

# Supply and Demand for Land at Highway Interchanges

WILLIAM L. GARRISON, Professor of Geography, Northwestern University

THE PROBLEM posed is an ambitious one; it is to estimate, through 1980, demands for land in the vicinity of approach roads and freeway interchanges and to compare these demands with estimates of land supplies. Special concern is with the identification of certain periods within this time span and the identification of areas where land development problems are critical. (Critical in the sense identified in the following discussion of the relevance of the research problem.)

The present paper is more limited than the large supply and demand problem. When estimates are discussed, statements regarding supplies of and demands for land are based on rather simple projections. There will be continuing needs for estimates, and it would be worthwhile to improve methods of estimation. This paper reviews what can be done with available materials and sets out some of the important features of the situation not treated explicitly in estimates.<sup>1</sup> It is hoped that recognition of the difficulties of estimation and some of the reasons for these difficulties will assist in improving estimates as work on interchange problems is continued.

## RELEVANCE

There has been a gradual realization that the attractiveness of sites for traffic intensive land uses at or near freeway interchanges may create acute problems. (A traffic intensive land use is defined as one which generates a large amount of traffic per unit of land; for example, a shopping center.) There may be friction between traffic leaving the freeway (after it leaves the limited-access area) and traffic entering or leaving sites, with consequent backing up of cars onto the freeway facility. There is also opportunity for other types of conflict. Intensive land uses near interchanges may conflict with low density housing nearby, for example.

Some of these conflicts may be resolved—at least in part—at the freeway design level. But the designer must have correct information regarding demands to be placed on interchange facilities. In many ways, though, these problems are beyond the scope of the design authority. Conflicts between incompatible land uses can hardly be treated by highway authorities. Congestion on urban streets with consequent effects on freeway traffic provides another example of a problem which may be outside the span of control and responsibility of the agency designing the freeway.

## A RESEARCH APPROACH

The supply and demand for land problem is one segment of a several pronged research approach to the problem of land use developments at interchanges. This phase of the research provides an over-all picture of the "where, when, and how much land development" part of the question. Other phases of the research, which must be mentioned here to give perspective to the present paper, include:

1. Studies of land use developments and associated problems in places where interchanges have been constructed.

There is a large technical and theoretical literature on the estimation of supply and demand equations. (Many examples from this literature may be found in the journal *Econometrica*.) In situations such as that under discussion here, however, it is difficult to make use of this valuable literature. In the present case, observations on price and quantity are limited and market interrelationships resulting from urban morphology are known only in a vague way.

2. Studies of special land use problems occasioned by highway users demands for gasoline, lodging, etc.

3. Studies of administrative and legislative devices that provide alternate solutions for the problem; that is, solutions that reduce conflicts without thwarting over-all development objectives.

Selected questions and results from these phases of the research are discussed by Marble and Graves in this symposium, and were discussed by Horwood.<sup>2</sup>

It also should be stressed that this research can take advantage of recent work by others pertaining to the general interchange problem<sup>3</sup> and its legal aspects,<sup>4</sup> and recent work on models of transportation and urban growth and development.<sup>5</sup>

## A RESULT

It is clear that by 1980 intensive land developments will occur in the vicinity of interchanges in large metropolitan areas. This conclusion from this study is already apparent, just as it may be inferred from interpolations from recent materials on urban growth.<sup>6</sup> Notes on the mechanics underlying the conclusion are given shortly. (No attempt is made to reproduce data within this cursory paper, because of the necessity of justifying and interpreting estimates with bulky supporting materials.) First, remarks are made on some of the implications of this conclusion.

### Pertinence of Economic Impact Studies

One of the uncertainties regarding the generality of economic impact studies stem from the short time span over which developments have been observed. The large-scale freeway program is new, and the question of the extent to which early impact results should be incorporated into planning, taxation schemes, and special benefit considerations in right-of-way acquisition has been somewhat open, subject to the question of whether impact study results are representative of long-run trends.

As is widely known, impact studies have shown over and over again how land use developments accompany freeway developments. It is expected that land development will continue to accompany freeway development because of the large demands for new urban land. So information developed in impact studies is usable in research such as that under discussion here. Indeed, the current research is an expansion of the type of work represented by impact studies.

### Problems Vary in Magnitude

Another implication of the broad conclusion deserves special mention. To extend the conclusion somewhat, land near interchanges will be in short supply relative to demands in and near large urban centers. The reverse is true near small urban

2/ Horwood, E.M., "Freeway Impact on Municipal Land Planning Effort." HRB Bull. 268 (1960).

3/ For example, unpublished studies by Arthur F. Loeben, Deputy Director of the Montgomery County (Penna.) Planning Staff and studies by William Pendleton, U.S. Department of Agriculture.

4/ Stanhagen, W.H., "Highway Transportation Criteria in Zoning Law" and W.H. Stanhagen and J.J. Mullins, Jr., "Police Power and Planning Controls for Arterial Streets," Highway and Land Administration Division, U.S. Bureau of Public Roads (October 1960); Frank M. Covey, "Roadside Protection Through Access Control," Automotive Safety Foundation (1960); and J.W. Beuscher, et al., "Highway Planning and Protection Measures in Wisconsin: A Panel Discussion," HRB Bull. 232, pp. 84-118 (1959).

5/ The papers relating to urban structure read by R. Muth, L. Wingo, and H. Mohring at a joint session of the Econometric Society and the Regional Science Association, St. Louis, December 1960, are examples of important recent work. An additional important recent work is W. Alonso's, "A Model of the Urban Land Market: Location and Density of Dwellings and Businesses," Ph.D. Thesis, Univ. of Pennsylvania (1960).

6/ Notably Jerome P. Pickard's, "Metropolitanization of the United States," Research Monograph No. 2, Urban Land Institute (1959) and M. Clawson, R.B. Held, and C.H. Stoddard's, "Land for the Future," Johns Hopkins Press (1960).

centers. Thus problems of friction among land uses and between land uses and traffic will vary in intensity among urban centers, depending on the size of the urban center. Friction may be translated into needs for action to plan and control land use and traffic. In some states and urban areas, needs for action will be great. In others, needs for action will be less urgent.

Because needs for action are uneven among states and urban areas, broad interest in the problem of intensive land use developments at and near interchanges is not to be expected, and there are inherent dangers in this situation. States with only a small part of their area subject to problems may not be aware of problems, or find it practicable to seek their solution. The problem is greatest in large metropolitan areas. But metropolitan planning and traffic agencies often have only small resources and little authority, if these agencies exist at all. There will be cases where problems are too limited to interest state agencies, but beyond the span of the effective control of county and urban agencies. A special effort must be made to avoid this situation.

### NOTES ON THE ESTIMATES

The statement of the magnitude and extent of the problem made earlier was based on several projections of the supply and demand aspects of the problem. These are sketched here to an extent sufficient to illustrate methods of treating the problem and furnish background materials for ensuing discussion of certain indeterministic elements troublesome in projections of this type.

#### Demands for Land

1. Census Bureau estimates of population growth and household formation were used to project housing starts and consequent demand for residential and associated lands. Historical records indicate a lagged relation between household formations and housing starts, and a projection of this relation was made using a regression equation.
2. Simple projections of the expansion of output and employment were made by industry sectors. Results were essentially the same as those of NPA judgment models<sup>7</sup> and similar materials. Some information is available on space requirements per employee by industries<sup>8</sup> and supplemental materials were developed. Then output-employment-land per employee materials formed the basis of these projections of land requirements. As was pointed out early in this paper, one phase of the research, which is not under discussion here, has made extensive use of new materials on space used by industry.
3. Aggregated indices of land uses were used, together with census population projections to project space demands. It is possible, for example, to compute per capita land uses from Bartholomew's materials.<sup>9</sup> Simple multiplication of these ratios by new population yields extremely crude but useful estimates. Other materials are available from which similar, but somewhat less crude, estimates may be made.
4. Demands for land were allocated among cities in different size classes using census materials on differential rates of growth of urban centers. Also, Urban Land Institute results were used for the same purpose.<sup>10</sup>

#### Supply

The supply estimates were made by selecting cities of different size classes and finding how much land is brought within commuting range of the city by freeway construction. This is not quite as arbitrary and unrealistic as it might seem at first

<sup>7</sup> National Planning Association, "Long-Range Projections for Economic Growth, The American Economy" in 1970, Planning Pamphlet No. 107 (1959).

<sup>8</sup> Muncy, Dorothy A., "An Analysis of Site and Location Requirements," Urban Land Institute, Technical Bulletin No. 23 (1954); Institute for Urban Studies, University of Pennsylvania, "Four-County Industrial Land and Facilities Requirements" (1957) and "Industrial Land and Facilities for Philadelphia" (1956); and Sioux City (Iowa) Planning Commission, "1959 Economic Report" (1959).

<sup>9</sup> Bartholomew, Harland, "Land Uses in American Cities," Harvard University Press (1959).

<sup>10</sup> Pickard, op. cit.

glance, especially for large cities where estimates are critical. In general, large cities will double in area during the next two decades, if new residential construction is at the same density as that at the edge of large cities.<sup>11</sup> By taking as a criteria of commuting range travel times now tolerated, the area is marked out within which current density may develop. If this area is less than demand measured using current density, then density may increase. These statements are very rough, of course. Much depends on the elasticity of demand for residential land on which no information is available.<sup>12</sup>

At any rate, the critical part of the supply problem is that of land near interchange. The amount of residential land needed gives an estimate of the sprawl of residential land and its extension along freeways, the extent of freeways in built-up areas, and, thus, the availability of land about freeways.

### Setting Demand and Supply Equal

Over the estimation period the amount of land supplied will be that used for urban uses and this same amount will be the amount demanded. So the estimates previously discussed must be fitted together. This was done by allocating the more intensive land uses to more accessible sites along freeways and residential lands to freeway interstices. When this is done it is quickly seen that, in large cities, intensive developments will be associated with all freeways where land is available.

Ideally, one would like to have some type of friction, pressure, or price relationship to allocate land and determine densities. It hardly seems necessary to point out however, that the state-of-the-arts and information are such that it is idle to carp about the lack of the use of such relationships here.

## SOME OPEN QUESTIONS

The estimates used in this study quite rightly may be characterized as naive, they represent simple extensions of present trends. The state-of-the-estimating-arts together with lack of empirical information and general knowledge regarding urban growth and development, bound one's ability to produce estimates of greater logical appeal. In the remainder of this paper some of the problems of improving the quality of such estimates are considered. Improvement in quality seems necessary to the provision of information for planning to meet approach road congestion problems.

### Supply and Demand Functions

A statement containing information on the supply of land should indicate supplies available at various prices, just as a statement on demands should indicate amounts demanded at various prices. A more pointed way to put this is to say that supply and demand functions are needed. The intersection of these functions determines the level of supply and demand as well as the price for land.

It is easy to say that these functions are needed. It is much harder to see how they can be obtained or be approximated. One very complicating feature of the problem is the shifting of supply as freeways are constructed and increase the amount of land available for development.<sup>13</sup> For the most part, urban freeways are new, so there is limited empirical experience with the phenomenon it is desired to measure.

<sup>11/</sup> This conclusion was reached, for example, in the case of Chicago, The Chicago Area Transportation Study, Vol. II, "Data Projections," p. 32 (1960).

<sup>12/</sup> And the situation is complicated by the changing age structure of the population. In relative terms, there will be more old people and more young people in the near future. The population pyramid is taking on an hour-glass shape. Because of these changes, there may be changes in structure of demand for housing at various densities.

<sup>13/</sup> Models have been developed displaying the "taking-up" of urban land (for example J.D. Herbert and B.H. Stevens, "A Model for the Distribution of Residential Activity in Urban Areas," J. of Regional Science, 2 (1960), pp. 21-36). It would be useful if these models were extended to include the availability of lands at different locations made available from time to time by freeway construction.

Another complicating feature of the estimation problem is that of prices. The price or cost of using urban land represents a complex mixture of site and location costs. It seems that the costs of greatest pertinence are the costs of travel. The supply function should be couched in terms of amounts of land at various travel costs. Although some approximate measures of travel costs are available, it is not known how suitable these are to the type of problem under discussion here.

Last, but not least, is the complication provided by the interaction of land uses of different types and at different locations. Land supplied or demanded pertain to a mix of various types of sites for various uses. Also, the supply and demand picture may contain elements from places at widely varying geographic locations. A manufacturer, for example, might examine interchanges at city X and decide, in light of his inability to obtain the amount of land he desires at the travel and site costs he will accept, to relocate at city Y, where land is available and his over-all cost picture is acceptable. In this case, excess demand at X is met by excess supply at Y. It might be pointed out that the decision of the imaginary manufacturer may affect the number of jobs at X and Y and, thus, demands for residential lands.

#### Differential Rates of Growth of Urban Centers

It is widely accepted that most net population increase in this country will occur in large metropolitan areas. This information is an extension of recent experience and is a generalization is undoubtedly true. The extent to which rates of urban growth may vary among cities is somewhat open.

One factor affecting urban growth not recognized by empirical experience is the effect of freeway systems. Every transportation improvement shifts the comparative advantage of places, so interregional freeways shift the relative advantages of the urban places they serve. This effect is yet to be fully recognized and, because it has not been experienced, poses especially difficult estimation problems.<sup>14</sup>

#### Developmental Sequencies

Freeways take time to build, so the supply of land unfolds over time, just as changes in the economy and population growth unfold additional demands for land. The problem of sequencing supply with demand seems unrecognized, and especially difficult to treat. An excursion into an imaginary situation may be helpful in laying-out some aspects of the problem.

Imagine a situation in which there is no net growth in population and in the economy for a period of years. These years of no net growth are then followed by years of rapid growth. A freeway system constructed during the period of no growth would, in spite of the absence of net growth, set off new developments. More land would be available at given levels of travel time and cost from the center of cities, so more land would be used. Residential expansion might be at low population densities and manufacturing and commercial concerns might use large and expansive sites.

The period of net growth begins. Now supplies are short relative to demands and more intensive land developments occur, densities are greater and problems of congestion occur. These areas of congestion and high density might have been avoided by delaying freeway development until the period of rapid growth began.<sup>15</sup>

There are other problems of sequencing. There is an apparent tendency for residential development to load in the areal expansion of urban areas, followed by govern-

The author attempted to state and deal with this problem in, "Connectivity of the Interstate Highway System," Proceedings, Regional Science Association, 6 (1960), pp. 1-37. Leon Moses of Northwestern University has the interesting notion (unpublished) that the problem of differential rates of regional and metropolitan area growth may be interpreted in terms of shifts in the relative costs of long versus short hauls, and of material versus finished product hauls. The relative decrease in short haul cost has encouraged the sprawl of metropolitan areas. The relative increase in the cost of interregional hauling of finished products, together with economies of agglomeration (Isard, "Location and Space Economy," Wiley, pp. 173-88, 1956), has encouraged the growth of metropolitan areas in many regions.

But this conflicts with implicit national policy, which dictates that public works be expanded when growth in the private sector of the economy is small, and that public works be cut back when growth in the private sector is rapid.

ment services and commercial and industrial developments. The latter developments are more traffic intensive than are residences, especially low density housing. The residences were there first, though, and may have occupied many sites suitable for more intensive development. There is a shortage of suitable sites for traffic intensive uses, so they are developed with high densities and resultant congestion.

There are many examples of areas near interchanges occupied by residential developments. The extent to which these developments occasion congestion elsewhere by forcing more intensive developments than would have occurred is not known, nor is the degree to which residential development leads other development in urban sprawl. It is interesting to note, though, that congestion may occur in the vicinity of some interchanges because traffic intensive land uses are prevented from developing at other interchanges.

### SUMMARY

Several implications from and problems of estimation of the demand and supply of land in the vicinity of freeway interchanges have been discussed in this paper. It was noted that rapid growth of large urban areas may be expected in coming years, and there will be great pressure for the development of traffic intensive land uses near interchanges in these large urban areas. A number of elements are present in the situation that makes estimation of land use developments difficult. These elements include lack of pertinent price information and information on interrelationships from area to area, from land use to land use, and from time to time.