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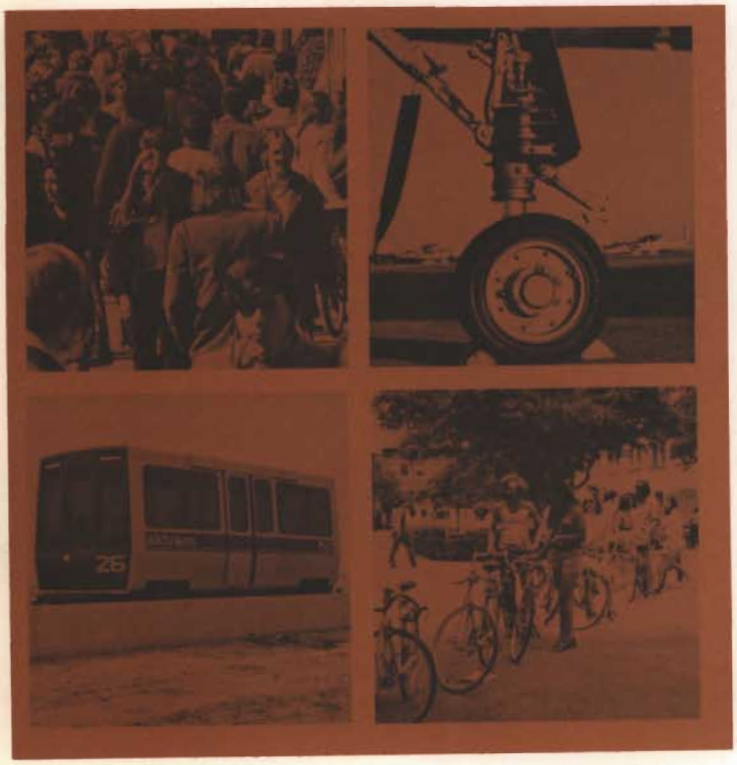
TRANSPORTATION IMPACT RESEARCH: A REVIEW OF PREVIOUS STUDIES AND A RECOMMENDED METHODOLOGY FOR THE STUDY OF RURAL COMMUNITIES



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COUNCIL FOR ADVANCED TRANSPORTATION STUDIES

THE UNIVERSITY OF TEXAS AT AUSTIN

TRANSPORTATION IMPACT RESEARCH: A REVIEW OF PREVIOUS STUDIES AND A RECOMMENDED METHODOLOGY FOR THE STUDY OF RURAL COMMUNITIES

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Report

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PREFACE

This is the third in a series of reports describing the activities and findings as a part of the work done under the research project entitled, "Transportation to Fulfill Human Needs in a Rural/Urban Environment." The project is divided into five topics, and this is the first report under the topic "The Influence on the Rural Environment of Interurban Transportation Systems." This report is a review of the findings of previous studies in the field of transportation impact research, an analysis of the methodologies most commonly used, and a proposed methodology suitable to the study of the impact of transportation changes on rural communities. It is intended to provide both a picture of the state-of-the-art and a summary of specific results, especially those which have a direct bearing on the study of interurban transportation in rural environments.

This review has shown the need to re-evaluate the methodology of impact studies in general and to develop from specific case studies a methodology appropriate to transportation systems impact on small communities.

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ABSTRACT

This report has four main phases. (1) It presents a brief classification and definition of the types of methodology used in transportation impact studies. (2) It summarizes in detail the findings of previous research according to the type of impact investigated. (3) The report comments on the usefulness and the limitations of previous studies. (4) Finally, a proposed strategy is offered for future research as seems appropriate both to the state of the art and to the needs of this research effort.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Mobility is and has always been a major characteristic of American society. Land development, economic activity, and social habits have all been dependent upon this feature of American life. The major development of the nation was made possible with the expansion of the railroad system across the continent. Cities with their attendant economic activities grew up at the focal points in the transportation system, those locations where rail lines crossed each other and where the local road systems were connected to the railroads. Later on, when the automobile opened new possibilities for private mobility, the major investment in transportation facilities went for the building of highways, and there followed an increase in economic activity and changes in social habits which were as dramatic as those produced by the development of the railways.

This close connection between the development of highway transportation and land development and economic activity has been subject to a great number of impact studies, especially in the time period after the National System of Interstate and Defense Highways was established by the 1956 Federal Aid Highway Act. These impact studies have become more and more comprehensive and have increasingly provided valuable information about different types of effects caused by highway improvements in different areas.

Study Procedure

This literature review is a part of the research project called "The Influence on the Rural Enviroment of Inter-Urban Transportation Systems." This research project, sponsored by the Department of Transportation, the Council for Advanced Transportation Studies, and the University of Texas at Austin, is directed at developing a predictive model capable of expressing a rural community's potential for development as influenced by either existing or planned interurban transportation systems. Such a model will be of great value for transportation and land development planners and for the rural community in determining the effect that changes in the transportation system might have, given the local economic and human resources.

Communities in the South-Eastern area of Texas are considered appropriate for use in developing such a predictive model because there are a large number of communities with populations in the range of 1,000 - 50,000 and because major

changes in transportation systems have occurred in this area during the last two decades. Initially it was felt that a review of existing literature covering transportation systems impact was necessary in order to give the researchers a through understanding of the complex cause-effect relationship between transportation systems and community development. Also, a definition of the "state-of-the-art" was necessary prior to any development of overall methodology and more specific study techniques suited to the different areas of transportation systems impact. The literature review, together with preliminary studies of local conditions in the first community to be examined and a survey of information available on transportation systems and community development has resulted in a specific work plan for the first year of the project and a more general plan for the two following years.

Literature review will continue throughout the entire study period and, this report is therefore a summary of the literature examined during the first twelve months of the project. More recent studies will be reviewed as published, and as the research project advances and the study scope is widened to include a greater variety of community impact, appropriate literature will be reviewed. Also, as the study techniques require special studies of modeling techniques, etc., the researchers will qualify themselves through studies of existing literature on the subject.

Literature Sources Studied

The available literature sources include a variety of textbooks, research reports, and articles. The literature studied, or to be studied, may be divided into three broad categories:

(1) General theoretical background;
(2) Previous research reports;
(3) Specific modeling efforts.

The first category, general theoretical background, includes specific subjects in textbooks on transportation planning, land use planning, community planning, sociology, and economics, as well as a variety of papers describing general techniques of research and modeling. Studies in this category are not included in the first report, but will be referred to in the reports dealing with specific areas of transportation systems impact.

The second category, previous research reports, includes impact studies, and thus gives factual information about impact as observed in a great number of research projects. Most of the research has been conducted by universities or by state and federal highway agencies. These studies in most cases prove that changes in transportation systems have an influence on development and activities in adjacent communities, and they attempt to measure the effect in each case as much as possible. However, because of the variety of individual cases, these studies cannot be used to predict the degree of the impact of proposed changes in a transportation system on communities other than those studied.

The last category, specific modeling efforts, includes the relatively few previous efforts on modeling the impact of highways on specific adjacent areas. Because of the amount of literature dealing with some aspect of transportation impact, the literature reviewed has been selected so as to include what would be of importance for the research project to date. So far, therefore, most of the literature reviewed deals with transportation systems impact on land use, land values, business activities, and general community economics.

The major purpose has been to locate and trace all previous studies which may be of sufficient importance to warrant further examination. It is believed that the results will yield not only a comprehensive summary of previous findings, but also important information about the different methodologies that have been used. This should both clarify the complexity of the problem and disclose the shortcomings of other research in the field.

Most studies reviewed to date are from the period 1960 - 1970. Studies prior to 1960 are given less emphasis, as it is believed that later research reflects experience gained from earlier methodology. Also, the most important interurban transportation system of today, the interstate system, was constructed mainly after 1960.

Characteristics of Reviewed Impact Studies

So far, practically all of the impact studies deal exclusively with the effect of interurban highways, mainly the interstate system and the effect of circumferential or through routes in urban areas. Thus limited-access highways have received the most attention. However, arterials without access-control and even farm roads have been studied to some degree.

Geographically, there are highway impact studies from every part of the nation. Only in Texas has there been carried out a series of studies, using the same methodology (1 - 8).* Of the literature reviewed, these give the most comparable information. Because of the wide variance in study techniques and the dates of different studies, it has not been found appropriate to try to compare studies from different parts of the nation in order to find any specific difference in impact according to geographical location. Although the areas studied include both urban and rural communities, in this literature review, studies from rural communities have been given the most emphasis.

"Highway improvements" are in most cases defined as the construction of new highways. A new facility may be located relatively close to and serve the same traffic as an old facility, or it may be a new link in the overall road network, thus creating new travel patterns. Most of the previous research has concentrated on new interchange areas or on bypass routes, locations where the most obvious changes take place.

The basic methodology has involved the study of changes in land development and activities in a period before and a period after completion of the new facility. Thus, changes in land use, business activities,etc., can be related to highway improvement. Such variables as distance to nearest city, population density and traffic volumes are also investigated in some studies. The effect of proximity to the highway improvement is also examined to some degree.

METHODOLOGIES USED

All studies involve definition of the area in which the effect is measured. Different types of areas have different characteristics and may require different study techniques. Consequently, each study concentrates on one type of area. Study areas may be divided into two major categories, urban and rural. In some cases a third category, "urban fringe," is used. However, it may be difficult to give a unique definition of area type. Studies of small towns can in most cases be said to be studies of rural areas.

In addition to type of area, the previous studies may be classified according to type of highway improvement which has occurred. It is reasonable

* All references are listed according to the order in which they appear in the text. See List of References Cited, p 51.

to use three categories:

(1) Interchanges

(2) Bypass routes

(3) Rural highway routes

Studies of the two first categories involve both rural and urban study areas.

The methodology used to evaluate such changes as alterations in land use, land value, economic activity,etc., usually involves one of, or a combination of the following:

(1) Before-and-after study

(2) Survey-control area study

(3) Case study

(4) Multiple regression analysis

(5) Other study techniques

The "before-and-after study" method, combined with one of the other methods, is used primarily to determine the effect of road improvement. In these studies, the "before" period includes 2 - 5 years prior to the highway's construction, and the "after" period usually spans 2 - 5 years following the completion of the highway. The before-and-after method is most often used to study the effect of a new highway in an area which did not have a previous roadway,e.g., an area where a new bypass is built.

The "survey-control area study" method is the most common technique used to isolate the influence of a highway on nearby land, often in combination with the before-and-after study method. The procedure is to measure land development both in the study area located adjacent to the facility and in a control area located far enough from the highway to have been unaffected by the facility. The change between the before period and the after period in the control area is compared with the change in the survey area, and the effect of the highway is measured as the difference between the two.

The "case study" approach deals with a rather detailed analysis of events which have taken place nearby a highway facility. Such events may be the construction of new industrial plants or new commercial development. By examining selected cases with emphasis on their relationship to the highway, the case studies may indicate the variety and the extent of significant changes attributable to the highway.

Multiple regression analysis is used in a few cases where appropriate control areas could not be found, or as a check on the results of the survey-control area method. With this technique, changes in land development or land values are assumed to be a result of many different factors, both highway and non-highway oriented. The most significant results are achieved by partial correlation. This method requires that the different variables be represented quantitatively.

Techniques other than the above mentioned, or variations of them, are also used in the studies reviewed. Among these are the "projected land use -- value relationship approach" and the "neutral road comparison" method.

The first of these two techniques involves comparing the probable land development which might have occurred had the highway not been built with the development which actually took place. The "neutral road comparison" involves comparisons of alternative highway locations to a hypothetical economically neutral road.

The different techniques used require a separation of highway and non-highway related impact. The non-highway caused impact is usually analyzed in terms of such factors as distance to nearest trading center or city, population density, and area-classification (urban, urban, and rural).

Regardless of the methodology used, most of the studies examine the average effect in the study area. Only a few studies examine the geographical distribution of the effect, usually by classifying areas as within or outside some specified distance from the highway facility.

IMPACT OF HIGHWAY IMPROVEMENT

The impact of highway improvement or location on rural communities is usually measured in terms of the effect on one or more of the following:

(1) Land use
(2) Land value
(3) Business activity
(4) Industry location
(5) Social habit
(6) The general community

A grouping like this may help to clarify the basic relationship between the transportation system and its improvement, on the one hand, and the community characteristics and their development, on the other. However, one should have in mind the interaction between the listed groups, e.g., between land use and land value.

Impact on Land Use

Interchange Areas. Most of the highway impact studies investigate land use adjacent to a highway. Because changes in land use due to a highway facility tend to occur primarily at interchanges, a number of the studies deal only with interchange areas.

It is important to know what development is likely to take place in an interchange area and how this development varies with interchange type, access, and geographical location. A study of 66 interchanges along I-94 in Michigan (9) shows a significant difference in development for different types of interchanges. The findings are summarized in Table 1.

TABLE 1. LAND DEVELOPMENT IN PERCENT BY TYPE OF INTERCHANGE (9)*

Interchange Type	Commercial	Industrial	Residential	Governmental	Vacant
Closed Interchanges			14.8		85.2
Partial Interchanges	7.1		7.1	21.5	64.3
Full Interchanges	40.6	5.2	14.1	6.6	33.5

This table shows that development of different types of land use depends upon the kind of access. "Closed" interchanges are intersections of two limited-access highways. Thus, adjoining land is accessible only by indirect routes. "Partial" interchanges serve on-and-off traffic in only one direction. "Full" interchanges allow the motorist to leave the freeway in either direction. Commercial development seems to be the most dependent upon good access, but industrial or governmental use also depends greatly on ready access.

* Numbers in parenthesis refer to the sources from which the figures or tables are derived.

The same study also examines full interchanges in order to show the relation between development and geographical location. The interchange locations were classified as:

Major city routes: Major routes, population > 10,000

Secondary city routes: Secondary routes, population > 10,000

Small town: Main intersection, population < 10,000

Rural: All interchanges not associated with a city or a town

Table 2 shows the result from this study. The study ranks land-use as follows: commercial, industrial, residential, and vacant. It should be noted that the table shows only the highest ranked land use in each quadrant in the interchange. Consequently, the exact nature of land development in each quadrant is not truly represented. The governmental classification is used for land owned by governmental agencies and in this study is not considered available for development.

TABLE 2. PERCENTAGE BREAKDOWN OF QUADRANT DEVELOPMENT FOR FULL INTERCHANGES (9)

Interchange location	Developed Land in per cent					
	Developed	Vacant	Commercial	Industrial	Residential	Govern.
Major city route	87.5	12.5	78.1		9.4	
Secondary c. route	76.9	23.1	40.4	15.4	11.5	9.6
Small town	65.4	34.6	44.2	1.9	15.4	3.9
Rural	51.3	48.7	22.4	2.6	17.1	9.2

Most interesting for this project are the results for small towns and rural areas. There seems to be a significant difference in the precentage of developed interchange quadrants for these two areas. Most conspicuous is the result for commercial development; twice as many quadrants have commercial land use in small towns as in rural areas.

To give an idea of the magnitude of development, as well as the relative kind of land use, Table 3 shows the average number of commercial activities by type. In this table is also included the average number of activities from a study of interchanges in Pennsylvania. (10)

TABLE 3. NUMBER OF DEVELOPMENTS (WITHIN 1000 FT.) PER FULL INTERCHANGE (9), (10)

Interchange Location	Service Stations	Restaurants	Motels	Shopping Centers	Other Sales Uncommitted*
Major city route	3.38	2.38	1.25	0.38	0.38
Secondary c. route	1.38	0.46	0.15	0.08	0.54
Small Town	1.23	0.54	0	0	0.62
Rural	0.44	0.28	0	0	0.50
Average, Michigan	1.33	0.71	0.31	0.08	0.52
Average, Pennsylvania**	0.6	0.3	0.3	0	0.6

*Known sales where no construction has started.

**Figures from 36 non-urban interchanges.

According to the Michigan study, service stations and restaurants represent the only kind of interchange development in small towns and rural areas. A rather high number of uncommitted sales indicates that about one property per two interchanges is held for future use. The Pennsylvania study, however, shows a relatively high number of non-highway oriented businesses, although even here service stations, restraurants and motels account for most of the development.

Two recent studies, from interstates in North Carolina and Indiana, (11), (12), also show the percentage of developed land in interchange areas. Tables 4 and 5 give a comparison between the findings from the two studies.

TABLE 4. PERCENTAGE DEVELOPED QUADRANTS, AND AVERAGE NUMBER OF DEVELOPMENTS PER INTERCHANGE (11) and (12)

Interchange Location	NORTH CAROLINA		INDIANA	
	Developed Quadrants	Developments per Interchange	Developed Quadrants	Developments per Interchange
Urban	79%	6.5		18.3
Suburban	70%	5.5		6.3
Rural	35%	1.5		2.4

TABLE 5. INTERSTATE INTERCHANGE DEVELOPMENT (PERCENTAGE) BY LOCATION OF INTERCHANGE (11) and (12)

Development	NORTH CAROLINA*			INDIANA**		
	Urban	Suburban	Rural	Urban	Suburban	Rural
Gas, service stations	27	41	70	28.4	44.7	58.2
Truck stops	5	4	5	1.6	2.4	5.7
Restaurants	1	5	5	10.2	6.1	4.5
Motels	8	12	5	6.3	5.5	8.5
Shopping centers	3	4				
Office & Institutions	11	4	2			
Retail & misc. sales	21	11	6			
Public facilities				3.1	4.2	9.1
Residential				14.5	11.6	8.0
Trailer parks				3.1	3.0	3.4
Educational					0.6	0.5
Commercial				19.2	10.3	1.7
Industrial	24	19	7	12.6	12.2	5.7

These two studies show clearly that service stations are the dominating source of land use at interchanges in rural areas. Also indicated is that industrial and commercial use is much more likely in urban or suburban areas. With regard to motels and restaurants, however, these two studies from North Carolina and Indiana seem to indicate no significant difference for interchange location.

Despite many similarities in land development at different interchange locations, too little is known about the underlying factors to be able to predict future land use at a specific interchange. One major factor, time, is barely considered in the studies reviewed. This does not, however, mean that time is without interest when short or long term impact on a community is to be determined.

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* Approximate percentages

** Actual figures from the report.
For some unexplained reason, the figures do not total 100.0% in each category.

The interchange studies seem to indicate:

(1) Highway-oriented services catering to the highway traffic are the first to develop and are the major sources of land use at interchange areas.

(2) The second most important land-use category to develop at interchanges is that of commercial activities which need to be easily accessible from highways. Such activities are shopping centers, some industry, and outdoor theaters.

(3) The third group of land-use categories to develop at interchanges may include non-highway oriented activities (e.g., individual stores) and individual residences. This group has no especially high need for direct access.

Analysis of Interchange Development

In the Pennsylvania study (10), the following variables were included in the analysis of each interchange area in addition to the number and kind of developments: type of interchange, average daily traffic volumes on the interstate and the crossroute, distance to the nearest urban area, age of interchange, topography within the interchange community, population characteristics, and market value characteristics. No complete regression analysis was made, but simple correlation analysis shows that the most important variable is traffic volume (ADT) on the cross-route. Other important factors are topography, distance from nearest urban area, and population change. Table 6, p 12, shows the result from this study.

This study also shows the effect of an increasing distance to the nearest urban area. There seems generally to be a drastic reduction in the number of developments when the distance is more than 5 - 10 miles. The results are shown in Figure 1, p 13.

The amount of development in an interchange area will depend upon interchange type, characterized by design type and access control. The Pennsylvania study (10) indicates that of all design types, full diamond and full and partial cloverleaf attract more interchange development than other types. (All "full" interchanges provide access to each interchange quadrant from both directions on the main route.) However, other studies (13,14) have indicated that the most desirable location for highway-oriented development is the quadrant with a direct exit ramp from the main highway. In the case of diamond and cloverleaf design types, these quadants are often referred to as "right hand quadrants."

Table 6 Correlations[a] of Variables with Total Highway-Oriented Development (10)

Variable	Correlation Coefficient	Proportion of Variation Explained (percent)
Cross-Route Average Daily Traffic (ADT)	0.514[b]	26.4
Topography (Average Slope)	-0.388[c]	15.1
Distance from Nearest Urban Area	-0.360[c]	13.0
County Population Change	0.333[c]	11.0
Local Municipal Market Value Change	0.320	10.2
Local Municipal Population Change	0.305	9.3
Nearest Urban Area Population	0.289	8.4
Nearest Urban Area Population Change	0.235	5.5
Age of Interchange	-0.195	3.8
County Population	0.188	3.5
Interstate Average Daily Traffic (ADT)	0.174	3.0
Local Municipal Market Value	0.135	1.8
Local Municipal Population	0.099	1.0

[a] Total Units include only service stations, restaurants, and motels. Only complete interchanges were considered.

[b] The correlation coefficient is significant at the 1 percent level.

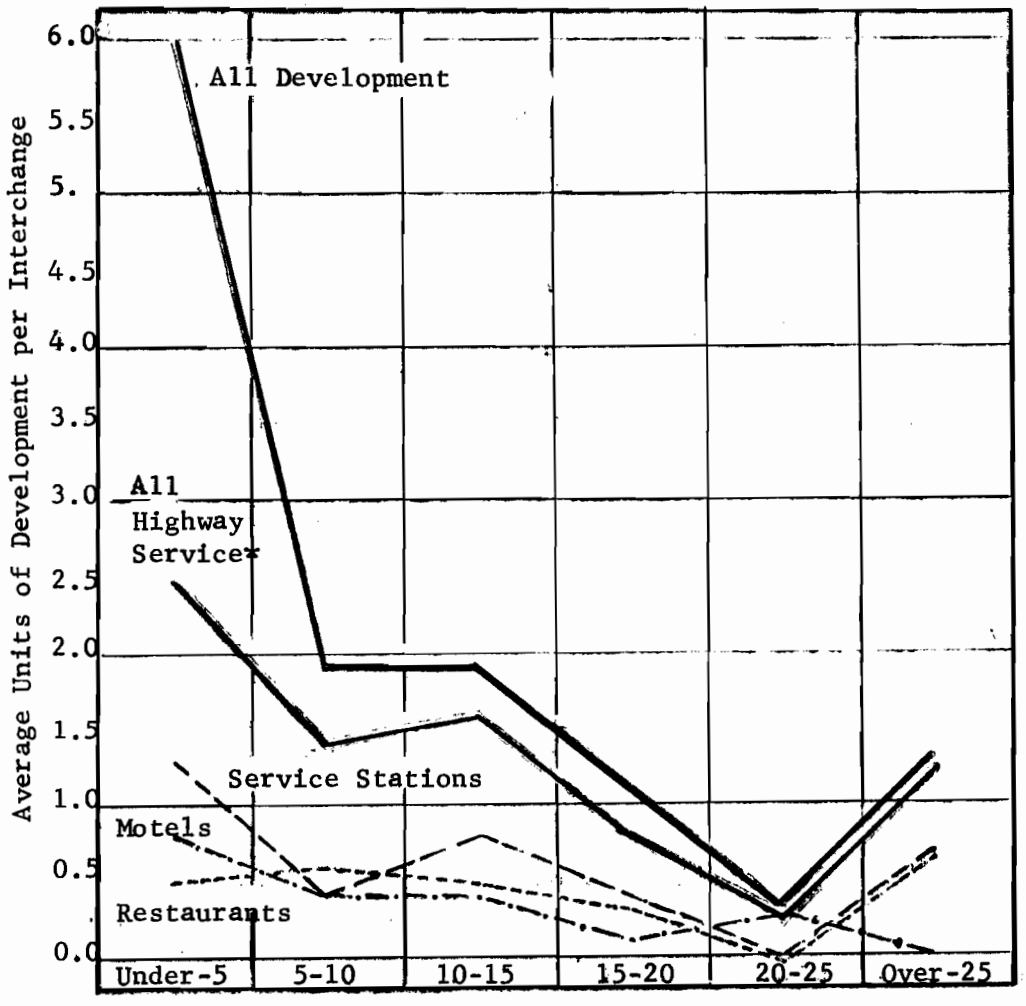
[c] The correlation coefficient is significant at the 5 percent level.

Figure 1

DEGREE OF DEVELOPMENT

AND

DISTANCE FROM NEAREST URBAN AREA (10)



* Highway Service, Service Stations, Motels, Restaurants

Table 7 shows clearly how different types of activities tend to locate according to their dependence upon access from the main highway.

Table 7, Distribution of Land Development, in percent, by highway interchange quadrants (13,14)

Land Use	Quadrants	
	Right Hand	Other
Highway related	59 %	41%
Commercial	51	49
Residential	50	50
Agricultural	49	51
Vacant	48	52
Institutional	43	57
Industrial	43	57

As expected, highway related activities tend to concentrate near the off-ramps, while industrial activities are more frequently located in other quadrants. The rather equal percentage of vacant land in both right hand and other quadrants may indicate that most of the interchange areas were not fully developed and that the distribution of land uses consequently was not influenced by scarcity of land.

Bypass Studies. A number of impact studies from Texas, (1-8), have examined what changes are likely to take place in the area along a new bypass route. The before-and-after study method is the technique used in these studies to give information about the impact of the bypass route on adjacent land.

As the summary of these findings, Table 8, shows, there is an obvious trend in the land use pattern, even though the area characteristics vary. The data from the period before construction of the highway facility shows that most of the land was held for agricultural use. For some areas, a significant part is classified as "held for future use." To what degree this is caused by the highway planning and purchase of right of way for the facility is not investigated.

TABLE 8. CHANGES IN LAND USE FOR SOME AREAS ADJACENT TO NEW BYPASS ROUTE (3-6)

AREA	Year	Agricultural	Timberland	Held for Future Use	Rural Residential	Urban Residential	Commercial, Traffic-serving	Commercial, Non-traffic-serving	Industrial	Institutional Municipal	Other
Rural area E. Houston	1954	6000		5500	500	500	10	10	50	5	625
	1962	3371		7600	657	517	11	15	360	17	652
	Change	-2629		2100	157	17	1	5	310	12	27
Chambers County	1955	22620	1320	535	130		0	2	55	2	1136
	1965	22513	1208	544	216		8	43	55	55	1158
	Change	-107	-112	9	86		8	41	0	53	22
Conroe	1958	9678	4672	3087	424	570	62	7	57	1743	0
	1965	6025	2904	7356	582	928	69	115	73	1921	327
	Change	-3653	-1768	4269	158	358	7	108	16	178	327
Huntsville	1954	4000	1600	1416	231	289	16	13	1	1007	227
	1964	3607	1374	1460	343	486	31	25	1	905	568
	Change	-393	-226	44	112	197	15	12	0	-102	341

The most significant change in land use between the before-and after-periods is the decrease in agricultural land use and the increase in land held for future use. Many of the properties shifted owners before they shifted land use. This indicates speculation in land caused by the construction of the bypass route. Therefore, the changes in land use which have taken place indicate more about anticipated future exploitation than about real changes in land use.

The after-period in these studies varies from 2 - 5 years beyond the time when the bypass section was opened to traffic. Thus it may be said that the studies show only a short term effect on land use. As the area classified "held for future use" constitutes up to 70% of the study areas, the long term effect may be different from the short term effect.

Change in land use depends largely upon distance to the highway facility. These studies from Texas show that the change is most likely to take place in the abutting tracts. The highway impact on land use studied in these cases is therefore limited to a very narrow strip along the facility. The number of abutting tracts according to land use is shown in Table 9.

TABLE 9: VARIATION IN NUMBER OF ABUTTING TRACTS ACCORDING TO LAND USE ALONG BY-PASS ROUTE (8,9,11,12)

STUDY AREA	Period	Agricultural	Timberland	Held for Future Use	Rural Residential	Urban Residential	Commercial, Traffic serving	Commercial, Non-traffic serving	Industrial	Institutional Municipal
Waxahachie	a			28	5	8	1	1	1	1
Chambers County	1947-55	43	5	21	0	0	0	0	0	1
	1960-65	43	4	22	4	0	5	1	0	2
Conroe	1952-58	15	25	43	5	6	0		0	6
	1963-65	7	3	58	6	6	5		0	8
Huntsville	1950-54	14	16	1	2	0	0	0	0	6
	1960-69	3	9	24	8	4	7	2	0	6

a - Difference between after period (1959-62) and before period (1951-55).

Effect on Agricultural Land Use. The highway effect upon agricultural land use found in the bypass - studies, (1) to (8), is not representative of the over-all effect from the interstate system. In the bypass-studies most of the tracts were located just outside of towns ranging from 8,000 to 25,000 in population, and the resulting effect is caused by the combined effect of highway and nearness to a city.

Of the studies reviewed, only three from Texas (15) to (17) deal with the effect of construction of a new highway facility through a rural area. These studies cover a period beginning one year before construction and ending one year after the highway section was opened to traffic. In order to account for any external or general influences not attributable to the highway during the period, data were also collected from a control area that was similar to the study area in the before period.

These studies seem to indicate that there is no evidence of major change in land use as a result of the highway construction, except for the fact that parts of tracts of land are acquired for the highway right of way.

Further findings state that the loss of land for right of way seems not to have any noticeable effect on the average net-cash operating-income of properties in the study area.

In most cases the new highway improved the farmers' access to the nearest trading center. The ones who continued to use their regular routes to town reported less traffic and congestion on those routes after construction of the new highway.

Most of the farmers whose lands were affected by the highway experienced an increase in travel distance necessary to operate the remainder of their tracts adjacent to the highway. The additional distance to reach these tracts varied from about .1 to 4 miles. In the three studies, the average of additional miles per farmer per year varied from 120 to 390 miles.

Highway Effects on Recreation Areas. Highways are usually considered to have a positive effect upon recreation areas. The construction of highways results in the taking of land for right of way, but this adverse effect is usually minor compared to the increased accessibility to recreation and park areas provided by the facility.

Recreation travel may be a significant part of the total traffic in some areas. In fact, all recreational parks rely on good highway transportation.

In Yellowstone National Park, for example, the number of annual visiters increased from 52,000 before 1917, when no cars were permitted inside the park, to 250,000 annually in the 1917 - 1927 period. In 1959 1.4 million persons visited Yellowstone. Total figures for the number of visitors to the different types of recreational areas all over the nation are not known. However, with the existing degree of urbanization, almost all recreational activities depend extensively on the use of the private automobile. What value the access to these areas provides with regard to mental and physicial benefit for the public can probably not be measured in terms of money. In terms of income from tourist activities some areas depend to a high degree upon the numerous visitors. The need to provide, limit, and distribute access to recreational areas is an important concern, and it is bound to be given more attention in the future.

Impact on Land Values

The studies tend to verify that accessibility is a key catalyst for changes in land value. Since land value is a function of the possibility of economic activity, and since this possibility changes with ease of access, it is obvious that the value of land varies with its connection to a transportation system.

Thus, land value may reflect the economic impact of the highway facility; in this way, land value might be considered an important indicator of both real and anticipated effect of the transportation system.

However, accessibility is only one factor and should not be regarded as isolated from traveller characteristics or land use characteristics. Different kinds of economic activities depend upon different groups of travellers (e.g., local traffic or through traffic); therefore, access has to be related to land use and, in some degree, to other general characteristics of the location of the study area.

Interchange Areas. The study of interchanges along I-94 in Michigan, (9), clearly shows that study area location and land use must be taken into consideration when land value is analyzed. This study investigates land values for different land uses in full interchanges. Table 10 gives a summary of the findings.

Table 10: CHANGES IN LAND VALUES BY LAND USE TYPE IN FULL INTERCHANGES (9)

Interchange Location	Average Land Values ($ per acre) 1960 - 1964		Percent Change*	
	Service Stations	Other	Service Stations	Other
Major City routes	54 653	8 600	441	227
Sec. City routes	18 650	1 830	388	215
Small Town	11 100	995	641	205
Rural	26 470	512	627	161

* Period 1958 - 1959 compared with period 1960 - 1964

Table 10 shows that investors in service stations were willing to pay far more per acre than other investors. The difference is especially high at interchanges in rural areas. The main reason for this is probably the difference in net annual return for other activities, which, unlike service stations are more dependent on the general population density in the area. Service stations on the other hand serve the traffic, and it may be expected that traffic volumes are more important than the nature of the area in which the interchange is located. As service stations depend more upon direct access from the highway than other activities (see table 7), it may be expected that land values vary considerably in the different quadrants according to the interchange design.

Another reason for the difference between the price paid for service stations and that for other land uses may be the fact that the freeway was a relatively new concept in 1960, and thus the investor had little experience in calculating possible future profit. Therefore, these prices may express the investor's anticipations and ability to pay more than real, long-term changes in land value.

Effect of Bypass Routes. The four studies from Texas seem to indicate especially high increases in land value along bypass routes (1), (2), and (5) to (7). The before-after study method is used; to account for general increase in land value, a control area similar to the study area in the before period is also examined.

Since the construction of the new bypass route is the principal difference between the study and the control area during the after period, the divergence in land values between the two areas is attributed to the highway improvement. Possible factors other than the new highway facility are therefore not considered.

As can be seen from Table 11, there is a significantly higher land value in the study areas during construction and in the after period than in the control areas. The control areas seem to have a rather stable pattern with regard to land value. The land values in the separate study areas fluctuate to such a degree between one study period and another that it is difficult to see a clear pattern. What can be learned, however, is that there is a significant increase in land values, over and above the expected increase, between the before and the after periods.

Table 11 gives the average sales prices per acre, regardless of land use. As land value is highly dependent upon land use, a dominance in sales of land devoted to a given use in a particular period may explain the great variation in sales price between one period and another.

TABLE 11: CHANGES IN LAND VALUES IN UNIMPROVED AREAS ALONG BYPASS ROUTES (1),(2),(5) to (7)

Study Area	Study Period (b)	Average price per acre ($) (a)			Percent Increase		Highway Influence	
		Abutting	Non-Abutting	Control Area	Study Area	Control Area	$/acre	percent
Temple (I)	1941-48	58	58	57				
	1949-54	440	91	112	168	45	733	1227
	1955-57	920	214	108	430	-4		
Temple (II)	1943-48	91	91	98				
	1949-54	921	549	136	531	39	2331	2562
	1958-61	3779	2062	143	2601	0		
Waxahachie	1951-55	172	243	109				
	1956-58	1123	429	142	290	30	590	288
	1958-62	847	833	141	20	-1		
Conroe	1952-58	1231	497	793				
	1959-62	500	436	930	3	17	702	95
	1963-65	1658	684	698	77	-25		
Huntsville	1950-54	1197	891	400				
	1955-59	8127	1460	487	192	22	2376	253
	1960-64	7205	1038	497	26	-2		

a) All prices adjusted to Labor Statistics Consumer Price Index, 1947-49 - 100.

b) The first period for each study is the "before" period, the second is the "construction" period, and the third is the "after" period.

Increase in land use for improved areas is not shown in Table 11. The studies indicate, however, that this is smaller than the increase for unimproved areas. One reason for this may be that improved lots are fixed in land use, and their prices normally do not respond so readily to changing surroundings as do unimproved lots.

In order to determine the effect on land values of proximity to the highway facility, the sales were classified as abutting and non-abutting. As shown in Table 11, the unimproved properties abutting the highway right-of-way received a much greater highway influence than nonabutting properties. As there were frontage roads along most of the bypass routes, this difference between abutting and nonabutting properties should be caused by the direct access to the frontage road for abutting properties.

Effect in Rural Areas. Studies of highway impact in rural areas in most cases also show an increase in land value due to the highway facility (18), (3), (4), (19). The increase in these areas, however, seems to be less than in the proximity of cities. A study from three different interstate routes in North Carolina, (18) shows great variation of value for different land uses. The average percent increase for all land uses varied from 3.6 to 133 percent, and for some of the land uses the variance was even higher. However, the results from this study do not indicate a general pattern for increase in land value according to land use.

While the value of farm land in the study from North Carolina showed an increase ranging from 21 to 198 percent, three studies from Texas, (15,16,17) did not indicate any significant increase for farm land.

A study of the influence of highways on rural land values in the United States, (3), shows that land value varies with the quality of the road. Farms were classified according to both the surface of the road they were served by (hard-surfaced roads, gravel roads, and dirt roads) and the quality of land. For all groups of land quality, sales price per acre of property increased with better quality of service road.

Impact on Business Activity

As it has been pointed out, land value varies with land use. Apparently there also is a relationship between the net return of business activity and what the investor is willing to pay for a special site. Some types of businesses are to a high degree dependent upon good access; thus it is reasonable to think

that transportation facilities have a great influence on these business activities.

Interchange Areas. The study of interchanges along I-94 in Michigan, (9), analyzes service station gallonage at full interchanges. The gallonage is averaged within each interchange classification (major city, secondary city, small town, and rural area). A statistical analysis was made to test whether there was a significant difference in business success between one interchange classification and the other. The major city interchange stands out from all other classes with a pumpage almost double the average of the others. A significant difference was not found between the other classes, even though the average pumpage for service stations in small towns was a little higher than the average at secondary city and rural interchanges.

To find the influence of proximity to the highway, the difference in pumpage for service stations within or outside a distance of 400 feet from the freeway was tested. The difference was found to be statistically significant and sharply focuses on benefits derived from the freeway.

Bypass Routes. Several studies from Texas investigate the influence on business activities of new bypass routes, (2),(3),(5) to (7). In these studies the average of the gross sales for different business activities is calculated for different time periods. To provide a truer picture of what is really happening, this part of each study includes businesses located along both the new facility and the old route. The result is summarized in Table 12.
see page 23.

Traffic-serving businesses, such as service stations, motels,etc., are separated from non-traffic serving businesses. However, it is difficult to draw any general tendency from the table. As can be seen in the table the variation is less for non-traffic service businesses than for traffic serving businesses. Also, the non-traffic services in all but a few cases have an increase in annual gross sales, while many traffic-serving activities show great decreases. The only conclusion to be drawn from this table is that traffic-serving businesses seem to be more affected by the highway facility than other business.

Rural Areas. A study of businesses along secondary roads in Kentucky (20), may indicate the effect of highway improvement in rural areas. Two periods, 1938-50 and 1955-60, were studied. The total number of businesses in the area

TABLE 12: PERCENT CHANGE IN ANNUAL GROSS SALES OF BUSINESSES ALONG BY-PASS ROUTES (2), (3), (5) to (7)

Study Area	Study Periods a)	Traffic Serving					Non Traffic Serving				Grand Total
		O Old route B Both routes	Service Stations	Food Service	Motels	Total	Grocery	Services	Misc.	Total	
mple (II)	54,57	O	10.6	-19.1	-54.4	-15.3	5.5		19.2	8.2	4.7
	54,57	B									7.7
ll County	54,57										12.6
ate of Texas	54,57										19.5
xahachie	58,62	B	-18.7	0.8	43.3	-13.5[1]					3.5[2]
	58,62	O					-19.4	33.8	25.0	10.1	
otal City W.	58,62										13.1
tate of Texas	58,62										17.8
ural, East of ouston	58,62					6.7	-7.2		36.7	-1.0	0.5
onroe	62,65	O[3]	-10.0	-14.0	17.0	-9.0	6.0	80.0	-3.0	25.0	9.0
	62,65	B	-20.0	-15.0	17.0	-17.0	1.0	63.0	171.0	53.0	
ntsville	58,64	O[3]	25.0	6.4	-23.7	13.4	-21.5	15.3	50.0	20.9	19.1
	58,64	O	-8.5	23.3	19.3	2.4					
	58,64	B	19.1	47.1	48.7	29.0	85.0	97.0	43.0	58.1	
rkel	58,62	B				64.7				24.9	
otal City M.	58,62		55.1	70.9	-66.6	53.3	7.2	32.7	4.5	13.1	18.9

The study periods are indicated by the latest year in each period.

Figures from 36 businesses.

Figures from all 73 businesses.

Figures only from firms operating both first and last year in a period.

increased, even though there was a decrease in the number of "open-country" stores. Analysis of the data shows that improvement of intercounty routes and of intracounty "collectors" appears to be of primary benefit. But the reports do not give enough information about the design of the highway facility or about community related factors to explain why, when both old and new routes are considered, service stations and motels in some areas gain an increase in gross sales while those in other areas show a decrease.

Impact on Industrial Location and Manufacturing Growth

Two of the studies reviewed try to determine which factors are important for industrial location. One of the studies included interviews of a small number of the owners of industrial firms currently located on free access roads (21). All of the firms but one were mainly dependent upon trucks to transport their final product.

All firms, except one, felt that location in close proximity to a major highway was necessary. However, little priority was given to specific types of highway facilities. If the road was paved and in good condition, it was judged adequate. Advertising benefits resulting from location obtained little consideration by the owners. This factor was viewed as an extra benefit rather than a necessity. Some concern for the value of advertising benefits was indicated for firms serving consumer as opposed to industrial markets.

Another study analyzes a nationwide questionnaire survey of manufacturing, wholesale and warehousing establishments. (22). Each of the firms had made one or more moves during the period 1955-59.

Survey findings indicate that on the questionnaire involving 13 different plant location factors, the most frequently mentioned concern was proximity to good highways. On the average the next four most important factors were, in this order, abundant labor supply, availability of suitable land, proximity to markets, and rail service. However, different establishments ranked the rail service differently in importance from first to eleventh place. Industries giving emphasis to both highway proximity and rail service are printing and publishing, wholesale trade, fabricated metal products, furniture and warehousing.

In two highway impact studies (bypass-studies), operators of retail businesses report advantages and disadvantages of the construction of a new highway facility (6) and (7).

The results from both studies are quite similiar. There was a general agreement by both traffic-serving businesses and others that the new bypass route relieved traffic problems. As Table 13 shows, non-traffic serving businesses reported more advantages of the new facility than did traffic serving businesses (this is in harmony with reported business activity in Conroe according to Table 12).

TABLE 13. ADVANTAGES AND DISADVANTAGES OF A BYPASS ROUTE AS REPORTED BY OWNERS OF RETAIL BUSINESSES (6)

Item	Number of Businesses	
	Traffic Serving	Nontraffic Serving
Advantages:		
Relieved traffic problem	22	24
Helped personal business	4	10
Helped all except traffic serving	9	3
Helped all businesses	3	4
Other	8	10
Disadvantages:		
Failed to relieve traffic problem	0	1
Hurt personal business	16	3
Hurt only traffic serving	0	8
Hurt all businesses	9	2
Others	3	7

One of the few studies investigating air, rail and water transportation in addition to highways deals with the effect of transportation on urban manufacturing growth. (23). One hundred and six different city pairs (freeway located cities matched by similiar non-freeway located cities) all over the nation are included.

In short, the conclusions drawn by this study are:

(1) Modern highways significantly affect manufacturing growth, but not in all situations. Freeway cities grew faster only in regions where traffic flow along regular highways is seriously impeded.

(2) Freeway cities with populations greater than 16,000 grew faster than corresponding non-freeway cities.

(3) Cities with airline connections grew significantly faster, particularly in the South and West, for pairs above 19,000 population. This suggests that industry is attracted especially to freeway cities when there is concomitant air service.

(4) Cities with poor rail service might experience "catch-up growth" with the advent of a freeway, the road becoming a substitute for rail service.

(5) For the five waterway pairs included in the study, both freeway and non-freeway cities showed lower employment rates.

(6) The relationship between growth and distance to the freeway is described by a probability curve peaking at 9 miles and with a standard deviation of roughly five miles. Benefits do not occur to cities located more than about ten miles from the nearest freeway.

(7) Freeways probably stimulate existing industry as well as attract new plants.

Social Impact of Highway Improvement

The literature on this subject is rather imcomplete. However, there seem to be few studies concerned with the social impact of interurban transportation links on rural communities (24). Although some information of this type does exist for urban areas, (25) and (26), it is questionable whether such data can be of use to this project because of the basic differences in the profile and composition of rural and urban communities.

Most studies have shown positive consequences resulting from highway construction. The Federal Highway Administration reports that Interstate Highways have received broad community support because of reduced congestion of a town's roads, reduced noise and air pollution, better access to recreational facilities, and higher economic levels for the town's businesses. For rural communities, in particular, they have served to upgrade primary and secondary educational facilities, improved vocational training possibilities, and made medical care more accessible (27). Also, increased accessibility to shopping and recreational facilities as well as to church, lodge, and organized farm-related functions has resulted (28).

The best discussion so far found is presented by Dansereau (29). In his study of rural/suburban communities he found that when a highway is introduced into an area, certain results occur. The population increased because of the inward migration of younger and higher-income people, thus, raising the standard of living. This population increase occurs more rapidly in communities located on arteries of the highway than in those not located on arteries. In the areas studied, levels of living rose visibly with the introduction of new manufacturing concerns (attracted, in part, by the new highway). It was further found that towns which were located nearer highways were more likely to develop a

comprehensive community plan. However, most of the users of the highway were those who were in higher occupational, income, and educational groups, who held many memberships in organizations, and who were newcomers to the area.

It was found that a highway and its bypass routes can influence a city's growth pattern as well. In order, then, to allow the city to grow in an orderly manner, the highway should be located a considerable distance from the community's prime growth center (30).

Community Response to Highway Improvement

Presence of Other Resources. Little has been done in investigating community response to highway improvement. Even though some of the fundamental effects of highway improvement upon land use, land value, business activities and location of industry are known, the resulting effect upon a community's development is unknown.

This lack of knowledge, to choose one example, led to the effort to reverse economic trends in Appalachia by means of a highway system, the Connecticut Turnpike (31). This example seems to illustrate that merely providing a highway system does not necessarily mean an economic boom for the adjacent communities. Highways can be a stimulus for change, but the response to this stimulus depends on the capacity for change existing in the areas to be served. What the change will be depends greatly on both economic and human responses.

Walter C. McKain states (31):

> Highways can furnish only the external stimulus for change. The response made to this stimulus depends on the capacity for change existing in the areas to be served. The presence of other resources, the availability of community leaders, and a plan for action are needed components for social action. Depending on the availability of these other elements, a new road can be either a minor irritant or a positive force for change. The ingredients for community development go far beyond adequate or even superior transportation.

The effect of the turnpike of the individual communities in eastern Connecticut varied. Retail sales, as measured by tax receipts, increased 54 percent in an eight year period for the entire area served by the Connecticut Turnpike. In four of the towns, the revenue increased by 300 percent or more, in three other towns the increase was less than 35 percent, and in two towns, there was actually a decline. Although manufacturing employment increased 42

percent for the entire area, in nine towns the number of jobs declined. Real estate values rose in every town, but not uniformly in the entire area.

One plausible reason for the difference in development may be attributed to differences in the resources of separate communities. The potential for development is a function of the interaction of natural and human resources, and thus a given community will respond to change in accordance with its own potential. For example, a textile mill in one community is said to have created a group of workers who do not readily improve their skills. More generally, some communities tended to resist change and adopted a crisis approach to social action.

Population Mobility. One important effect of highway facilities on a community is to increase mobility. The interurban transportation system, consisting of modern freeways, and the private automobile have shortened travel time drastically. People thus can commute over longer distances in the same amount of time. This means greater opportunities for employment in nearby metropolitan areas for the people in the outlying community, but it also means that industry may locate away from the central city. Thus, there is a need to investigate the net change in the socio-economic structure of communities affected by the alteration of the interurban transportation system.

EFFECTS OF OTHER TRANSPORTATION MODES

Effect of Airports

No previous study was found which evaluated the impact of air transportation. What can be said is that with the rapid growth in aviation during recent years, an airport is a valuable addition to a community.

A study from Texas Aeronautic Commission gives the results of an attitude survey among towns and communities in Texas (32). The report states that towns of 2,000 - 5,000 population are most apt to be aware of the importance of the need for an adequate airport to attract new business and to maintain and enhance its position in the struggle for economic growth. Small communities placed considerable emphasis on their proximity to adequate airport facilities in adjacent metropolitan areas. Interest in commercial service began when a city reached a population of 25,000 or more.

A nationwide study of cities located along freeways, (20), indicates that for places with a population of more than 19,000, cities with air transportation grew faster than cities without air transportation. This was particularily the case for cities located in the South and West. Possibly industry is especially attracted to cities with air facilities in areas with significant distance between one city and another and no developed public interurban transportation system.

Rail or Bus Services

Wheat (20), points to the fact that the effect of highway improvement to some degree may be influenced by existing rail service. Cities with poor rail service might experience "catch-up-growth" with the advent of being connected to the freeway network, with the freeway becoming a substitute for rail. No report reviewed deals with the effect of decreased rail services, and no report has been found which explains the importance of the presence of public interurban bus transportation.

MODELING OF HIGHWAY IMPACT

Very little effort has been made actually to model the impact of highway improvement. This is probably explained by the complex cause/effect relationship between highway improvement and community characteristics and also by the fact that many important variables are qualitative and not quantifiable. As modeling efforts in most cases depend upon obtaining information for previous years from local records, available data may limit the number of different factors included in the analysis.

Different models may be created according to the purpose of particular highway impact studies. So far only models of land development and land value have been reviewed.

Land Development

One important effect of land development in an interchange is increased traffic volumes, possibly producing capacity problems on entrance or exit ramps. The study of interchange along Interstates in Indiana (11)

evaluates a model to predict magnitude of road user developments at an interchange.

The interchange development is expressed as "weighted development"; different land uses are given different weights, since they have different traffic generation rates. The following weights are used:

Service stations	1
Restaurants	1
Motels (small or large chain)	1/2 - 1 1/2
Truck stops	4
Neighborhood shopping centers	3
Regional shopping centers	6
Service stations combined with short order restaurants	1 1/2

"Total weighted development" is the weighted sum of the establishments at the interchange. The final model gives the following expression:

$$\begin{aligned}\text{Weighted development} = {} & 2.016 \\ & + 1.18 \times (\text{ramp volume}) \times 10^{-3} \\ & - 0.5897 \times (\text{population within 20 miles}) \times 10^{-4} \\ & - 2.49069 \times (\text{interchange age}) \times 10^{-1} \\ & - 0.84518 \times (\text{economic index}) \times 10^{-3} \\ & - 25.18036 \frac{(\text{economic index})}{(\text{population index})}\end{aligned}$$

The population index is an expression of population in the highway corridor divided by distance from the interchange under consideration. The economic index expresses the influence of parallel routes.

Standard error of estimate turned out to be 13.87, and $R^2 = 0.5989$. The above model was found to be the best that could be developed without adding extensive additional data. The degree to which "weighted development" is an appropriate measure for interchange development may be questioned, as may also the use of the two theoretical variable indices. To refine the model further, more factors describing the transportation and the community probably would have to be considered.

Land Values

Another study from Indiana (33) was undertaken to develop a techique for predicting the impact of highway improvement on the value of adjacent land parcels. Two different sets of data, one from Indiana and another from Florida, were used to run a regression analysis of the change in land value as a function of different variables.

The predictor variables included in this study were:

(1) Parcel size (in acres)
(2) Time elapsed between completion of highway improvement and sale of parcel (in months)
(3) Type of highway improvement (interstate, primary or secondary highway)
(4) Type of land use (residential, commercial, agricultural or vacant)
(5) Type of area (urban, urban fringe or rural)
(6) Type of access control (full, partial or none)

Each type within variables three to six was treated as a dummy variable, which assumed a value of one or zero depending on whether or not it was observed for the parcel in question.

All but four of the 100 parcels in the Florida data included interstate highways with full access control. The regression analysis showed that the variables included in the regression equations gave an R^2 varying from 0.24 to 0.46 depending upon the form of the regression equation. Consequently, at most only 46% of the change in land values could be explained by the above mentioned variables.

The Indiana data (33 parcels) indicated a much stronger relation between change in land values and the independent variables. The regression analysis gave an $R^2 = 0.87$. Some classes of the variables contained only a few observations, and the regression equation is consequently not presented as a reliable predictive model. Figure 2 (p 32) shows the relative importance of the independent variables used in the regression analysis. According to the analysis, the type of highway improvement is the most important variable, followed by type of area, land use type, type of access control, time elaspsed after highway improvement, and size of parcel.

As can also be seen, construction of a secondary or primary road causes greater changes in land values than does construction of an interstate highway. The changes in land value are greatest in urban areas. Without regard to type

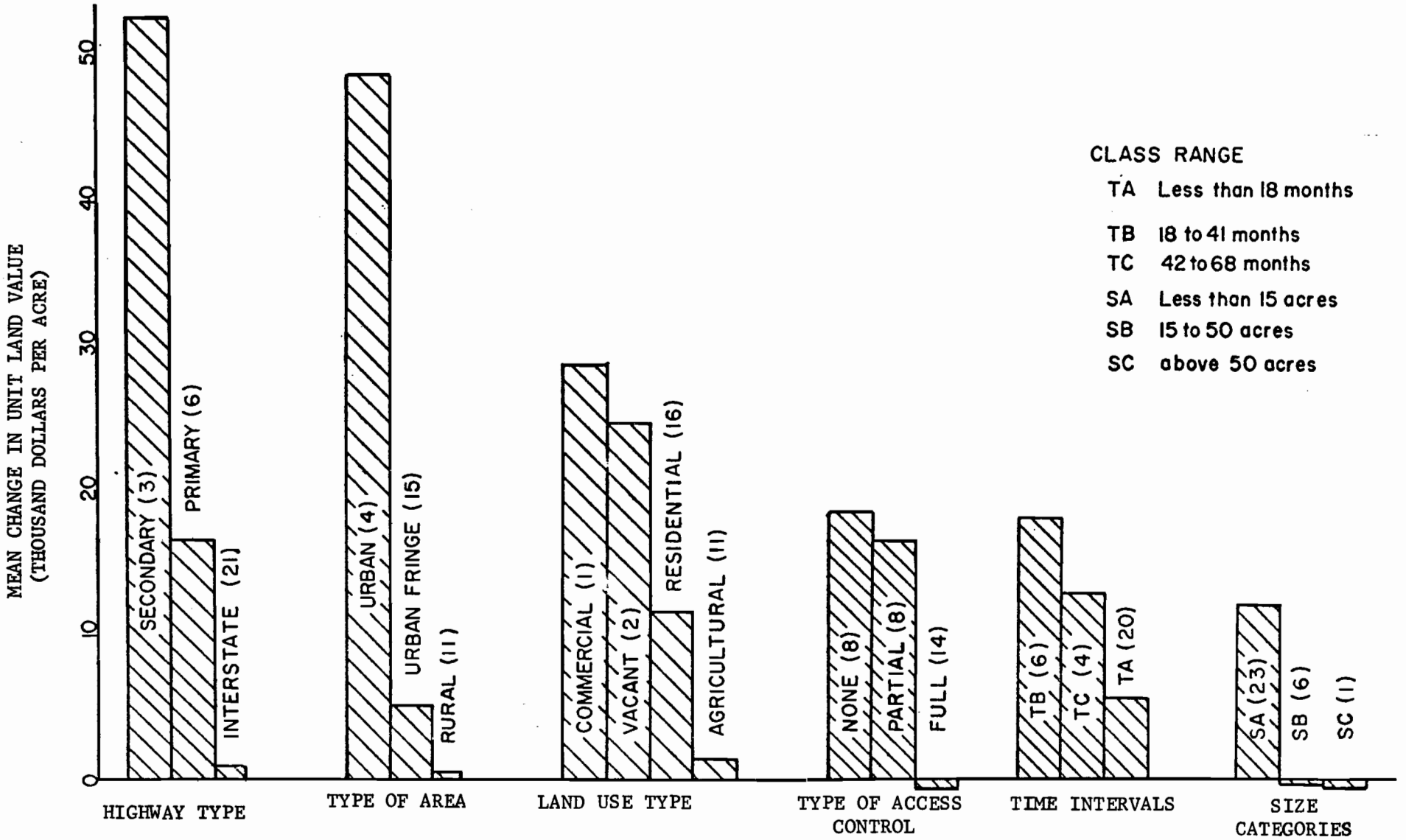


FIGURE 2.

VARIATION IN LAND VALUE

BY TYPE OF VARIABLES (33)

of area, land used for commercial purposes and vacant land show a greater increase in land value than residential or agricultural uses. Full access control can result in a decrease in land value. Parcels smaller than 15 acres evidently increased more in land value than did large parcels.

One should have in mind that this study was limited to "remainder" parcels which sold some time after the highway improvement. No information is available about which factors influence an owner's decision to sell or not to sell a remainder parcel. The model, consequently, is not of general use for predicting the value of parcels adjacent to or in the proximity of highway improvement.

A more general modeling effort of land values was done in North Carolina (18). The study included interstate construction in different rural areas. The dependent variable was land value, and the independent variables included size of parcel, year of sale, land use, distance to right-of-way, distance to business district, distance to interstate access,etc. The most important single variable influencing land value was found to be the size of the parcel; the smaller the parcel, the higher the unit price. For specific land uses, certain other variables showed high simple correlation with unit price, but these correlations vanished when the multiple regression analysis was used. This indicates a relationship between the independent variables rather than between the dependent and the independent variables. No information about R^2 for this analysis was given.

COMMENTS ON THE PREVIOUS STUDIES

All impact studies reviewed, with one exception, concentrate on impact from highway improvement. Even though the private automobile is the major mode of transportation today, these studies cannot reveal any information about the consequences of changes in air, rail or bus services. The studies show clearly that highway improvement has a significant impact, and usually a positive impact, on the areas along the facility, but not one of the studies reviewed evaluates the consequences of reduction in transportation service, as has been the case in most areas with rail service during the last two decades.

The previous highway impact studies provide a great deal of information, but their limitations should be noted. Many studies are directed more towards describing an impact, and the magnitude of the impact, than toward examining the cause/effect relationship. These studies are of value in showing the benefits of public investment in highway improvement, and they justify the spending of public funds in terms of "non-highway user" cost/benefit. However, they are of less value as a tool for highway or community planners since they cannot be used to predict the future impact of changes in the highway system in a particular community. All of the studies support general observations about the development of adjacent land, the increase in business activity and increasing land values close to the new facility, but few of them are designed to reveal the impact on the community as a whole.

The fact that each community has its own characteristic in terms of economic and human resources, geographical location, etc., makes it difficult to use the highway impact observed in one community to forecast the effect of highway improvement in another community. A forecast would be possible only where general community characteristics are included in the analysis, but unfortunately this is not usually the case.

In addition to these general limitations, previous highway impact studies are subject to criticism on more specific grounds, depending upon the particular methodology used in the research. Consequently, it is important to examine the advantages and limitations inherent in each of the five categories of study methodology before recommending a strategy for future research.

The Before and After Technique

This technique is the most commonly used; it is used either singly or in combination with other techniques in all studies dealing with changes in highway facilities. The main advantages of this approach are, first, that it is simple to apply and, second, that it is easy to understand. The technique measures the value of some of the characteristics of an area before and then after the highway improvement; the difference is said to be the effect of the improvement. Consequently, the only quantity measured is the change in value between one time period and another. The greatest disadvantage is very obvious: this technique cannot relate the measured effect to any specific cause. Since in most cases there will be a span of 3 - 5 years between the before and the after period, many factors other than highway improvement are likely to influence the study area. Thus, this technique cannot determine whether an effect is, or is not, caused by the road improvement. In an attempt to isolate highway effect, the survey- control area technique is often used with the before-after technique. However, as will be shown in the next section, the survey - control area technique is not itself a sufficient way of revealing the scope of the highway impact.

Most studies are conducted in the after period. This may cause difficulties in determining or measuring the nature of the study area in the before period. The only way to avoid this shortcoming is to select an area where the necessary information on the before period is available, thus considerably limiting the number of areas which may be studied. Even assuming that sufficient information from the study area is available, there still remains a major disadvantage to the before and after technique. For each characteristic to be measured, only one value can be assigned for each of the two time periods. The before period, theoretically, has only one defined limit, usually the date on which construction of the improvement was begun; the after period is also defined by narrow limits, usually the period between completion of the highway facility and the date of the study itself. In practice the average length of the before period is approximately only two years; the length of the after period usually varies from two to four years. (In reality, the length of the "before" period is undefinable because it is not known when knowledge of a proposed highway improvement begins to influence the development of an area.)

Figure 3, p 37, shows the possible pattern of a single response, in this case land value, to changes in the highway system. As can be seen, the before-after technique reveals no information about the trend in the before or the after period. The measured effect of the improvement will be the same regardless of the trend during the time preceeding the change in the highway facility. It is reasonable to say that the effect of the improvement is greater in cases where an existing "downward" trend is reversed than in the cases where the trend is already "upward," even though the measured effect in terms of a value for community response is the same. Consequently, it would be more logical to measure the effect in terms of the difference between the response to actual transportation improvement and a projection of the before-trend (assuming that no improvement had occurred). This situation is represented in figure 4, p 38. The total community impact over a time period would be the area between the two curves. Different phases in the improvement planning and implementation process may have different effects on community response (also indicated in figure 4). What the general shape of such a curve would be, assuming that the effect caused by the highway system development could be isolated for each period, is not known.

It is assumed that general public knowledge of the project, purchase of right of way and so on, will have an influence on the community response, even if not of the same magnitude as the actual construction of the improvement. Since events other than construction usually fall outside the scope of the before and the after study periods, their effect cannot be determined.

The Survey-Control Area Technique

This is the most common technique used to isolate highway impact. It has been frequently used to study the effect on land values in areas adjacent to a new highway facility. The technique does not involve an effort to identify the effect of each of the non-highway related factors influencing the development in the survey area. To find the total effect of the non-highway related factors, a control area, similar to the survey area, is selected. This control area is usually chosen far enough from the highway to have been unaffected by the highway facility.

In theory, the survey area and the control area would have to be exactly alike in all respects during the period just prior to the highway improvement. Also, the factors affecting development in the two areas should be the same,

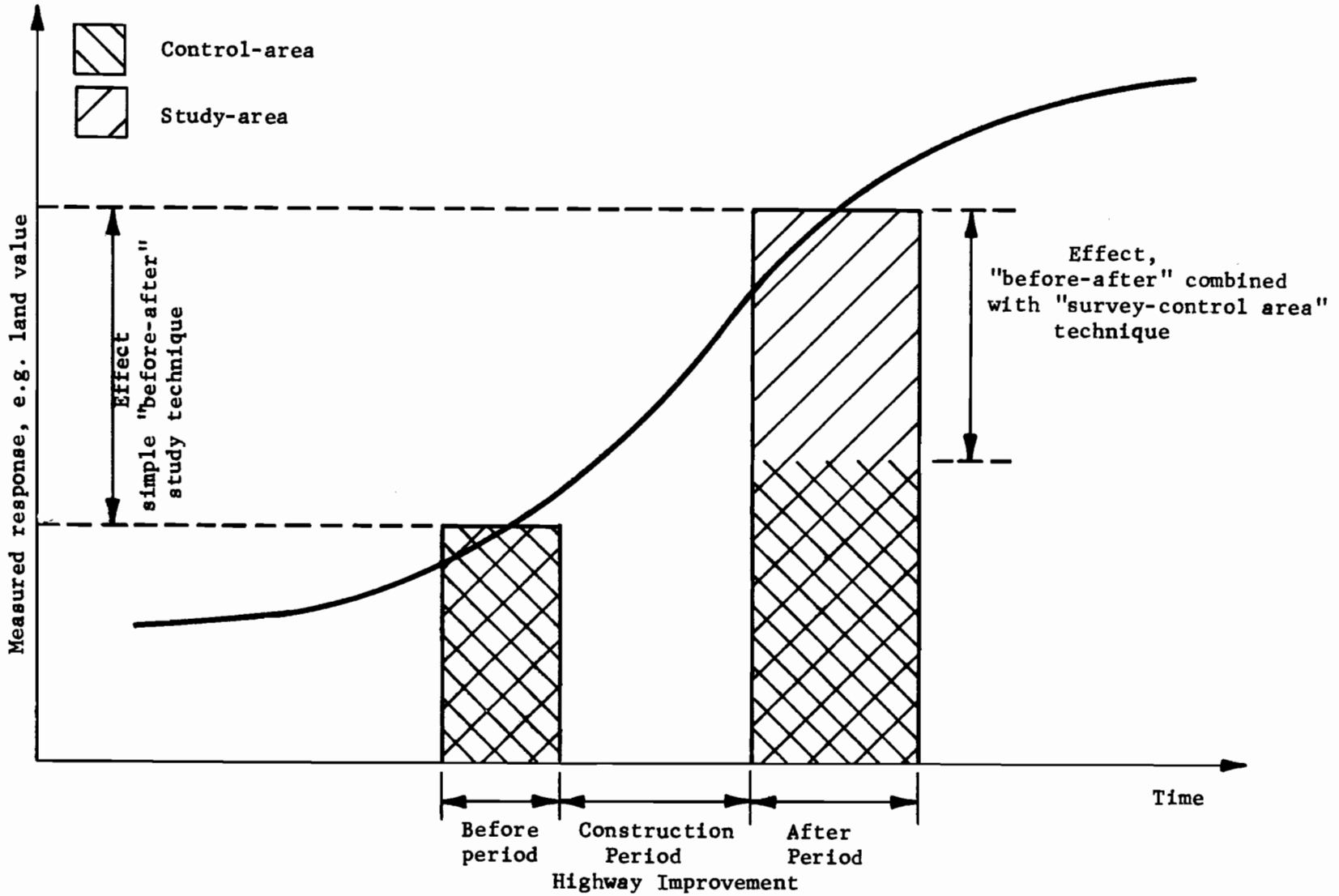


Figure 3

BEFORE-AFTER STUDY TECHNIQUE

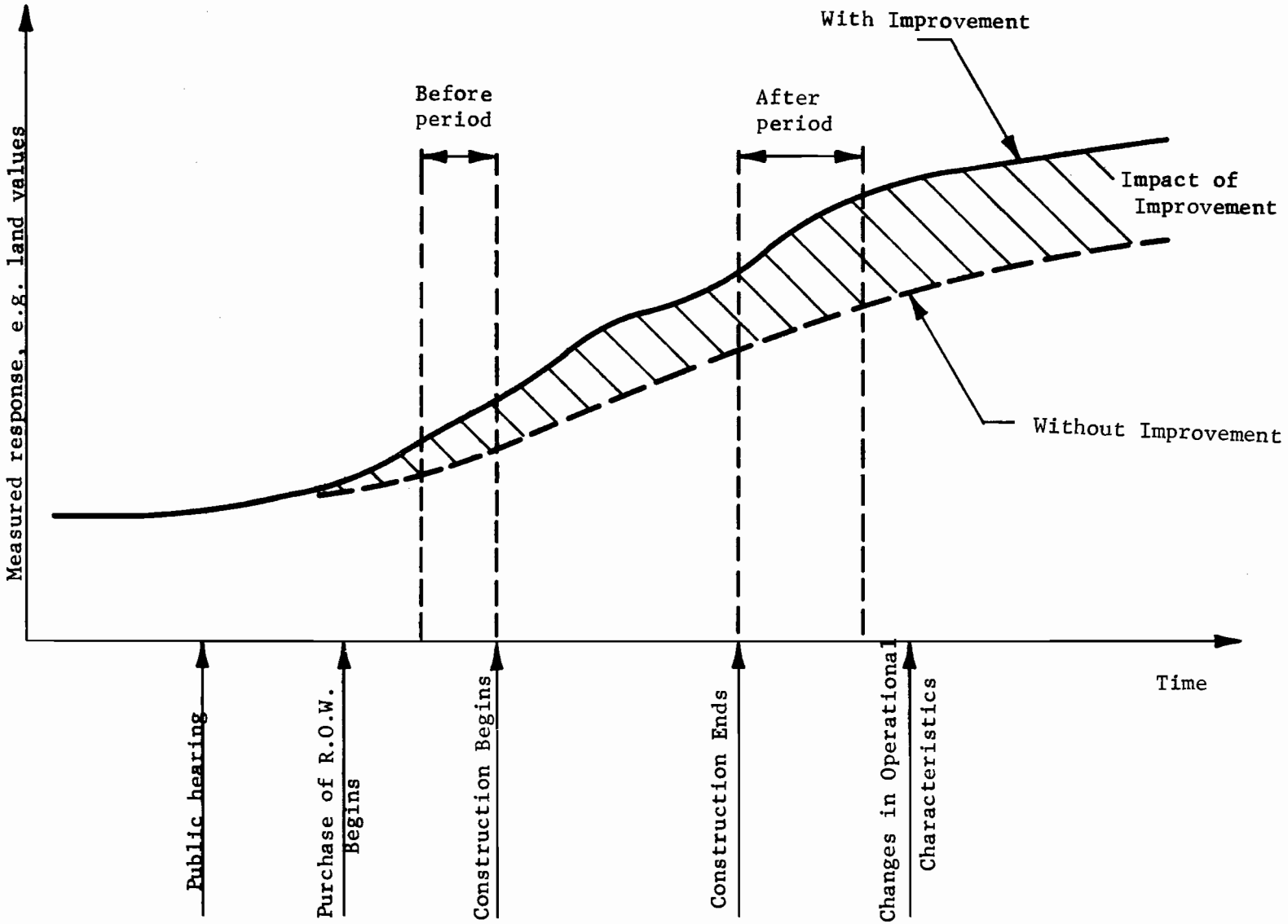


Figure 4

POSSIBLE EFFECT OF DIFFERENT PHASES IN HIGHWAY IMPROVEMENT

except the highway improvement. These requirements are hard to meet, as the spatial limits or distribution of the highway impact are not known in advance, and it is difficult to gather information relating to all non-highway related factors. For example, certain social classes frequently dominate certain areas of the community, and thus economic activity may be linked to a limited area, and land development may be strongly influenced by the local power-structure. Consequently, it may not be possible to find an ideal control area.

The survey - control area approach does not give any information about the spatial distribution of the impact unless the survey area is divided into sectors, bands, etc. Usually, this has not been done. Figure 5, p 40, shows survey and control areas as selected in an actual study. It is obvious that the effect of the different factors will not be evenly distributed over the two areas. Both of them include parts of the city, but they also extend several miles beyond the city limits. When the average value for each area is used, the character of this spatial distribution is lost, and thus the interpretation of any results of the study would be extremely limited.

The same figure also illustrates that these two areas, as chosen, could not be used to describe the effect of changes in the total transportation system if the changes were more extensive than merely the construction of the bypass route. Changes in rail or air service and alterations in local traffic conditions could affect the survey area and the control area differently, making it impossible to measure the total effect of changes in the transportation system.

While the survey - control area approach has offered an easy way to determine impact in a limited survey area, providing the requirements for the selection of a control area can be met, the method cannot be used to study the effect on the entire community. The community effect will include the effect in both the survey and the control areas; consequently, the "zero" effect in the control area, as well as all degrees of effect up to the maximum in the areas adjacent to the new highway facility, are of interest. This is illustrated in figure 6, p 41. The average community effect depends on both magnitude and spatial distribution of the effect on the entire community area.

In a small community, it probably would be difficult to find any control area not influenced by major changes in the transportation system. A new facility will possibly cause new activities to be established, but it might also cause already established activities to move from their old locations to

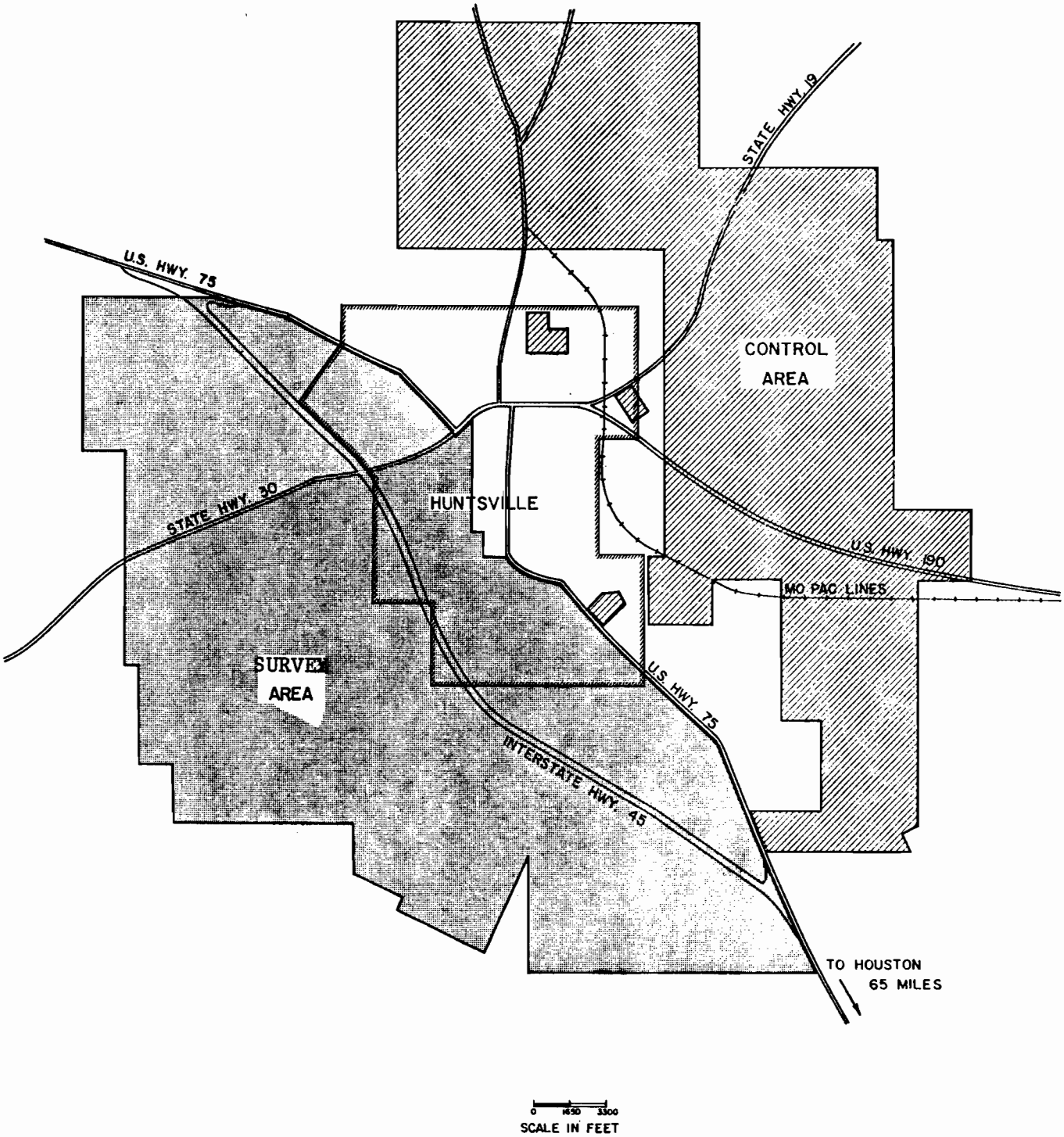


Figure 1. A map showing the relationship of the study and control areas to Huntsville and the transportation facilities in 1964.

Figure 5

EXAMPLE OF SELECTED SURVEY AND CONTROL AREAS

(From Reference 5)

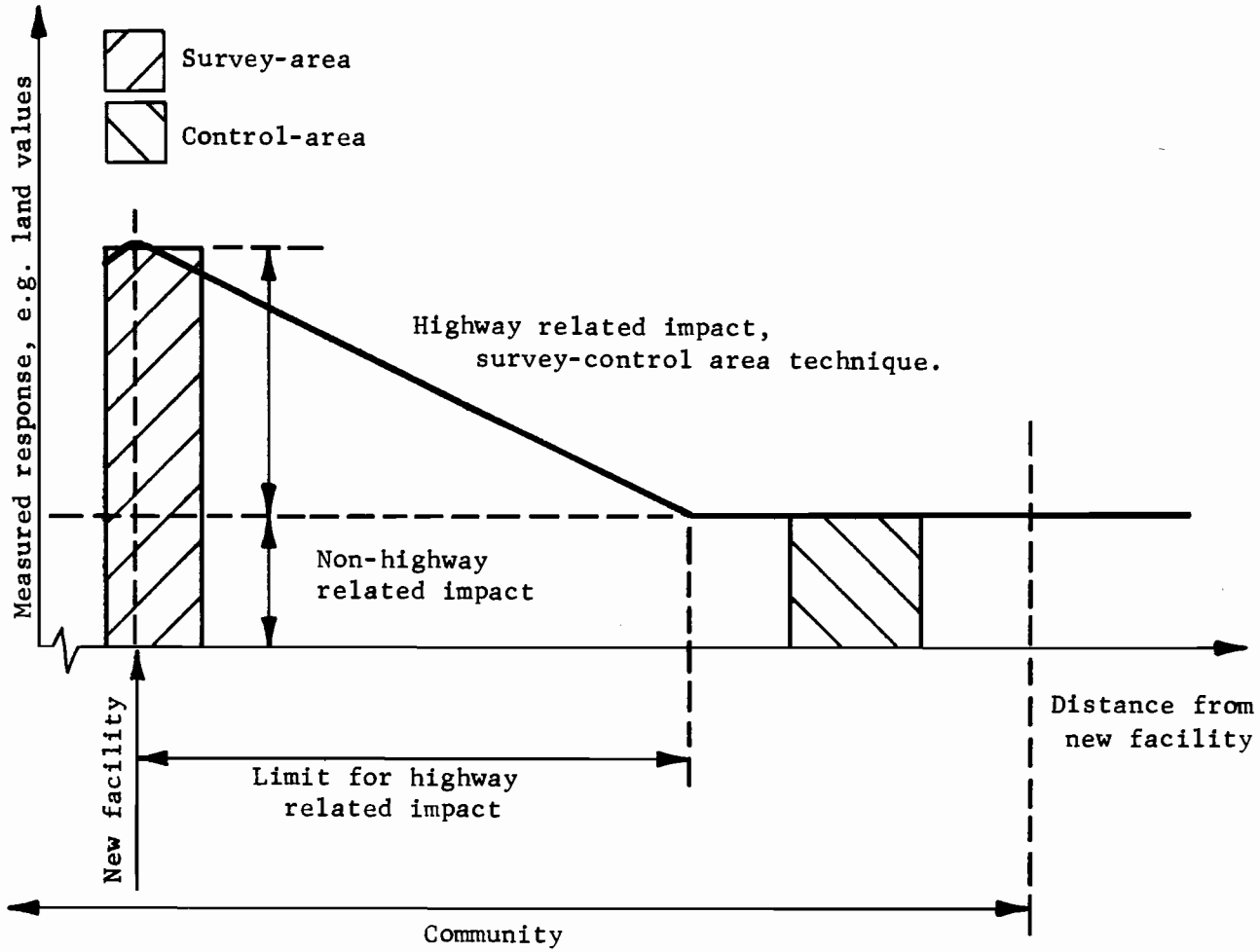


Figure 6

SURVEY-CONTROL AREA STUDY TECHNIQUE

sites closer to the new facility. Thus, because of limited resources and the relatively small number of activities in a community, it is likely that there will be a shift in the spatial distribution of activities affecting the entire area. This is illustrated in figure 7, p 43. According to the survey - control area technique, the highway impact is measured as the change in the survey area minus the change in the control area. As a result, any negative effect outside the survey area actually will contribute to an increase in the total measured highway impact. Such a situation may occur frequently in small communities where major changes in the transportation system will cause businesses to move, resulting in both positive and negative effects in the area as indicated on figure 7.

Thus, although the survey - control area approach is designed to correct for the limitations of the simple before and after study, in practice and in theory it has not been wholly successful. The problems involve finding a suitable control area, identical to the survey area in all respects except for the change in the highway facility, and isolating the impact on the survey area from the impact on the control area. The multitude of highway and non-highway related factors which are involved in the changes to be measured create a more complicated situation than the assumptions of the survey - control area method would account for.

Multiple Regression Analysis

This technique requires more information about the non-highway related factors than the other techniques, and it has in most cases been used when appropriate control areas could not be found. In this method the highway impact is isolated by examining both highway-related and non-highway-related factors. Consequently, the technique is not strictly limited to the analysis of highway impact, and it may also be used to anlayze the complex cause/effect relationship in a more complete manner than do the previously described approaches. In practice, however, it has not been possible to include all relevant factors because of the lack of general knowledge about how to determine relevancy or how to quantify qualitative characteristics. At the same time, it is not always possible to gather sufficient data on those factors whose significance is known. However, these limitations do not apply to the methodology as such but rather to its present state of development.

The dependent variable in the regression equation is the specific area effect to be studied, e.g., land development or land value; the independent

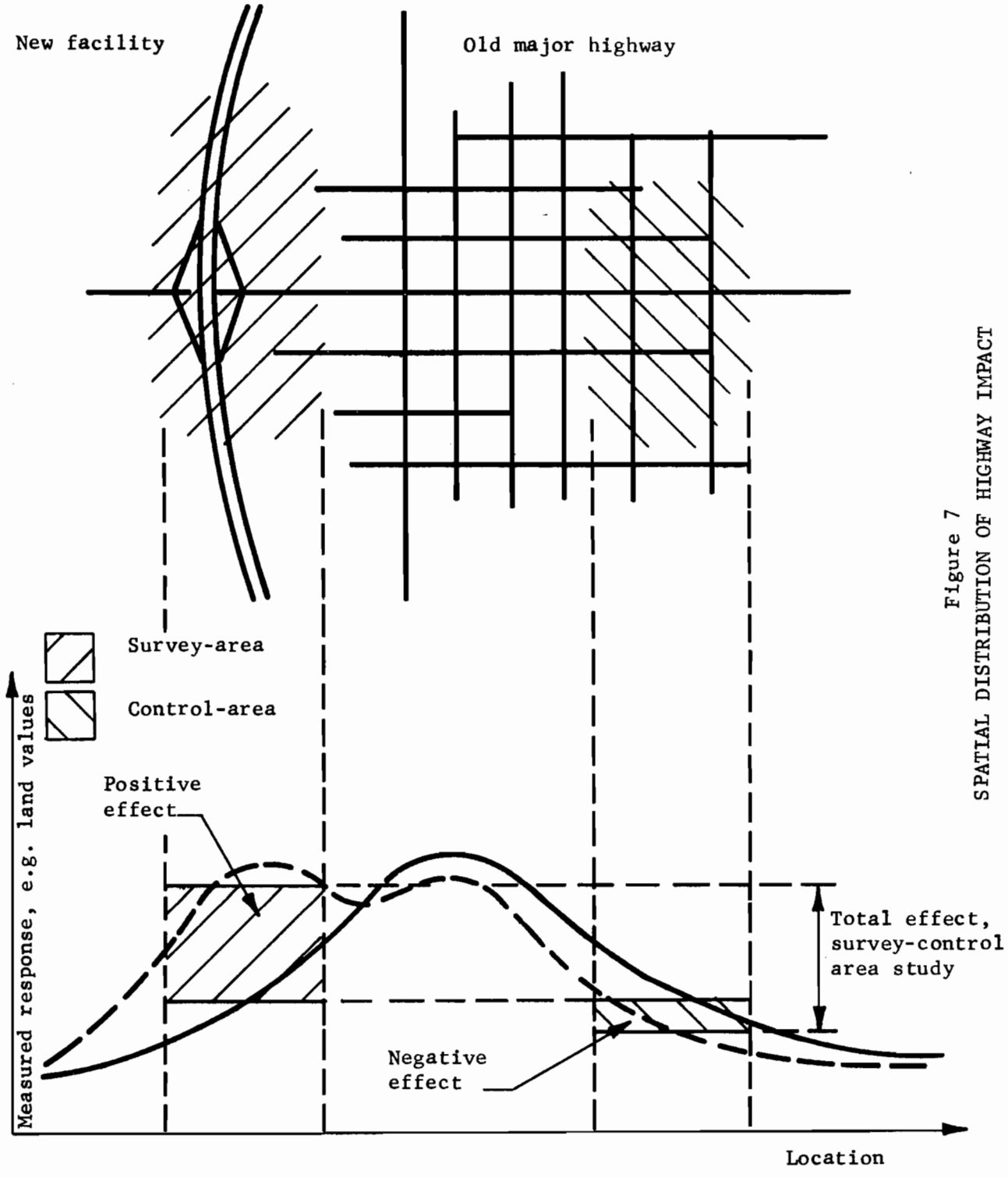


Figure 7
SPATIAL DISTRIBUTION OF HIGHWAY IMPACT

variables are all the relevant factors contributing to any part of the effect to be measured. By ordinary regression analysis, the best regression model can be found. The degree to which the included variables can explain the effect and an expression for the model's accuracy can be found. The "best" regression model does not necessarily show the relative importance of the different factors in a simple manner, as in most cases there will be a complex interaction between the factors.

In order to get a meaningful expression for the effect, all of the factors included in the regression model must be represented quantitatively. This creates great problems because many factors are qualitative, and no technique to give them a meaningful quantitative representation has yet been evaluated. This problem should be overcome, however, as more knowledge about the different factors involved in highway impact studies are acquired through future research.

Multiple regression analysis may be used together with a refined before and after approach to reveal information about changes in some community characteristic, e.g., land value, due to changes in both the transportation system and other aspects of the community.

It is important to be aware of the limitations connected to a regression model, especially since in most cases the model may seem to be general in character. The "best regression model" is entirely an empirical equation based on a given set of data, and it is not known whether the model can describe the effect when the range of any factor is extended beyond that in the data set previously analyzed. As "time" usually will be one factor in the model, it cannot be used for prediction of future impact unless certain assumptions about the future are made.

Case Studies

The case study approach deals with rather detailed analysis of specific events which have taken place. Such events may be as simple as the decision to construct a new industrial plant in a given location or as complicated as the whole set of events involved in the construction of a new transportation facility. The case study can be an intensive examination of the entire situation in one specific area. Consequently, although detailed knowledge about the cause/effect relationship in the specific case may be obtained, the findings are not claimed to be general.

The value of a case study lies in the possibilities for detailed analysis, and thereby in providing experience on which broader studies of more general character can be based. Since general studies have to cover a wide spectrum of different cases, it is important to identify the most significant factors, to determine what information is available, and to establish the most efficient way of data processing and analysis.

Other Techniques

Techniques other than those discussed above have been used, but to very little extent. The major reason for this lies probably in the degree of complexity of the models and in the subjectivity of their assumptions.

One of these techniques is the "projected land use - value relationship approach." This technique is used for examining changes in land value, and it tries to take care of the close interaction between land use and land value as well as the acceleration or deceleration in land development. Realizing that land use may change in any case, highway improvement or not, the after situation cannot be directly compared to the before situation. To get a correct picture of the impact, the situation after highway improvement will have to be compared with a hypothetical projection of the before situation. Thus the researcher will have to make some general assumptions or do a thorough job of projecting land use development as it might have occured supposing that no highway improvement took place. Because of the lack of sufficient information about trends in land use development in the before period, the projections often will have to depend on personal judgement and subjective assumptions. Personal judgement will also always be involved in determining land values in connection with the projected land use.

The projected land use - value relationship approach may be valuable in connection with other techniques. The projected land use may serve as a check on the appropriateness of control areas selected, or as a check on the actual highway impact affecting land use in an area close to a new highway facility.

A similar technique for evaluating the differences in impact on business activity in different locations is the "neutral road approach." Since the neutral facility cannot be physically constructed, it is a hypothesized road which can handle future traffic without causing any change in existing trends in land use development or business growth. The basic reason for adopting this approach is the necessity for retaining a perspective on over-all possibilities

for area business volume in the future. It is expected that alternative highway locations will result in different predicted business volumes. The measurable effect is not the variation of each alternative from the neutral road, but the differences among the variations, which theoretically should be the result of facility location and design.

Major Shortcomings of Previous Studies

This discussion of the most commonly used methodologies in the previous transportation impact studies has revealed several shortcomings which should be observed when planning comprehensive impact studies. The comments should, however, be seen in connection with the actual study planned, and, consequently, simpler methodologies might be used for studies of limited character.

Most of the previous studies are of limited character as they concentrate on a limited study area. In studies of small towns in rural areas the entire community has to be included in order to provide a true picture of the total effect. In such communities, with limited resources and few existing activities, an increase in one particular geographic area may have a detrimental effect in other areas of the community.

Today, the private automobile is the most common mode of trnasportation in the United States. In spite of this, an impact study should include in its analysis any transportation mode available in the community during the time period under consideration. Again, small communities may be very sensitive to, e.g., changes in railway services simply because in many cases they grew up along the railway line.

Many of the previous studies fail to give a good description of the total transportation system and other important community characteristics both before and after the improvement. For this reason it is difficult to see which factors of the improvement are the most decisive and in what types of communities they will cause the specific effect predicted.

As a last major point, it may be added that the studies reviewed reveal little information about the time when an effect occured relative to particular human decisions or physical changes. Public hearings, right of way designations, highway construction - all are particular moments in a process and cannot be detached from the total cause/effect relationship.

RECOMMENDED STUDY METHODOLOGY

The ultimate goal of this project is to provide a general model capable of predicting the impact of an interurban transportation system on a rural community. It is reasonable to divide the study into three phases:

(1) Evaluation of descriptive models for the transportation system and the community.

(2) Study of cause/effect relationship on specific areas of transportation impact.

(3) Evaluation of a comprehensive, predictive model.

Requirements for Future Research

In order to succeed in each phase, the study methodology and the study area (s) will have to meet the following requirements:

(1) The study period must be long enough to include all the important changes in both the community and the transportation system.

(2) The study should be continuous over time to reveal the general trends in community development both before and after changes in the transportation system.

(3) The geographic limits of the study area must incorporate the entire community, including extraterritorial controls.

(4) The effects on the community examined must include all physical, social and economic factors of importance for characterizing the community and for measuring the community's potential for growth and development.

(5) The transportation system must include all of the modes serving or influencing the community, and the study method must make it possible to determine what characteristics of the transportation system are of the greatest importance for community development.

Proposed Study Methodology

Studying the community impact of a change in the transportation system requires a methodology derived from a wide range of disciplines including engineering, sociology, and economics. In order to deal effectively with the different problems which will arise, the research team should be divided into groups, each group being charged with responsibility for a specific topic. However, because of the connection between topics, there must be close coordination between the groups.

Case Study. The first step in developing a study methodology would be an in-depth case-study. A set of descriptive models would be developed for both the quantitative and the qualitative characteristics of the transportation system and the community. The qualitative characteristics would be defined through indices expressing certain levels of service quality, community activity, political influence, and so forth. This initial phase of model development for the transportation system and the community necessarily overlaps with the analysis of the causal relationship between changes in transportation and community impact. Techniques of analysis will help refine model development, and as models are evaluated, analysis will become more inclusive.

The case study approach is valuable because of the present uncertainty involved in selecting the factors to be included in the model and the uncertainty concerning available information. A case study would ease the problem of data collection and simplify the process of evaluating specific methodology and research techniques. It will also simplify the first statistical analysis since the functional relationships should prove simpler in the consideration of only one community.

General Study. The case study could reveal the appropriate study techniques and at the same time suggest which factors are the most important for general consideration. However, since a case study involves only one community, the preliminary study techniques and descriptive models will have to be refined and expanded in order to be of general value. The first two phases of the case study will, consequently, extend into the period of a general study. The major task of a general study, however, would be to link together all of the separate efforts into a comprehensive model.

The many weaknesses of the "before-and-after" and the "survey - control area" approaches are overcome by employing a continuous long term study period. It would be necessary to make the continuous study period over the entire term, before, during, and following major changes in the intercity transportation system. This makes it possible to relate community response to an actual change. Figure 8, p 49, shows briefly the proposed technique.

The major feature of this approach is the ability to relate the indicator (s) under study to previous changes both in the transportation system and in the community itself. As an overall approach, it should be suitable to any indicator capable of study, even though it is perhaps not feasible to use statistical

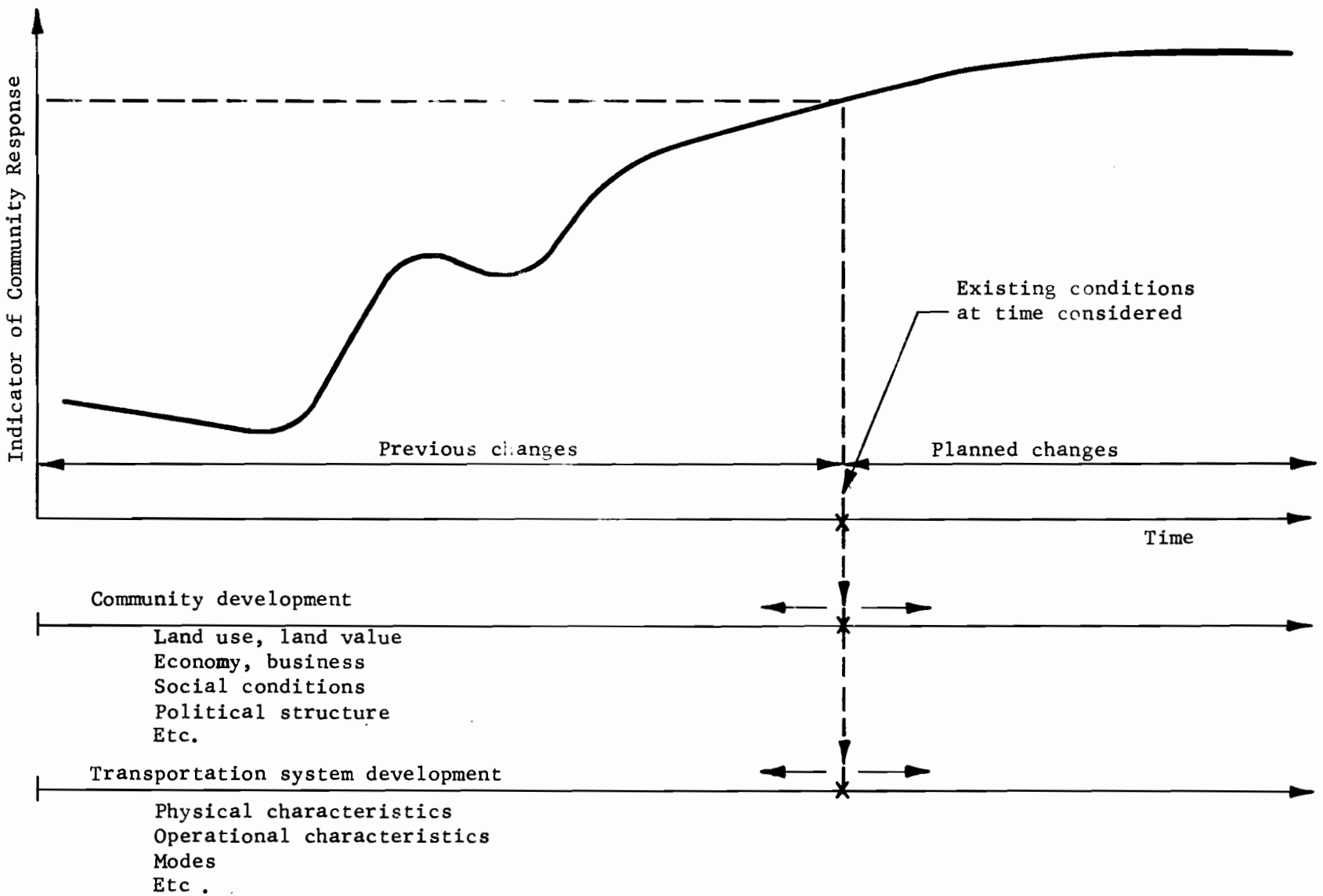


Figure 8

CONTINUOUS STUDY APPROACH

analysis for all indicators. These may vary from directly measurable indicators, e.g., land value, to such less quantifiable indicators as the history of a community's political and social structure. This general approach should make it possible to reveal the relationship between the effect in a community and the factors producing the effect. Consequently, for any case, it should be possible not only to describe what happened, but also to explain why it happened.

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An effort to find the influence on land value and use by use of multiple regression techniques. Great variations for different sites. Land value = f (size of parcel, year of sale, vacant -non-vacant land use, rural-urban land use, subdivision, roadside, alternate roadway, distance to right-of-way, distance to CBD, distance to access.

Dansereau, H. Kirk. "Five Years of Highway Research: A Sociological Perspective." Highway Research Record No. 75, Highway Research Board (1965), pp 76-81.

Discusses various highway-community relationships, namely, population, changes in levels of linving as measured by a social class rating, community values as evidenced to an extent by attitudes expressed, and degree of community organization as ascertained through use of an Index of Community Complexity. Sites studied in Pennsylvania - Monroeville (Pittsburgh), Blairsville (Indiana County) and four interchanges near York.

Dansereau, H. K., R. A. Rehberg, and J. R. Maiolo. "Specified Social Determinants of Attitudes Toward Community Planning and Zoning." Pennsylvania State University (1966).

Study of attitudes toward planning and zoning in interchange communities, and identification of some factors related to differences in those attitudes.

Ellis, Raymond H. "Toward Measurement of the Community Consequences of Urban Freeways." Highway Research Record No. 229, Highway Research Board (1968), pp 38-52.

This article proposes a strategy for quantitative estimation of community consequences of urban freeways. Discussion about how to consider community consequences and transportation impact on the existing community linkages.

Ellis. R. H., and R. D. Worral. "Towards Measurement of Community Impact: The Utilization of Longitudinal Travel Data to Define Residential Linkages." Highway Research Record No. 277, Highway Research Board (1969), pp 25-39.

An effort to present a methodology for using residential linkages as a strategy for measuring community impact of transportation projects.

Eyerly, Raymond W. "Land Use and Land Value in Four Interchange Communities: An Interim Report on the York Study." The Pennsylvania State University, 1968.

The study included all properties within two miles of the interchanges. It investigates the rate of formation of new properties, types of land uses, and changing land values.

Fabbroni, Lawrence P. "Land Use Development at Interstate Interchanges in Indiana." Joint Highway Research Project, Purdue University, Project C-36-70D, May, 1973, pp 1-85 and appendices.

Brief review of past research in this area: collects data from 102 interchanges along 8 interstate sections and makes an effort to set up a model to determine the extent of land use development along crossroads (1 mile to each side). More detailed studies of 10 intersections and discussion of available planning tools which might have been used in one of the "case areas."

Fleishman, Edward R. "The Impact After Seven Years of a Highway Improvement in a Small City." Joint Highway Research Project C-36-64D, Purdue University, May, 1968.

Study from Lafayette, Indiana (population 62,000 in 1967), considering changes in traffic patterns, accidents, travel times, and to some degree land use, values, due to construction of a new bridge over Wabash River.

Franklin, William D. "The Effect of Access on Right of Way Costs and the Determination of Special Benefits. Texas Transportation Institute, Research Report No. 82-1F (1968).

The effects of granted access contrasted with non-access on amount paid for damages connected with property acquisition.

Frey, J. C., H. K. Dansereau, R. D. Pashek, and A. Twark. "Land Use Planning and the Interchange Community." Bulletin 327, Highway Research Board (1962).

Discussion of land-use adjustment at interchange locations and importance of land-use regulations and control in preserving highway efficiency. No methodology to predict development which will take place at the interchange.

Garrison, William L. "Land Uses in the Vicinity of Freeway Interchanges." University of Washington, December 1961.

Discussion of simulation models of interchange - urban growth and development, a deterministic land development model, and the problems of estimation of supply and demand in the vicinity of freeway interchanges.

Goldberg, Michael A. "Economics of Transportation Corridors: Further Empirical Analysis." Highway Research Record 410, Highway Research Board (1972), pp 37-51.

Study of 325 properties within 0.2 mile of the Trans-Canada Highway (Vancouver). Showed that even the properties closest to the freeway only increased at a compound annual rate of 2.85 percent net inflation (properties in Richmond as a whole 5.23 percent net inflation).

Greenbie, B. B. "Interchange Planning in Rural Area." Traffic Quarterly, April, 1970, pp 265-278.

Example of interchnge area planning (1-90 and 1-74) in Monroe County, Wisconsin.

Grossman, D. A., and M. R. Levin. "Area Development and Highway Transportation." Highway Research Record 16, Highway Research Board (1963).

Discussion of "distressed" areas in the light of Area Redevelopment Act of 1961.

Holshouser, E. C. "An Investigation of Some Economic Effects of Two Kentucky Bypasses: The Methodology." Bulletin 268, Highway Research Board (1960), pp 74-79.

One bypass provided free access, the other limited access. The belt-line had positive influence mainly within 1/4 mile of the facility, the effect of the limit access expressway reached 2-3 miles. Discussion of methodologies: survey-control area comparison, case study method, multiple regression analysis, projected land use-value relationship approach.

Horwood, Edgar M. "Freeway Impact on Municipal Land Planning Effort." Bulletin 268, Highway Research Board (1960), pp 1-12.

A discussion of some factors which impose limitations on the city planning and highway development processes.

Isibor, Edward I. "Modeling the Impact of Highway Improvements on the Value of Adjacent Land Parcels." Joint Highway Research Project C-36-64G, Purdue University, (December, 1969).

Use of regression analysis to find a model for change in land value as a function of size, time after construction, type of highway, type of land use, type of area, and type of access control. Only adjacent parcels (from two right-of-way studies, Florida and Indiana) included in the study.

Jordan, Jack D. "Final Report on Studies of Right of Way Remainders." Texas Highway Department, 1970.

Analysis of 300 remainder properties from Right of Way taking. Relationship of dollar amount of appraised damages to actual damages or enhancements.

Kahn, H. M., and A. Kriken. "Social Characteristics of Neighborhoods as Indicators of the Effects of Highway Improvements." Marshall Kaplan, Gans, and Kahn, San Francisco, California.

Study of the social impact of highways on neighborhoods (4 cases), where a predictive "Social Feasibility Model" was developed. The model is based on secondary data. No quantitative measurement of the degree of impact.

Kemp, Barbara H. "Social Impact of a Highway on an Urban Community." Highway Research Record No. 75, Highway Research Board (1965), pp 92-102.

Discusses the effects of a loop through D. C. on those who would have to move and those who would remain in the area and to formulate programs to reduce possible harmful effects on the people concerned.

Kiley, Edward V. "Highways as a Factor in Industrial Location." Highway Research Record No. 75, Highway Research Board (1965), pp 48-52.

Survey of 4,150 industrial establishments, by American Trucking Association. Included all states. Proximity to highways was found to be one of the most frequently mentioned location factors.

Klein, G. E., et al. "Methods of Evaluation of the Effects of Transportation Systems on Community Values." Stanford Research Institute, April, 1971.

An effort to develop methods of identifying, measuring and valuating selected community attributes that are affected by transportation system changes. Looks into the effects of accessibility to services, property development, relocation, disruption, and noise and air pollution.

Lang, A. S., and M. Wohl. "Evaluation of Highway Impact", Bulletin 268, Highway Research Board (1960), pp 105-119.

The authors state that "there is no logical basis for assuming highway improvements can produce any net economic benefits over and above user (vehicular) benefits." Secondary benefits such as increase in land values, etc., however, are of importance in the over-all picture of land-use development. Followed by a discussion of the arguments by Sidney Goldstein, Bureau of Public Roads.

Levin, David R. "Informal Notes on Sociological Effects of Highways." Highway Research Record No. 75, Highway Research Board (1965), pp 82-84.

Raises questions on the degree transportation and sociology are related. Also, some considerations a transportation planner should look at. Concerned mainly with urban transportation.

Levin, D. R. "The Highway Interchange Land-Use Problem." Bulletin 288, Highway Research Board (1961), pp 1-24.

Rather general discussion of development at freeway interchanges, land use problem at the interchange, types of land associated with interchanges, land use and access control.

Long, Gale A, Gary D. Long, and Raymond W. Hooker. "A Corridor Land Use Study: The Impact of an Interstate Highway on Land Values, Private Investment and Land Use in Southwestern Wyoming." Division of Business and Economic Research, University of Wyoming, October, 1970.

Land value in city outskirts rose, while it tended to decrease a little in CBD. Induced private investment only the first years after completion.

Longley, J. W., and B. T. Goley. "A Statistical Evaluation of the Influence of Highways on Rural Land Values in the United States." Bulletin 327, Highway Research Board (1962), pp 21-55.

Analysis of 5,000 rural land sales, to determine existing differences in land values by type of road as to price per acre and distance from nearest trading center. Distance to nearest trading center seems to be most significant.

McKain, W. C. "Community Response to Highway Improvement." Highway Research Record No. 96, Highway Research Board (1965), pp 19-23.

The Connecticut Turnpike had a favorable impact on many towns, while others in the same area were left relatively untouched. Discussion of possible social and employment factors; labor force does not readily improve its skills, communities may tend to resist change, and a crisis approach to social action.

Miller, Stanley F., Jr. "Effects of Proposed Highway Improvements on Property Values." National Cooperative Highway Research Program, Report 114 (1971).

Basic principles of real estate values, valuation practices and procedures, factors causing enhancement or diminuation of value, and legal considerations.

Meuth, H. G. "Right of Way Effects of Controlled Access Type Highway on a Ranching Area in Madison County, Texas." Texas Transportation Institute, Research Report 58-4 (1968).

The study describes changes in land tenure, land use, income and travel patterns of th operators affected by acquisition of right of way and construction of IH45 in Madison County.

Meuth, H. G., and J. L. Buffington. "Right of Way Effects of Controlled Access Type Highway on a Farming Area in Ellis County, Texas." Texas Transportation Institute, Research Report 58-5 (1969).

Changes in kind and intensity of rural land use, number of farm and ranch units, cost of adjustment to new farm and operating conditions, and changes in farm income, due to acquisition of right of way and construction of IH35 in an intensive farming area, Ellis County.

Meuth, H. G. "Right of Way Effects of Controlled Access Type Highway on a Farming Area in Colorado and Fayette Counties, Texas. Texas Transportation Institute, Research Report 58-6 (1970).

How operators in a diversified farming area were affected by, and how they adjusted to right of way acquisitions for IH70, in Colorado and Fayette Counties. (Land value, land use, travel patterns, and income, etc.)

National Center for Highway Research. "A Review of Transportation Aspects of Land-Use Control." National Cooperative Highway Research Program, Report No. 31 (1966).

Mainly a literature review on the subject of the relationships between land-use control, traffic generation and transportation systems in urban areas. Chapters: Urban Structure, Land-use Control, Land-use Stability, The Highway System, Highway Functional Classification, Access Controls, Highway Design Control, Traffic Generation, Freeway Interchanges.

Ohio Department of Highways. "Factors Influencing Land Development-Subdivision Development Study." September, 1970.

Study of 16 subdivisions in different locations to freeways. Average percentage of sales per month used as a measure of success and analyzed on the background of freeway exposure of lots, distance to CBD-area, commercial influence, etc.

Pendleton, W. C. "Relation of Highway Accessibility to Urban Real Estate Values." Highway Research Record No. 16, Highway Research Board (1963).

A study of Washington metropolitan area showed that sales prices set in the real estate market do reflect accessibility differences.

Pillsbury, Warren A. "Economics of Highway Location: A Critique of Collateral Effect Analysis." Highway Research Record No. 75, Highway Research Board (1965), pp 53-61.

Discussion of different methods for economic analysis of possible highway locations. Highway economic impact may be one factor in the analysis, but nothing is said about how to calculate economic effect in a highway corridor.

Raup, P. M. "The Land Use Map Versus the Land Value Map - A Dichotomy." Bulletin 227, Highway Research Board (1959), pp 83-88.

Discussion of the sequence of changes in land-use and land values. Land values may express anticipated development, and not the actual changes. Also discussion of a mapping technique for land use and land values.

Sauerlender, O. H., R. B. Donaldson, and R. D. Twark. "Factors That Influence Economic Development at Non-urban Interchange Locations." The Pennsylvania State University, 1967.

The development in 36 typical interchanges in Pennsylvania was analyzed on the background of the characteristics of each interchange and the surrounding region. Indicates factors that should be useful as predictors of development.

Spears, John D., and Charles G. Smith. "Final Report on a Study of the Land Development and Utilization in Interchange Areas Adjacent to Interstate 40 in Tennessee." University of Tennessee, July, 1970.

Study of adjacent properties to 74 interchanges on I-40 between Memphis and Knoxville, with listing of tracts, property sales and land uses. Summary of interchange development in different groups of interchanges.

Stein, Martin M. "Highway Interchange Area Development - Some Recent Findings." Public Roads Vol. 35, No. 11 (December, 1969), pp 241-250.

The study of 332 interchanges in 16 states shows that interchange land development is affected both by type of intersecting road and by the relative accessibility of the interchange quadrants.

Stover, V. G., W. G. Adkins, and J. C. Goodknight. "Guidelines for Medical and Marginal Access Control on Major Roadways." National Cooperative Highway Research Program, Report 93 (1970).

One of the chapters, "Highways and Economic Development," summarizes previous research about economic impact on land values in interchanges, bypass effect, etc.

Stroup, R. H., and L. A. Vargha. "Economic Impact of Secondary Road Improvements." Highway Research Record No. 16, Highway Research Board (1963), pp 1-13.

The study may show that there is a relationship between changes in retail business and road improvement. The geographic dispersion of business may be expressed as a function of population density, per capita income and proportions of farms on all-weather roads. Rural area (six counties) in Kentucky.

Stroup, R. H., L. A. Vargha, and R. K. Main. "Predicting the Economic Impact of Alternate Interstate Route Locations." Bulletin 327, Highway Research Board (1962), pp 67-72.

Report of a study method used in an examination of the comparative economic impact of three alternative routes for 1-65, Kentucky.
Use of the concept of an economically "neutral" road, against which the three alternative routes are compared (on the basis of access, visibility of establishment, development potential, etc.)

Texas Aeronautics Commission. "Importance of a Modern Airport, Austin, Texas, 1965."

Attitude survey among towns and small communities in Texas about how important they consider an airport to be.

Texas Transportation Institute. "Economic Effects of Bypasses and Freeways." Bibliography.

Listing and short description of 38 papers and studies about economic effect of highways.

Thiel, Floyd I. "Social Effects of Modern Highway Transportation." Bulletin 327, Highway Research Board (1962), pp 1-20.

Discussion of some ways in which highways affect the way of living. Effect on population mobility, residences, relocation, employment conditions, public services, education, rural employment and improvement (reference to a study, Montana), recreation, etc.

_____. "Seminar on Sociological Effects of Highway Transportation, Introductory Remarks." Highway Research Record No. 75, Highway Research Board (1965), p 75.

Five different articles, dealing with sociological effects and (one article) trip generation.

_____. "Highway Interchange Area Development." Public Roads Vol. 33, No. 8 (June, 1965), pp 153-166.

About controlling the development in interchange areas. Includes discussion of development problems, available means of controls, application of control, space needs at interchanges, and techniques to implement interchange planning.

U. S. Congress. "Final Report of the Highway Cost Allocation Study." House Document No. 72, 87th Congress, 1st Session, January 1961.

Mainly summary of changes in land values from previous highway impact studies.

U. S. Department of Transportation. "Benefits of Interstate Highways." Federal Highway Administration, U. S. Department of Transportation, June 1970.

Summary of user and non-user benefits from interstate highways. General economic and community benefits: land use and value, industrial and commercial effect, non-work opportunities, opportunities for community change, etc.

U. S. Department of Transportation. "Economic and Social Effect of Highways." Federal Highway Administration, U. S. Department of Transportation, 1972.

Review of 200 studies of the economic and social effects of highways, a narrative discussion of the studies and abstract of 178 studies.

U. S. Department of Transportation. "Guide for Highway Impact Studies." Federal Highway Administration, 1973.

States the need for impact studies and indicates types of studies that may be especially appropriate in identifying social and economic effects. Lists and describes socioeconomic studies proposed, studies in progress, and studies recently completed.

Vargha, Louis A. "Highway Bypasses, Natural Barriers, and Community Growth in Michigan." Bulletin 268, Highway Research Board (1960), pp 29-36.

The freeway as a physical barrier.

Vaughan, C. M. "Development Aspects of Kentucky's Toll Roads." American Society of Mechanical Engineering Publication 73-ICT-19 (1973).

The study uses the analysis of covariance to separate the rate of change in manufacturing employment and personal per capita income in those counties which have limited access highways, toll roads and interstates, from those countries which have neither of the aforementioned.

Vogt, Ivers & Associates. "Social and Economic Factors Affecting Intercity Travel." National Cooperative Highway Research Program Report 70 (1969).

Warner, A. E. "The Impact of Highways on Land Uses and Property Values." Michigan State University, March, 1958.

A Review of current studies with bibliography.

Wheat, Leonhard F. "The Effect of Modern Highways on Urban Manufacturing Growth." Highway Research Record No. 277, Highway Research Board (1969), pp 9-24.

Nationwide study of manufacturing growth in 212 cities (population 10,000-50,000), 106 "freeway-cities" (<7 miles from freeway) and 106 "non-freeway-cities" (>16 miles from freeway). The study findings indicate that modern highways do significantly affect manufacturing growth, but not in all situations. Freeway-cities grew faster only in regions where traffic flow along regular highways is seriously impeeded. The study also considers effect of air service, rail, waterways, and distance to freeway.

Wootan, C. V. and H. G. Meuth. "Economic Impact Study, Temple Texas." Texas Transportation Institute, Bulletin 14 (1960).

Study of the economic impact of the new by-pass route for IH 35, Temple, Texas. The study area is located along a section (3 miles) of the new IH 35. Changes in land values compared to a control area; changes in land use along the new route; and changes in business activity along the new and old route.

Wynn, F. Houston. "Who Makes the Trips? Notes on an Exploratory Investigation of One-Worker Households in Chattonooga." Highway Research Record No. 75, Highway Research Board (1965), pp 84-91.

Studies question: given shorter working days and/or shorter working weeks - how will this affect future urban travel demands?

Zinkefoose, Paul W. "Economic Survey of Anthony, New Mexico - Texas." New Mexico State University, Bulletin No. 41 (May, 1970).

Study of the impact of highway relocation in a small town having practically no economic data. More or less a general description of the effect.

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