Methodology for Assessing Local Land Use Impacts of Highways

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A methodology to project and evaluate the potential land use impacts of a proposed limited-access highway extension in the Rochester, New York, metropolitan area is described. The analysis, the result of a 1-year consultant study for the New York State Urban Development Corporation and local sponsors, examined the potential impacts of linking the towns of Brockport and Albion, west of Rochester, to the Rochester central business district (CBD) via an extension of Route 531. An important constraint that affected the selection of assessment methodologies was the relatively modest amount of time and resources available for the study. This type of resource constraint, which was probably the norm for planning studies, precluded the development of a grand land use/transportation modeling effort in the style of the National Bureau of Economic Research Study, Puget Sound, or Bay Area Simulation pioneered several decades ealier. It required instead the use of methodologies or models that would not require enormous amounts of data, time, or effort to calibrate. The approach used to project potential residential location decisions was to develop a gravity model of residential location. In general, gravity models, when applied to residential location, require calculation of accessibility index scores for subareas that are then used to reallocate a region-wide growth projection to the subareas. The key advantage of this approach was that it was sensitive to changes in travel times between residential zones and major employment nodes. A qualitative approach was used to evaluate business impacts. The basic methodology involved a review of the competitive advantages of the area with and without the highway extension that included surveys of businesses inside and outside the Brockport-Albion corridor. A separate region-wide marketing analysis was performed to assess retail development possibilities in the Brockport-Albion corridor.

Western Monroe County and eastern Orleans County in upstate New York are economically linked to the city of Rochester, but lack adequate highway access to that urban center. Route 31, which is the main roadway connecting Spencerport, Brockport, and Albion to Rochester (Figure 1), is a two-lane road that is used heavily and is often congested. In addition to commuters working in Rochester, students and employees at the State University of New York at Brockport are also major users of Route 31. Trucks headed to and from industries in western Monroe and eastern Orleans counties also add to the roadway congestion.

The need for a new roadway in this area was recognized as long ago as the late 1960s and an expressway was included in transportation plans prepared in the 1960s and 1970s. In 1978, the Western Monroe County Transportation Study examined the expressway issue once again. A total of 26 transportation alternatives were evaluated for the area and a new expressway was recommended to connect I-490 with Washington Street in the town of Ogden. However, an extension further west as far as Brockport could not be justified by the New York State Department of Transportation (NYSDOT), primarily because of projected traffic volumes.

The first extension of Route 531 (as the new expressway was designated) was completed in 1986 for the 1-mi stretch between Elmgrove and Manitou Roads. The remainder of the state-approved Route 531 extension, from Manitou Road to Washington Street, is a high-priority project for the NYSDOT. In July 1988, money was appropriated in the state budget for final design of this extension. Construction of the roadway could begin as early as 1990.

Extension of Route 531 beyond Washington Street may take several more years to be built, if it is built at all, because of the NYSDOT recommendation that the road could not be justified on the basis of projected traffic levels. Many local legislators, business people, interest groups, and individuals believe, however, that such a policy does not recognize the development situation in the Brockport-Albion corridor and ignores current and future economic conditions. At local urging, the state legislature appropriated funds to the New York State Urban Development Corporation for a study to evaluate further westward extension of the highway—to the town of Brockport and possibly to Albion—from an economic development perspective.

The Brockport-Albion Highway Economic Impacts Study was commissioned because, despite the NYSDOT's conclusion that the full roadway could not be justified by potential traffic levels on the basis of current conditions, the economic development that might occur once the roadway was constructed might generate enough traffic to make the road necessary. Recent closings of two major manufacturing plants in Brockport added to the concern about local growth, job creation, and increased local tax base.

RESIDENTIAL IMPACTS

With the construction of the highway, the Brockport-Albion area would become, at least in one dimension, a more attractive residential location because of improved access, i.e., reduced travel times to places of employment, recreation, and educational facilities.

Several possible formal methodologies, identified in the planning literature, might have been used to identify and define this effect. One approach was to calibrate a statistical model, such as a multiple regression model, which relates changes in residential densities to changes in travel time, while holding other neighborhood characteristics constant. Calibra-

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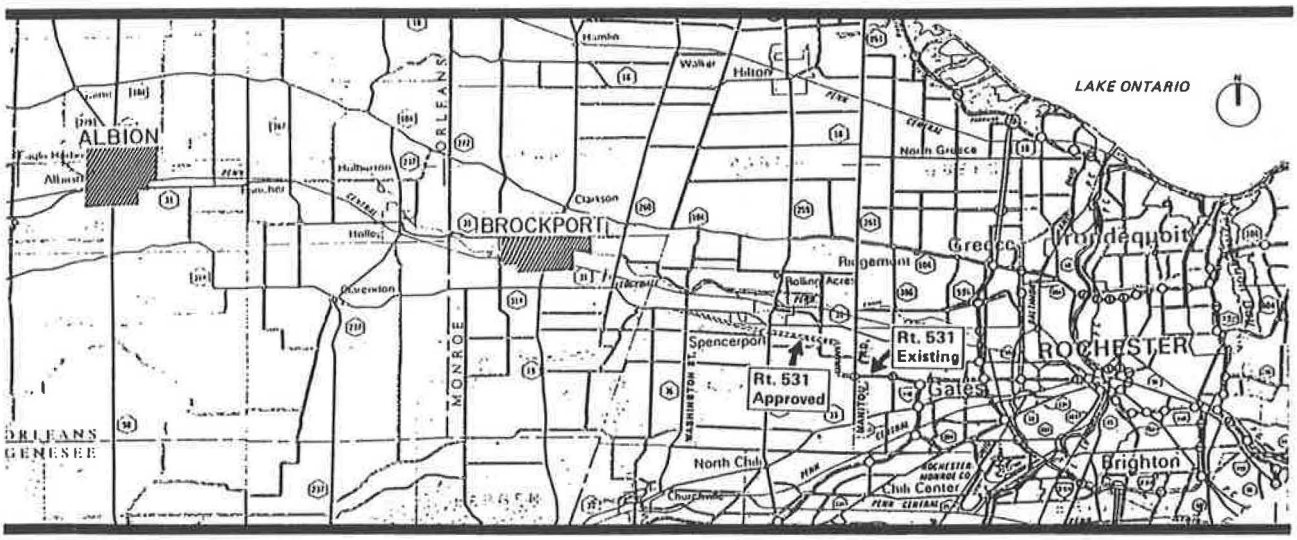

FIGURE 1 Brockport-Albion highway economic impact study area.

tion is made using an analog corridor within the same region that experienced a similar highway improvement at an earlier date. This approach requires compilation of a substantial data base and time-consuming calibration of a prediction equation, including the appropriate model specification.

A second and far simpler approach was to use one of several possible formulations of a gravity model. In general, gravity models, when applied to residential location in a region, require calculations of accessibility index scores for subregions, that are then used to reallocate projected region-wide growth to the subregions. Accessibility index scores are a function of composite-weighted travel times to the downtown core and to other major employment centers in the region. Other factors that affect residential expansion and density, such as availability of developable land, are also taken into account. From a formal demographic standpoint, the gravity model seeks to gauge the impacts of transportation access on the migration component of population change.

In studies of this nature, where serious time and resource constraints prevail, the gravity model approach offered two major advantages. First, it did not require calibration of a statistical model but instead required only one empirical parameter with a typical value that has been established by previous studies. Second, it allowed the analyst to relate changes in travel time in a highway corridor to changes in population. Therefore, it was the approach used in the study.

A review of the literature pointed to the Hansen formulation of the gravity model as the basic form to be used for the study (*1*,*2*). The basic form of this model states that

$$G_j = G_t \frac{L_j A_j}{\sum_{i=1}^{n} L_i A_i} \tag{1}$$

where

G_j = population growth increment allocated to subregion j;
G_t = total growth projected for the region;
L_j = developable land in subregion; and
A_j = travel time to employment centers from subregion j.

A basic assumption of the gravity model is that the overall regional population projection, generally an official county-level forecast, would remain constant. In effect, the overall regional projection is treated as a stable control total within which small area projections are allowed to vary.

The value A_j is a composite weighted (inverse of) travel time between the subregion j and all subregions, where the weights are the number of jobs (employees) in each subregion. A typical formulation would be

$$A_j = \sum_{i=1}^{n} \frac{E_i}{T_{ij}^a} \tag{2}$$

where

E_i = employment in each subregion,
T_{ij} = the travel time between subregion j and the other subregion, and
a = exponential time-impedance parameter, usually equal to about 2.0 in most applications of this technique.

The A_j value can be referred to as an accessibility index score.

Of course, other factors in addition to accessibility and developable land capacity can influence the growth share, such as net natural increase, anticipated economic growth, land use controls, infrastructure, tax rates, and local public services. Thus, the basic gravity formulation of Equation 1 can be extended by substituting a product of causal factors that interacts with accessibility for the single vacant land (L_j) factor:

$$V_j = (V_a \times V_b \times V_c \times \ldots) \tag{3}$$

Therefore, the baseline growth share for each subregion can be reformulated as follows:

$$G_j = G_t \frac{V_j A_j}{\sum_{i=1}^{n} V_i A_i} \tag{4}$$

where V_j represents a product of attributes that interacts with accessibility and affects residential population.

As a practical matter, application of the gravity model technique, as formulated in Equation 4, requires that municipalities be regarded as the subareas. The analyst must then compute changes in each town's A_j score so that revised growth shares for each town can be derived and applied to the regional population projections.

To apply the gravity model, it was not necessary to measure the individual elements of V_j explicitly for each town in the study area. Instead, it was reasoned that the V_j values could be computed on the basis of existing official town population projections because these projections could be assumed to already take into account the various factors of V_j that affect local population change. In particular, once baseline A_j values are calculated, it becomes possible to derive implicit values for V_j. Further, by separating out these V_j values it becomes possible to empirically compute changes in the A_j scores with the highway extension while holding the V_j values constant. In effect, the procedure allows the analyst to run the gravity model by varying the accessibility scores while holding all other influences constant.

For the study, a no-highway-improvement baseline was first established. This baseline was calibrated to correspond to the latest set of town population projections for the Rochester region prepared by the New York State Department of Environmental Conservation (NYSDEC) in 1985 for its Water Quality Management Plan.

For the model, the Rochester region was defined as Monroe County plus a ring of surrounding towns in Orleans, Livingston, Ontario, and Wayne counties. These towns were included because they are approximately the same distance (or less) from the Rochester CBD as the town of Albion. The modeling area was delineated in this way to fairly reflect the competition between suburban towns, which, under a highway-build scenario, would have roughly the same travel times to the CBD as does Albion.

Because each town's baseline projected growth share was known from the NYSDEC town population projections (i.e., the ratio of the town's projected growth divided by total regional population growth), the implicit value of V_j was computed for each town as a simple residual value after deriving the baseline A_j accessibility index values. A_j values were derived for each town using employment data from the 1980-Census Urban Transportation Planning Package and zone-to-zone highway travel time data from the Rochester regional transportation model.

To simplify the analysis, the measurement of travel times was limited to six selected employment concentrations thought to be the most important home-based work trip destinations in the metropolitan region, including the CBD.

Next, the gravity model was rerun using revised A_j accessibility index scores for each town while holding the residual V_j values constant. The revised A_j scores reflected expected reductions in travel times between towns in the Brockport-Albion corridor and the major employment zones because of the extension of Route 531. To the extent that growth shares for towns in the corridor increased as a result of the extension of the highway (and decreased elsewhere in the region), the model reallocated population from other areas within the region to the corridor. Differences in the baseline population projection and the with-highway projection represented the changes in each town's population attributable to the highway extension.

The results of the gravity model analysis presented in Table 1 indicate the magnitude of the potential impacts of the highway extension on population in the Brockport-Albion corridor. The table shows differences in projected populations with and without the highway in those towns in Monroe and Orleans counties that would enjoy significant improvements in travel access. Population projections are shown for the year 2010. These impacts are also translated into changes in the number of households using an average household size factor of 2.86 for the Rochester area. Also shown in the table are changes in the A_j accessibility index scores.

In total, the corridor was projected to experience a population gain of about 3,870 residents as a result of the extension of Route 531 from Spencerport west to Brockport and then to Albion, or about 1,350 households. This increase is over and above the officially projected increase in corridor population of 7,950 residents between the years 1980 and 2010.

Several caveats regarding the results and application of the technique are warranted. First, increases in accessibility scores are not, in all cases, correlated with significant population increases. The town of Gaines, for example, would experience a 21 percent increase in its accessibility score indicating significant travel time improvements to key employment zones. However, the gravity model projected no increase in population as a result of these highway-related accessibility improvements. The gravity model assumes an interaction between accessibility and all other factors influencing population (as reflected in the residual V_j values). Therefore, towns such as Gaines and Clarkson, which are under the baseline, are projected to undergo slow or zero population growth and would remain slow-growth or no-growth towns even with the accessibility improvements. In effect, the gravity model assumes that locales with constrained residential growth would continue to be constrained even with the highway extension. This characteristic of the gravity model may mean that the population increases projected in these communities are too conservative, particularly for communities such as Clarkson, and appear to be growing faster than official projections.

Second, in reallocating population growth, the model assumes that only the residential choices of new households, either in-migrants to the Rochester region or newly formed households, would be affected by the highway. In the short run, this assumption was reasonable. However, over the long run, the highway's impacts could be expected to also extend to long-time residents in the region. Over time, established residents are also likely to move from one place to another within the region, with the number of intraregional migrants increasing over a longer period of time. Thus, a number of long-term area residents may also move to the Brockport-Albion corridor from other locales as a result of improved accessibility in the corridor. In the short run, however, this level of migration within the region should be somewhat small because most residents now living in the region are probably firmly established in their communities.

Taken together, these caveats suggest that the residential impacts forecast by the gravity model may be understated, particularly in the long run.

TABLE 1 BROCKPORT-ALBION CORRIDOR RESIDENTIAL IMPACTS SUMMARY FOR YEAR 2010

Town	County*	1985 Population	2010 Baseline Population	2010 Baseline A sub j Score	2010 With-highway A sub j Scores	Pct Change A sub j Scores	2010 With-Highway Population	Population Change (vs. Baseline)	Household Change (vs. Baseline)
Ogden	1	15400	16500	670.470	701.537	1.046	16482	0	0
Clarkson	1	4150	4200	195.203	234.806	1.203	4207	7	2
Hamlin	1	8400	8550	180.957	221.181	1.222	8572	22	8
Sweden	1	14750	16850	467.371	606.190	1.297	17310	460	161
Murray	2	4800	5400	125.910	217.728	1.729	5775	375	131
Albion	2	6550	7550	104.640	209.116	1.998	8428	878	307
Carlton	2	2950	3900	74.156	129.981	1.753	4515	615	215
Barre	2	2150	2400	100.036	201.320	2.012	2623	223	78
Kendall	2	2500	3250	100.140	164.653	1.644	3659	409	143
Clarendon	2	2250	3250	205.353	410.070	1.997	4127	877	307
Gaines	2	2650	2650	76.913	139.397	1.812	2650	0	0
Corridor Total:		66550	74500				78348	3866	1352

* 1=Monroe County
2=Orleans County

BUSINESS IMPACTS

A literature review, conducted as part of this study, revealed virtually no methodologies available that could have predicted changes in industrial activity and employment for a small area such as the Brockport-Albion corridor as a result of improvements in the performance of the transportation system. Although there were input-output (I/O) models, which may have been adapted for purposes of projecting these changes for a region, they were not very useful for specific subareas such as that examined in this study. In addition, it was difficult to make I/O models sensitive to changes in travel times. As a result, a primarily qualitative approach was used in the Brockport-Albion study.

The basic methodology selected involved a survey of businesses inside and outside the corridor and a review of the competitive advantages of the area with and without the highway extension. This methodology included a detailed evaluation of such factors as developable industrial land, zoning regulations, transportation facilities, infrastructure expansions, and available financial incentive programs.

The objective was to determine the importance of the highway extension to businesses and to determine what other factors would influence the decisions of companies to locate facilities in the corridor. Although the highway extension itself might have generated substantial economic development, there might have been other characteristics of the corridor that could have positively or negatively impacted such decisions.

The business survey included personal interviews with local business persons, elected officials, industrial development officials, and planning agency personnel. This survey was supplemented by questionnaires mailed to businesses in the Brockport-Albion corridor and to businesses outside the corridor but within the Genesee-Finger Lakes region.

The purpose of this survey was to determine expansion plans for companies inside and outside the corridor, the importance of the highway extension to local businesses, the factors that companies considered important in facility location decisions, and the possibilities that companies outside the corridor would consider locating facilities in the corridor if the highway were built.

The surveys and interviews provided some valuable insights into the need for, and the probable effects of, a Route 531 expansion. A few conclusions were drawn from the results, although they were mostly general in nature. Most were sufficiently verifiable to be used as the basic assumptions for the impact analysis, however:

- The Brockport-Albion area had several advantages for businesses, including lower land and building prices, and availability of low-cost utilities. Improved access to the east was another major factor that could have attracted new businesses to the area.
- Businesses in the corridor generated approximately 500 truck trips per day. The capacity of the existing road system was believed by most of these companies to be adequate, but there were problems caused by traffic delays, weight and trailer size restrictions, and lower speed limits.
- Over 80 percent of the firms surveyed in the corridor had plans to expand in the next 5 years, either at their existing location or at another site in the same general area.

- Almost half of the local companies rated the Route 531 extension vital or very important to their business. One-third of these firms indicated the possibility of moving from the area if the road were not extended.
- Only about one-third of the firms outside of the Brockport-Albion area, but still within the region, had plans to expand in the next 5 to 10 years.
- Only 11 percent of these region-wide firms had ever considered locating a facility in Brockport-Albion.
- Only 12 percent of the regional firms would explore the possibility of locating a facility in Brockport-Albion if Route 531 were extended there.

On the basis of the interviews and surveys, the primary industrial benefit from the new highway would have been a strengthening of companies already in the corridor. These businesses would have been able to cut costs and compete more effectively, thereby permitting them to expand their local facilities. The highway would have also helped retain those firms that indicated the possibility of moving from the area if the highway were not built.

Although the surveys suggested the possibility that firms outside the immediate area could have been attracted to the Brockport-Albion corridor because of the highway extension, it was considered a lesser probability. In fact, there were some indications from the interviews that executives of firms already in the region may have had a bias against the corridor, with few willing to even consider locating facilities there. One reason for this bias was the impression that the more desirable locations for executive homes were east and south of Rochester, which was a long commute to Brockport-Albion. Another reason was that the area was perceived as being industrial and blue collar.

An additional finding was that although there may have been interest in the corridor by firms outside the region, the addition of the new highway alone was not enough to attract their attention. To affect their location decisions, firms from outside of the region would have had to perceive the Brockport-Albion corridor as having significant competitive advantages at the local level, including such elements as local financial incentives such as industrial development bonds and revolving loan funds, availability of relatively inexpensive space in well-situated industrial parks, cooperative zoning and planning boards, and adequate support services, especially basic utilities and sewerage. These local competitive advantages were necessary to differentiate an area from its surrounding neighbors and became even more important when an area had an image problem to overcome.

An evaluation of these business location factors was done to determine the potential attractiveness of the Brockport-Albion corridor for industry. Although it was found that the area had advantages for business development, it also had disadvantages or deficiencies that should be rectified before the completion of the highway extension. In addition, there were other improvements that should be implemented to complement the beneficial impacts of the highway. Some of the improvements found to be needed were additional local financial incentives, zoning of industrial land near the highway, extension of water and sewer service to that property, improvements to north-south routes leading to the New York State Thruway, and upgrading of the local general aviation airport. A local program to provide these additional amenities before the highway's opening would stimulate much more interest in the area from firms seeking to site new facilities.

RETAIL DEVELOPMENT

During the study, it became evident that the Brockport-Albion corridor contained relatively little major retail development (i.e., shopping centers serving a regional market area) when compared to other suburban parts of the Rochester metropolitan area. Because lack of adequate highway access to local retail centers could have been one factor contributing to this deficiency, a separate analysis was done to estimate the amount of new regionally oriented retail space that could be supported by the area and might be developed if a new highway were built.

Firm predictions could not be reliably made regarding the amount or whether regionally oriented shopping centers would develop as a result of the highway extension. However, it was possible to make an order-of-magnitude estimate of the amount of such retail development that could occur.

One reasonable approach of doing this, which was ultimately used in the study, was to use an analog corridor as a benchmark by relating the total amount of regional retail development to the population in the analog corridor and applying this information to the Brockport-Albion area.

The Route 104 Webster Highway corridor northeast of Rochester was chosen for this comparison because it had many of the same characteristics that the Brockport-Albion corridor would have had with the Route 531 extension. Data from the 1987 *Shopping Center Directory* (*3*) indicate that the Webster Highway corridor contained at least 2 million ft^2 gross of regionally oriented retail shopping center space, compared to only about 0.4 million ft^2 gross in the Brockport-Albion corridor.

Further, the total resident population in the Webster Corridor was about 72,500 people, which supported about 28 ft^2 gross of regionally oriented retail space per capita. In contrast, the Brockport-Albion market area would contain, in the year 2010, a total population of about 78,000 (with the full highway extension to Albion). Thus, assuming that no additional regional shopping centers were developed in the Brockport-Albion corridor, its regional-retail space per capita ratio would be only 5.1.

Although the Brockport-Albion corridor extended over a larger geographic area than the Webster Highway corridor, it was not unreasonable to assume that the Brockport-Albion corridor could support a substantial amount of new regional shopping center development. A modest doubling of the gross square feet per capita multiplier in the Brockport-Albion corridor (from 5.1 to 10.2), for example, would have resulted in the development of an additional 400,000 ft^2 gross of regional retail shopping center space in the study corridor.

Although an untapped market was found to exist in the Brockport-Albion corridor, a highway interchange providing access from all parts of the area was a virtual necessity to realize the market potential. If the highway were built, an area near one of the interchanges would become an ideal site for a new shopping center.

SUMMARY AND CONCLUSION

In this paper, methodologies were described that were used to forecast local economic impacts of a highway extension in the Rochester metropolitan area. In part, these methodologies were selected because of relatively limited time and resources available to perform the study and because the analysis was concerned with impacts on a small geographic scale. These requirements made data-intensive and time-consuming methodologies, such as econometric modeling of regional location decisions, impractical. In addition, input-output analysis was also rejected for use in this study because I/O models measure economic impacts at the regional rather than local level and are not directly responsive to changes in a travel time variable.

Impacts on residential location decisions were forecast using a gravity model. This approach was selected for two reasons. First, this approach did not require new statistical calibration but instead relied on a previously calibrated mathematical parameter expressing the relationship between travel time and population change. Second, the gravity model is sensitive to travel time changes on a small-area scale.

The gravity model projected population impacts that appeared reasonable in terms of the magnitude of the corridor-wide impacts. In particular, the travel time saving that would have resulted from extending Route 531 was relatively small—about 4 min, on average, or a 12 percent travel time saving. Correspondingly, the overall increase in corridor population was also projected by the gravity model to be modest, about 5 percent. However, the model as applied had several limitations.

First, the model may have understated the potential for growth resulting from improved highway access in areas that were otherwise projected to experience little or no growth without the highway improvement. This understatement resulted from the model's assuming an interaction between accessibility and other factors influencing population. When other factors were expected to fully constrain growth, the model effectively assumed that these constraints would override the impact of improved accessibility, and the population would remain constant.

Second, the model may have also underpredicted population growth in the corridor because it considered only the location decisions of newly formed households and in-migrants to the region. However, over the long run, the location decisions of long-time residents could also have been affected.

Third, the application of the model relied on an exponential travel time parameter, assumed to equal 2.0, that was derived in the late 1950s. This parameter may, in fact, be outdated because the dynamics of metropolitan population change in the United States has changed considerably since that time. Metropolitan areas were then experiencing greater levels of inter- and intraregional migration than is presently occurring in most U.S. cities. Indeed, the dynamism of metropolitan growth during the 1950s and early 1960s was partly fueled by the rapid development of the Interstate highway system as well as highway construction within metropolitan areas. Because metropolitan populations are less mobile now, it is possible that the travel time parameter used in the study may have overstated the current impact of highway accessibility on household location decisions.

In order to evaluate the highway's impacts on business location decisions, a qualitative approach had to be used. The review of literature did not reveal any formal methodologies that could have been used to predict these impacts on a subregional level. Even if a quantitative approach could have been developed, however, surveys and interviews of business leaders should have been a complementary task, because other, non-travel-related issues could have had major impacts on such business decisions. As was shown in this study, such factors as financial incentives, additional infrastructure improvements, and, perhaps most important, a bias against the area could have considerable positive or negative impacts on industrial development even if transportation access were improved.

In order to overcome or at least minimize the problems, a program of basic research is recommended on the relationship between location decisions and transportation access. Perhaps the most valuable research would be to recalibrate the exponential travel time parameter under contemporary conditions. Validation of new travel time parameters against a variety of actual highway developments would also improve the reliability of gravity model technique. Although to predict what these newer results might be is impossible, the hypothesis is that the travel time parameter would be less than 2.0.

With greater commitment of research effort, more complete models of urban structure, including the impact of transportation system changes on long-term locational behavior of residences and business, could be developed under contemporary conditions. By explicitly isolating the impacts of factors besides accessibility, a more fully specified multiple regression model would reduce the underprediction biases that are now present in the model.

REFERENCES

1. W. Hansen. How Accessibility Shapes Land Use. *Journal of the American Institute of Planners*, Vol. 25, 1959, pp. 73–76.
2. D. A. Krueckeberg and A. L. Silvers. *Urban Planning Analysis: Methods and Models*. John Wiley, New York, 1974.
3. *Shopping Center Directory*. Urban Land Institute, Washington, D.C., 1976.