combines to a certain extent both types of analysis, as shown in Figure 6.3-3. The graph now has two 'flexible' sides. By adequate selection of statistical tools, the construction of the simulation model can be improved.

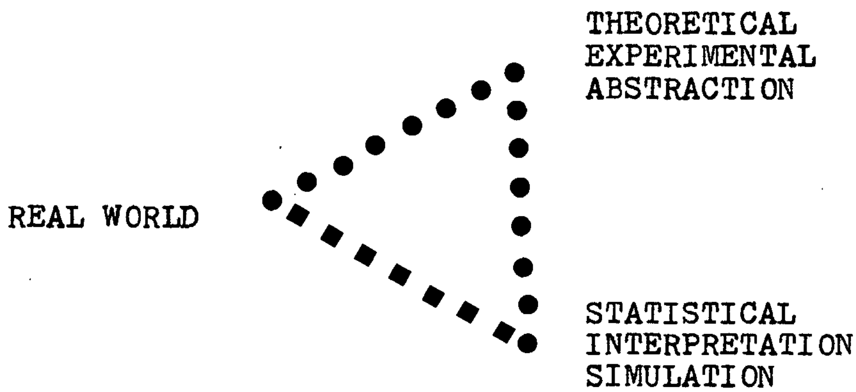


FIGURE 6.3-3
INDUCTIVE-DEDUCTIVE ANALYSIS

CONCEPT OF STATISTICAL ANALYSIS

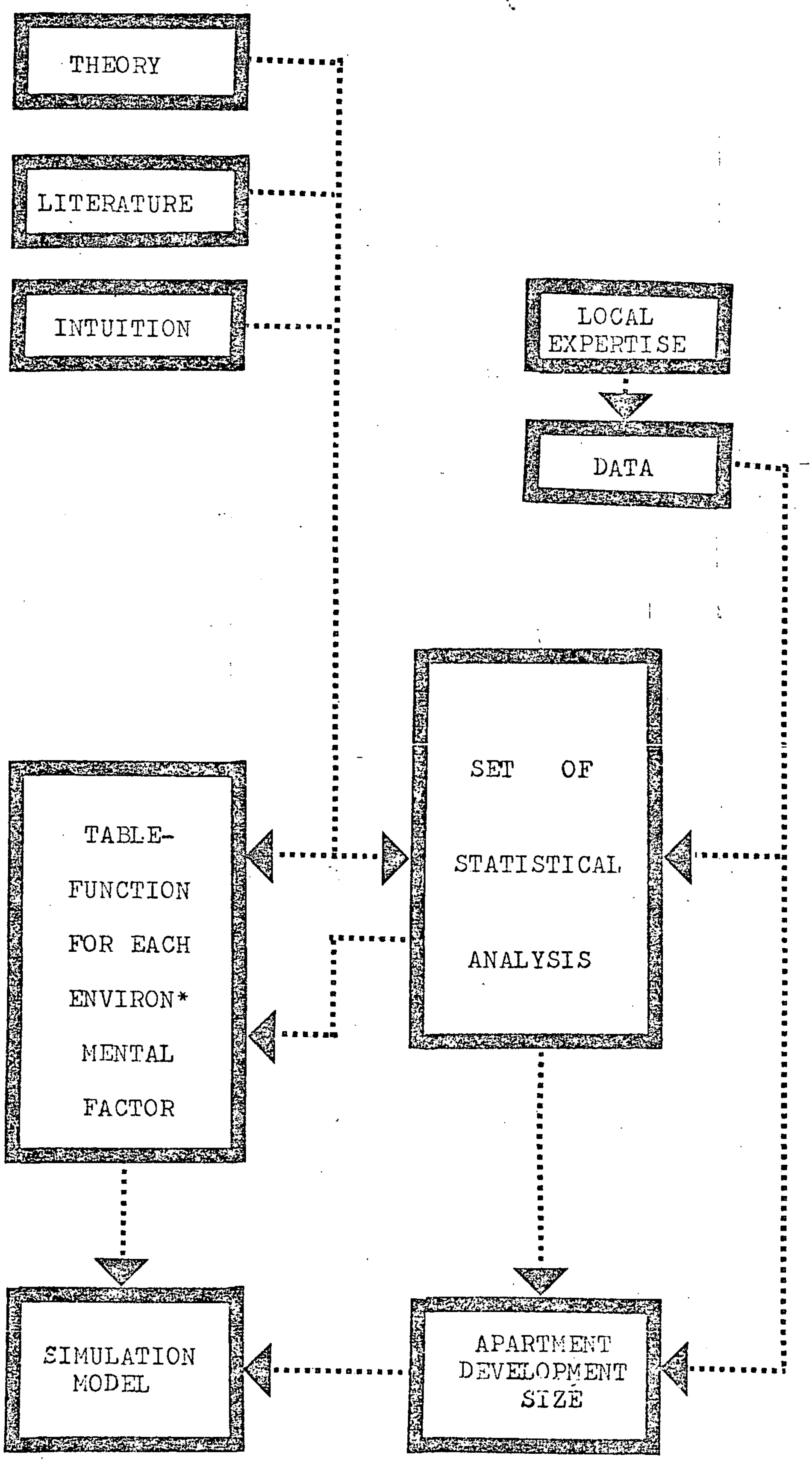
There are two reasons why statistical analysis was undertaken. First, it was difficult to conceptualize all the data collected. Therefore, statistical analysis was used to comprehend the data, to obtain a broad understanding of the patterns, ranges, interrelations, etc. Second, it was expected that the first approximation of the table functions (relationship between land use and environmental variables) could be improved and better justified. In addition, the apartment building and apartment development size functions were derived by statistical methods. Figure 6.3-4 demonstrates where the statistical analysis fits into the general framework of this study.

CHARACTERISTICS AND DIMENSIONS OF THE DATA

Only five variables selected to predict land uses have interval scale (NEWCON, TECHCON, LANDAV, LANDVC, CEILCAP), i.e., they have continuous values. The remaining 8 variables are of nominal scale, which means that their values can only be ranked (1,2,3...., and 2 is bigger than 1); and the interval between two values is not measurable. However, the fact that these variables are of discrete nature does not diminish their value for the present analysis. The degree of information and the precision is sufficient for the variables under consideration, such as neighborhood quality, access to non-CBD areas, influence of parkland close to the station. They are only quantifiable within certain ranges and cannot be encountered with precise values, which would imply higher accuracy than legitimately can be expected. However, the handling of ordinal data makes statistical analysis in general more difficult. Measurements of central tendency and normality can only be determined within constraints.

Another problem is the non-linearity of the table functions. The attractivity scores, which are assigned to the environmental conditions found

FIGURE 6.3-4
CONCEPT OF
STATISTICAL
ANALYSIS



around the stations, decrease rapidly to zero when the characteristics are not favorable. If the conditions are favorable, the attractivity scores increase, but at a reduced rate. After a certain threshold, the value of the variable remains at the maximum level (because the sewer system, for example, is limiting, if the capacity is exhausted, but excess capacity of the system will not attract more apartments). Again, most statistical analyses handle poorly non-linear data.

SELECTION OF STATISTICAL TECHNIQUES

Two criteria were used in selecting the statistical methods. First, the above-described characteristics of the data (non-linearity, ordinal scale, dynamic entities). Second, those methods were sought which yield most explicitly the relationships among variables. That means, for example, that correlation does not satisfy these criteria well, because the single indicator (correlation coefficient) gives only information on the "fit" in a highly abstracted manner.

The flow chart in Figure 6.3-6 shows the analytical methods chosen and the sequence of analysis. Most of the computer programs used are contained in the manual "Statistical Package for Social Science" (SPSS).[1]

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1. Nie, et.al., (1970).

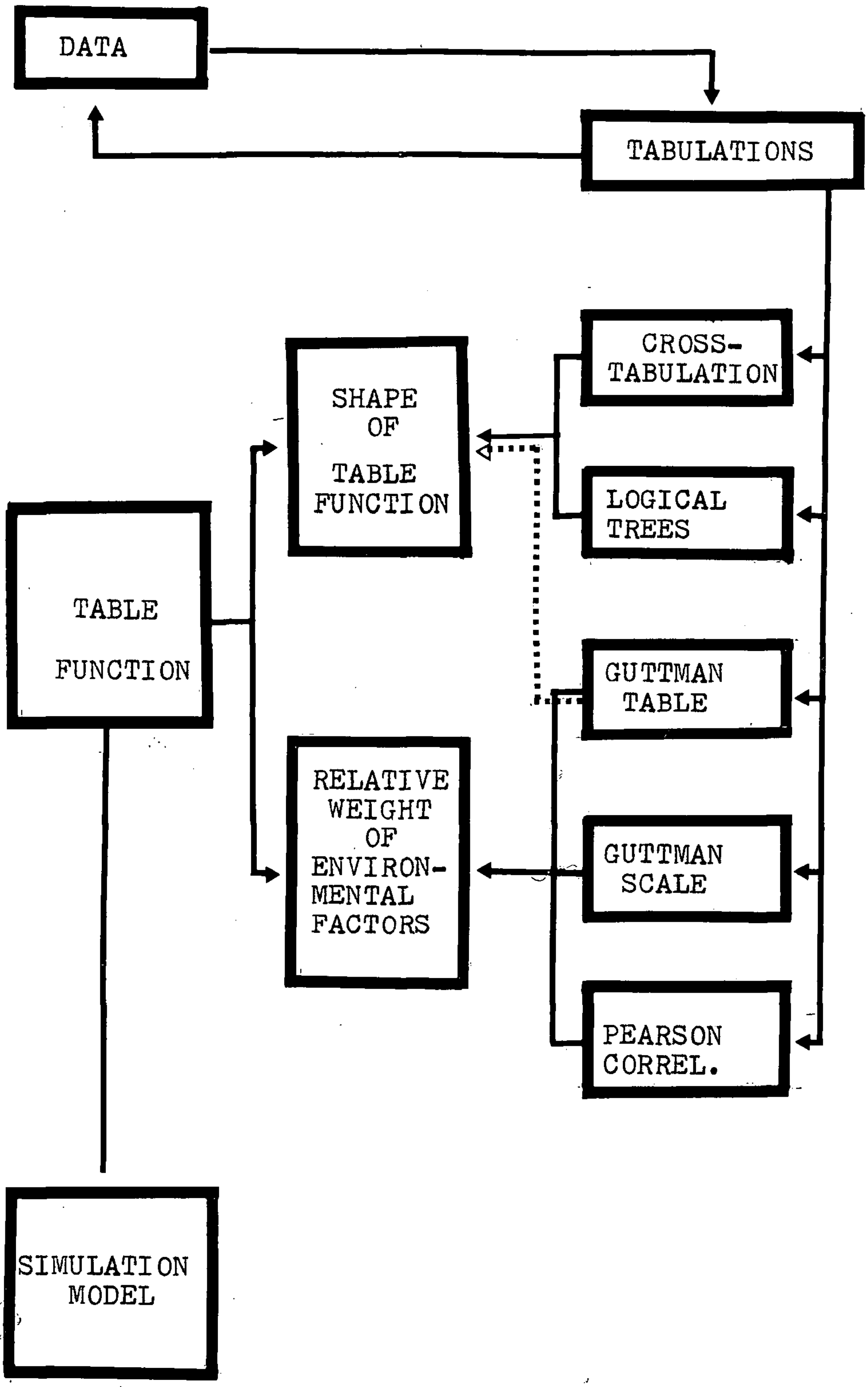

FIGURE 6.3-6
SEQUENCE OF
ANALYSIS

OBJECTIVES OF STATISTICAL ANALYSIS

The main objective of statistical analysis was to determine the shape and weight of the environmental factors in determining the number and location of apartments to be built. The weights, indicating the relative importance of environmental factors are necessary because the attractivity scores in the table functions are (for practical reasons[1]) normalized - that means they all have the same weight. The relative importance of the environmental factors is obtained by multiplying the table function values obtained for a given station sub-area by the appropriate weight.

Figures 6.3-7A and B demonstrate the effect of the weight. The normalized environmental factor "lot size" is "squeezed" by multiplying it with its weight 0.2 (assumed weight).

RESULTS OF STATISTICAL ANALYSIS

The statistical analyses were performed for each subway line separately in order to find out whether different table functions should be applied to the different corridors. Based on the results it was decided to use in the present analysis the same functions for all lines. However,

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1. In determining the values of a table function, it is difficult to comprehend at the same time shape and weight, because the weight varies for the variables and deforms the picture of the function.

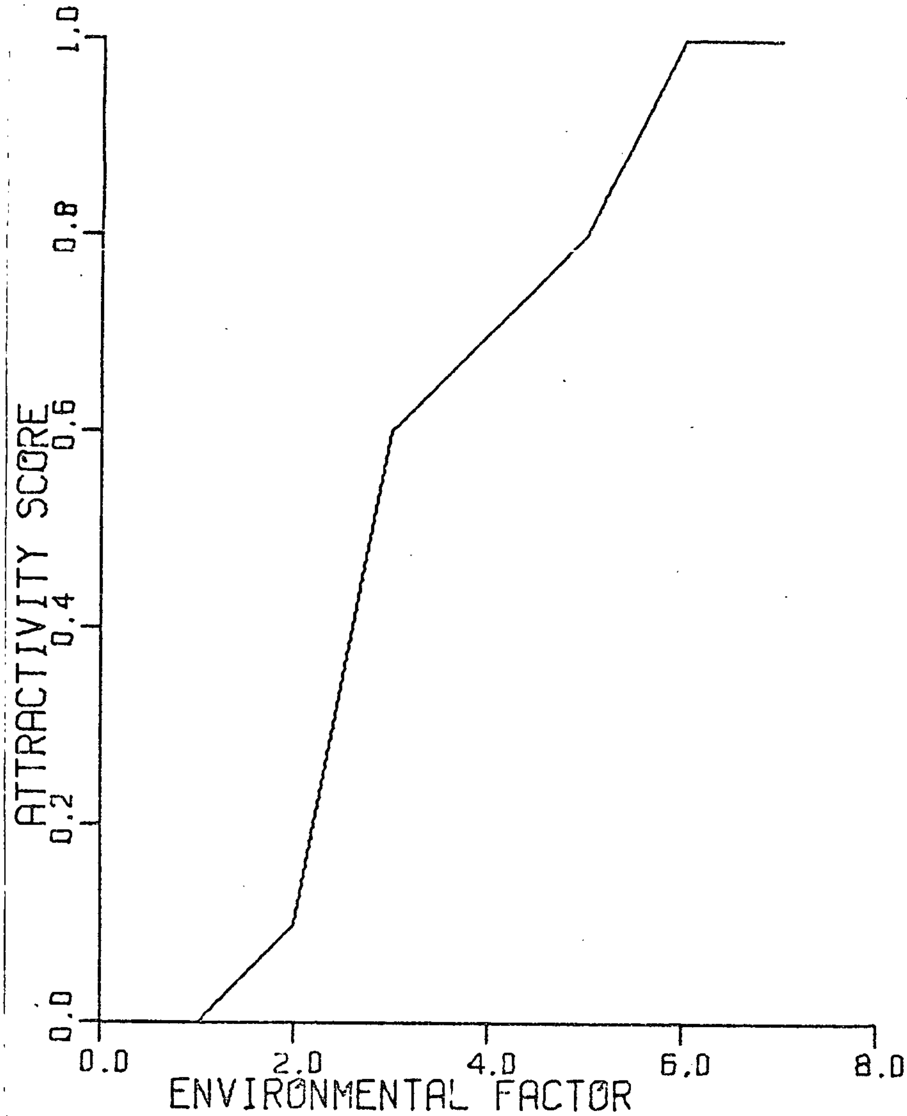

FIGURE 6.3-7A

TABLEFUNCTION LOTSIZE

A NORMALIZED ATTRAC-TIVITY SCORES, UNWEIGHTED

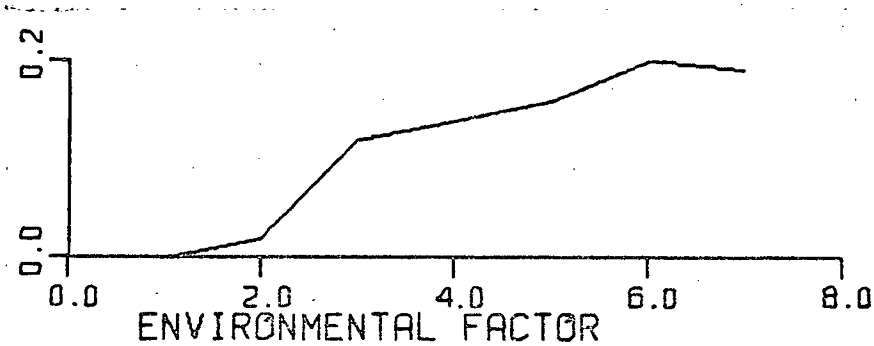

FIGURE 6.3-7B

TABLEFUNCTION LOTSIZE

B WEIGHTED ATTRACT-IVITY SCORES

a differentiation could easily be introduced during simulation by multiplying the attractivity scores of the station sub-areas of each line by coefficients. Therefore any number of environmental factors or their corresponding attractivity scores could be modified for different lines or stations.

In Appendixes A.C-1 through A.C-3 brief descriptions of the statistical methods used and the summarized results are given. Based on these analyses both the first approximation of table functions presented in Chapter 4.3 and the relative importance (weight) of each environmental factor were refined. Table 6.3-I gives the list of weights attributed to the environmental factors for the calibration of the simulation model. Figures 6.3-8 through 6.3-20 depict the refined table functions. As it was noted earlier only five of the selected proxi-variables (NEWCON, TECHCON, LANDAV, LANDVC, CEILCAP) have interval scale and thus can assume any value between zero and the indicated maximum on the X axis. For the remaining 8 variables with nominal scale the continuous line of the graph is somewhat meaningless, for the model interprets only those predefined values which were used to "scale" the proxi-variables. That is 2.8, for example, for NEIGHQ does not correspond with any attractivity value on the Y axis since NEIGHQ waa defined as having a value on the nominal scale of 1,2,3,4 only.

TABLE 6.3-I

WEIGHTS OF ENVIRONMENTAL FACTORS

	Weight	
Environmental Factor	First Approximation from Literature and Empirical Evidence	Weight Adjusted After Statistical Analysis
Construction of new apartments	16	15
Technological constraints	3	2
Available land for new construction	3	4
Vacant land	12	11
Building age mixture	5	4
Neighborhood quality	12	10
Average lot size	12	13
Proximity to major open space	7	5
Surface accessibility	5	8
Measurement of nodality	5	7
Zoning	9	10
Ceiling capacity	0	0
Commercial development	3	4
Undesirable conditions	8	8
	100	100

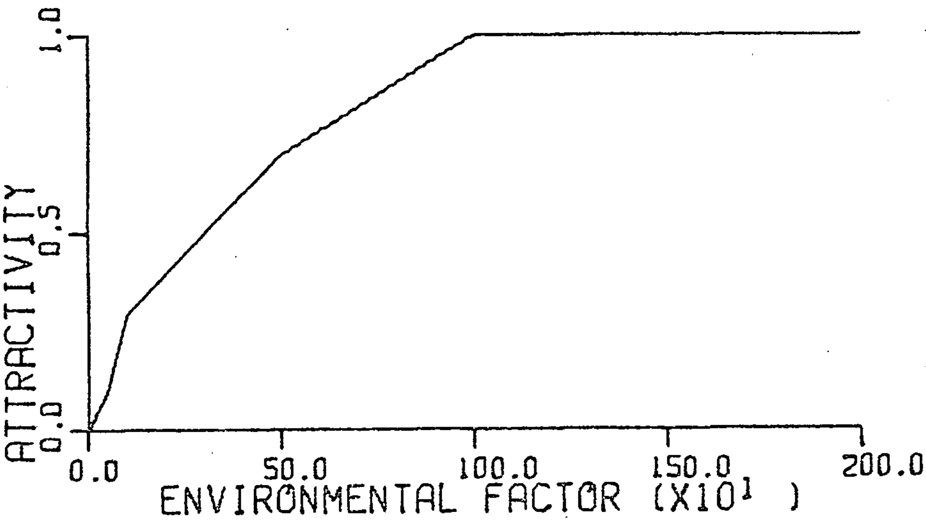

FIGURE 6.3-8
CONSTRUCTION
OF NEW
APARTMENTS

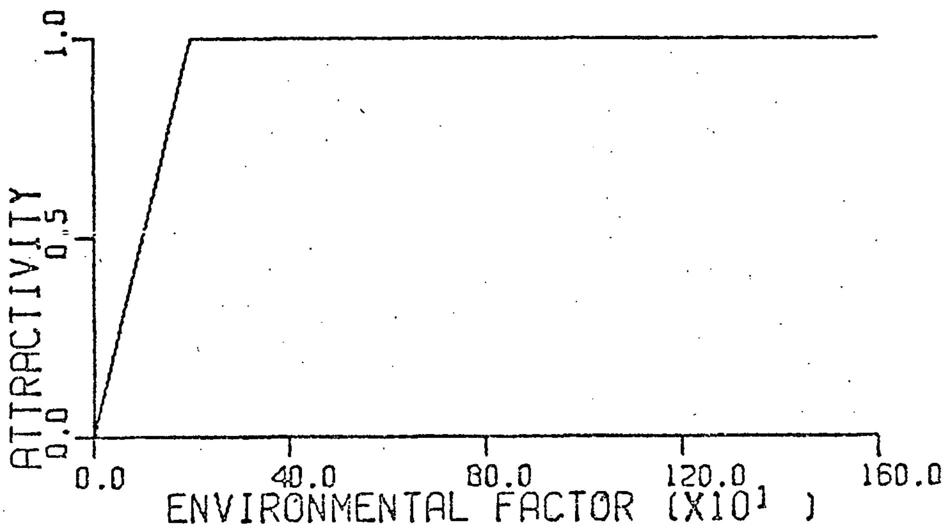

FIGURE 6.3-9
TECHNOLOGICAL
CONSTRAINTS

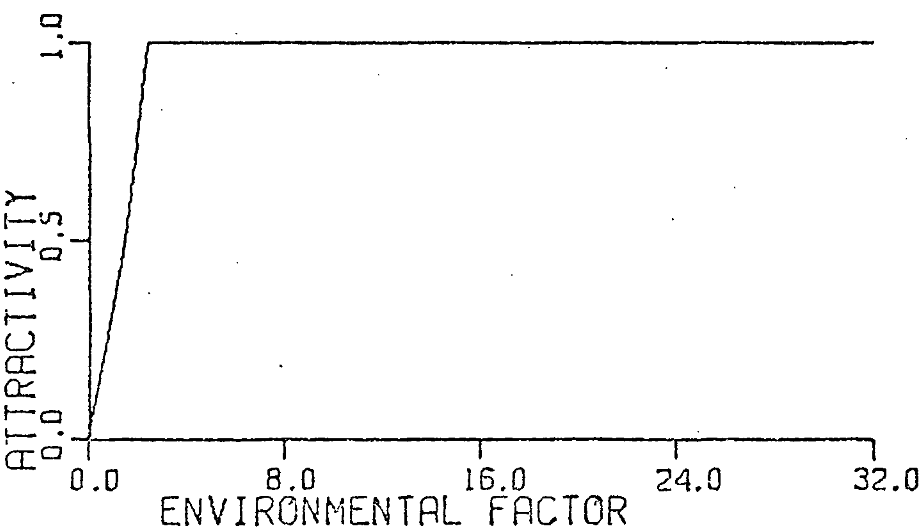

FIGURE 6.3-10
AVAILABLE
LAND FOR NEW
CONSTRUCTION

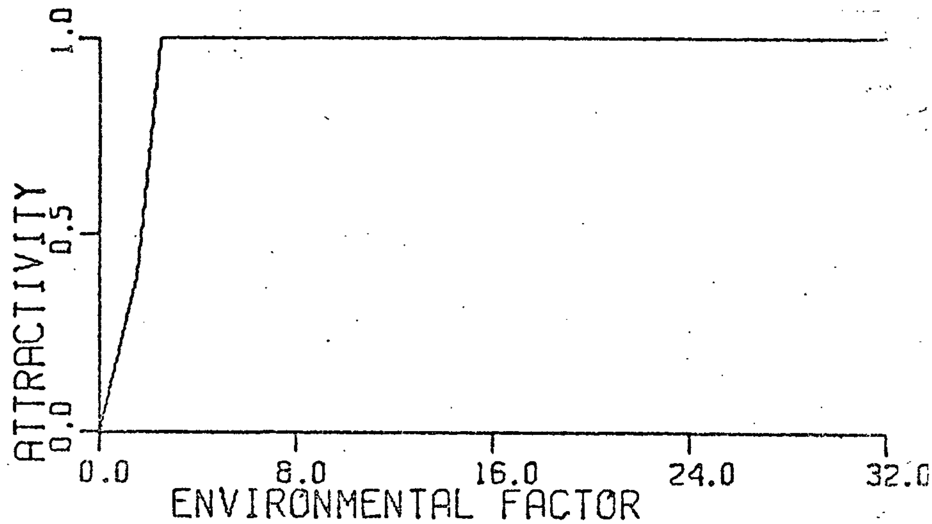

FIGURE 6.3-11
VACANT LAND

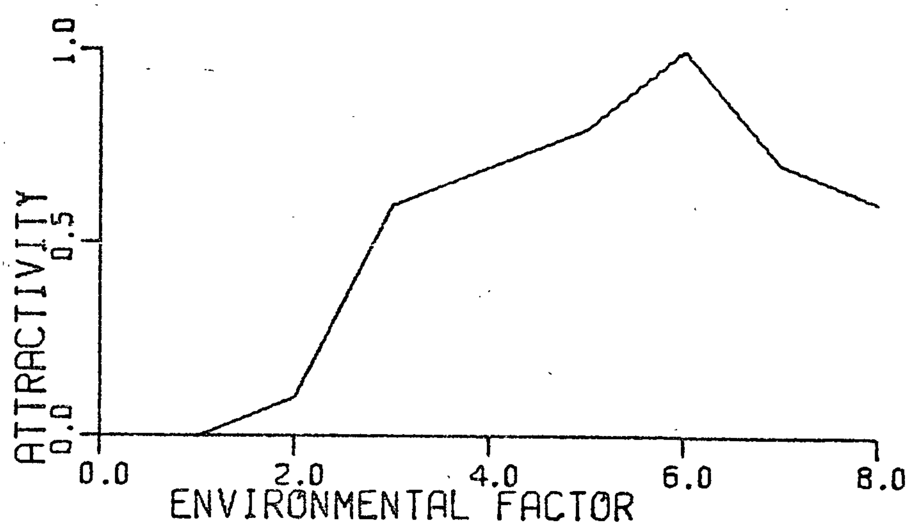

FIGURE 6.3-12
BUILDING AGE
MIXTURE

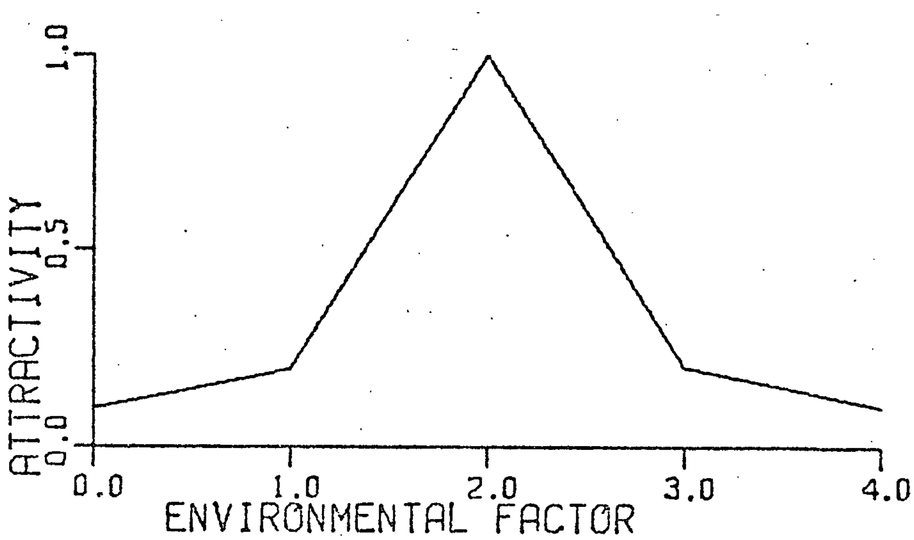

FIGURE 6.3-13
NEIGHBORHOOD
QUALITY

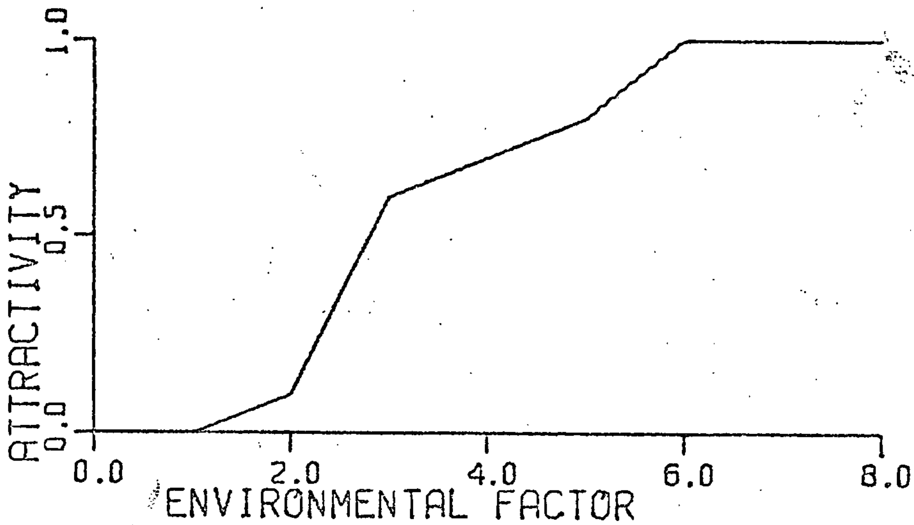

FIGURE 6.3-14
AVERAGE
LOT SIZE

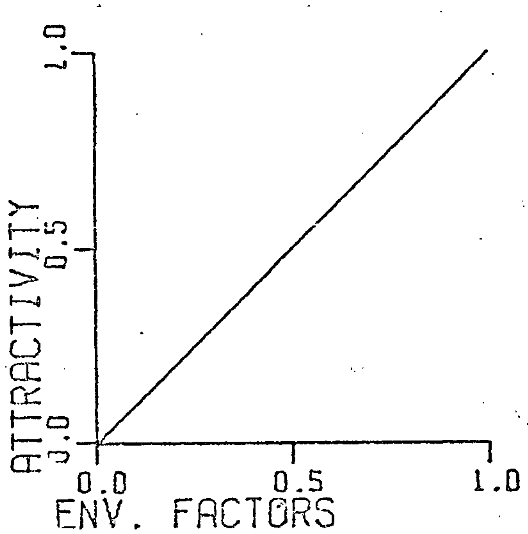

FIGURE 6.3-15
PROXIMITY TO
MAJOR
OPEN SPACE

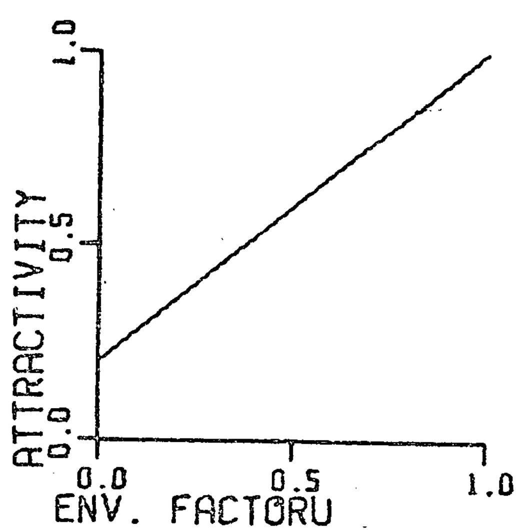

FIGURE 6.3-16
SURFACE
ACCESSIBILITY

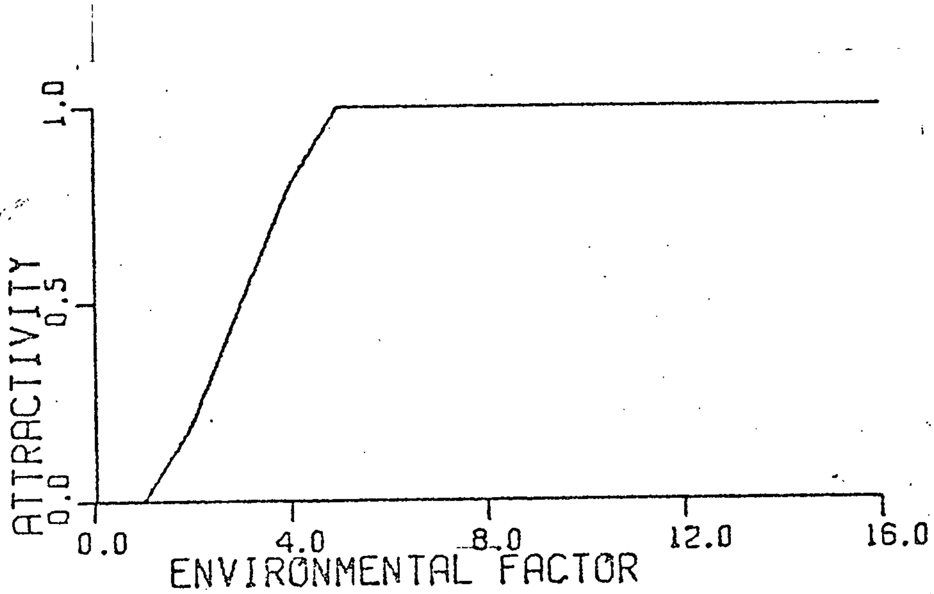

FIGURE 6.3-17
MEASURMENT
OF NODALITY

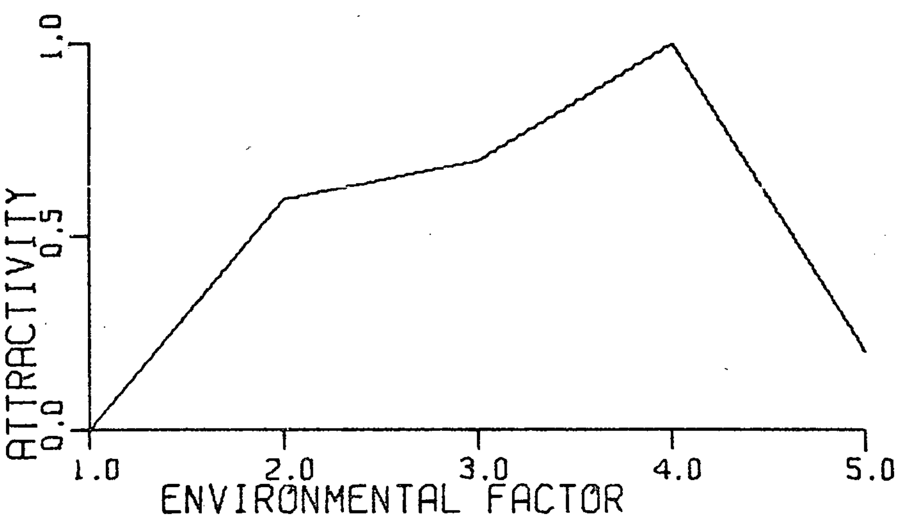

FIGURE 6.3-18
ZONING

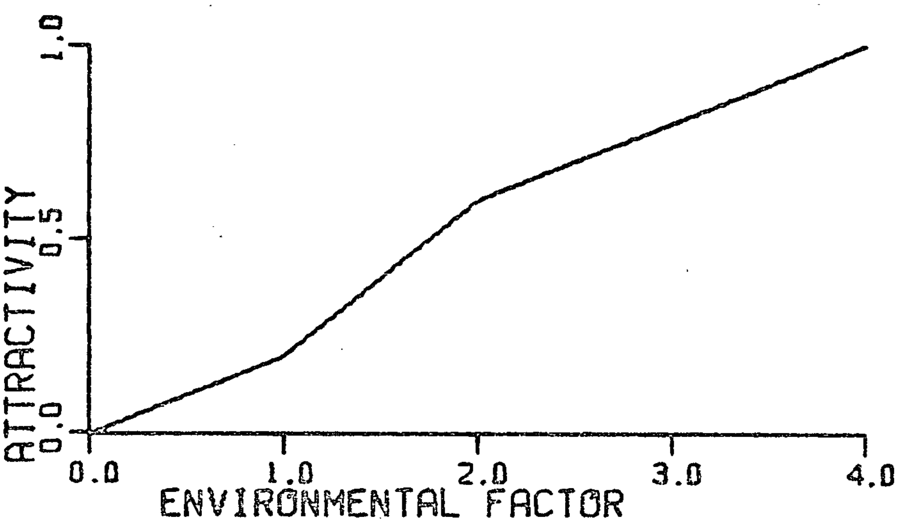

FIGURE 6.3-19
COMMERCIAL
DEVELOPMENT

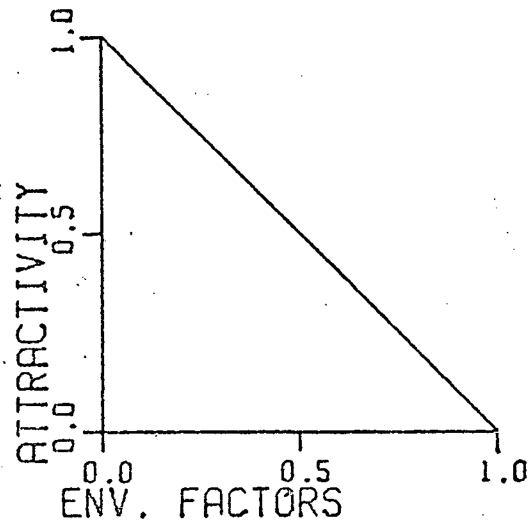

FIGURE 6.3-20
UNDESIRABLE
CONDITIONS

APARTMENT DEVELOPMENT

For the assignment of apartment growth to station sub-areas, a series of cumulative apartment development size functions were calculated in order to determine whether the magnitude of development sizes is changing over the years. The analysis was first made for the apartment building size (dwellings per single apartment structure, see chapter 6.2). However, for the simulation, the apartment development size had to be analyzed - i.e., the number of dwelling units built per station sub-area. This was necessary because growth is assigned to sub-areas, and not to city-blocks or individual properties (see discussion on aggregation in the next chapter). Figure 6.3-21 shows the time spans for which the apartment development functions were calculated.

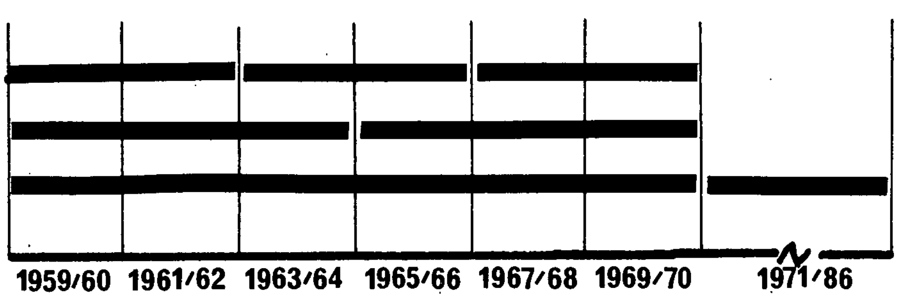

FIGURE 6.3-21 TIME PERIODS OF ANALYSIS OF APARTMENT DEVELOPMENT SIZE DISTRIBUTION

Figures 6.3-22 to 6.3-28 depict the apartment development size distribution. They clearly demonstrate the increasing scale of apartment developments over time. The apartment development size increased at a higher rate than the apartment building size. For the simulation, four size functions were chosen - 1959-63, 1964-67, 1968-70 and 1971-86.[1]

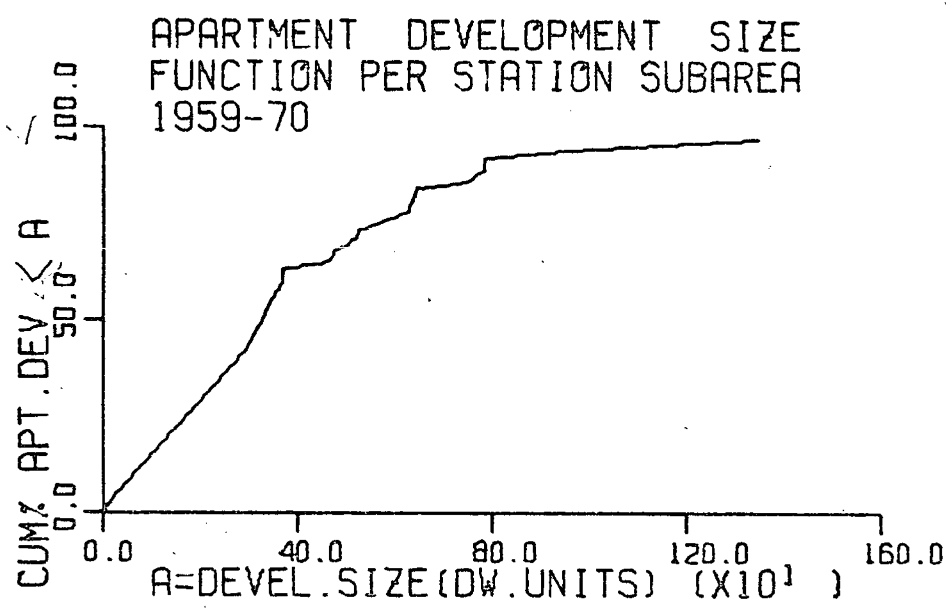

FIGURE 6.3-22
APARTMENT DEVELOPMENT SIZE FUNCTION PER STATION SUB-AREA 1959-1970

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1. In addition, the simulation model contains an option which weights the development size functions according to the overall attractivity of the various subway lines in each year (see Chapter 7.1).

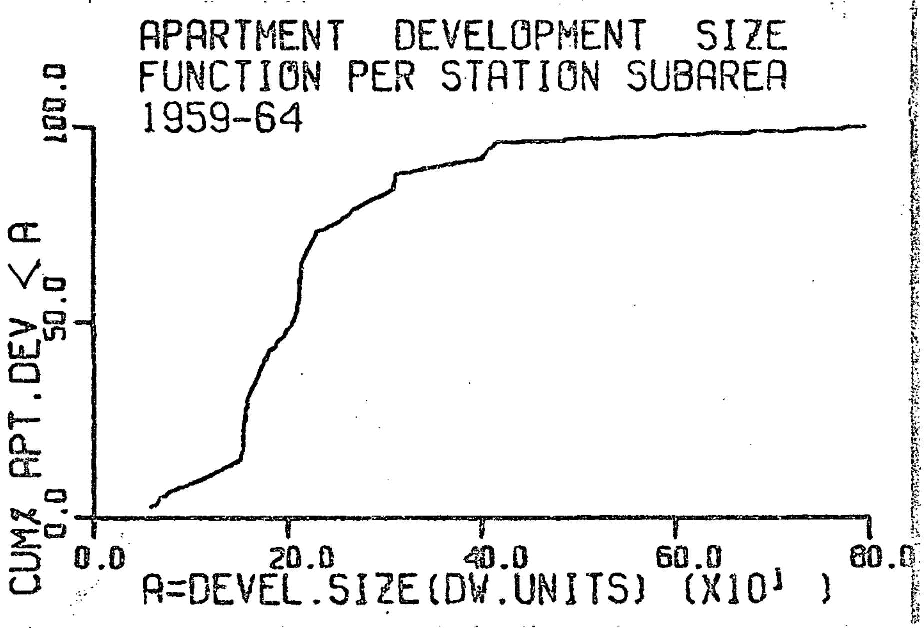

FIGURE 6.3-23
APARTMENT
DEVELOPMENT
SIZE FUNCTION
PER STATION
SUB-AREA
1959-1964

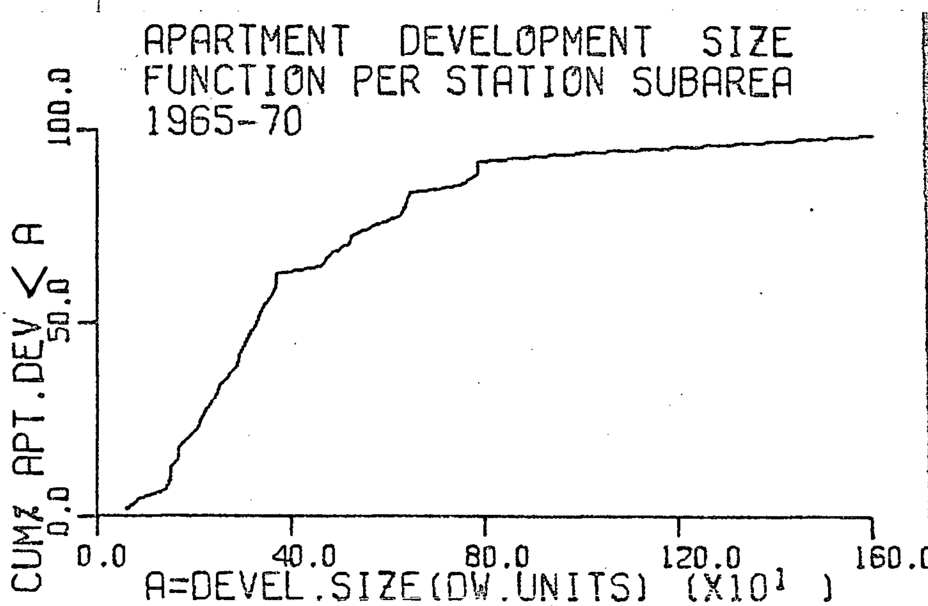

FIGURE 6.3-24
APARTMENT
DEVELOPMENT
SIZE FUNCTION
PER STATION
SUB-AREA
1965-1970

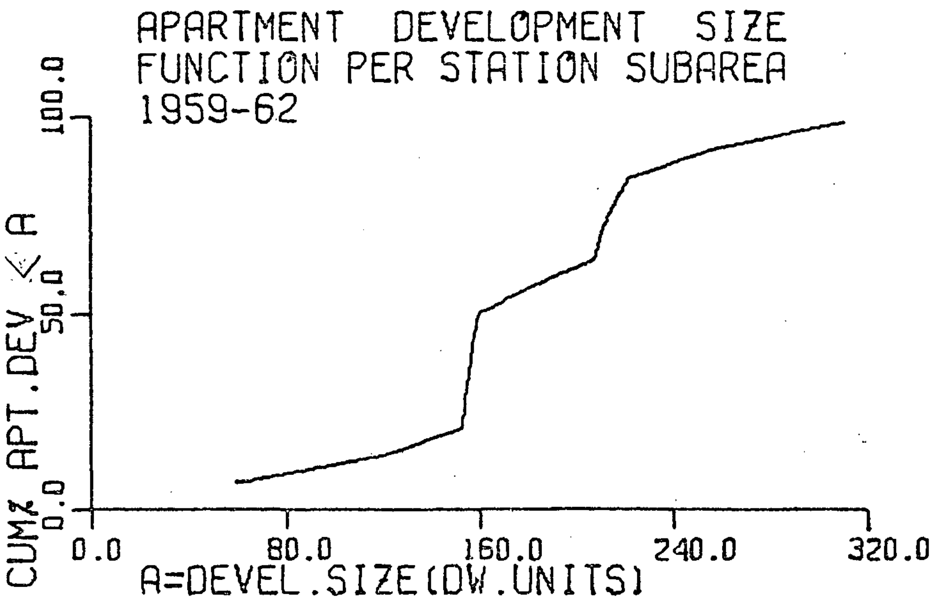

FIGURE 6.3-25
APARTMENT DEVELOPMENT SIZE FUNCTION PER STATION SUB-AREA 1959-1962

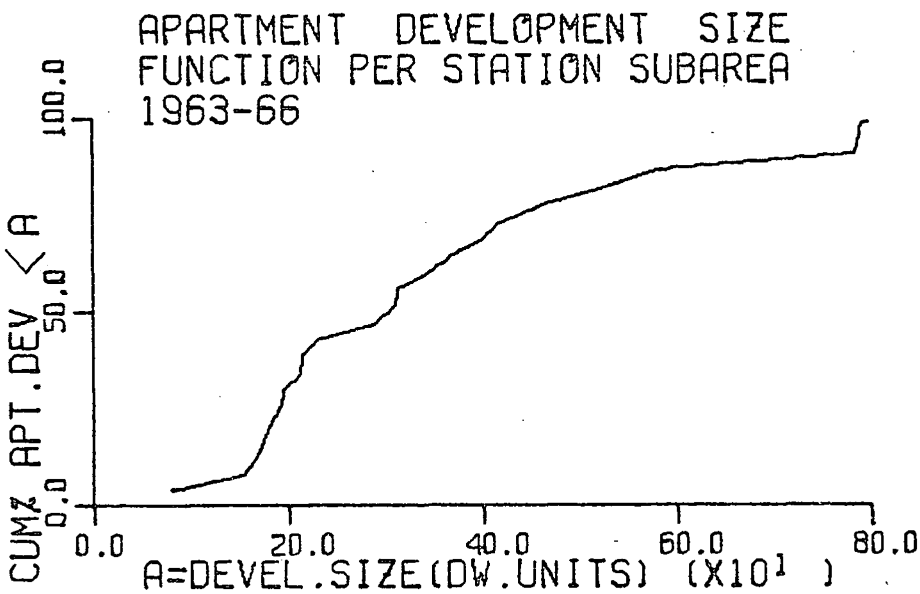

FIGURE 6.3-26
APARTMENT DEVELOPMENT SIZE FUNCTION PER STATION SUB-AREA 1963-1966

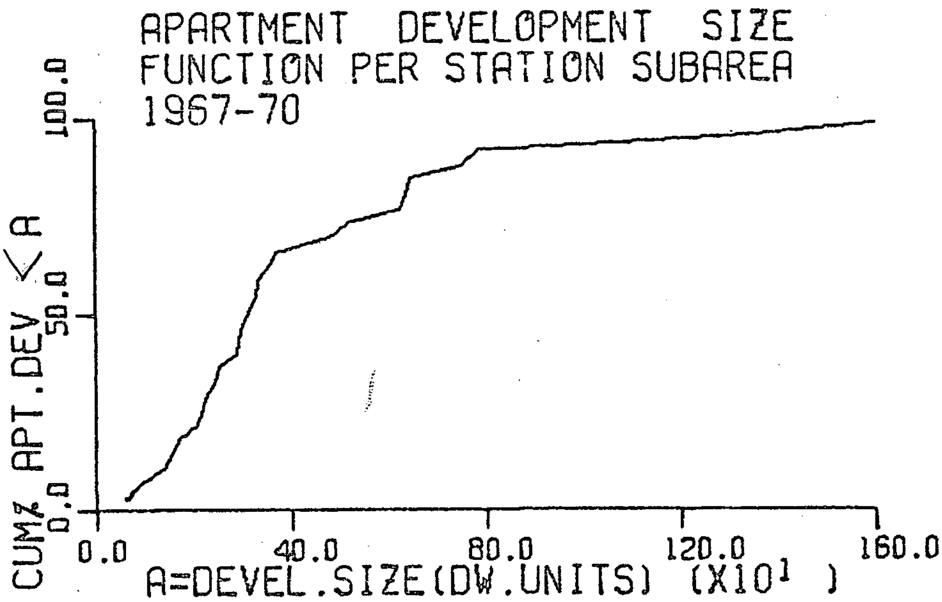

FIGURE 6.3-27
APARTMENT DEVELOPMENT SIZE FUNCTION PER STATION SUB-AREA 1967-1970

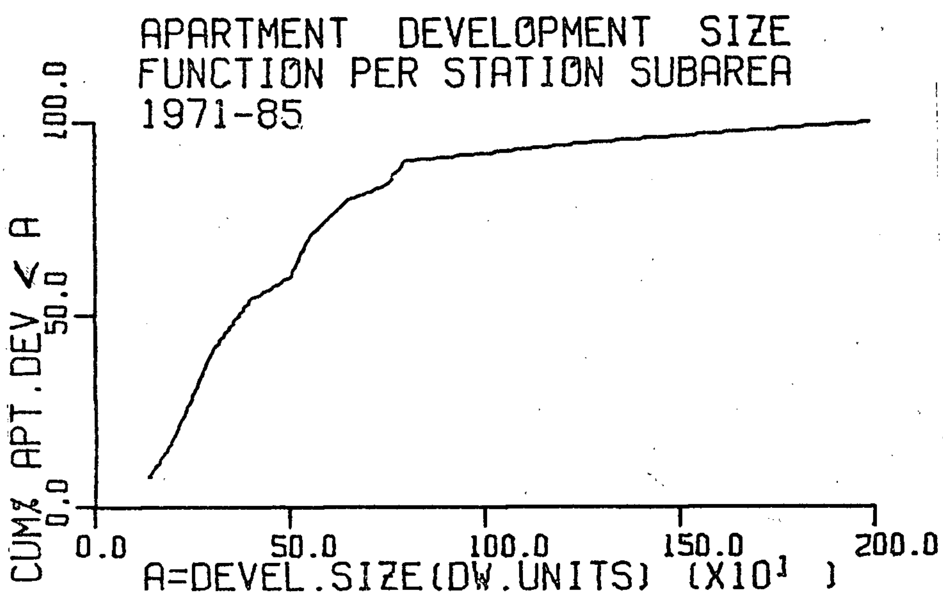

FIGURE 6.3-28
APARTMENT DEVELOPMENT SIZE FUNCTION PER STATION SUB-AREA 1971-1985

Boorse, J.W., (1968), Rapid Transit in Canada, Almo Press, Philadelphia.

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7

simulation model

This chapter presents in its first part the model structure, the functioning of the model and the characteristics of the program written for the simulation. In the second part, the model calibration is described. The third part presents the sensitivity analysis and forecast runs made with the model to test alternative policies, and the last part summarizes and criticizes the modelling approach.

A list of abbreviations and codes used in the model precedes this chapter. Details of the model (the full program and part of the results) are contained in Appendices A.a-1 to A.a-7.

ABBREVIATIONS
CODES
SYMBOLS

The fourteen environmental factors are grouped under three headings: dynamic, static and policy/intervention variables. The chosen taxonomy represents not in all cases how the variable behaves in 'reality'. The classification rather indicates how the variables were treated in the present version of the model.

ENVIRONMENTAL FACTORS

Dynamic Variables:

NEWCON = Construction of new apartments.

TECHNC = Technological constraints.

LANDAV = Available land for new construction.

LANDVC = Vacant land.

Static Variables:

BUILAG = Building age mixture.

NEIGHQ = Neighborhood quality.

LOTSIZ = Average lot size.

PARKLD = Proximity to major open space.

Policy and Intervention Variables:

SURACC = Surface accessibility.

NODAL = Measurement of nodality.

ZON = Zoning.

CEICAP = Ceiling capacity.

COMDEV = Commercial development.

UNDCON = Undesirable conditions.

SUBWAY LINES

CODE	SUBWAY LINE	SIMULATION PERIOD WHEN LINE CAME INTO OPERATION
YONGE	Yonge	1
BWO	Bloor West Old	4
BWN	Bloor West New	5
BEO	Bloor East Old	4
BEN	Bloor East New	5

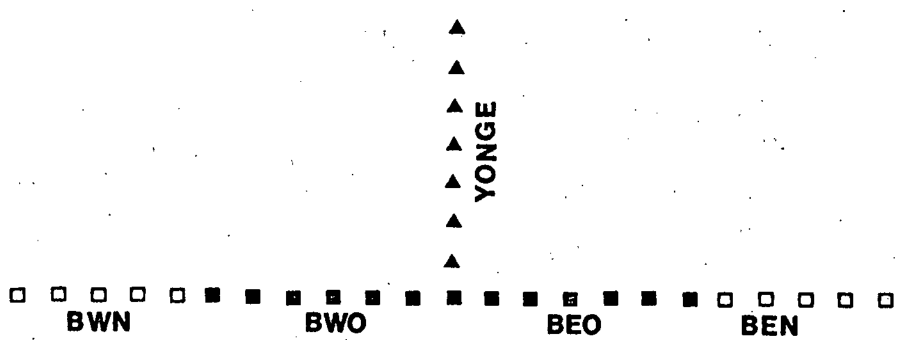


FIGURE 7-1
SUBWAY LINES

STATION CODE

Each Station Sub-Area has a code which indicates to which line and station it belongs. See Figures 7-2 and 7-3.

Station Sub-Area Number (X,Y,ST,SA)

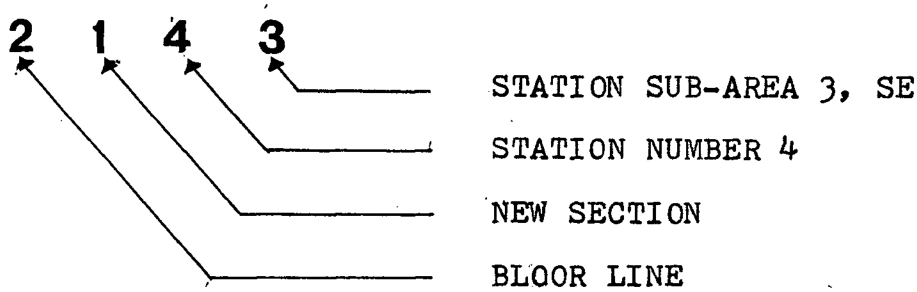
X Line (e.g. BLOOR)

Y Subline (e.g. 'old' or 'new')

ST Station

SA Station Sub-Area

<u>Example:</u>



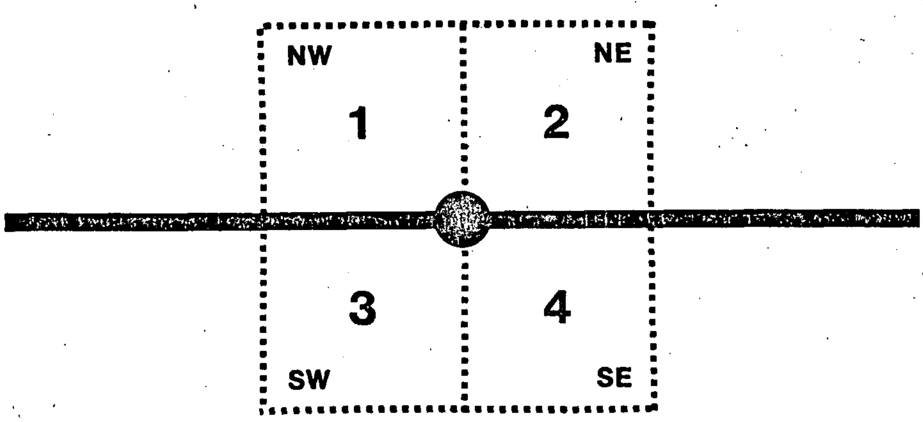


FIGURE 7-2
STATION
SUB-AREA
CODE

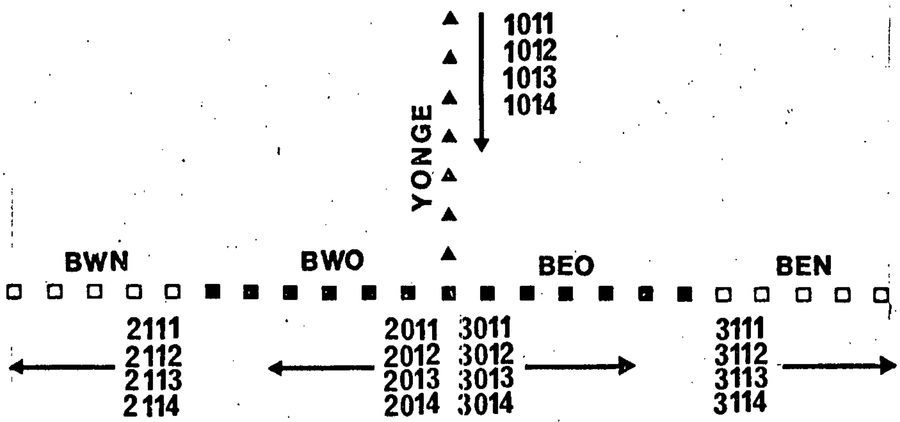


FIGURE 7-3
STATION
CODE

ACTUAL AND SIMULATED GROWTH

In all symbols,

E indicates actual apartment growth,

S indicates simulated apartment growth.

MOVING AVERAGES FOR MODEL EVALUATION

E(X,Y) = Number of apartments ~~actually~~ built over X time periods with time period Y as center of the moving average (in dwelling units). See Figure 7-4.

S(X,Y) = Number of apartments simulated.

X Number of time periods over which the moving average is calculated (X can be 2, 3, or 5, indicating the moving average two, three and five respectively).

Y Time period which is the center of the moving average.[1]

Example: E(3,4) = Moving average 3, i.e. number of dwelling units actually built over the three time periods 3, 4 and 5, 4 being the center of the average.

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1. For the moving average two, Y is the starting period of summation.

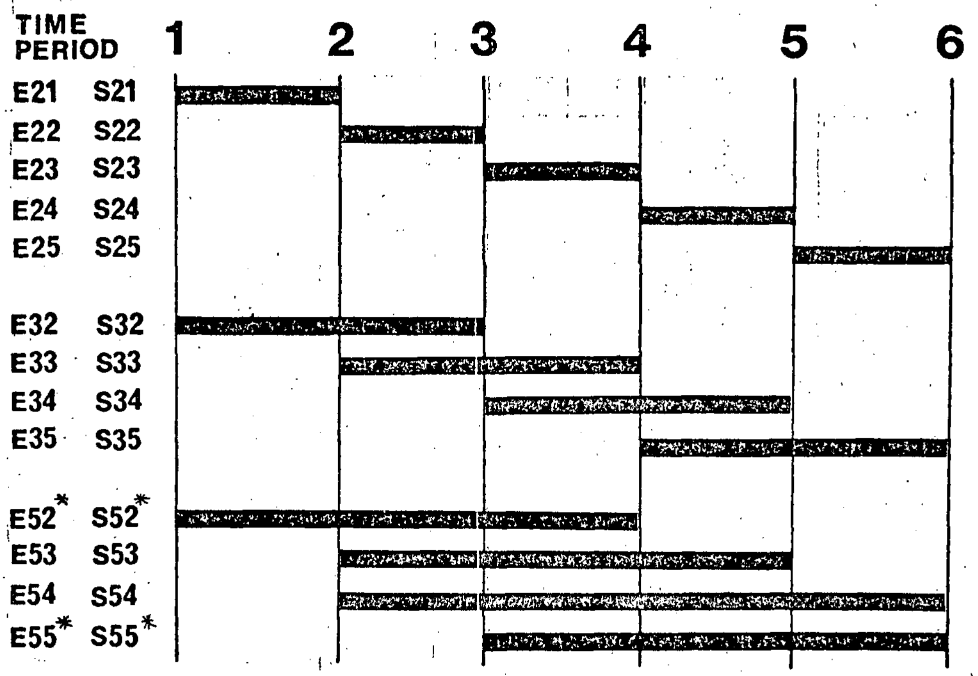


FIGURE 7-4

MOVING AVERAGES FOR MODEL EVALUATION

* The moving averages 52 and 55 cover only four time periods; otherwise, however, they follow the conventions of the moving average 5. Their center period is 2 and 5 respectively.

7.1

MODEL DESCRIPTION

The model is described in three stages:

i. model structure

ii. functioning of model

iii. program structure and characteristics.

MODEL STRUCTURE

Figure 7.1-1 illustrates the general model structure with the first and second-order distribution process for land use. The first-order distribution allocates land uses at a city scale primarily as a function of the accessibility surface. The second-order distribution assigns land uses and activities to station sub-areas within the transportation corridor based on the environmental conditions of the stations.

The specific structure of the simulation model designed for this thesis is shown in Figure 7.1-2. The model treats a single land use - high density residential - defined for this purpose as a high rise structure of more than 4 storeys and situated normally within a 2.5 density zoning area (for zoning definitions see chapter 6.2). The environmental factors determining the growth distrubution within the transportation corridor are grouped into three categories:

i. dynamic variables (feedback)

ii. static variables

iii. policy and intervention variables.

The taxonomy chosen does not represent in all cases how the variables behave in 'reality'. As discussed below, some simplifications were made for the present version of the model. Therefore, the classification represents how variables were treated in the model.

DYNAMIC VARIABLES

i. Dynamic variables alter as a function of the dependent variable (apartment growth) and therefore their contribution to the attractivity of a station sub-area changes whenever a station receives growth in a time period. The first variable, NEWCON, is the cumulative number of apartments per station sub-area (including apartments built before 1959). The second variable, TECHNC, is a summary variable for all technological constraints and reduces the attractivity of an area as soon as one of the constraints is approached, i.e. if the capacity

FIGURE 7.1-1
GENERAL
MODEL
STRUCTURE

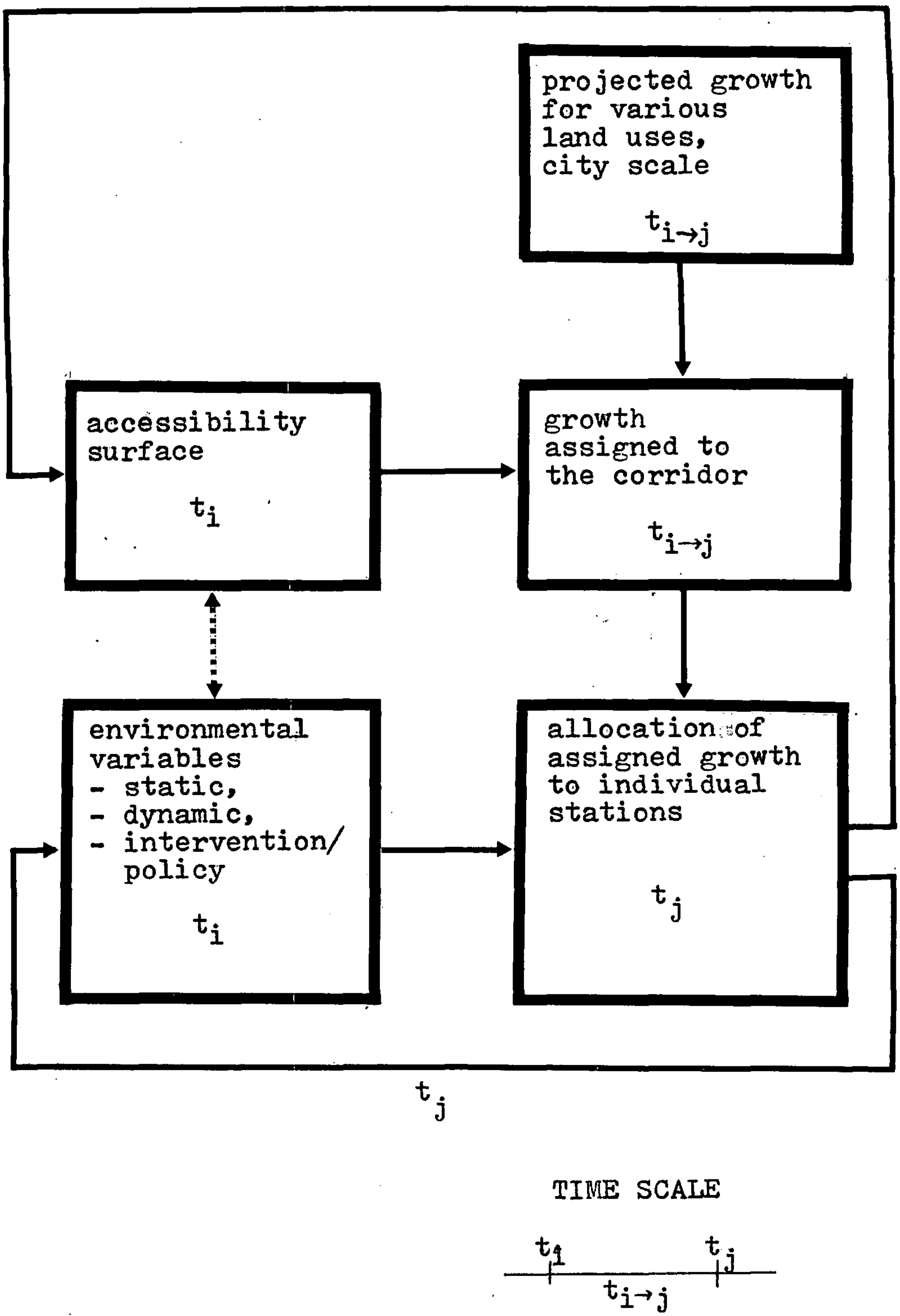
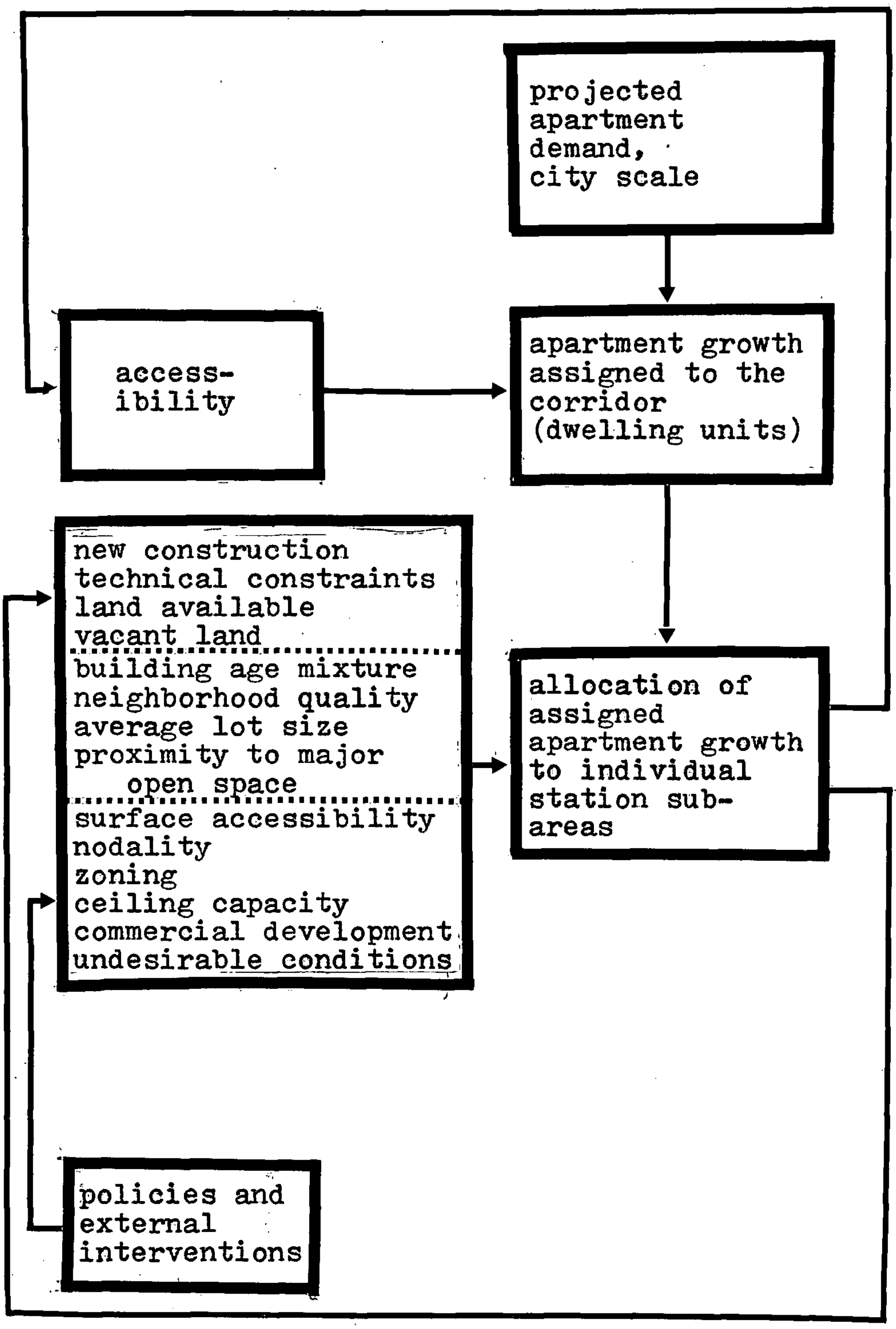


FIGURE 7.1-2
SPECIFIC
MODEL
STRUCTURE



is used up. TECHNC is expressed in dwelling units (i.e., number of dwelling units which can be served by sewer, schools, etc.). The third and fourth dynamic variables express the stock of available land (LANDAV, in acres) and vacant land (LANDVC, in acres) left in any time period for apartment development.

STATIC VARIABLES

ii. The static variables - average lot size (LOTSIZ), proximity to major open space (PARKLD), neighborhood quality (NEIGHQ), and building age mixture (BUILAG) - although not changing over time, alter their relative contribution to the station attractivity over time.

Only the first two of these variables can in fact be considered static. In a relative highly developed urban environment as one finds along the subway lines, the average lot size does not change before a developer moves in for land assembly (at which time he is already committed for development) and no major open space can be expected to be created in the proximity of the stations. Neighborhood quality, which was felt to be a crucial variable for apartment development was nonetheless treated as static. This was for the simple reason that the present state of the art in social and behavioural research allows hardly to qualify and describe a thing called 'neighborhood quality';[1] much less can it be predicted.

The building age mixture does not change over time, because this variable applies only to the remaining land suitable for apartment development, therefore excluding the land area newly developed for apartments during simulation. (The influence of new apartment construction is considered in a separate variable NEWCON which expresses the pooling effect). It would be desirable to include explicitly the filtering process into the model because, although the bias possibly introduced in the model is a systematic one, i.e. applies to all stations, the filtering process exhibits a threshold behaviour. That means that the attractivity scores of this variable would diminish much later in station areas with generally young housing stock than in old areas.

INTERVENTION AND POLICY VARIABLES

iii. Policy and intervention variables can both be altered externally to allow interaction with the development process. They can be changed during the run of the simulation at a computer terminal, if desired, taking into account results

1. For that reason, a very crude and intuitive assignment of values for this variable had to be applied, as discussed in Chapter 6.2.

of the aprtment distribution of previous time periods.[1] This has two purposes. Alternative policies can be tested as they are introduced by politicians, planners, etc., <u>over time</u>. Some of these decisions are not known at the outset of a simulation which covers a relatively long time period because actions taken are influenced by the developments occurring subsequently. Other intervention variables, such as commercial development (COMDEV) and surface accessibility (SURACC),[2] serve in addition as a corrective mechanism in the present stage of the model. Because the model does not treat other land uses internally, feedback from developments in other activity sectors must be entered into the model through intervention.

Ceiling capacity is a dummy variable and does not contribute directly to the station attractivity. It serves to simulate policy decisions to improve

---

1. The necessary information is printed out during the simulation, after each time period.
2. It must be emphasized that this variable expresses <u>not</u> the accessibility to the downtown as this is already accounted for when apartment growth is assigned to the subway corridors. The variable SURACC expresses the accessibility to the rest of the metropolitan area, i.e., for recreation, shopping, etc. Its values were estimated rather crudely, based on the present and future highway network and the activity centers.

or add services (schools, sewers, etc). The additional capacity is transferred by the model to the dynamic variable; technological constraint (TECHNC).

FUNCTIONING OF THE MODEL

The model has basically three dimensions, as shown in Figure 7.1-3:

i. Time dimension

ii. Spatial dimension (subway lines, stations, station sub-areas)

iii. Environmental qualities.

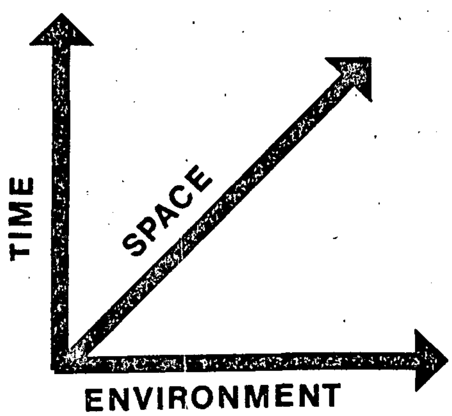


FIGURE 7.1-3 DIMENSIONS OF MODEL

However, because of the stratification of the spatial dimension by line, station and station sub-area, a five-dimensional array is used in the model.[1] When the model was designed, a reasonable

1. Or in other words, sets of at least five nested do-loops were in the program.

choice had to be made as to the maximum number of items to provide for in each dimension. This choice was governed on the one hand by the desire to make the model generally applicable, i.e. to other cities with different number of lines and stations, and on the other hand to allow for the inclusion of subway extensions (additional lines and/or stations) over time. The upper limits of the dimensions were made by considering the efficiency of programming (and therefore cost of model runs) and the expected dimensions of a future subway network may have. Table 7.1-I indicates the upper limit of items per dimension for the present model and Table 7.1-II the dimensions of the simulated system in Toronto.

PROGRAM STRUCTURE

Figure 7.4-1 depicts the elements of the model, the relationships and feedback among them and the logical structure. Figure 7.1-5 illustrates the general program structure. The functions and the calculations performed by the program and its subroutines are summarized briefly below. Additional details and the full program write-up is contained in Appendices A.a-1 through A.a-5.

TABLE 7.1-I
DIMENSION LIMITS OF THE MODEL

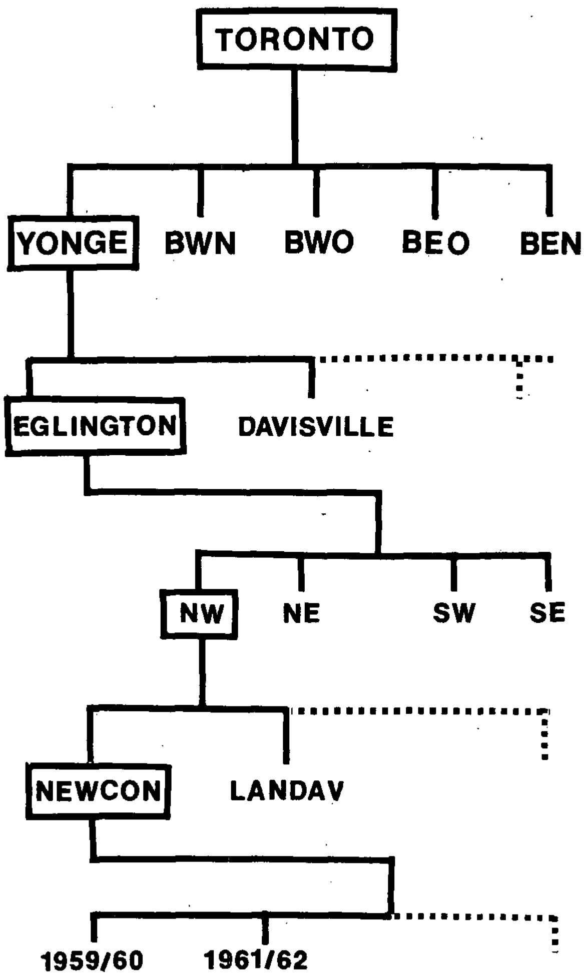
DIMENSION	MAXIMUM NUMBER OF ITEMS PER DIMENSION
Lines*	5
Stations per line	30
Sub-areas per station	4
Environmental factors	14
Time Periods**	14

* Lines can be extended in two ways: they can receive additional stations at the end of the line or can split into two or more branches.

** The length of the time periods can be assumed. For Toronto, two years were chosen which relate to the average apartment development cycle, i.e. the time between application for building permit and completion of construction.

TABLE 7.1-II
DIMENSIONS OF
THE TORONTO
SUBWAY SYSTEM

DIMENSIONS	NO. OF ITEMS
SPATIAL	
City	1
Line	3*
Station	42
Sub-area	128
ENVIRONMENTAL	14
TIME	14



* BWN and BEN were not treated as new separate lines but as extensions of the lines BWO and BWN respectively. That means that in future additional lines could be included in the simulation.

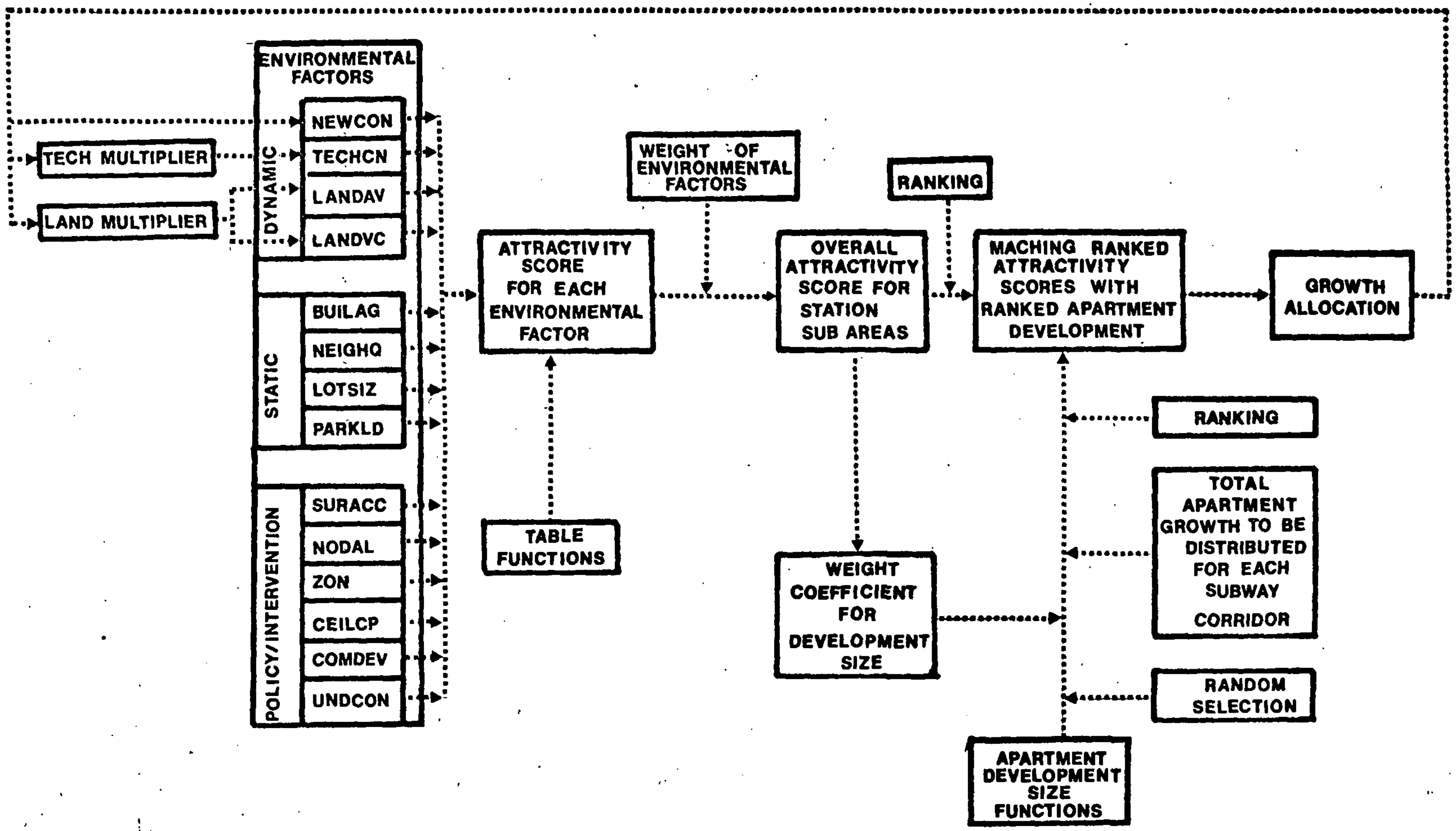
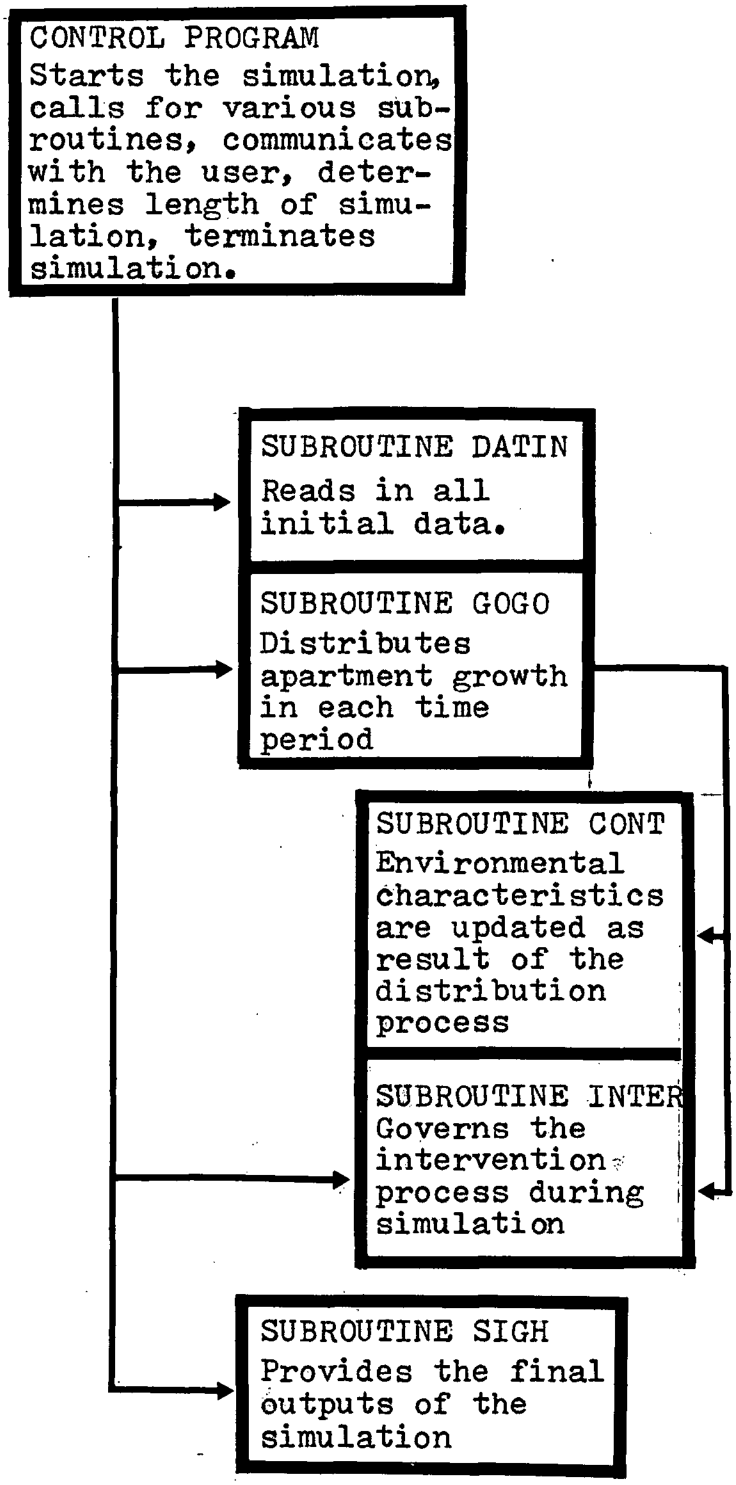


FIGURE 7.4-1
ELEMENTS AND RELATIONSHIPS OF THE MODEL

FIGURE 7.1-5
GENERAL
PROGRAM
FLOWCHART



CONTROL PROGRAM

CONTROL PROGRAM

i. The control program askes the user:

- to enter a random number seed (for the selection of apartment development sizes),
- how many time periods he wishes to simulate initially,
- if he wants to adjust the apartment development sizes along each subway line as a function to the overall attractivity of that line (as compared to all other lines. See subroutine GOGO),
- after each time period, if he wishes to interact,
- after the number of time periods initially and subsequently specified, if he wishes to continue the simulation and for how many periods,
- when the user wishes to finish the simulation or after 14 time periods , and what version of output he wishes (see subroutine SIGH).

This is followed by the indication of the successful end of the simulation. In addition, the control program governs the calling of the various subroutines throughout the simulation.

SUBROUTINE DATIN

ii. SUBROUTINE DATIN. This routine reads the folliwing initial data necessary for the simŭlation (from the input medium specified on the RUN command):

- X-Values of the points defining the table functions (values of environmental factors). The X-values are subsequently normalized.
- Y-Values (already normalized) for the table functions (i.e., attractivity scores assigned to specific environmental qualities; they assume values between 0 and 1).

- The relative weight of each environmental factor. (The sum of the weights is equal 100).

- Matrix with initial environmental characteristics of all station sub-areas. (The values must be smaller than the maximum X-value of the respective table function).

- Apartment growth to be distributed in each year and for each line (number of dwelling units).

- Apartment development size functions (exactly four, each to be applied for a specific number of simulation periods. Each function can be defined by a maximum of 60 points.

The subroutine signals many possible mistakes in the data set-up by error messages (which leads to immediate termination of the simulation). For purposes of checking, a listing of data can be obtained by choosing PAR=FULL.

iii. SUBROUTINE GOGO. This subroutine performs the following calculation necessary to distribute the apartment growth and to determine the development size in each time period: SUBROUTINE GOGO

- Normalizes the matrix of environmental characteristics (environmental conditions regarding all environmental factors of each station sub-area).

- Calculates the attractivity score for each value of the above matrix (according to the table functions).

- Weights the attractivity scores according to the relative importance of each environmental factor.

- Sums the attractivity scores for each station sub-area. This sum represents the composite or total attractivity for each sub-area. It assumes values between 0 and 1.

- Selects randomly the number and size of apartment developments necessary to provide for the specified growth of the given time period and line, using the apartment size function applicable in this time period.

- Adjusts the development size for each line, if chosen so by the user at the beginning of the simulation. The adjustment is made as a function of the overall attractivity of a given line as compared to all other lines. (The attractivity scores of each station sub-area is summed for each line and divided by the number of sub-areas of the respective line. The resulting value of each line is then divided by the biggest X which yields the adjustment coefficient. This coefficient assumes values smaller than 1 for all but the line with the highest overall attractivity, for which it has the value 1.

- Ranks the resultant apartment developments according to their sizes and assigns them in order of the highest to lower total attractivity to the station sub-areas, checking whether the land available at the station sub-area is sufficient to accommodate the assigned growth. (Otherwise the growth is assigned to the area with the next lower attractivity score).[1]

iv. <u>SUBROUTINE CONT</u>. This subroutine at the end of each time period adjusts the environmental characteristics of the dynamic variables NEWCON, LANDVC, TECHNC, LANDAV. If any of

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1. In this case, the station does compete for the remaining smaller apartment developments to be assigned in this or any following time period.

the latter two variables for any sub-area reaches the value when they begin to limit growth (i.e., not enough land available for future apartment development or services are inadequate, e.g., exhausted sewer capacity), the respective station sub-area is no longer available for apartment assignments in consecutive time periods.[1] If the user chooses in the RUN command PAR=FULL, then most of the results of the calculations in subroutine CONT and GOGO are printed out after each simulation period. A sample of this is given in Appendix A.a-3.

v. SUBROUTINE INTER. This subroutine governs the interaction process. After each time period, the user has the option of interacting with any one of the six policy variables for any of the station sub-areas. The subroutine asks the respective questions and replaces the newly entered environmental characteristics in the matrix. The user is informed, for each interaction, of the old value of the variable he intends to change and the range of values he may choose to enter. Any

1. If by interaction in a later time period additional services are provided, the station can enter the competition for growth again.

mistake during the interaction is countered by an error message, after which the correction may be entered. An example of the interaction process is given in Appendix A.a-4.

The remainder, more specific characteristics of the program (input/output units, RUN command, cost of simulation, error messages, etc.) are described in Appendix A.a-1.

7.2

MODEL CALIBRATION AND EVALUATION

There are two prerequisites for a successful application of a simulation model.

i. The model must be calibrated for a situation for which the outcoming, in this case the actual apartment growth, is known.

ii. The sensitivity of the model has to be tested in order to allow a judgement on the extent to which the model can be applied to other cases (cities) and other time periods (length of forecast period).

TOOLS OF MODEL ANALYSIS

In order to calibrate a model, the results of the model must be evaluated. This evaluation requires <u>analytical tools</u> which allow a comparison between reality and simulation and <u>criteria</u> of success, i.e., it has to be decided what degree of reproduction of reality is necessary and succifient as to accept the model. The following tools of evaluation were chosen; they all compare the outcome of the simulation with the actual apartment growth in Toronto for the years 1959-1970 (6 simulation periods).

i. Graphical presentation of the results in histograms.

ii. Comparison of the difference in percentage.

iii. Correlation analysis.

iv. Graphical presentation of correlation in scattergrams.

This set of evaluations were performed three times. After each evaluation, the model parameters were changed. It should be noted that the first run achieved fairly good results. The changes necessary during calibration were the following:

- changes in the table function for zoning,
- changes in the relative weights for five environmental factors.

The reason why only minor changes were necessary probably lies in the extensive statistical analysis which preceded the simulation and prepared the model inputs. The following Table 7.2-I summarizes the changes in weights.

CRITERIA OF MODELLING SUCCESS

For a growth distribution model, the following criteria might be used for the evaluation of success: the quality of the <u>distribution</u>, i.e., if the "right" stations received growth, the quality of <u>allocation</u> of growth, i.e., if the

TABLE 7.2-1

REFINED WEIGHTS OF ENVIRONMENTAL FACTORS

First Approximation from Literature and Empirical Evidence:

Environmental Variable	Weight: First Approx.	Weight: Adjusted after statis. analysis	Weight: Adjusted during model calibr.
Construction of new apartments	16	15	15
Technological constraints	3	2	1
Available land for new construction	3	4	3
Vacant land	12	11	11
Building age mixture	5	4	2
Neighborhood quality	12	10	12
Average Lot size	12	13	13
Proximity to major open space	7	5	1
Surface accessibility	5	8	8
Measurement of nodality	5	7	7
Zoning	9	10	11
Ceiling capacity	0	0	0
Commercial development	3	4	4
Undesirable conditions	8	8	12
TOTAL	100	100	100

"right" amount of apartments were assigned to station sub-areas, and the timing of allocation. All four evaluation tools listed above provide answers to both questions, however to a different extent. Each of the methods will be described briefly in the light of these differences. The results of the last (third) mode calibration are given, partly in this section, partly in Appendices A.d-1 to A.d-3.

HISTOGRAMS

The histograms allow a quick inspection of the results. As the sample in Figure 7.2-1 demonstrates, information is provided on which stations received how much growth (expressed in number of dwelling units and as a percentage of the total growth in a specific subway corridor and time period). The corresponding figures are given for the actual growth. Appendix C contains the full set of histograms and Appendix A the program for the plotting of the histograms.

FIGURE 7.2-1

```
S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1963/1964          TIME PERIOD   3
                                                          NO OF APARTMENTS
STATION                                                       ABSOLUT  %
          0 %        10 %        20 %        30 %       40 %       50

EGLIN NW                                                          0  0
GTON  NE XXXXXXXXXXXXXXXXXXXXXXXXXX                             389 26
      SW                                                          0  0
      SE                                                          0  0
DAVIS NW                                                          0  0
VILLE NE                                                          0  0
      SW XXXXXXXXXXXXXXXXXXX                                    281 19
      SE XXXXXXXXXXXXX                                          198 13
ST.   NW                                                          0  0
CLAIR NE XXXXXXXXXX                                             158 10
      SW                                                          0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXX                          425 29
SUMME NW                                                          0  0
RHILL NE                                                          0  0
      SW                                                          0  0
      SE                                                          0  0
ROSE  NW                                                          0  0
DALE  NE                                                          0  0
      SW                                                          0  0
      SE                                                          0  0
                                                         TOTAL 1451100
IN TIME PERIOD   3  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
1451  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   3
```

TIMING OF ALLOCATION

It was neither expected nor does it seem essential that the timing of allocation, within limites, has to be very precise. That is, if a station sub-area receives its growth in one period "too early or too late", it is less important than if the proper stations received a reasonably accurate amount of apartment growth. Therefore, the results were not only compared for each time period, but the moving averages over 2, 3 and 5 time periods were compared. The moving averages are defined at the beginning of this chapter. They are the sum of apartment growth over 2, 3 and 5 time periods (both for actual and simulated growth). All further analysis was made for the full set of moving averages and on a time period by time period basis.

PERCENTAGE DIFFERENCE

The difference of simulated and actual growth was calculated as a percentage of simulated growth by the following formula:

$$\text{Percentage Difference} = \frac{E(X,Y) - S(X,Y)}{S(X,Y)} \cdot 100 \qquad (1)$$

E = Effective growth)
S = Simulated growth) all moving averages

Cases where no growth was simulated[1] and effective growth took place are indicated by a "999" in the percentage column; cases where growth was simulated where no development took place, by a "444".

Table 7.2-II gives a sample of the percentage comparison. The full set of comparisons are contained in Appendix A.d-2.

CORRELATION ANALYSIS

Correlation analysis provides only a measurement for the quality of allotment. The quality of distribution can not be compared, because all data-pairs used in a correlation must have non-zero values (i.e., cases where growth took place but was not simulated and vice versa are not included in the analysis). Again the analysis was performed

1. The same applies in the case where the simulated figure was less than one-third of the effective figure. Otherwise the percentage figure would increase exponentially because of the structure of formula (1).

TABLE 7.2-II

C O M P A R I S O N O F E F F E C T I V E A N D S I M U L A T E D A P A R T M E N T G R O W T H

DIFFERENCE EXPRESSED AS PERCENTAGE OF SIMULATED GROWTH

999 SIMULATED GROWTH WAS LESS THAN 1/3 OF THE ACTUAL GROWTH

444 GROWTH WAS SIMULATED WHEN NO GROWTH ACTUALLY TOOK PLACE

E EFFECTIVE GROWTH (IN DWELLING UNITS)
S SIMULATED GROWTH (IN DWELLING UNITS)
P PERCENTAGE DIFFERENCE ((E-S)/S*100)

APPLICABLE TO LINE		YONGE			YONGE		
STATION	AREA	TIME PERIOD 2			TIME PERIOD 3		
		E52	S52	P52	E53	S53	P53
EGLINGTON	1011	0	0	0	168	0	999
EGLINGTON	1012	1118	1771	-37	1369	2408	-43
EGLINGTON	1014	602	154	999	971	154	999
DAVISVILLE	1023	333	437	-24	333	437	-24
DAVISVILLE	1024	1100	536	105	1745	1613	8
ST.CLAIR	1031	427	476	-10	427	476	-10
ST.CLAIR	1032	0	312	444	0	312	444
ST.CLAIR	1034	1422	1730	-18	2170	2493	-13

APPLICABLE TO LINE		YONGE			YONGE		
STATION	AREA	TIME PERIOD 4			TIME PERIOD 5		
		E54	S54	P54	E55	S55	P55
EGLINGTON	1011	168	244	-31	168	244	-31
EGLINGTON	1012	1459	2135	-32	1204	1976	-36
EGLINGTON	1014	1061	420	153	902	266	999
DAVISVILLE	1021	0	246	444	0	246	444
DAVISVILLE	1023	153	437	-65	0	281	444
DAVISVILLE	1024	2528	2393	6	2408	2238	7
ST.CLAIR	1031	427	268	59	212	0	999
ST.CLAIR	1032	311	938	-67	311	784	-50
ST.CLAIR	1034	2525	2296	10	2303	2139	7

for all moving averages. Table 7.2-III shows the correlation matrix.

TABLE 7.2-III

E ACTUAL APARTMENT GROWTH (in dwelling units)
S SIMULATED APARTMENT GROWTH (in dwelling units)

The correlation analysis includes all stations which received actual and simulated growth for all lines which were in operation in the respective time periods.

MOVING AVERAGE 2

TIME PERIOD	CORRELATION BETWEEN	CORR. COEFF.	SIG. LEVEL	NO. OF CASES
2	E22 - S22	.64	.088	6
3	E23 - S23	NA	-	3
4	E24 - S24	.79	.032	6
5	E25 - S25	.77	.001	16

MOVING AVERAGE 3

TIME PERIOD	CORRELATION BETWEEN	CORR. COEFF.	SIG. LEVEL	NO. OF CASES
2	E32 - S32	.87	.012	6
3	E33 - S33	.74	.047	6
4	E34 - S34	NA	-	3
5	E35 - S35	.71	.021	10

MOVING AVERAGE 5

TIME PERIOD	CORRELATION BETWEEN	CORR. COEFF.	SIG. LEVEL	NO. OF CASES
2	E52 - S52	.78	.034	6
3	E53 - S53	.83	.021	6
4	E54 - S54	.90	.001	8
5	E55 - S55	.86	.014	6

SCATTERGRAMS

The scattergrams give the most complete information for evaluation and are at the same time easily comprehendable. They represent the correlation between actual and simulated growth. The correlation is good if the points lie close to a line through the origin of the coordinate system in the following figures.[1] Points along the X and Y-axis indicate cases where either the actual or simulated growth was zero when the simulated and effective growth were not zero respectively. Figures 7.2-2 to 7.2-6 show the comparison of actual and simulated growth for <u>all</u> moving averages 2, 3 and 5 for <u>each</u> time period. Figures 7.2-6 to 7.2-8 give an overall indication of the quality of simulation in regard to the sliding averages 2, 3 and 5 respectively (for <u>all</u> time periods together). Therefore they indicate for each of the three levels of significance (accepted deviation of simulation results from reality) the performance of the simulation.

---

1. The line has not to be the 45-degree line because the two axes are differently scaled.

CORRELATION BETWEEN ACTUAL AND SIMULATED APARTMENT GROWTH
ERROR 2/3/5 PERIOD 1961/1962

ERRORS IN DIAGONAL INDICATE GOOD CORRELATION
ERRORS ALONG X-AXIS INDICATE THAT NO GROWTH WAS SIMULATED WHEN GROWTH ACTUALLY TOOK PLACE AND VS FOR THE Y-AXIS

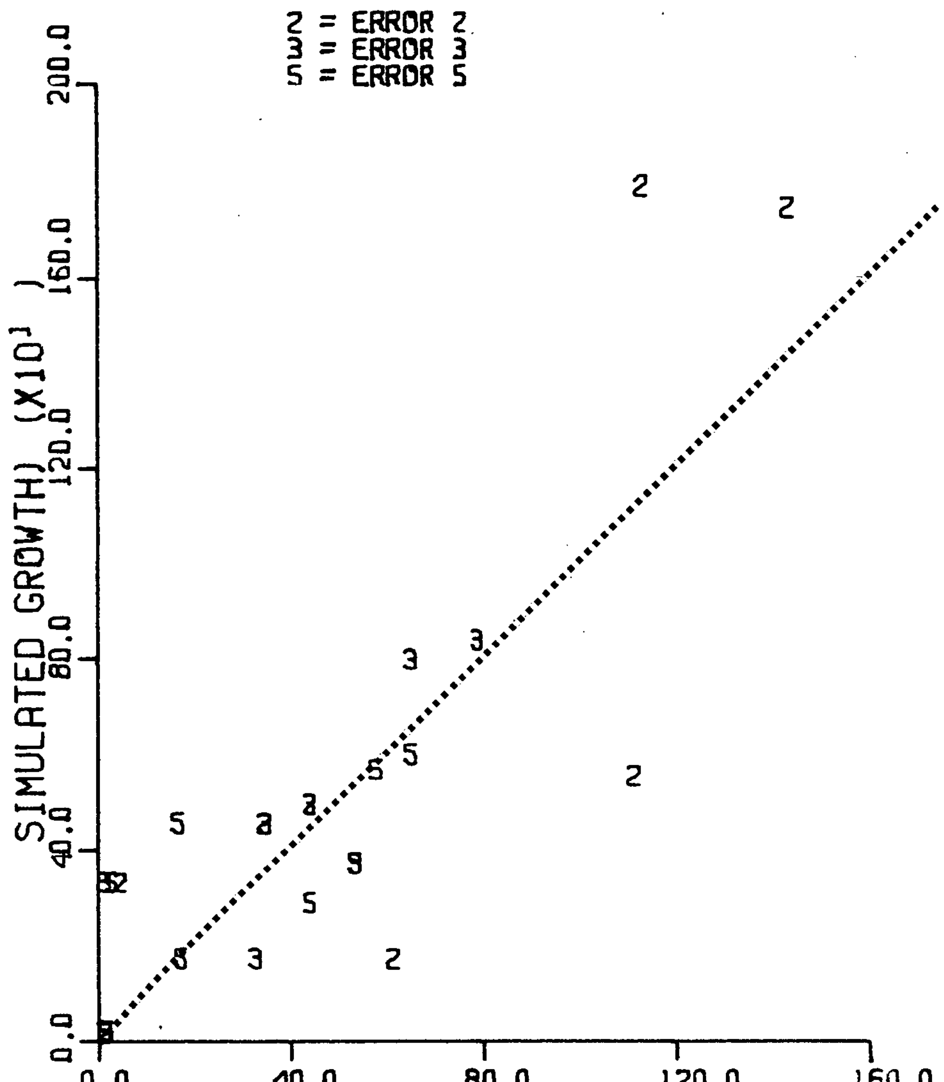


FIGURE 7.2-2
SCATTERGRAM

FIGURE 7.2-3
SCATTERGRAM

CORRELATION BETWEEN ACTUAL AND
SIMULATED APARTMENT GROWTH
ERROR 2/3/5 PERIOD 1963/1964

ERRORS IN DIAGONAL INDICATE
GOOD CORRELATION
ERRORS ALONG X-AXIS INDICATE
THAT NO GROWTH WAS SIMULATED
WHEN GROWTH ACTUALLY TOOK
PLACE AND VS FOR THE Y-AXIS

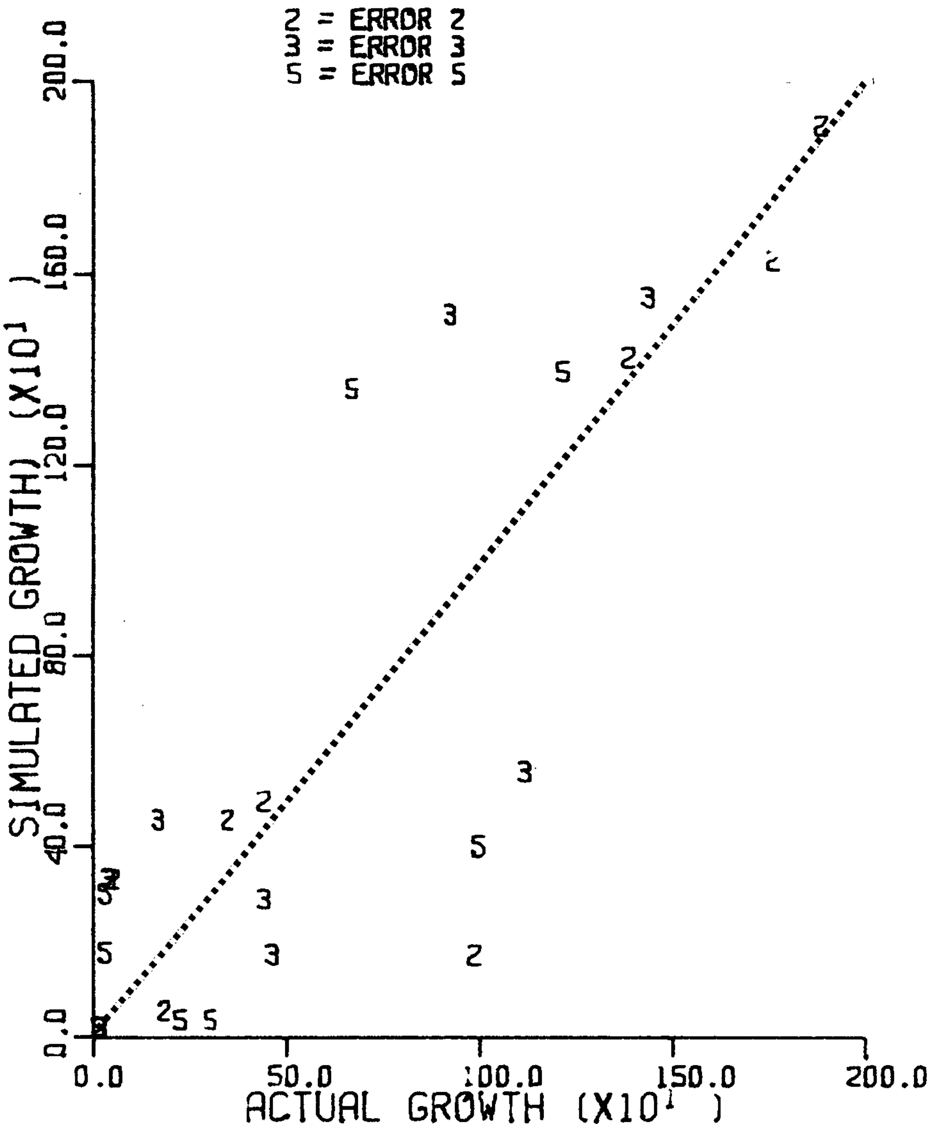
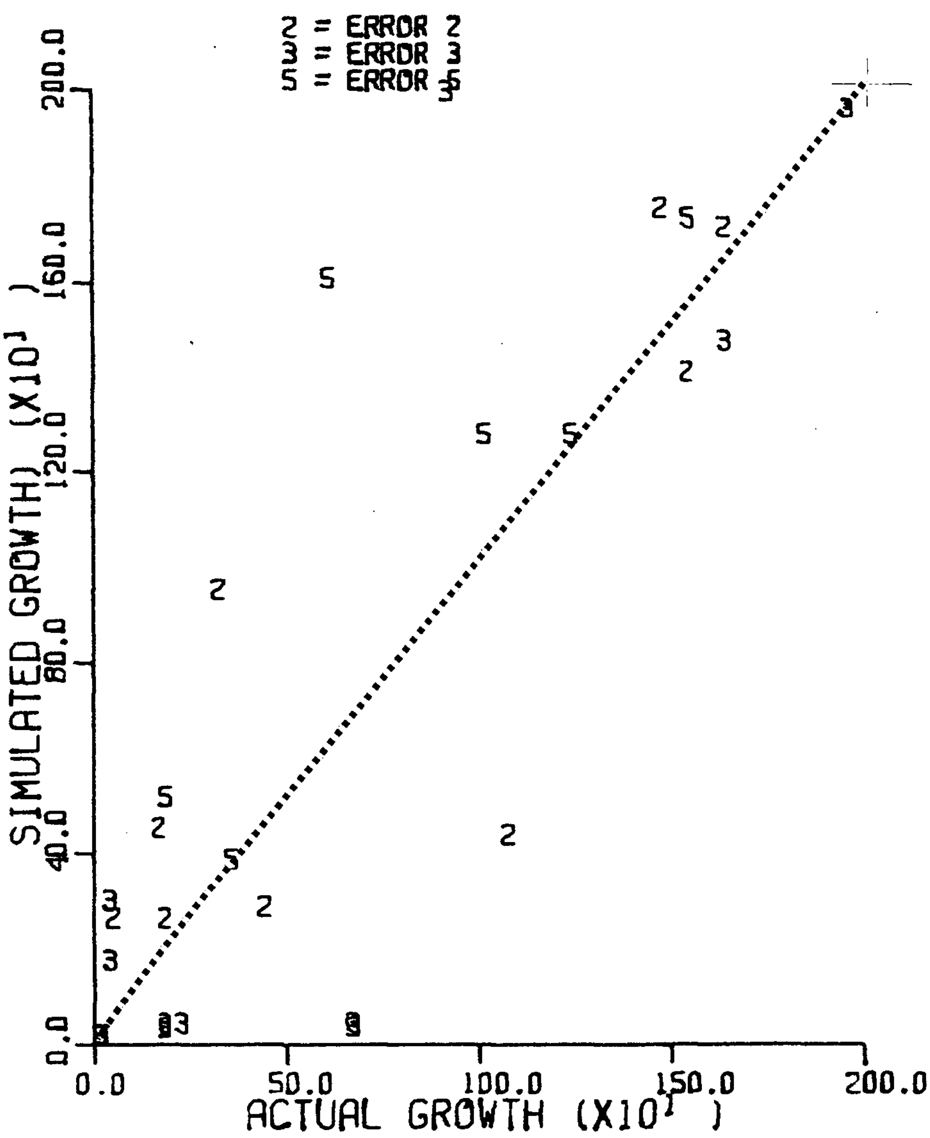


FIGURE 7.2-4
SCATTERGRAM

CORRELATION BETWEEN ACTUAL AND
SIMULATED APARTMENT GROWTH
ERROR 2/3/5 PERIOD 1965/1966

ERRORS IN DIAGONAL INDICATE
GOOD CORRELATION
ERRORS ALONG X-AXIS INDICATE
THAT NO GROWTH WAS SIMULATED
WHEN GROWTH ACTUALLY TOOK
PLACE AND VS FOR THE Y-AXIS



CORRELATION BETWEEN ACTUAL AND SIMULATED APARTMENT GROWTH
ERROR 2/3/5 PERIOD 1967/1968

FIGURE 7.2-5
SCATTERGRAM

ERRORS IN DIAGONAL INDICATE GOOD CORRELATION
ERRORS ALONG X-AXIS INDICATE THAT NO GROWTH WAS SIMULATED WHEN GROWTH ACTUALLY TOOK PLACE AND VS FOR THE Y-AXIS

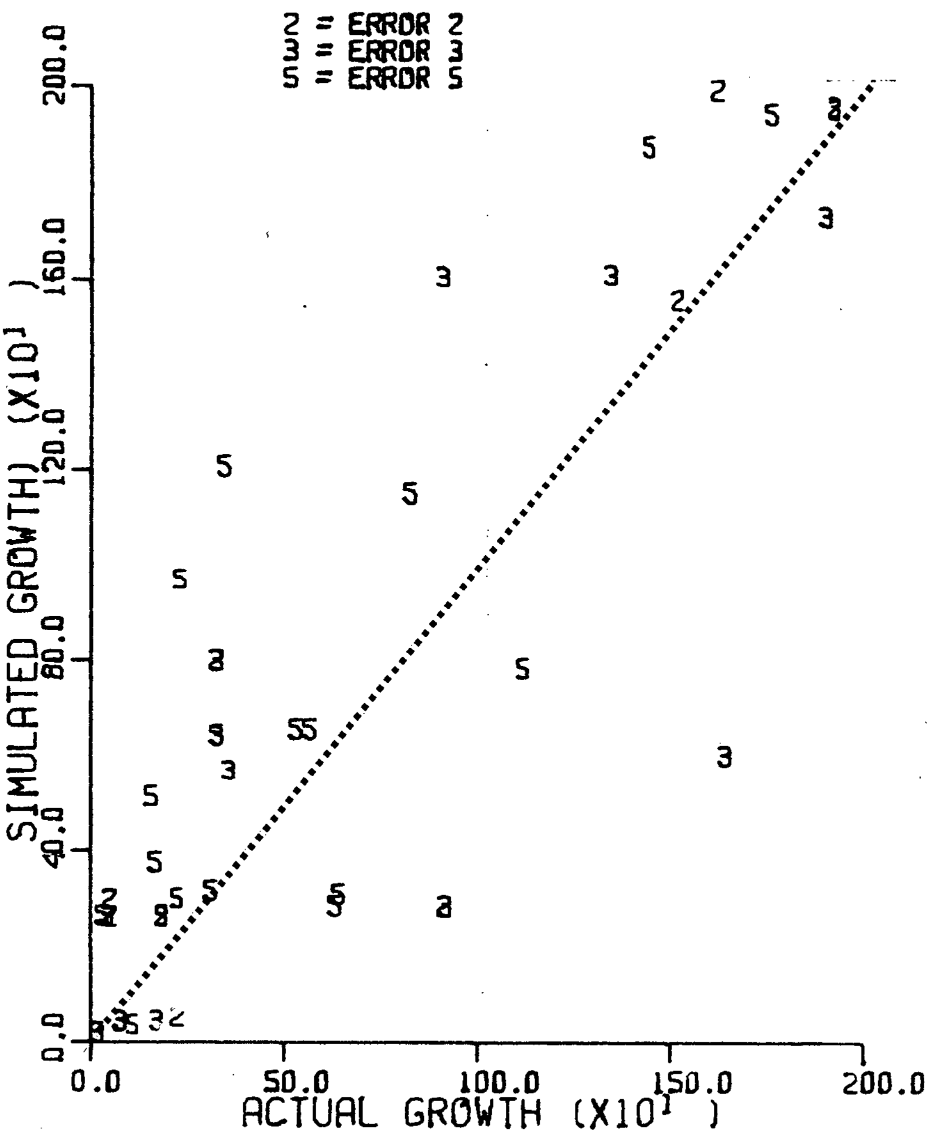


FIGURE 7.2-6
SCATTERGRAM

CORRELATION BETWEEN ACTUAL AND
SIMULATED APARTMENT GROWTH
ALL ERRORS 2 ALL TIME PERIODS

(INDICATION FOR THE QUALITY
OF THE SIMULATION IN REGARD
TO THE ERROR 2

ERRORS IN DIAGONAL INDICATE
GOOD CORRELATION
ERRORS ALONG X-AXIS INDICATE
THAT NO GROWTH WAS SIMULATED
WHEN GROWTH ACTUALLY TOOK
PLACE AND VS FOR THE Y-AXIS

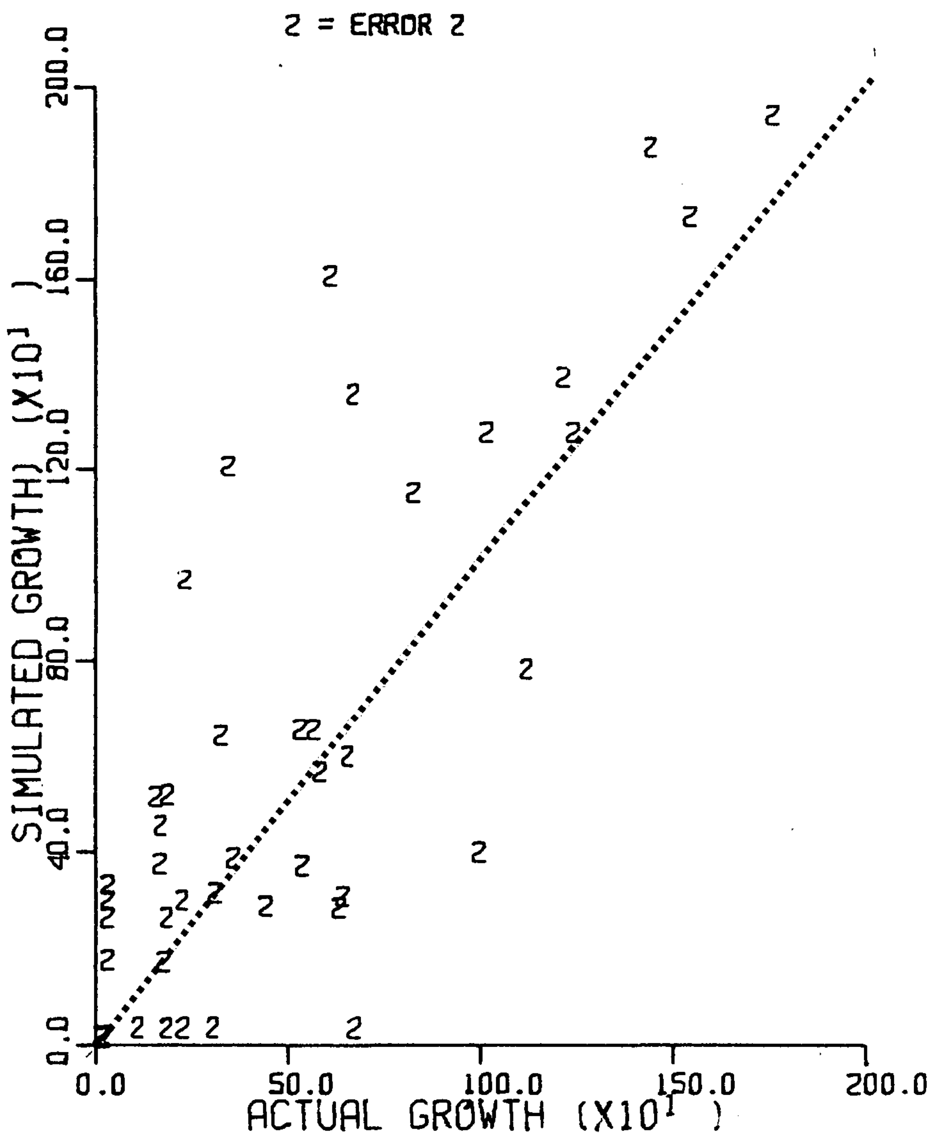


FIGURE 7.2-7
SCATTERGRAM

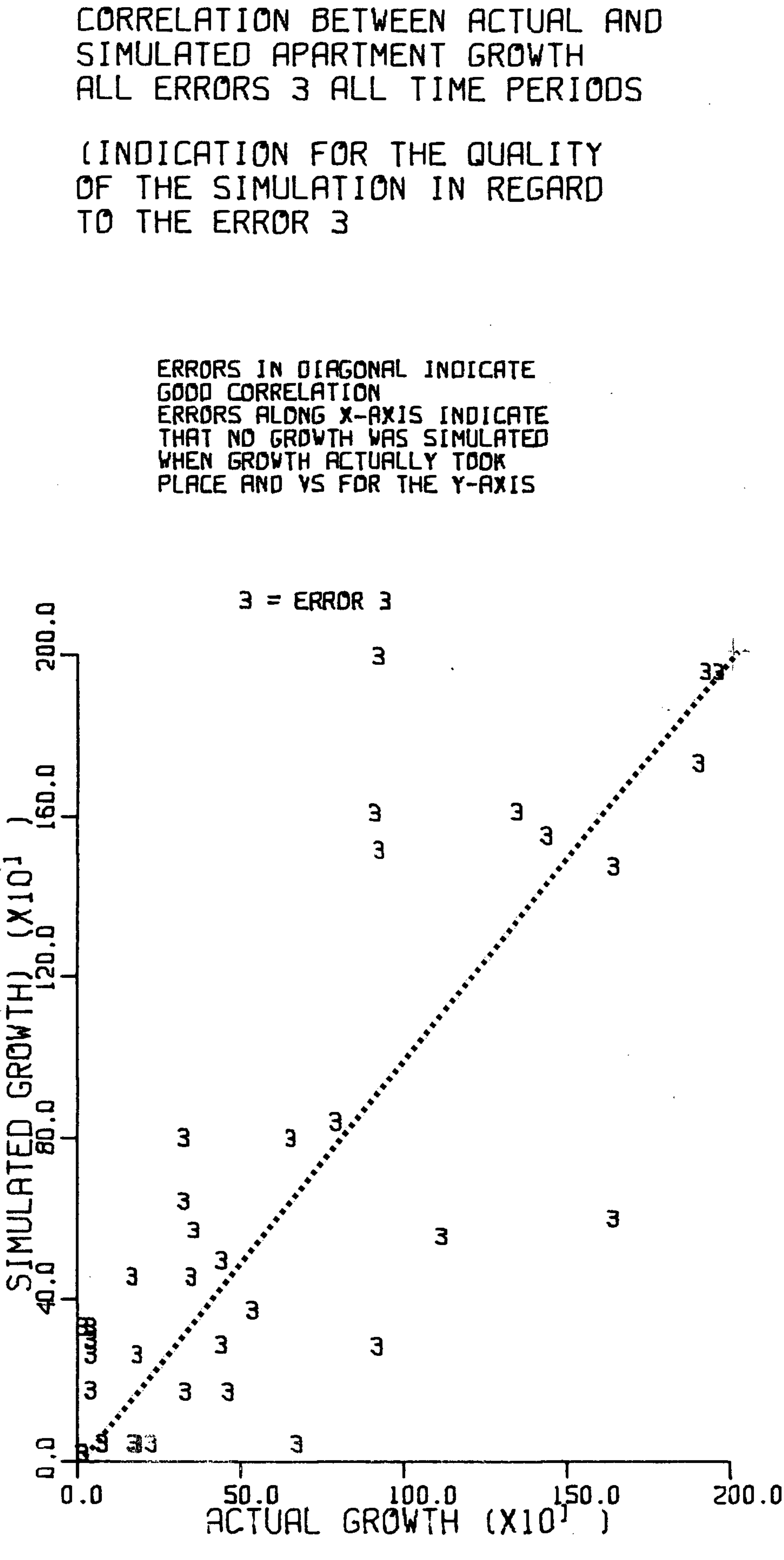
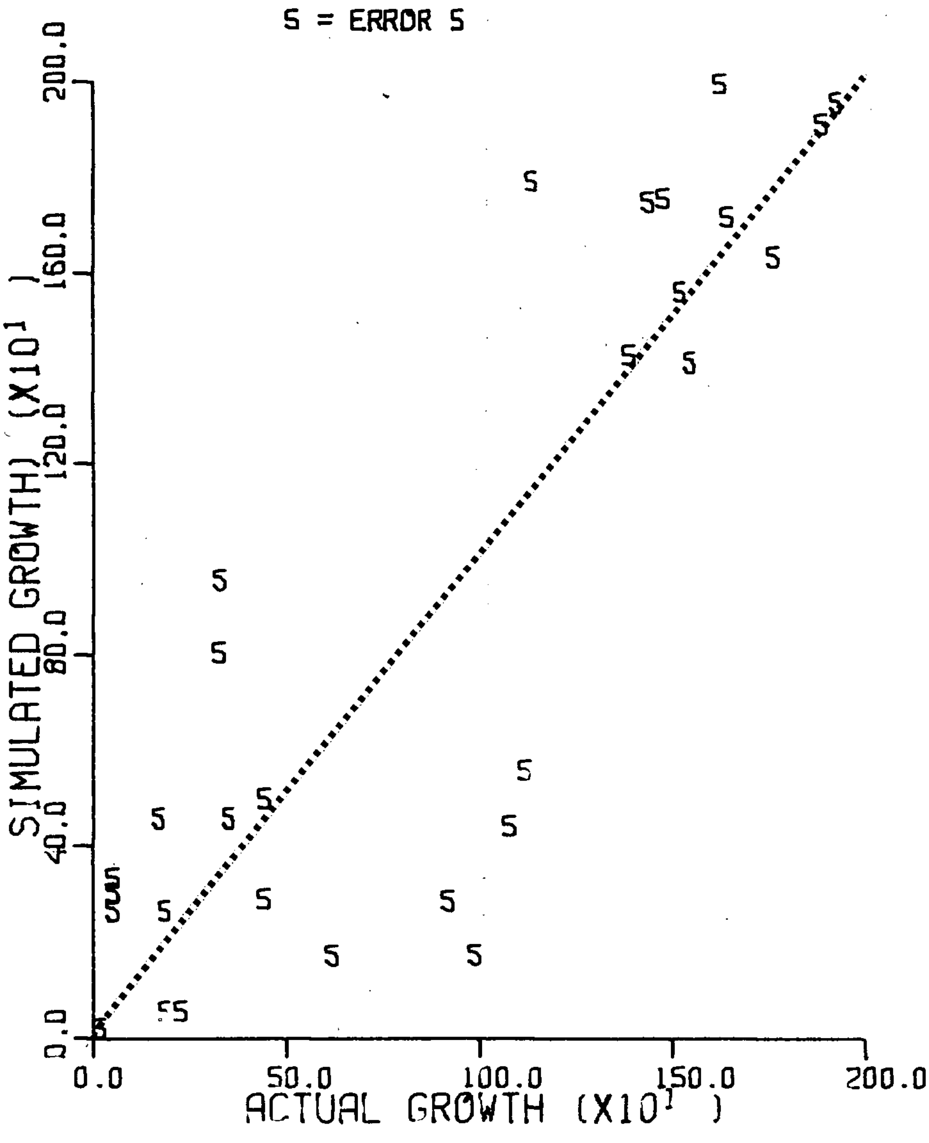


FIGURE 7.2-8
SCATTERGRAM

CORRELATION BETWEEN ACTUAL AND
SIMULATED APARTMENT GROWTH
ALL ERRORS 5 ALL TIME PERIODS

(INDICATION FOR THE QUALITY
OF THE SIMULATION IN REGARD
TO THE ERROR 5

ERRORS IN DIAGONAL INDICATE
GOOD CORRELATION
ERRORS ALONG X-AXIS INDICATE
THAT NO GROWTH WAS SIMULATED
WHEN GROWTH ACTUALLY TOOK
PLACE AND VS FOR THE Y-AXIS



7.3

SENSITIVITY ANALYSIS

Basically, there are three areas of interest in analyzing the sensitivity of simulation models for changes in parameters, that is the constances and table functions that describe relationships within the system:[1]

i. does modification of table functions result in changes in the performance of the model?

ii. are these parameters to which the model exhibits strong sensitivity controllable through planning policies?

iii. does the replacement of one proxi-variable measuring a parameter with another result in any significant changes in the performance of the model?

In the first area of interest the sensitivity analysis is aimed to gain some understanding. whether quantitative changes in the postulated parameters affect any aspect of the system. When

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1. Forester, 1969.

sensitive elements of the model are identified, further and more extensive research can be conducted focussing on these particular relationships in order to improve the model's predicting ability.

In the second area of interest the emphasis is placed on those parameters that do effect the system's condition. Here those sensitive variables are identified which can be changed or controlled through actual planning interventions.

The third purpose of the sensitivity analysis is to identify whether the employment of alternative proxi-variables measuring particular parameters would essentially produce identical outcomes in the long run. That is to gather detailed information on age, family structure, disposable income, etc. to describe the neighborhood quality parameter of our model may not be necessary if an alternative proxi-variable, for example the percentage of blue collar workers, sufficiently describes the parameter.

Thus extensive evaluation of the system's sensitivity to changes in its parameters is an integral part of model building and indeed often the ultimate goal of the exercise. However, the procedure of setting up elaborate runs within which various parameters are held constant and evaluate each experiment is time consuming and expensive. The budgetary and time limitations within which this work was undertaken necessitated a drastic reduction in the experimental runs.

FORECAST
1971-1986

The performance and sensitivity of the calibrated model was tested for three different sets of conditions. Simulation 'A' was carried out by incorporating the general policies laid down by the official plan for the spatial confinement of various land uses for the next thirty years in Toronto. (See Figure 7.3-1). Here the technological constraints for station sub-areas were sequentially relaxed in accordance with scheduled construction of new water mains, sewer lines, and school space. For sub-areas where the official plan designated high-density residential uses, the zoning variable was changed to assume the value of 4 (zoned for high density residential) and similarly the intervention variable for the external generation of commercial development was modified where the plan envisaged future retail and office space development. The variable of undesired conditions was changed for the Eglington, Davisville, Summerhill and Islington station areas where plans existed for the elimination or covering of open railway lines in the near future. On the basis of information received during a personal interview with T.T.C. officials, the proposed extension of the feeder system was incorporated into the simulation through the alteration of the nodality variable. However, two changes envisaged in the official plan were omitted in this run. First, no modification was entered in surface accessibility variables since the proposed Spadina Express Way is not expected to be constructed. Similarly, the impact of the future extension of the subway line in the median strip of the freeway was discounted in light of the high uncertainty (level) that this expansion will ever take place.

Simulation 'B' tested the influence of alternative grouping of the interactive policy variable to achieve different spatial distribution of future apartment development. Here the objective was to create a smaller number of, but more intensive, nodal developments and thus to investigate whether there is any ground for the fears of many municipalities that rapid transit merely improves the strength of the CBD at the expense of development elsewhere, or alternatively, if with good and vigorous policy interventions this trend can be reduced. However, the comparison of the two runs cannot be explicitly related to one another, since a number of nodal developments was proposed for stations where some apartment development was assigned by the official plan as well.

Simulation 'C' tested the influence of non-policy variables. Conceptually, it would have been desirable to treat all fourteen variables as 'interactive', but this treatment would have resulted in a more expensive and a more troublesome manipulation. Thus a number of variables (neighborhood quality, lot size, etc.) which were not expected to be sensitive for alternative policies were sunk into the model as non-interactive. Consequently, changing the values of these variables necessitated the alterations of the initial conditions. For the purpose of this simulation run, these changes were made quite arbitrarily, as the objective of the run was <u>not</u> to achieve any spatial distribution of apartment construction, but rather to test the influence of policy versus the non-interactive variables on the evolving pattern. Here three sets of changes were introduced. First, the policy variables reflecting the objectives of the official plan were maintained; second, similar policy variables were introduced to a number of other stations; and finally, the non-interactive variables of neighborhood quality and

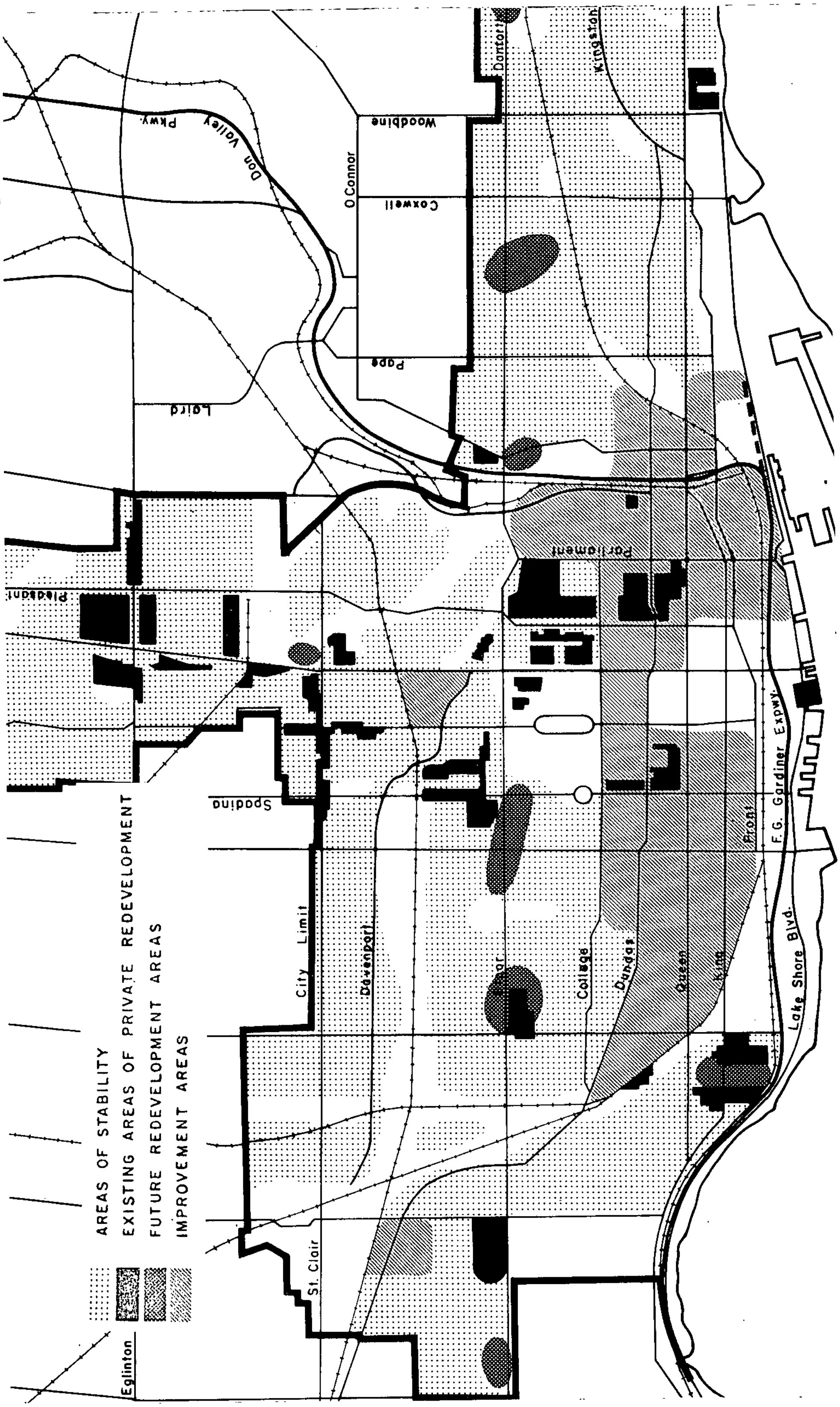


FIGURE 7.3-1
DESIGNATED AREAS FOR HIGH DENSITY RESIDENTIAL DEVELOPMENT

Source: Proposed Plan for Toronto, Toronto Planning Department, 1967, p.105

lot size were favorably changed for a third set of stations, but no policy variable other than the relaxation of technological constraints was modified.

The results of the three simulation runs were compiled in three maps for comparison. (Figure 7.3-2,3,4). From the first inspection of these maps, it is evident that through the policies adopted by the Metropolitan Planning Board, future apartment development can be channeled to the predesignated areas (Simulation 'A'). The fact that not all of these areas received growth during the simulated period may be due to either the too small assignment of <u>total</u> growth to the corridor, or that the official plan envisaged a time period for the growth of these station areas longer than the simulated time.

When the results of Simulation 'A' are contrasted with the development patterns simulated by the alternative grouping of policy variables (Simulation 'B'), only limited improvement is evident. Although concentrated nodal development is apparent at the Islington, Broadview-Chester and Jane Street subway sections at the expense of Pape and Dufferin stations, the second simulation run reproduced essentially similar growth in sub-areas around Eglington, Davisville, St. Claire, High Park, and Main Street subway stations. These results gave rise to speculations that policy interventions have a more moderate impact on channeling development than was previously expected. Thus the reasonable fit between the spatial distribution of simulated growth and the location of apartment construction envisaged in the general plan of Toronto is rather attributable to the correct anticipation of the attractivity of other components of the environmental context than the effectiveness of currently available policy devices.

The distribution pattern produced by the third simulation run essentially confirmed the above assumption. The spatial concentration of new apartments became less accentuated and more dispersed. Areas with favorable neighborhood quality and large lot sizes diverted growth from areas which received concentrated apartment growth in Simulation 'A', despite the fact that the policy variables were identical in both sets of station sub-areas. Furthermore, those stations also attracted some limited development where the otherwise favorable non-interactive variables were not reinforced by policy variables encouraging concentration.

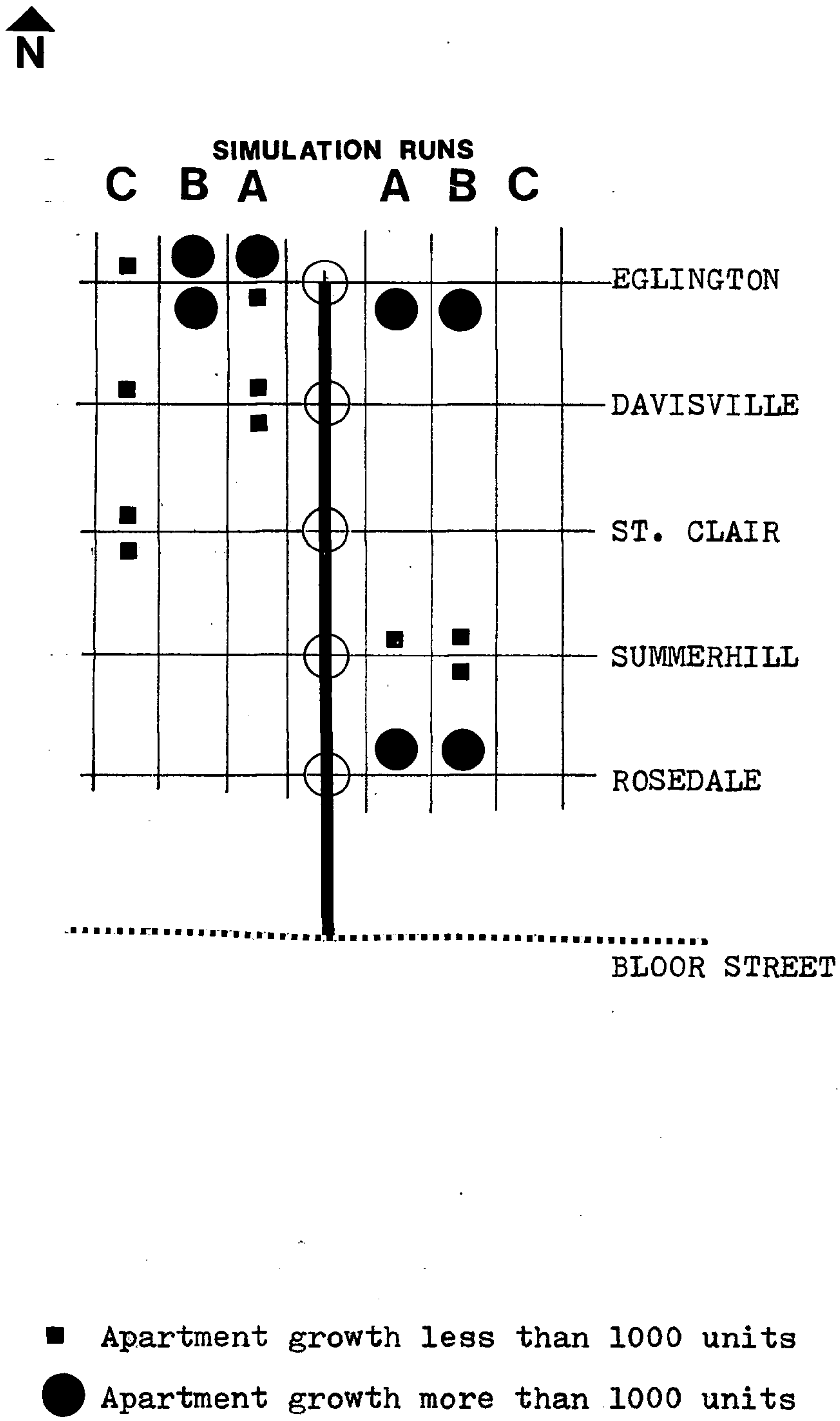


FIGURE 7.3-2
SIMULATED
CUMULATIVE
APARTMENT
GROWTH
SUBWAY LINE
YONGE
1970-1986

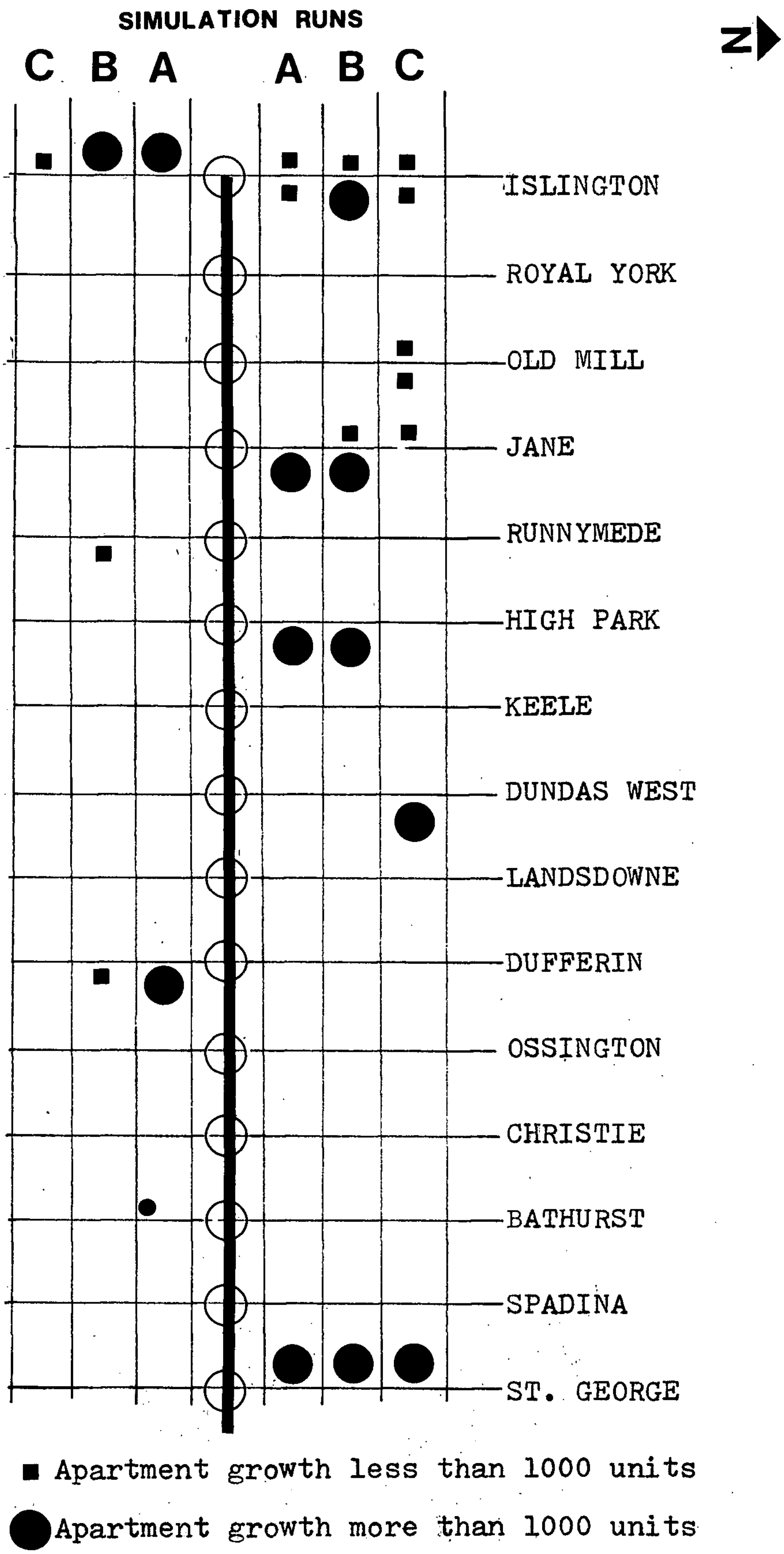
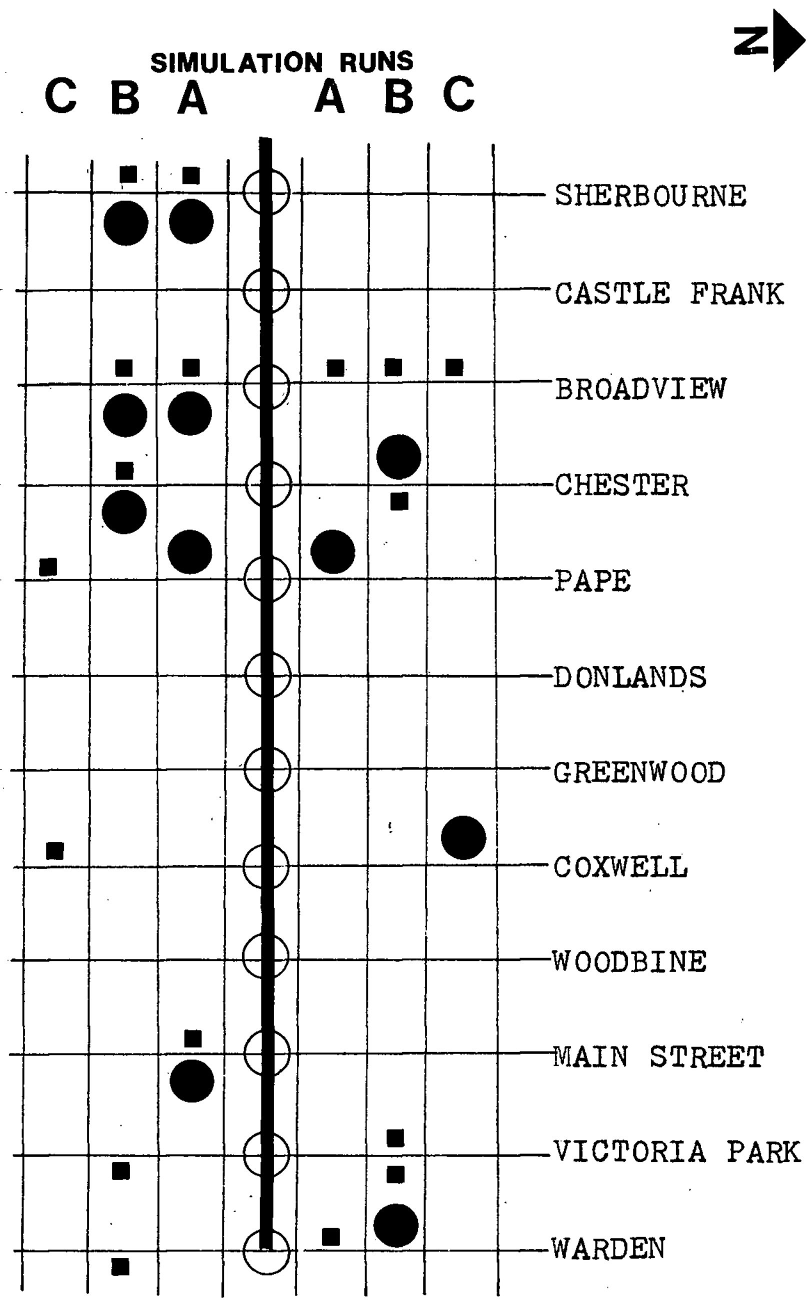


FIGURE 7.3-3
SIMULATED
CUMULATIVE
APARTMENT
GROWTH
SUBWAY LINE
BWO, BWN
1970-1986



■ Apartment growth less than 1000 units

● Apartment growth more than 1000 units

FIGURE 7.3-4
SIMULATED CUMULATIVE APARTMENT GROWTH
SUBWAY LINE BEO, BEN
1970-1986

7.4

CONCLUSIONS ON THE SIMULATION

As evident from this chapter, the usefulness of the simulation model can be concluded from two sets of considerations. Firstly, the model calibration which indicates how well the model "works", i.e. if it is able to reproduce the past; secondly, the quality of the model in regards to sensitivity analysis, to test alternative policies and to forecast their consequences. The first condition - that the model works - is of course a prerequisite for the second. However, it has to be ascertained as to what extent the quality of the results of calibration is a consequence of imperfect data or the model itself.

RESULTS OF CALIBRATION

The results of the model calibration are generally satisfactory. Three criteria of success were established to measure the model quality; performance in regard to apartment distribution, allotment and timing.

Of the 128 station sub-areas, 22 actually received growth in the time period 1959-1970.[1] In 19 of those cases the model predicted growth for the respective areas. The model simulated growth for one additional station, where in actuality no growth took place. Therefore the distribution achieves favourable results.

As previously discussed, the model was not expected to predict growth precisely in the time period in which the actual apartment development took place. During the calibration period 59 apartment developments occurred. In only 50% of the cases did the simulation allocate growth in the proper time period. To measure the quality of timing, the 2, 3 and 5-year moving averages were introduced. The results indicate that in 80% of the cases the timing was satisfactory when the moving average 2 was used, i.e. eight out of ten developments were predicted not more than one time period too early or too late. In other words, 50% were predicted in the right time period, 30% with a deviation of plus/minus one period and 20% with a greater deviation.[2]

1. This number deviates from the figure 25 used in the statistical analysis in chapter 6.3. The statistical analysis included three developments along the Bloor line which took place shortly before the subway was introduced.
2. The moving average of 3 and 5 did not improve the results beyond 80%.

The allocation of growth, i.e. the actual size of predicted apartment developments was less accurate. The percentage differences between actual and simulated growth lies generally in a range of plus/minus 30 to 50%, some of them reaching up to 80 to 100% (see Table 7.2-2 and Appendix A.d-2). However, this difference is much smaller if the moving averages are compared, where the difference is usually less than plus/minus 30% or if the cumulative total of predicted and simulated apartment growth is compared at the end of the 11-year calibration period. That indicates that although the individual development sizes were rather inaccurately predicted, the amount forecasted over a longer time period is much closer to reality. The most likely reason for this is the fact that the analysis was made on a station sub-area basis rather than using city-blocks.[1] This aggregation levels out many environmental differences. In addition, the apartment development size is much greater for a sub-area than the apartment building size for a block or an individual property as demonstrated in chapter 6.2 and 6.3. That indicates that the random distribution process of apartment

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1. The reasons for this limitation in the present analysis are discussed in Chapter 6.1.

sizes "bigger" mistakes in the case of sub-area aggregation.

RESULTS OF SENSITIVITY AND FORECAST ANALYSIS

As discussed in chapter 7.3, the model does allow for sensitivity analysis and simulation of alternative policies. However it is in this area where further work is required.[1] Additional sensitivity analysis is necessary to analyze precisely which combination of environmental factors influence the apartment growth. As of now, the sensitivity of factors is expressed in their weight and in the shape of the table functions. In the range where the gradient of the function is steep, conditions are unstable and attractivity scores change significantly if the environmental conditions change slightly.

The sensitivity of not only isolated factors but also of the concerted influence of any number and combination of factors can only be tested in a carefully designed sequence of simulation runs. This could at present only be done to a limited

1. In the present analysis, some of the sensitivity analysis and policy testing runs were combined for budget reasons. The extensive print outs of of intermediate results made it possible to trace and separate the two processes and their results even if they are combined in one run.

extent for time and especially for money reasons. The sensitivity analysis provides for two possibilities. Firstly, data collection for an improved simulation for Toronto or for any other city may now be limited to the important, i.e. high weight factors. This allows for a reduction in data collection and to allocate more funds to achieve a higher quality of the data basis. Secondly, and more importantly, the sensitivity analysis isolates those factors and groups of factors which are suitable and successful in achieving desired changes, i.e. those which provide information for the planning and decision-making processes. These general implications of the model are now discussed in more detail in the following and concluding chapter.

Foster, J.W., (1969), Urban Dynamics, The M.I.T. Press, Cambridge, Massachusetts.

Metropolitan Planning Department, Proposed Plan for Toronto, Toronto, 1967.

synthesis

8

- 8.1 Implications for Planning
- 8.2 Directions for further research.

8.1

IMPLICATIONS FOR PLANNING

Planning implies the rational ordering of the environment to suit proitious events of man and society. This ordering is achieved by employing a number of tools and policies and by choosing among options of commitments which are at the disposal of society as a whole and of planners in particular. While it has been repeatedly emphasized that tools, policies and commitments must not be treated as ends in themselves, but rather as appropriate actions designed to <u>serve</u> most fully the society's present and future needs, there is still less than sufficient attention paid to understand and ultimately anticipate the <u>objective</u> consequences of various actions. When a downtown office tower is built, it not merely accommodates a particular activity, but defines the spatial concentration of a number of people at specific times, alters the locational choices of a number of other activities, represents some loading on related transportation/communication channels and it becomes a landmark to be proud or ashamed of. Thus to conceive the downtown office tower as a specific commitment serving a specific goal (that is the sheltering of commercial activities) means to ignore the ramifications of the project within the larger context of urban environment.

One of the most powerful tools currently available for planners to influence the spatial evolution of cities is the transportation/communication network. This network facilitates and defines the ease of interaction among various members of the community and by doing so, it bridges the resources and the opportunities of the city. Since the need for easy interaction gave birth to the whole process of urban agglomeration and remained the single most important force underlying its rapid growth, the thorough understanding of the consequences of transportation investments remains of major importance, if we are to master the quality of our urban environment and the level of opportunities within it.

In recent years one particular transportation system, the rapid transit, has received considerable attention despite the fact that the last two decades witnessed a marked decrease in mass transportation patronage. Partizans for the revitalization of rapid transit often use emotionally charged arguments to prove the superiority of the system over the automobile for specific purposes. To describe the various points of these arguments would be a repetition of what has already been said in previous chapters, yet to provide a proper perspective for the planning implications of this study one point of the reasoning is repeated here.

Large segments of the city population are denied convenient access to urban opportunities, such as employment, education, recreation, medical care, etc. in the automobile oriented city, because they cannot afford to buy a car, or simply are unable to drive. Mass transportation coupled with a high level of service can lower the barrier to urban opportunities by offering an improved personal mobility to the disadvantaged. However, this argument implicitly assumes the simultaneous occurrence of two favorable conditions. First, that residential areas where the economically disadvantaged are concentrated remains essentially unchanged after the rapid transit station is introduced, and second, that there is a significant concentration of urban activities attracted to somewhere along the line and which can now be reached more quickly by those from whom the convenient access to urban services and facilities have been previously denied. When either, or both of these conditions are missing the social objective of the transportation investment cannot be achieved.

In its present form the model is designed to give answers within some range of limitations to the first problem, that is whether or not the first people to be replaced by the residential redevelopment triggered by the introduction of rapid transit lines, are those for whom the system originally was designed. If the model is extended to simulate the spatial distribution of other activities attracted to the line, the second condition can also be tested.

A further application of the model within the planning process is its capacity to evaluate the relative attractivity of various stations for capturing some portion of the future development growth. The concentration of high density residential, employment, shopping and entertainment centers is essential for the economical and successful operation of rapid transit. In fact. one of the basic rationale behind the introduction of rapid transit is to facilitate the spatially and temporally confined high density travel trips within an urban area. Thus it is ironic that whereas the relative density of residential development has been rapidly increasing over the last decade, and the absolute growth of the core area as the employment center is still considerable, the patronage of rapid transit in most North American cities has relatively declined during the same time period. One explanation for this phenomenon could be sought in the relative attractivity of environments within which rapid transit stations are located. In Toronto, for example, 22 of the 128 station sub-areas were identified as not capable of attracting future development. Thus with the model it is possible not only to test new development stimulus potential of various network layouts, but also to alter the magnitude of this stimulus by placing stations in alternative environmental context, or with vigorous planning policies creating new ones.

8.2

DIRECTIONS FOR FURTHER RESEARCH

It is often argued that the significance of scientific investigations should not be evaluated solely in terms of the answers given to specific problems, but rather in terms of the new questions which those answers generated. The theoretical limitations of this study enumerated in chapter 5.2; the evaluation of the simulation model in chapter 7.4 and the critical remarks throughout the thesis discussing additional problems encountered during the course of analysis and model building, suggest several lines of further research.

The model itself could be profitably extended in two directions. First, the spatial distribution of a wider range of activities such as office, retail, other commercial (theatres, stadiums, exhibition parks) and some institutional, all of which require the concentration of a significant number of <u>people</u> rather than goods for the economic scale of their operation, could be included in the model. The incorporation of competing land uses which have been treated as exogenous variables in this study should increase the dynamics of the model and ultimately portray a more adequate picture of changes taking place after the rapid transit lines are introduced. The addition of this new dimension does not require conceptual changes in the <u>structure</u> of the model, however it would require some modifications of program. New land uses would be determined by a specific subset of all environmental factors.[1] The spatial distriburion of additional land uses may be influenced partly by the same, partly exclusive environmental variables. In any case, the weight configuration would be different for each land use. Further, the development size functions would have to be specified for each use. The feedback among land uses would be reflected in the change of those environmental factors which are common to two or more land uses. The output of the program would consist of the amount of growth for each land use.[2]

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1. The fourteen presently used environmental variables might have to be expanded.
2. In the case of limited budget and time, the model could be run for each land use separately, with a different data file which would include environmental factors applicable to the respective land uses. However, the feedback among land uses would have to be entered externally by interaction, as it was done for the present analysis.

Second, further research is required to test the model's reproducing and forecasting ability in other cities as well. Although it is suggested that both the table functions and the relative importance of environmental components represent an important input in locational choices, the universal applicability of these table functions and weighting scales could be validated only when additional information is available from other cities, with other rapid transit network configurations and different stages of development.

Both the preliminary statistical analysis and the model essentially focus on those locational shifts which involved new constructions or replacements of existing physical structures. The emphasis on these specific changes, however, was only partially due to the time limitation on data collection. The consequences of locational and investment decisions that result in significant alteration or renewal of the physical stock represent more substantial changes in the spatial structure of the city than those resulting from the continuous shifting and filtering of activities within the standing stock. Yet, conceptually the two processes cannot be divorced entirely from one another, for changes in the rate of filtering (e.g. the conversion of single family houses to renting accommodation) ultimately lead to changes in the rate of replacement. Thus further research concerning the magnitude and spatial distribution of changes within the existing buildings could add an important dimension to the model.

Furthermore, the literature reveals insufficient information as to how the total amount of new construction in the city can be related to the amount of development which locates near to rapid transit stations. The method the writers employed to assign new apartment units to the line admittedly represents a rather crude estimation procedure, although it is believed that it could serve as a reasonable assumption on which additional research can be based.

There are at least two reasons for continued interest in the impact of rapid transit stations on the spatial distribution of activities within the urban field. First, there is a need to understand how high density development can be channeled to become spatially associated with the network, for the economically successful operation of transit lines the interaction of high density nodes is necessary. Second, the rate of urbanization, predicted to culminate by the end of the century, will result in a further spatial expansion of urban agglomerations. If the objective consequences of rapid transit is recognized it can be used as a tool to catalize and integrate future development into high density functional nodes. These nodes, in turn, could become organic nuclei giving structure to the otherwise disintegrated expansion of metropolises.

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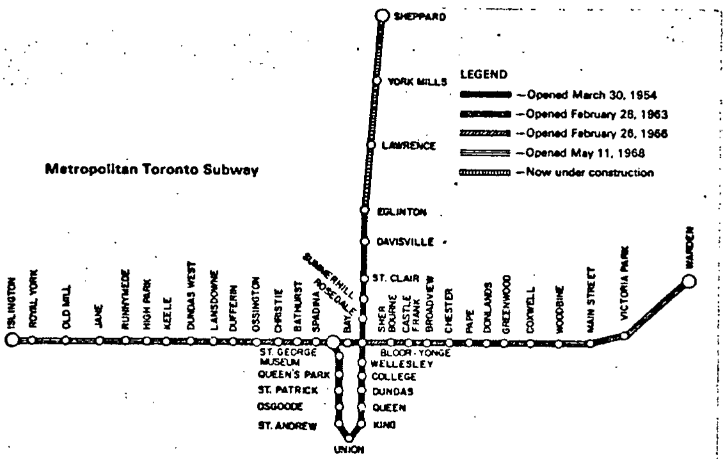
appendices

keymap



Metropolitan Toronto Subway
LEGEND
—Opened March 30, 1954
—Opened February 28, 1963
—Opened February 26, 1966
—Opened May 11, 1968
—Now under construction
SHEPPARD
YORK MILLS
LAWRENCE
EGLINTON
DAVISVILLE
ST. CLAIR
SUMMERHILL
ROSEDALE
BLOOR - YONGE
WELLESLEY
COLLEGE
DUNDAS
QUEEN
KING
UNION
ST. ANDREW
OSGOODE
ST. PATRICK
QUEEN'S PARK
MUSEUM
ST. GEORGE
ISLINGTON
ROYAL YORK
OLD MILL
JANE
RUNNYMEDE
HIGH PARK
KEELE
DUNDAS WEST
LANSDOWNE
DUFFERIN
OSSINGTON
CHRISTIE
BATHURST
SPADINA
BAY
SHER BOURNE
CASTLE FRANK
BROADVIEW
CHESTER
PAPE
DONLANDS
GREENWOOD
COXWELL
WOODBINE
MAIN STREET
VICTORIA PARK
WARDEN

technical notes

A.a

appendix

(See Chapter 7.1)

A. a-1

PROGRAM CHARACTERISTICS

In Chapter 7.1 the general program structure was discussed. The specific program characteristics are described in this appendix, providing sufficient information to run the simulation model.

RUN COMMAND

The following sample illustrates the RUN command.

```
$RUN MODEL.0 4=*SING* 5=DATA 6=PRINT
7=CFILE GUSER=INP PAR=FULL
```

In this case, the object program (compiled program) is in a file called MODEL.O, the interaction is displayed on a terminal. The input data are on a file called DATA and all outputs come from the line-printer except the output for further use, which will be entered into the file FILE. PAR=FULL is optional and indicates that the full set of outputs is desired; GUSER indicates that the user will respond to the questions asked by the model during simulation. The format of the DATA file is described at the end of this appendix.

The program was written in FORTRAN IV and requires seven routines from the UBC Program Library (DATE, PAR, FINDC, FINDST, INFREE, RAND and FRAND).

LOGICAL OUTPUT UNITS AND FORMAT

Subroutine SIGH activates the outputs chosen by the user on the RUN command. The following outputs are provided by the model on logical unit:

4 - Unit 4 is used to interrogate the user about various aspects of the model and the output required. Responses to these requests are made via GUSER.

6 - Two types of output are provided through this unit.

1. If PAR=FULL is given, then a considerable amount of intermediate data is provided as the model procedes (see sample, Appendix a.a-2).

2, When simulation is complete and regardless of the parameter, a final listing of incremental and cumulative apartments for each substation in eacy year is provided in a form to fit on 8½"x11" paper (see sample, Appendix a.d-4).

7 - If desired (depending upon the response to a question) a file may be prepared via this unit which contains the incremental and cumulative apartments for each substation in each year in a form which may be easily used as input by other programs. In particular, this format is used for the evaluation of the model calibration (Chapter 7.2) and for the graphical presentation (histograms, scattergrams).

COST OF SIMULATION RUNS

The cost of the runs varies with the amount of interaction and the outputs desired, and can be up to $30 for a 14 time period run. However, the cost can be reduced drastically, if PAR=FULL is not chosen (PAR=FULL is mainly a device for the calibration of the model) or if it is chosen, the results can be written on a tape and afterwards printed at a lower rate factor (batch or overnight). The cost was reduced further by using the FORTRAN H. compiler. In addition, the whole simulation can be run on the batch, provided all answers to the questions during the simulation are compiled properly. The average cost of a full run was therefore reduced to approximately $6-8 on terminal, $4-5 on batch.[1] If PAR=FULL, the printing of the results requires an additional $6-8. The

1. Or $2-3 for overnight runs.

model then, in its present state, is extremely economical.

ERROR-MESSAGES

The program provides an exhaustive list of error-messages (see sample in Appendix A). This has two advantages. First, if the model is applied to any other city or subway network, the data base has to be established and provided for, in the format required by the simulation. However, any mistake made in the preparation of the data inputs is commented on by error-message, which guides the user in his corrections. Second, any mistake made during the simulation, and especially during the interaction, is answered by an error-message which allows the user to repeat his commant. This prevents the abortion of the simulation and therefore considerably reduces the cost. A sample of error-messages is given in Appendix A.a-4 for all those errors which do not cause immediate termination of the simulation.

FORMAT OF THE DATA FILE

The data file is divided into 5 logical sections:

1. Raw X "table" function values.
2. Normalized Y "table" function values
3. Initial station characterisitcs
4. Total apartment numbers
5. Project size functions.

1. Raw X "Table" Function Values

There are exactly 14 records in this section, one record for each table function (characteristic).

FORMAT (I1, 2(1X,I2), F3.0,10F5.0)

Column	Contents
1	1
2	Blank
3-4	The number of the table function to which the values refer (1 to 14)
5	Blank
6-7	The number of points which define the function (Max. = 10)
8-10	The weight to be associated with the characterisitc when summing the partial attractivity scores.
11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60	The raw X values of the function. Up to 10 X values may be defined but in a particular function there must be exactly the number of points specified in columns 6-7.

No $ENDFILE record is to follow this data.

2. Normalized Y Values of the "Table Functions"

There are exactly 14 records in this section, one record for each table function (characteristic).

FORMAT(I1,2(1X,I2),3X,10F5.0)

Column	Contents
1	2
2	Blank
3-4	The number of the "table" function to which the values refer (1 to 14)
5	Blank
6-7	Number of points which define the function, (max.=10)
8-10	Blank
11-15, 16-20, 21-25, 26-30, 31-35, 36-40, 41-45, 46-50, 51-55, 56-60	Normalized Y values of the function. Up to 10 Y values may be defined but in a particular function, there must be exactly the number of points specified in columns 6-7.

3. Initial Station Characteristics

The model is represented by up to 5 rapid transit lines made up of stations with 4 sub-areas each. The characteristics of the sub-areas are read in from up to 5 sets of records, each record representing a sub-area. There may be up to 120 sub-areas per line. If there are less than 120 sub-areas on a line then a $ENDFILE must follow the last substation of that line. If there are exactly 120 sub-areas no $ENDFILE record is required. If there are no substations on the line (i.e. the line does not exist) then only a $ENDFILE must be included.

Each data record will have the following format:

FORMAT (I1,I4,1X,2F6.0,2F5.1,10X,4F2.0,8X,3F2.0,4X,3F2.0,1X,I2)

Column	Contents
1	3
2-5	a number which designates the sub-area (they must be in numerical order)
6	Blank
7-12	Number of apartments initially in the sub-area
13-18	The effect of technological constraints.
19-23	Total land available (including vacant land)
24-28	Vacant land

29-38	Blank
39-40	Building age mix
41-42	Neighbourhood quality
43-44	Lot size
45-46	Park land availability
47-54	Blank
55-56	Surface access to central area
57-58	Nodality
59-60	Zoning
61-64	Blank
65-66	Ceiling Capacity
67-68	Commercial development
69-70	Undesirable conditions
71	Blank
72-73	Year in which sub-area enters the model.

4. Total Apartments to be Built: by Line and Year

Each record represents a year and contains the total number of apartments to be built on each of the 5 lines. If less than 14 years are provided, then $ENDFILE must follow the last record. If exactly 14 are provided, then no $ENDFILE is to be included:

The format of each record is as follows:

FORMAT(I1,1X,5(F6.0))

Column	Contents
1	4
2	Blank
3-8	Number of apartments for line 1
9-14	Number of apartments for line 2
15-20	Number of apartments for line 3
21-26	Number of apartments for line 4
27-32	Number of apartments for line 5

5. Project Size Functions

The total apartments for each line are allocated on the basis of projects which are executed at each sub-area. The size of these projects is determined randomly from one of 4 cumulative probability functions. Up to 60 points may be defined for each function (each record defines 1 point). The records must be ordered by numerical order of the independent variable. If less than 60 points are defined, then a $ENDFILE must appear after the last record. If exactly 60 points are provided for a function then no $ENDFILE is needed. All four functions are required. The format for each record is as follows:

appendix

(See Chapter 7.1)

A.a-2

SAMPLE OUTPUT

This appendix contains a sample output for the case if the user chooses PAR=FULL.

The following sets of data are printed after each simulation period:

i. NORMALIZED CHARACTERISTIC VALUES

These are the normalized values of the fourteen environmental factors, i.e. the environmental conditions for each station sub-area (as up-dated at the end of the former time period).

ii. FUNCTION VALUES

Attractivity scores corresponding to the above environmental characteristics as determined by the appropriate table functions.

iii. ATTRACTIVITY SCORES

Total or composite attractivity score for each station sub-area.

iv. APARTMENT GROWTH

Number of apartments allocated to each station sub-area.

In addition, all initial data are listed and at the end, the incremental and cumulative apartment growth by station sub-areas for all time periods are printed (see sample in Appendix A.d-4).

BEGINNING OF TIME PERIOD 5
NORMALIZED CHARACTERISTIC VALUES

1011	0.02620	1.00000	0.40000	0.0	0.28571	1.00000	0.28571	1.00000	1.00000	0.75000	0.40000	0.0	0.33333	0.0
1012	0.25743	0.82278	0.14560	0.0	0.28571	0.66667	0.42857	0.0	1.00000	0.75000	0.40000	0.0	1.00000	0.0
1013	0.00980	1.00000	0.30000	0.0	0.28571	1.00000	0.57143	0.0	1.00000	0.75000	0.20000	0.0	0.33333	0.0
1014	0.02240	0.98460	0.36920	0.0	0.28571	0.66667	0.42857	0.0	1.00000	0.75000	0.40000	0.0	1.00000	0.0
1021	0.01080	1.00000	0.36000	0.0	0.28571	1.00000	0.71429	1.00000	1.00000	0.33333	0.20000	0.0	0.33333	0.0
1022	0.0	1.00000	0.40000	0.0	0.28571	1.00000	0.28571	0.0	1.00000	0.33333	0.40000	0.0	0.33333	0.0
1023	0.04550	0.05341	0.16920	0.21840	0.28571	0.66667	1.00000	1.00000	1.00000	0.33333	0.60000	0.0	0.33333	1.00000
1024	0.03930	0.96870	0.43740	0.0	0.28571	0.66667	0.71429	1.00000	1.00000	0.33333	0.40000	0.0	0.33333	0.0
1031	0.13151	0.90249	0.12500	0.0	0.28571	0.66667	0.71429	0.0	1.00000	0.50000	0.40000	0.0	1.00000	0.0
1032	0.02160	0.98460	0.06920	0.0	0.57143	0.66667	0.42857	1.00000	1.00000	0.50000	0.40000	0.0	1.00000	0.0
1033	0.00160	1.00000	0.10000	0.0	0.85714	0.66667	0.14286	1.00000	1.00000	0.50000	0.40000	0.0	1.00000	1.00000
1034	0.17602	0.83058	0.16120	0.0	0.57143	0.66667	0.85714	1.00000	1.00000	0.50000	0.40000	0.0	1.00000	0.0
1041	0.0	1.00000	0.30000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.0	0.60000	0.0	0.33333	0.0
1042	0.0	1.00000	0.40000	0.0	0.57143	0.33333	0.28571	0.0	0.0	0.0	0.40000	0.0	0.33333	1.00000
1043	0.0	1.00000	0.20000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.0	0.40000	0.0	0.33333	1.00000
1044	0.0	1.00000	0.20000	0.40000	0.0	0.0	1.00000	0.0	0.0	0.0	1.00000	0.0	0.33333	1.00000
1051	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.08333	0.60000	0.0	0.66667	0.0
1052	0.0	1.00000	0.40000	0.0	0.57143	1.00000	0.42857	0.0	0.0	0.08333	0.40000	0.0	0.33333	0.0
1053	0.0	1.00000	0.20000	0.0	1.00000	0.33333	0.28571	1.00000	0.0	0.08333	0.60000	0.0	0.66667	0.0
1054	0.0	1.00000	0.10000	0.0	0.57143	1.00000	0.42857	1.00000	0.0	0.08333	0.40000	0.0	0.33333	0.0
2011	0.02730	0.98070	0.36140	0.0	0.85714	0.66667	1.00000	0.0	1.00000	0.33333	0.60000	0.0	0.33333	0.0
2012	0.08311	0.95430	0.30860	0.0	0.85714	0.66667	1.00000	0.0	1.00000	0.33333	0.80000	0.0	0.33333	0.0
2013	0.0	1.00000	0.0	0.0	0.0	0.0	0.85714	0.0	1.00000	0.33333	1.00000	0.0	0.33333	0.0
2014	0.0	1.00000	0.0	0.0	0.0	0.0	0.85714	0.0	1.00000	0.33333	1.00000	0.0	0.33333	0.0
2021	0.05841	0.97160	0.34320	0.0	1.00000	0.66667	0.85714	0.0	1.00000	0.08333	0.80000	0.0	0.66667	0.0
2022	0.0	1.00000	0.40000	0.0	0.85714	0.66667	0.28571	0.0	0.0	0.08333	0.60000	0.0	0.66667	0.0
2023	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.08333	0.60000	0.0	0.66667	0.0
2024	0.0	1.00000	0.0	0.0	0.0	0.0	1.00000	0.0	0.0	0.08333	1.00000	0.0	0.33333	0.0
2031	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.66667	0.0
2032	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.66667	0.0
2033	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.66667	0.0
2034	0.0	1.00000	0.28000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.16667	0.60000	0.0	0.66667	0.0
2041	0.0	1.00000	0.0	0.0	0.0	0.0	1.00000	1.00000	0.0	0.0	1.00000	0.0	0.33333	0.0
2042	0.00250	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.0	0.60000	0.0	0.33333	0.0
2043	0.0	1.00000	0.16000	0.0	1.00000	0.33333	0.28571	1.00000	0.0	0.0	0.40000	0.0	0.33333	0.0
2044	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.0	0.40000	0.0	0.33333	0.0
2051	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
2052	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.14286	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
2053	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
2054	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
2061	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.14286	0.0	1.00000	0.08333	0.40000	0.0	0.33333	0.0
2062	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.14286	0.0	1.00000	0.08333	0.40000	0.0	0.33333	0.0
2063	0.0	1.00000	0.10000	0.0	1.00000	0.33333	0.14286	0.0	1.00000	0.08333	0.40000	0.0	0.33333	0.0
2064	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.57143	0.0	1.00000	0.08333	0.40000	0.0	0.66667	0.0
2071	0.0	1.00000	0.02000	0.0	1.00000	0.33333	0.14286	0.0	0.0	0.16667	1.00000	0.0	0.33333	1.00000
2072	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.14286	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
2073	0.0	1.00000	0.16000	0.0	1.00000	0.33333	0.14286	0.0	0.0	0.16667	0.40000	0.0	0.33333	1.00000
2074	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
2081	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.14286	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
2082	0.0	1.00000	0.04000	0.0	1.00000	0.33333	0.14286	0.0	0.0	0.16667	0.40000	0.0	0.33333	1.00000
2083	0.01170	1.00000	0.40000	0.0	1.00000	0.33333	0.14286	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
2084	0.0	1.00000	0.08000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	1.00000
2091	0.03340	1.00000	0.32000	0.0	0.85714	0.66667	0.71429	1.00000	1.00000	0.08333	0.40000	0.0	0.33333	0.0
2092	0.0	1.00000	0.40000	0.0	0.85714	0.33333	0.28571	0.0	1.00000	0.08333	0.40000	0.0	0.33333	0.0
2093	0.0	1.00000	0.0	0.0	0.0	0.0	1.00000	1.00000	1.00000	0.08333	1.00000	0.0	0.33333	0.0
2094	0.0	1.00000	0.40000	0.0	1.00000	1.00000	0.42857	1.00000	1.00000	0.08333	0.40000	0.0	0.33333	0.0
2101	0.01350	1.00000	0.30000	0.0	0.28571	0.66667	0.28571	0.0	0.0	0.08333	0.40000	0.0	0.33333	0.0
2102	0.08171	1.00000	0.40000	0.0	0.85714	0.66667	0.71429	1.00000	0.0	0.08333	0.60000	0.0	0.33333	0.0
2103	0.00740	1.00000	0.28000	0.0	0.28571	1.00000	0.42857	1.00000	0.0	0.08333	0.20000	0.0	0.33333	0.0
2104	0.0	1.00000	0.0	0.0	0.0	0.0	1.00000	1.00000	0.0	0.08333	1.00000	0.0	0.33333	0.0
2111	0.0	1.00000	0.40000	0.0	0.28571	1.00000	0.57143	0.0	0.0	0.25000	0.40000	0.0	0.33333	0.0
2112	0.0	1.00000	0.40000	0.0	0.28571	1.00000	0.28571	0.0	0.0	0.25000	0.40000	0.0	0.33333	0.0
2113	0.0	1.00000	0.40000	0.0	0.14286	1.00000	0.57143	0.0	0.0	0.25000	0.40000	0.0	0.33333	0.0
2114	0.0	1.00000	0.40000	0.0	0.14286	1.00000	0.14286	0.0	0.0	0.25000	0.40000	0.0	0.33333	0.0
2121	0.0	1.00000	0.36000	0.0	0.28571	1.00000	0.14286	0.0	1.00000	0.33333	0.20000	0.0	0.66667	0.0
2122	0.0	1.00000	0.40000	0.0	0.28571	0.66667	0.57143	0.0	1.00000	0.33333	0.60000	0.0	0.66667	0.0
2123	0.0	1.00000	0.40000	0.0	0.28571	1.00000	0.28571	0.0	1.00000	0.33333	0.20000	0.0	0.66667	0.0
2124	0.0	1.00000	0.40000	0.0	0.28571	0.66667	0.14286	0.0	1.00000	0.33333	0.20000	0.0	0.66667	0.0
2131	0.01600	1.00000	0.30000	0.0	0.42857	1.00000	0.71429	1.00000	0.0	0.16667	0.20000	0.0	0.33333	0.0
2132	0.01730	1.00000	0.20000	0.06000	0.42857	0.66667	0.71429	1.00000	0.0	0.16667	0.40000	0.0	0.33333	0.0
2133	0.02340	1.00000	0.10000	0.0	0.28571	1.00000	0.85714	1.00000	0.0	0.16667	0.20000	0.0	0.33333	0.0
2134	0.0	1.00000	0.0	0.0	0.0	0.0	1.00000	1.00000	0.0	0.16667	1.00000	0.0	0.33333	0.0
2141	0.0	1.00000	0.40000	0.0	0.28571	1.00000	0.28571	0.0	0.0	0.25000	0.20000	0.0	0.33333	0.0
2142	0.0	1.00000	0.40000	0.0	0.28571	1.00000	0.28571	0.0	0.0	0.25000	0.20000	0.0	0.33333	0.0
2143	0.0	1.00000	0.40000	0.0	0.28571	1.00000	0.28571	0.0	0.0	0.25000	0.20000	0.0	0.33333	0.0
2144	0.0	1.00000	0.40000	0.0	0.28571	1.00000	0.28571	0.0	0.0	0.25000	0.20000	0.0	0.33333	0.0
2151	0.03480	1.00000	0.16000	0.08000	0.28571	0.66667	0.28571	1.00000	1.00000	0.50000	0.40000	0.0	0.33333	1.00000
2152	0.01800	1.00000	0.24000	0.06000	0.28571	0.66667	0.42857	0.0	1.00000	0.50000	0.40000	0.0	0.33333	1.00000
2153	0.0	1.00000	0.40000	0.0	0.28571	0.33333	0.42857	0.0	1.00000	0.50000	0.40000	0.0	0.33333	0.0
2154	0.0	1.00000	0.40000	0.0	0.28571	0.33333	0.28571	0.0	1.00000	0.50000	0.40000	0.0	0.33333	0.0
3011	0.00570	1.00000	0.08000	0.0	1.00000	0.33333	0.28571	0.0	1.00000	0.08333	0.20000	0.0	0.33333	0.0
3012	0.0	1.00000	0.12000	0.0	1.00000	0.33333	0.28571	0.0	1.00000	0.08333	0.20000	0.0	0.33333	0.0
3013	0.02890	1.00000	0.40000	0.0	0.42857	0.33333	0.14286	0.0	1.00000	0.08333	0.80000	0.0	0.33333	0.0
3014	0.21712	0.90639	0.81680	0.0	1.00000	0.66667	0.57143	0.0	1.00000	0.08333	0.60000	0.0	1.00000	0.0
3021	0.0	1.00000	0.16000	0.0	0.57143	1.00000	0.42857	1.00000	0.0	0.0	0.20000	0.0	0.33333	0.0
3022	0.0	1.00000	0.0	0.0	0.0	0.0	1.00000	1.00000	0.0	0.0	1.00000	0.0	0.33333	0.0
3023	0.0	1.00000	0.12000	0.0	0.57143	1.00000	0.85714	1.00000	0.0	0.0	0.20000	0.0	0.33333	0.0
3024	0.0	1.00000	0.0	0.0	0.0	0.0	1.00000	1.00000	0.0	0.0	1.00000	0.0	0.33333	0.0
3031	0.11011	0.92439	0.24880	0.0	0.57143	0.66667	0.71429	1.00000	1.00000	0.33333	0.40000	0.0	0.66667	0.0
3032	0.0	1.00000	0.40000	0.0	0.57143	0.33333	0.28571	0.0	1.00000	0.33333	0.20000	0.0	0.66667	0.0
3033	0.01100	1.00000	0.04000	0.0	0.85714	0.66667	0.14286	1.00000	1.00000	0.33333	0.80000	0.0	0.66667	1.00000
3034	0.01020	1.00000	0.40000	0.0	0.85714	0.66667	0.42857	1.00000	1.00000	0.33333	0.40000	0.0	0.66667	0.0
3041	0.0	1.00000	0.30000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.0	0.20000	0.0	0.33333	0.0
3042	0.00280	1.00000	0.40000	0.0	1.00000	0.33333	0.14286	0.0	0.0	0.0	0.40000	0.0	0.33333	0.0
3043	0.00400	1.00000	0.28000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.0	0.40000	0.0	0.33333	0.0
3044	0.0	1.00000	0.32000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.0	0.40000	0.0	0.33333	0.0
3051	0.00800	1.00000	0.36000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.33333	0.40000	0.0	0.33333	0.0
3052	0.00190	1.00000	0.40000	0.0	0.57143	0.33333	0.28571	0.0	0.0	0.33333	0.40000	0.0	0.33333	0.0
3053	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	1.00000	0.0	0.33333	0.40000	0.0	0.33333	0.0
3054	0.0	1.00000	0.40000	0.0	1.00000	0.33333	0.28571	0.0	0.0	0.33333	0.40000	0.0	0.33333	0.0
3061	0.0	1.00000	0.40000	0.0	0.57143	0.33333	0.14286	0.0	0.0	0.0	0.40000	0.0	0.33333	0.0
3062	0.00240	1.00000	0.04000	0.0	0.57143	0.33333	0.14286	0.0	0.0	0.0	0.40000	0.0	0.33333	0.0
3063	0.0	1.00000	0.16000	0.0	1.00000	0.33333	0.14286	0.0	0.0	0.0	0.40000	0.0	0.33333	0.0
3064	0.0	1.00000	0.12000	0.0	1.00000	0.33333	0.14286	0.0	0.0	0.0	0.40000	0.0	0.33333	0.0
3071	0.0	1.00000	0.36000	0.06000	0.57143	0.33333	0.28571	0.0	0.0	0.08333	0.40000	0.0	0.33333	0.0
3072	0.0	1.00000	0.40000	0.0	0.42857	0.33333	0.28571	0.0	0.0	0.08333	0.40000	0.0	0.33333	0.0
3073	0.0	1.00000	0.30000	0.0	1.00000	0.33333	0.28571	1.00000	0.0	0.08333	0.40000	0.0	0.33333	1.00000
3074	0.0	1.00000	0.40000	0.0	0.85714	0.33333	0.28571	0.0	0.0	0.08333	0.40000	0.0	0.33333	0.0
3081	0.0	1.00000	0.40000	0.0	0.28571	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
3082	0.0	1.00000	0.40000	0.0	0.28571	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
3083	0.0	1.00000	0.40000	0.0	0.71429	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
3084	0.0	1.00000	0.08000	0.0	0.57143	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	1.00000
3091	0.0	1.00000	0.40000	0.0	0.28571	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
3092	0.00590	1.00000	0.36000	0.0	0.42857	0.33333	0.14286	0.0	0.0	0.16667	0.40000	0.0	0.33333	0.0
3093	0.0	1.00000	0.32000	0.0	0.57143	0.33333	0.14286	0.0	0.0	0.16667	0.40000	0.0	0.33333	1.00000
3094	0.0	1.00000	0.40000	0.0	0.42857	0.33333	0.28571	0.0	0.0	0.16667	0.40000	0.0	0.33333	1.00000
3101	0.0	1.00000	0.40000	0.0	0.42857	0.33333	0.28571	0.0	0.0	0.41667	0.40000	0.0	0.33333	0.0
3102	0.0	1.00000	0.40000	0.0	0.42857	0.33333	0.28571	0.0	0.0	0.41667	0.40000	0.0	0.33333	0.0

FUNCTION VALUES

1011	0.46200	1.00000	1.0C000	0.0	0.10000	0.10000	0.1C000	1.00000	1.00000	1.C0CCC	0.60000	0.0	0.20000	1.0CC00
1012	1.CC0C0	1.00000	1.0CCC0	0.0	0.10000	1.00000	0.70000	0.0	1.00000	1.00CC0	0.60000	0.0	0.50000	1.0CC00
1013	0.29200	1.00000	1.0C000	0.0	0.10000	0.100C0	1.CCC00	0.0	1.C0000	1.00CC0	C.0	0.0	0.2C000	1.CCCCC
1014	0.42400	1.C0000	1.CCCC0	0.0	0.10000	1.000C0	0.70000	0.0	1.C0000	1.0CCC0	0.60000	0.0	0.50000	1.0CC00
1021	0.30800	1.00000	1.0C000	0.0	0.1C000	0.100C0	1.0C000	1.00000	1.00000	0.80CCC	C.0	0.0	0.2C000	1.CCCCC
1022	0.C	1.C0C00	1.CCCC0	0.0	0.1CC00	0.100C0	0.1CC00	0.0	1.C0000	0.80CC0	0.6C000	0.0	0.20000	1.CCCC0
1023	0.65500	1.00000	1.CCCC0	1.00000	0.1C000	1.000C0	1.0C000	1.00C00	1.00000	0.80CCC	C.700C0	0.0	0.2C000	0.C
1024	0.59300	1.00000	1.0C000	0.0	0.1C000	1.00000	1.CCC00	1.00000	1.C0000	0.8CCC0	0.60000	0.0	0.20000	1.CCCC0
1031	1.CC000	1.00000	1.CCCC0	0.0	0.1C000	1.000C0	1.0C000	0.0	1.00000	1.C0CC0	C.6C000	0.0	0.5C000	1.CCCC0
1032	0.41600	1.00000	1.CC000	0.0	0.7C000	1.000C0	0.7CC00	1.00C00	1.C0000	1.00CC0	0.60000	0.0	0.50000	1.CCCC0
1033	0.C3200	1.00000	1.0CCC0	0.0	1.CC000	1.000C0	0.0	1.00000	1.00000	1.00CCC	C.60C0	0.0	0.5C000	0.C
1034	1.CCCC0	1.00000	1.0C000	0.0	0.7C000	1.00000	1.CC000	1.00C00	1.C0000	1.0CCC0	0.60000	0.0	0.50000	1.0CCC0
1041	0.C	1.C0000	1.0CCC0	0.0	C.7C000	0.200C0	0.10000	0.0	0.20000	0.0	C.700C0	0.0	0.2C000	1.CCCCC
1042	0.0	1.00000	1.0C000	0.0	0.7C000	0.20000	0.1C000	0.0	0.20000	0.0	0.60000	0.0	0.20000	0.0
1043	0.C	1.C0000	1.0CCC0	0.0	0.70000	0.200C0	0.1C000	0.0	0.20000	0.0	C.6C0C0	0.0	0.2C000	0.C
1044	0.C	1.00000	1.0C000	1.00000	0.0	0.100C0	1.CC000	0.0	0.20000	0.0	0.20000	0.0	0.20000	0.0
1051	0.C	1.00000	1.0CCC0	0.0	0.7C000	0.200C0	0.1C000	0.0	0.20000	0.0	C.700C0	0.0	0.1C000	1.CCCCC
1052	0.0	1.00000	1.0C000	0.0	0.7C000	0.100C0	C.7CC00	0.0	0.20000	0.0	0.60000	0.0	0.20000	1.0CCC0
1053	0.C	1.00000	1.0C000	0.0	C.7C000	0.200C0	0.1C000	1.00000	0.20000	0.0	C.700C0	0.0	0.1C000	1.CCCCC
1054	0.0	1.00000	1.CCC00	0.0	0.7C000	0.100C0	C.7C000	1.00000	0.20000	0.0	0.60000	0.0	0.20000	1.CCCC0
2011	0.47300	1.C0000	1.CCCC0	0.0	1.CC000	1.000C0	1.CCC00	0.0	1.C0000	0.80CC0	C.70C0	0.0	0.2C000	1.CCCCC
2012	0.89860	1.00000	1.CC000	0.0	1.C0000	1.000C0	1.CC000	0.0	1.C0000	0.80CC0	1.00000	0.0	0.20000	1.0CCC0
2013	0.C	1.00000	0.0	0.0	C.0	0.100C0	1.00000	0.0	1.C0000	0.80CC0	C.200C0	0.0	0.2C000	1.CCCCC
2014	0.0	1.00000	0.0	0.0	0.0	0.10000	1.CCC00	0.0	1.C0000	0.8CCC0	0.20000	0.0	0.2C000	1.0CC00
2021	0.75040	1.00000	1.CCCC0	0.0	0.7C000	1.000C0	1.C0000	0.0	1.00000	0.0	1.CC0C0	0.0	0.1C000	1.CCCCC
2022	0.0	1.00000	1.0C000	0.0	1.C0000	1.000C0	0.1CC00	0.0	0.20000	0.0	0.70000	0.0	0.10000	1.CCCC0
2023	0.C	1.00000	1.CCCC0	0.0	0.7C000	0.20000	0.1C000	0.0	0.20000	0.0	C.7C0C0	0.0	0.1C000	1.CCCC0
2024	0.C	1.00000	0.0	0.0	C.0	0.100C0	1.CCC00	0.0	0.2C000	0.0	0.20000	0.0	0.20000	1.0CCC0
2031	0.C	1.00000	1.CCCC0	0.0	0.7CC00	0.200CC	0.1C000	0.0	0.20000	0.2CCC0	C.6C0C0	0.0	0.1C000	1.CCCCC
2032	0.C	1.00000	1.CC000	0.0	C.7C000	0.200C0	0.1CC00	0.0	0.20000	0.2CCC0	0.60000	0.0	0.1C000	1.0CCC0
2033	0.C	1.00000	1.CCC00	0.0	0.7CC00	0.200C0	0.1C000	0.0	0.20000	0.20CC0	C.6C0C0	0.0	0.1C000	1.CCCCC
2034	0.0	1.00000	1.CC000	0.0	0.7C000	0.200CC	0.1CC00	0.0	0.20000	0.2CCC0	0.70000	0.0	0.1C000	1.CCCC0
2041	0.C	1.C0000	0.0	0.0	0.0	0.100C0	1.CCC00	1.00000	0.20000	0.0	C.2C0C0	0.0	0.2C000	1.CCCCC
2042	0.C5C00	1.00000	1.0C000	0.0	0.7C000	0.20000	0.1CC00	0.0	0.20000	0.0	0.70000	0.0	0.20000	1.CCCCC
2043	0.C	1.00000	1.CCCC0	0.0	C.7C000	0.200CC	0.1C000	1.00000	0.20000	0.0	C.60000	0.0	0.2C000	1.CCCCC
2044	0.0	1.00000	1.CC000	0.0	0.7C000	0.200CC	C.1CC00	0.0	0.20000	0.0	0.60000	0.0	0.20000	1.CCCC0
2051	0.C	1.C0C00	1.CCCC0	0.0	C.7C000	0.200C0	0.1C000	0.0	0.20000	0.2CCC0	C.6C0C0	0.0	0.2C000	1.CCCCC
2052	0.C	1.00C00	1.0C000	0.0	0.7C000	0.200C0	C.0	0.0	0.20000	0.2CCC0	0.60000	0.0	0.20000	1.CCCCC
2053	0.C	1.00C00	1.CCCC0	0.0	C.7C000	0.200C0	0.1C000	0.0	0.20000	0.20CC0	C.6C0C0	0.0	0.2C000	1.CCCCC
2054	0.0	1.00000	1.CCC00	0.0	0.7C000	0.200C0	0.1CC00	0.0	0.20000	0.2CCC0	C.60C0	0.0	0.20000	1.0CCC0
2061	0.C	1.00000	1.CCCC0	0.0	C.7CC00	0.200CC	0.0	0.0	1.C0000	0.0	C.6C0C0	0.0	0.2C000	1.CCCCC
2062	0.C	1.C0000	1.CC000	0.0	0.7C000	0.200C0	C.0	0.0	1.C0000	0.0	0.60000	0.0	0.20000	1.CCCC0
2063	0.C	1.00C00	1.CCCC0	0.0	0.7C000	0.20000	0.0	0.0	1.00000	0.0	C.600C0	0.0	0.2C000	1.CCCCC
2064	0.0	1.00000	1.CC000	0.0	0.7C000	0.200C0	1.CCC00	0.0	1.C0000	0.0	0.60000	0.0	0.10000	1.CCCC0
2071	0.C	1.00C00	0.33333	0.0	0.7C000	0.200C0	0.0	0.0	0.20000	0.20CC0	C.2C0C0	0.0	0.2C000	0.C
2072	0.0	1.00000	1.CCC00	0.0	0.7C000	0.200CC	C.0	0.0	0.20000	0.2CCC0	0.60000	0.0	0.20000	1.CCCC0
2073	0.C	1.C0000	1.0CC00	0.0	0.7C000	0.200C0	0.0	0.0	0.20000	0.2CCC0	C.6C0C0	0.0	0.2C000	0.C
2074	0.0	1.00000	1.0C000	0.0	0.7C000	0.200C0	0.1CC00	0.0	0.20000	0.2CCC0	0.60000	0.0	0.20000	1.0CCC0
2081	0.C	1.C0000	1.CCCC0	0.0	C.7C000	0.200CC	0.0	0.0	0.20000	0.2CCC0	C.6C0C0	0.0	0.2C000	1.CCCCC
2082	0.0	1.00000	0.75000	0.0	0.7C000	0.200C0	C.0	0.0	0.20000	0.2CCC0	0.60000	0.0	0.20000	0.0
2083	0.31700	1.C0000	1.CCCC0	0.0	0.7C000	0.200CC	0.0	0.0	0.20000	0.20CC0	C.6C0C0	0.0	0.2C000	1.CCCCC
2084	0.C	1.00000	1.0C000	0.0	0.7C000	0.20000	0.1CC00	0.0	0.20000	0.2CCC0	0.60000	0.0	0.20000	0.0
2091	0.53400	1.C0000	1.CCCC0	0.0	1.CC000	1.00000	1.C0000	1.00000	1.C0000	0.0	C.6C0C0	0.0	0.2C000	1.CCCCC
2092	0.0	1.00000	1.0C000	0.0	1.CC000	0.200C0	0.1CC00	0.0	1.C0000	0.0	0.60000	0.0	0.20000	1.0CCC0
2093	0.C	1.00C00	0.0	0.0	0.0	0.100C0	1.00000	1.00000	1.00000	0.0	C.200C0	0.0	0.20000	1.CCCCC
2094	0.0	1.00000	1.0C000	0.0	0.7C000	0.100C0	C.7C000	1.00C00	1.C0000	0.0	0.60000	0.0	0.20000	1.CCCC0
2101	0.33500	1.00000	1.0CCC0	0.0	0.1C000	1.000C0	0.10000	0.0	0.20000	0.0	C.6C0C0	0.0	0.2C000	1.CCCCC
2102	0.89020	1.00000	1.0C000	0.0	1.CC000	1.00000	1.CCC00	1.00C00	0.20000	0.0	0.70000	0.0	0.20000	1.0CCC0
2103	0.19600	1.00000	1.CCCC0	0.0	0.1CC00	0.100CC	0.7C000	1.00000	0.20000	0.0	C.0	0.0	0.2C000	1.CCCCC
2111	0.C	1.00000	1.CCC00	0.0	0.10000	0.100C0	1.00000	0.0	0.20000	0.50CC0	C.6C000	0.0	0.2C000	1.CCCCC
2112	0.0	1.00000	1.0C000	0.0	0.1CC00	0.100C0	0.1C000	0.0	0.20000	0.50CC0	0.60000	0.0	0.20000	1.0CCC0
2113	0.C	1.00000	1.CCCC0	0.0	0.0	0.10000	1.00000	0.0	0.20000	0.50CC0	C.60C0	0.0	0.2C000	1.CCCCC
2114	0.0	1.00000	1.0C000	0.0	0.0	0.100C0	0.0	0.0	0.20000	0.5CCC0	0.60000	0.0	0.2C000	1.0CCC0
2121	0.C	1.00000	1.CCCC0	0.0	0.1C000	0.10000	0.0	0.0	1.C0000	0.80CC0	C.0	0.0	0.1C000	1.CCCCC
2122	0.0	1.00000	1.0C000	0.0	0.1C000	1.000C0	1.CCC00	0.0	1.C0000	0.8CCC0	0.70000	0.0	0.10000	1.CCCCC
2123	0.C	1.00C00	1.CCCC0	0.0	0.10000	0.10000	0.10000	0.0	1.C0000	0.80CC0	C.0	0.0	0.1C000	1.CCCCC
2124	0.0	1.00000	1.CC000	0.0	0.1C000	1.000C0	C.0	0.0	1.C0000	0.80C0	0.0	0.0	0.10000	1.CCCC0
2131	0.36C00	1.00000	1.CCCC0	0.0	0.6CC00	0.100C0	1.C0000	1.00000	0.20000	0.20CC0	C.0	0.0	0.2C000	1.CCCCC
2132	0.37300	1.00000	1.0C000	0.40000	0.6C000	1.00000	1.CCC00	1.00000	0.20000	0.2CCC0	0.60000	0.0	0.20000	1.0CCC0
2133	0.43400	1.00000	1.CCCC0	0.0	0.10000	0.100C0	1.00000	1.00000	0.20000	0.2CCC0	C.0	0.0	0.2C000	1.CCCCC
2134	0.0	1.00000	0.0	0.0	C.0	0.100C0	1.CCC00	1.00C00	0.20000	0.2CCC0	0.20000	0.0	0.20000	1.CCCCC
2141	0.C	1.C0000	1.CCCC0	0.0	0.1C000	0.100C0	0.1C000	0.0	0.20000	0.50CC0	C.0	0.0	0.2C000	1.CCCCC
2142	0.0	1.00000	1.0C000	0.0	0.1C000	0.10000	0.1C000	0.0	0.20000	0.50CC0	0.0	0.0	0.20000	1.CCCCC
2143	0.C	1.00000	1.CCCC0	0.0	0.1CC00	0.100C0	0.1C000	0.0	0.20000	0.50CC0	C.0	0.0	0.2C000	1.CCCCC
2144	0.0	1.00000	1.CC000	0.0	0.1C000	0.100C0	0.1CC00	0.0	0.20000	0.5CCC0	0.0	0.0	0.20000	1.CCCC0
2151	0.54800	1.00000	1.CCCC0	0.70000	0.1C000	1.000C0	0.1C000	1.00C00	1.C0000	1.0CCC0	C.60C0	0.0	0.2C000	0.C
2152	0.38C00	1.00000	1.0CC00	0.40000	0.1C000	1.000CC	0.7CC00	0.0	1.C0000	1.00CC0	0.60000	0.0	0.20000	0.0
2153	0.C	1.C0000	1.CCC00	0.0	0.1C000	0.200C0	0.70000	0.0	1.C0000	1.0CCC0	C.6C0C0	0.0	0.2C000	1.CCCCC
2154	0.0	1.00C00	1.CC000	0.0	0.1C000	0.200C0	0.1CC00	0.0	1.C0000	1.CCCC0	0.60000	0.0	0.2C000	1.0CCC0
3011	0.12800	1.C0000	1.CCCC0	0.0	0.7C000	0.200C0	0.1C000	0.0	1.C0000	0.0	C.0	0.0	0.2C000	1.CCCCC
3012	0.0	1.00000	1.0C000	0.0	0.7C000	0.200C0	0.1CC00	0.0	1.C0000	0.0	0.0	0.0	0.2C000	1.CCCCC
3013	0.48900	1.C0000	1.0CCC0	0.0	C.6CC00	0.200CC	0.0	0.0	1.C0000	0.0	1.CC0C0	0.0	0.2C000	1.CCCCC
3014	1.CC000	1.00000	1.0C000	0.0	0.7C000	1.00000	1.CCC00	0.0	1.C0000	0.0	0.70000	0.0	0.50000	1.CCCC0
3021	0.C	1.00000	1.CCCC0	0.0	C.7C000	0.100C0	0.70000	1.00000	0.20000	0.0	C.0	0.0	0.2C000	1.CCCCC
3022	0.0	1.00000	0.0	0.0	0.0	0.10000	1.CC000	1.00C00	0.20000	0.0	0.20000	0.0	0.20000	1.0CCC0
3023	0.C	1.00000	1.CC0C0	0.0	C.7C000	0.100C0	1.00000	1.00C00	0.20000	0.0	C.0	0.0	0.2C000	1.CCCCC
3024	0.C	1.00000	0.0	0.0	0.0	0.100C0	1.CCC00	1.00C00	0.20000	0.0	0.20000	0.0	0.20000	1.CCCCC
3031	1.CCC00	1.C0000	1.CCCC0	0.0	0.7C000	1.00000	1.00000	1.00000	1.00000	0.80CC0	C.6C0C0	0.0	0.1C000	1.CCCCC
3032	0.0	1.00000	1.CC000	0.0	0.7C000	0.200C0	C.1CC00	0.0	1.C0000	0.8CCC0	0.0	0.0	0.10000	1.CCCC0
3033	0.31C00	1.C0000	0.75CC0	0.0	1.CC000	1.000C0	0.0	1.00C00	1.C0000	0.80CC0	1.C0C0	0.0	C.1C000	0.C
3034	0.3C200	1.00000	1.0C000	0.0	1.CC000	1.000CC	C.7CC00	1.00C00	1.C0000	0.8C0C0	0.60000	0.0	0.10000	1.CCCCC
3041	0.C	1.C0000	1.CCCC0	0.0	0.7C000	0.200CC	0.1C000	0.0	0.20000	0.0	C.0	0.0	0.2C000	1.CCCCC
3042	0.C5600	1.00000	1.0C000	0.0	0.7C000	0.200CC	0.0	0.0	0.20000	0.0	0.60000	0.0	0.2C000	1.CCCCC
3043	0.C8C00	1.C0000	1.CCCC0	0.0	C.7C000	0.200C0	0.1C000	0.0	0.20000	0.0	C.6C0C0	0.0	0.2C000	1.CCCCC
3044	0.0	1.00000	1.0C000	0.0	0.7C000	0.200C0	0.1CC00	0.0	0.20000	0.0	0.60000	0.0	0.20000	1.CCCC0
3051	0.22C00	1.00000	1.0CCC0	0.0	C.7C000	0.200C0	0.10000	0.0	0.20000	0.8CCC0	C.6C0C0	0.0	0.2C000	1.CCCCC
3052	0.C3800	1.00000	1.0C000	0.0	0.7C000	0.200C0	C.1CC00	0.0	0.20000	0.8CCC0	0.60000	0.0	0.20000	1.CCCCC
3053	0.C	1.C0000	1.0CCC0	0.0	C.7C000	0.200CC	0.1C000	1.00000	0.20000	0.8CCC0	C.6C0C0	0.0	0.2C000	1.CCCCC
3054	0.C	1.00000	1.CCC00	0.0	0.7C000	0.200CC	C.1CC00	0.0	0.20000	0.80CC0	0.60000	0.0	0.20000	1.0CCC0
3061	0.C	1.C0C00	1.CCCC0	0.0	0.7C000	0.200CC	0.0	0.0	0.20000	0.0	C.6C0C0	0.0	0.2C000	1.CCCCC
3062	0.048C0	1.00000	0.75000	0.0	0.7C000	0.200CC	C.0	0.0	0.20000	0.0	0.60000	0.0	0.20000	1.CCCC0
3063	0.C	1.C0C00	1.CCCC0	0.0	0.7C000	0.200C0	0.0	0.0	0.20000	0.0	C.6C0C0	0.0	0.2C000	1.CCCCC
3064	0.C	1.00000	1.CC000	0.0	0.7C000	0.200C0	0.0	0.0	0.20000	0.0	0.60000	0.0	0.2C000	1.CCCCC
3071	0.C	1.00000	1.CCCC0	0.40000	0.7C000	0.200C0	0.1C000	0.0	0.20000	0.0	C.6C0C0	0.0	0.2C000	1.CCCCC
3072	0.0	1.00000	1.CC000	0.0	0.6C000	0.20000	0.1CC00	0.0	0.20000	0.0	0.60000	0.0	0.20000	1.0CCC0
3073	0.C	1.00000	1.CCCC0	0.0	0.7C000	0.20000	0.10000	1.00000	0.20000	0.0	C.6C0C0	0.0	0.2C000	0.C
3074	0.0	1.00000	1.CCC00	0.0	1.C0000	0.20000	C.1C000	0.0	0.20000	0.0	0.60000	0.0	0.20000	1.CCCC0
3081	0.0	1.00000	1.CCC00	0.0	0.10000	0.20000	0.10000	0.0	0.20000	0.20CC0	C.60000	0.0	0.20000	1.CCCCC
3082	0.0	1.00000	1.CC000	0.0	0.10000	0.20000	0.1CC00	0.0	0.20000	0.2CCC0	0.60000	0.0	0.20000	1.0CCC0
3083	0.0	1.00000	1.CCCC0	0.0	0.80000	0.20000	0.10000	0.0	0.20000	0.20CC0	C.60000	0.0	0.20000	1.CCCC0
3084	0.0	1.00000	1.CC000	0.0	0.7C000	0.20000	0.1CC00	0.0	0.20000	0.2CCC0	0.60000	0.0	0.20000	0.0
3091	0.C	1.C0000	1.CCCC0	0.0	0.10000	0.200C0	0.10000	0.0	0.20000	0.2CCC0	C.6C0C0	0.0	0.2C000	1.CCCCC
3092	0.13600	1.00000	1.CC000	0.0	0.6CC00	0.20000	0.0	0.0	0.20000	0.20CC0	0.60000	0.0	0.20000	1.CCCC0
3093	0.C	1.00C00	1.CCCC0	0.0	0.7CC00	0.200CC	0.0	0.0	0.20000	0.2CCC0	C.6C0C0	0.0	0.2C000	0.C
3094	0.C	1.00000	1.CC000	0.0	0.6C000	0.200C0	0.1CC00	0.0	0.20000	0.2CCC0	0.60000	0.0	0.20000	0.0
3101	0.C	1.00C00	1.CCCC0	0.0	C.6C000	0.200CC	0.1C000	0.0	0.20000	1.00CC0	C.6C0C0	0.0	0.2C000	1.CCCCC
3102	0.C	1.00000	1.CC000	0.0	0.6C000	0.200C0	0.1C000	0.0	0.20000	1.0CCC0	0.60000	0.0	0.20000	1.CCCCC
3103	0.C	1.C0000	1.CCCC0	0.0	0.6C000	0.200C0	0.1C000	1.00000	0.20000	1.00CC0	C.6C000	0.0	0.2C000	1.CCCCC

ATTRACTIVITY SCORES

1011	0.49030	1012	0.75900	1013	0.50580	1014	0.67260
1021	0.50420	1022	0.39700	1023	0.73125	1024	0.72095
1031	0.79800	1032	0.69340	1033	0.43080	1034	0.82000
1041	0.31200	1042	0.18100	1043	0.18100	1044	0.33800
1051	0.30800	1052	0.36700	1053	0.31800	1054	0.37700
2011	0.72195	2012	0.81879	2013	0.0	2014	0.0
2021	0.73056	2022	0.41000	2023	0.30800	2024	0.0
2031	0.31100	2032	0.31100	2033	0.31100	2034	0.32200
2041	0.0	2042	0.31950	2043	0.31100	2044	0.30100
2051	0.31500	2052	0.30200	2053	0.31500	2054	0.31500
2061	0.35200	2062	0.35200	2063	0.35200	2064	0.47800
2071	0.1[illegible]800	2072	0.30200	2073	0.18200	2074	0.31500
2081	0.30200	2082	0.17450	2083	0.34955	2084	0.19500
2091	0.67410	2092	0.37100	2093	0.0	2094	0.44100
2101	0.43525	2102	0.67453	2103	0.32840	2104	0.0
2111	0.42900	2112	0.31200	2113	0.42700	2114	0.29700
2121	0.31400	2122	0.62900	2123	0.32700	2124	0.42200
2131	0.41600	2132	0.63595	2133	0.41710	2134	0.0
2141	0.24600	2142	0.24600	2143	0.24600	2144	0.24600
2151	0.56820	2152	0.57800	2153	0.50100	2154	0.42300
3011	0.31820	3012	0.29900	3013	0.46735	3014	0.75100
3021	0.31100	3022	0.0	3023	0.35000	3024	0.0
3031	0.79000	3032	0.35100	3033	0.47900	3034	0.65230
3041	0.23500	3042	0.29640	3043	0.31300	3044	0.30100
3051	0.39000	3052	0.36270	3053	0.36700	3054	0.35700
3061	0.28800	3062	0.28770	3063	0.28800	3064	0.28800
3071	0.34500	3072	0.29900	3073	0.19100	3074	0.30700
3081	0.30300	3082	0.30300	3083	0.31700	3084	0.19500
3091	0.30300	3092	0.32040	3093	0.18200	3094	0.19300
3101	0.36900	3102	0.36900	3103	0.37900	3104	0.54000
3111	0.73800	3112	0.0	3113	0.0	3114	0.42500
3121	0.74600	3122	0.0	3123	0.0	3124	0.34300

LINE NO.	1						
1011	0.0	1012	637.0	1013	0.0	1014	0.0
1021	0.0	1022	0.0	1023	0.0	1024	1077.0
1031	0.0	1032	0.0	1033	0.0	1034	763.0
1041	0.0	1042	0.0	1043	0.0	1044	0.0
1051	0.0	1052	0.0	1053	0.0	1054	0.0
LINE NO.	2						
2011	215.0	2012	803.0	2013	0.0	2014	0.0
2021	283.0	2022	0.0	2023	0.0	2024	0.0
2031	0.0	2032	0.0	2033	0.0	2034	0.0
2041	0.0	2042	0.0	2043	0.0	2044	0.0
2051	0.0	2052	0.0	2053	0.0	2054	0.0
2061	0.0	2062	0.0	2063	0.0	2064	0.0
2071	0.0	2072	0.0	2073	0.0	2074	0.0
2081	0.0	2082	0.0	2083	0.0	2084	0.0
2091	0.0	2092	0.0	2093	0.0	2094	0.0
2101	0.0	2102	177.0	2103	0.0	2104	0.0
2111	0.0	2112	0.0	2113	0.0	2114	0.0
2121	0.0	2122	0.0	2123	0.0	2124	0.0
2131	0.0	2132	0.0	2133	0.0	2134	0.0
2141	0.0	2142	0.0	2143	0.0	2144	0.0
2151	0.0	2152	0.0	2153	0.0	2154	0.0
LINE NO.	3						
3011	0.0	3012	0.0	3013	0.0	3014	639.0
3021	0.0	3022	0.0	3023	0.0	3024	0.0
3031	1037.0	3032	0.0	3033	0.0	3034	0.0
3041	0.0	3042	0.0	3043	0.0	3044	0.0
3051	0.0	3052	0.0	3053	0.0	3054	0.0
3061	0.0	3062	0.0	3063	0.0	3064	0.0
3071	0.0	3072	0.0	3073	0.0	3074	0.0
3081	0.0	3082	0.0	3083	0.0	3084	0.0
3091	0.0	3092	0.0	3093	0.0	3094	0.0
3101	0.0	3102	0.0	3103	0.0	3104	0.0
3111	280.0	3112	0.0	3113	0.0	3114	0.0
3121	429.0	3122	0.0	3123	0.0	3124	0.0

appendix

(see Chapter 7.1)

A-a-3

This sample shows the questions asked during simulation and the range of answers required.

SAMPLE OUTPRINT OF INTERACTION

SAMPLE PRINTOUT OF INTERVENTION
****

```
$run p108:model.o 4=*sink* 5=p108:data 6=-print 7=-file


#EXECUTION BEGINS


         CONSEQUENCES OF RAPID TRANSIT

     MODEL DATE APRIL 14, 1972      04-27-72 19:34:02
     R. STUSSI       P. BAROSS

          D.W. PERVIS, PROGRAMMING


 ENTER A RANDOM NUMBER SEED.
?3895


 TOTAL APARTMENT UNIT NUMBERS HAVE BEEN READ IN
 FOR  14 TIME PERIODS.

 INITIALLY, HOW MANY TIME PERIODS ARE TO BE SIMULATED?
?2


 DO YOU WANT THE PROJECT SIZE FINCTIONS MODIFIED FOR EACH' LINE?
 ANSWER  1 FOR YES  OR  2 FOR NO.
?2
```

SAMPLE PRINTOUT OF INTERVENTION (CONTINUED)

```
 BEGINNING OF TIME PERIOD  1

 LINE NO.  1

  1012   217.0
  1031   212.0
  1034   136.0
 LINE NO.  2

 LINE NO.  3

 THIS IS THE END OF TIME PERIOD   1


 THE FOLLOWING CHARACTERISTICS OF ONE OR MORE SUBSTATIONS
 MAY NOW BE CHANGED:

     1  SURFACE ACCESS
     2  NODALITY
     3  ZONING
     4  CEILING CAPACITY (TECHNICAL CONSTRAINTS)
     5  COMMERCIAL DEVELOPMENT
     6  UNDESIRABLE CONDITIONS

 DO YOU WISH TO MAKE ANY CHANGES AT THIS TIME?
 ANSWER 1 FOR   YES OR  2 FOR NO.
?1

 ENTER THE STATION NUMBER.
?1014

 WHICH CHARACTERISTICS OF  1014 DO YOU WANT TO CHANGE?
 ENTER  UP TO 6 CODE NUMBERS AS ABOVE (IE. 1,2,3, ETC.) WITH AT
 LEAST 1 BLANK BETWEEN THEM.
?2 3

 WHAT IS THE NEW VALUE OF INTERVENTION CHARACTERISTIC   2 OF STATION NO. 10
 VALID VALUES ARE BETWEEN 0.0 AND   12.0
 PRESENT VALUE IS    9.0
?12
```

SAMPLE PRINTOUT FOR INTERVENTION (CONTINUED)

```
 INTERVENTIONAL CHARACTERISTIC     2 OF STATION NO.
 1014 NOW HAS THE VALUE OF   12.00000


 WHAT IS THE NEW VALUE OF INTERVENTION CHARACTERISTIC    3 OF STATION NO. 101
 VALID VALUES ARE BETWEEN 0.0 AND    5.0
 PRESENT VALUE IS    2.0
?4

 INTERVENTIONAL CHARACTERISTIC     3 OF STATION NO.
 1014 NOW HAS THE VALUE OF    4.00000

 DO YOU WISH TO CHANGE THE INTERVENTIONAL CHARACTERISTICS F ANY MORE STATION
 ANSWER 1 FOR YES  OR  2 FOR NO.
?2

 BEGINNING OF TIME PERIOD  2

 LINE NO.  1

  1031   225.0
  1012   214.0
  1034   211.0
  1014   164.0       THIS STATION OBTAINED GROWTH ALREADY IN
  1023   156.0       TIME PERIOD 2 BECAUSE OF INTERVENTION
  1024   153.0
  1032   130.0
 LINE NO.  2

 LINE NO.  3

 DO YOU WISH TO CONTINUE SIMULATION?
 ENTER 1 FOR YES  OR  2 FOR NO.
?2

 DO YOU WANT INCREMENTAL AND CUMULATIVE ALLOTMENTS
 PRODUCED IN 'FILE FORMAT' AS WELL AS ON PAPER?
 ANSWER  1 FOR YES  OR  2 FOR NO.
?2

 THE SIMULATION HAS BEEN SUCCESSFULLY COMPLETED.

  STOP      0
#EXECUTION TERMINATED
#
```

appendix

(see Appendix A.a-1)

A.a-4

SAMPLE OF ERROR-MESSAGES

- This sample shows all error-messages which do not lend to an immediate termination of the simulation.
- Errors which do lead to an abortion of the simulations are errors in the data file and in the command.

SAMPLE PRINTOUT FOR E R R O R M E S S A G E S
****

```
 $run p108:model.o 4=*sink* 5=p108:data 6=-print 7=-file


#EXECUTION BEGINS

           CONSEQUENCES OF RAPID TRANSIT

    MODEL DATE APRIL 14, 1972       04-27-72 19:47:16

    R. STUSSI       P. BAROSS

          D.W. PERVIS, PROGRAMMING

 ENTER A RANDOM NUMBER SEED.
?abcd
 INVALID  REAL NUMBER "ABCD" : INVALID CHARACTER(S)
 PLEASE RE-ENTER LINE FROM POINT OF ERROR
?3790

 TOTAL APARTMENT UNIT NUMBERS HAVE BEEN READ IN
 FOR  14 TIME PERIODS.

 INITIALLY, HOW MANY TIME PERIODS ARE TO BE SIMULATED?
?2
 DO YOU WANT THE PROJECT SIZE FINCTIONS MODIFIED FOR EACH' LINE?
 ANSWER  1 FOR YES  OR  2 FOR NO.
?yes
 INVALID  INTEGER  "YES" : INVALID CHARACTER(S)
 PLEASE RE-ENTER LINE FROM POINT OF ERROR
?1

 BEGINNING OF TIME PERIOD  1


 LINE NO.  1

  1012   221.0
  1031   208.0
  1034   140.0
```

SAMPLE PRINTOUT FOR ERROR MESSAGES (CONTINUED)
****

```
  NE NO.  3

 THIS IS THE END OF TIME PERIOD   1
 THE FOLLOWING CHARACTERISTICS OF ONE OR MORE SUBSTATIONS
 MAY NOW BE CHANGED:



    1  SURFACE ACCESS
    2  NODALITY
    3  ZONING
    4  CEILING CAPACITY (TECHNICAL CONSTRAINTS)
    5  COMMERCIAL DEVELOPMENT
    6  UNDESIRABLE CONDITIONS


 DO YOU WISH TO MAKE ANY CHANGES AT THIS TIME?
 ANSWER 1 FOR   YES OR  2 FOR NO.
?no
 INVALID  INTEGER  "NO" : INVALID CHARACTER(S)
 PLEASE RE-ENTER LINE FROM POINT OF ERROR
?1

 ENTER THE STATION NUMBER.
?eglington
 INVALID  INTEGER  "EGLINGTON" : INVALID CHARACTER(S)
 PLEASE RE-ENTER LINE FROM POINT OF ERROR
?1014


 WHICH CHARACTERISTICS OF  1014 DO YOU WANT TO CHANGE?
 ENTER  UP TO 6 CODE NUMBERS AS ABOVE (IE. 1,2,3, ETC.) WITH)AT
 LEAST 1 BLANK BETWEEN THEM.
?4

 WHAT IS THE NEW VALUE OF INTERVENTION CHARACTERISTIC   4 OF STATION NO. 10
 VALID VALUES ARE BETWEEN 0.0 AND    0.0
 PRESENT VALUE IS    0.0
?7
   7.000 IS AN INVALID VALUE FOR INTERVENTIONAL 'CHARACTERISTIC   4
 WHAT IS THE NEW VALUE OF INTERVENTION CHARACTERISTIC   4 OF STATION NO. 10
 VALID VALUES ARE BETWEEN 0.0 AND    0.0
 PRESENT VALUE IS    0.0
?0
 INTERVENTIONAL CHARACTERISTIC    4 OF STATION NO.
 1014 NOW HAS THE VALUE OF    0.0


 DO YOU WISH TO CHANGE THE INTERVENTIONAL CHARACTERISTICS F ANY MORE STATIO
 ANSWER 1 FOR YES  OR  2 FOR NO.
?no
 INVALID  INTEGER  "NO" : INVALID CHARACTER(S)
 PLEASE RE-ENTER LINE FROM POINT OF ERROR
?2
```

SAMPLE PRINTOUT FOR ERROR MESSAGES (CONTINUED)
****

```
 BEGINNING OF TIME PERIOD  2

 LINE NO.  1

  1031   235.0
  1012   215.0
  1034   214.0
  1023   211.0
  1024   190.0
  1032   153.0
 LINE NO.  2

 LINE NO.  3

 DO YOU WISH TO CONTINUE SIMULATION?
 ENTER 1 FOR YES  OR  2 FOR NO.
?no
 INVALID  INTEGER  "NO" : INVALID CHARACTER(S)
 PLEASE RE-ENTER LINE FROM POINT OF ERROR
?2
 DO YOU WANT INCREMENTAL AND CUMULATIVE ALLOTMENTS
 PRODUCED IN 'FILE FORMAT' AS WELL AS ON PAPER?
 ANSWER  1 FOR YES  OR  2 FOR NO.
?yws on file
 INVALID  INTEGER  "YWS " : INVALID CHARACTER(S)
 PLEASE RE-ENTER LINE FROM POINT OF ERROR
?2
 THE SIMULATION HAS BEEN SUCCESSFULLY COMPLETED.

  STOP     0
#EXECUTION TERMINATED
#
```

appendix

A.a-5

(see Chapter 7.1)

PROGRAM FOR SIMULATION MODEL

- This program executes the complete simulation.
- It was programmed by D.W. Pervis, Computing Center, University of British Columbia.

LAND USE SIMULATION

```
C        ***************************************************
C        *                                                 *
C        * THE PURPOSE OF THIS PROGRAM IS TO SIMULATE CHANGES  *
C        * IN PHYSICAL STRUCTURE (LAND USE) INITIATED BY RAPID *
C        * TRANSIT STATIONS. THE MODEL REPRESENTS PART OF A    *
C        * STUDY CONDUCTED BY                                  *
C        *                      - PAUL BAROSS  AND             *
C        *                      - ROBERT STUSSI                *
C        *   U.B.C. SCHOOL OF COMMUNITY AND REGIONAL PLANNING  *
C        *                                                 *
C        ***************************************************
C        *                                                 *
C        *         DENNIS W. PERVIS, PROGRAMMING            *
C        *           U.B.C. COMPUTING CENTRE                *
C        *                                                 *
C        *                 MARCH 1972                       *
C        *                                                 *
C        ***************************************************
C


C                 *** CONTROL PROGRAM ***
C
      LOGICAL*1 IST(6)/6*' '/,FULL,LCALC/.FALSE./
      DIMENSION D(2),T(2)
      COMMON FULL
C
C              *** WRITE OUT A TITLE
C
      FULL=.FALSE.
      CALL DATE(D,T)
      WRITE(6,1)D,T
      WRITE(4,1)D,T
1     FORMAT(T10,' CONSEQUENCES OF RAPID TRANSIT',/T5,
     1'MODEL DATE APRIL 17, 1972                ',T35,2(1X,2A4)//,
     2T15,'R. STUSSI',T35,'P. BAROSS'//T15,'D.W. PERVIS, PROGRAMMING')
      WRITE(4,20)
20    FORMAT(' ENTER A RANDOM NUMBER SEED.')
      CALL INFREE(27,AR)
      WRITE(6,21)AR
21    FORMAT(' RANDOM NUMBER SEED IS ',F8.2)
      Z=RAND(AR)
```

```
C               *** GET PARAMETER STRING AND SET UP LOGIC SWITCH ***
C
      CALL PAR(IST,NI,6,&2,&100)
      IF(NI.LT.6)NI=NI+1
      CALL FINDC(IST,NI,' ',1,1,NC,NL,&101)
      IF(NC.EQ.1) GO TO 102
      CALL FINDST(IST,NI,'FULL',4,1,NC,&103)
      FULL=.TRUE.
C
C            *** CALL THE ROUTINE WHICH WILL READ IN ALL INITIAL DATA *
C
2     CALL DATIN
      WRITE(4,4)
4     FORMAT(' INITIALLY, HOW MANY TIME PERIODS ARE TO BE SIMULATED?')
      CALL INFREE(11,NT)
      WRITE(4,22)
22    FORMAT(' DO YOU WANT THE PROJECT SIZE FUNCTIONS MODIFIED FOR EACH
     1' LINE?'/' ANSWER  1 FOR YES  OR  2 FOR NO.')
23    CALL INFREE(11,IL)
      IF(IL.GT.2.OR.IL.LT.1) GO TO 106
      IF(IL.EQ.1)LCALC=.TRUE.
      IS=1
8     CALL GOGO(IS,NT,LCALC)
      IF(NT.EQ.14) GO TO 5
      WRITE(4,6)
6     FORMAT(' DO YOU WISH TO CONTINUE SIMULATION?'/' ENTER ',
     1'1 FOR YES  OR  2 FOR NO.')
9     CALL INFREE(11,I1)
      IF(I1.LT.1.OR.I1.GT.2) GO TO 104
      IF(I1.EQ.2) GO TO 5
      NTT=14-NT
      WRITE(4,7)NTT
7     FORMAT(' YOU MAY SIMULATE UP TO ',I3,/,
     1'MORE TIME PERIODS - HOW MANY DO YOU WANT?')
10    CALL INFREE(11,I1)
      IF(NT+I1.GT.14) GO TO 105
      IS=NT+1
      NT=NT+I1
      CALL INTER(IS-1)
      GO TO 8
5     CALL SIGH
```

```
C              *** NOTE A SUCCESSFUL RUN AND STOP ***
C
      WRITE(4,3)
3     FORMAT(' THE SIMULATION HAS BEEN SUCCESSFULLY COMPLETED.')
      STOP
C
C                 *** ERROR MESSAGES **
C
100   WRITE(4,1000)
1000  FORMAT(' PARAMETER STRING IS TOO LONG.')
      STOP 1
101   WRITE(4,1001)
1001  FORMAT(' INCORRECT PARAMETER - NO BLANK FOUND.')
      STOP 2
102   WRITE(4,1002)
1002  FORMAT(' FIRST CHARACTER OF PARAMETER IS BLANK.')
      STOP 3
103   WRITE(4,1003) IST
1003  FORMAT(1X,6A1,' IS AN INCORRECT PARAMETER.')
      STOP 4
104   WRITE(4,1004) I1
1004  FORMAT(1X,I3,' IS AN INVALID RESPONSE.')
      GO TO 9
105   WRITE(4,1005) I1,NTT
1005  FORMAT(1X,I4,' IS GREATER THAN',I4)
      GO TO 10
106   WRITE(4,1006) IL
1006  FORMAT(1X,I3,' IS AN INVALID RESPONSE')
      GO TO 23
      END


      SUBROUTINE DATIN
C
C       ***************************************************
C       *                                                 *
C       * THE PURPOSE OF THIS SUBROUTINE IS TO READ IN THE DATA *
C       * WHICH REPRESENTS THE INITIAL CONDITIONS OF THE SYSTEM *
C       *                                                 *
C       ***************************************************
C
      INTEGER STANO(4,30,5)
      LOGICAL*1 FULL
      DIMENSION NO(14),SC(14,4,30,5),W(14),IC(5)
      COMMON FULL /DAT1/XN(10,14),YN(10,14),NO,W,IC
      COMMON /DAT1/ASIZ(60,2,4),APTS(5,14),IX,XMAX(14),INCL(4,30,5)
      COMMON /DAT2/ANEWS(4,30,5,2,14),SC/DAT3/STANO
C
C       *** LIMITS  - 14 FUNCTIONS (CHARACTERISTICS)
C                     10 POINTS PER FUNCTION
C                     30 STATIONS WITH 4 SUBSTATIONS
C                        EACH = 200 SUBSTATIONS
C                      5 LINES
```

```
C       *** READ IN THE X VALUES AND WEIGHTS OF EACH FUNCTION ***
C
      DO 90 IEE=1,14
      DO 90 IE=1,2
      DO 90 IF=1,5
      DO 90 IG=1,30
      DO 90 IH=1,4
      ANEWS(IH,IG,IF,IE,IEE)=0.
90    CONTINUE
      IF(FULL) WRITE(6,60)
60    FORMAT(T10,' RAW X VALUES OF ''TABLE'' FUNCTIONS'/)
      DO 1 I=1,14
      READ(5,2,END=100)IK,N,NN,W(I),(XN(J,I),J=1,NN)
2     FORMAT(I1,2(1X,I2),F3.0,10F5.0)
      NO(I)=NN
C
C       *** IF DESIRED - WRITE OUT THE DATA **
C
      IF(FULL) WRITE(6,3) IK,N,NN,W(I),(XN(J,I),J=1,NN)
3     FORMAT(1X,I1,2(1X,I2),F3.0,10F8.2)
C
C         *** CHECK CARD CODING ***
C
      IF(IK.NE.1)GO TO 101
1     CONTINUE
C
C       *** NORMALIZE THE X'S ***
C
      IF(FULL) WRITE(6,61)
61    FORMAT('1',T10,'NORMALIZED X''S'/)
      DO 6 I=1,14
      N=NO(I)
      XMAX(I)=XN(N,I)
      DO 4 J=1,N
      XN(J,I)=XN(J,I)/XN(N,I)
4     CONTINUE
C
C       *** IF DESIRED WRITE OUT NORMALIZED X'S ***
C
      IF(FULL) WRITE(6,7) (XN(K,I),K=1,N)
7     FORMAT(1X,10F7.5)
6     CONTINUE
```

```
C         *** READ IN NORMALIZED Y'S ***
C
      IF(FULL) WRITE(6,62)
62    FORMAT('1',T10,'NORMALIZED Y''S'/)
      DO 9 I=1,14
      READ(5,17,END=102) IK,N,NN,(YN(J,I),J=1,NN)
17    FORMAT(I1,2(1X,I2),3X,10F5.0)
C
C          *** IF DESIRED, WRITE OUT THE DATA ***
C
      IF(FULL)WRITE(6,14)IK,N,NN,(YN(J,I),J=1,NN)
14    FORMAT(1X,I1,2(1X,I2),3X,10F8.2)
C
C          *** CHECK CARD CODING ***
C
      IF(IK.NE.2) GO TO 103
C
C          *** CHECK NO. OF POINTS TO BE DEFINED ***
C
      IF(NN.NE.NO(I)) GO TO 104
9     CONTINUE
C
C          *** READ IN INITIAL STATION CHARACTERISTIC DATA ***
C
      IF(FULL) WRITE(6,63)
63    FORMAT('1',T10,'INITIAL STATION CHARACTERISTICS'/)
      DO 30 L=1,5
      IS=0
      IC(L)=0
      DO 10 I=1,30
      DO 10 J=1,4
      READ(5,11,END=30)IK,STANO(J,I,L),(SC(K,J,I,L),K=1,14),INCL(J,I,L)
11    FORMAT(I1,I4,1X,2F6.0,2F5.1,10X,4F2.0,8X,3F2.0,4X,3F2.0,1X,I2)
C
C          *** IF DESIRED WRITE OUT DATA ***
C
      IF(FULL)WRITE(6,12) IK,STANO(J,I,L),(SC(K,J,I,L),K=1,14),
     1INCL(J,I,L)
12    FORMAT(1X,I1,1X,I4,3(1X,F7.0),1X,F5.0,10X,4(1X,F2.0),8X,3(1X,F2.0)
     1,1X,F6.0,2(1X,F2.0),1X,I2)
      IC(L)=IC(L)+1
C
C          *** CHECK CARD CODING ***
C
      IF(IK.NE.3) GO TO 105
C
C          *** CHECK THE ORDER OF THE STATION NUMBERS ***
C
      IF(STANO(J,I,L).LE.IS) GO TO 106
      IS= STANO(J,I,L)
10    CONTINUE
```

```
C
C        *** READ IN THE NO. OF APARTMENT BLOCKS TO BE
C            DISTRIBUTED ALONG THE VARIOUS LINES
C                   LIMITS - 5  LINES
C                           14 YEARS ***
C
      IF(FULL) WRITE(6,64)
64    FORMAT('1',T10,'TOTAL APARTMENT BLOCKS FOR EACH YEAR'/)
      IX=0
      DO 18 I=1,14
      READ(5,19,END=21) IK,(APTS(J,I),J=1,5)
19    FORMAT(I1,1X,5(F6.0))
      IX=IX+1
C
C        *** IF DESIRED WRITE OUT DATA ***
C
      IF(FULL) WRITE(6,20) IK,(APTS(J,I),J=1,5)
20    FORMAT(1X,I1,5(1X,F6.0))
C
C        *** CHECK CARD CODING ***
C
      IF (IK.NE.4) GO TO 107
18    CONTINUE
21    IF(FULL) WRITE(6,22) IX
      WRITE(4,22) IX
22    FORMAT(' TOTAL APARTMENT UNIT NUMBERS HAVE BEEN READ IN ',
     1/,' FOR ',I3,' TIME PERIODS.'/)
C
C        *** READ IN THE APARTMENT SIZE FUNCTIONS ***
C
      IF(FULL) WRITE(6,65)
65    FORMAT('1',T10,'APARTMENT SIZE FUNCTIONS'/)
      IZ=0
      DO 23 I=1,4
      IKK=0
      DO 29 K=1,60
27    READ(5,24,END=25) IK,(ASIZ(K,J,I),J=1,2)
24    FORMAT(I1,42X,F5.0,44X,F4.0)
      IKK=IKK+1
C
C        *** IF DESIRED WRITE OUT DATA ***
C
      IF(FULL) WRITE(6,26) IK,(ASIZ(K,J,I),J=1,2)
26    FORMAT(1X,I1,2(1X,F5.0))
C
C        *** CHECK CARD CODING ***
C
      IF(IK.NE.5) GO TO 108
```

```
C         *** CHECK CARD ORDER ***
C
      IF(ASIZ(K,2,I).LT.IZ) GC TO 109
      IZ=ASIZ(K,2,I)
29    CONTINUE
25    IZ=0
      IF(FULL) WRITE(6,28)IKK,I
28    FORMAT(1X,I4,' POINTS HAVE BEEN DEFINED FOR PROJ SIZE FUNC. NO. ',
     1I3,'.'/)
23    CONTINUE
      RETURN
C
C         *** ERROR MESSAGES ***
C
100   WRITE(4,1000) I
1000  FORMAT(' END OF FILE ENCOUNTERED AS ',I3,'TH CARD OF X VALUES.')
      STOP 5
101   WRITE(4,1001) I
1001  FORMAT(' A 1 DOES NOT APPEAR IN THE FIRST COLUMN OF THE ',I3,'TH X
     1 VALUE CARD.')
      STOP 6
102   WRITE(4,1002) I
1002  FORMAT(' END-OF-FILE ENCOUNTERED AS ',I3,'TH Y VALUE CARD.')
      STOP 7
103   WRITE(4,1003) I
1003  FORMAT(' A 2 DOES NOT APPEAR IN THE FIRST COLUMN OF THE ',I3,'TH Y
     1 VALUE CARD.')
      STOP 8
104   WRITE(4,1004) I,NO(I),NN
1004  FORMAT(' FOR FUNCTION NO. ',I3,',',I3,' X VALUES HAVE BEEN GIVEN A
     1ND ',I3,' Y VALUES - THEY '/' SHOULD HAVE THE SAME NO. OF VALUES.'
     2)
      STOP 9
105   WRITE(4,1005) STANO(J,I,L),IS
1005  FORMAT(' A 3 DOES NOT APPEAR IN STATION CHARACTERISTIC CARD NUMBER
     1 ',I4,' WHICH FOLLOWS NO. ',I4,'.')
      STOP 10
106   WRITE(4,1006) IS,STANO(J,I,L)
1006  FORMAT(' STATION CHARACTERISTIC CARD IS OUT OF ORDER - NO. ',I5,'
     1HAS BEEN PLACED BEFORE NO. ',I5,'.')
      STOP 11
107   WRITE(4,1007) K
1007  FORMAT(1X,' A 4 DOES NOT APPEAR IN COL. 1 OF CARD ',I2,
     1' OF THE TOTAL  APARTMENT DATA.')
      STOP 12
108   WRITE(4,1008) K,I
1008  FORMAT(' A 5 DOES NOT APPEAR IN COL. 1 OF THE ',I3,'TH',
     1' CARD OF APT. SIZE FUNCT. NO. ',I3,'.')
      STOP 13
109   WRITE(4,1009) I,ASIZ(K,2,I),IZ
1009  FORMAT(' CARDS FOR APARTMENT SIZE FUNCTION NO. ',I2,' ARE',
     1' OUT OF SEQUENCE ',/1X,I3,' FOLLOWS ',I3,'.')
      STOP 14
      END
```

```
C
C        *** THE PURPOSE OF THIS SUBROUTINE IS TO PERFORM THE
C            CALCULATIONS INVOLVED IN THE YEAR BY YEAR PROJECTION
C            OF THE CHANGES IN LAND USE ***
C
C              - DENNIS W. PERVIS, PROGRAMMING
C
      INTEGER STANO(4,30,5)
      LOGICAL*1 FULL,LCALC
      DIMENSION X(14,4,30,5),ATS(4,30,5),ACSIZ(4,30),ANEWS(4,30,5,2,14)
     1,COEF(5),ICC(5)
      DATA ATS/600*0./
      COMMON FULL/DAT1/XN(10,14),YN(10,14),NO(14),
     1W(14),IC(5),ASIZ(60,2,4),APTS(5,14),IX,XMAX(14),
     1INCL(4,30,5) /DAT2/ANEWS,SC(14,4,30,5)/DAT3/STANO
C
C        *** NOTE - XN(10,14)     - NORMALIZED X'S FOR EACH POINT OF
C                                   THE TABLE FUNCTIONS
C                   YN(10,4)      - SAME AS ABOVE FOR Y'S
C                   NO(14)        -NUMBER OF POINTS DEFINED FOR EACH
C                                   TABLE FUNCTION
C                   SC(14,4,30,5) - STATION CHARACTERISTICS
C                                      - 14 CHARACTERISTICS
C                                      -  4 SUBSTATIONS
C                                      - 30 STATIONS
C                                      - 5 LINES
C                   W(14)         - WEIGHTS OF EACH CHARACTERISTIC
C                   IC            - TOTAL NO. OF SUBSTATIONS ACTUALLY IN
C                                   THE MODEL
C                   STANO(4,30,5) - ASSIGNED SUBSTATION NUMBERS
C                   ASIZ(60,2,3)- X AND Y VALUES OF 3 PROJECT SIZE
C                                   FUNCTIONS
C                                   MAX. 60 POINTS DEFINED
C                   APTS(5,14)    - NO. OF APTS. TO BE DISTRIBUTED AMONG
C                                   SUBSTATIONS OF A TRANSIT LINE DURING
C                                   A GIVEN TIME PERIOD. - LIMITS 5 LINES
C                                                            14 TIME PERIODS
C                   IX            - NO. OF TIME PERIODS ACTUALLY READ IN
C                   XMAX(14)      - MAXIMUM RAW X VALUES
      IF(NT.GT.IX)GO TO 110
      DO 1 I=IS,NT
      WRITE(4,80)I
80    FORMAT(//' BEGINNING OF TIME PERIOD',I3/)
```

```
81    FORMAT('1',T10,'BEGINNING OF TIME PERIOD',I3/)
      DO 50 IAC=1,5
      DO 51 IAD=1,30
      DO 52 IAE=1,4
      ATS(IAE,IAD,IAC)=0.
52    CONTINUE
51    CONTINUE
50    CONTINUE
C
C        *** FIRST CALCULATE ATTRACTIVITY SCORES FOR EACH SUBSTATION
C              GIVEN THE CHARACTERISTIC QUANTITIES IN SC ***
C
      IF(FULL) WRITE(6,60)
60    FORMAT(    T10,'NORMALIZED CHARACTERISTIC VALUES'/)
      DO 24 LL=1,5
      ISAT=IC(LL)/4
      IF(IC(LL).EQ.0) GO TO 24
      DO 2 J=1,ISAT
      DO 2 K=1,4
      DO 3 L=1,14
C
C        *** NORMALIZE THE X INPUT VALUES ***
C
C        *** CHECK IF VALID X VALUE ***
C
      IF (SC(L,K,J,LL).GT.XMAX(L)) GO TO 111
C
C         ***CHECK TO SEE IF SUBSTATION IS TO BE INCLUDED ***
C
      IF(INCL(K,J,LL).GT. I)GO TO 27
C        *** NOW DO IT ***
C
      X(L,K,J,LL)=SC(L,K,J,LL)/XMAX(L)
      GO TO 3
27    X(L,K,J,LL)=0.
    3 CONTINUE
      IF(FULL) WRITE(6,8) STANC(K,J,LL),(X(L,K,J,LL),L=1,14)
8     FORMAT(1X,I5,14(1X,F7.5))
    2 CONTINUE
C
C        *** IF DESIRED WRITE OUT RESULT ***
C
24    CONTINUE
C
C        *** NOW FIND THE ATTRACTIVITY SCORES
C
      IF(FULL) WRITE(6,62)
62    FORMAT('1',T10,'FUNCTION VALUES'/)
      DO 25 LL=1,5
      IF(IC(LL).EQ.0) GO TO 25
      ISAT=IC(LL)/4
      DO 10 J=1,ISAT
      DO 10 K=1,4
      DO 11 L=1,14
```

```
C          ***CHECK FOR ZERO ***
C
      IF(X(L,K,J,LL).EQ.0)GO TO 22
C
C          *** FIND TABLE FUNCTION INTERVAL ***
      IJ=0
      MM=NO(L)
      DO 13 M=1,MM
      IJ=IJ+1
      IF(X(L,K,J,LL).LT.XN(M,L))GO TO 21
   13 CONTINUE
C
C          *** CALCULATE VALUE ***
21    X(L,K,J,LL)=YN(IJ-1,L)+((X(L,K,J,LL)-XN(IJ-1,L))*((YN(IJ,L)
     1-YN(IJ-1,L))/(XN(IJ,L)-XN(IJ-1,L))))
      GOTO 11
22    IF(INCL(K,J,LL).LE.I)X(L,K,J,LL)=YN(1,L)
   11 CONTINUE
      IF(FULL) WRITE(6,8)STANO(K,J,LL),(X(L,K,J,LL),L=1,14)
   10 CONTINUE
C
C          *** IF DESIRED WRITE OUT RESULTS ***
C
25    CONTINUE
C
C          *** WEIGHT AND ADD TO GET ATTRACTIVITY SCORES ***
C
      IF(FULL) WRITE(6,63)
63    FORMAT('1',T10,'ATTRACTIVITY SCORES'/)
      DO 26 LL=1,5
      IF(.NOT.LCALC) GO TO 94
      ICC(LL)=0
      COEF(LL)=0.
94    IF(IC(LL).EQ.0) GO TO 26
      ISAT=IC(LL)/4
      DO 29 J=1,ISAT
      DO 14 K=1,4
      IF(INCL(K,J,LL).GT.I) GO TO 14
      IF(X(2,K,J,LL).EQ.0.OR.X(3,K,J,LL).EQ.0.) GO TO 28
      DO 15 L=1,14
      ATS(K,J,LL)=ATS(K,J,LL)+X(L,K,J,LL)*W(L)/100.
   15 CONTINUE
      GO TO 91
28    ATS(K,J,LL)=0.
```

```
C   *** GET SUM AND MEAN OF ATTRACTIVITY SCORES ***
C
91     IF(.NOT.LCALC)GO TO 14
       ICC(LL)=ICC(LL)+1
       COEF(LL)=COEF(LL)+ATS(K,J,LL)
   14 CONTINUE
       IF(FULL)WRITE(6,64)(STANO(KK,J,LL),ATS(KK,J,LL),KK=1,4)
64     FORMAT(4(1X,I5,1X,F7.5,3X))
29     CONTINUE
       IF(ICC(LL).GT.0)COEF(LL)=COEF(LL)/ICC(LL)
26     CONTINUE
C
C      *** DETERMINE WHICH FUNCTION TO USE ***
C
       IF(I.GT.8)GO TO 53
       IF(I.LT.9 .AND. I.GT.4) GO TO 54
       IF(I.LT.5.AND.I.GT.2) GO TO 57
       IF(I.LT.3) NFUN=1
       GO TO 92
53     NFUN=4
       GO TO 92
54     NFUN=3
       GO TO 92
57     NFUN=2
C
C    ***  CALCULATE COEFFICIENTS ***
C
92     IF(.NOT.LCALC)GO TO 55
       ZO=AMAX1(COEF(1),COEF(2),COEF(3),COEF(4),COEF(5))
       DO 93 J1=1,5
       IF(ICC(J1).EQ.0)GO TO 93
       COEF(J1)=COEF(J1)/ZO
93     CONTINUE
C
C    * DETERMINE THE NUMBER OF UNITS TO BE BUILT
C      AT EACH SUBSTATION ON EACH LINE ***
C
55     DO 30 LL=1,5
       ACSUM=0
       DO 48 IAC=1,30
       DO 49 IAD=1,4
       ACSIZ(IAD,IAC)=0.
49     CONTINUE
48     CONTINUE
C
C    *** CHECK TO SEE IF THE LINE EXISTS ***
C
       IF(IC(LL).EQ.0) GO TO 30
C
C     *** DETERMINE NO. OF STATIONS IN LINE ***
C
       ISAT=IC(LL)/4
       DO 31 J=1,ISAT
```

```
C
      IF(INCL(K,J,LL).GT.I)GO TO 32
C    *** GET A RANDOM NUMBER ***
C
      Z=FRAND(DUM)*100.
C
C   *** NOW FIND FUNCTION VALUES ***
C
      IJ=0
      DO 33 II=1,60
      IJ=IJ+1
      IF(Z.LT.ASIZ(II,2,NFUN)) GO TO 34
     33    CONTINUE
34    IF(IJ.EQ.1) GO TO 35
      MIJ=IJ-1
      ACSIZ(K,J)=ASIZ(MIJ,1,NFUN)+((Z-ASIZ(MIJ,2,NFUN))*
     1((ASIZ(IJ,1,NFUN)-ASIZ(MIJ,1,NFUN))/(ASIZ(IJ,2,NFUN)-
     2ASIZ(MIJ,2,NFUN))))
      GO TO 43
35    ACSIZ(K,J)=ASIZ(1,1,NFUN)
C
C  ***MAKE IT AN INTEGER ***
C
43    IF(LCALC) ACSIZ(K,J)=ACSIZ(K,J)*COEF(LL)
      ACSIZ(K,J)=AINT(ACSIZ(K,J)+.5)
C
C  *** ADD UNITS FOR THIS LINE AND CHECK WITH MAX ***
C
      ACSUM=ACSUM+ACSIZ(K,J)
      IF(ACSUM.GE.APTS(LL,I)) GO TO 36
32    CONTINUE
31    CONTINUE
C
C  *** ALLOT THE BLOCKS OF UNITS TO SUBSTATIONS ***
C
C  *** FIND LARGEST BLOCK OF UNITS ***
C
36    IF(FULL)WRITE(6,66)LL
      WRITE(4,66) LL
66    FORMAT(' LINE NO.',I3/)
      ACSUM=0.
      DO 45 LJ=1,J
      DO 44 LK=1,4
      BLL=0
      DO 37 JJ=1,J
      DO 38 KK=1,4
      IF(ACSIZ(KK,JJ).LE.BLL) GO TO 38
      JN=JJ
      KN=KK
      BLL=ACSIZ(KK,JJ)
38    CONTINUE
37    CONTINUE
```

```
C   *** FIND SUBSTATION WITH LARGEST ATTRACTIVITY SCORE ***
C
      BATS=0.
      DO 39 JJ=1,ISAT
      DO 40 KK=1,4
      IF(INCL(KK,JJ,LL).GT.I)GO TO 40
      IF(ATS(KK,JJ,LL).LE.BATS)GO TO 40
      IF(SC(3,KK,JJ,LL).LT..01*ACSIZ(KN,JN)) GO TO 40
      JNN=JJ
      KNN=KK
      BATS=ATS(KK,JJ,LL)
40    CONTINUE
39    CONTINUE
      IF(BATS.EQ.0.) GO TO 46
C
C    *** NOTE NO. OF UNITS AND SUBSTATION ***
C
      ANEWS(KNN,JNN,LL,1,I)=ACSIZ(KN,JN)
      WRITE(4,70) STANO(KNN,JNN,LL),ANEWS(KNN,JNN,LL,1,I)
70    FORMAT(1X,I5,2X,F6.1)
      ACSUM=ACSUM+ACSIZ(KN,JN)
      IF(ACSUM.GE.APTS(LL,I))GO TO 46
      ACSIZ(KN,JN)=0.
      ATS(KNN,JNN,LL)=0.
44    CONTINUE
45    CONTINUE
46    DO 90 IK1=1,ISAT
      DO 90 IK2=1,4
      IQ=I-1
      IF(INCL(IK2,IK1,LL).GT.I)GO TO 90
      IF(I.EQ.1)IQ=1
      ANEWS(IK2,IK1,LL,2,I)=ANEWS(IK2,IK1,LL,2,IQ)+ANEWS(IK2,IK1,LL,1,I)
90    CONTINUE
      IF(.NOT.FULL) GO TO 30
      DO 86 ID=1,ISAT
      WRITE(6,88)(STANO(KK,ID,LL),ANEWS(KK,ID,LL,1,I),KK=1,4)
88    FORMAT(4(1X,I5,1X,F7.1,3X))
86    CONTINUE
30    CONTINUE
      CALL CONT(I)
      IF(I.EQ.NT) GO TO 1
      CALL INTER(I)
    1 CONTINUE
      RETURN
C
C        *** ERROR MESSAGES ***
C
  110 WRITE(4,1010) IX
 1010 FORMAT(' TOTAL TIME PERIODS ARE GREATER THAN ',I3,'.')
      STOP 15
  111 WRITE(4,1011) STANO(K,J,LL),L,SC(L,K,J,LL),XMAX(L)
 1011 FORMAT(' FOR STATION NO. ',I5,' CHARACTERISTIC NO.',I3,/' THE VALU
     1E IS ',F10.5,' BUT SHOULD BE LESS THAN ',F10.5,'.')
      STOP 16
```

```
      SUBROUTINE CONT(IY)
C
C  *** THE PURPOSE OF THIS SUBROUTINE IS TO UPDATE THE STATION
C      CHARACTERISTICS IE. SC(14,4,30,5) WITH THE RESULTS OF THE
C      'ABBERATIONS' OF THE CURRENT TIME PERIOD IE. ANEWS(4,30,5) ***
C
      LOGICAL*1 FULL
      COMMON FULL /DAT2/ANEWS(4,30,5,2,14),SC(14,4,30,5)
     1/DAT1/XN(10,14),YN(10,14),NO(14),
     2W(14),IC(5),ASIZ(60,2,4),APTS(5,14),IX,XMAX(14),
     3INCL(4,30,5)
      DO 1 I=1,5
      ISAT=IC(I)/4
      IF(ISAT.EQ.0)GO TO 1
      DO 2 J=1,ISAT
      DO 3 K=1,4
      IF(INCL(K,J,I).GT.IY)GO TO 3
C
C   *** ADJUST NO. OF NEW APT UNITS ***
C
      SC(1,K,J,I)=SC(1,K,J,I)+ANEWS(K,J,I,1,IY)
C
C   *** ADJUST TECH. CONSTRAINTS ***
C
      SC(2,K,J,I)=SC(2,K,J,I)-ANEWS(K,J,I,1,IY)
C
      IF(SC(2,K,J,I).LT.0.) SC(2,K,J,I)=0.
C
C   *** ADJUST AVAILABLE LAND ***
C
      SC(3,K,J,I)=SC(3,K,J,I)-(.01*ANEWS(K,J,I,1,IY))
      IF(SC(3,K,J,I).LE.0.) SC(3,K,J,I)=0.
C
C   ***ADJUST VACANT LAND ***
C
      SC(4,K,J,I)=SC(4,K,J,I)-(0.01*ANEWS(K,J,I,1,IY))
      IF(SC(4,K,J,I).LE.0.) SC(4,K,J,I)=0.
3     CONTINUE
2     CONTINUE
1     CONTINUE
      RETURN
      END
       SUBROUTINE INTER(IY)
C
C   *** THE PURPOSE OF THIS SUBROUTINE IS TO ALLOW THE USER TO
C       CHANGE THE VALUES OF THE INTERVENTIONAL CHARACTERISTICS OF
C       SUBSTATIONS ***
C
      LOGICAL*1 FULL
      INTEGER STANO(4,30,5),CCDES(6)/6*0/
      REAL RR(6)/1.0,12.0,5.0,9999.0,3.0,1.0/
      COMMON FULL/DAT2/ANEWS(4,30,5,2,14),SC(14,4,30,5)/DAT3/STANO
```

```
C    *** ARE THERE TO BE ANY CHANGES? ***
C
      WRITE(4,1)IY
1     FORMAT(' THIS IS THE END OF TIME PERIOD ',I3,/,
     1' THE FOLLOWING CHARACTERISTICS OF ONE OR MORE SUBSTATIONS
     1'/' MAY NOW BE CHANGED:',
     2/T5,'1  SURFACE ACCESS',
     3/T5,'2  NODALITY',
     4/T5,'3  ZONING',
     5/T5,'4  CEILING CAPACITY (TECHNICAL CONSTRAINTS)',
     6/T5,'5  COMMERCIAL DEVELOPMENT',
     7/T5,'6  UNDESIRABLE CONDITIONS',
     8/' DO YOU WISH TO MAKE ANY CHANGES AT THIS TIME?'/' ANSWER 1 FOR
     9 YES OR  2 FOR NO.')
8     CALL INFREE(11,ISN)
      IF(ISN.LT.1.OR.ISN.GT.2)GO TO 100
      IF(ISN.EQ.2)RETURN
C
C    *** OK WHAT ARE THEY ***
C
4     WRITE(4,3)
3     FORMAT(' ENTER THE STATION NUMBER.')
      CALL INFREE(11,ISN)
C
C    *** FIND OUT IF THE STATION EXISTS ***
C
      DO 5 I=1,5
      DO 5 J=1,30
      DO 5 K=1,4
      IF(ISN.EQ.STANO(K,J,I)) GO TO 6
5     CONTINUE
      WRITE(4,7) ISN
7     FORMAT(1X,I5,' IS NOT A VALID STATION NUMBER.'/' DO YOU WANT TO E
     1NTER ANOTHER NUMBER?'/' ANSWER 1 FOR YES  OR  2 FOR NO.')
      GO TO 8
C
C    *** WHICH CHARACTERISTICS ARE TO BE CHANGED? ***
C
6     WRITE(4,9)STANO(K,J,I)
9     FORMAT(' WHICH CHARACTERISTICS OF ',I5,' DO YOU WANT TO CHANGE?'/
     1' ENTER  UP TO 6 CODE NUMBERS AS ABOVE (IE. 1,2,3, ETC.) WITH AT'/
     2' LEAST 1 BLANK BETWEEN THEM.')
      CALL INFREE(11,CODES(1),CODES(2),CODES(3),CODES(4),CODES(5),
     1CODES(6))
C
C    *** CHECK TO SEE IF THEY ARE ALL VALID ***
      DO 10 L=1,6
      DO 11 M=1,7
      MM=M-1
      IF(CODES(L).EQ.MM) GO TO 10
11    CONTINUE
      WRITE(4,12)CODES(L)
12    FORMAT(1X,I9,' IS AN INVALID CHARICTERISTIC DESIGNATION.')
      CODES(L)=0
```

```
C
C    *** NOW FIND OUT THE NEW VALUES ***
C
      DO 13 II=1,6
      IF(CODES(II).EQ.0)GO TO 13
26    WRITE(4,14)CODES(II),STANO(K,J,I)
14    FORMAT(' WHAT IS THE NEW VALUE OF INTERVENTION CHARACTERISTIC ',
     1I3,' OF STATION NO.',I5)
      ICI=CODES(II)
      IF(ICI.EQ.4)RR(ICI)=9999.0-SC(2,K,J,I)
      WRITE(4,19)RR(ICI),SC(ICI+8,K,J,I)
19    FORMAT(' VALID VALUES ARE BETWEEN 0.0 AND ',F6.1/,
     1' PRESENT VALUE IS ',F6.1)
22    CALL INFREE(27,R)
C
C    *** CHECK IF VALUES VALID ***
C
      IF(R.LT.0..OR.R.GT.RR(ICI)) GO TO 23
      GO TO 24
23    WRITE(4,25)R,CODES(II)
25    FORMAT(1X,F7.3,' IS AN INVALID VALUE FOR INTERVENTIONAL '
     1'CHARACTERISTIC ',I3)
      GO TO 26
C
C    *** OK PUT IT IN ***
C
24    JJ=CODES(II)+8
      IF(ICI.NE.4) GO TO 36
      SC(2,K,J,I)=SC(2,K,J,I)+R
      SC(12,K,J,I)=+R
      GO TO 35
36    SC(JJ,K,J,I)=R
35    WRITE(4,37)CODES(II),STANO(K,J,I),SC(JJ,K,J,I)
37    FORMAT(' INTERVENTICNAL CHARACTERISTIC ',I4,' OF STATION NO.'/,
     1I5,' NOW HAS THE VALUE OF ',F10.5)
13     CONTINUE
C    *** ANY MORE? ***
C
      WRITE(4,27)
27    FORMAT(' DO YOU WISH TO CHANGE THE INTERVENTIONAL CHARACTERISTICS
     1F ANY MORE STATIONS AT THIS TIME'/,
     2' ANSWER 1 FOR YES  OR  2 FOR NO.')
C
C    *** ZERO OUT CODES ***
C
      DO 28 IJ=1,6
      CODES(IJ)=0
28    CONTINUE
      GO TO 8
```

```
C    *** ERROR MESSAGES ***
C
100   WRITE(4,1000)ISN
1C00  FORMAT(1X,I4,'IS AN INVALID RESPONSE.')
      GO TO 8
      END
      SUBROUTINE SIGH
      INTEGER STANO(4,30,5)
      LOGICAL*1 FULL
      COMMON FULL/DAT2/ANEWS(4,30,5,2,14),SC(14,4,30,5)/DAT3/STANO
     1/DAT1/XN(10,14),YN(10,14),NC(14),
     2W(14),IC(5)
C
C    *** THE PURPOSE OF THIS SUBROUTINE IS TO PRINT OUT SOME FINAL
C        RESULTS ***
C
C
C    *** IF DESIRED WRITE OUT FINAL STATION CHARACTERISTICS ***
C
      IF(.NOT.FULL)GO TO 35
      DO 30 L=1,5
      ISAT=IC(L)/4
      IF(ISAT.EQ.0)GO TO 30
      DO 31 I=1,ISAT
      DO 31 J=1,4
      WRITE(6,1)STANO(J,I,L),(SC(K,J,I,L),K=1,14)
1     FORMAT(1X,I5,14(1X,F6.1))
31    CONTINUE
30    CONTINUE
C
C    *** FIND OUT IF 'FILE FORMAT' OUTPUT IS DESIRED ***
C
35    WRITE(4,2)
2     FORMAT(' DO YOU WANT INCREMENTAL AND CUMULATIVE ALLOTMENTS'/,
     1' PRODUCED IN ''FILE FORMAT'' AS WELL AS CN PAPER?'/,
     2' ANSWER  1 FOR YES  OR  2 FOR NO.')
7     CALL INFREE(11,ICC)
      IF(ICC.LT.1.OR.ICC.GT.2) GO TO 100
      IF(ICC.EQ.2) GO TO 8
      DO 20 K=1,5
      ISAT=IC(K)/4
      IF(ISAT.EQ.0) GOTO 20
      WRITE(7,3) (((STANO(I,J,K),((ANEWS(I,J,K,L,M),L=1,2),
     1M=1,14),I=1,4),J=1,ISAT))
3     FORMAT(1X,I5,1X,28F7.1)
20    CONTINUE
```

```
C    *** WRITE OUT STANDARD FINAL OUTPUT ***
C
8      DO 4 I=1,4
       IA=(I*4)-3
       IB=IA+3
       IF(I.EQ.4)IB=14
       WRITE(6,5) IA,IB
5      FORMAT(/' PERIODS ',I4,' TO ',I4/)
       DO 10 L=1,5
       ISAT=IC(L)/4
       IF(ISAT.EQ.0.)GO TO 10
       IF(I.EQ.4) GO TO 11
       WRITE(6,6)(((STANO(J,K,L),((ANEWS(J,K,L,M,N),M=1,2),N=IA,IB),
      1J=1,4),K=1,ISAT))
       GO TO 10
11     WRITE(6,12)(((STANO(J,K,L),((ANEWS(J,K,L,M,N),M=1,2),N=IA,IB),
      1J=1,4),K=1,ISAT))
12     FORMAT((1X,I5,1X,2(F5.0,1X,F5.0)))
10     CONTINUE
4      CONTINUE
6      FORMAT((1X,I5,1X,4(F5.0,1X,F5.0,3X)))
       RETURN
C
C    *** ERROR MESSAGES ***
C
100    WRITE(4,1000)ICC
1CCC   FORMAT(1X,I4,' IS AN INVALIC RESPONSE.')
       GO TO 7
```

appendix

A.a-6

(see Chapter 7.2)

PROGRAM
FOR
HISTOGRAMS

- This program allows to draw histograms and was used to compare actual and simulated apartment growth (see Appendix A.d-1).
- It was programmed by Dr. H. Koike, University of British Columbia, and adapted for this thesis.

```
C     A P A R T M E N T   G R O W T H            P L O T T I N G
C     ******************************            ***************



C     THESIS  PAUL BAROSS  AND  ROBERT  STUSSI

C     SCHOOL OF COMMUNITY AND REGIONAL PLANNING
C     UNIVERSITY OF BRITISH COLUMBIA
C     APRIL  1972, VANCOUVER,  B.C.


C     PROGRAMMED DATE: JUNE 1971, PLACE: UBC, VANCOUVER,B.C.,CANADA
C-----PROGRAM 'HSTGM1' AND 'HSTGM2' ARE DESIGNED TO PLOT UNIVARIATE AND
C     BIVARIATE PERCENTAGE HISTOGRAMS RESPECITVELY.
      PROGRAMMER: DR. HIRCTOKA KOIKE

C     ADAPTED VERSION TO PLOT INCREMENTAL AND CUMULATIVE APARTMENT GROWTH
C     ALONG SUBWAY CORRIDORS       (APRIL 1972)
C     THE PROGRAM IS DESIGNED TO PLOT ACTUAL OR SIMULATED APARTMENT
C     GROWTH FOR UP TO 4 SUBWAY LINES WITH UP TO 12 STATIONS
C     EACH STATION HAVING 4 STATION SUB-AREAS

C     THE INCREMENT OR CUMULATIVE GROWTH A STATION SUB-AREA RECEIVES
C     IS PLOTTED AS A PERCENTAGE OF THE TOTAL GROWTH OF A
C     GIVEN SUBWAY LINE. IN ADDITION, THE PERCENTAGE AND THE
C     NUMBER OF APARTMENTS ARE WRITTEN AT THE LEFT SIDE OF THE
C     HISTOGRAM FOR EACH STATION SUB-AREA

C     THE PLOTTING CAN BE MADE FOR 4 LINES AND 14 TIME PERIODS IN
C     ONE RUN (IE. 56 HISTOGRAMS CAN BE PLOTTED)

C     THE INPUT DATA FOR THE PLOTTING ARE GENERATED BY THE
C     SIMULATION MODEL WHICH FORECASTS APARTMENT GROWTH ALONG
C     SUBWAY CORRIDORS


      DIMENSION NAME(128,2)   ,IVAL(130)  ,
     1TIME(15)  ,FMT(14)         ,TITLE(14,3),M(5),LINE(4,10)
      INTEGER TIME
C
C     CONTROL CARDS (IN THIS ORDER)
C
C     TIME   TIME PERIOD IN WHICH GROWTH TOOK PLACE
C     TITLE  TITLE CARD, 1 FOR EACH TIME PERIOD    3A4
C     LINE   NAME OF SUBWAY LINES, THERE ARE 4 LINE'S TO BE
C            READ IN,(YONGE,BLCOR WEST OLD, BLOOR WEST NEW,
C            BLOOR EAST)    10A4
C     NAME   NAME OF STATION SUB AREAS AND LOCATION
C            OF SUBAREA (NE,NW,SE,SW), THE NAME IS ON THE
C            FIRST AND SECOND CARD OF EACH 4 CARDS TO BE
C            WRITTEN    EACH I5,X,I2 (EG.EGLING SW      TON   SE)
C
C     SET OF CONTROLCARDS AND DATA TO BE READ IN FOR EACH TIME PERIOD
C
```

```
C      M       NUMBER OF STATIONS PER LINE, THERE ARE 5 N'S TO
C              BE READ IN WITH N=0 IF THE LINE IS NOT EXIXTING
C              IN A GIVEN TIME PERIOD
C      FMT     FORMAT, THERE IS ONE FORMAT FOR EACH TIME
C              PERIOD TO BE READ IN (IE. 14)
C      IVAL    NUMBER OF APARTMENTS PER STATION SUB-AREA
C              (CUMULATIVE OR INCREMENT)
C
       READ 13,(TIME(J),J=1,15)
 13    FORMAT(15I5)
       DO 31 K=1,14
 31    READ 11,(TITLE(K,J),J=1,3)
 11    FORMAT(19A4)
       DO 96 I=1,4
 96    READ 11,(LINE(I,J),J=1,10)
       DO 17 I=1,128
 17    READ 11,(NAME(I,J),J=1,2)
       K=1
 5     REWIND 4
       IF(TIME(K).EQ.99999) GO TO 20
       READ 14,(M(I),I=1,5)
14     FORMAT(5I5)
       M1=1
       READ 11,(FMT(I),I=1,14)
       IF(M(5)) 7,7,8
 8     M(4)=M(4)+M(5)
 7     CONTINUE
       M2=0
       MM=1
       DO 1 J=1,4
       IF(M(J).EQ.1) GO TO 9
       N=M(J)
       M2=M2+M(J)
       READ(4,FMT)(IVAL(I),I=M1,M2)
       CALL HSTGM1 (N,NAME,IVAL,TITLE,TIME,LINE,M1,M2,K,MM)
       M1=M2+1
       MM=MM+1
 1     CONTINUE
 9     CONTINUE
       K=K+1
       GO TO 5
 20    CONTINUE
       STOP
       END
```

```
      SUBROUTINE HSTGM1 (N,NAME,IVAL,TITLE,TIME,LINE,M1,M2,K,MM)
      DIMENSION NAME(128,2),IVAL(128),PRCNT(128),PER(128),MS(128),
     1MDOT(128),TITLE(14,3),IT(5),TIME(15),LINE(4,10)
      INTEGER TIME,SUB
C
C     PRCNT  NUMBER OF APARTMENTS PER STATION SUB-AREA
C            CALCULATED FROM IVAL
      INTEGER BLANK, STAR
      DATA BLANK/1H /,STAR/1HX/
      ISUM=0
      DO 1 I=M1,M2
    1 ISUM=ISUM+IVAL(I)
      SMAX=0.
      IF(ISUM.EQ.0) RETURN
      DO 2  I=M1,M2
      PRCNT(I)=FLOAT(IVAL(I))/FLOAT(ISUM)*100.
      SMAX=AMAX1(SMAX,PRCNT(I))
    2 CONTINUE
      IF(SMAX.GT.10.) GO TO 11
      F=5.
      GO TO 16
   11 IF(SMAX.GT.20.) GO TO 12
      F=2.5
      GO TO 16
   12 IF(SMAX.GT.25.) GO TO 13
      F=2.
      GO TO 16
   13 IF(SMAX.GT.50.) GO TO 14
      F=1.
      GO TO 16
   14 F=.5
   16 CONTINUE
      DO 20 I=M1,M2
      PER(I)=F*PRCNT(I)
      MS(I)=IFIX(PER(I))
      IF(PER(I)-FLOAT(MS(I))-.5) 20,18,18
   18 MS(I)=MS(I)+1
   20 CONTINUE
      PRINT 205
  205 FORMAT(1H1,5X)
      PRINT 200,(LINE(MM,I),I=1,10),(TITLE(K,I),I=1,3),TIME(K)
  200 FORMAT(1H ,9X,49HS I M U L A T E D   A P A R T M E N T   G R O W T H
     1/10X,17HSUBWAY CORRIDOR  ,10A4/10X,6HYEAR  ,3A4,5X,13HTIME PERIOD
     1 ,I2)
      DO 25 I=1,5
   25 IT(I)=I*IFIX(10./F)
```

```
      PRINT 201,(IT(I),I=1,5)
201   FORMAT(1H ,59X,16HNO OF APARTMENTS/10X,7HSTATION,49X,10HABSOLUT   %
     1/18X,3H0 %,I8,1X,1H%,I8,
     11X,1H%,I8,1X,1H%,I8,1X,1H%,I8/)
      DO 40 I=M1,M2
      DO 36 L=1,50
36    MDOT(L)=BLANK
      NMAX=MS(I)
      IF(NMAX) 39,39,37
37    DO 38 L=1,NMAX
38    MDOT(L)=STAR
39    CONTINUE
       IPERCN=PRCNT(I)
70    PRINT 202,(NAME(I,L),L=1,2),(MDOT(J),J=1,50),IVAL(I),IPERCN
202   FORMAT(10X,2A4,1X,50A1,I4,I3)
40    CONTINUE
      SUB=N/4
      PRINT 212,ISUM,TIME(K),(LINE(MM,NX),NX=1,10),SUB,N
212   FORMAT(1H ,62X,6HTOTAL ,I4,3H100/
     1          10X,14HIN TIME PERIOD,2X,I2,2X,15HTHE SUBWAY LINE,2X,
     110A4 ,/10X,5HHAD  ,I2,2X,
     115HSTATIONS WITH  ,I3,2X,18HSTATION SUB-AREAS.)
      PRINT 300,ISUM,TIME(K)
300   FORMAT(10X,I4,2X,51HIS THE TOTAL # OF APARTMENTS BUILT IN TIME PER
     1IOD  ,I2)
      RETURN
```

appendix

(see Chapter 7.2)

A.a-7

PROGRAM FOR SCATTERGRAMS

- This program allows to plot scattergrams and was used to compare actual and simulated apartment growth (see chapter 7.2).
- It was programmed by Dr. H. Koike, University of British Columbia, and adapted for this thesis.

```
C
C
C      S C A T T E R G R A M
C
C
C      A P P E R T M E N T   G R O W T H        SCATTERGRAM
C      ******************************           ***********
C
C      THESIS  PAUL BAROSS  AND  ROBERT  STUSSI
C      SCHOOL OF COMMUNITY AND REGIONAL PLANNING
C      UNIVERSITY OF BRITISH COLUMBIA
C      APRIL 1972, VANCOUVER, B.C.
C
C
C-----A PROGRAM TO PLOT A SERIES OF SCATTERGRAMS
C
      DIMENSION X(500),Y(500),ITYPE(500),FMT(20),BCD(15)
      INTEGER BCD
      CALL PLOTS
 1    REWIND 4
C
C      IF LOG=1, X AXIS HAS LOG/SCALE
C      NTITLE = NUMBER OF TITLE CARDS IN CONTROLDECK
C      IF IFLAG = 1, SIGN1 IS USED FOR PLOTTING,
C      IBID FOR IFLAG=2,3
C
      READ 10,LOG,NTITLE,IFLAG
 10   FORMAT(5X,9I5)
      IF(LOG.EQ.99999) GO TO 999
C
C      N2 IS NUMBER OF CARDS PER STRATA
C      FMT IS THE FORMAT STATEMENT FOR EACH STRATA
C      N2 AND FTM FOLLOW EACH OTHER ON SEPERATE CARDS,
C      STARTING WITH N2, ENDING WITH N2=99
C      ENDING WITH N2=99
C
      N=0
      N1=1
 2    READ 12,N2
 12   FORMAT (I5)
      IF(N2.EQ.99) GO TO 3
      N=N+N2
      READ 11,(FMT(I),I=1,20)
11    FORMAT(20A4)
C
C      READ DATA CARDS WITH ITYPE,X,Y
C
C      THE VALUE OF ITYPE WILL DEFINE THE SYMBOL TO BE PLOTTED
C
C      IF SIGN1 IS CHOOSEN, ITYPE CAN RANGE FROM 1 TO 12
C      RESULTING IN PLOTTING SIGNS 1,2,.......,9,0,A,B,H.
C
C      IF SIGN2, ITYPE CAN TAKE VALUES FROM 1,2,..5 RESULTING
C      IN PLOTTING SIGNS 4,0,3,3,3  (SEE PLOTTING MANUAL)
C
C      IF SIGN3, ITYPE CAN TAKE VALUES FROM1 TO 3 RESULTING
C      IN PLOTTING SIGNS 3,3,0 (SEE PLOTTING MANUAL)
C      3,3,0 (SEE PLOTTING MANUAL)
C
```

```
C
C
C
C     S C A T T E R G R A M                               CONTINUED
C
      READ(4,FMT)(ITYPE(I),X(I),Y(I),I=N1,N)
      N1=N+1
      GO TO 2
 3    CONTINUE
      IF(LOG.NE.1) GO TO 50
      DO 45 I=1,N
45    X(I)=ALOG10(X(I))
50    CONTINUE
      CALL PLOT(3.,0.,-3)
C
C     SET UP OF THE CONTROL CARD DECK
C     ******************************
C
C
C     CARD WITH LOG, NTITLE, IFLAG   (5X,3I5)
C
C     CARD WITH N2, (I5), FOLLOWED BY FMT ON THE NEXED CARD
C     THIS CARDS ARE REPEATED FOREACH STRATA IN THE DATA,
C     AFTER THE LAST PAIR OF N/FTM CARDS, N2 IS = 99 WHICH
C     INDICATES THE END OF DATA FOR ONE PLOT
C
C     NEXT, NTITLE TITLE CARDS FOLLOW WITH XT,YT,HT,NCHAR
C
C     THEN A NEW SET OF CONTROL CARDS BEGINS OR A CARD
C     CONTAINING LOG=99999 INDICATES THE END OF THE RUN
C     INDICATES THE END OF THE RUN
C
      DO 100 L=1,NTITLE
      READ 15,XT,YT,HT,NCHAR,(BCD(K),K=1,15)
15    FORMAT(3F5.0,I5,15A4)
      IF(NCHAR.EQ.-1) GO TO 60
      CALL SYMBOL(XT,YT,HT,BCD,0.,NCHAR)
      GO TO 100
60    IBCD=BCD(1)
      CALL SYMBOL(XT,YT,HT,IBCD,0.,-1)
100   CONTINUE
      CALL SCATTR(X,Y,N,ITYPE,IFLAG)
      CALL PLOT(10.,0.,-3)
      GO TO 1
999   CALL PLOTND
      STOP
      END
```

```
C
C
C
C     S C A T T E R G R A M                    CONTINUED
C
C
      SUBROUTINE SCATTR(X,Y,N,ITYPE,IFLAG)
C
      DIMENSION X(N),Y(N),ITYPE(N),SIGN1(13),SIGN2(5),SIGN3(3)
      INTEGER BCD,SIGN1,SIGN2,SIGN3
      DATA SIGN1/1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H0,1HA,1HB,1H /,
     1SIGN2/4,0,3,3,3/,SIGN3/3,3,0/
      CALL SCALE (X,N,4.,XMIN,DX,1)
      CALL SCALE (Y,N,6.,YMIN,DY,1)
      CALL AXIS(0.,1.,13HACTUAL GROWTH,-13,4.,0.,XMIN,DX)
      CALL AXIS(0.,1.,'SIMULATED GROWTH)',17,6.,90.,YMIN,DY)
      DO 20 I=1,N
      IT=ITYPE(I)
      NCHAR=1
      Y(I)=Y(I)+1.
      GO TO (11,12,13,14),IFLAG
11    IF(IT.GT.12) GO TO 16
      BCD=SIGN1(IT)
      GO TO 15
16    BCD=SIGN1(13)
      GO TO 15
12    IF(IT.LT.12) GO TO 17
      BCD=SIGN1(IT)
      GO TO 15
17    BCD=SIGN1(13)
      GO TO 15
13    BCD=SIGN2(IT)
      NCHAR=-1
      GO TO 15
14    BCD=SIGN3(IT)
      NCHAR=-1
15    CONTINUE
      CALL SYMBOL(X(I),Y(I),0.10,BCD,0.,NCHAR)
20    CONTINUE
      RETURN
      END


$COPY PROG
```

data

A.b

appendix

(See Chapter 6.2)

A.b-1

APARTMENT
DEVELOPMENTS
ALONG
SUBWAY
CORRIDORS

- Number of Apartment Buildings built in each year
- Number of Dwelling units per floor
- Number of storeys per apartment buildings
- Number of dwelling units per apartment building

A P A R T M E N T   D E V E L O P M E N T   A L O N G

T H E   T O R O N T O   S U B W A Y   C O R R I D O R S

NUMBER OF APARTMENTS BUILT IN EACH YEAR
ALONG ALL SUBWAY CORRIDORS

THE APARTMENTS BUILT BEFORE 1958 ARE IN
A SEPERATE GROUP (SEE MISSING VALUES)

YEAR	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE FREQ (PERCENT)
1959	59	3	1.4	3.2	3.2
1961	61	10	4.8	10.5	13.7
1962	62	3	1.4	3.2	16.8
1963	63	13	6.3	13.7	30.5
1964	64	3	1.4	3.2	33.7
1965	65	12	5.8	12.6	46.3
1966	66	7	3.4	7.4	53.7
1967	67	8	3.9	8.4	62.1
1968	68	15	7.2	15.8	77.9
1969	69	11	5.3	11.6	89.5
1970	70	10	4.8	10.5	100.0
1958	58	112	54.1	MISSING	100.0
	TOTAL	207	100.0	100.0	100.0

VALID   OBSERVATIONS -   95
MISSING OBSERVATIONS -   112

A P A R T M E N T   D E V E L O P M E N T   A L O N G

T H E   T O R O N T O   S U B W A Y   C O R R I D O R S

AVERAGE NUMBER OF DWELLING UNITS PER FLOOR

(FOR ALL APARTMENT DEVELOPMENTS AFTER 1958,
UP TO THE YEAR 1970, ALONG ALL SUBWAY LINES)

NUMBER OF DWELLINGS PER FLOOR	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	CUMULATIVE FREQ (PERCENT)
LESS THAN 10	6	5	5.3	5.3
6-10	10	17	17.9	23.2
11-13	13	18	18.9	42.1
14-16	16	25	26.3	68.4
17-20	20	23	24.2	92.6
21-30	30	7	7.4	100.0
	TOTAL	95	100.0	100.0

VALID OBSERVATIONS - 95
MISSING CBSERVATIONS - 0

A P A R T M E N T   D E V E L O P M E N T   A L O N G

T H E   T O R O N T O   S U B W A Y   C O R R I D O R S

NUMBER OF STORIES PER APARTMENT STRUCTURE

TABLE 1 APARTMENTS CONSTRUCTED BEFORE 1958 ARE INCLUDED

NUMBER OF STORIES	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	CUMULATIVE FREQ (PERCENT)
2 STORIES	2	54	26.1	26.1
3 STORIES	3	43	2 .8	46.9
4 STORIES	4	10	4.8	51.7
5 STORIES	5	11	5.3	57.0
6-10 STORIES	10	15	7.2	64.3
11-15 STORIES	15	16	7.7	72.0
16-20 STORIES	20	29	14.0	86.0
21-30 STORIES	3	27	13.0	99.0
MORE THAN 3 STORIES	31	2	1.	1 .
	TO	207	100.0	100.0

MISSING OBSERVATIONS - 0
VALID OBSERVATIONS - 207

TABLE 2 APARTMENTS BUILT BEFORE 1958 ARE N C T INCLUDED

NUMBER OF STORIES	VALUES	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	CUMULATIVE FREQ (PERCENT)
3 STORIES	3	2	2.1	2.1
5 STORIES	5	6	6.3	8.4
6-10 STORIES	10	13	13.7	22.1
11-15 STORIES	15	16	16.8	38.9
16-20 STORIES	20	29	30.5	69.5
21-30 STORIES	30	27	28.4	97.9
MORE THAN 30	31	2	2.1	100.0
	TO	95	100.0	100.0

VALID OBSERVATIONS - 95
MISSING OBSERVATIONS - 0

A P A R T M E N T   D E V E L O P M E N T   A L O N G

T H E   T O R O N T O   S U B W A Y   C O R R I D O R S

NUMBER OF DWELLING UNITS PER APARTMENT STRUCTURE

THE APARTMENTS BUILT BEFORE 1958 FORM THREE SEPERATE
GROUPS WHICH ARE TREATED AS MISSING VALUES
(SEE COLUMN 'FREQUENCY' AND 'ADJ.FREQUENCY' IN TABLE)

NUMBER OF DWELLINGS PER APARTMENT STRUCTURE	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE FREQ (PERCENT)
48- 60	60	21	10.1	17.8	17.8
61- 80	80	15	7.2	12.7	30.5
81-120	120	8	3.9	6.8	37.3
121-160	160	6	2.9	5.1	42.4
161-200	200	13	6.3	11.0	53.4
201-300	300	29	14.0	24.6	78.0
301-400	400	16	7.7	13.6	91.5
+ 400	401	10	4.8	8.5	100.0
L T 20	20	31	15.0	MISSING	100.0
21-30	30	28	13.5	MISSING	100.0
31-30	47	30	14.5	MISSING	100.0
	TO	207	100.0	100.0	100.0

VALID OBSERVATIONS - 118
MISSING OBSERVATIONS - 89

appendix

(See Chapter 6.2)

A.b-2

APARTMENT
GROWTH

Incremental growth for each time period; up to year 1959 and 1959 to 1971.

D I S T R I B U T I O N O F A P A R T M E N T U N I T S

ANNUAL INCREASE OF APARTMENT UNITS
BY TIME PERIOD AND BY STATION SUB-AREA

SUBWAY LINE Y O N G E

	STATION NUMBER AND SUBAREA NUMBER	NUMBER OF STATION SUB-AREAS	NUMBER OF A P A R T M E N T S BUILT UNTIL 1958	I N T I M E P E R I O D 1959 +1960	1961 +1962	1963 +1964	1965 +1966	1967 +1968	1969 +1970
EGLINGTON	1011	1	262	0	0	0	0	168	0
	1012	2	802	210	255	310	343	251	300
	1013	3	98	0	0	0	0	0	0
	1014	4	70	155	159	0	288	369	245
DAVISVILLE	1021	5	108	0	0	0	0	0	0
	1022	6	0	0	0	0	0	0	0
	1023	7	101	180	153	0	0	0	0
	1024	8	80	0	120	400	580	645	783
ST.CLAIR	1031	9	340	0	215	212	0	0	0
	1032	10	62	0	0	0	0	0	311
	1033	11	16	0	0	0	0	0	0
	1034	12	66	0	222	416	784	748	355
SUMMERHILL	1041	13	0	0	0	0	0	0	0
	1042	14	0	0	0	0	0	0	0
	1043	15	0	0	0	0	0	0	0
	1044	16	0	0	0	0	0	0	0
ROSEDALE	1051	17	0	0	0	0	0	0	0
	1052	18	0	0	0	0	0	0	0
	1053	19	0	0	0	0	0	0	0
	1054	20	0	0	0	0	0	0	0
TOTAL # OF APARTMENTS BUILD BY TIME PERIOD, CORRIDOR Y O N G E			2005	545	1124	1338	1995	2181	1994

SUBWAY LINE B L O O R W E S T O L D

ST.GEORGE	2011	1	0	0	0	80	0	0	0
	2012	2	217	0	157	0	192	150	0
	2013	3	0	0	0	0	0	0	0
	2014	4	0	0	0	0	0	0	0
SPADINA	2021	5	93	0	207	0	169	0	140
	2022	6	0	0	0	0	0	0	0
	2023	7	0	0	0	0	0	0	0
	2024	8	0	0	0	0	0	0	0
BATHURST	2031	9	0	0	0	0	0	0	0
	2032	10	0	0	0	0	0	0	0
	2033	11	0	0	0	0	0	0	0
	2034	12	0	0	0	0	0	0	0
CHRISTIE	2041	13	0	0	0	0	0	0	0
	2042	14	25	0	0	0	0	0	0
	2043	15	0	0	0	0	0	0	0
	2044	16	0	0	0	0	0	0	0

SUBWAY LINE B L O O R W E S T O L C CONTINUED

			1958	59/60	61/62	63/64	65/66	67/68	69/70
OSSINGTON	2051	17	0	0	0	0	0	0	0
	2052	18	0	0	0	0	0	0	0
	2053	19	0	0	0	0	0	0	0
	2054	20	0	0	0	0	0	0	0
DUFFERIN	2061	21	0	0	0	0	0	0	0
	2062	22	0	0	0	0	0	0	0
	2063	23	0	0	0	0	0	0	0
	2064	24	0	0	0	0	0	0	0
LANDSDCWNE	2071	25	0	0	0	0	0	0	0
	2072	26	0	0	0	0	0	0	0
	2073	27	0	0	0	0	0	0	0
	2074	28	0	0	0	0	0	0	0
DUNDAS WEST	2081	29	0	0	0	0	0	0	0
	2082	30	0	0	0	0	0	0	0
	2083	31	117	0	0	0	0	0	0
	2084	32	0	0	0	0	0	0	0
KEELE	2091	33	21	0	0	313	520	480	332
	2092	34	0	0	0	0	0	0	0
	2093	35	0	0	0	0	0	0	0
	2094	36	0	0	0	0	0	0	0
TOTAL # OF APARTMENTS BUILD BY TIME PERIOD, CORRIDOR B L O C R W E S T O L D			437	0	364	295	881	630	472

SUBWAY LINE B L O O R W E S T N E W

			1958	59/60	61/62	63/64	65/66	67/68	69/70
HIGHPARK	2101	1	135	0	0	0	0	0	0
	2102	2	124	0	0	231	462	638	525
	2103	3	74	0	0	0	0	0	0
	2104	4	0	0	0	0	0	0	0
RUNNYMEDE	2111	5	0	0	0	0	0	0	0
	2112	6	0	0	0	0	0	0	0
	2113	7	0	0	0	0	0	0	0
	2114	8	0	0	0	0	0	0	0
JANE	2121	9	0	0	0	0	0	0	0
	2122	10	0	0	0	0	0	0	0
	2123	11	0	0	0	0	0	0	0
	2124	12	0	0	0	0	0	0	0
OLD MILL	2131	13	160	0	0	0	0	0	0
	2132	14	19	0	0	0	154	0	0
	2133	15	234	0	0	0	0	0	0
	2134	16	0	0	0	0	0	0	0
ROYAL YPRK	2141	17	0	0	0	0	0	0	0
	2142	18	0	0	0	0	0	0	0
	2143	19	0	0	0	0	0	0	0
	2144	20	0	0	0	0	0	0	0
ISLINGTON	2151	21	0	0	154	194	0	60	0
	2152	22	0	0	0	180	0	0	0
	2153	23	0	0	0	0	0	0	0
	2154	24	0	0	0	0	0	0	0
TOTAL # OF APARTMENTS BUILT BY TIME PERIOD, CORRIDOR B L O O R W E S T NEW+OLD			1219	0	518	998	1497	1328	997

SUBWAY LINE B L O O R E A S T O L D

			1958	59/60	61/62	63/64	65/66	67/68	69/70
SHERBOURNE	3011	1	57	0	0	0	0	0	0
	3012	2	0	0	0	0	0	0	0
	3013	3	74	0	0	215	0	93	0
	3014	4	34	0	274	947	951	1697	1347
CASTLE FRANK	3021	5	0	0	0	0	0	0	0
	3022	6	0	0	0	0	0	0	0
	3023	7	0	0	0	0	0	0	0
	3024	8	0	0	0	0	0	0	0
BROADVIEW	3031	9	165	0	0	180	370	216	0
	3032	10	0	0	0	0	0	0	0
	3033	11	110	0	0	0	0	0	0
	3034	12	102	0	0	0	0	226	288
CHESTER	3041	13	0	0	0	0	0	0	0
	3042	14	28	0	0	0	0	0	0
	3043	15	40	0	0	0	0	0	0
	3044	16	0	0	0	0	0	0	0
PAPE	3051	17	80	0	0	0	0	0	0
	3052	18	19	0	0	0	0	0	0
	3053	19	0	0	0	0	0	0	0
	3054	20	0	0	0	0	0	0	0
DONLANDS	3061	21	0	0	0	0	0	0	0
	3062	22	24	0	0	0	0	0	0
	3063	23	0	0	0	0	0	0	0
	3064	24	0	0	0	0	0	0	0
GREENWOOD	3071	25	0	0	0	0	0	0	0
	3072	26	0	0	0	0	0	0	0
	3073	27	0	0	0	0	0	0	0
	3074	28	0	0	0	0	0	0	0
COXWELL	3081	29	0	0	0	0	0	0	0
	3082	30	0	0	0	0	0	0	0
	3083	31	0	0	0	0	0	0	0
	3084	32	0	0	0	0	0	0	0
WOODBINE	3091	33	0	0	0	0	0	0	0
	3092	34	0	0	59	0	0	0	0
	3093	35	0	0	0	0	0	0	0
	3094	36	0	0	0	0	0	0	0

TOTAL NUMBER OF APARTMENTS BUILT
BY TIME PERIOD, CORRIDOR

	1958	59/60	61/62	63/64	65/66	67/68	69/70
B L O O R E A S T O L D	733	0	333	1342	1321	2231	1635

			1958	59/60	61/62	63/64	65/66	67/68	69/70
MAIN STREET	3101	1	0	0	0	0	0	0	0
	3102	2	0	0	0	0	0	0	0
	3103	3	0	0	0	0	0	0	0
	3104	4	0	0	0	0	0	0	625
VICTORIA PARK	3111	5	0	0	0	0	0	0	208
	3112	6	0	0	0	0	0	0	294
	3113	7	0	0	0	0	0	0	0
	3114	8	0	0	0	0	0	0	0
WARDEN	3121	9	0	0	0	0	0	0	330
	3122	10	0	0	0	0	0	0	0
	3123	11	0	0	0	0	0	0	0
	3124	12	0	0	0	0	0	0	0

TOTAL # OF APARTMENTS BUILT
BY TIME PERIOD, CORRIDOR

	1958	59/60	61/62	63/64	65/66	67/68	69/70
B L O O R E A S T OLD+NEW	733	0	333	1342	1321	2231	3092

appendix

(See Chapter 6.2)

A.b-3

APARTMENT GROWTH

Cumulative growth 1959-1970, <u>including</u> apartments built before 1959, for each time period.

D I S T R I B U T I O N O F A P A R T M E N T U N I T S

TOTAL CUMULATIVE NUMBER OF APARTMENT UNITS
BY TIME PERIOD AND BY STATION SUB-AREA,
INCLUDING APARTMENTS BUILT UP TO 1958 (INCLUSIVE)

SUBWAY LINE Y O N G E

	STATION NUMBER AND SUBAREA NUMBER	NUMBER OF STATION SUB-AREAS	N U M B E R O F A P A R T M E N T S B U I L T U P T O Y E A R						
			1958	1960	1962	1964	1966	1968	1970
EGLINGTON	1011	1	267	0	0	0	0	168	0
	1012	2	802	1012	1267	1577	1920	2171	2471
	1013	3	98	98	98	98	98	98	98
	1014	4	70	225	384	384	672	1041	1286
DAVISVILLE	1021	5	108	108	108	108	108	108	108
	1022	6	0	0	0	0	0	0	0
	1023	7	101	281	434	434	434	434	434
	1024	8	80	80	200	600	1180	1825	2608
ST.CLAIR	1031	9	340	340	555	767	767	767	767
	1032	10	62	62	62	62	62	62	373
	1033	11	16	16	16	16	16	16	16
	1034	12	66	66	288	704	1488	2236	2591
SUMMERHILL	1041	13	0	0	0	0	0	0	0
	1042	14	0	0	0	0	0	0	0
	1043	15	0	0	0	0	0	0	0
	1044	16	0	0	0	0	0	0	0
ROSEDALE	1051	17	0	0	0	0	0	0	0
	1052	18	0	0	0	0	0	0	0
	1053	19	0	0	0	0	0	0	0
	1054	20	0	0	0	0	0	0	0

SUBWAY LINE B L O O R W E S T O L D

ST.GEORGE	2011	1	0	0	0	80	80	80	80
	2012	2	217	217	374	374	566	716	716
	2013	3	0	0	0	0	0	0	0
	2014	4	0	0	0	0	0	0	0
SPADINA	2021	5	93	93	300	300	469	469	609
	2022	6	0	0	0	0	0	0	0
	2023	7	0	0	0	0	0	0	0
	2024	8	0	0	0	0	0	0	0
BATHURST	2031	9	0	0	0	0	0	0	0
	2032	10	0	0	0	0	0	0	0
	2033	11	0	0	0	0	0	0	0
	2034	12	0	0	0	0	0	0	0

SUBWAY LINE B L O O R W E S T O L D CONTINUED

			1958	1960	1962	1964	1966	1968	1970
CHRISTIE	2041	13	0	0	0	0	0	0	0
	2042	14	25	25	25	25	25	25	25
	2043	15	0	0	0	0	0	0	0
	2044	16	0	0	0	0	0	0	0
OSSINGTON	2051	17	0	0	0	0	0	0	0
	2052	18	0	0	0	0	0	0	0
	2053	19	0	0	0	0	0	0	0
	2054	20	0	0	0	0	0	0	0
DUFFERIN	2061	21	0	0	0	0	0	0	0
	2062	22	0	0	0	0	0	0	0
	2063	23	0	0	0	0	0	0	0
	2064	24	0	0	0	0	0	0	0
LANDSDOWNE	2071	25	0	0	0	0	0	0	0
	2072	26	0	0	0	0	0	0	0
	2073	27	0	0	0	0	0	0	0
	2074	28	0	0	0	0	0	0	0
DUNDAS WEST	2081	29	0	0	0	0	0	0	0
	2082	30	0	0	0	0	0	0	0
	2083	31	117	117	117	117	117	117	117
	2084	32	0	0	0	0	0	0	0
KEELE	2091	33	21	21	21	334	854	1334	1666
	2092	34	0	0	0	0	0	0	0
	2093	35	0	0	0	0	0	0	0
	2094	36	0	0	0	0	0	0	0

SUBWAY LINE B L O O R W E S T N E W

HIGH PARK	2101	1	135	135	135	135	135	135	135
	2102	2	124	124	124	355	817	1455	1980
	2103	3	74	74	74	74	74	74	74
	2104	4	0	0	0	0	0	0	0
RUNNYMEDE	2111	5	0	0	0	0	0	0	0
	2112	6	0	0	0	0	0	0	0
	2113	7	0	0	0	0	0	0	0
	2114	8	0	0	0	0	0	0	0
JANE	2121	9	0	0	0	0	0	0	0
	2122	10	0	0	0	0	0	0	0
	2123	11	0	0	0	0	0	0	0
	2124	12	0	0	0	0	0	0	0
OLD MILL	2131	13	160	160	160	160	160	160	160
	2132	14	19	19	19	19	173	173	173
	2133	15	234	234	234	234	234	234	234
	2134	16	0	0	0	0	0	0	0
ROYAL YORK	2141	17	0	0	0	0	0	0	0
	2142	18	0	0	0	0	0	0	0
	2143	19	0	0	0	0	0	0	0
	2144	20	0	0	0	0	0	0	0
ISLINGTON	2151	21	0	0	154	348	348	408	408
	2152	22	0	0	0	180	180	180	180
	2153	23	0	0	0	0	0	0	0
	2154	24	0	0	0	0	0	0	0

SUBWAY LINE B L O O R E A S T O L D

			1958	1960	1962	1964	1966	1968	1970
SHERBCURNE	3011	1	57	57	57	57	57	57	57
	3012	2	0	0	0	0	0	0	0
	3013	3	74	74	74	289	289	382	382
	3014	4	34	34	308	1255	2206	3903	5250
CASTEL FRANK	3021	5	0	0	0	0	0	0	0
	3022	6	0	0	0	0	0	0	0
	3023	7	0	0	0	0	0	0	0
	3024	8	0	0	0	0	0	0	0
BROADVIEW	3031	9	165	165	165	345	715	931	931
	3032	10	0	0	0	0	0	0	0
	3033	11	110	110	110	110	110	110	110
	3034	12	102	102	102	102	102	328	616
CHESTER	3041	13	0	0	0	0	0	0	0
	3042	14	28	28	28	28	28	28	28
	3043	15	40	40	40	40	40	40	40
	3044	16	0	0	0	0	0	0	0
PAPE	3051	17	80	80	80	80	80	80	80
	3052	18	19	19	19	19	19	19	19
	3053	19	0	0	0	0	0	0	0
	3054	20	0	0	0	0	0	0	0
DONLANDS	3061	21	0	0	0	0	0	0	0
	3062	22	24	24	24	24	24	24	24
	3063	23	0	0	0	0	0	0	0
	3064	24	0	0	0	0	0	0	0
GREENWOOD	3071	25	0	0	0	0	0	0	0
	3072	26	0	0	0	0	0	0	0
	3073	27	0	0	0	0	0	0	0
	3074	28	0	0	0	0	0	0	0
COXWELL	3081	29	0	0	0	0	0	0	0
	3082	30	0	0	0	0	0	0	0
	3083	31	0	0	0	0	0	0	0
	3084	32	0	0	0	0	0	0	0
WOODBINE	3091	33	0	0	0	0	0	0	0
	3092	34	0	0	59	59	59	59	59
	3093	35	0	0	0	0	0	0	0
	3094	36	0	0	0	0	0	0	0

SUBWAY LINE B L O O R E A S T N E W

MAIN STREET	3101	1	0	0	0	0	0	0	0
	3102	2	0	0	0	0	0	0	0
	3103	3	0	0	0	0	0	0	0
	3104	4	0	0	0	0	0	0	625
VOCTORIA PARK	3111	5	0	0	0	0	0	0	208
	3112	6	0	0	0	0	0	0	294
	3113	7	0	0	0	0	0	0	0
	3114	8	0	0	0	0	0	0	0
WARDEN	3121	9	0	0	0	0	0	0	330
	3122	10	0	0	0	0	0	0	0
	3123	11	0	0	0	0	0	0	0
	3124	12	0	0	0	0	0	0	0

appendix

(See Chapter 6.2)

A.b-4

Cumulative growth 1959-1970, excluding apartments built before 1959, for each time period.

DISTRIBUTION OF APARTMENT UNITS

TOTAL CUMULATIVE NUMBER OF APARTMENTS BUILT BY TIME PERIOD AND BY STATION SUB-AREAS, EXCLUDING APARTMENTS BUILT UP TO 1958 (INCLUSIVE)

SUBWAY LINE YONGE

	STATION NUMBER AND SUBAREA NUMBER	NUMBER OF STATION SUB AREAS	NUMBER OF APARTMENTS AFTER 1958, UP TO YEAR 1960	1962	1964	1966	1968	1970
EGLINGTON	1011	1	0	0	0	0	168	168
	1012	2	210	465	775	1118	1369	1669
	1013	3	0	0	0	0	0	0
	1014	4	155	314	314	602	971	1216
DAVISVILLE	1021	5	0	0	0	0	0	0
	1022	6	0	0	0	0	0	0
	1023	7	180	333	333	333	333	333
	1024	8	0	120	520	1100	1745	2528
ST.CLAIR	1031	9	0	215	427	427	427	427
	1032	10	0	0	0	0	0	311
	1033	11	0	0	0	0	0	0
	1034	12	0	222	638	1422	2170	2525
SUMMERHILL	1041	13	0	0	0	0	0	0
	1042	14	0	0	0	0	0	0
	1043	15	0	0	0	0	0	0
	1044	16	0	0	0	0	0	0
ROSEDALE	1051	17	0	0	0	0	0	0
	1052	18	0	0	0	0	0	0
	1053	19	0	0	0	0	0	0
	1054	20	0	0	0	0	0	0

SUBWAY LINE BLOOR WEST OLD

ST.GEORGE	2011	1	0	0	80	80	80	80
	2012	2	0	157	157	349	499	499
	2013	3	0	0	0	0	0	0
	2014	4	0	0	0	0	0	0
SPADINA	2021	5	0	207	207	376	376	516
	2022	6	0	0	0	0	0	0
	2023	7	0	0	0	0	0	0
	2024	8	0	0	0	0	0	0
BATHURST	2031	9	0	0	0	0	0	0
	2032	10	0	0	0	0	0	0
	2033	11	0	0	0	0	0	0
	2034	12	0	0	0	0	0	0

SUBWAY LINE B L O O R W E S T O L D CONTINUED

			1960	1962	1964	1966	1968	1970
CHRISTIE	2041	13	0	0	0	0	0	0
	2042	14	0	0	0	0	0	0
	2043	15	0	0	0	0	0	0
	2044	16	0	0	0	0	0	0
OSSINGTON	2051	17	0	0	0	0	0	0
	2052	18	0	0	0	0	0	0
	2053	19	0	0	0	0	0	0
	2054	20	0	0	0	0	0	0
DUFFERIN	2061	21	0	0	0	0	0	0
	2062	22	0	0	0	0	0	0
	2063	23	0	0	0	0	0	0
	2064	24	0	0	0	0	0	0
LANDSDOWNE	2071	25	0	0	0	0	0	0
	2072	26	0	0	0	0	0	0
	2073	27	0	0	0	0	0	0
	2074	28	0	0	0	0	0	0
DUNDAS WEST	2081	29	0	0	0	0	0	0
	2082	30	0	0	0	0	0	0
	2083	31	0	0	0	0	0	0
	2084	32	0	0	0	0	0	0
KEELE	2091	33	0	0	313	833	1313	1645
	2092	34	0	0	0	0	0	0
	2093	35	0	0	0	0	0	0
	2094	36	0	0	0	0	0	0

SUBWAY LINE B L O O R W E S T N E W

HIGHPARK	2101	1	0	0	0	0	0	0
	2102	2	0	0	231	693	1331	1856
	2103	3	0	0	0	0	0	0
	2104	4	0	0	0	0	0	0
RUNNYMEDE	2111	5	0	0	0	0	0	0
	2112	6	0	0	0	0	0	0
	2113	7	0	0	0	0	0	0
	2114	8	0	0	0	0	0	0
JANE	2121	9	0	0	0	0	0	0
	2122	10	0	0	0	0	0	0
	2123	11	0	0	0	0	0	0
	2124	12	0	0	0	0	0	0
OLD MILL	2131	13	0	0	0	0	0	0
	2132	14	0	0	0	154	154	154
	2133	15	0	0	0	0	0	0
	2134	16	0	0	0	0	0	0
ROYAL YORK	2141	17	0	0	0	0	0	0
	2142	18	0	0	0	0	0	0
	2143	19	0	0	0	0	0	0
	2144	20	0	0	0	0	0	0
ISLINGTON	2151	21	0	154	348	348	408	408
	2152	22	0	0	180	180	180	180
	2153	23	0	0	0	0	0	0
	2154	24	0	0	0	0	0	0

SUBWAY LINE B L O O R E A S T O L D

			1960	1962	1964	1966	1968	1970
SHERBOURNE	3011	1	0	0	0	0	0	0
	3012	2	0	0	0	0	0	0
	3013	3	0	0	215	215	308	308
	3014	4	0	274	1221	2172	3869	5216
CASTLE FRANK	3021	5	0	0	0	0	0	0
	3022	6	0	0	0	0	0	0
	3023	7	0	0	0	0	0	0
	3024	8	0	0	0	0	0	0
BROADVIEW	3031	9	0	0	180	550	766	766
	3032	10	0	0	0	0	0	0
	3033	11	0	0	0	0	0	0
	3034	12	0	0	0	0	226	514
CHESTER	3041	13	0	0	0	0	0	0
	3042	14	0	0	0	0	0	0
	3043	15	0	0	0	0	0	0
	3044	16	0	0	0	0	0	0
PAPE	3051	17	0	0	0	0	0	0
	3052	18	0	0	0	0	0	0
	3053	19	0	0	0	0	0	0
	3054	20	0	0	0	0	0	0
DONLANDS	3061	21	0	0	0	0	0	0
	3062	22	0	0	0	0	0	0
	3063	23	0	0	0	0	0	0
	3064	24	0	0	0	0	0	0
GREENWOOD	3071	25	0	0	0	0	0	0
	3072	26	0	0	0	0	0	0
	3073	27	0	0	0	0	0	0
	3074	28	0	0	0	0	0	0
COXWELL	3081	29	0	0	0	0	0	0
	3082	30	0	0	0	0	0	0
	3083	31	0	0	0	0	0	0
	3084	32	0	0	0	0	0	0
WOODBINE	3091	33	0	0	0	0	0	0
	3092	34	0	59	59	59	59	59
	3093	35	0	0	0	0	0	0
	3094	36	0	0	0	0	0	0

SUBWAY LINE B L O O R E A S T N E W

MAIN STREET	3101	1	0	0	0	0	0	0
	3102	2	0	0	0	0	0	0
	3103	3	0	0	0	0	0	0
	3104	4	0	0	0	0	0	625
VICTORIA PARK	3111	5	0	0	0	0	0	208
	3112	6	0	0	0	0	0	294
	3113	7	0	0	0	0	0	0
	3114	8	0	0	0	0	0	0
WARDEN	3121	9	0	0	0	0	0	330
	3122	10	0	0	0	0	0	0
	3123	11	0	0	0	0	0	0
	3124	12	0	0	0	0	0	0

statistical analysis

A.c

appendix A.c-1

(See Chapter 6.3)

STATISTICAL ANALYSIS

CROSS-TABULATION AND CORRELATION ANALYSIS

In order to establish the table functions, the relationships between apartment growth and the environmental factors had to be established. As already mentioned, correlation and regression analysis is not suitable to determine the shape of the table functions, because the relationships between apartment growth and the environmental factors are hypothesized as non-linear. The use of logarithmic scales did not improve the results, because most of the ordinal variables have only a few values which they can assume.[1] Crosstabulation served as a substitute for correlation analysis. The tables contain , as shown in Table A.c-1-I and Table A.c-1-II, the frequency, the row, column and total percentage and the category totals (absolute and in percent, at the left side and bottom of the

---

1. Ordinal scale itself is not hindering to execute regression, since non-parametric regression packages are available. However, there were no non-linear regression packages easily accessible.

table) of the joint appearances of attributes - environmental conditions in this case.

TABLE A.c-1-I
SAMPLE OF CROSS-TABULATION

PARKLD	COUNT / ROW PCT / COL PCT / TOT PCT	SURACC: AVERAGE 0.0	ABOVE AVERAGE 1.00	ROW TOTAL
NO PARKLAND	0.0	62	27	89
		69.7	30.3	69.5
		77.5	56.3	
		48.4	21.1	
PARKLAND	1.00	18	21	39
		46.2	53.8	30.5
		22.5	43.8	
		14.1	16.4	
	COLUMN TOTAL	80	48	128
		62.5	37.5	100.0

COUNT = Absolute Frequency

ROW PCT = Relative Row Frequency (Percentage)

COL PCT = Relative Column Frequency (Percentage)

TOT TCT = Relative Total Frequency (Percentage)

By inspection (without rigorous statistical test of significance), the interrelation between apartment growth and environmental factors and among the factors could be obtained. It was also tested how apartment development <u>over time</u> (i.e., the cumulative and incremental number of apartments in each year) was related to the initial environmental

C R O S S T A B U L A T I O N   A N A L Y S I S

TABLE A.c-1-II

CROSS-TABULATION FOR BUILDING AGE AND NEIGHBORHOOD QUALITY

SAMPLE MATRIX FOR THE VARIABLES...

BUILAG BUILDING AGE MIXTURE
NEIGHQ NEIGBORHOODQUALITY

BUILAG	COUNT / ROW PCT / COL PCT / TOT PCT	NEIGHQ: PRED NON RESID. 0.0	LOW QUALITY 1.00	AVERAGE QUALITY 2.00	HIGH QUALITY 3.00	ROW TOTAL
NONE BEF 1920	0.0	13	1	0	0	14
		92.9	7.1	0.0	0.0	11.0
		100.0	1.5	0.0	0.0	
		10.2	0.8	0.0	0.0	
0-10 % BEF 1920	1.00	0	1	0	2	3
		0.0	33.3	0.0	66.7	2.4
		0.0	1.5	0.0	9.1	
		0.0	0.8	0.0	1.6	
11-20 % BEF 1920	2.00	0	5	14	14	33
		0.0	15.2	42.4	42.4	26.0
		0.0	7.6	53.8	63.6	
		0.0	3.9	11.0	11.0	
21-30 % BEF 1920	3.00	0	7	1	1	9
		0.0	77.8	11.1	11.1	7.1
		0.0	10.6	3.8	4.5	
		0.0	5.5	0.8	0.8	
31-40 % BEF 1920	4.00	0	8	3	4	15
		0.0	53.3	20.0	26.7	11.8
		0.0	12.1	11.5	18.2	
		0.0	6.3	2.4	3.1	
51-60 % BEF 1920	6.00	0	2	8	0	10
		0.0	20.0	80.0	0.0	7.9
		0.0	3.0	30.8	0.0	
		0.0	1.6	6.3	0.0	
61-70 % BEF 1920	7.00	0	42	0	1	43
		0.0	97.7	0.0	2.3	33.9
		0.0	63.6	0.0	4.5	
		0.0	33.1	0.0	0.8	
	COLUMN TOTAL	13	66	26	22	127
		10.2	52.0	20.5	17.3	100.0

conditions.[1] However, a distinct trend over time could not be determined which would show exactly how the influence of the initial environmental conditions changes. However, it was not expected to obtain this result, for a simulation would not be necessary if patterns could be isolated that easily. The only significant relation could be detected among apartment growth itself, i.e., the pooling effect of apartment construction. Table A.c-1-III gives the correlation matrices which were calculated for the variable 'cumulative apartment growth'.

---

1. i.e., the number of apartments, the only variable for which time-series data are available, was treated as a dependent variable and related to the environmental conditions at time of the introduction of the transit lines.

TABLE A.c-1-III

C O R R E L A T I O N   M A T R I X

PEARSON CORRELATION MATRIX FOR THE VARIABLES:

CUMULATIVE NUMBER OF APARTMENTS BUILT ON TIME PERIOD......

POOLING EFFECT OF APARTMENT DEVELOPMENTS

S U B W A Y   L I N E   Y O N G E

	1959/1960	1961/1962	1963/1964	1965/1966	1967/1968	1969/1970
59/60	1.0000000	0.9774710	0.8946449	0.7357091	0.6135920	0.5550011
61/62	0.9774710	1.0000000	0.9565128	0.8357314	0.7297869	0.6712341
63/64	0.8946449	0.9565128	1.0000000	0.9503509	0.8777841	0.8349330
65/66	0.7357091	0.8357314	0.9503509	1.0000000	0.9819852	0.9583747
67/68	0.6135920	0.7297869	0.8777841	0.9819852	1.0000000	0.9897400
69/70	0.5550011	0.6712341	0.8349330	0.9583747	0.9897400	1.0000000

A L L   S U B W A Y   L I N E S

	1959/1960	1961/1962	1963/1964	1965/1966	1967/1968	1969/1970
59/60	1.0000000	0.9545683	0.7761039	0.6233986	0.4891046	0.4277512
61/62	0.9545683	1.0000000	0.8917429	0.7669098	0.6469781	0.5880917
63/64	0.7761039	0.8917429	1.0000000	0.9595280	0.9011655	0.8617829
65/66	0.6233986	0.7669098	0.9595280	1.0000000	0.9805204	0.9530225
67/68	0.4891046	0.6469781	0.9011655	0.9805204	1.0000000	0.9879882
69/70	0.4277512	0.5880917	0.8617829	0.9530225	0.9879882	1.0000000

appendix

A.c-2

(See Chapter 6.3)

STATISTICAL ANALYSIS;

LOGICAL TREE ANALYSIS

For the second set of statistical analysis, a number of 'logical trees' were constructed.[1] They were expected to reveal the pattern of environmental conditions and to contribute to the formulation of both weight and shape of the table functions. The logical trees in Figures A.c-2-1 and A.c-2-2 give for all stations which received growth over the period under consideration (1959-1970) the initial environmental conditions (at the time of the introduction of rapid transit). Similarly, Figures A.c-2-3 and A.c-2-4 show the logical trees constructed for stations which received no growth in order to test if the environmental factors also work on the 'negative' side, i.e., if they value the missing attractivity.

---

1. They were obtained through an alteration of the SPSS program "Breakdown".

The information from the tree can be obtained by 'reading' it horizontally and vertically. Horizontally, common appearance for several environmental characteristics for a certain number of stations is displayed. This is an indicator of the weight of an environmental factor. If all branches of the tree have either many or no encircled frequencies, the variables in the column headings have high weights because they discriminate well stations which receive growth from those which do not.

Vertically, the occurrence and frequencies of the values of each environmental variable can be inspected.[1] For a given breakpoint in the table function (i.e., attractivity score = 0.8), the number of stations which achieve ("pos") or do not achieve ("neg") the corresponding environmental value can be summed up. This procedure yields information on the shape of the table function.

---

1. In the beginning, trees were computed including the whole value range of each environmental variable. This resulted in huge, complicated trees which then were narrowed down.

The logical trees allow to determine the shape of the table functions and the weight of the environmental factors. They reveal the pattern of environmental conditions along the subway lines and how well specific environmental factors discriminate between stations which received apartment growth and stations which did not.

LOGICAL TREES

Abbreviations

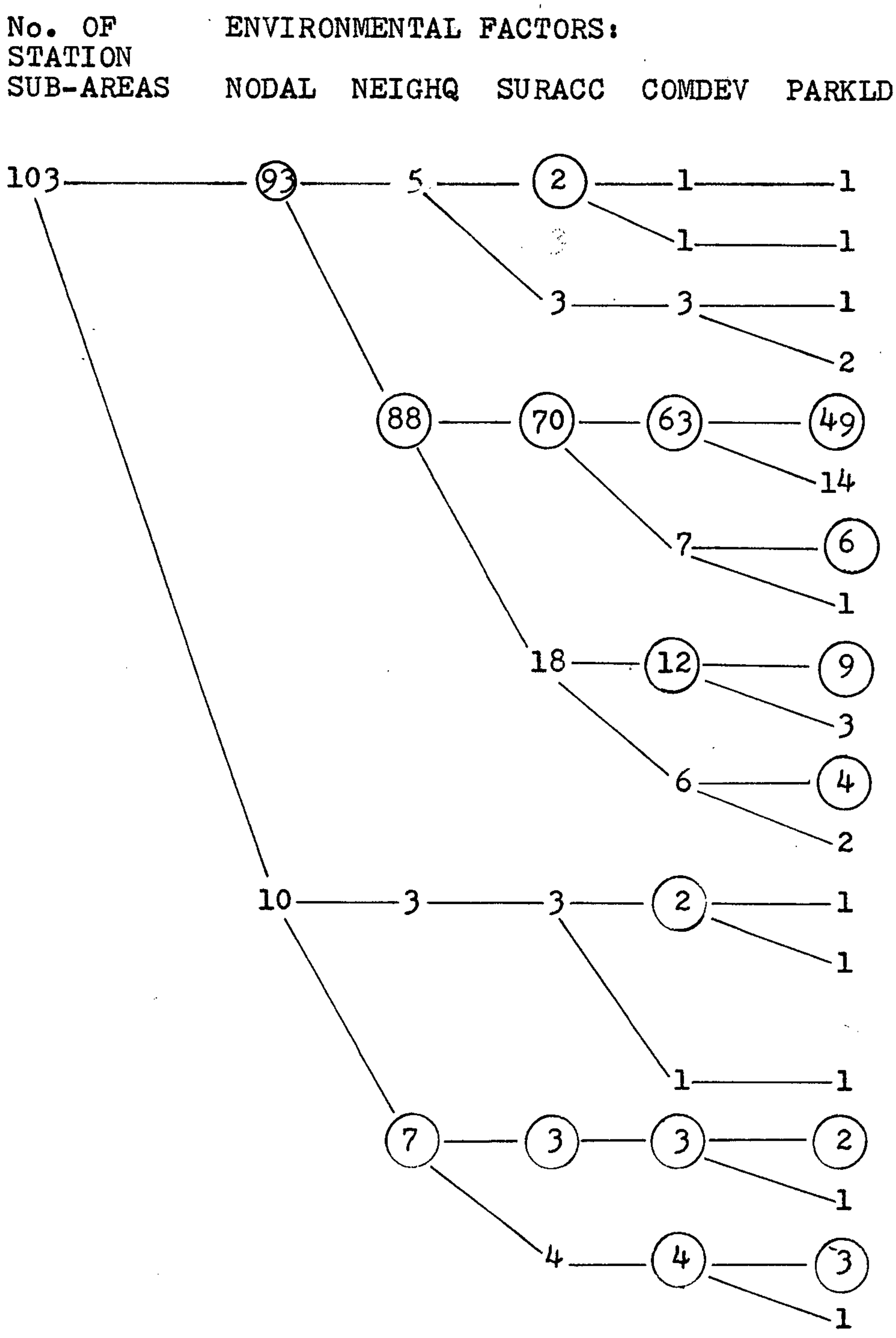
TOTAL	Number of station sub-areas included in logical tree analysis
NEG	Number of station sub-areas with attractivity scores less than .8 for the environmental factor in the respective column heading
POS	Number of station sub-areas with attractivity scores between .8 and 1 for the environmental factor in the respective column heading.

Environmental Factors:

ASTART	Pooling effect of apartment construction
BUILAG	Building age mixture
NEIGHQ	Neighborhood quality
LOTSIZ	Average lot size
PARKLD	Proximity to major open space
SURACC	Surface accessibility
NODAL	Measurement of nodality
ZON	Zoning
COMDEV	Commercial development
UNDCON	Undesirable conditions

FIGURE
A.c-2-1

LOGICAL TREE FOR STATION SUB-AREAS <u>WITHOUT</u> GROWTH

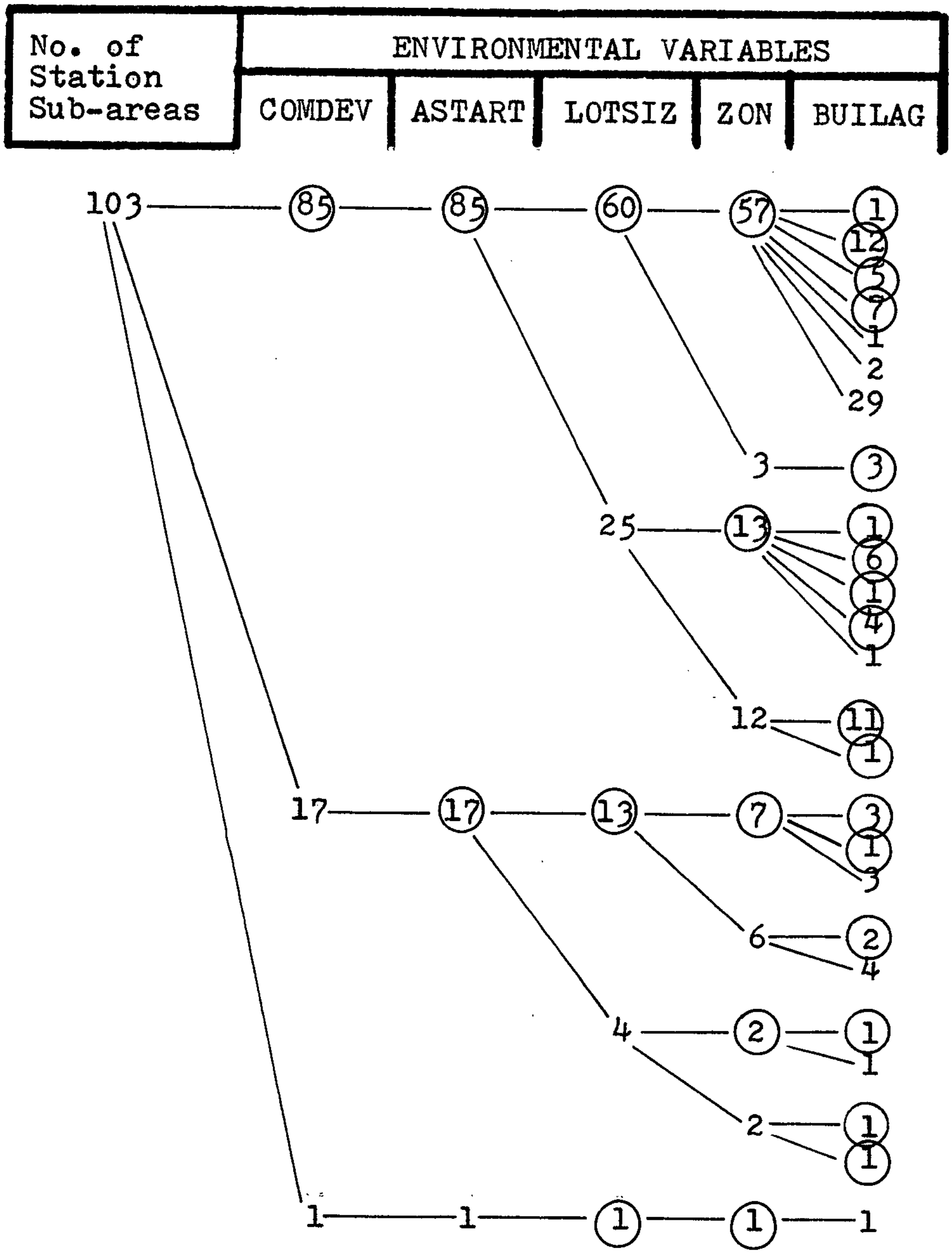


	NODAL	NEIGHQ	SURACC	COMDEV	PARKLD
NEG	93	95	75	85	77
POS	10	8	28	18	26
TOTAL	103	103	103	103	103

Station sub-areas which satisfy the criterion "NEG".

FIGURE
A.c-2-2

LOGICAL TREE,
STATION SUB-
AREAS WITHOUT
GROWTH

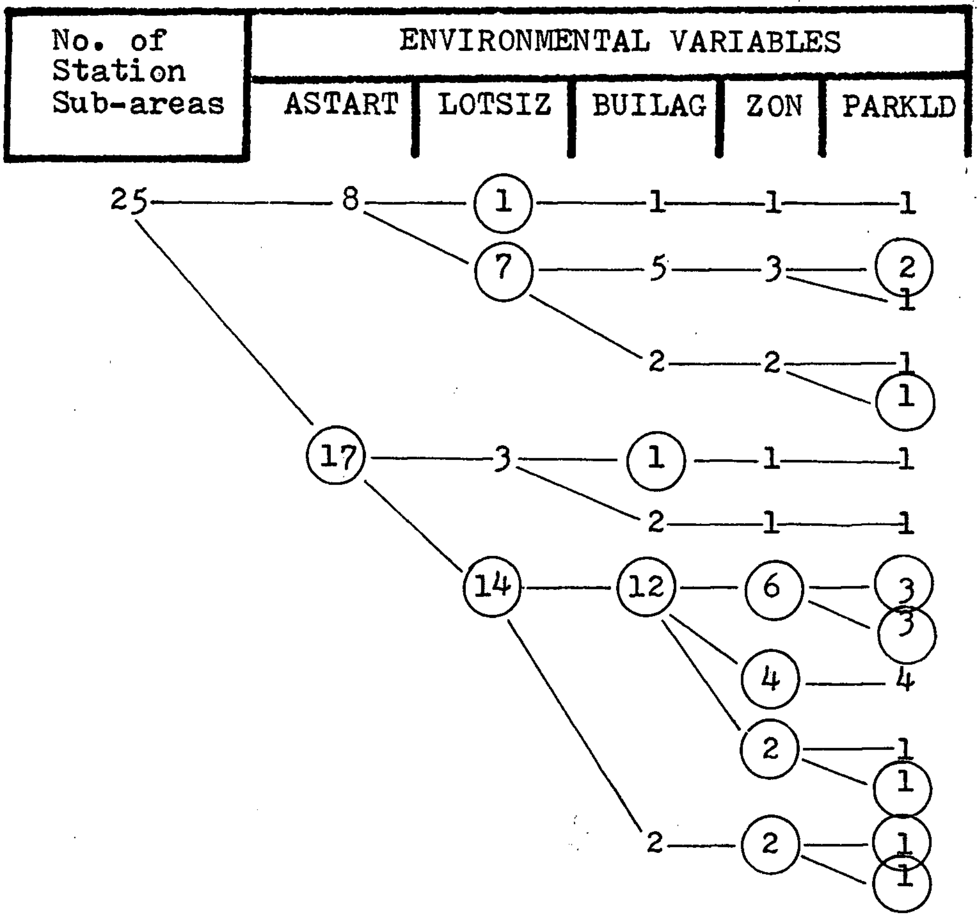


	COMDEV	ASTART	LOTSIZ	ZON	BUILAG
NEG	85	102	74	80	61
POS	18	1	29	23	42
TOTAL	103	103	103	103	103

○ Station sub-areas which satisfy the criterion of "NEG".

FIGURE A.c-2-3

LOGICAL TREE, STATION SUB-AREAS WITH GROWTH



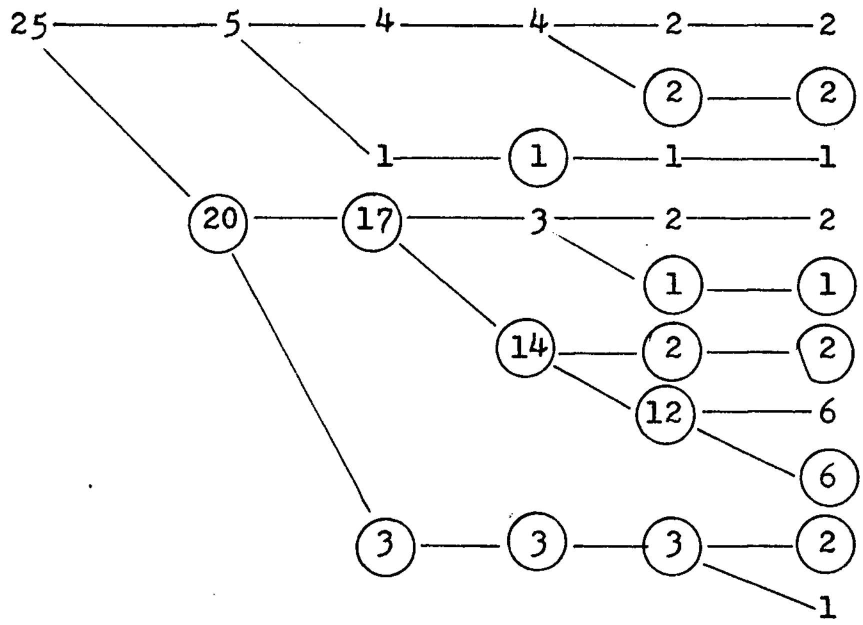
	ASTART	LOTSIZ	BUILAG	ZON	PARKLD
POS	17	21	19	21	13
NEG	8	4	6	4	12
TOTAL	25	25	25	25	25

○ Station sub-areas which satisfy the criterion of "POS".

FIGURE
A.c-2-4

LOGICAL TREE, STATION SUB-AREAS <u>WITH</u> GROWTH

No. of Station Sub-areas	ENVIRONMENTAL VARIABLES				
	SURACC	UNDCON	NODAL	NEIGHQ	PARKLD



POS	20	21	18	18	13
NEG	5	4	7	7	12
TOTAL	25	25	25	25	25

○ Station sub-areas which satisfy the criterion of "POS".

RESULTS OF LOGICAL TREE ANALYSIS

Tables A.c-2-I and A.c-2-II summarize the results of the logical tree analysis and gives the weight coefficients which are explained twice. The weight coefficients are slightly higher for the analysis of stations without apartment growth, which indicates that the environmental factors discriminate better for those stations than for the stations which received growth. In particular, the variables 'building age mixture' and 'proximity to major open space' perform relatively weak in the analysis; their weights are reduced accordingly.

The weight coefficients for individual variables indicate how good the chosen weight of a given environmental factor applies to all station sub-areas and if the factor discriminates for the stations which received growth as well as for the stations which did not receive apartment growth. The coefficients are computed as follows:

WEIGHT CO-EFFICIENTS FOR INDIVIDUAL VARIABLES

i. <u>For stations WITH apartment growth</u>:

$$\text{Weight Coefficient} = 1 - \frac{\text{NEG}}{\text{TOTAL}}$$

ii. <u>For stations WITHOUT apartment growth</u>:

$$\text{Weight Coefficient} = 1 - \frac{\text{POS}}{\text{TOTAL}}$$

NEG - Number of station sub-areas with attractivity scores less than .8 for the environmental factor in the respective column heading

POS - Number of station sub-areas with attractivity scores between .8 and 1 for the environmental factor in the respective column heading.

TOTAL-Number of stations which received growth (i) or which received no growth (kk).

The values of the weight coefficients can assume values between 0. and 1, one being the "best" value.

The overall coefficient indicates how good a given set of weights for a number of environmental factors will perform in the analysis. Any set of weights does apply with varying accuracy to the different station sub-areas. That makes it difficult to arrive at an optimal set of weights. The overall weight coefficient is computed as follows and assumes again values between 0. and 1.

OVERALL WEIGHT COEFFICIENTS

i. For stations WITH apartment growth:

$$\text{Overall Weight Coefficient} = 1 - \frac{\text{Sum of NEG for all Environmental Factors}}{\text{TOTAL times Number of Environmental Factors}}$$

ii. For stations WITHOUT apartment growth:

$$\text{Overall Weight Coefficient} = 1 - \frac{\text{Sum of POS for all Environmental Factors}}{\text{TOTAL times Number of Environmental Factors}}$$

TABLE
A.c-2-I

SUMMARY OF LOGICAL TREE ANALYSIS FOR STATIONS WITHOUT APARTMENT GROWTH

Number of Station sub-areas = 103

ENVIRONMENTAL FACTOR	FREQUENCIES NEG	POS	WEIGHT COEFFICIENT
Measurement of nodality	93	10	.90
Neighborhood quality	95	8	.92
Surface accessibility	75	28	.73
Commercial development	85	18	.83
Proximity to major open space	77	26	.75
Pooling effect of apartment growth	102	1	.99
Average lot size	74	29	.72
Zoning	80	23	.77
Building age mixture	61	42	.59
OVERALL WEIGHT COEFFICIENT			.80

TABLE A.c-2-II

SUMMARY OF LOGICAL TREE ANALYSIS FOR STATIONS WITH APARTMENT GROWTH

Number of Station sub-areas = 25

ENVIRONMENTAL FACTOR	FREQUENCIES POS	FREQUENCIES NEG	WEIGHT COEFFICIENT
Pooling effect of apartment growth	17	8	.68
Average lot size	21	4	.84
Building age mixture	19	6	.76
Zoning	21	4	.84
Proximity to major open space	13	12	.52
Surface accessibility	20	5	.80
Undesirable conditions	21	4	.84
Measurement of nodality	18	7	.72
Neighborhood quality	18	7	.72
OVERALL WEIGHT COEFFICIENT			.76

appendix

A.c-3

(See Chapter 6.3)

STATISTICAL ANALYSIS;

GUTTMAN TABLES AND GUTTMAN SCALES

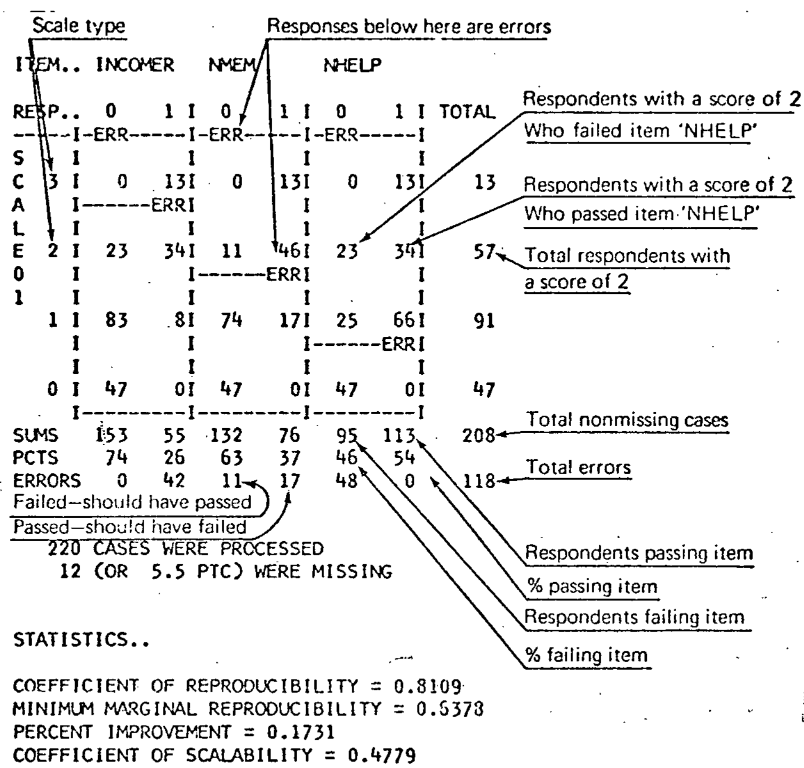
The Guttman table allows a ranking of variables which are all unidimensional in the same direction (e.g., increasing if they express favourable conditions) and cumulative - that is each variable contributes to the reduction of unexplained variance in an increasing order.[1] Both are satisfied in the present case. The results of the analysis give an indication of the weight of the variables and of the pattern of appearance (i.e., the table demonstrates for stations with (1) a high score of an environmental score with a high weight, and (2) which do have apartment growth, how many other attractivity scores are high too).[2]

1. That means that some variables are better indicators for a phenomenon than others and that they can be ranked. For details, see SPSS Subprogram Guttman Scale.
2. The cut-off point of the scale for each variable can be determined by the researcher. This allows again to test values in the table functions. The success of the manipulation of the cut-off points is measured by the coefficient of reproducibility - Table A.c-3-VII.

Figure A.c-3-1 explains how to interpret the Guttman table. Tables A.c-3-I to A.c-3-VI show the results of the analysis for the Yonge subway line and for the whole subway system.

FIGURE A.c-3-1

INTERPRETATION OF GUTTMAN TABLE



Source: SPSS Manual, p. 200.

TABLE A.c-3-I

GUTTMAN TABLE ALL SUBWAY LINES, ALL STATION SUB-AREAS (128)

```
SUBFILE   YONGE      WBLOOR      NWBLOOR     EBLOOR      NEEBLOOR

* * * * * * * * * *   G U T T M A N   S C A L E   ( T O T A L        )   U S I N G   * * * * * * * * * *
SURACC      SURFACE ACCESSIBILITY,                       DIVISION POINT =      1.00
UNDCON      UNDESIRABLE CONDITIONS                       DIVISION POINT =      1.00
NODAL       MEASUREMENT OF NODALITY                      DIVISION POINT =      4.00
NEIGHQ      NEIGHBORHOOD QUALITY                         DIVISION POINT =      2.00
C1970       CUMULATIVE APARTMENTGROWTH UP TO 1970        DIVISION POINT =      1.00
ASTART      NO OF APT AT TIME OF SIM START               DIVISION POINT =      1.00
LOTSIZ      AVARAGE LOT SIZE                             DIVISION POINT =      3.00
BUILAG      BUILDING AGE MIXTURE                         DIVISION POINT =      1.00
ZON         ZONING                                       DIVISION POINT =      2.00
* * * * * * * * * * * *   RESP = 1 FOR VALUES EQUAL TO DIVISION POINT AND ABOVE   * * * * * * * * * * * *
```

ITEM..	C1970		NEIGHQ		ASTART		NODAL		SURACC		LOTSIZ		ZON		UNDCON		BUILAG		
RESP.. (TOTAL)	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	TOTAL
9	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	10
8	0	5	0	5	2	3	1	4	0	5	0	5	0	5	2	3	0	5	5
7	3	5	2	6	1	7	3	5	2	6	4	4	0	8	1	7	0	8	8
6	4	3	6	1	3	4	2	5	1	6	1	6	4	3	0	7	0	7	7
5	12	1	11	2	9	4	4	9	4	9	7	6	5	8	0	13	0	13	13
4	28	1	27	2	20	9	19	10	18	11	19	10	11	18	3	26	0	29	29
3	40	0	40	0	40	0	39	1	39	1	32	8	9	31	1	39	0	40	40
2	15	0	15	0	15	0	15	0	15	0	14	1	6	9	10	5	0	15	15
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUMS	103	25	102	26	91	37	84	44	80	48	78	50	36	92	18	110	0	128	128
PCTS	80	20	80	20	71	29	66	34	63	38	61	39	28	72	14	86	0	100	
ERRORS	0	15	0	11	3	17	6	20	7	12	31	9	29	9	17	0	0	0	186

TABLE A.c-3-II

GUTTMAN TABLE ALL SUBWAY LINES, STATION SUB-AREAS WHICH RECEIVED GROWTH (25) BETWEEN 1959-1970

```
SUBFILE   YONGE      WBLOOR      NWBLOOR     EBLOOR      NEEBLOOR

* * * * * * * * * *   G U T T M A N   S C A L E   ( Y E S            )   U S I N G   * * * * * * * * * *
SURACC      SURFACE ACCESSIBILITY,                       DIVISION POINT =      1.00
UNDCON      UNDESIRABLE CONDITIONS                       DIVISION POINT =      1.00
NODAL       MEASUREMENT OF NODALITY                      DIVISION POINT =      3.00
NEIGHQ      NEIGHBORHOOD QUALITY                         DIVISION POINT =      2.00
C1970       CUMULATIVE APARTMENTGROWTH UP TO 1970        DIVISION POINT =      1.00
ASTART      NO OF APT AT TIME OF SIM START               DIVISION POINT =      1.00
LOTSIZ      AVARAGE LOT SIZE                             DIVISION POINT =      2.00
BUILAG      BUILDING AGE MIXTURE                         DIVISION POINT =      1.00
ZON         ZONING                                       DIVISION POINT =      2.00
* * * * * * * * * * * *   RESP = 1 FOR VALUES EQUAL TO DIVISION POINT AND ABOVE   * * * * * * * * * * * *
```

ITEM..	NODAL		NEIGHQ		SURACC		UNDCON		ASTART		LOTSIZ		ZON		C1970		BUILAG		
RESP.. (YES)	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	TOTAL
9	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	10
8	1	6	1	6	0	7	3	4	2	5	0	7	0	7	0	7	0	7	7
7	3	0	1	2	2	1	0	3	0	3	0	3	0	3	0	3	0	3	3
6	2	1	3	0	1	2	0	3	1	2	1	2	1	2	0	3	0	3	3
5	1	0	1	0	1	0	0	1	0	1	1	0	0	1	0	1	0	1	1
4	0	1	1	0	1	0	1	0	1	0	0	1	1	0	0	1	0	1	1
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUMS	7	18	7	18	5	20	4	21	4	21	2	23	2	23	0	25	0	25	25
PCTS	28	72	28	72	20	80	16	84	16	84	8	92	8	92	0	100	0	100	
ERRORS	0	8	1	2	2	2	3	1	3	0	2	0	2	0	0	0	0	0	26

TABLE A.c-3-III

GUTTMAN TABLE ALL SUBWAY LINES, STATION SUB-AREAS WHICH DID NOT RECEIVE GROWTH (103) BETWEEN 1959-1970

```
SUBFILE   YONGE       WBLOOR  ,  NWBLOOR    EBLOOR      NEBBLOOR

* * * * * * * * * *   G U T T M A N   S C A L E   ( N E G A T I V E )   U S I N G   * * * * * * * * * *
C1970                                                    DIVISION POINT =      1.00
ASTART     NO OF APT AT TIME OF SIM START                DIVISION POINT =      1.00
ZON        ZONING                                        DIVISION POINT =      2.00
NEIGHQ     NEIGHBORHOOD QUALITY                          DIVISION POINT =      2.00
NODAL      MEASUREMENT OF NODALITY                       DIVISION POINT =      3.00
SURACC     SURFACE ACCESSIBILITY,                        DIVISION POINT =      1.00
COMDEV     COMMERCIAL DEVELOPMENT                        DIVISION POINT =      1.00
LOTSIZ     AVARAGE LOT SIZE                              DIVISION POINT =      2.00
* * * * * * * * * * * *   RESP = 1 FOR VALUES EQUAL TO DIVISION POINT AND ABOVE   * * * * * * * * * * *

ITEM..  LOTSIZ     SURACC     ASTART     ZON        COMDEV     NEIGHQ     C1970      NODAL

RESP..    0    1I    0    1I    0    1I    0    1I    0    1I    0    1I    0    1I    0    1I TOTAL
-----I-ERR------I-ERR------I-ERR------I-ERR------I-ERR------I-ERR------I-ERR------I-ERR------I
N    I          I          I          I          I          I          I          I          I
E  8 I    0   28I    0   28I    0   28I    0   28I    0   28I    0   28I    0   28I    0   28I    28
G    I-------ERRI          I          I          I          I          I          I          I
A    I          I          I          I          I          I          I          I          I
T  7 I   16   13I    1   26I    3   26I    1   28I    3   26I    0   29I    0   29I    3   26I    29
I    I          I-------ERRI          I          I          I          I          I          I
V    I          I          I          I          I          I          I          I          I
E  6 I   18   10I    8   20I    9   19I   13   15I    6   22I    1   27I    0   28I    1   27I    28
     I          I          I-------ERRI          I          I          I          I          I
     I          I          I          I          I          I          I          I          I
   5 I    9    2I    9    2I    2    9I    4    7I    4    7I    2    9I    1   10I    2    9I    11
     I          I          I          I-------ERRI          I          I          I          I
     I          I          I          I          I          I          I          I          I
   4 I    6    1I    5    2I    3    4I    3    4I    2    5I    2    5I    3    4I    4    3I     7
     I          I          I          I          I-------ERRI          I          I          I
     I          I          I          I          I          I          I          I          I
   3 I   11    1I   10    2I    7    5I    7    5I    4    8I    8    4I   10    2I    3    9I    12
     I          I          I          I          I          I-------ERRI          I          I
     I          I          I          I          I          I          I          I          I
   2 I    8    0I    8    0I    8    0I    4    4I    4    4I    8    0I    6    2I    2    6I     8
     I          I          I          I          I          I          I-------ERRI          I
     I          I          I          I          I          I          I          I          I
   1 I    5    0I    5    0I    5    0I    0    5I    5    0I    5    0I    5    0I    5    0I     5
     I          I          I          I          I          I          I          I-------ERRI
     I          I          I          I          I          I          I          I          I
   0 I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I     0
     I----------I----------I----------I----------I----------I----------I----------I----------I
SUMS     73   55    48   80    37   91    32   96    28  100    26  102    25  103    20  108     128
PCTS     57   43    38   63    29   71    25   75    22   78    20   80    20   80    16   84
ERRORS    0   27     1   26    12   18    18   18    15   12    13    0    20    0    20    0     202

   128 CASES WERE PROCESSED
     0 (OR  0.0 PCT) WERE MISSING
```

TABLE A.c-3-IV

GUTTMAN TABLE SUBWAY LINE YONGE, ALL STATION SUB-AREAS (20)

```
SUBFILE   YONGE

* * * * * * * * * *   G U T T M A N   S C A L E   ( T O T A L       )   U S I N G   * * * * * * * * * *
SURACC     SURFACE ACCESSIBILITY,                        DIVISION POINT =      1.00
UNDCON     UNDESIRABLE CONDITIONS                        DIVISION POINT =      1.00
NODAL      MEASUREMENT OF NODALITY                       DIVISION POINT =      4.00
NEIGHQ     NEIGHBORHOOD QUALITY                          DIVISION POINT =      2.00
C1970      CUMULATIVE APARTMENTGROWTH UP TO 1970         DIVISION POINT =      1.00
ASTART     NO OF APT AT TIME OF SIM START                DIVISION POINT =      1.00
LOTSIZ     AVARAGE LOT SIZE                              DIVISION POINT =      3.00
BUILAG     BUILDING AGE MIXTURE                          DIVISION POINT =      1.00
ZON        ZONING                                        DIVISION POINT =      2.00
* * * * * * * * * * * *   RESP = 1 FOR VALUES EQUAL TO DIVISION POINT AND ABOVE   * * * * * * * * * * *

ITEM..  NEIGHQ     C1970      ASTART     SURACC     NODAL      LOTSIZ     UNDCON     ZON        BUILAG

RESP..    0    1I    0    1I    0    1I    0    1I    0    1I    0    1I    0    1I    0    1I    0    1I TOTAL
-----I-ERR------I-ERR------I-ERR------I-ERR------I-ERR------I-ERR------I-ERR------I-ERR------I-ERR------I
T    I          I          I          I          I          I          I          I          I          I
O  9 I    0    6I    0    6I    0    6I    0    6I    0    6I    0    6I    0    6I    0    6I    0    6I     6
T    I-------ERRI          I          I          I          I          I          I          I          I
A    I          I          I          I          I          I          I          I          I          I
L  8 I    0    1I    0    1I    0    1I    0    1I    0    1I    0    1I    1    0I    0    1I    0    1I     1
     I          I-------ERRI          I          I          I          I          I          I          I
     I          I          I          I          I          I          I          I          I          I
   7 I    1    1I    1    1I    0    2I    0    2I    0    2I    2    0I    0    2I    0    2I    0    2I     2
     I          I          I-------ERRI          I          I          I          I          I          I
     I          I          I          I          I          I          I          I          I          I
   6 I    2    0I    2    0I    0    2I    0    2I    0    2I    0    2I    0    2I    2    0I    0    2I     2
     I          I          I          I-------ERRI          I          I          I          I          I
     I          I          I          I          I          I          I          I          I          I
   5 I    1    0I    1    0I    1    0I    0    1I    0    1I    1    0I    0    1I    0    1I    0    1I     1
     I          I          I          I          I-------ERRI          I          I          I          I
     I          I          I          I          I          I          I          I          I          I
   4 I    2    0I    2    0I    2    0I    2    0I    2    0I    0    2I    0    2I    0    2I    0    2I     2
     I          I          I          I          I          I-------ERRI          I          I          I
     I          I          I          I          I          I          I          I          I          I
   3 I    3    0I    3    0I    3    0I    3    0I    3    0I    3    0I    0    3I    0    3I    0    3I     3
     I          I          I          I          I          I          I-------ERRI          I          I
     I          I          I          I          I          I          I          I          I          I
   2 I    3    0I    3    0I    3    0I    3    0I    3    0I    2    1I    3    0I    1    2I    0    3I     3
     I          I          I          I          I          I          I          I-------ERRI          I
     I          I          I          I          I          I          I          I          I          I
   1 I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I     0
     I          I          I          I          I          I          I          I          I-------ERRI
     I          I          I          I          I          I          I          I          I          I
   0 I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I    0    0I     0
     I----------I----------I----------I----------I----------I----------I----------I----------I----------I
SUMS     12    8    12    8     9   11     8   12     8   12     8   12     4   16     3   17     0   20      20
PCTS     60   40    60   40    45   55    40   60    40   60    40   60    20   80    15   85     0  100
ERRORS    0    2     0    1     0    2     0    1     0    0     3    1     1    0     3    0     0    0      14
```

SUBFILE YONGE

* * * * * * * * * * GUTTMAN SCALE (YES) USING * * * * * * * * * *

Item	Description		
SURACC	SURFACE ACCESSIBILITY,	DIVISION POINT =	1.00
UNDCON	UNDESIRABLE CONDITIONS	DIVISION POINT =	1.00
NODAL	MEASUREMENT OF NODALITY	DIVISION POINT =	3.00
NEIGHQ	NEIGHBORHOOD QUALITY	DIVISION POINT =	2.00
C1970	CUMULATIVE APARTMENTGROWTH UP TO 1970	DIVISION POINT =	1.00
ASTART	NO OF APT AT TIME OF SIM START	DIVISION POINT =	1.00
LOTSIZ	AVARAGE LOT SIZE	DIVISION POINT =	2.00
BUILAG	BUILDING AGE MIXTURE	DIVISION POINT =	1.00
ZON	ZONING	DIVISION POINT =	2.00

* * * * * * * * * * * RESP = 1 FOR VALUES EQUAL TO DIVISION POINT AND ABOVE * * * * * * * * * * *

ITEM..	UNDCON		NEIGHQ		SURACC		NODAL		C1970		ASTART		LOTSIZ		BUILAG		ZON		
RESP..	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	TOTAL
YES 9	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	6
8	1	1	1	1	0	2	0	2	0	2	0	2	0	2	0	2	0	2	2
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUMS	1	7	1	7	0	8	0	8	0	8	0	8	0	8	0	8	0	8	8
PCTS	13	88	13	88	0	100	0	100	0	100	0	100	0	100	0	100	0	100	
ERRORS	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2

TABLE A.c-3-V

GUTTMAN TABLE SUBWAY LINE YONGE, STATION SUB-AREAS WHICH RECEIVED GROWTH (8) BETWEEN 1959-1970

SUBFILE YONGE

* * * * * * * * * * GUTTMAN SCALE (NEGATIV) USING * * * * * * * * * *

Item	Description		
C1970		DIVISION POINT =	1.00
ASTART	NO OF APT AT TIME OF SIM START	DIVISION POINT =	1.00
ZON	ZONING	DIVISION POINT =	2.00
NEIGHQ	NEIGHBORHOOD QUALITY	DIVISION POINT =	2.00
NODAL	MEASUREMENT OF NODALITY	DIVISION POINT =	3.00
SURACC	SURFACE ACCESSIBILITY,	DIVISION POINT =	1.00
COMDEV	COMMERCIAL DEVELOPMENT	DIVISION POINT =	1.00
LOTSIZ	AVARAGE LOT SIZE	DIVISION POINT =	2.00

* * * * * * * * * * * RESP = 1 FOR VALUES EQUAL TO DIVISION POINT AND ABOVE * * * * * * * * * * *

ITEM..	LOTSIZ		SURACC		ASTART		C1970		NEIGHQ		NODAL		COMDEV		ZON		
RESP..	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	TOTAL
NEGATIV 8	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	2
7	2	2	1	3	0	4	0	4	0	4	0	4	0	4	1	3	4
6	1	2	0	3	0	3	0	3	0	3	0	3	2	1	3	0	3
5	1	0	1	0	1	0	0	1	0	1	0	1	0	1	0	1	1
4	1	1	2	0	2	0	1	1	0	2	2	0	0	2	0	2	2
3	1	0	1	0	1	0	1	0	1	0	0	1	0	1	0	1	1
2	2	0	2	0	2	0	1	1	2	0	1	1	1	1	1	1	2
1	5	0	5	0	5	0	5	0	5	0	5	0	5	0	0	5	5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUMS	13	7	12	8	11	9	8	12	8	12	8	12	8	12	5	15	20
PCTS	65	35	60	40	55	45	40	60	40	60	40	60	40	60	25	75	
ERRORS	0	5	1	3	0	0	0	2	0	0	2	1	3	0	5	0	22

20 CASES WERE PROCESSED
0 (OR 0.0 PCT) WERE MISSING

TABLE A.c-3-VI

GUTTMAN TABLE SUBWAY LINE YONGE, STATION SUB-AREAS WHICH DID NOT RECEIVE GROWTH (20) BETWEEN 1959-1970

COEFFICIENTS OF GUTTMAN ANALYSIS

Table A.c-3-VII summarizes the coefficients which measure the quality of the Guttman analysis. The <u>coefficient of reproducibility</u> is calculated from the number of errors and should lie in the order of .9 for a good result. The <u>coefficient of scalability</u> indicates if the hierarchy of the variables is clear (cumulative entity discussed above). Values around .6 are considered good. Low values of this coefficient combined with low values of <u>percent improvement coefficient</u> indicate that there is high correlation among variables (which reduces, of course, the scalability). For all cases in the table, this correlation is relatively high except for the Yonge line. This corridor shows for all stations and for the stations which received no growth a hierarchical pattern of environmental factors.

GUTTMAN SCALE

Based on the Guttman analysis, for each Guttman table a new variable was constructed which substitutes or summarizes all the environmental factors. The frequency distribution of these scale values are shown in Table A.c-3-VIII (1-3). In Table 1, 23 station sub-areas have a scale value higher than 7 (there are 25 station sub-areas which actually received growth).[1] This indicates that the environmental factors are likely to explain apartment growth well.

TABLE A.c-3-VII

COEFFICIENTS OF GUTTMAN ANALYSIS

		All Stations	Stations with Growth	Stations* without Growth
All Subway Lines	A	.84	.88	.81
	B	.1	.02	.1
	C	.35	.16	.26
Subway Line Yonge	A	.92	.97	.86
	B	.23	.00	.25
	C	.75	.00	.64

* For this case, the environmental values were reversed in order to obtain a cumulative, unidimensional scale.

A Coefficient of Reproducibility

B Percent Improvement

C Coefficient of Scalability

1. Table 3, which is the complement to Table 1 with the reversed environmental values, shows 25 station sub-areas with scores of less than 4, as was to be expected.

TABLE
A.c-3-VIII

G U T T M A N   S C A L E A N A L Y S I S

COMPARISON OF THE ENVIRONMENTAL CARACTERISTICS
OF THE STATIONS WHICH HAD APARTMENT DEVELOPMENTS
IN THE TIME PERIOD 1959-1970 WITH THOSE OF THE
STATIONS WHICH HAD NO GROWTH

TABLE 1   GUTTMAN SCALE VALUES FOR ALL STATIONS
****

SCALE VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
1	1	0.8	0.8
2	15	11.7	12.5
3	40	31.3	43.8
4	29	22.7	66.4
5	13	10.2	76.6
6	7	5.5	82.0
7	8	6.2	88.3
8	5	3.9	92.2
9	10	7.8	100.0
TOTAL	128	100.0	100.0

VALID OBSERVATIONS   128

TABEL 2   GUTTMAN SCALE VALUES FOR THE STATIONS
*******   WHICH HAD APARTMENT DEVELOPMENTS

SCALE VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
4	1	4.0	4.0
5	1	4.0	8.0
6	3	12.0	20.0
7	5	20.0	40.0
8	5	20.0	60.0
9	10	40.0	100.0
TOTAL	25	100.0	100.0

VALID OBSERVATIONS   25

G U T T M A N   S C A L E   A N A L Y S I S

CONTINUED

'NEGATIVE' ENVIRONMENTAL SCORES

'NEGATIVE' ENVIRONMENTAL SCORES ARE THE COMPLIMENTS TO THE 'NORMAL' ONES. THEY INDICATE STATIONS WHICH ARE NOT FAVORABLE TO APARTMENT DEVELOPMENT. THEIR SCALE VALUES SHOULD THEREFORE BE H I G H IF A STATION IS N O T SUITABLE FOR APARTMENT DEVELOPMENT.

TABLE 3   GUTTMAN SCALE VALUES FOR
********   NEGATIVE ENVIRONMENTAL SCORES

SCALE VALUE	ABSOLUTE FREQUENCY	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
1	5	3.9	3.9
2	8	6.2	10.2
3	12	9.4	19.5
4	7	5.5	25.0
5	11	8.6	33.6
6	28	21.9	55.5
7	29	22.7	78.1
8	28	21.9	100.0
TOTAL	128	100.0	100.0

VALID OBSERVATIONS - 128

simulation

A.d

appendix

A.d-1

(See Chapter 7.2)

CONTROL MEASUREMENT FOR MOVING AVERAGES

The moving averages 2, 3 and 5 should be inter-correlated among themselves. However, there could be a possibility that the moving average 5 (or even 3) could be biased, if in many cases for example the first, second and third time period of the moving average have apartment growth, but the fourth and fifth not. Some of the corresponding moving averages of the lower-order could then be zero (and not greater than zero as the higher-order moving average). To check the validity of the moving averages, they were correlated among themselves. The resulting correlation coefficients are quite high, as shown in Table A.d-1-1.

TABLE A.d-1-1

INTER-CORRELATION AMONG MOVING AVERAGES

TIME PERIOD	CORRELATION BETWEEN		CORR. COEFF.	SIG. LEVEL	No. of CASES
	S22	S32	.01	.002	7
2	S22	S52	.89	.004	7
	S32	S52	.95	.001	7
	S23	S33	1.	.001	5
3	S23	S53	.92	.013	5
	S33	S53	.95	.001	7
	S24	S34	NA*	-	3
4	S24	S54	NA*	-	3
	S34	S54	.91	.016	5
	S25	S35	.85	.001	10
5	S25	S55	.77	.021	7
	S35	S55	.99	.001	7

* NA - Not applicable because number of cases is too small.

appendix

A-d-2

(See Chapter 7.2)

MODEL CALIBRATION; HISTOGRAMS

- The Histograms compare actual and simulated growth for <u>each time period</u> and for <u>each line</u>.
- The apartment growth is given in dwelling units and as a percentage of the total apartment growth of a line for each station sub-area.
- The number of stations and station sub-areas and the total apartment growth for the given time period are shown at the bottom of the histograms.

```
S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1959/1960          TIME PERIOD   1
                                                          NO OF APARTMENTS
STATION                                                        ABSOLUT  %
           0 %        10 %        20 %        30 %        40 %       50

EGLIN NW                                                             0  0
GTON  NE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                  273 40
      SW                                                             0  0
      SE                                                             0  0
DAVIS NW                                                             0  0
VILLE NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
ST.   NW XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                            208 30
CLAIR NE                                                             0  0
      SW                                                             0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             197 29
SUMME NW                                                             0  0
RHILL NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
ROSE  NW                                                             0  0
DALE  NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
                                                              TOTAL  678100
IN TIME PERIOD   1  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
 678  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD    1
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```
E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1959/1960          TIME PERIOD   1
                                                          NO OF APARTMENTS
STATION                                                        ABSOLUT  %
           0 %        10 %        20 %        30 %        40 %       50

EGLIN NW                                                             0  0
GTON  NE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                    210 38
      SW                                                             0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXX                              155 28
DAVIS NW                                                             0  0
VILLE NE                                                             0  0
      SW XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         180 33
      SE                                                             0  0
ST.   NW                                                             0  0
CLAIR NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
SUMME NW                                                             0  0
RHILL NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
ROSE  NW                                                             0  0
DALE  NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
                                                              TOTAL  545100
IN TIME PERIOD   1  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
 545  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD    1
```

```
S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1961/1962          TIME PERIOD   2
                                                          NO OF APARTMENTS
STATION                                                        ABSOLUT  %
           0 %        5 %        10 %        15 %        20 %       25

EGLIN NW                                                             0  0
GTON  NE XXXXXXXXXXXXXXXXXXXXXXXXXX                                159 13
      SW                                                             0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXX                                154 12
DAVIS NW                                                             0  0
VILLE NE                                                             0  0
      SW XXXXXXXXXXXXXXXXXXXXXXXXXX                                156 12
      SE XXXXXXXXXXXXXXXXXXXXXXXXXX                                155 12
ST.   NW XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX             268 22
CLAIR NE XXXXXXXXXXXXXXXXXXXXXXXXXX                                154 12
      SW                                                             0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXX                                157 13
SUMME NW                                                             0  0
RHILL NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
ROSE  NW                                                             0  0
DALE  NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
                                                              TOTAL  1203100
IN TIME PERIOD   2  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
 1203  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD    2
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```
E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1961/1962          TIME PERIOD   2
                                                          NO OF APARTMENTS
STATION                                                        ABSOLUT  %
           0 %        5 %        10 %        15 %        20 %       25

EGLIN NW                                                             0  0
GTON  NE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX              255 22
      SW                                                             0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXX                               159 14
DAVIS NW                                                             0  0
VILLE NE                                                             0  0
      SW XXXXXXXXXXXXXXXXXXXXXXXXXX                                153 13
      SE XXXXXXXXXXXXXXXXXXXX                                      120 10
ST.   NW XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                    215 19
CLAIR NE                                                             0  0
      SW                                                            -0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                    222 19
SUMME NW                                                             0  0
RHILL NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
ROSE  NW                                                             0  0
DALE  NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
                                                              TOTAL  1124100
IN TIME PERIOD   2  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
 1124  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD    2
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S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1963/1964          TIME PERIOD   3
                                                          NO OF APARTMENTS
STATION                                                        ABSOLUT  %
           0 %        10 %        20 %        30 %        40 %       50

EGLIN NW                                                             0  0
GTON  NE XXXXXXXXXXXXXXXXXXXXXXXXXX                                399 26
      SW                                                             0  0
      SE                                                             0  0
DAVIS NW                                                             0  0
VILLE NE                                                             0  0
      SW XXXXXXXXXXXXXXXXXXX                                       281 19
      SE XXXXXXXXXXXXX                                             198 13
ST.   NW                                                             0  0
CLAIR NE XXXXXXXXXX                                                158 10
      SW                                                             0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             425 29
SUMME NW                                                             0  0
RHILL NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
ROSE  NW                                                             0  0
DALE  NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
                                                              TOTAL  1451100
IN TIME PERIOD   3  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
 1451  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD    3
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E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1963/1964          TIME PERIOD   3
                                                          NO OF APARTMENTS
STATION                                                        ABSOLUT  %
           0 %        10 %        20 %        30 %        40 %       50

EGLIN NW                                                             0  0
GTON  NE XXXXXXXXXXXXXXXXXXXXXXX                                   310 23
      SW                                                             0  0
      SE                                                             0  0
DAVIS NW                                                             0  0
VILLE NE                                                             0  0
      SW                                                             0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             400 29
ST.   NW XXXXXXXXXXXXXXX                                           212 15
CLAIR NE                                                             0  0
      SW                                                             0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                           416 31
SUMME NW                                                             0  0
RHILL NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
ROSE  NW                                                             0  0
DALE  NE                                                             0  0
      SW                                                             0  0
      SE                                                             0  0
                                                              TOTAL  1338100
IN TIME PERIOD   3  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
 1338  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD    3
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S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1965/1966          TIME PERIOD   4
                                                                  NO OF APARTMENTS
STATION                                                             ABSOLUT  %
         0 %      10 %      20 %      30 %      40 %      50

EGLIN NW                                                                 0  0
GTON  NE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                 950 45
      SW                                                                 0  0
      SE                                                                 0  0
DAVIS NW                                                                 0  0
VILLE NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXX                                                      183  8
ST.   NW                                                                 0  0
CLAIR NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                 951 45
SUMME NW                                                                 0  0
RHILL NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
ROSE  NW                                                                 0  0
DALE  NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
                                                              TOTAL  2084100

IN TIME PERIOD   4  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
2084  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   4
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E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1965/1966          TIME PERIOD   4
                                                                  NO OF APARTMENTS
STATION                                                             ABSOLUT  %
         0 %      10 %      20 %      30 %      40 %      50

EGLIN NW                                                                 0  0
GTON  NE XXXXXXXXXXXXXXXXX                                             343 17
      SW                                                                 0  0
      SE XXXXXXXXXXXXXX                                                288 14
DAVIS NW                                                                 0  0
VILLE NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                 580 29
ST.   NW                                                                 0  0
CLAIR NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                       784 39
SUMME NW                                                                 0  0
RHILL NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
ROSE  NW                                                                 0  0
DALE  NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
                                                              TOTAL  1995100

IN TIME PERIOD   4  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
1995  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   4
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S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1967/1968          TIME PERIOD   5
                                                                  NO OF APARTMENTS
STATION                                                             ABSOLUT  %
         0 %      10 %      20 %      30 %      40 %      50

EGLIN NW                                                                 0  0
GTON  NE XXXXXXXXXXXXXXXXXXXXXXXXX                                     637 25
      SW                                                                 0  0
      SE                                                                 0  0
DAVIS NW                                                                 0  0
VILLE NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                  1077 43
ST.   NW                                                                 0  0
CLAIR NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                763 30
SUMME NW                                                                 0  0
RHILL NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
ROSE  NW                                                                 0  0
DALE  NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
                                                              TOTAL  2477100

IN TIME PERIOD   5  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
2477  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   5
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E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1967/1968          TIME PERIOD   5
                                                                  NO OF APARTMENTS
STATION                                                             ABSOLUT  %
         0 %      10 %      20 %      30 %      40 %      50

EGLIN NW XXXXXXX                                                       168  7
GTON  NE XXXXXXXXXXX                                                   251 11
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXX                                              369 16
DAVIS NW                                                                 0  0
VILLE NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                 645 29
ST.   NW                                                                 0  0
CLAIR NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                            748 34
SUMME NW                                                                 0  0
RHILL NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
ROSE  NW                                                                 0  0
DALE  NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
                                                              TOTAL  2181100

IN TIME PERIOD   5  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
2181  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   5
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S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1969/1970          TIME PERIOD   6
                                                                  NO OF APARTMENTS
STATION                                                             ABSOLUT  %
         0 %      10 %      20 %      30 %      40 %      50

EGLIN NW XXXXXXXXXXX                                                   244 11
GTON  NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXXXXXX                                                  266 12
DAVIS NW XXXXXXXXXXX                                                   246 11
VILLE NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                          780 36
ST.   NW                                                                 0  0
CLAIR NE XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                  626 28
      SW                                                                 0  0
      SE                                                                 0  0
SUMME NW                                                                 0  0
RHILL NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
ROSE  NW                                                                 0  0
DALE  NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
                                                              TOTAL  2162100

IN TIME PERIOD   6  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
2162  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   6
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E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  Y O N G E
YEAR  1969/1970          TIME PERIOD   6
                                                                  NO OF APARTMENTS
STATION                                                             ABSOLUT  %
         0 %      10 %      20 %      30 %      40 %      50

EGLIN NW                                                                 0  0
GTON  NE XXXXXXXXXXXXXXX                                               300 15
      SW                                                                 0  0
      SE XXXXXXXXXXXX                                                  245 12
DAVIS NW                                                                 0  0
VILLE NE                                                                 0  0
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                       783 39
ST.   NW                                                                 0  0
CLAIR NE XXXXXXXXXXXXXXX                                               311 15
      SW                                                                 0  0
      SE XXXXXXXXXXXXXXXXX                                             355 17
SUMME NW                                                                 0  0
RHILL NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
ROSE  NW                                                                 0  0
DALE  NE                                                                 0  0
      SW                                                                 0  0
      SE                                                                 0  0
                                                              TOTAL  1994100

IN TIME PERIOD   6  THE SUBWAY LINE  Y O N G E
HAD   5  STATIONS WITH   20  STATION SUB-AREAS.
1994  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   6
```

SIMULATED APARTMENT GROWTH
SUBWAY CORRIDOR BLOOR WEST OLD
YEAR 1965/1966 TIME PERIOD 4

STATION		0 % 10 % 20 % 30 % 40 % 50	NO OF APARTMENTS ABSOLUT	%
ST.GE	NW		0	0
ORGE	NE	XXXXXXXXXXXXXXXXXXXX	193	20
	SW		0	0
	SE		0	0
SPA	NW	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	284	30
DINA	NE		0	0
	SW		0	0
	SE		0	0
BATH	NW		0	0
URST	NE		0	0
	SW		0	0
	SE		0	0
CHRIS	NW		0	0
TIE	NE		0	0
	SW		0	0
	SE		0	0
OSSIN	NW		0	0
GTON	NE		0	0
	SW		0	0
	SE		0	0
DUFFE	NW		0	0
RIN	NE		0	0
	SW		0	0
	SE		0	0
LANDS	NW		0	0
DOWNE	NE		0	0
	SW		0	0
	SE		0	0
DUND	NW		0	0
AS W.	NE		0	0
	SW		0	0
	SE		0	0
KEELE	NW	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	457	48
	NE		0	0
	SW		0	0
	SE		0	0
		TOTAL	934	100

IN TIME PERIOD 4 THE SUBWAY LINE BLOOR WEST OLD
HAD 9 STATIONS WITH 36 STATION SUB-AREAS.
934 IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD 4

EFFECTIVE APARTMENT GROWTH
SUBWAY CORRIDOR BLOOR WEST OLD
YEAR 1965/1966 TIME PERIOD 4

STATION		0 % 20 % 40 % 60 % 80 % 100	NO OF APARTMENTS ABSOLUT	%
ST.GE	NW		0	0
ORGE	NE	XXXXXXXXXXX	192	21
	SW		0	0
	SE		0	0
SPA	NW	XXXXXXXXX	169	19
DINA	NE		0	0
	SW		0	0
	SE		0	0
BATH	NW		0	0
URST	NE		0	0
	SW		0	0
	SE		0	0
CHRIS	NW		0	0
TIE	NE		0	0
	SW		0	0
	SE		0	0
OSSIN	NW		0	0
GTON	NE		0	0
	SW		0	0
	SE		0	0
DUFFE	NW		0	0
RIN	NE		0	0
	SW		0	0
	SE		0	0
LANDS	NW		0	0
DOWNE	NE		0	0
	SW		0	0
	SE		0	0
DUND	NW		0	0
AS W.	NE		0	0
	SW		0	0
	SE		0	0
KEELE	NW	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX	520	59
	NE		0	0
	SW		0	0
	SE		0	0
		TOTAL	881	100

IN TIME PERIOD 4 THE SUBWAY LINE BLOOR WEST OLD
HAD 9 STATIONS WITH 36 STATION SUB-AREAS.
881 IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD 4

SIMULATED APARTMENT GROWTH
SUBWAY CORRIDOR BLOOR WEST OLD
YEAR 1967/1968 TIME PERIOD 5

STATION		0 % 20 % 40 % 60 % 80 % 100	NO OF APARTMENTS ABSOLUT	%
ST.GE	NW		0	0
ORGE	NE	XXXXXXX	177	14
	SW		0	0
	SE		0	0
SPA	NW	XXXXXXXXX	215	17
DINA	NE		0	0
	SW		0	0
	SE		0	0
BATH	NW		0	0
URST	NE		0	0
	SW		0	0
	SE		0	0
CHRIS	NW		0	0
TIE	NE		0	0
	SW		0	0
	SE		0	0
OSSIN	NW		0	0
GTON	NE		0	0
	SW		0	0
	SE		0	0
DUFFE	NW		0	0
RIN	NE		0	0
	SW		0	0
	SE		0	0
LANDS	NW		0	0
DOWNE	NE		0	0
	SW		0	0
	SE		0	0
DUND	NW		0	0
AS W.	NE		0	0
	SW		0	0
	SE		0	0
KEELE	NW	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	803	67
	NE		0	0
	SW		0	0
	SE		0	0
		TOTAL	1195	100

IN TIME PERIOD 5 THE SUBWAY LINE BLOOR WEST OLD
HAD 9 STATIONS WITH 36 STATION SUB-AREAS.
1195 IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD 5

EFFECTIVE APARTMENT GROWTH
SUBWAY CORRIDOR BLOOR WEST OLD
YEAR 1967/1968 TIME PERIOD 5

STATION		0 % 20 % 40 % 60 % 80 % 100	NO OF APARTMENTS ABSOLUT	%
ST.GE	NW		0	0
ORGE	NE	XXXXXXXXXXXX	150	23
	SW		0	0
	SE		0	0
SPA	NW		0	0
DINA	NE		0	0
	SW		0	0
	SE		0	0
BATH	NW		0	0
URST	NE		0	0
	SW		0	0
	SE		0	0
CHRIS	NW		0	0
TIE	NE		0	0
	SW		0	0
	SE		0	0
OSSIN	NW		0	0
GTON	NE		0	0
	SW		0	0
	SE		0	0
DUFFE	NW		0	0
RIN	NE		0	0
	SW		0	0
	SE		0	0
LANDS	NW		0	0
DOWNE	NE		0	0
	SW		0	0
	SE		0	0
DUND	NW		0	0
AS W.	NE		0	0
	SW		0	0
	SE		0	0
KEELE	NW	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	480	76
	NE		0	0
	SW		0	0
	SE		0	0
		TOTAL	630	100

IN TIME PERIOD 5 THE SUBWAY LINE BLOOR WEST OLD
HAD 9 STATIONS WITH 36 STATION SUB-AREAS.
630 IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD 5

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S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  B L O O R  W E S T  N E W
YEAR  1967/1968          TIME PERIOD   5
                                                        NO OF APARTMENTS
STATION                                                   ABSOLUT  %
        0 %        20 %        40 %        60 %        80 %     100

HIGH  NW                                                          0   0
PARK  NE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  283 100
      SW                                                          0   0
      SE                                                          0   0
BUNNY NW                                                          0   0
MEDE  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
JANE  NW                                                          0   0
      NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
OLD   NW                                                          0   0
MILL  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
ROYAL NW                                                          0   0
YORK  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
ISLIN NW                                                          0   0
GTON  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
                                                        TOTAL   283 100
IN TIME PERIOD    5  THE SUBWAY LINE  B L O O R  W E S T  N E W
HAD   6  STATIONS WITH   24  STATION SUB-AREAS.
 283  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD    5
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E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  B L O O R  W E S T  N E W
YEAR  1967/1968     /    TIME PERIOD   5
                                                        NO OF APARTMENTS
STATION                                                   ABSOLUT  %
        0 %        20 %        40 %        60 %        80 %     100

HIGH  NW                                                          0   0
PARK  NE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX        638  91
      SW                                                          0   0
      SE                                                          0   0
BUNNY NW                                                          0   0
MEDE  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
JANE  NW                                                          0   0
      NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
OLD   NW                                                          0   0
MILL  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
ROYAL NW                                                          0   0
YORK  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
ISLIN NW XXXX                                                    60   8
GTON  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
                                                        TOTAL   698 100
IN TIME PERIOD    5  THE SUBWAY LINE  B L O O R  W E S T  N E W
HAD   6  STATIONS WITH   24  STATION SUB-AREAS.
 698  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD    5
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S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  B L O O R  W E S T  N E W
YEAR  1969/1970          TIME PERIOD   6
                                                        NO OF APARTMENTS
STATION                                                   ABSOLUT  %
        0 %        20 %        40 %        60 %        80 %     100

HIGH  NW                                                          0   0
PARK  NE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  298 100
      SW                                                          0   0
      SE                                                          0   0
BUNNY NW                                                          0   0
MEDE  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
JANE  NW                                                          0   0
      NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
OLD   NW                                                          0   0
MILL  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
ROYAL NW                                                          0   0
YORK  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
ISLIN NW                                                          0   0
GTON  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
                                                        TOTAL   298 100
IN TIME PERIOD    6  THE SUBWAY LINE  B L O O R  W E S T  N E W
HAD   6  STATIONS WITH   24  STATION SUB-AREAS.
 298  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD    6
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E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  B L O O R  W E S T  N E W
YEAR  1969/1970          TIME PERIOD   6
                                                        NO OF APARTMENTS
STATION                                                   ABSOLUT  %
        0 %        20 %        40 %        60 %        80 %     100

HIGH  NW                                                          0   0
PARK  NE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  525 100
      SW                                                          0   0
      SE                                                          0   0
BUNNY NW                                                          0   0
MEDE  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
JANE  NW                                                          0   0
      NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
OLD   NW                                                          0   0
MILL  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
ROYAL NW                                                          0   0
YORK  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
ISLIN NW                                                          0   0
GTON  NE                                                          0   0
      SW                                                          0   0
      SE                                                          0   0
                                                        TOTAL   525 100
IN TIME PERIOD    6  THE SUBWAY LINE  B L O O R  W E S T  N E W
HAD   6  STATIONS WITH   24  STATION SUB-AREAS.
 525  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD    6
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S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  B L O O R  W E S T  O L D
YEAR  1969/1970          TIME PERIOD   6
                                                         NO OF APARTMENTS
STATION                                                        ABSOLUT  %
         0 %       10 %       20 %       30 %       40 %      50

ST.GE  NW                                                          0  0
ORGE   NE XXXXXXXXXXXXXXXXXXXXXX                                 180 22
       SW                                                          0  0
       SE                                                          0  0
SPA    NW XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                    281 35
DINA   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
BATH   NW                                                          0  0
URST   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
CHRIS  NW                                                          0  0
TIE    NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
OSSIN  NW                                                          0  0
GTON   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
DUFFE  NW                                                          0  0
RIN    NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
LANDS  NW                                                          0  0
DOWNE  NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
DUND   NW                                                          0  0
AS W.  NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
KEELE  NW XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX             331 41
       NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
                                                         TOTAL  792100
IN TIME PERIOD   6  THE SUBWAY LINE  B L O O R  W E S T  O L D
HAD   9  STATIONS WITH   36  STATION SUB-AREAS.
 792  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   6
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E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  B L O O R  W E S T  O L D
YEAR  1969/1970          TIME PERIOD   6
                                                         NO OF APARTMENTS
STATION                                                        ABSOLUT  %
         0 %       20 %       40 %       60 %       80 %      100

ST.GE  NW                                                          0  0
ORGE   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
SPA    NW XXXXXXXXXXXXXX                                         140 29
DINA   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
BATH   NW                                                          0  0
URST   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
CHRIS  NW                                                          0  0
TIE    NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
OSSIN  NW                                                          0  0
GTON   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
DUFFE  NW                                                          0  0
RIN    NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
LANDS  NW                                                          0  0
DOWNE  NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
DUND   NW                                                          0  0
AS W.  NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
KEELE  NW XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                    332 70
       NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
                                                         TOTAL  472100
IN TIME PERIOD   6  THE SUBWAY LINE  B L O O R  W E S T  O L D
HAD   9  STATIONS WITH   36  STATION SUB-AREAS.
 472  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   6
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S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  B L O O R  E A S T
YEAR  1965/1966          TIME PERIOD   4
                                                         NO OF APARTMENTS
STATION                                                        ABSOLUT  %
         0 %       20 %       40 %       60 %       80 %      100

SHERB  NW                                                          0  0
OURNE  NE                                                          0  0
       SW                                                          0  0
       SE XXXXXXXXXXXXXXXXXXXXXXXXXXX                            916 54
CASTL  NW                                                          0  0
FRANK  NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
BROAD  NW XXXXXXXXXXXXXXXXXXXXXXX                                756 45
VIEW   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
CHES   NW                                                          0  0
TER    NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
PAPE   NW                                                          0  0
       NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
DON    NW                                                          0  0
LANDS  NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
GREEN  NW                                                          0  0
WOOD   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
COX    NW                                                          0  0
WELL   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
WOOD   NW                                                          0  0
BINE   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
                                                        TOTAL  1672100
IN TIME PERIOD   4  THE SUBWAY LINE  B L O O R  E A S T
HAD   9  STATIONS WITH   36  STATION SUB-AREAS.
1672  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   4
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```
E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR  B L O O R  E A S T
YEAR  1965/1966          TIME PERIOD   4
                                                         NO OF APARTMENTS
STATION                                                        ABSOLUT  %
         0 %       20 %       40 %       60 %       80 %      100

SHERB  NW                                                          0  0
OURNE  NE                                                          0  0
       SW                                                          0  0
       SE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                   951 71
CASTL  NW                                                          0  0
FRANK  NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
BROAD  NW XXXXXXXXXXXXXX                                         370 28
VIEW   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
CHES   NW                                                          0  0
TER    NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
PAPE   NW                                                          0  0
       NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
DON    NW                                                          0  0
LANDS  NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
GREEN  NW                                                          0  0
WOOD   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
COX    NW                                                          0  0
WELL   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
WOOD   NW                                                          0  0
BINE   NE                                                          0  0
       SW                                                          0  0
       SE                                                          0  0
                                                        TOTAL  1321100
IN TIME PERIOD   4  THE SUBWAY LINE  B L O O R  E A S T
HAD   9  STATIONS WITH   36  STATION SUB-AREAS.
1321  IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD   4
```

SIMULATED APARTMENT GROWTH
SUBWAY CORRIDOR B L O O R E A S T
YEAR 1967/1968 TIME PERIOD 5

STATION		0 % 10 % 20 % 30 % 40 % 50	NO OF APARTMENTS ABSOLUT	%
SHERB	NW		0	0
OURNE	NE		0	0
	SW		0	0
	SE	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	1037	43
CASTL	NW		0	0
FRANK	NE		0	0
	SW		0	0
	SE		0	0
BROAD	NW	XXXXXXXXXXXXXXXXXXXXXXXXXX	639	26
VIEW	NE		0	0
	SW		0	0
	SE		0	0
CHES	NW		0	0
TER	NE		0	0
	SW		0	0
	SE		0	0
PAPE	NW		0	0
	NE		0	0
	SW		0	0
	SE		0	0
DON	NW		0	0
LANDS	NE		0	0
	SW		0	0
	SE		0	0
GREEN	NW		0	0
WOOD	NE		0	0
	SW		0	0
	SE		0	0
COX	NW		0	0
WELL	NE		0	0
	SW		0	0
	SE		0	0
WOOD	NW		0	0
BINE	NE		0	0
	SW		0	0
	SE		0	0
MAIN	NW		0	0
ST.	NE		0	0
	SW		0	0
	SE		0	0
VICT.	NW	XXXXXXXXXXXX	280	11
PARK	NE		0	0
	SW		0	0
	SE		0	0
WAR	NW	XXXXXXXXXXXXXXXXXX	429	17
DEN	NE		0	0
	SW		0	0
	SE		0	0
		TOTAL	2385	100

IN TIME PERIOD 5 THE SUBWAY LINE B L O O R E A S T
HAD 12 STATIONS WITH 48 STATION SUB-AREAS.
2385 IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD 5

EFFECTIVE APARTMENT GROWTH
SUBWAY CORRIDOR B L O O R E A S T
YEAR 1967/1968 TIME PERIOD 5

STATION		0 % 20 % 40 % 60 % 80 % 100	NO OF APARTMENTS ABSOLUT	%
SHERB	NW		0	0
OURNE	NE		0	0
	SW	XX	93	4
	SE	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	1697	76
CASTL	NW		0	0
FRANK	NE		0	0
	SW		0	0
	SE		0	0
BROAD	NW	XXXXX	216	9
VIEW	NE		0	0
	SW		0	0
	SE	XXXXX	226	10
CHES	NW		0	0
TER	NE		0	0
	SW		0	0
	SE		0	0
PAPE	NW		0	0
	NE		0	0
	SW		0	0
	SE		0	0
DON	NW		0	0
LANDS	NE		0	0
	SW		0	0
	SE		0	0
GREEN	NW		0	0
WOOD	NE		0	0
	SW		0	0
	SE		0	0
COX	NW		0	0
WELL	NE		0	0
	SW		0	0
	SE		0	0
WOOD	NW		0	0
BINE	NE		0	0
	SW		0	0
	SE		0	0
MAIN	NW		0	0
ST.	NE		0	0
	SW		0	0
	SE		0	0
VICT.	NW		0	0
PARK	NE		0	0
	SW		0	0
	SE		0	0
WAR	NW		0	0
DEN	NE		0	0
	SW		0	0
	SE		0	0
		TOTAL	2232	100

IN TIME PERIOD 5 THE SUBWAY LINE B L O O R E A S T
HAD 12 STATIONS WITH 48 STATION SUB-AREAS.
2232 IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD 5

S I M U L A T E D   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR B L O O R E A S T
YEAR 1969/1970   TIME PERIOD 6

STATION		0 % 10 % 20 % 30 % 40 % 50	NO OF APARTMENTS ABSOLUT	%
SHERB	NW		0	0
OURNE	NE		0	0
	SW		0	0
	SE	XXXXXXXXXXXXXXXXXXXXXXXXXXX	888	27
CASTL	NW		0	0
FRANK	NE		0	0
	SW		0	0
	SE		0	0
BROAD	NW	XXXXXXXXX	311	9
VIEW	NE		0	0
	SW		0	0
	SE	XXXXXXXXXXXXXXXXXXXX	638	20
CHES	NW		0	0
TER	NE		0	0
	SW		0	0
	SE		0	0
PAPE	NW		0	0
	NE		0	0
	SW		0	0
	SE		0	0
DON	NW		0	0
LANDS	NE		0	0
	SW		0	0
	SE		0	0
GREEN	NW		0	0
WOOD	NE		0	0
	SW		0	0
	SE		0	0
COX	NW		0	0
WELL	NE		0	0
	SW		0	0
	SE		0	0
WOOD	NW		0	0
BINE	NE		0	0
	SW		0	0
	SE		0	0
BAIN	NW		0	0
ST.	NE		0	0
	SW		0	0
	SE	XXXXXXXXX	289	9
VICT.	NW		0	0
PARK	NE	XXXXXXXXX	298	9
	SW		0	0
	SE		0	0
WAR	NW	XXXXXXXXXXXXXXXXXXXXXXX	761	23
DEN	NE		0	0
	SW		0	0
	SE		0	0
		TOTAL	3185	100

IN TIME PERIOD 6 THE SUBWAY LINE B L O O R E A S T
HAD 12 STATIONS WITH 48 STATION SUB-AREAS.
3185 IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD 5

E F F E C T I V E   A P A R T M E N T   G R O W T H
SUBWAY CORRIDOR B L O O R E A S T
YEAR 1969/1970   TIME PERIOD 6

STATION		0 % 10 % 20 % 30 % 40 % 50	NO OF APARTMENTS ABSOLUT	%
SHERB	NW		0	0
OURNE	NE		0	0
	SW		0	0
	SE	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	1347	43
CASTL	NW		0	0
FRANK	NE		0	0
	SW		0	0
	SE		0	0
BROAD	NW		0	0
VIEW	NE		0	0
	SW		0	0
	SE	XXXXXXXXX	288	9
CHES	NW		0	0
TER	NE		0	0
	SW		0	0
	SE		0	0
PAPE	NW		0	0
	NE		0	0
	SW		0	0
	SE		0	0
DON	NW		0	0
LANDS	NE		0	0
	SW		0	0
	SE		0	0
GREEN	NW		0	0
WOOD	NE		0	0
	SW		0	0
	SE		0	0
COX	NW		0	0
WELL	NE		0	0
	SW		0	0
	SE		0	0
WOOD	NW		0	0
BINE	NE		0	0
	SW		0	0
	SE		0	0
BAIN	NW		0	0
ST.	NE		0	0
	SW		0	0
	SE	XXXXXXXXXXXXXXXXXXXX	625	20
VICT.	NW	XXXXXX	208	6
PARK	NE	XXXXXXXXXX	294	9
	SW		0	0
	SE		0	0
WAR	NW	XXXXXXXXXX	330	10
DEN	NE		0	0
	SW		0	0
	SE		0	0
		TOTAL	3092	100

IN TIME PERIOD 6 THE SUBWAY LINE B L O O R E A S T
HAD 12 STATIONS WITH 48 STATION SUB-AREAS.
3092 IS THE TOTAL # OF APARTMENTS BUILT IN TIME PERIOD 6

appendix

A.d-3

(See Chapter 7.2)

MODEL CALIBRATION; PERCENTAGE DIFFERENCE

- The difference between actual and simulated apartment growth is expressed as a percentage of the simulated growth.
- The comparison is made for each time period and each moving average; for each station sub-area which received either actual or simulated growth or both.

C O M P A R I S O N O F E F F E C T I V E A N D S I M U L A T E D A P A R T M E N T G R O W T H

DIFFERENCE EXPRESSED AS PERCENTAGE OF SIMULATED GROWTH

999 SIMULATED GROWTH WAS LESS THAN 1/3 OF THE ACTUAL GROWTH

444 GROWTH WAS SIMULATED WHEN NO GROWTH ACTUALLY TOOK PLACE

E EFFECTIVE GROWTH (IN DWELLING UNITS)
S SIMULATED GROWTH (IN DWELLING UNITS)
P PERCENTAGE DIFFERENCE ((E-S)/S*100)

APPLICABLE TO LINE		YONGE			YONGE			YONGE		
STATION	AREA	TIME PER 1			TIME PER 2			TIME PER 3		
		E11	S11	P11	E12	S12	P12	E13	S13	P13
EGLINGTON	1012	210	273	-23	255	159	60	310	389	-20
EGLINGTON	1014	155	0	999	159	154	3	0	0	0
DAVISVILLE	1023	180	0	999	153	156	-2	0	281	444
DAVISVILLE	1024	0	0	0	120	155	-23	400	198	102
ST.CLAIR	1031	0	208	444	215	268	-20	212	0	999
ST.CLAIR	1032	0	0	0	0	154	444	0	158	444
ST.CLAIR	1034	0	197	444	222	157	41	416	425	-2

APPLICABLE TO LINE		YONGE,BWO,BEO			ALL LINES			ALL LINES		
STATION	AREA	TIME PER 4			TIME PER 5			TIME PER 6		
		E14	S14	P14	E15	S15	P15	E16	S16	P16
EGLINGTON	1011	0	0	0	168	0	999	0	244	444
EGLINGTON	1012	343	950	-64	251	637	-61	300	0	999
EGLINGTON	1014	288	0	999	369	0	999	245	266	-8
DAVISVILLE	1021	0	0	0	0	0	0	0	246	444
DAVISVILLE	1024	580	183	999	645	1077	-40	783	780	0
ST.CLAIR	1032	0	0	0	0	0	0	311	626	-50
ST.CLAIR	1034	784	951	-18	748	763	-2	355	0	999
ST.GEORGE	2012	0	193	444	150	177	-15	0	180	444
SPADINA	2021	0	284	444	0	215	444	140	281	-50
KEELE	2091	0	457	444	480	803	-40	332	331	0
HIGHPARK	2102	0	0	0	638	283	125	525	298	76
ISLINGTON	2151	0	0	0	60	0	999	0	0	0
SHERBOURNE	3014	0	916	444	1697	1037	64	1347	888	52
BROADVIEW	3031	0	756	444	216	639	-66	0	311	444
BROADVIEW	3034	0	0	0	226	0	999	288	638	-55
MAIN STREET	3104	0	0	0	0	0	0	625	289	116
VICTORIA PARK	3111	0	0	0	0	280	444	208	0	999
VICTORIA PARK	3112	0	0	0	0	0	0	294	298	-1
WARDEN	3121	0	0	0	0	429	444	330	761	-57

P E R C E N T A G E C O M P A R I S O N (CONTINUED)

APPLICABLE TO LINE		YONGE			YONGE		
STATION	AREA	TIME PERIOD 2			TIME PERIOD 3		
		E32	S32	P32	E33	S33	P33
EGLINGTON	1012	775	821	-6	908	1498	-39
EGLINGTON	1014	314	154	104	447	154	190
DAVISVILLE	1023	333	437	-24	153	437	-65
DAVISVILLE	1024	520	353	47	1100	536	105
ST.CLAIR	1031	427	476	-10	427	268	59
ST.CLAIR	1032	0	312	444	0	312	444
ST.CLAIR	1034	638	779	-18	1422	1533	-7

APPLICABLE TO LINE		YONGE			YONGE,BWO,BEO		
STATION	AREA	TIME PERIOD 4			TIME PERIOD 5		
		E34	S34	P34	E35	S35	P35
EGLINGTON	1011	168	0	999	168	244	-31
EGLINGTON	1012	904	1976	-54	894	1587	-44
EGLINGTON	1014	657	0	999	902	266	999
DAVISVILLE	1021	0	0	0	0	246	444
DAVISVILLE	1023	0	281	444	0	0	0
DAVISVILLE	1024	1625	1458	11	2008	2040	-2
ST.CLAIR	1031	212	0	999	0	0	0
ST.CLAIR	1032	0	158	444	311	626	-50
ST.CLAIR	1034	1948	2139	-9	1887	1714	10
ST.GEORGE	2012	0	0	0	342	550	-38
SPADINA	2021	0	0	0	309	780	-60
KEELE	2091	0	0	0	1332	1591	-16
HIGHPARK	2102	0	0	0	1625	581	180
OLD MILL	2132	0	0	0	154	0	999
ISLINGTON	2151	0	0	0	60	0	999

P E R C E N T A G E   C O M P A R I S O N   (CONTINUED)

APPLICABLE TO LINE		YONGE			YONGE		
STATION	AREA	TIME	PERIOD 2		TIME	PERIOD 3	
		E22	S22	P22	E23	S23	P23
EGLINGTON	1012	565	548	3	653	1339	-51
EGLINGTON	1014	159	154	3	288	0	999
DAVISVILLE	1023	153	437	-65	0	281	444
DAVISVILLE	1024	520	353	47	980	381	157
ST.CLAIR	1031	427	268	59	212	0	999
ST.CLAIR	1032	0	312	444	0	158	444
ST.CLAIR	1034	638	582	10	1200	1376	-13

APPLICABLE TO LINE		YONGE,BWO,BWNN,BEN			YONGE,BWO,BWN,BEN		
STATION	AREA	TIME	PERIOD 4		TIME	PERIOD 5	
		E24	S24	P24	E25	S25	P25
EGLINGTON	1011	168	0	999	168	244	-31
EGLINGTON	1012	594	1587	-63	551	637	-14
EGLINGTON	1014	657	0	999	614	266	131
DAVISVILLE	1021	0	0	0	0	246	444
DAVISVILLE	1024	1225	1260	-3	1428	1857	-23
ST.CLAIR	1032	0	0	0	311	626	-50
ST.CLAIR	1034	1532	1714	-11	1103	763	45
ST.GEORGE	2012	342	370	-8	150	357	-58
SPADINA	2021	169	499	-66	140	496	-72
KEELE	2091	1000	1260	-21	812	1134	-28
SHERBOURNE	3013	0	0	0	93	0	999
SHERBOURNE	3014	0	0	0	3044	1925	58
BROADVIEW	3031	0	0	0	216	950	-77
BROADVIEW	3034	0	0	0	514	638	-19
MAIN STREET	3104	0	0	0	625	289	116
VICTORIA PARK	3111	0	0	0	208	280	-26
VICTORIA PARK	3112	0	0	0	294	298	-1
WARDEN	3121	0	0	0	330	1190	-72

appendix

A.d-4

(See Chapter 7.2)

MODEL CALIBRATION; CORRELATION ANALYSIS

In Chapter 7.2, the results of correlation analysis between actual and simulated growth were given. Here, additional correlation coefficients are listed which measure the pooling effect of apartment growth. As found in Chapter 6.3, the actual apartment growth shows very distinctly a pooling effect. The following Tables A.d-4-1 to A.d-4-4 indicate that the corresponding trend for the simulated apartment growth is less marked, in particular if the growth in each time period is compared. However, the comparison for the moving averages exhibits more explicitly the pooling effect of simulated growth.

POOLING EFFECT OF SIMULATED APARTMENT GROWTH

TABLE A.d-4-1 COMPARISON FOR EACH TIME PERIOD

	S02	S03	S04	S05
S02	1	.88 (.024)	.86 (.167)	NA
S03		1	.99 (.047)	NA
S04			1	.36 (.102)
S05				1

	S22	S23	S24	S25
S22	1	.93 (.011)	.99 (.043)	.16 (.399)
S23		1	.97 (.077)	NA
S24			1	.46 (.214)
S25				1

.97 Correlation Coefficient

(.007) Level of Significance

NA Not Applicable because the number of cases is too small.

TABLE A.d-4-3

COMPARISON FOR MOVING AVERAGE 3

	S32	S33	S34	S35
S32	1	.93 (.001)	.81 (.050)	.64 (.123)
S33		1	.89 (.021)	.65 (.117)
S34			1	.81 (.095)
S35				1

TABLE A.d-4-4

COMPARISON FOR MOVING AVERAGE 5

	S52	S53	S54	S55
S52	1	.92 (.001)	.72 (.034)	.72 (.052)
S53		1	.91 (.002)	.92 (.005)
S54			1	1.0 (.001)
S55				1

.97 Correlation Coefficient

(.007) Level of Significance

NA Not Applicable because the number of cases is too small.

appendix

(See Chapter 7.3)

A.d-5

TESTING OF ALTERNATIVE POLICIES

SAMPLE OUTPRINT

For each model run which tests an alternative policy (and similarly for each sensitivity analysis), the following outprint is produced by the simulation model. It gives the incremental and cumulative apartment growth by station sub-areas and time period for each subway line.

F U T U R E   A P A R T M E N T   D E V E L O P M E N T

FUTURE INCREMENTAL AND CUMULATIVE GROWTH FOR TIME
PERIODS 5 - 14   (1967 - 1986)

SIMULATED ACCORDING TO OFFICIAL POLICIES AND THE
TORONTO PLAN   (SEE CHAPTER 7.3)

INCR = INCREMENTAL APARTMENT GROWTH PER
TIME PERIOD
CUM = CUMULATIVE APARTMENT GROWTH UNTIL
TIME PERIOD

S U B W A Y   Y O N G E

STAT ION	1967- 1968 INCR	CUM	1969- 1970 INCR	CUM	1971- 1972 INCR	CUM	1973- 1974 INCR	CUM
1011	0.	0.	244.	244.	0.	244.	0.	244.
1012	637.	2408.	0.	2408.	0.	2408.	0.	2408.
1013	0.	0.	0.	0.	0.	0.	0.	0.
1014	0.	154.	266.	420.	870.	1290.	649.	1939.
1021	0.	0.	246.	246.	0.	246.	644.	890.
1022	0.	0.	0.	0.	0.	0.	0.	0.
1023	0.	437.	0.	437.	158.	595.	0.	595.
1024	1077.	1613.	780.	2393.	0.	2393.	0.	2393.
1031	0.	476.	0.	476.	0.	476.	0.	476.
1032	0.	312.	626.	938.	322.	1260.	0.	1260.
1033	0.	0.	0.	0.	0.	0.	0.	0.
1034	763.	2493.	0.	2493.	0.	2493.	0.	2493.
1041	0.	0.	0.	0.	0.	0.	0.	0.
1042	0.	0.	0.	0.	0.	0.	0.	0.
1043	0.	0.	0.	0.	0.	0.	0.	0.
1044	0.	0.	0.	0.	0.	0.	0.	0.
1051	0.	0.	0.	0.	0.	0.	0.	0.
1052	0.	0.	0.	0.	0.	0.	0.	0.
1053	0.	0.	0.	0.	0.	0.	0.	0.
1054	0.	0.	0.	0.	0.	0.	0.	0.

F U T U R E   A P A R T M E N T   G R O W T H

S U B W A Y   B L O O R   W E S T

STAT ION	1967- 1968 INCR	CUM	1969- 1970 INCR	CUM	1971- 1972 INCR	CUM	1973- 1974 INCR	CUM
2011	0.	0.	0.	0.	0.	0.	0.	0.
2012	177.	370.	180.	550.	0.	550.	0.	550.
2013	0.	0.	0.	0.	0.	0.	0.	0.
2014	0.	0.	0.	0.	0.	0.	0.	0.
2021	215.	499.	281.	780.	0.	780.	0.	780.
2022	0.	0.	0.	0.	0.	0.	0.	0.
2023	0.	0.	0.	0.	0.	0.	0.	0.
2024	0.	0.	0.	0.	0.	0.	0.	0.
2031	0.	0.	0.	0.	0.	0.	0.	0.
2032	0.	0.	0.	0.	0.	0.	0.	0.
2033	0.	0.	0.	0.	0.	0.	0.	0.
2034	0.	0.	0.	0.	0.	0.	0.	0.
2041	0.	0.	0.	0.	0.	0.	0.	0.
2042	0.	0.	0.	0.	0.	0.	0.	0.
2043	0.	0.	0.	0.	0.	0.	0.	0.
2044	0.	0.	0.	0.	0.	0.	0.	0.
2051	0.	0.	0.	0.	0.	0.	0.	0.
2052	0.	0.	0.	0.	0.	0.	0.	0.
2053	0.	0.	0.	0.	0.	0.	0.	0.
2054	0.	0.	0.	0.	0.	0.	0.	0.
2061	0.	0.	0.	0.	0.	0.	0.	0.
2062	0.	0.	0.	0.	0.	0.	0.	0.
2063	0.	0.	0.	0.	0.	0.	0.	0.
2064	0.	0.	0.	0.	0.	0.	0.	0.
2091	803.	1260.	331.	1591.	0.	1591.	0.	1591.
2092	0.	0.	0.	0.	0.	0.	0.	0.
2093	0.	0.	0.	0.	0.	0.	0.	0.
2094	0.	0.	0.	0.	0.	0.	0.	0.
2101	0.	0.	0.	0.	0.	0.	0.	0.
2102	283.	283.	298.	581.	289.	870.	636.	1506.
2103	0.	0.	0.	0.	0.	0.	0.	0.
2104	0.	0.	0.	0.	0.	0.	0.	0.
2111	0.	0.	0.	0.	0.	0.	0.	0.
2112	0.	0.	0.	0.	0.	0.	0.	0.
2113	0.	0.	0.	0.	0.	0.	0.	0.
2114	0.	0.	0.	0.	0.	0.	0.	0.
2121	0.	0.	0.	0.	0.	0.	0.	0.
2122	0.	0.	0.	0.	1452.	1452.	225.	1677.
2123	0.	0.	0.	0.	0.	0.	0.	0.
2124	0.	0.	0.	0.	0.	0.	0.	0.
2131	0.	0.	0.	0.	0.	0.	0.	0.
2132	0.	0.	0.	0.	0.	0.	214.	214.
2133	0.	0.	0.	0.	0.	0.	0.	0.
2134	0.	0.	0.	0.	0.	0.	0.	0.
2141	0.	0.	0.	0.	0.	0.	0.	0.
2142	0.	0.	0.	0.	0.	0.	0.	0.
2143	0.	0.	0.	0.	0.	0.	0.	0.
2144	0.	0.	0.	0.	0.	0.	0.	0.
2151	0.	0.	0.	0.	0.	0.	0.	0.
2152	0.	0.	0.	0.	0.	0.	150.	150.
2153	0.	0.	0.	0.	0.	0.	0.	0.
2154	0.	0.	0.	0.	0.	0.	0.	0.

F U T U R E   A P A R T M E N T   G R O W T H

S U B W A Y   B L O O R   E A S T

STAT ION	1967- 1968 INCR	CUM	1969- 1970 INCR	CUM	1971- 1972 INCR	CUM	1973- 1974 INCR	CUM
3011	0.	0.	0.	0.	0.	0.	0.	0.
3012	0.	0.	0.	0.	0.	0.	0.	0.
3013	0.	0.	0.	0.	0.	0.	0.	0.
3014	1037.	1953.	888.	2841.	628.	3469.	1519.	4988.
3021	0.	0.	0.	0.	0.	0.	0.	0.
3022	0.	0.	0.	0.	0.	0.	0.	0.
3023	0.	0.	0.	0.	0.	0.	0.	0.
3024	0.	0.	0.	0.	0.	0.	0.	0.
3031	639.	1395.	311.	1706.	215.	1921.	0.	1921.
3032	0.	0.	0.	0.	0.	0.	0.	0.
3033	0.	0.	0.	0.	0.	0.	0.	0.
3034	0.	0.	638.	638.	181.	819.	0.	819.
3041	0.	0.	0.	0.	0.	0.	0.	0.
3042	0.	0.	0.	0.	0.	0.	0.	0.
3043	0.	0.	0.	0.	0.	0.	0.	0.
3044	0.	0.	0.	0.	0.	0.	0.	0.
3051	0.	0.	0.	0.	0.	0.	0.	0.
3052	0.	0.	0.	0.	0.	0.	0.	0.
3053	0.	0.	0.	0.	0.	0.	0.	0.
3054	0.	0.	0.	0.	0.	0.	0.	0.
3061	0.	0.	0.	0.	0.	0.	0.	0.
3062	0.	0.	0.	0.	0.	0.	0.	0.
3063	0.	0.	0.	0.	0.	0.	0.	0.
3064	0.	0.	0.	0.	0.	0.	0.	0.
3071	0.	0.	0.	0.	0.	0.	0.	0.
3072	0.	0.	0.	0.	0.	0.	0.	0.
3073	0.	0.	0.	0.	0.	0.	0.	0.
3074	0.	0.	0.	0.	0.	0.	0.	0.
3081	0.	0.	0.	0.	0.	0.	0.	0.
3082	0.	0.	0.	0.	0.	0.	0.	0.
3083	0.	0.	0.	0.	0.	0.	0.	0.
3084	0.	0.	0.	0.	0.	0.	0.	0.
3091	0.	0.	0.	0.	0.	0.	0.	0.
3092	0.	0.	0.	0.	0.	0.	0.	0.
3093	0.	0.	0.	0.	0.	0.	0.	0.
3094	0.	0.	0.	0.	0.	0.	0.	0.
3101	0.	0.	0.	0.	0.	0.	0.	0.
3102	0.	0.	0.	0.	0.	0.	0.	0.
3103	0.	0.	0.	0.	0.	0.	0.	0.
3104	0.	0.	289.	289.	0.	289.	0.	289.
3111	280.	280.	0.	280.	144.	424.	0.	424.
3112	0.	0.	298.	298.	115.	413.	0.	413.
3113	0.	0.	0.	0.	0.	0.	0.	0.
3114	0.	0.	0.	0.	0.	0.	0.	0.
3121	429.	429.	761.	1190.	363.	1553.	0.	1553.
3122	0.	0.	0.	0.	0.	0.	0.	0.
3123	0.	0.	0.	0.	0.	0.	0.	0.
3124	0.	0.	0.	0.	0.	0.	0.	0.

F U T U R E   A P A R T M E N T   G R O W T H

S U B W A Y   L I N E   Y O N G E

STAT ION	1975- 1976 INCR	CUM	1977- 1978 INCR	CUM	1979- 1980 INCR	CUM	1981- 1982 INCR	CUM
1011	155.	399.	789.	1188.	633.	1821.	0.	1821.
1012	0.	2408.	0.	2408.	0.	2408.	0.	2408.
1013	0.	0.	0.	0.	0.	0.	0.	0.
1014	0.	1939.	0.	1939.	0.	1939.	0.	1939.
1021	0.	890.	0.	890.	0.	890.	0.	890.
1022	0.	0.	0.	0.	0.	0.	0.	0.
1023	532.	1127.	0.	1127.	0.	1127.	0.	1127.
1024	0.	2393.	0.	2393.	0.	2393.	0.	2393.
1031	0.	476.	0.	476.	0.	476.	0.	476.
1032	277.	1537.	0.	1537.	0.	1537.	0.	1537.
1033	0.	0.	0.	0.	140.	140.	0.	140.
1034	0.	2493.	0.	2493.	0.	2493.	0.	2493.
1041	0.	0.	0.	0.	0.	0.	0.	0.
1042	0.	0.	0.	0.	0.	0.	0.	0.
1043	0.	0.	0.	0.	0.	0.	0.	0.
1044	147.	147.	617.	764.	140.	904.	0.	904.
1051	0.	0.	0.	0.	0.	0.	0.	0.
1052	0.	0.	0.	0.	0.	0.	613.	613.
1053	0.	0.	0.	0.	0.	0.	0.	0.
1054	0.	0.	0.	0.	0.	0.	465.	465.

F U T U R E   A P A R T M E N T   G R O W T H

S U B W A Y   L I N E   B L O O R   W E S T

STAT ION	1975- 1976 INCR	CUM	1977- 1978 INCR	CUM	1979- 1980 INCR	CUM	1981- 1982 INCR	CUM
2011	0.	0.	0.	0.	0.	0.	0.	0.
2012	0.	550.	0.	550.	0.	550.	0.	550.
2013	0.	0.	0.	0.	0.	0.	0.	0.
2014	0.	0.	0.	0.	0.	0.	0.	0.
2021	0.	780.	0.	780.	0.	780.	0.	780.
2022	0.	0.	0.	0.	0.	0.	0.	0.
2023	0.	0.	0.	0.	0.	0.	0.	0.
2024	0.	0.	0.	0.	0.	0.	0.	0.
2031	0.	0.	0.	0.	0.	0.	0.	0.
2032	0.	0.	0.	0.	0.	0.	0.	0.
2033	0.	0.	0.	0.	0.	0.	0.	0.
2034	0.	0.	0.	0.	0.	0.	0.	0.
2041	0.	0.	0.	0.	0.	0.	0.	0.
2042	0.	0.	0.	0.	0.	0.	0.	0.
2043	0.	0.	0.	0.	0.	0.	0.	0.
2044	0.	0.	0.	0.	0.	0.	0.	0.

F U T U R E   A P A R T M E N T   G R O W T H

S U B W A Y   L I N E   B L O O R   W E S T

STAT ION	1975- INCR	1976 CUM	1977- INCR	1978 CUM	1979- INCR	1980 CUM	1981- INCR	1982 CUM
2051	0.	0.	0.	0.	0.	0.	0.	0.
2052	0.	0.	0.	0.	0.	0.	0.	0.
2053	0.	0.	0.	0.	0.	0.	0.	0.
2054	0.	0.	0.	0.	0.	0.	0.	0.
2061	0.	0.	0.	0.	0.	0.	0.	0.
2062	0.	0.	0.	0.	0.	0.	0.	0.
2063	0.	0.	0.	0.	0.	0.	0.	0.
2064	0.	0.	0.	0.	519.	519.	547.	1066.
2071	0.	0.	0.	0.	0.	0.	0.	0.
2072	0.	0.	0.	0.	0.	0.	0.	0.
2073	0.	0.	0.	0.	0.	0.	0.	0.
2074	0.	0.	0.	0.	0.	0.	0.	0.
2081	0.	0.	0.	0.	0.	0.	0.	0.
2082	0.	0.	0.	0.	0.	0.	0.	0.
2083	0.	0.	0.	0.	0.	0.	0.	0.
2084	0.	0.	0.	0.	0.	0.	0.	0.
2091	0.	1591.	0.	1591.	0.	1591.	0.	1591.
2092	0.	0.	0.	0.	0.	0.	0.	0.
2093	0.	0.	0.	0.	0.	0.	0.	0.
2094	0.	0.	0.	0.	0.	0.	0.	0.
2101	0.	0.	0.	0.	0.	0.	0.	0.
2102	444.	1950.	0.	1950.	0.	1950.	0.	1950.
2103	0.	0.	0.	0.	0.	0.	0.	0.
2104	0.	0.	0.	0.	0.	0.	0.	0.
2111	0.	0.	0.	0.	0.	0.	0.	0.
2112	0.	0.	0.	0.	0.	0.	0.	0.
2113	0.	0.	0.	0.	0.	0.	0.	0.
2114	0.	0.	0.	0.	0.	0.	0.	0.
2121	0.	0.	0.	0.	0.	0.	0.	0.
2122	0.	1677.	294.	1971.	0.	1971.	0.	1971.
2123	0.	0.	0.	0.	0.	0.	0.	0.
2124	0.	0.	0.	0.	0.	0.	0.	0.
2131	0.	0.	0.	0.	0.	0.	0.	0.
2132	0.	214.	0.	214.	0.	214.	0.	214.
2133	0.	0.	0.	0.	0.	0.	0.	0.
2134	0.	0.	0.	0.	0.	0.	0.	0.
2141	0.	0.	0.	0.	0.	0.	0.	0.
2142	0.	0.	0.	0.	0.	0.	0.	0.
2143	0.	0.	0.	0.	0.	0.	0.	0.
2144	0.	0.	0.	0.	0.	0.	0.	0.
2151	759.	759.	0.	759.	0.	759.	0.	759.
2152	0.	150.	600.	750.	0.	750.	0.	750.
2153	0.	0.	222.	222.	662.	884.	611.	1495.
2154	0.	0.	0.	0.	0.	0.	0.	0.

F U T U R E   A P A R T M E N T   G R O W T H

S U B W A Y   L I N E   B L O O R   E A S T

STAT ION	1975- 1976 INCR	CUM	1977- 1978 INCR	CUM	1979- 1980 INCR	CUM	1981- 1982 INCR	CUM
3011	0.	0.	0.	0.	0.	0.	0.	0.
3012	0.	0.	0.	0.	0.	0.	0.	0.
3013	0.	0.	0.	0.	0.	0.	0.	0.
3014	0.	4988.	0.	4988.	0.	4988.	0.	4988.
3021	0.	0.	0.	0.	0.	0.	0.	0.
3022	0.	0.	0.	0.	0.	0.	0.	0.
3023	0.	0.	0.	0.	0.	0.	0.	0.
3024	0.	0.	0.	0.	0.	0.	0.	0.
3031	0.	1921.	0.	1921.	0.	1921.	0.	1921.
3032	0.	0.	0.	0.	0.	0.	0.	0.
3033	0.	0.	0.	0.	0.	0.	0.	0.
3034	784.	1603.	362.	1965.	0.	1965.	0.	1965.
3041	0.	0.	0.	0.	0.	0.	0.	0.
3042	0.	0.	0.	0.	0.	0.	0.	0.
3043	0.	0.	0.	0.	0.	0.	0.	0.
3044	0.	0.	0.	0.	0.	0.	0.	0.
3051	0.	0.	621.	621.	0.	621.	643.	1264.
3052	0.	0.	0.	0.	0.	0.	0.	0.
3053	0.	0.	0.	0.	1512.	1512.	190.	1702.
3054	0.	0.	0.	0.	0.	0.	0.	0.
3061	0.	0.	0.	0.	0.	0.	0.	0.
3062	0.	0.	0.	0.	0.	0.	0.	0.
3063	0.	0.	0.	0.	0.	0.	0.	0.
3064	0.	0.	0.	0.	0.	0.	0.	0.
3071	0.	0.	0.	0.	0.	0.	0.	0.
3072	0.	0.	0.	0.	0.	0.	0.	0.
3073	0.	0.	0.	0.	0.	0.	0.	0.
3074	0.	0.	0.	0.	0.	0.	0.	0.
3081	0.	0.	0.	0.	0.	0.	0.	0.
3082	0.	0.	0.	0.	0.	0.	0.	0.
3083	0.	0.	0.	0.	0.	0.	0.	0.
3084	0.	0.	0.	0.	0.	0.	0.	0.
3091	0.	0.	0.	0.	0.	0.	0.	0.
3092	0.	0.	0.	0.	0.	0.	0.	0.
3093	0.	0.	0.	0.	0.	0.	0.	0.
3094	0.	0.	0.	0.	0.	0.	0.	0.
3101	0.	0.	0.	0.	0.	0.	0.	0.
3102	0.	0.	0.	0.	0.	0.	0.	0.
3103	0.	0.	0.	0.	0.	0.	0.	0.
3104	738.	1027.	0.	1027.	0.	1027.	0.	1027.
3111	0.	424.	0.	424.	0.	424.	0.	424.
3112	0.	413.	0.	413.	0.	413.	250.	663.
3113	0.	0.	0.	0.	0.	0.	0.	0.
3114	0.	0.	0.	0.	0.	0.	0.	0.
3121	0.	1553.	239.	1792.	0.	1792.	0.	1792.
3122	0.	0.	0.	0.	0.	0.	0.	0.
3123	0.	0.	0.	0.	0.	0.	0.	0.
3124	0.	0.	0.	0.	0.	0.	0.	0.

F U T U R E   A P A R T M E N T   G R O W T H

S U B W A Y   L I N E   Y O N G E

STAT ION	1983- INCR	1984 CUM	1985- INCR	1986 CUM
1011	0.	1821.	0.	1821.
1012	0.	2408.	0.	2408.
1013	229.	229.	325.	554.
1014	0.	1939.	0.	1939.
1021	0.	890.	0.	890.
1022	0.	0.	0.	0.
1023	0.	1127.	0.	1127.
1024	0.	2393.	0.	2393.
1031	0.	476.	0.	476.
1032	0.	1537.	0.	1537.
1033	251.	391.	0.	391.
1034	0.	2493.	0.	2493.
1041	0.	0.	0.	0.
1042	0.	0.	0.	0.
1043	0.	0.	0.	0.
1044	0.	904.	0.	904.
1051	0.	0.	0.	0.
1052	526.	1139.	535.	1674.
1053	0.	0.	0.	0.
1054	0.	465.	0.	465.

F U T U R E   A P A R T M E N T   G R O W T H

S U B W A Y   L I N E   B L O O R   W E S T

STAT ION	1983- INCR	1984 CUM	1985- INCR	1986 CUM
2011	548.	548.	605.	1153.
2012	0.	550.	0.	550.
2013	0.	0.	0.	0.
2014	0.	0.	0.	0.
2021	0.	780.	0.	780.
2022	0.	0.	0.	0.
2023	0.	0.	0.	0.
2024	0.	0.	0.	0.
2031	0.	0.	0.	0.
2032	0.	0.	0.	0.
2033	0.	0.	0.	0.
2034	0.	0.	0.	0.
2041	0.	0.	0.	0.
2042	0.	0.	0.	0.
2043	0.	0.	0.	0.
2044	0.	0.	0.	0.

F U T U R E   A P A R T M E N T   G R O W T H

S U B W A Y   L I N E   B L O O R   W E S T

STAT ION	1983- INCR	1984 CUM	1985- INCR	1986 CUM
2051	0.	0.	0.	0.
2052	0.	0.	0.	0.
2053	0.	0.	0.	0.
2054	0.	0.	0.	0.
2061	0.	0.	0.	0.
2062	0.	0.	0.	0.
2063	0.	0.	0.	0.
2064	638.	1704.	0.	1704.
2071	0.	0.	0.	0.
2072	0.	0.	0.	0.
2073	0.	0.	0.	0.
2074	0.	0.	0.	0.
2081	0.	0.	0.	0.
2082	0.	0.	0.	0.
2083	0.	0.	0.	0.
2084	0.	0.	0.	0.
2091	0.	1591.	0.	1591.
2092	0.	0.	0.	0.
2093	0.	0.	0.	0.
2094	0.	0.	0.	0.
2101	0.	0.	0.	0.
2102	0.	1950.	0.	1950.
2103	0.	0.	0.	0.
2104	0.	0.	0.	0.
2111	0.	0.	0.	0.
2112	0.	0.	0.	0.
2113	0.	0.	0.	0.
2114	0.	0.	0.	0.
2121	0.	0.	0.	0.
2122	0.	1971.	0.	1971.
2123	0.	0.	0.	0.
2124	0.	0.	0.	0.
2131	0.	0.	0.	0.
2132	0.	214.	0.	214.
2133	0.	0.	0.	0.
2134	0.	0.	0.	0.
2141	0.	0.	0.	0.
2142	0.	0.	0.	0.
2143	0.	0.	0.	0.
2144	0.	0.	0.	0.
2151	0.	759.	0.	759.
2152	0.	750.	0.	750.
2153	0.	1495.	244.	1739.
2154	0.	0.	0.	0.

F U T U R E   A P A R T M E N T   G R O W T H

S U B W A Y   L I N E   B L O O R   E A S T

STAT ION	1983- 1984 INCR	CUM	1985- 1986 INCR	CUM
3011	0.	0.	0.	0.
3012	0.	0.	0.	0.
3013	273.	273.	0.	273.
3014	0.	4988.	0.	4988.
3021	0.	0.	0.	0.
3022	0.	0.	0.	0.
3023	0.	0.	0.	0.
3024	0.	0.	0.	0.
3032	0.	0.	0.	0.
3033	187.	187.	0.	187.
3034	0.	1965.	0.	1965.
3041	0.	0.	0.	0.
3042	0.	0.	0.	0.
3043	0.	0.	0.	0.
3044	0.	0.	0.	0.
3051	326.	1590.	0.	1590.
3052	0.	0.	0.	0.
3053	284.	1986.	0.	1986.
3054	0.	0.	0.	0.
3061	0.	0.	0.	0.
3062	0.	0.	0.	0.
3063	0.	0.	0.	0.
3064	0.	0.	0.	0.
3071	0.	0.	0.	0.
3072	0.	0.	0.	0.
3073	0.	0.	0.	0.
3074	0.	0.	0.	0.
3081	0.	0.	0.	0.
3082	0.	0.	0.	0.
3083	0.	0.	0.	0.
3084	0.	0.	0.	0.
3091	0.	0.	0.	0.
3092	0.	0.	0.	0.
3093	0.	0.	0.	0.
3094	0.	0.	0.	0.
3101	0.	0.	975.	975.
3102	0.	0.	0.	0.
3103	0.	0.	0.	0.
3104	0.	1027.	0.	1027.
3111	0.	424.	0.	424.
3112	0.	663.	0.	663.
3113	0.	0.	0.	0.
3114	0.	0.	594.	594.
3121	0.	1792.	0.	1792.
3122	0.	0.	0.	0.
3123	0.	0.	0.	0.
3124	0.	0.	0.	0.