Rail Rapid Transit Investment and CBD Revitalization: Methodology and Results

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ABSTRACT

A $450 million light rapid rail transit (LRRT) system is currently under construction in Buffalo, New York. This project represents a large public investment for a transportation system for which user benefits are not the sole or even a major consideration. Anticipated increases in service employment, retail activity and land development, mainly in the declining CBD area, are viewed as the major benefits. This paper describes the methodological framework used for the analysis of these impacts. Based on the empirical results from this methodology, the paper then evaluates the overall potential of the project to promote CBD revitalization.

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1. INTRODUCTION

In mid 1979 construction began on a 6.4 mile Light Rail Rapid Transit system (LRRT) in Buffalo, New York. This project, located within a declining central city area, represents a large ($450 million) public investment for which user or transportation benefits were not the sole or even a major consideration. Economic and land development and the creation of jobs primarily in the CBD area were major factors in the funding decision. As such, the project was viewed as a major effort on the part of the public sector to stop the decline of a depressed urban core area and encourage revitalization by stimulating additional public and private investments.

This paper describes the methodology designed for analyzing the projected impacts of the LRRT project on the CBD area and the principal results derived from using this methodology. On the basis of these results it then evaluates the potential ability of the LRRT investment to reverse the current trend of decline of the CBD area and promote its revitalization.

Quite a large number of studies have been done in the past on the analysis of impacts of transportation projects (e.g., Boyce et al., 1972; Cousins and Heightchew, 1971). Relatively little however was done to explore the transportation and non-transportation impacts of a transit investment on the downtown; in particular, on the capability of such projects to revitalize a declining CBD (see Mackett, 1980; and Poulton, 1980, for such studies). Consequently, the first step in exploring the project's impact required the design of an appropriate methodology which would enable the carrying out of a number of different prediction tests.

The next section of the paper describes the details of this methodology. Afterwards section 3 analyzes major regional economic and demographic long-run trends which are inputs to a number of specific models. These models are described in Section 4. Principal tests and results are described in Section 5. Section 6 discusses the implications of public policies for the revitalization of the CBD. It is important to emphasize at the outset that no attempt is made here to assess the desirability of CBD revitalization as a social goal. Given the transit investment decision the focus is rather on the evalution of the project's impact relative to the objective of CBD revitalization.

2. METHODOLOGY: DESIGN

The Buffalo LRRT project is a massive capital investment focused on a small well-defined area, taking place over a relatively short period of time (5-6 years). The LRRT corridor is located in a region of general economic decline whose major characteristics are typical of many northeastern cities in the U.S. Because of the regional outmigration of population, and the intraregional sustained trend of suburbanization, there has been a continuous decline in population in the Central City from 1960 to the present. Another characteristic is the constant change in the composition of the regional labor force from traditional blue collar industries toward an increase in the white collar employment. These trends are shown to have profound effects on shopping patterns, employment location and travel behavior.

In developing the methodology for the study a number of working assumptions were made. These assumptions also serve as a guideline for the study. First, it was assumed that the LRRT project will produce a large number of interrelated impacts which for analytical purposes may be categorized into distinct impact groups and consequently can be treated separately. Four such impact groups were identified: transportation, economic, shopping patterns and land-use.

The second working assumption was that no one model can simultaneously treat all these impact types. Therefore, a set of models and techniques should be used.

The third working assumption is that the potential effect on any of the above impact types will be enhanced or constrained by the regional trends mentioned above. Unlike growth areas, where a facility can be built in the anticipation of generated demand for its use, investment in a declining area must consider the amount of activity that can be supported by the limited demographic and economic resources. As a consequence, it was mandatory that the scope and magnitude of these trends be evaluated prior to the impact analysis.

Fourth, it was assumed that while the various effects of the LRRT project will be felt regionwide, their main domain of influence will be in the immediate corridor and the CBD. The focus here is on impacts in these two areas. Impacts on other areas are therefore discussed only when directly pertaining to the downtown impacts.

Lastly, we have assumed that the revitalization of the CBD depends, in addition to the LRRT impacts, upon public and private sector policies. These policies are of two types: reinforcing or conflicting with the LRRT objectives. The importance of this assumption lies in the fact that in Buffalo metropolitan area all development is not targeted to complement the transit investment. Development in other parts of the region, which occur through public sector incentives, may actually be conflicting with the LRRT objectives by attempting to serve the same market.

The methodological framework of the study was designed on the basis of these working assumptions. It is presented in Diagram 1. The diagram

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Diagram 1 here

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shows how major trends in the Buffalo region are combined with a set of models to analyze the LRRT impacts. These impacts are categorized into distinct groups which together influence the economic vitality of the CBD. In the following two sections we will elaborate on the principal components of the methodology, namely, underlying trends and models.

3. PRINCIPAL REGIONAL TRENDS

Three categories of trends are to be evaluated here to show how constraints are established for the estimation of transit impacts. These are demographic and employment, retail patterns and transportation. It should be noted that these trends are hardly unique to Buffalo; they have been present in many cities in the Northeastern part of the U.S. for the last three decades.

A. Population and Employment Trends: These variables most appropriately describe the state of the region's level of development and economic health. Table 1 shows the population and employment trends in Buffalo metropolitan area for the period 1950-1980.[1]

Table 1 here

From these, it is seen that the city population decreased from a high of 580,000 in 1950 to a low of 357,000 in 1980, a reduction of over 38 percent of the total number of city residents. While many of these people left the region altogether, a large portion simply left the city for the suburban areas. Yet, even on the county level there was an overall population decline between 1970 and 1980 of 100,000 residents.

Population changes are of course related to concurrent employment changes. Between the years 1970-1980 Erie County employment declined from 422,000 to 403,000 employees, while in Buffalo blue collar employment declined from 97,000 to 80,000 employees. The net employment figures have been affected by two phenomena: (1) outmigration of the labor force and (2) the addition to the labor force of household members who previously did not work.

A further analysis of the employment trend shows that in this period two major shifts in the employment make-up has occurred. First, while blue collar city employment dropped 17.7 percent between 1970 and 1980, service employment in the city has increased 47 percent during this

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[1]The city of Buffalo is within Erie County and Buffalo SMSA is made up of Erie and Niagra Counties. The study area is all SMSA, but major results of the anaysis discussed below pertain mainly to the metropolitan area (Erie County) and the CBD area (see map 1).

10-year period. These figures point to a trend of structural change in employment make-up where employment in manufacturing declines while that in services rises. A second and related major shift is the significant increase in the rates of participation by women in the labor force. In 1980, 40 percent of the total labor force in the metropolitan area were women compared with 35 percent a decade ago.

The importance of these trends lies in the fact that service-related jobs, in contrast with manufacturing, is the major industry category of the CBD. While the region has lost employment in the last decade, total employment in the CBD has remained stable. About 50 percent of total city's white collar employment is currently concentrated in the CBD area (GBDF, 1978).

Retail Patterns: As the city population and the manufacturing industry have been observed to have exited in great proportions from Buffalo to the suburbs and beyond, so too has another economic sector which by nature is dependent on being located in proximity to residential and employment areas, the retail industry. Historically the CBD enjoyed central roles with regard to retail and commercial activity, even though it has increasingly had to share its pre-eminence with the suburban areas over the decades. Over time, new construction of retail centers has taken place at an increasing rate at increasing distances from the inner city area. Retail malls have become progressively larger, both in terms of store space as well as parking spaces provided. It is for that reason that while in 1960 CBD sales were 27 percent of city totals and 15.7 percent of SMSA total sales, in 1977 the figures were 13.1 percent and 2.3 percent respectively.

A factor which seems to mitigate this trend is that patronage of some CBD retail outlets is rising in recent years mainly because of increases in the number of women who work at the CBD and also shop there. Nevertheless, the CBD area had over the years lost much of its retail dominance to the suburban areas, a fact which largely explains the decline in its economic viability. (GBDF, 1978)

Transportation Trends: The Buffalo metropolitan area has the familiar post-war pattern of circumferential and radial expressway system providing a high level of accessibility throughout the region and especially within the suburban area. With an excellent highway network surrounding and bisecting the entire region, there are virtually no heavy congestion points in the area in peak periods. This benefit can ironically be partially attributed to the fact that the network was designed and constructed for anticipated regional population increases.

The present public transportation bus network, operated by the Niagara Frontier Transportation Authority (NFTA), also provides good service mainly within the city limits. Current modal split figures are depicted in Table 2. The overall transportation picture which emerges is

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Table 2 here

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that of high level of accessibility throughout the region by private automobile coupled with a good inner-city transit system. The fact that most households live within 10 minutes of auto travel time from a major shopping center indicates that transportation services in Buffalo are presently adequate, and they provide high levels of accessibility to virtually every location in the region.

In summarizing the overall effect of these trends, three points should be recognized. First, the combination of population decline, an increasingly dispersed shopping pattern, and high levels of accessibility throughout the region have focused economic development and activity location away from the downtown. Second, current shifts of employment to white collar jobs in which women participate at high rates and the location of these jobs in the downtown indicate the potential of the CBD to capitalize on these conditions through future development. Third, given the current state of the transportation system, it is clear that the above non-transportation impacts are the crucial factors for CBD revitalization.

4. MODELS USED IN IMPACT ANALYSIS

In Diagram 1 it was shown that the set of impacts of the LRRT project is divided into four categories for analysis. Therefore with regard to model formulation and use in projection the principal models used in the analysis are, in part, impact specific.

The metropolitan region was subdivided into thirty-four zones for the purpose of the model analysis. Zonal division of the metropolitan area is depicted in part in Map 1, while the basic data on land use, population and employment are provided in Appendix A. Below are described the four principal models which are used in the analysis. Since the economic base model and the land use model are discussed in the literature in great detail, they are explained here only to the extent necessary to explain the various tests performed.

Economic Base Model: In addition to the nearly $450 million of federal and local investment in the LRRT itself (1978-1983), another $300 million of public and private investment, which directly relates to the construction of the system, is currently planned. Much of the investment in offices, a convention center, and a transit mall, tie their origins to a 1972 master plan for the city of Buffalo that considered the transit system in the center of Main Street to be the cornerstone of CBD revitalization. The impact of these investments on the Buffalo economy are likely to be realized through changes in the labor force directly related to the LRRT construction. These are of two types. The first is temporary and medium-term employment created by LRRT and related construction activities. The second is long-term employment created by the LRRT system and LRRT-related new facilities like those mentioned above. Additional labor force impacts are likely to arise in the service sector as explained below. These results are, of course, time dependent, as certain time lags exist between the date of an investment and the time its impacts become tangible. Other impacts from the investment relate to regional income which is likely to rise and, in turn, affect local expenditures.

An economic base model was used to evaluate these impacts.[2] The model asserts that new non-services employment will generate demand for services of various types. These additional services, in turn, will

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[2]Oppenheim (1980) provides a good review of this model and its theoretical underpinnings.

create more jobs in the service sector, which subsequently will generate further demand and jobs in services. These additional increments of employment which represent the employment multiplier effect and which were initiated by the LRRT total (direct and related) investment, are also used to compute the consequent increases in population and in regional income.[3]

Accessibility Model (ACCESS): The ACCESS model was designed to measure the change in total accessibility within the Buffalo area on a zonal basis due the construction of the LRRT system. Accessibility is defined here as a combination of interzonal travel time and zonal activity level, and it is separately calculated for shopping and work activities. As these two trip types often occur at different times, peak and off peak travel times by mode were used for computing changes in zonal total accessibility.

The model is a derivative of Davidson's (1977) model. Total accessibility of a zone, X_i, is assumed be to composed of three factors

$$X_i = X_i^I + X_i^T + X_i^C \qquad i = 1,\ldots,N \qquad (1)$$

where X_i^I = intrazonal accessibility of zone i; X_i^T = interzonal accessibility of zone i by transit; X_i^C = interzonal accessibility of zone i by auto. These latter two components are computed as gravity functions of the type

$$X_i = \sum_j a_j \exp(-\beta d_{ij}) \qquad i,j = 1,\ldots,N \qquad (2)$$

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[3]An independent input-output model for Buffalo (Dickson, 1978) gave values for the economic base model's coefficients.

where a_j is level of attractiveness of zone j, $(j \neq i)$, d_{ij} is travel time between i and j, and β is an impedance parameter.

Let $X_i^{(1)}$ = Accessibility before LRRT; and $X_i^{(2)}$ = Accessibility after LRRT. Then change in total accessibility for service purpose[4], ΔS, for zone i, is

$$\Delta S_i = \frac{1}{\gamma} O_i \left[\ln \frac{X_i^{(1)}}{X_i^{(2)}} \right] \qquad i = 1,\ldots,N \qquad (3)$$

where O_i = number of households in zone i, (H_i) times their trip rate (h), i.e., $O_i = H_i h$; and γ = impedance parameter for interzonal shopping trips. Change in total accessibility for work purposes, ΔW, for zone i, is

$$\Delta W_i = \frac{1}{\lambda} D_i \left[\ln \frac{X_i^{(1)}}{X_i^{(2)}} \right] \qquad i = 1,\ldots,n \qquad (4)$$

where D_i = number of employees in zone i (E_i), times their trip rate (e), i.e., $D_i = E_i e$ and λ = impedance parameter for interzonal work trips. Total summation over all of (3) and (4) show total change in service and work accessibility due to LRRT regionwide.

The input data needed for the accessibility model consists of base year data to measure current (pre LRRT) accessibility, $X_i^{(1)}$, and future year (1985) data, to measure post LRRT accessibility level, $X_i^{(2)}$.

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[4]When the model was run, retail activities were used as a surrogate for service activities. Henceforth, in the paper, they will be used interchangeably.

A Shopping Probability Model: A major indicator of the impact of the transit investment, especially in the CBD area, is the consequent change in level of retail activity. In the Buffalo case it is hypothesized that the construction of a LRRT system connecting the city fringe with the downtown will enhance shopping in the CBD which will be manifested in higher levels of retail trips and sales. To evaluate this hypothesized impact of the new transit system, it was necessary to develop and calibrate a model which simulates individuals' propensity to shop at a given shopping facility given their socio-economic characteristics, the set of all available retail facilities and accessibility variables. Afterwards, exogenous changes in the explanatory variables (like reduced travel times or increase in retail floor space) attributed to the LRRT investment, are introduced and their effects on the simulated shopping behavior are observed.

An underlying assumption in this model is that trip frequency to a given shopping facility represents individuals' choice probability of selecting that facility, given all other available retail outlets in other zones. Another assumption is that all individuals sampled have a common choice set of shopping facilities.

Three major determinants of retail trip frequency have been identified for analysis. These include, socio-economic attributes of the individual including income, car availability, and household size; attractiveness of the retail center including size (floor space), number of employees and volume of retail sales;[5] accessibility to the shopping

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[5]The selection of these variables emenates from a separate study carried out by the authors for that purpose (see Paaswell, Berechman, 1981).

center, mainly travel time. The statistical model which was finally estimated is:

$$\text{Ln } P_r^i = C + \alpha_k \text{Ln } H_{sk}^i + \beta \text{Ln } A_{rt} + \gamma L_{sr} \qquad (5)$$

where P_r^i is the trip frequency of total shopping trips of individual i to a shopping center, in location r; H_{sk}^i is the vector of <u>k</u> socio-economic attributes of individual i located in s; A_{rt} is the level of attractiveness measured by variable t, of center in r; L_{sr}^i is the measure of accessibility between residential location s, and shopping center r. C, a_k, β and γ are parameters to be estimated.[6]

<u>Urban Activity Model</u> (GLMOD): As explained above, the large investment in light rail transit is likely to impact land use, in addition to travel and shopping patterns. Since changes in the land use system are a major determinant of urban revitalization, there was a need to evaluate such changes in the entire study area and, in particular, in the LRRT corridor. The specific model used for this purpose is a derivative of the well-known Garin-Lowry model (Garin, 1966). It is based on Foot (1978), with a considerable number of analytical and empirical changes made to meet the particular needs of this study.

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[6]Notice that in model 5 frequency of travel to a shopping center in r is unaffected by any characteristic of other centers. Thus, competition between centers is not directly accounted for and the possibility that CBD shopping will gain because of changes in other centers is not considered. However, by requiring that, in the estimation of 5, $\sum_r P_r^i = 1.0$, competition between centers is introduced indirectly. See Paaswell and Berechman, 1981, on the theoretical background and development of this model.

The model assumes that the essential structure of a subregion can be described in terms of population and employment. By starting with a base year basic employment, the model will then simulate the base year distribution of total population and total (basic and service) employment in the subregion. For that purpose the model uses activity allocation functions which, for the residential location submodel, have the following general form:

$$T_{ij} = A_i E_i \exp(-\delta c_{ij}) \qquad i,j = 1,\ldots,N \qquad (6)$$

$$A_i = [\sum_j H_j \exp(-\delta c_{ij})]^{-1} \qquad i = 1,\ldots,N \qquad (7)$$

where T_{ij} is the number of employees traveling from work zone i to residential zone j, E_i is employment at zone i, H_j is the residential attractor for zone j, c_{ij} is generalized cost of travel from zone i to j and δ is an impedance parameter. The service location submodel employs a similar allocation function to compute the number of service employees demanded by the population of zone j who work at zone i.

The first stage in the model's operation is calibration in which the parameters of the above allocation functions are estimated. It is carried out in a way which provides the best fit between the observed and simulated distribution of activities. Following calibration, the variables within the model can be altered in order to test the impact of major changes in the subregion and to simulate the outcomes of policy alternatives. This is the prediction stage. The overall approach including the set of equations and analytical operation are well documented (see, Batty, 1976). The chart in Appendix B describes the various components of the model and its operation.

Several important points about this model should be noted. First, with regard to activity type, this model is highly aggregated. Households are not disaggregated by socio-economic characteristics while employment is categorized either as basic or service employment. This feature of the model, while it may be viewed as a major deficiency, nevertheless facilitates computations to a large degree. Also since the main focus in this study is the overall impact on the CBD area of a transit investment we did not view this lack of disaggregation of activities as a major problem for the interpretation of our findings.

A second point to be noted is that this model is a static model; it does not contain any time element. The spatial system is treated as if it were in a static equilibrium. As noted by Foot (1978), this enhances the models suitability for impact analysis since it allows a comparison of equilibrium distributions of activities.

Finally, this model allows for the imposition of constraints on zonal activity levels which reflect either physical limitations on land availability or density policies. Consequently , there is an additional step in the process which is the constraints procedure, and which can be introduced in the calibration and prediction phases of the analysis.

The models developed for the impact analysis form a comprehensive package that provides a variety of tools for investigating the range of LRRT impacts. In the following section the major tests performed and the results of the analysis are presented.

5. TESTS AND RESULTS

The methodology and models outlined above were used for the evaluation of the LRRT four impact categories, namely, investment, accessibility, shopping pattern and land use.

Investment Analysis Results: The first step in the investment analysis was to compute the new labor force which is the direct result of the LRRT investment ($450 million) and the LRRT-related investments ($300 million). Taking 65 percent of these investments to generate long-term employment, a new labor force of 5,370 workers was computed. These calculations are based on labor prodcutvity rates of capital expenditures on labor and material (i.e., number of employees per 1 million dollar investment) and the estimated yearly capital expenditures.[7] This employment figure was then introduced into the economic base model in order to project increments of population (P) and dependent service employment (S). Using the 1980 county ratio of residents to employees (2.5 from Table 2). The results were 25,576 and 4,800, respectively.

If we assume that of the 5,370 additional labor force only 75 percent will be new employees then P = 19,050 and S = 3,620. Based on these figures it is expected that total net increase in population due to the LRRT will be in the range of 19,000 to 25,000 people, while the net increase in total employment will be 7,000 to 10,000 employees. In terms of income generated, the above capital expenditure is expected to generate $1,040 million in regional income over the LRRT investment's period (1978-1985).

[7]The figures used in this analysis of the new labor force generated by the LRRT project are from Dickson, 1978 and NFTC, 1977.

Accessibility Model Results

From models (3) and (4) above, accessibility indices were computed for each zone for the current (pre LRRT) and projected year (post LRRT). The pre LRRT interzonal travel time matrices were computed using actual network data and information on bus service including bus frequencies, location of stops and routes. The after LRRT travel times were computed on the assumptions that the actual light rail travel times and bus operation parameters will be as those indicated by the system's planners. When number of households is set equal to unity for each zone ($O_i = 1$, $i = 1,\ldots,N$) in model (3), its impact on the model is neutralized. The results then indicate the level of accessibility for service trip purposes measured by time units only and for presentation purposes are labeled here "time accessibility." Otherwise, the results are labeled as "total accessibility." A similar approach was applied for work trips. The post LRRT Information on O_i and D_i as well as the parameters γ and λ, were obtained from the land-use model.

The results of measuring time and total accessibility before and after LRRT, for work and service trip purposes were used to rank the study zones from most accessible (rank 1) to least accessible (rank 34). These results are given below in Table 3.

Table 3 here

A number of points should be observed about these results. First, there are major differences in the accessibility of a zone for work trip purpose and service trip purposes. Not only are work trips carried out mainly at peak times while service (shopping mostly) trips are done mainly at off-peak times, but modal split also differs for these trips, so that more transit trips are done for work purposes at peak time.

A second point is that for both trip types there are differences in the resultant rankings between time accessibility and total accessibility. However, within each trip type and accessibility measure there is almost no change in the ranking of the zones before and after the introduction of the LRRT. The principal implication of these results is that relative accessibility, however measured, for a given trip type, will not change significantly after the LRRT system begins operation.

Another point worth observing is that the zones which are most accessible for work are suburban zones (for reference, see Map 1). The explanation is that these zones are serviced quite adequately by major highways and roads and that they contain a relatively large number of trip generating activities. The CBD on the other hand (zones 1, 2) is ranked medium for work trips--mainly due to the bus system which provides high level service to this area, and the high concentration of employment activities there. For service trip purposes these zones will still have low to medium level of accessibility after the LRRT mainly because most shopping trips are carried out using the car. Note however, the impact of activity level on total accessibility rank of the CBD. Whereas zones 1 and 2 are ranked 34 and 32 respectively for service purposes on the time accessibility scale, they are ranked 23 and 17 respectively on the total accessibility scale. The latter scale contains the impact of zonal activity level.

Those zones in the study area with current high accessibility levels gained little with the introduction of the LRRT, while those zones adjacent to the LRRT corridor gained the most. However, these gains were not substantial enough to offset the high accessibility of suburban zones already well served by an extensive highway network.

The results of the Accessibility Model runs lead to the following conclusions:

First, total accessibility and time accessibility will change but very moderately by the construction of the LRRT system.

Second, given the planned route of the LRRT system, trip makers in most zones not immediately adjacent to it will still use the highway system or the current bus system in their daily trips. Hence it is very unlikely that current modal split ratios will change significantly once the system is in full operation.

Third, given the results regarding the actual changes in the levels of accessibility in the zones adjacent to the LRRT route, it can be expected that for a special portion of the public residing in those zones, there will be a significant increase in actual and perceived accessibility. Those inner city residents who do not own an automobile, or who are considered to be transportation disadvantaged (elderly and handicapped) should get the most benefit of improved accessibility first to the CBD and eventually to the region.

Fourth, since travel times in the post LRRT period will not be greatly improved, the only way the CBD can increase its share of shopping and employment is if other characteristics which affect level of attractiveness are improved.

Shopping Analysis Results

Recall that this model (5) contains variables of three types: households' socio-economic characteristics, accessibility and attractiveness of a shopping facility. The socio-economic variables used were level of household's income and car availability. Input information for these variables was obtained in the survey of shopping patterns in Buffalo (Paaswell et al., 1979). Location of households and their preferred shopping centers were also obtained from this survey.

The accessibility measures used in the analysis were travel times by private car and by transit. In addition, it was necessary to determine which areas will be included as shopping destinations, as it was assumed that the CBD competes directly with major shopping centers, and not with local or neighborhood stores. Thus, for the analysis the entire Buffalo metropolitan area was divided into four "super" retail areas namely CBD, Other City, Suburban Malls and all others. The attractiveness variables selected for the model were: number of retail establishments in an area, total square feet of retail space, total number of retail employees and total retail sales.

Seven principal tests were carried out. For these runs the following symbols are used: C = regression's constant; β_1 = household income coefficient; β_2 = car availability coefficient; γ = coefficient of an attractiveness variable (AT); δ = coefficient of an accessibility variable (AV); N = number of observations in a given test. F = F test for regression. Unless indicated as "not significant" (NS), and except for δ all coefficients were significant at 0.01 level (t-test). Below the 7 tests are defined. AT and AV are for all runs as in test 1.

Test 1: the entire 246 observations were used. AT = floor space in Sq. feet, and AV = combined auto and transit travel times.

Test 2: households with income categorized as low income.

Test 3: households with income cateogrized as high income.

Test 4: households which shop downtown and live inside the city.

Test 5: households which shop downtown but live outside the city.

Test 6: households which shop at suburban malls and reside in suburban zones.

Test 7: households which travel less than 20 minutes for shopping.

The results of these tests are reported in Table 4.

Table 4 here

Several key points should be observed. In all the 7 tests, the value for the accessibility coefficient, δ, is insignificant and small. It should be noted that 91 percent of the sampled households live less than 20 minutes from their selected areas of shopping. Given the distribution of shopping centers in the region, travel time variables were found not to affect households' shopping choices in Buffalo. Put alternatively, improved travel times would not alter prevailing shopping choices, holding constant all the other independent variables.

The only variable whose coefficient is significant for all of these runs is level of attraction of the shopping area. This result is extremely important in the context of the present analysis as it implies that a positive impact of the LRRT on the level of attraction of the downtown may in fact cause a greater proportion of households to shop there. Below we further elaborate on this result in conjunction with the results of the other models. Here it will suffice to conclude that any increase in the share of the CBD in the regional retail activity through the LRRT, is conditional upon the degree to which the system will increase the CBD attractiveness as a shopping area by generating more and better retail outlets and not upon the CBD's relative level of accessibility. In that respect, the results of the accessibility model which indicated that the LRRT will have little if any impact on the relative accessibility of the CBD, may not diminish the importance of the LRRT system as a potential factor in improving the CBD attractiveness.

Land Use Model Results

The major inputs to the model included basic and non-basic employment, residential population, land availability, activity multipliers, employment and residential density constraints, and employment and shopping travel times all disaggregated by zone. Appendix A presents some of this information.

Following calibration, the model was used to predict the impacts of a large number of changes generated by the LRRT system. The results of two runs, which directly relate to our objectives here are given below. The first is a test for the impact of the LRRT total direct investment only while the second is a test for the overall impact of the project.

a. Prediction of Investment Effect: The direct effect of the investment is to increase basic employment. The additional basic employment as computed above from the economic base model, was introduced into the land use model, and the resultant vectors of population and employment distributions were observed. These results in terms of percent changes from original (base year) data, are reported in Table 5.

Table 5 here

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b. Prediction of Overall Impact of LRRT: In this prediction run the effects of the investment, of changes in the zonal level of attraction for activity location (mainly services) and of changes in accessibility were simultaneously introduced into the model. The predicted percent change in the distribution of population and employment are reported in Table 5.

These results indicate that the impact of the investment factor alone is to increase service employment in the CBD (zones 1 and 2) while reducing residential population there. However, since total population in these zones is currently small, this latter effect can be ignored. On the other hand, base year level of service employment in the CBD is the highest in the region (45,687 employees). Thus, the predicted 34 percent increase implies an addition of 15,330 employees which, in itself, is larger than any amount of service labor at any other zone, at the base year. The planned commercial and retail facilities in the CBD discussed above are the main sources for this new service employment.

The predicted population distribution from the total impact of the LRRT suggests a similar decline of residents in the CBD. A more dramatic result is the large increase in population in major suburban zones (e.g., zones 21, 22, 23, 27). This additional population, which is generated by LRRT related employment, is allocated by the model in these zones for reasons similar to those which underlie the long-run trends of suburbanization. These include greater availability of residential land, lower densities and high levels of accessibility.

With regard to service employment, the results of the total impact test again show that the CBD is bound to benefit most from the LRRT system. This large gain (over 100 percent) is mainly because of the increase in attractiveness of zones 1 and 2 for services, which corroborates the results obtained before, from the other models. The new service employment is consistent with anticipated development. In addition, the analysis shows a high percent increase in service employment in zone 18, which is located at the northern end of the LRRT route (Map 1). This also indicates the positive effect of the system on the attractiveness of zones, but because of the relatively small number of service employees in the base year in this zone, the implications of this result are limited.

The final set of results to be observed pertains to the impact of LRRT on zones immediately adjacent to its corridor. With regard to population, the current trend of population decline is not going to be reversed. Moreover these adjacent zones are also not going to benefit much from the LRRT with regard to service employment. In contrast to the CBD zones, where the bulk of the physical development is planned, only very limited development which is related to the LRRT will occur in those zones. When coupled with the virtually no change in accessibility levels after the LRRT implementation, this lack of development explains the results for the adjacent zones.

Overall Downtown Results of LRRT

From the results presented in this section, the following major conclusions can be stated.

A: Economy of Downtown: The LRRT is expected to have a positive impact upon the economy of the downtown. This is seen in two ways. First, it will increase service employment. Secondly, it will stimulate private investments, which are related to LRRT construction.

B: Accessibility of Downtown: The accessibility of downtown to all other zones by mode and trip type will not change significantly after the LRRT construction.

C. Shopping at Downtown: If, as projected, the LRRT will have positive impact on downtown attractiveness, a larger share of the regional retail trade will be captured by the CBD, all other factors remaining the same.

6. POLICY CONCLUSIONS

All the potential positive impacts of the LRRT on the CBD, discussed above amount to a necessary but not a sufficient condition for CBD revitalization. The principal reason is that non-LRRT public policies may enhance or conflict with these benefits and thus reinforce or depress CBD revitalization by the LRRT. Some of the simulation-prediction runs of the land-use model were in fact tests of such policies. For example, the introduction of service zoning restrictions tended to decrease the amount of new service employment predicted by the model for the CBD area.

The ability of the LRRT system to bring a large number of people to the CBD in short intervals is one thing. What these people will do there is still another issue. The significant impact of the LRRT on the attractiveness of the downtown is mainly due to a massive physical development in a well-defined small area. But attractiveness of an area is also determined by features like variety and quality of activities, personal safety and comfort, ease of access to retail outlets, and additional developments of real estate. All these issues are affected by urban public policies, and as a result, it is apparent that proper private and public sector programs are necessary to ensure these features.

The lack of regional or even city-wide coordination of policies to ensure the attainment of the LRRT objectives is probably the most serious threat to the revitalization of the downtown. Highway, parking and transit policies are examples of this problem. Since the LRRT route does not extend to the suburbs, suburbanites who wish to use the system need to drive and park their cars at the nearest LRRT station. Given that so far no parking facilities have been planned and that the highway system provides adequate access to the CBD, no significant changes in modal split can be expected. Moreover, express buses which operate between suburban zones and the downtown also reduce the effectiveness of the new system. Still another example of the consequences of lack of policy coordination is the concurrent development of retail and commercial facilities in suburban zones. Even though this development is not as massive as that at the downtown, the proximity of these facilities to residential population is likely to counterbalance the positive impacts of the LRRT on the attractiveness of the CBD.

The Buffalo transit development was consistent with a 1972 downtown plan that linked CBD access via rail to downtown renewal. However, related investment projects, like a new hotel, new office buildings, and a pedestrian mall which integrate travel with adjacent activities were not begun until transit construction funds were secure. In this sense, more than many other urban projects, the impact of transit investment, and the stimulus that transit provide through its interaction with other activities, are seen as the main determinants of CBD revitalization. Thus the general lesson from this study is that capital investment must be targeted and the implications of investment--land development, employment increase and location of service facilities--must be clearly determined and enforced through complementary policies.

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APPENDIX A

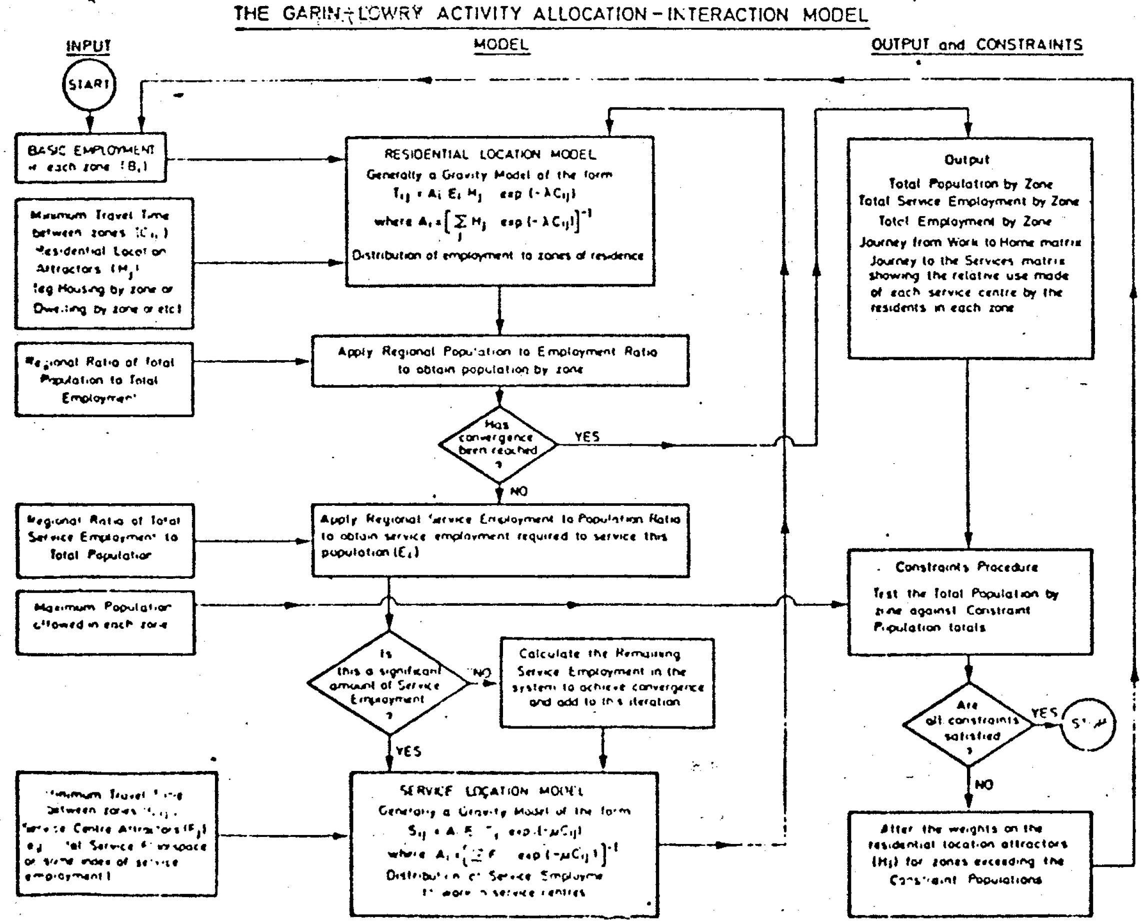
Basic Information on Study Area

	Total Area(mi^2)	Unusable Land	Basic Industry Land	Retail Industry Land	Resi-dential Land	Vacant Land	Popu-lation (1972)	Population Density (residential land only; persons/mi^2)
1	1.34	0.71	0.08	0.24	0.12	0.19	7,415	61,792
2								
3	1.70	0.92	0.05	0.07	0.65	0.02	26,374	40,575
4	1.31	0.51	0.03	0.21	0.54	0.03	19,559	36,220
5	0.92	0.34	0.03	0.06	0.46	0.04	16,582	36,048
6	1.07	0.44	0.09	0.07	0.34	0.13	13,584	39,953
7	1.79	0.63	0.41	0.09	0.48	0.18	20,696	43,117
8	2.08	1.21	0.12	0.06	0.58	0.10	27,800	47,931
9	1.74	0.92	0.03	0.07	0.70	0.02	21,724	31,034
10	3.10	0.93	0.87	0.19	0.93	0.17	30,465	32,758
11	3.60	1.44	0.36	0.18	1.51	0.11	34,498	22,846
12	5.01	2.00	0.35	0.25	2.25	0.15	62,761	27,894
13	4.16	1.29	0.67	0.21	1.83	0.17	68,304	37,325
14	4.67	1.12	1.59	0.19	1.17	0.61	36,680	31,350
15	9.69	1.07	4.17	0.19	1.65	2.62	15,962	9,674
16	8.91	0.80	0.27	0.62	7.13	0.09	84,258	11,817
17	6.52	2.61	0.78	0.26	2.54	0.33	11,886	4,680
18	6.89	0.28	0.76	0.55	5.03	0.28	34,623	6,883
19	6.19	1.73	0.25	0.12	3.84	0.25	40,486	10,543
20	6.30	0.38	2.14	0.38	2.39	1.01	25,462	10,654
21	10.03	1.91	1.60	0.50	4.71	1.30	50,054	10,627
22	7.37	0.15	3.02	0.07	1.70	2.43	13,048	7,675
23	11.58	0.93	4.52	0.12	1.74	4.17	15,222	8,748
24	10.27	2.26	0.82	0.41	6.16	0.62	29,237	4,746
25	34.29	2.06	25.03	0.34	4.46	2.40	28,024	6,283
26	38.53	1.93	26.20	0.19	2.12	8.09	5,946	2,805
27	32.85	3.94	1.64	0.33	4.27	22.67	17,278	4,046
28	29.87	1.78	13.05	0.89	3.56	10.38	79,223	22,254
28a	8.90	0.36	4.90	0.09	0.71	2.85		
29	21.37	1.50	2.99	0.64	8.98	7.27	50,692	5,645
30	9.87	3.75	2.86	0.20	1.97	1.09	47,791	24,259
31	5.69	0.40	2.16	0.23	2.11	0.80	24,914	11,808
32	31.40	1.57	8.79	0.63	9.42	11.00	35,338	3,751
33	48.78	2.93	15.12	0.49	7.32	22.93	40,058	5,472
34	4.96	0.50	1.64	0.29	1.59	0.94	19,151	12,045
City of Buffalo	42.36	16.21	7.54	2.09	13.53	3.01	436,506	32,262
Total Study	382.75	45.30	127.39	9.43	94.96	105.44	1,055,095	11,111

Source: Paaswell, R. and Berechman, J. (1981).

APPENDIX B

THE GARIN-LOWRY ACTIVITY ALLOCATION-INTERACTION MODEL



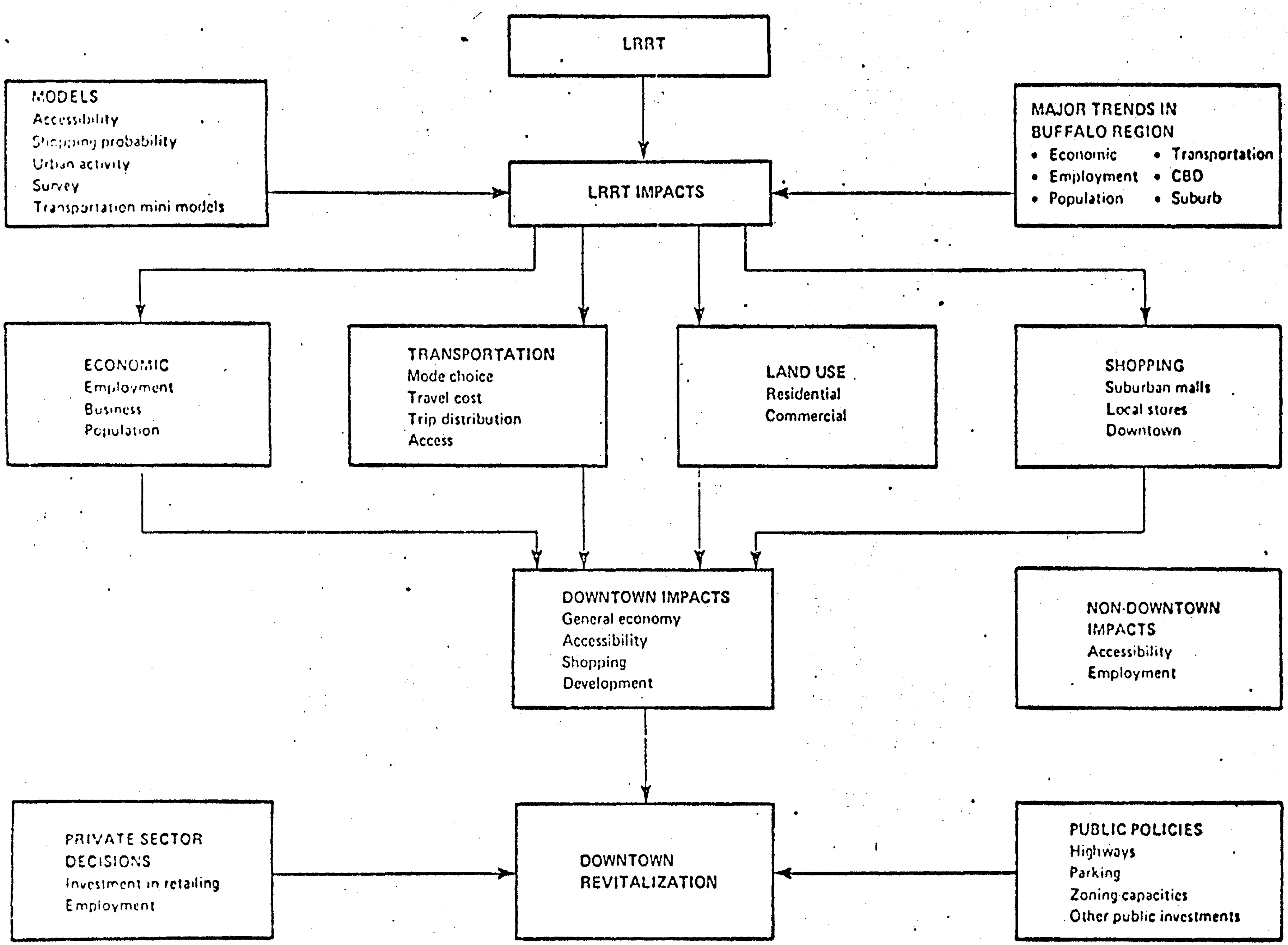
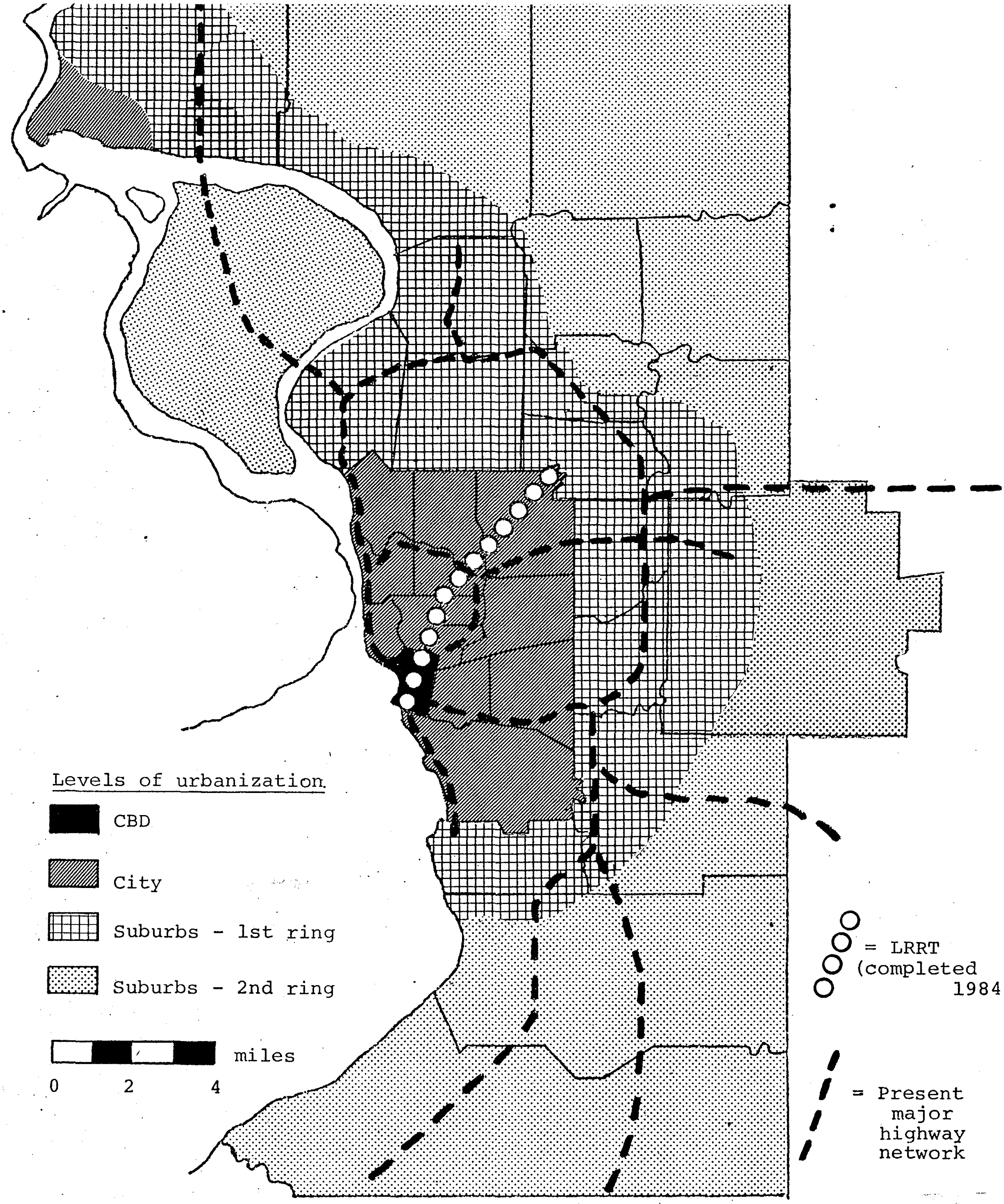


DIAGRAM 1

METHODOLOGICAL FRAMEWORK OF JOINT DEVELOPMENT ANALYSIS



Map 1
Light Rail Transit and Development Patterns - Buffalo Metropolitan Area, 1980

TABLE 1

Population and Employment Trends in Buffalo Metropolitan Area 1950-1980[a]

	BUFFALO (CITY)					ERIE COUNTY (including Buffalo)				
	POPULATION	TOTAL EMPLOYMENT	% UNEMPLOYMENT	BLUE COLLAR EMPLOYEES	WHITE COLLAR EMPLOYEES	POPULATION	TOTAL EMPLOYMENT	% UNEMPLOYMENT	BLUE COLLAR EMPLOYEES	WHITE COLLAR EMPLOYEES
1950	580,132	232,371	6.7	132,726	93,626	899,238	350,033	5.7	199,025	142,505
1960	532,759	198,285	8.5	105,626	77,929	1,064,688	389,062	6.7	195,210	170,472
1970	462,768	171,880	6.0	97,266	72,852	1,113,491	422,179	4.7	214,122	204,998
1980[b]	357,002	187,467	7.1[b]	80,003	107,464	1,013,373	403,148	6.7[b]	185,863	217,285

SOURCE: U.S. Census, Population and Housing, 1970.
Erie and Niagara Counties Regional Planning Board, 1975.

[a]SMSA population in 1980 is approximately 1,300.000.

[b]Estimates

TABLE 2

Percent Transit Use Peak/off Peak, City, Suburbs

Destination \ Origin		City	Suburban
City[a]	peak	12	7
	off peak	5	4
Suburban[b]	peak	7	4
	off peak	4	3

[a]City of Buffalo only (see map 1).

[b]First ring (see map 1).

Source: Paaswell, R. and Berechman, J. (1981).

TABLE 3

Comparison of Zone Rank by Time and Total Accessibility for

Work and Service Trips, Before and After LRRT

Zones	Rank Before Time Access		Rank After Time Access		Rank Before Total Access		Rank After Total Access	
	Work	Service	Work	Service	Work	Service	Work	Service
1	16	34	15	34	12	25	13	23
2	14	32	16	32	14	16	14	17
3	30	16	29	16	31	15	31	18
4	27	14	24	14	25	19	24	20
5	17	24	14	24	20	18	17	14
6	22	26	22	26	21	21	19	19
7	28	20	28	20	28	20	28	21
8	24	17	26	17	26	24	27	26
9	13	22	13	22	16	17	15	13
10	29	13	30	13	29	27	29	28
11	20	9	18	9	23	26	18	22
12	18	4	17	4	15	14	16	16
13	23	2	25	2	22	13	25	15
14	32	10	32	10	30	29	30	29
15	25	27	27	27	17	31	20	21
16	31	1	31	1	21	23	32	25
17	26	31	23	31	27	33	26	33
18	21	11	20	11	24	28	23	27
19	15	8	19	8	18	22	22	24
20	19	21	21	21	19	30	21	31
21	5	6	5	6	5	2	5	2
22	3	30	3	30	4	6	4	7
23	2	29	2	29	2	5	2	5
24	1	18	1	18	1	4	1	4
25	11	23	11	23	9	10	10	10
26	8	33	9	33	8	12	9	12
27	4	28	4	28	6	8	6	8
28	7	3	7	3	3	1	3	1
29	6	7	6	7	13	3	7	3
30	33	5	33	5	34	32	34	30
31	34	19	34	19	33	34	33	34
32	9	15	8	15	7	7	8	6
33	10	12	10	12	10	9	11	9
34	12	25	12	25	11	11	12	11

TABLE 4:

Coefficients Estimation of the Shopping Probability Model, 7 Tests[a]

Run	N	C	β_1	β_2	γ	δ^b	F	r^2
1	246	-1.137	-.122	.338	.368	0.02 (0.50)	98.1	.549
2	95	- .957	NS	.322	.209	-0.43 (0.67)	17.7	.278
3	151	-1.727	-.151	NS	.438	-0.01 (0.72)	298.4	.667
4	113	-1.063	NS	.552	.229	-0.31 (0.90)	23.1	.296
5	133	-1.710	NS	NS	.436	-0.11 (0.15)	275.0	.677
6	106	- .768	NS	NS	.181	-0.07 (0.65)	286.2	.734
7	225	-1.205	-.112	.374	.380	0.02 (0.55)	97.5	.570

[a]NS = not significant at 0.01 level

[b]Because of the importance of these coefficients for the analysis we report their estimates and standard errors. None is significant at 0.01 or 0.05 level.

TABLE 5: Results of Two Prediction Runs of Land Use Model

Investment Impact			Total Impact		
ZONE	percent change in population	percent change in employment	ZONE	percent change in population	percent change in employment
1	4.3	34.4	1	10.2	-.2
2	-54.2	34.4	2	-59.5	105.6
3	-20.8	35.0	3	-31.6	-2.9
4	0.03	5.7	4	5.6	22.8
5	-25.1	10.3	5	-33.6	-8.4
6	-64.9	0.4	6	-68.3	-5.0
7	-15.7	-0.2	7	36.0	18.8
8	56.5	10.2	8	34.2	-7.1
9	-2.5	19.9	9	2.9	21.8
10	14.3	19.1	10	0.2	1.0
11	1.7	21.3	11	7.4	7.1
12	1.1	31.8	12	6.7	16.5
13	-10.2	19.6	13	26.2	20.1
14	10.2	-4.8	14	25.4	15.7
15	48.1	37.1	15	36.9	33.8
16	4.0	38.5	16	1.3	36.8
17	7.1	40.1	17	13.1	88.8
18	0.05	50.2	18	5.6	103.5
19	0.9	52.6	19	6.6	55.9
20	30.4	43.1	20	42.5	46.6
21	82.0	19.3	21	59.3	15.6
22	89.2	15.6	22	67.6	9.3
23	125.6	20.3	23	99.3	46.2
24	4.3	29.2	24	10.1	15.5
25	24.8	-16.2	25	10.4	-21.7
26	78.3	31.9	26	58.5	-30.5
27	119.8	-1.1	27	92.6	-20.3
28	-5.2	6.7	28	0.1	39.7
29	-5.2	20.5	29	0.1	25.6
30	56.4	8.2	30	38.9	-27.3
31	114.8	21.0	31	93.2	11.7
32	78.0	6.3	32	63.2	18.6
33	79.4	-5.3	33	67.3	5.0
34	1.5	-34.0	34	-11.1	