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16. Abstract

The effect of highway bypass construction on small cities is analyzed. While important, previous research work on this topic is not conclusive. This previous work, along with case study analyses, provided the foundation for establishing a basic framework for examining the impacts of bypass. An econometric for various business sectors demonstrates that other non-bypass variables are important determinants to business activity in small cities and towns. The results do suggest that bypasses have a marginally negative effect on retail sales volumes.

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ECONOMIC IMPACTS OF HIGHWAY BYPASSES

by

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Research Report 1247-3F

Research Project 3-8-91/2-1247

Economic Impact of Highway Bypasses and Loops

conducted for the

Texas Department of Transportation

in cooperation with the

U.S. Department of Transportation
Federal Highway Administration

by the

CENTER FOR TRANSPORTATION RESEARCH
Bureau of Engineering Research
THE UNIVERSITY OF TEXAS AT AUSTIN

November 1992

IMPLEMENTATION STATEMENT

Based on the research summarized in this report, TxDOT can estimate potential economic impacts of highway bypasses for small communities. Importantly, the research demonstrates that a bypass is one small variable among a variety of other more significant factors affecting the economics of small towns and cities. The model presented in this report is an important tool that can assist transportation planners in evaluating potential impacts of future bypasses.

Prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

DISCLAIMERS

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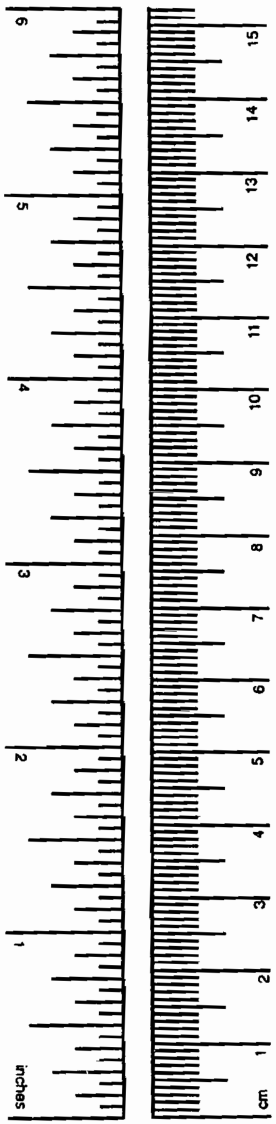
METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	0.3048	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.395	hectares	ha
		MASS (weight)		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.0328	meters cubed	m^3
yd^3	cubic yards	0.0765	meters cubed	m^3

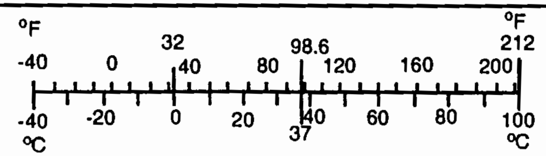
NOTE: Volumes greater than 1,000 L shall be shown in m^3.

Symbol	When You Know	Multiply by	To Find	Symbol
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
m^2	meters squared	1.20	square yards	yd^2
km^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1,000 kg)	1.103	short tons	T
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

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SUMMARY

This report summarizes the previous reports for Project 1247 and presents a refined model for estimating the economic impacts of highway bypasses. While there are numerous factors affecting the economic vitality of a city, this research provides insight into the relationships of several important variables. Based on the model, bypasses have a small negative effect on retail sales in small communities.

CHAPTER 1. INTRODUCTION

Highway bypasses have long provided a practical approach to improving levels of service by re-routing through traffic around small cities, particularly in rural settings.

Road investment in highway bypass construction normally produces immediate benefits for road users in the form of reduced journey times and vehicle operating costs, and improvements in safety. It also reduces environmental nuisance from traffic to residents and pedestrians along the bypassed roads. In addition, highway transportation projects, such as bypass construction, typically yield local economic impacts of the following nature:

(1) the creation of jobs and subsidiary revenue from facility planning, construction and operations;
(2) the indirect impact of increased production because of reduced transportation costs and delays; and
(3) the indirect impact of the above upon non-users because of inter-industry or business effects.

The construction of bypasses, however, has not always met with unanimous local approval. Communities have feared that their economies would be adversely affected by highway bypass construction. Business interests in the bypassed cities have generally resisted efforts to build bypasses in the belief that large numbers of customers would be diverted from the business district, thereby impairing the community's economic health. These concerns have raised a number of questions: Is the economy of the bypassed city negatively impacted by new highways? Are retail sales harmed by bypassing? What specific types of businesses are harmed, if any? What are the temporary effects and what are the long-term economic effects? For the community as a whole, what is the net effect of the highway bypass on economic activity?

The Texas Department of Transportation commissioned a study at the Center for Transportation Research at The University of Texas at Austin to examine the broad question of bypass impacts and specifically address these types of questions. This report is one of three reports prepared under Research Study 1247. The other two reports are: Research Report 1247-1, *Economic Effects of Highway Bypasses on Business Activities in Small Cities;* and Research Report 1247-2, *Traffic and Spatial Impacts and the Classification of Small Highway Bypassed Cities.* This report presents a summary of analyses in these earlier reports, together with a new model based on the combined inputs from these reports.

STUDY OBJECTIVES

The objective of this study is twofold:

(1) to explore and identify the primary economic impacts of highway bypasses on business activities in small cities throughout Texas, and
(2) to develop a procedure to estimate the economic impacts of highway bypasses on local businesses at the city level, a procedure based on certain unique local conditions and factors.

The procedure for identifying economic impacts will assist transportation planners in evaluating bypass alternatives, and will help TxDOT personnel in their discussions with local officials and businesspersons.

METHODOLOGIES

Several methodological perspectives were employed in this study to address the economic impacts of bypasses. A case study analysis of several Texas cities was performed to provide a basis for more formal analyses with greater applicability. A data base was established, containing data on pertinent variables for both bypassed cities and non-bypassed control cities. For each bypassed city, a control city (with characteristics similar to those of the bypassed city) was chosen to control for the effect of the bypass. Econometric models are used to identify economic effects of highway bypasses on business activities by examining both highway-related and non-highway-related factors. Cluster analysis, a multivariate statistical procedure, is used to explore the possible existence of an underlying structure within the bypassed cities. The results of the clustering process are then used to improve the specification of the econometric models.

SCOPE OF THE REPORT

Chapter 2 presents a background review, which includes a discussion of the concepts, methods, and previous findings that govern the economic consequences of highway improvements in general and of highway bypasses in particular.

Chapter 3 provides a working definition of a bypass, and then inventories and categorizes highway bypasses in Texas. The development of a data base for all bypassed and control cities is also discussed.

Chapter 4 presents the case study methodology. The methodology is discussed briefly, followed by a summary of key findings.

Chapter 5 includes data validation and exploratory data analysis, using descriptive statistics to compare bypassed and control cities. The objective is to verify changes in business volumes vis-a-vis the highway bypass construction. This chapter consists of three parts. In the first part, comparative trends of the bypassed and control cities are analyzed. In the second, econometric models are introduced in an attempt to identify the economic impact of highway bypasses on business activities. The third part deals with cluster analysis, a multivariate statistical procedure, to explore the possible existence of an underlying structure within the bypassed cities.

Chapter 6 presents new, improved models for business activity. These models use results from the clustering models to improve the specification of the econometric models.

Finally, Chapter 7 presents the conclusions and recommendations derived from the study.

CHAPTER 2. BACKGROUND REVIEW

This chapter provides a background review of the general economic impacts of highway bypasses. An account is given of bypass impacts on specific communities, identifying positive and negative effects of the bypass. Variables are identified that describe the impact of a bypass on specific communities. An overview is then provided of methodologies useful for this study.

GENERAL IMPACTS OF BYPASSES

Historically, transportation has been a vital component in almost every aspect of economic development. The traditional view has been that the development or improvement of transportation infrastructure is a necessary precursor to economic development in a region. Some researchers have found a significant relationship between highways and economic growth. However, a summary of economic impact studies made in the 1970's and 1980's generally concludes that many other factors, besides highway improvements, significantly affect regional growth. (Weisbrod, Glen E., and James Beckwith, "Measuring Economic Development Benefits for Highway Decision Making: The Wisconsin Case," paper presented at the 69th Annual Meeting of the Transportation Research Board, Washington, D.C., January 1990.) In well-integrated economic systems, the effects of transportation improvements are complex and difficult to predict.

Evidence exists showing that highway bypasses, as a transportation investment, affect different communities in a variety of ways. Several highway bypass studies have explored the economic impacts on small communities, identifying three important operational effects from highway bypasses:

(1) higher service levels for through traffic,
(2) increased levels of service and improved traffic safety on the bypassed route and local streets, and
(3) reduced or increased revenues for local business establishments.

Mobility becomes easier and more convenient for local residents and non-locals, and there is a reduction in noise, air pollutants, and other deleterious effects of heavy traffic. Businesses that cater largely to the needs of transient motorists will be adversely affected if they remain near the old route, while those that serve the needs of local residents may be relatively unharmed. Some businesses may even experience an increase in sales because of reduced congestion. For the community as a whole, the important issue is the net effect of the highway bypass on economic activity. Some researchers have found that bypasses can be justified because of the expectation that social welfare benefits outweigh expected detrimental effects. (Gamble, Hays B., and Thomas B. Davinroy, *Beneficial Effects Associated with Freeway Construction: Environmental, Social and Economic*, National Cooperative Highway Research Program Report 193, Transportation Research Board, Washington, D.C., 1978.)

The economic impact of a highway bypass can take many forms, such as a decrease or an increase in retail sales, employment, personal income, and the population growth rate. In most previous research, the economic impacts of highway bypasses have been measured by employment figures, retail sales, and personal income. (McKain, Walter, "Community Response to Highway Improvement," *Highway Research Record 96*, Highway Research Board, Washington, D.C., 1965.)

In a compilation of bypass studies, Horwood, et al, found that the economic impact of highway bypasses seriously affected highway-oriented businesses (i.e., those providing fuel, food, and accommodations for travelers). (Horwood, Edgar, Carl Zellner, and Richard Ludwig, *Community Consequences of Highway Improvement,* National Cooperative Highway Research Program Report 18, Highway Research Board, Washington, D.C., 1965.) To remain competitive, service stations and restaurants often successfully adjusted their merchandise and marketing methods to attract local trade. Motels and hotels, however, were unable to adjust as easily, and suffered the greatest losses. Valid results came from studies that included control areas in their analysis, indicating little or no economic effect from the highway bypass.

The effect of city size is also documented in some of the early bypass studies. There is an indication that cities with a population of 5,000 and over have a somewhat better chance of adjusting to the economic changes induced by a bypass. Greater benefits accrued to larger urban centers and to non-highway-oriented business sectors, presumably owing to decreased traffic volumes, greater pedestrian amenities in shopping areas, and an enlarged trade area. Small towns without a central business district typically suffered from a highway bypass.

In reviewing several Texas highway bypass studies, researchers found it very difficult to establish a relationship between highway bypass construction and changes in local business volumes. The non-traffic-oriented businesses had, in almost all cases, an increase in annual gross sales, while many traffic-serving businesses, such as service stations and motels, showed large decreases. The conclusion drawn from these studies was that traffic-serving businesses seemed to be more affected by the highway facility than other businesses. (Skorpa, Lidvard, Richard Dodge, C. Michael Walton, and John Huddleston, *Transportation Impact Research: A Review of Previous Studies and a Recommended Methodology for the Study of Rural Communities,* Council for Advanced Transportation Studies, The University of Texas at Austin, March 1974.)

A study of 32 bypassed English cities, which had bypass construction in the 1970's, identified the highway facility's effects on land use and town development. The largest bypass effect on land use and town development involved the siting of new industry, which tended to locate near bypass access points, particularly if the bypass was part of a major national route. Some small towns suffered a loss of trade, but generally the removal of through traffic was seen as a benefit to shopping centers, with a subsequent increase in turnover and investment. (Mackie, A. M., "Effect of Bypasses on Town Development and Land Use," Planning and Transportation Research, Summer Annual Meeting, Volume P239, London, England, 1983.)

The economic impact of a bypass on a city in a rural setting must also be seen against the background of ongoing, non-highway-related economic and social changes. The continuing urban centralization of trade, economic, and social relationships has diminished the importance of many small towns. (Fuguitt, Glen V., David L. Brown, and Calvin L. Beale, *Rural and Small Town America,* Russel Sage Foundation, New York, 1989.) The ability of a community to retain its residents is largely dependent on its economic base. (Garkovich, Lorraine, "Population and Community in Rural America," *Contributions in Sociology,* Number 84, Greenwood Press, New York, 1984.) For instance, agricultural communities in the United States have experienced a nearly steady loss of population over the past two decades due to increased mechanization and a shift to corporate-owned farms.

Analysis of the literature demonstrates the complexity of measuring and determining highway bypass effects. Many factors influence the economy in a given area, often so many that it is difficult to statistically determine a specific highway bypass effect. (Siccardi, A. J., "Economic Effects of Transit and Highway Construction and Rehabilitation," *Journal of Transportation Engineering,* Vol 112, No. 1, January 1986.)

METHODS IN HIGHWAY IMPACT STUDIES

In order to enhance the quality of results, it is appropriate to employ several methods to investigate highway bypass impacts. Several methods are discussed in this section. A more detailed description of these and other methods are is given in the other reports for this project. (Helaakoski, Reijo, Hani S. Mahmassani, C. Michael Walton, Mark A. Euritt, and Robert Harrison, *Economic Effects of Highway Bypasses on Business Activities in Small Cities,* Research Report 1247-1, Center for Transportation Research, The University of Texas at Austin, October 1992.) (Andersen, S. Johann, Hani S. Mahmassani, C. Michael Walton, Mark A. Euritt, and Robert Harrison, *Traffic and Spatial Impacts and the Classification of Small Highway Bypassed Cities,* Research Report 1247-2, Center for Transportation Research, The University of Texas at Austin, October 1992.)

Before-and-After Method

One of the techniques used to study highway impacts is the before-and-after technique. This methodology was utilized by various researchers and agencies in addressing the impact of a bypass on a community. (Bardwell, George E., and Paul R. Merry, "Measuring the Economic Impact of a Limited Access Highway on Communities, Land Use, and Land Value," *Highway Research Record* No. 268, 1960.) The main advantage of this technique is that it is simple to apply and easy to understand. The technique measures the value of some characteristic of an area before and then after highway improvement; the difference is then 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 principal limitation of this approach is that it cannot relate the measured effect to any specific cause. It cannot determine whether an effect is, or is not, caused by the road improvement.

Case Studies

Case studies are often combined with the before-and-after technique and deal with a more detailed analysis of specific events which have taken place. Detailed knowledge about the cause/effect relationship in the specific case may be obtained, but the findings are not claimed to be general. The value of case studies lies in the insights gained from detailed analysis, thereby providing experience on which broader analyses can be based.

Survey-Control Area Method

The most common technique used to isolate highway improvement is the survey-control area technique. (Holshouser, Eugene C., "An Investigation of Some Economic Effects of Two Kentucky Bypasses: The Methodology," *Highway Research Board Bulletin* No. 268, 1960.) In theory, the survey area and the control area should be exactly alike during the period just prior to the highway improvement. Also, the factors affecting development in the two areas should be the same, except for the highway improvement. These requirements are normally hard to meet, as the spatial limits and/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. 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. The effect of the different factors will not be evenly distributed over the two areas. When the average for each area is used, the character of this spatial distribution is lost, and thus the interpretation of any results of the study is limited. Generally, the control area is chosen to be part of the city being studied. Due to the small size of the cities being studied and the spatial proximity of the survey and control areas, it is very hard to isolate the impacts of the bypass. Horwood et al identified the extensive use of this method when summarizing the statistics of various bypass studies. (Horwood, et al, 1965.)

Matched Pairs

A way, simultaneously, to increase confidence in study results and to possibly conduct studies less expensively, was recently described by Hartgen for transportation planning applications. (Hartgen, David T., Alfred W. Stuart, Wayne A. Walcott, and James W. Clay, "Role of Transportation in Manufacturers' Satisfaction with Locations," *Transportation Research Record 1274*, Transportation Research Board, Washington, D.C., 1990.) The procedure, which is applicable to many problems common in transportation, involves structuring the study as a comparison of matched pairs of observations, termed twins. Studies designed in this fashion are shown to have a much greater reliability at a much lower cost than similar transportation studies not so designed. Twin studies are based on the principle of matched pairs of observations, which are monitored over time. Twins are actually a special case of a more general design in which observations in a sample are paired (correlated) both over time and across the design (doubly correlated).

Econometric Models

Econometric models provide an approach that attempts to isolate the economic impacts of highway construction by examining both highway-related and non-highway-related factors. Such models require more information about non-highway-related factors than other analysis techniques. Several researchers have utilized this method to relate highway construction with economic development. (Buffington, Jesse, and Dock Burke, *Employment and Income Impacts of Highway Expenditures on Bypass, Loop and Radial Highway Improvements,* Research Report 1066-F, Texas Transportation Institute, College Station, Texas, 1981.) (Eagle, David, and Yorgos J. Stephanedes, "Dynamic Highway Impacts on Economic Development," *Transportation Research Record 1116,* Transportation Research Board, Washington, D.C., 1987.)

The dependent variable in the regression equation can be, for example, business volumes in the specific area to be studied, and the independent variables can include all of the relevant factors contributing to any part of the measured economic effect.

Econometric methods can be used to analyze data of two major types:

(1) Cross-sectional data, which consist of observations from different areas, but for a point in time for each area; and

(2) Time-series data, which consist of observations of the same area taken at different points in time.

Both methods, by definition, could exclude a large part of important data from analysis. The cross-sectional method excludes any data collected over time, and the time-series method excludes data from all areas except the one under study. As a result, with either method, the analysis may not benefit from additional information, even when such information exists. Nevertheless, this limitation can be overcome by combining the two methods through the use of panel data, where data from different time periods and areas are pooled together.

Econometric modeling is a methodology that can be used for relating highway construction and economic development. However, at all times model specification should be derived from the theory that a researcher has about the process. Econometric methods make sense only when used in connection with a theoretical framework. They provide tools to test theories against actual observations.

The Classification of Bypassed Cities

The last section of this review deals with the development of a typology or classification. It is a fundamental process of the practice of science, since classificatory systems contain the concepts necessary for the development of theories within a science. No attempt has yet been made to classify bypassed cities, or to explore the possibility of an underlying structure within a sample of bypassed cities. One of the most appropriate methods to obtain this classification is cluster analysis.

Cluster analysis is a multivariate statistical procedure that starts with a data set containing information about a sample of entities and attempts to organize these entities into relatively homogeneous groups.(Aldenderfer, Mark S., and Roger K. Blashfield, *Cluster Analysis,* Sage Publications, Beverly Hills, 1984.) There are various ways to compute similarities between entities, such as correlation coefficients and distance measures. Different heuristic clustering methods can then be used to obtain the various groupings. Cluster analysis has found applications in a variety of fields. The social sciences have long maintained an interest in cluster analysis. In the field of transportation engineering, Townsend, among others, used cluster analysis for the classification and analysis of the multi-day travel/activity patterns of households and their members. (Townsend, Trevor, "Classification and Analysis of the Multi-Day Travel/Activity Patterns of Households and Their Members," paper presented at the Sixth International Conference on Travel Behavior, Quebec, May 1991.) He then explored the combination of characteristics that are important in determining the pattern group membership of each individual household.

SUMMARY

Evidence exists showing that highway bypasses, as a transportation investment, affect communities in a variety of ways. The overall mobility of a community is improved by rerouting through traffic and reducing congestion in the city business district. Bypass construction may have an impact on local businesses. Businesses that cater largely to the needs of transient motorists may be adversely affected. Various literature demonstrates the complexity of measuring and determining highway bypass effects. Many factors influence the economy in a given area, often so many that it is difficult to statistically determine a specific highway bypass effect.

The variables relevant to the objectives of this study are identified in the background review, along with the appropriateness of econometric modeling for quantifying bypass effects. It is not clear from the literature how to control for the effect of the bypass, i.e., isolate bypass effects. The latter, and the classification of bypass cities, will be explored in later chapters. Identification of relevant variables and methodologies enables one to establish an appropriate study data base that will be used for further analysis.

CHAPTER 3. DATA ACQUISITION

The data base developed for the study is presented in this chapter. The relevant variables to address bypass impacts, which form the core of the data base, were identified in the previous chapter. The first step in the data base development is to identify all highway bypasses in Texas. From this inventory, a sample of bypassed cities for further study is obtained. A control city for each bypassed city is chosen, allowing for control of bypass effects in later statistical procedures. Finally, data for the pertinent variables are obtained from various data sources.

BYPASS CATEGORIZATION AND SAMPLING PROCEDURE

Initially, it is necessary to develop a working definition of a bypass. A highway bypass is that segment of a new highway intended to reroute through traffic around a central business district, leaving the remainder of the intercity route unchanged. The former route through the central business district is termed the bypassed route. The bypass is formed once the highway links up with the bypassed route on the opposite side of the city from where the highway entered the city.

A total of 103 highway bypasses with characteristics relevant to the objectives of this study were identified in Texas. The locations of these bypasses are shown in Figure 3.1. A listing of these bypasses is found in each of the earlier project reports. (Helaakoski, et al, 1992.) (Andersen, et al, 1992.)

Interstate bypasses are excluded from this analysis, since the interstate system is largely in place and future bypass construction will involve mainly State and U.S. highways. It is also postulated that the characteristics of the road users on the interstate system are different from those of users of other highways. State and U.S. highway bypasses were categorized by highway characteristics, geographical location, population characteristics, and year of construction. These categories are discussed hereafter.

HIGHWAY CHARACTERISTICS

The following types of bypasses were defined based on a detailed review of Texas District Traffic Maps and Texas County Maps:

Standard Bypass

As illustrated in Figure 3.2, this type conforms to the earlier definition of a bypass. There are currently 90 standard bypasses in Texas.

Multiple City Bypass

This type is similar to the standard bypass, with the exception that more than one city is bypassed. Generally, these bypassed cities are in close proximity to each other. Consequently, it is difficult to assess the impacts on a single location, since the cities may be interdependent. This type of bypass was excluded from further analysis. The multiple city bypass is illustrated in Figure 3.3.

Multiple Highway Bypass

In some cases a State or U.S. highway bypass was built after the first bypass. This is often the first stage in the development of a loop. Figure 3.4 illustrates this type of bypass. Currently, there are 6 of these bypasses in Texas.

Partial Bypass

A bypass segment not directly linked to the bypassed route on the other side of the city is called a partial bypass. Typically, the partial bypass connects to another highway also passing through the city. The through traffic demand generally does not justify the development of a standard highway bypass. The partial bypass may also represent a phase of construction, eventually leading to a standard bypass at completion. Because of the ambiguity surrounding the status of a partial bypass, the existence of this type of bypass is recognized, but

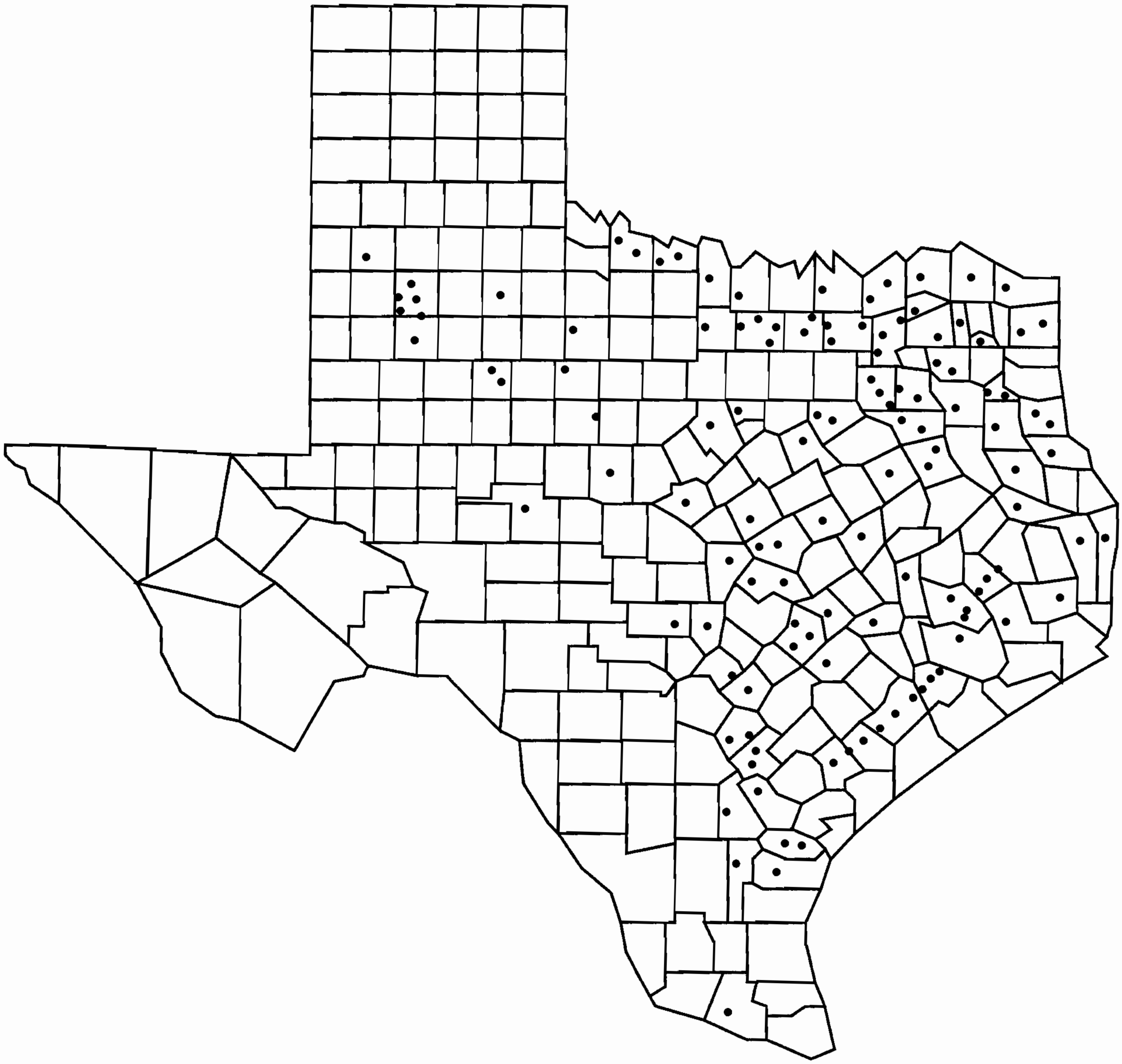

Figure 3.1 Geographical location of bypassed cities in Texas

is not considered for further analysis. The partial bypass is illustrated in Figure 3.5.

Loop

Loops are a designated portion of the highway. Typically, they are formed by connecting two or more bypasses (Figure 3.6). Loops are most often associated with areas of rapid development and/or large populations. Land values and uses associated with loops are very different from those associated with bypasses and thus fall outside the objectives of this study.

GEOGRAPHICAL LOCATION

In recognizing the diversity of the Texas economy, it was deemed appropriate to categorize bypasses according to geographical location, with the economic base of a region forming the basis of this categorization. From Figure 3.1 it can be seen that most of the bypasses are in the densely populated northern and eastern parts of Texas. There are only a few bypasses in the western part of the state where traffic volumes are generally low, as opposed to the more traveled northern and eastern parts. The six different economic

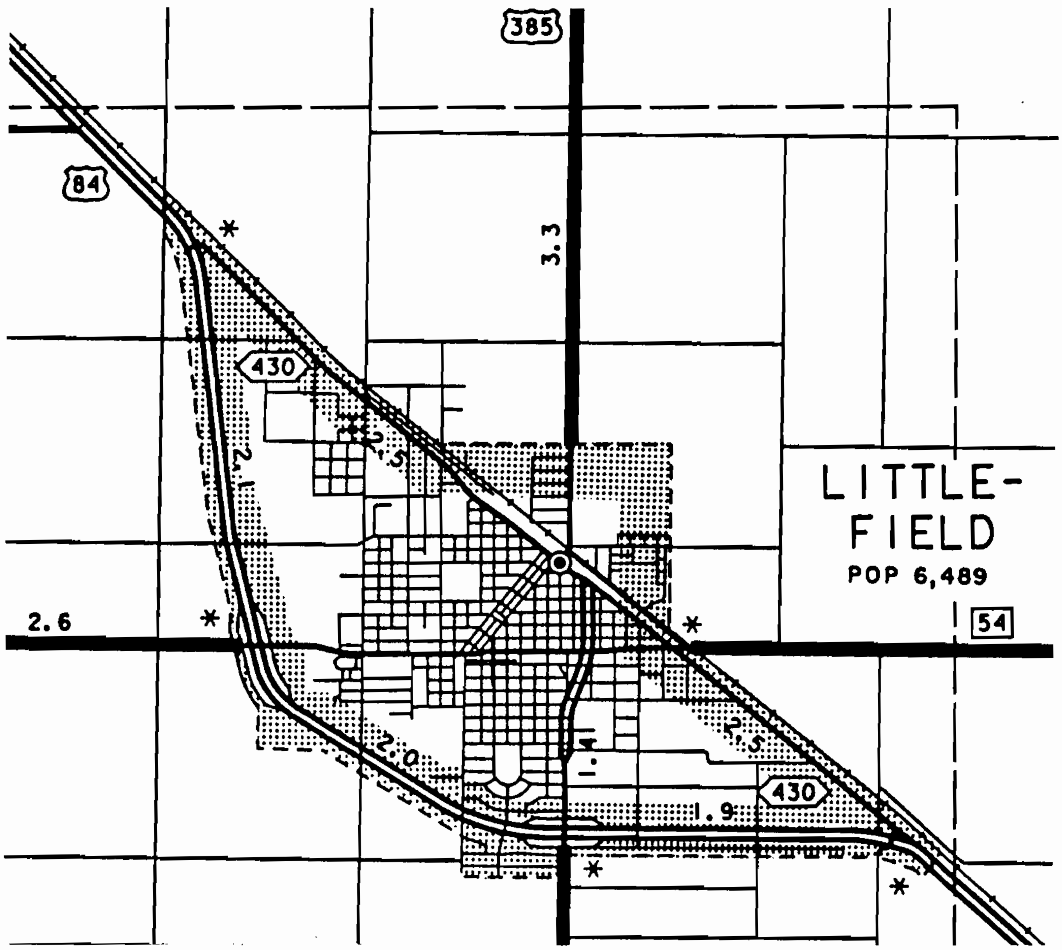

Figure 3.2 *Standard bypass*

regions of Texas—Plains, Metroplex, East Texas, Gulf Coast, Central Corridor, and Border—are illustrated in Figure 3.7. (*Texas Almanac 1990-1991*, The Dallas Morning News, Dallas, Texas, 1989.)

These regions form the basis for categorizing bypasses in Texas according to geographical location. A brief discussion of each is presented hereafter.

The Plains. The economic activity of this region is tied closely to its exhaustible natural resources. Oil and gas production dominates the economy in certain parts of this region while farming and ranching also have an important share in the economy.

Metroplex. This is the major manufacturing, trade, distribution and finance center of the Southwest. It is the most urbanized of the six regions and boasts a healthy manufacturing sector built around the production of high-tech electronics, aerospace and military hardware.

East Texas. The economy of this region is built on its natural resources, namely timber, oil, gas, coal, and water.

Gulf Coast. This region's economy is dominated by the oil, gas, and petrochemical industries. It also supports a wide range of economic endeavors including shipbuilding, port activity, and agriculture.

Central Corridor. This region has long been a center of federal and state government and higher education. High-tech manufacturing and services have also increased in importance.

The Border. This is a very distinct region because of its economic ties with Mexico and an economy that has long been oriented towards trade and tourism. Farming and ranching operations provide large numbers of jobs throughout this region. It also hosts a large government sector.

POPULATION CHARACTERISTICS

The population of bypassed cities ranged from hamlets with less than 500 people to cities with a population of 120,000. The population data were gathered from U.S. Census information as well as from the Texas Almanac. The distribution of population for bypassed cities is given in Figure 3.8.

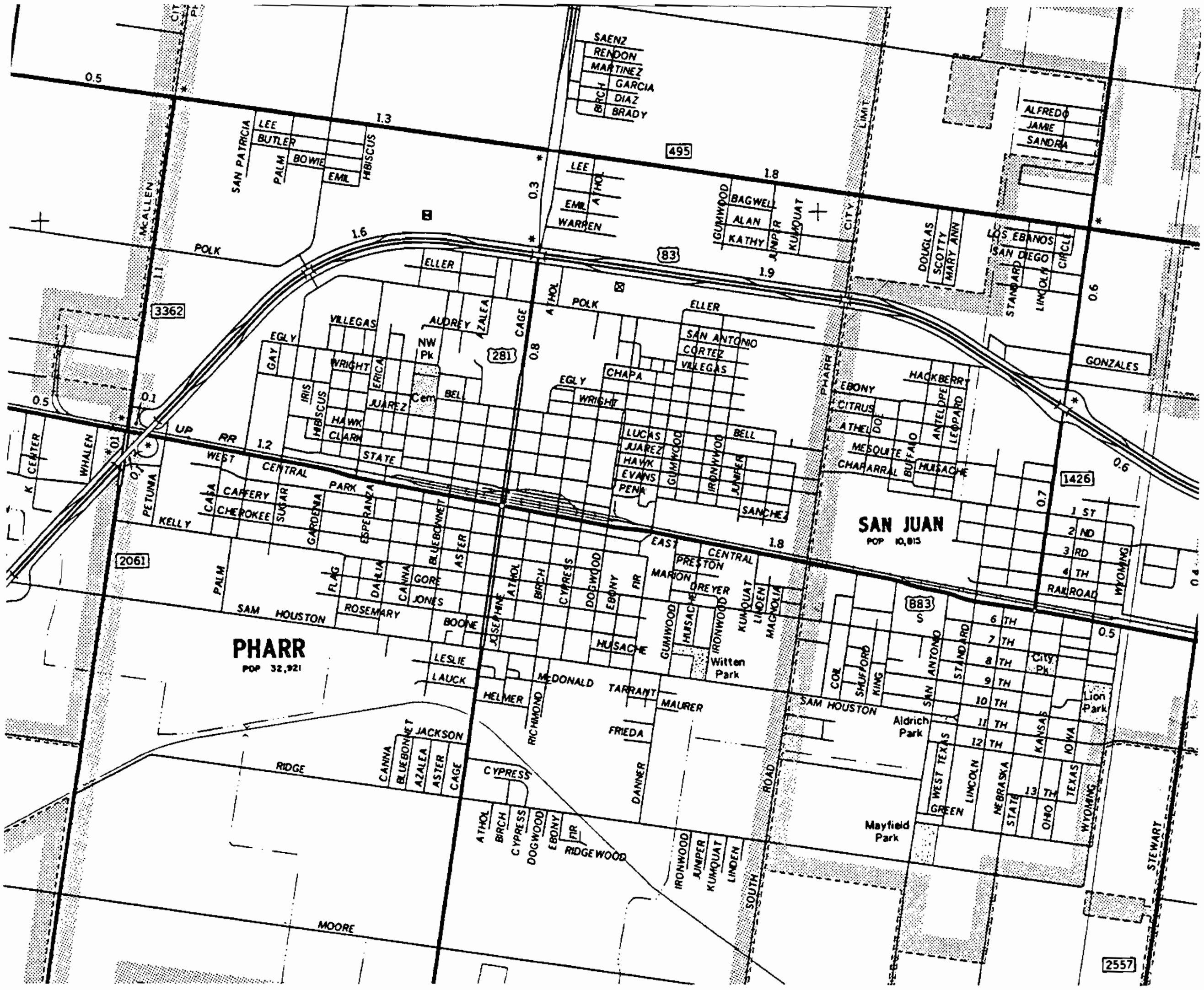

Figure 3.3 Multiple city bypass

A cumulative frequency distribution for population is depicted in Figure 3.9. It can be seen that almost one-half of all bypassed cities have a population of 2,500 or less, while approximately 3 percent have a population greater than 25,000.

YEAR OF BYPASS CONSTRUCTION

The year of bypass construction was identified as the year when traffic volumes on the bypass first appeared on District Highway Traffic Maps. Figure 3.10 illustrates the number of bypasses opened each year. Very few bypasses date back to the pre-1950 era. Most of the Texas bypasses were constructed either in the late 1950's or in the 1960's. The increase in bypass construction coincides with construction of the interstate system, a period characterized by increased use of the automobile.

BYPASS SAMPLE

The study team identified the standard bypass city as the basis for analysis. Additionally, bypassed cities were selected that met the following conditions.

(1) Cities with populations between 2,500 and 25,000 at the time of the bypass. The lower bound was set at 2,500 since census and economic information is generally not available for cities with populations less than 2,500. The upper bound was set at 25,000 since only six Texas cities remain in the category with populations greater than 25,000, and these cities have characteristics different from those of cities within the intended scope of this study.

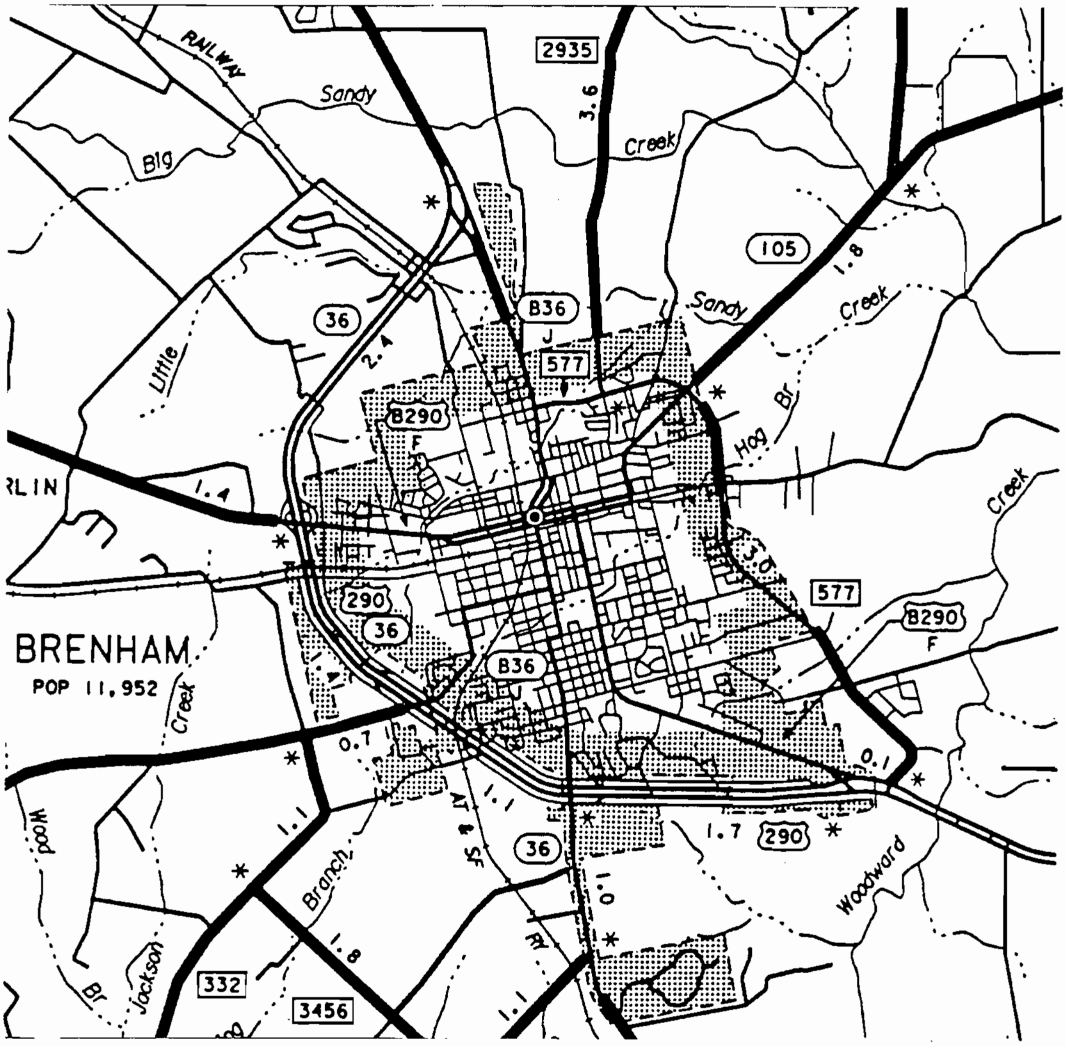

Figure 3.4 Multiple highway bypass

(2) Cities bypassed between 1960 and 1980. This was required so that long-term trends could be obtained and studied for the periods both before and after construction.
(3) Cities with only one bypass, conforming to the earlier definition of a bypass.
(4) Cities with highway bypasses that do not bypass more than one city at a time.

These conditions resulted in a final sample of 23 bypassed cities; they are listed in Table 3.1.

A control city was selected for each bypassed city. This allowed for comparison of changes in the economies of the bypassed cities with the changes in those of the control cities. Ideally, the control city and the bypassed city should have the following characteristics in common prior to the bypass being opened:

(1) highway district;
(2) proximity to a larger city;
(3) economic base;
(4) magnitude and trend of retail sales;
(5) population size category and growth trend; and
(6) highway network characteristics.

For each bypassed city, two to six control city candidates were evaluated and the most similar one was chosen as the control city. It was difficult to find a "perfect" control city, with the main discrepancies being a large difference in population size and different trends in retail sales. A control city was chosen for each bypassed city (Table 3.2), with the city numbers for the control cities corresponding to those of the bypassed cities.

THE STUDY DATA BASE

A data base was established by assembling information on variables pertinent to further statistical analysis. These variables were identifed principally by the literature review; they describe the characteristics of the individual cities that reflect changes with the advent of the bypass. A discussion of the variables follows, first with the dependent, and then with the explanatory variables.

The change in business activity is captured by the dependent variable. Typically, total retail sales is used as a short-term indicator reflecting the economic viability of the city as a whole. Also, as seen in the literature, it is expected that a bypass should specifically affect highway-oriented businesses. To this extent, data for gasoline sales, restaurant sales, and hotel and motel receipts are pertinent. U.S. Census data are the source for these variables. However, data on hotel receipts are available only when there are more than three hotel/motel establishments in a city. Since many of the cities under consideration had fewer than four hotels or motels, this variable could not be used.

The Standard Industrial Classification (SIC) code is used to categorize business activity. The relevant codes are SIC-code 58, referring to eating and drinking places, and SIC-code 554, referring to gas station sales. All sales figures were corrected for inflation by applying the Consumer Price Index (CPI), with 1987 as the base year. U.S. Census data for sales are available for the following years: 1948, 1954, 1958, 1963, 1967, 1972, 1977, 1982, and 1987. The objective is to have three data points before and after the opening of the bypass. This is possible in most cases, except for bypasses completed after 1977.

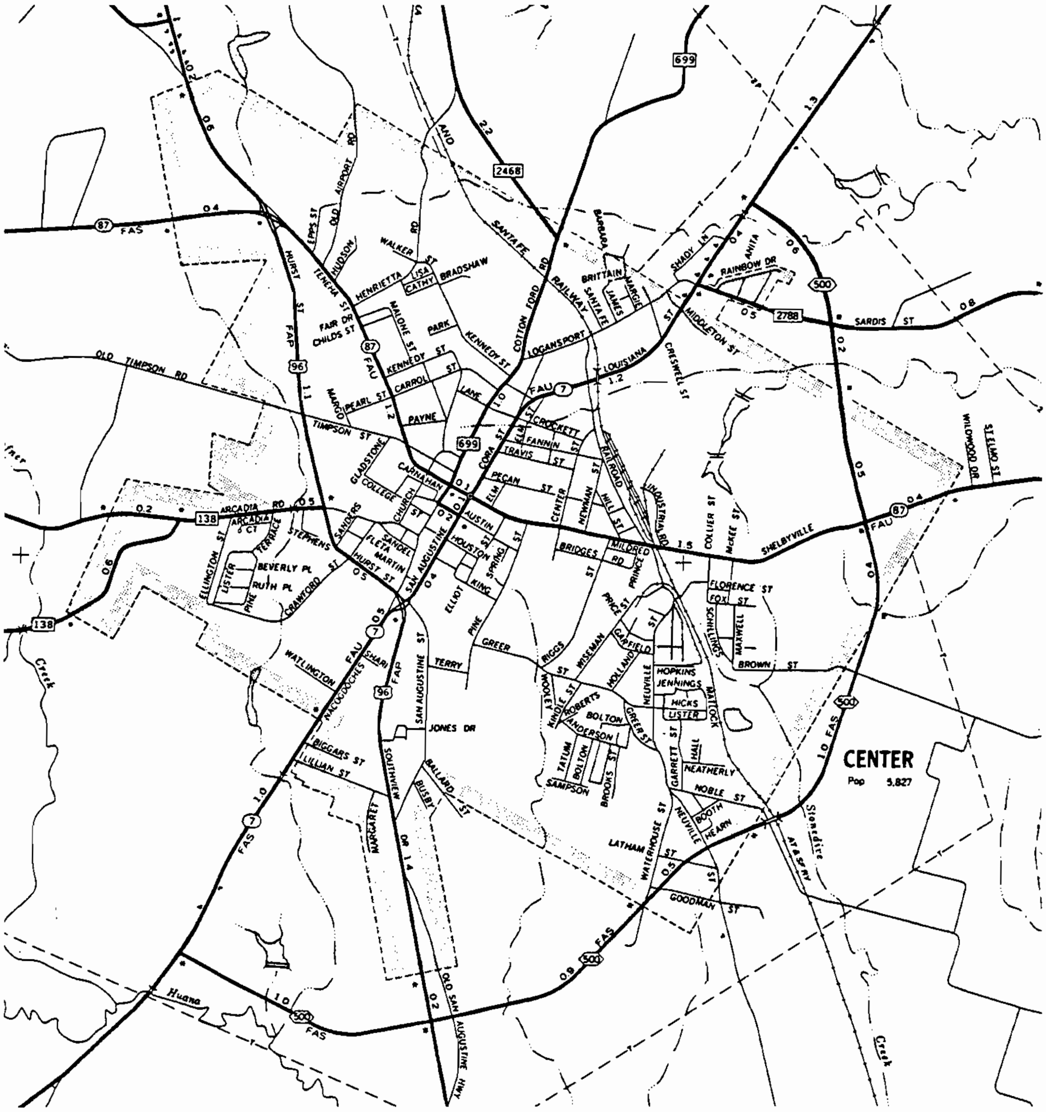

Figure 3.5 Partial bypass

Economic, geographic, and highway-related explanatory variables in the data base are listed in Table 3.3 with a short description. When the value of an explanatory variable is not available for one of the specific years mentioned above, linear interpolation between the existing data is used to estimate the missing value in the analysis.

Various sources were used to obtain these data. Information on population and retail trade were obtained from the U.S. Department of Commerce, Bureau of Census; personal income was found in the Texas Almanac; county maps were used to obtain all highway characteristics; and annual road and traffic maps of the Texas Department of Transportation provided all required information on traffic volumes.

SUMMARY

This chapter described the data acquisition phase. First, the procedure to obtain an inventory of Texas bypasses was outlined. A sample of bypassed cities and control cities in Texas was obtained. Finally, pertinent variables for the purpose of the study were defined and data were collected for all cities in the sample.

It was deemed important to corroborate the choice of variables in the analytical study data base. To this effect, it was decided to include case studies as a methodology. An account of field visits is given in the next chapter, in an effort to confirm the relevancy of the variables in the established data base.

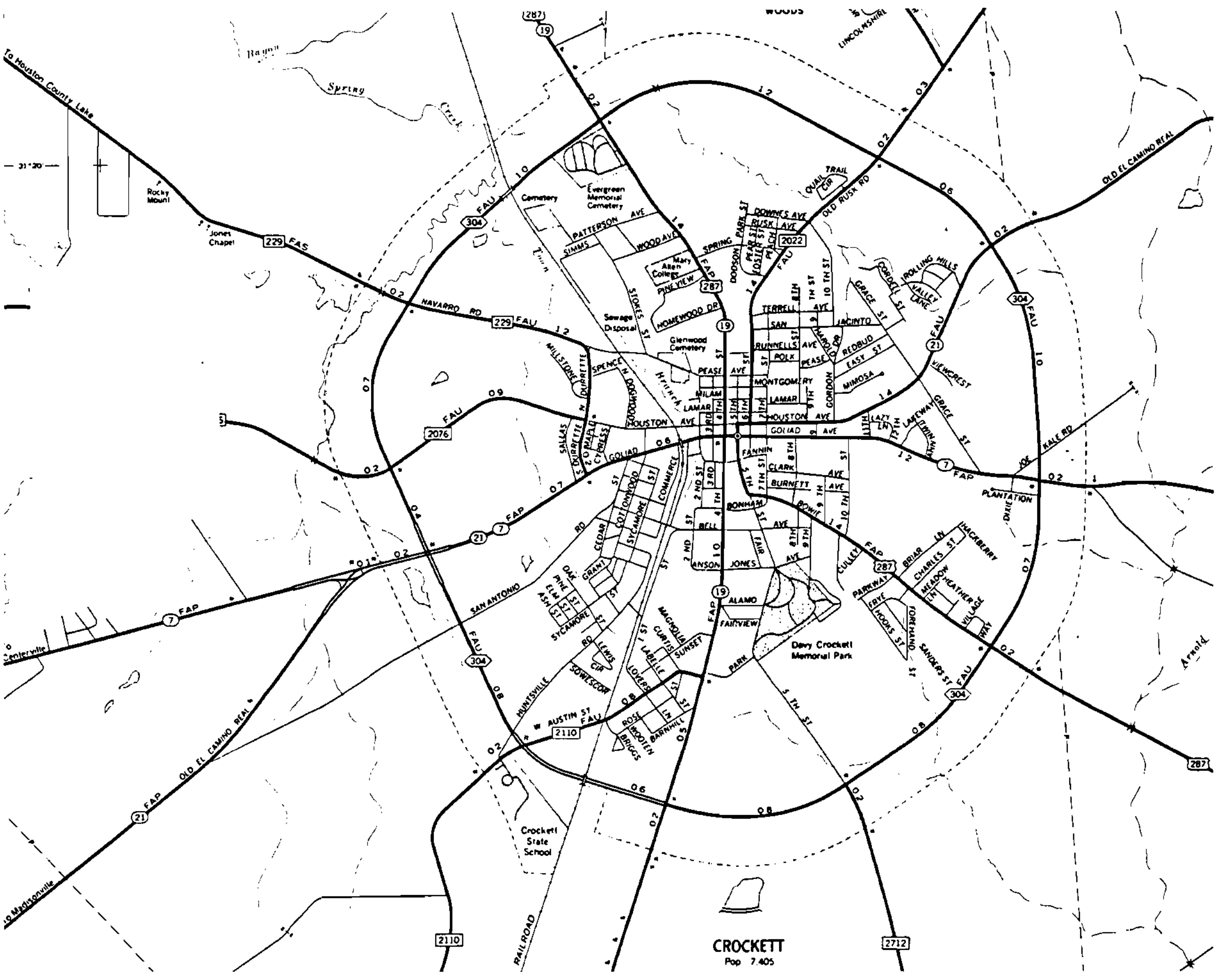

Figure 3.6 Loop

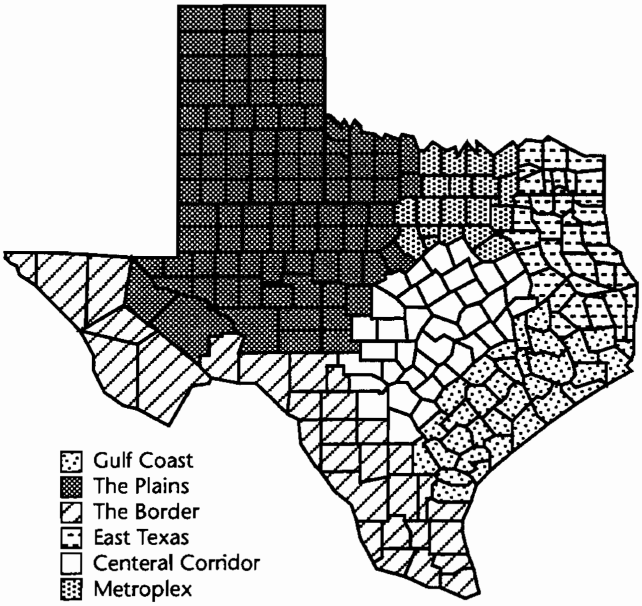

Figure 3.7 ***Economic regions of Texas***

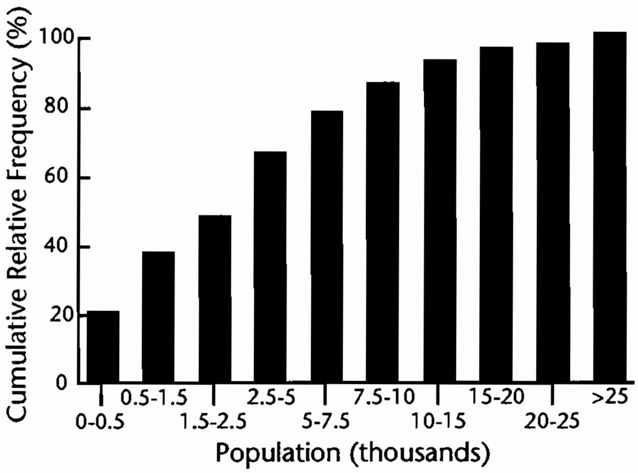

Figure 3.9 ***Cumulative frequency distribution for population size***

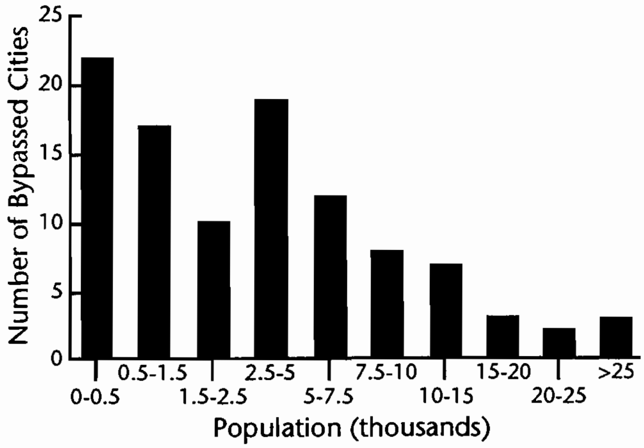

Figure 3.8 ***Population distribution of bypassed cities***

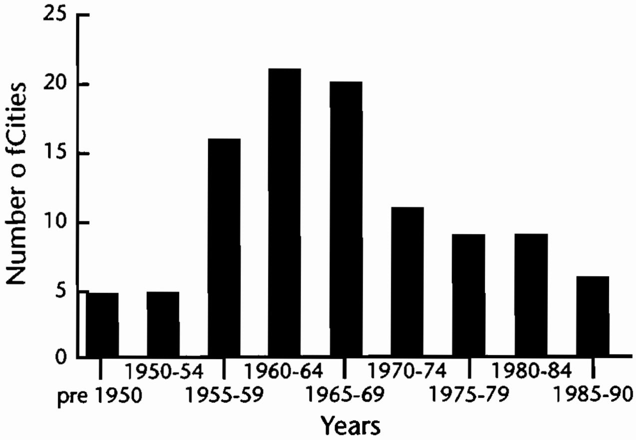

Figure 3.10 ***Distribution of bypass construction by years***

Table 3.1 Bypassed cities in the sample

City Number	Bypass City	County	Traffic District	Economic Region
1	Bonham	Fannin	1	Metro
2	Bridgeport	Wise	2	Metro
3	Vernon	Wilbarger	3	Plains
4	Electra	Wichita	3	Plains
5	Henrietta	Clay	3	Plains
6	Bowie	Montague	3	Metro
7	Littlefield	Lamb	5	Plains
8	Slaton	Lubbock	5	Plains
9	Tahoka	Lynn	5	Plains
10	Snyder	Scurry	8	Plains
11	Alvin	Brazoria	12	Gulf
12	Wharton	Wharton	13	Gulf
13	El Campo	Wharton	13	Gulf
14	Edna	Jackson	13	Gulf
15	Taylor	Williamson	14	Central
16	Bastrop	Bastrop	14	Central
17	Beeville	Bee	16	Gulf
18	Teague	Freestone	17	Central
19	Navasota	Grimes	17	Gulf
20	Atlanta	Cass	19	East
21	Silsbee	Hardin	20	Gulf
22	Edinburg	Hidalgo	21	Border
23	Coleman	Coleman	23	Plains

Table 3.2 Selected control cities

City Number	Control City	County	Traffic District	Economic Region
1	Clarsville	Red River	1	East
2	Comanche	Comanche	23	Plains
3	Graham	Young	3	Plains
4	Childress	Childress	25	Plains
5	Memphis	Hall	25	Plains
6	Nocona	Montague	3	Metro
7	Post	Garza	5	Plains
8	Brownfield	Terry	5	Plains
9	Morton	Cochran	5	Plains
10	Stamford	Jones	8	Plains
11	Angelton	Brazoria	12	Gulf
12	Bay City	Matagorda	13	Gulf
13	Eagle Lake	Colorado	13	Gulf
14	Cuero	De Witt	13	Gulf
15	Lockhart	Caldwell	14	Central
16	Giddings	Lee	14	Central
17	Alice	Jim Wells	16	Border
18	Hearne	Robertson	17	Central
19	Cameron	Milam	17	Central
20	Gilmer	Upshur	19	East
21	Liberty	Liberty	20	Gulf
22	Rio Grande City	Starr	21	Border
23	Brady	McCulloch	23	Plains

Table 3.3 Explanatory variables in the data base

Variable Name	Explanation
POPULATION	Population of the city
INCOME	Average personal income per capita in the county in 1987 dollars
GROWTH1	The growth rate per capita of real Gross National Product in the U.S.A. during the period between year t and t-1
GROWTH5	The growth rate per capita of real Gross National Product in the U.S.A. during the period between year t and t-5
LARGERCITY	Distance in miles to a city of a larger size within the state.
METRO-AREA	= 1 if the city is located in the metropolitan area; otherwise 0
US	Number of incoming U.S. highways to the city
STATE	Number of incoming State highways to the city
ADT-TOTAL	Average daily traffic volumes on incoming highways
LENGTHOLD	Length of an old bypassed route in miles
LENGTHNEW	Length of a bypass in miles
DISTANCE	The average distance in miles between a bypass and a bypassed route
CLASS	Classification of the bypass (U.S. highway=1, State highway=0)
ADT-BYPASS	Average daily traffic volumes on the bypass
SPLIT	The percentage of traffic diverted from the bypassed route to the bypass
ACCESS	Access type for the bypass (=1 if a bypass has limited access and grade separation; otherwise 0)
YEAR	Year for the data

CHAPTER 4. CASE STUDIES

The case studies present findings of field visits to six bypassed cities in Texas. The visits included interviews with the local Chambers of Commerce and business owners. During the visits, specific attention was given to the spatial adjustment of the cities to the bypass. The prime purpose of the case study methodology is to ensure that there are no additional variables necessary to successfully describe the bypass effects.

THE METHODOLOGY

Site visits and interviews with local businesspersons were conducted in six bypassed cities in Texas, four of which are included in the sample of 23 (Bowie, Littlefield, Taylor, and Navasota), and two which fall in the "under 2,500" population category (Alvord and Grapeland). The geographical location of these sites is shown in Figure 4.1.

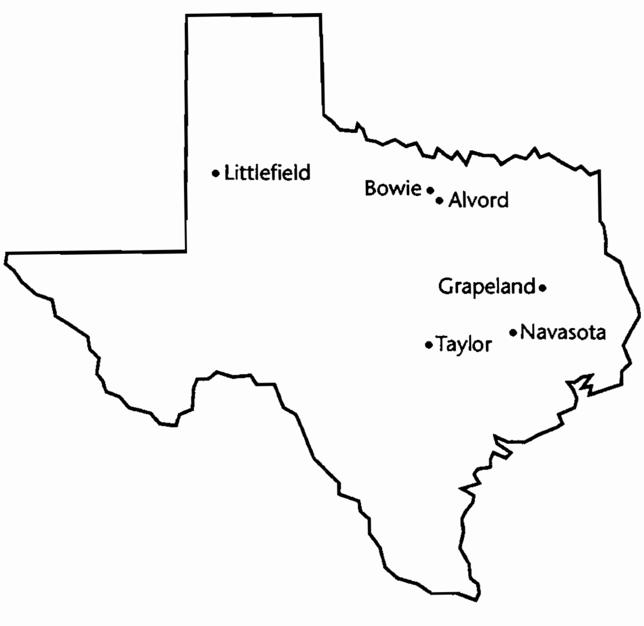

Figure 4.1 Location of bypassed cities where site visits were performed

The sites were chosen to reflect differences in geographical location, population, economic base, type of highway, traffic volumes, and trends in business volumes. In the case of Alvord and Bowie, an attempt was made to determine the similarity of cities in close proximity to each other.

Actual site visits and interviews were preceded by a literature review of each city's history and general characteristics. In addition, changes in the spatial distribution of highway-oriented businesses were studied by examining old telephone directories.

Interviews were held mostly with the local Chambers of Commerce and local businesspersons contacted through the Chambers of Commerce. These interviews focused on the current economic viability of the city, the perceived effect of the bypass on growth and businesses, adjustments to the bypass, and opinions of local people regarding the desirability of the bypass.

A detailed account of the site visits is presented in the other two reports of study 1247. (Helaakoski, et al, 1992.),(Andersen, et al, 1992.)

SUMMARY OF KEY FINDINGS FROM SITE VISITS AND INTERVIEWS

The site visits and interviews helped elucidate much of the functioning of small cities in rural areas. The subjective input provided by local people during the visits shed useful light on the perceived effects of the bypass. The key findings are summarized as follows:

(1) In general, the bypass was not perceived to have a devastating impact on any of the visited communities. The case studies do not suggest a strong relationship between a bypass and economic growth. Other factors have a much stronger effect on local businesses, such as:
   - (a) fluctuation in the agriculture or oil business,
   - (b) continuing urbanization trends, and
   - (c) establishment of large discount stores within the market area.

(2) The removal of a portion of through traffic from the downtown streets, especially heavy vehicles, is seen in a very positive light. Improved safety and cleaner air are seen as the most important benefits.

(3) There are ways to enhance and encourage downtown business activities. It is beneficial if the main shopping area is off the bypassed route, i.e., on a street perpendicular to the bypassed route. Parking maneuvering is often difficult on the bypassed route; widening of this route is often an alternative. Road signs on the highway advertising city amenities is a way to lure people into the city.

(4) Spatial changes are often confined to increased activity at the point where another highway intersects the bypass. Generally, few establishments were found at the split between the bypass and bypassed route. These typical changes in city form are shown in Figure 4.2.

(5) Spatial development towards the bypass are often constrained by factors which may not be evident to an outsider. Excessive distance between the bypass and bypassed route can result in utilities not being extended to the bypass because of cost. Physical obstructions such as a creek or hilly terrain may produce the same effect.

(6) Downtown businesses have typically experienced a drop in sales after the opening of the bypass. However, this drop was in many cases a temporary phenomenon, as business owners restructured their stores and/or reoriented their businesses. It was noted that many gas stations had closed on the bypassed route, corresponding to general declining trends because of industry restructuring nationally.

SUMMARY

Key findings of the site visits were presented in this chapter. These visits provided direct experience and insights into the economic effects of highway bypasses, ensuring that all the variables in the data base are deemed relevant and important to successfully describe bypass effects.

All required inputs and relevant methodologies are defined at this point. The next step is to explore the data and develop models to isolate the effect of highway bypasses.

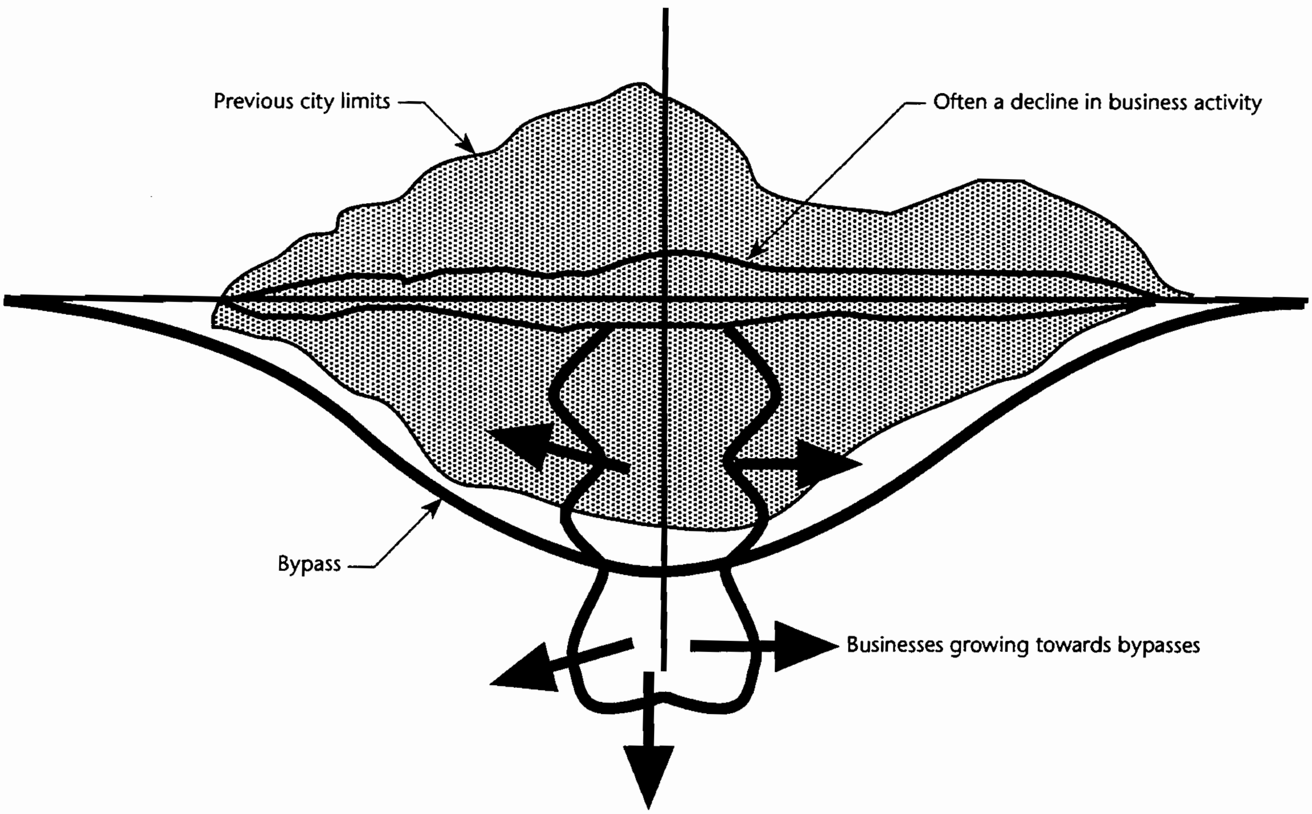

Figure 4.2 Typical land development in bypassed city

CHAPTER 5. MODEL DEVELOPMENT

This chapter deals with the different phases of developing models that isolate the effects of highway bypasses. Variables that were isolated during the background review and confirmed during site visits are now explored. Data for the bypass and control groups are also compared. Econometric models are then developed to relate retail sales, restaurant sales, gasoline sales, and service receipts to the pertinent characteristics of the area. Cluster analysis, a multivariate statistical procedure, is then used to identify some underlying structure within the set of bypassed cities. It is also used to define variables that may improve the specification and predictive ability of the models.

COMPARATIVE TREND ANALYSIS

Descriptive Statistics - Bypassed and Control City Group

Summary descriptive statistics are calculated for the variables in the data base to examine the overall similarity of bypassed and control cities for the period before the opening of a bypass. Table 5.1 shows the means, standard deviations, and medians of all the observations for the before period for comparable variables.

Observations represent many different decades, depending on when a bypass was opened. Each city has three observations, one for each consecutive five-year interval preceding the bypass opening.

The mean values of the variables in Table 5.1 for bypassed and control cities as two groups are approximately the same. The most noticeable difference is in average daily traffic (ADT) volumes on incoming highways; bypassed cities have on average 33 percent more traffic. There is also a slight difference in population; bypassed cities have, overall, 15 percent more inhabitants. Means for other variables in Table 5.1 are very similar for the two city groups.

Table 5.2 shows the means, standard deviations, and medians of all observations for the after period for comparable variables in the data base. Observations are from different decades, depending on when the bypass was opened. Mean values for bypassed and control city groups are also listed for the after period and are almost identical for all variables except ADT on incoming highways and population. Traffic volumes are, on average, 39 percent higher, and population is 11 percent higher for the bypassed cities.

Table 5.1 ***Means, standard deviations, and medians for dependent and key explanatory variables for the before period***

	Bypassed Cities			Control Cities		
	Mean	Standard Deviation	Median	Mean	Standard Deviation	Median
Total Retail Sales/Person	6,783	2,165	6,494	6,494	1,837	6,003
Gas Station Sales/Person	576	199	532	587	188	561
Restaurant Sales/Person	269	110	254	268	98	246
Service Receipts/Person	494	202	459	500	282	466
Income/Person	5,264	1,549	5,323	4,890	1,353	4,934
Population	6,981	3,974	6,142	6,088	3,812	5,459
Distance to Larger City	26	12	24	29	11	29
Number of Highways	4.1	1.1	4	3.8	1.1	4
ADT, Incoming Highways	13,630	5,660	13,490	10,220	4,440	9,040

Table 5.2 Means, standard deviations, and medians for dependent and key explanatory variables for the after period

	Bypassed Cities			Control Cities		
	Mean	Standard Deviation	Median	Mean	Standard Deviation	Median
Total Retail Sales/Person	7,435	2,480	7,278	7,073	2,102	6,668
Gas Station Sales/Person	604	249	577	612	284	587
Restaurant Sales/Person	343	166	344	339	144	321
Service Receipts/Person	1,009	684	830	1,027	813	771
Income/Person	7,455	2,144	7,639	6,950	1,861	6,647
Population	7,641	4,800	6,602	6,859	4,521	5,550
Distance to Larger City	26	12	25	29	11	29
Number of Highways	4.1	1.1	4	4.0	1.2	4
ADT, Incoming Highways	21,710	9,910	20,280	15,590	7,700	13,180

In order to draw statistical conclusions concerning the differences between the mean values for the bypassed cities and control cities as two groups, t-tests were performed for the means (bypassed city group and control city group) of the variables listed in Tables 5.1 and 5.2. The null hypothesis (H_0) is that the means of the key variables for the bypassed city group and control city group are the same. In this case, H_0 will be rejected at the 0.05 level, if a t-value is greater than 2.00. T-test results of the differences in means between bypassed and control city groups are shown in Table 5.3. The differences between bypassed and control groups are minor and insignificant, except for the variable ADT on incoming highways. The difference in this variable is very significant already for the before period; the bypass did not cause any notable change. Higher traffic volumes in the bypassed cities were, presumably, one of the reasons to construct the bypass in the first place.

Table 5.3 T-test for the differences in the means of key variables for bypassed and control city groups (bypassed - control)

	t-Value	
	Before Period	After Period
Total Retail Sales/Person	0.84	0.90
Gas Station Sales/Person	−0.33	−0.17
Restaurant Sales/Person	0.05	0.50
Service Receipts/Person	−0.14	−0.13
Income/Person	1.51	1.44
Population	1.34	0.96
ADT, All Incoming Highways	3.93*	3.95*

*Significant at the 0.05 level

MATCHED PAIR ANALYSIS

The data base consists of observations for bypassed cities and the selected control cities. Control cities were chosen in such a way that key explanatory variables had approximately the same values during the before period. Therefore, it is appropriate to assume that observations are paired for these matched cities.

A t-test was conducted for these paired observations for all dependent variables and for two explanatory variables, namely, for income per person and for population. Because of the significant difference in population size with some pairs, it was decided that per capita values for business volumes would be used instead of total city values for business volumes. In order to gain a broad viewpoint, a paired t-test for matched cities was performed for four time periods:

(1) six to ten years before the bypass was opened,
(2) one to five years before the bypass was opened,
(3) one to five years after the bypass was opened, and
(4) six to ten years after the bypass was opened.

It is important to remember that these observations are dependent upon when a bypass was opened and that they represent different decades.

The significance of the differences between the paired observations was tested. The null hypothesis (H_0) is that the mean of the differences for paired observations would be zero, in other words, paired observations are equal. In this case H_0 will be rejected at the 0.05 level, if the calculated t-value is greater than 2.07.

T-values in Table 5.4 show no statistically significant differences in business volumes for paired observations either for the before or for the after period. This result confirms the appropriateness of the control cities and the hypothesis that the construction of highway bypasses has not significantly affected business volumes. However, it is interesting to note the negative signs for all means in business volumes for the time period just after the bypass was opened (time period 3). This can be interpreted as a slightly negative effect of highway bypass construction on business volumes. Means and t-values for personal income and city population have positive signs in every time period, indicating slightly higher values for bypassed cities over the entire study period; two values for personal income are almost statistically significant at the 0.05 level of significance.

The next step is to test the significance of the difference between consecutive observations by using the equation:

$$DY_i = Y_{i,t} - Y_{i,t-5}$$

where

i paired cities and
t a year in the data base.

The data base contains observations for every fifth year. DY is the measure of the difference between consecutive observations for paired cities. In other words, this is a test of the differences in growth rate. Values for the control cities are subtracted from the corresponding values for the bypassed cities. Therefore, positive values mean that business volumes for bypassed cities grow faster than

Table 5.4 Paired t-test for matched cities (bypassed - control). Mean differences between paired observations with corresponding standard errors and t-values

Time Period	Variable	Mean	Standard Error	t-Value
(1) Six to ten years before the bypass was opened	Total Retail Sales/Person	277	1,887	0.70
	Gas Station Sales/Person	-27	141	-0.91
	Restaurant Sales/Person	25	125	0.95
	Service Receipts/Person	-5	207	-0.11
	Income/Person	483	1,166	1.98
	Population	900	4,026	1.07
(2) One to five years before the bypass was opened	Total Retail Sales/Person	415	1,686	1.18
	Gas Station Sales/Person	10	285	0.16
	Restaurant Sales/Person	-20	145	-0.66
	Service Receipts/Person	-22	532	-0.19
	Income/Person	204	797	1.22
	Population	871	4,784	0.87
(3) One to five years after the bypass was opened	Total Retail Sales/Person	-167	2,008	-0.39
	Gas Station Sales/Person	-48	231	-0.99
	Restaurant Sales/Person	-4	98	-0.19
	Service Receipts/Person	-63	403	-0.74
	Income/Person	338	851	1.90
	Population	961	4,117	1.11
(4) Six to ten years after the bypass was opened	Total Retail Sales/Person	696	2,408	1.38
	Gas Station Sales/Person	-68	400	-0.81
	Restaurant Sales/Person	11	160	0.32
	Service Receipts/Person	-82	917	-0.42
	Income/Person	348	1,093	1.52
	Population	1,030	5,252	0.94

Number of paired observations: 23

those for control cities. Both total and per capita values are included in the comparison shown in Table 5.5. It is also reasonable to compare total city values, because the interest in this case is in the growth rate, and, therefore, the differences in the city size for matched cities do not cause disparity in the values.

Table 5.5 has three blocks as follows:

(1) period before the bypass—both observations t and t-5 are from the before period;

(2) before-and-after comparison—observation t is from the after period and observation t-5 is from the before period; and

(3) period after the bypass—both observation t and observation t-5 are from the after period.

The null hypothesis (H_0) is that the mean of the differences for consecutive paired observations is zero; in other words, growth rates for paired observations are equal. In this case, H_0 will be rejected at the 0.05 level if the computed t-value for the sample is greater than 2.07.

Table 5.5 ***Paired t-test for matched cities (bypassed - control). Mean differences between consecutive observations (change over a five-year time interval) for paired observations with corresponding standard errors and t-values***

Time Interval	Variable	Mean	Standard Error	t-Value
(1) Before Bypass				
First observation: 6 to 10 years before	Total Retail Sales	-1,286	12,868	0.47
	Gas Station Sales	102	1,646	0.29
	Restaurant Sales	15	1,233	0.05
	Service Receipts	622	7,916	0.37
	Total Retail Sales/Person	-139	1,460	-0.45
Second observation: 1 to 5 years before	Gas Station Sales/Person	13	254	0.24
	Restaurant Sales/Person	4	142	0.13
	Service Receipts/Person	25	552	0.21
	Income/Person	45	1,167	0.18
	Population	-43	749	-0.27
(2) Before - After				
First observation: 1 to 5 years before	Total Retail Sales	45	9,861	0.02
	Gas Station Sales	-122	1,770	0.33
	Restaurant Sales	269	1,106	1.16
	Service Receipts	264	2,842	0.44
	Total Retail Sales/Person	-138	1,369	-0.48
Second observation: 1 to 5 years before	Gas Station Sales/Person	-37	244	-0.72
	Restaurant Sales/Person	45	116	1.86
	Service Receipts/Person	17	282	0.28
	Income/Person	279	1,112	1.20
	Population	28	333	0.40
(3) After Bypass				
First observation: 1 to 5 years before	Total Retail Sales	1,640	15,271	0.51
	Gas Station Sales	372	1,344	1.32
	Restaurant Sales	-240	1,302	-0.87
	Service Receipts	-63	5,069	-0.05
	Total Retail Sales/Person	583	1,027	2.72
Second observation: 5 to 10 years before	Gas Station Sales/Person	59	219	1.29
	Restaurant Sales/Person	-15	130	-0.55
	Service Receipts/Person	41	260	0.75
	Income/Person	-133	1,228	-0.51
	Population	-89	1,041	-0.41

* Significant at the 0.05 level
Number of paired observations: 23

During the before period, the average growth rates for the matched cities were almost identical, as can be seen from the t-values, which all have absolute values less than 0.50 (first group in Table 5.5). This result confirms the appropriateness of the control cities selected. The second group in Table 5.5 describes growth rates in the periods immediately preceding and immediately following the bypass opening. Means are not significantly different from zero, with the exception of restaurant sales, which were growing faster for bypassed cities than for control cities. Finally, the third group in Table 5.5 examines growth rates during the after period by comparing first and second observations for the after period. Again, the results of the paired t-test are not conclusive with respect to the effect of a highway bypass on local business activities in small cities. However, one significant value that can be observed is the value for total retail sales per person, which had a higher growth rate for the bypassed cities during the after period.

Generally speaking, Table 5.5 does not reveal different growth rates in total business volumes between the paired cities. However, significant differences for per capita values suggest that cities in some cases have benefited from the bypass construction.

ECONOMETRIC MODELING

One of the purposes of this research was to develop a qualitative predictor of business activity that would capture the effect of the underlying determinants of such activity and allow formal testing of hypotheses pertaining to their relative effects. Generally speaking, the tests performed in the previous section could not relate a significant change in overall business volumes to the opening of the highway bypass. Multivariate regression models are developed in this section to explain the following measures of business activity: total retail sales, gas station sales, restaurant sales, and service receipts in small cities. The models for each of the four dependent variables have the following usual linear form:

$$Y_{it} = bX_{it} + e_{it} \qquad \text{(Eq 1)}$$

where

Y_{it} is the measure of business activity (total retail sales, gas station sales, restaurant sales, or service receipts) for a city in year t;

X_{it} is a vector of explanatory variables for city i in year t;

b is a vector of parameters to be estimated; and

e_{it} is an error term of the usual type, with mean 0, and constant variance.

The vector of explanatory variables X_{it} consists of the kind of variables included in the data set, as shown in Table 3.3. It may also include city-specific binary variables that capture city-related differences in culture, base of economy, geography, etc., that change very slowly over time and are not captured well by the other explanatory variables in the model. The vectors of parameters b are estimated using ordinary least squares.

TOTAL RETAIL SALES MODEL

Retailing is generally the most important component of the local business infrastructure in small cities. The specification and associated parameter estimates of the model developed to explain retail sales are as follows (t-statistics are reported in parentheses):

$$\begin{aligned} \text{SALES} = & \underset{(-5.99)}{-14495} + \underset{(22.84)}{5.561\ \text{POPULATION}} \\ & + \underset{(1.41)}{0.576\ \text{INCOME}} + \underset{(1.81)}{3027\ \text{DLARGER}} \\ & + \underset{(9.76)}{1.305\ \text{ADT-TOTAL}} - \underset{(-4.91)}{12402\ \text{ACCESS}} \\ & + \underset{(5.88)}{31470\ \text{C22}} - \underset{(-7.09)}{44747\ \text{C23}} + \underset{(3.21)}{15186\ \text{C101}} \end{aligned} \qquad \text{(Eq 2)}$$

The most significant variable is POPULATION, as expected, since more residents generate more sales. A simple regression analysis performed for retail sales shows that a relatively high 74.4 percent (R^2) of total variation can be explained by the POPULATION variable alone. Theoretically, INCOME is considered as one of the most important explanatory variables. This variable is less significant than perhaps expected. However, in this specification, INCOME is taken as the average income per capita over a whole county, and, as such, may not entirely reflect buying power in a small city within the county.

The distance between a given city to the nearest city of equal or larger size (LARGERCITY, in Table 3.3) is expected to exert a positive effect on business volumes, because the further away the larger city, the less pull there is for residents to shop away from their own city. This attribute was specified as a binary indicator variable to reflect the finding that the distance to a larger city has a positive effect on retail sales only if such a city is situated at least 20 miles away. If a larger city is very close, it is easy for shoppers to drive a few miles and thereby reach a greater variety of shops. In this model, DLARGER is a binary indicator variable equal to 1, if the distance to a larger city is 20 miles or more; it is 0 otherwise.

Two traffic-related attributes are included in the model: ADT-TOTAL (average daily traffic volumes on incoming highways), and the bypass variable, ACCESS. The estimated value of the coefficient of this attribute shows that a bypass has a significantly negative effect on total retail sales in cases where the geometric characteristics of the facility provide for limited access from adjoining property. The estimated coefficient of the ACCESS variable indicates that the decrease in sales is, on average, about 20 percent per city in the cases where access is limited on the bypass. This value was obtained by applying the estimated model, using the sample mean for each variable and the estimated coefficients to calculate the corresponding value of the dependent variable. Ten cities in the sample have bypasses with limited access.

HIGHWAY ORIENTED BUSINESS

Gas Station Sales

The estimated parameters and corresponding t-statistics of the selected model specification are as follows:

GAS STATION SALES = −4390 + 4.596 YEAR′ + 0.438 POPULATION + 0.205 INCOME + 182 HIGHWAYS + 0.0544 ADT-TOTAL − 0.131 ADT-BYPASS + 2344 C13

t-statistics: −4390 *(−5.74)*; YEAR′ *(4.69)*; POPULATION *(15.05)*; INCOME *(4.14)*; HIGHWAYS *(2.37)*; ADT-TOTAL *(2.70)*; ADT-BYPASS *(−2.98)*; C13 *(3.96)*

(Eq 3)

As expected, POPULATION and INCOME are found to be significant attributes. The nature of gasoline station sales also explains the significance of two highway-related variables in the model: the number of incoming highways (HIGHWAYS), and the traffic volumes on these highways (ADT-TOTAL). Higher traffic volumes will definitely cause a higher volume of gasoline sales.

The final attribute included in the model is traffic volume on the bypass, ADT-BYPASS. It is statistically significant and indicates that a highway bypass has a negative effect on overall gasoline station sales in the sampled cities. This variable indicates, in principle, that the more traffic is diverted to the bypass from the bypassed route, the lower the gas sales that can be expected in the city. It can be estimated, based on the mean values of the variables and the corresponding estimated coefficients, that a highway bypass causes, on average, about a 15 percent decrease in gasoline station sales in a small city.

Restaurant Sales

The model for restaurant sales is as follows:

RESTAURANT SALES = −1827 + 0.366 POPULATION + 0.062 INCOME − 296 METRO-AREA + 0.016 ADT-TOTAL − 0.0674 ADT-BYPASS − 1704 C23 − 1022 C112 + 1745 C113

t-statistics: −1827 *(−9.68)*; POPULATION *(17.33)*; INCOME *(1.94)*; METRO-AREA *(−1.77)*; ADT-TOTAL *(8.57)*; ADT-BYPASS *(−2.42)*; C23 *(−3.54)*; C112 *(−2.75)*; C113 *(4.51)*

(Eq 4)

Again, POPULATION is the most significant variable. Also significant are ADT-TOTAL and INCOME. The only new variable is METRO-AREA, which appears to have a significant negative effect. This binary variable is equal to 1 if the city is located in a metropolitan area; it is 0 otherwise. Apparently, a greater variety of restaurants in a nearby large metropolitan area reduces sales in small cities, for reasons similar to those for the retail sales findings.

The highway bypass-related variable, ADT-BYPASS, is found to have a significant negative effect on restaurant sales. Additional calculation based on the mean values of the variables and the corresponding estimated coefficients suggests that a highway bypass is associated, on average, with a 10 to 15 percent decrease of restaurant sales in a small city.

SERVICE RECEIPTS

In developing the model to explain service receipts, the variables were transformed by taking their natural logarithms (ln-ln), eliminating heteroskedasticity and giving a significantly better R^2 value. The model is stated below in the following form:

$$\ln(\text{SERVICE RECEIPTS}) = \underset{(-12.08)}{-8.78} + \underset{(7.03)}{0.0243}\ \text{YEAR}$$

$$+ \underset{(15.99)}{1.022 \ln(\text{POPULATION})}$$

$$+ \underset{(4.35)}{0.388 \ln(\text{INCOME})}$$

$$+ \underset{(2.26)}{0.00303 \ln(\text{NEARBYCITY})}$$

$$+ \underset{(4.36)}{4.36 \ln(\text{ADT-TOTAL})}$$

$$- \underset{(-1.54)}{0.116\ \text{ACCESS}} - \underset{(-4.34)}{0.671\ \text{C6}}$$

$$+ \underset{(3.55)}{0.545\ \text{C118}} - \underset{(-5.08)}{0.870\ \text{C119}} \qquad \text{(Eq 5)}$$

As expected, POPULATION is again the most significant variable, although, this time, population alone explains only 48.8 percent of the variation in service receipts. INCOME level also has a significant influence on service receipts. In this model NEARBYCITY is introduced as a new variable, taking the value of 0 if the distance to the nearest larger city is less than 20; otherwise, it is set to the value of the variable LARGERCITY, the distance in miles from a bypassed or control city to the larger city. The new variable NEARBYCITY means that the geographical location of a city leads to higher service receipts in a small city only if a larger city is more than 20 miles away. With longer distances, the positive effect still increases gradually. Furthermore, service receipts are apparently also a traffic-related phenomenon, as can be seen from the significance of the ADT-TOTAL variable. Moreover, an overall increasing trend captured by the linear variable YEAR was found to be significant.

The last traffic characteristic found to have a significant effect on service receipts is the variable ACCESS. This variable indicates that a bypass has a significantly negative effect on service receipts in cases where the geometric characteristics of the facility provide for only limited access.

In addition to the model development presented above, the hypothesis was examined that cities with larger populations have a somewhat better chance of adjusting to economic changes that may be induced by the bypass. (Ibid.) For this purpose, the cities in the sample were divided into two population categories: those with a population between 2,500 and 6,000, and those with a population between 6,000 and 25,000. It was concluded that the negative effects of a highway bypass on total retail sales and highway-oriented sales have about the same significance for both categories. In small cities, a highway bypass does not have a significant negative effect on service receipts, whereas large cities are found to suffer losses because of a bypass. Finally, it was found that the econometric models developed can be used in predictions with fairly reasonable accuracy. (Ibid.)

CLUSTER ANALYSIS

Cluster analysis, a multivariate statistical procedure, involves the grouping of similar entities. This process is frequently stated as one of finding the "natural groups." Cluster analysis may be used as a tool to explore and reveal structure and relations in the data. Measures of similarity or distance between entities are computed. Different heuristic clustering methods can then be used to obtain the various groupings.(Aldenderfer and Blashfield, 1984.) Cluster analysis is used in this study to identify some underlying structure within the set of bypassed cities. This is done by comparing clusters formed for bypassed cities with those formed for the control cities. It is also used to define variables that may improve the specification and predictive ability of models similar to those discussed in the previous section.

The Cluster Analysis Procedure

The complete linkage method, part of the family of hierarchical clustering methods, is used for this analysis. At each stage in this method, after clusters p and q have been merged, the similarity between the new cluster (labeled t) and some other cluster r is determined as follows:

$$s_{tr} = \max(s_{pr}, s_{qr})$$

The quantity s_{tr} is the distance between the most distant members of clusters t and r. If clusters were merged, then every entity in the resulting cluster would be no farther than s_{tr} from every other entity in the cluster. The value of s_{tr} is the diameter of the smallest sphere which can enclose the cluster resulting from the merger of clusters t and r. The method is called complete linkage because all entities in a cluster are linked to each other at some maximum distance or minimum similarity.

Cluster analysis is performed separately, for both the bypass set and the control set. In both cases the choice set consists of 23 cities. The explanatory variables listed in Table 3.3 are utilized as variables for the clustering procedure, with the following additions:

(1) variables representing pre-bypass growth, and
(2) the economic region for each city (see Figure 3.7).

The cluster variables as input to the cluster procedure are summarized in Table 5.6.

Table 5.6 Variables used for cluster analysis

Variable
Population
Growth in Population
Income
Growth in Income
Distance to a Larger City
Total Incoming Traffic
Growth in Traffic
Economic Regions of Texas:
The Plains
East Texas
Border
Metroplex
Gulf Coast
Central Texas
Access Control

Cluster Analysis Results

Results from the cluster analyses for both groups (bypass and control cities) appear to be very similar. Three clear clusters emerge for both groups. The geographical variable is the most important clustering variable. The geographic locations of the three clusters obtained for the bypassed cities are shown in Figure 5.1. These clusters clearly represent the geographical regions of Texas. One cluster represents The Plains (or West Texas), which has a predominant agricultural economic base; another represents the oil and petroleum-based economic region of the Gulf Coast region; and the third cluster represents the Metroplex and Central Corridor economic regions, with high-tech and other manufacturing forming the basis of the economy, together with federal and state government and higher education. The East Texas and Border regions are represented by only one city each in the sample. The city of East Texas clusters with the Metroplex and Central Corridor group, while the border city stands on its own.

Inferences can be drawn about the effect of the bypass on a small city by comparing retail sales trends of bypassed and control cities. Both groups can be characterized by the retail sales trend for the pre-bypass period. The control cities were chosen on the basic premise of having the same retail sales trend for the period before the bypass was opened. The respective trends before bypass construction are therefore similar. The pre-bypass trend is extended for the post-bypass period to yield the projected trend. Actual data points for the post-bypass trend are then compared with the projected trend and the difference is determined. The differences for the two groups are summarized by informal descriptive statistics (see Andersen, et al, 1992, for a full account of the analysis). Comparisons are drawn between the bypass group and the control group as a whole. Also, corresponding clusters between the sets are compared. This analysis indicates that in all cases the differences for the bypassed groups are lower than the differences for the control groups, suggesting that the bypass has a small but negative effect on sales in a small city.

Cluster analysis provides some insight into the functioning of small cities. It appears that with the introduction of a bypass, no new phenomena are added that will change the characteristics of a city drastically. The similarity between the clustering of the bypassed and control groups suggests that the control cities were, in most cases, well chosen. Comparison between retail sales trends between similar clusters of the two sets suggests that a bypass has a slight negative impact on sales volumes. It appears that business performance is intrinsically tied to the area's particular economic base. This question was explored further by incorporating results from the cluster analysis into the previously described econometric models.

SUMMARY

The model development phase was described in this chapter. First, a comparison between the bypassed cities and the control cities showed no statistically significant differences between the two groups. Econometric models were then developed, relating total retail sales, gasoline sales, restaurant sales, and service receipts to the pertinent characteristics of the area. By using cluster analysis, cities in a rural setting in Texas were clustered according to the city-specific characteristics. The group of bypassed cities and the group of control cities clustered in a similar manner—indicating that the control cities were well chosen. Cluster analysis also highlighted the importance of the economic base of a city, as captured in the geographic regions. The econometric models that were developed do not contain explanatory variables that specifically refer to its geographic location. The next logical step is to include the geographic variables in the previous econometric models to enhance the quality of the models.

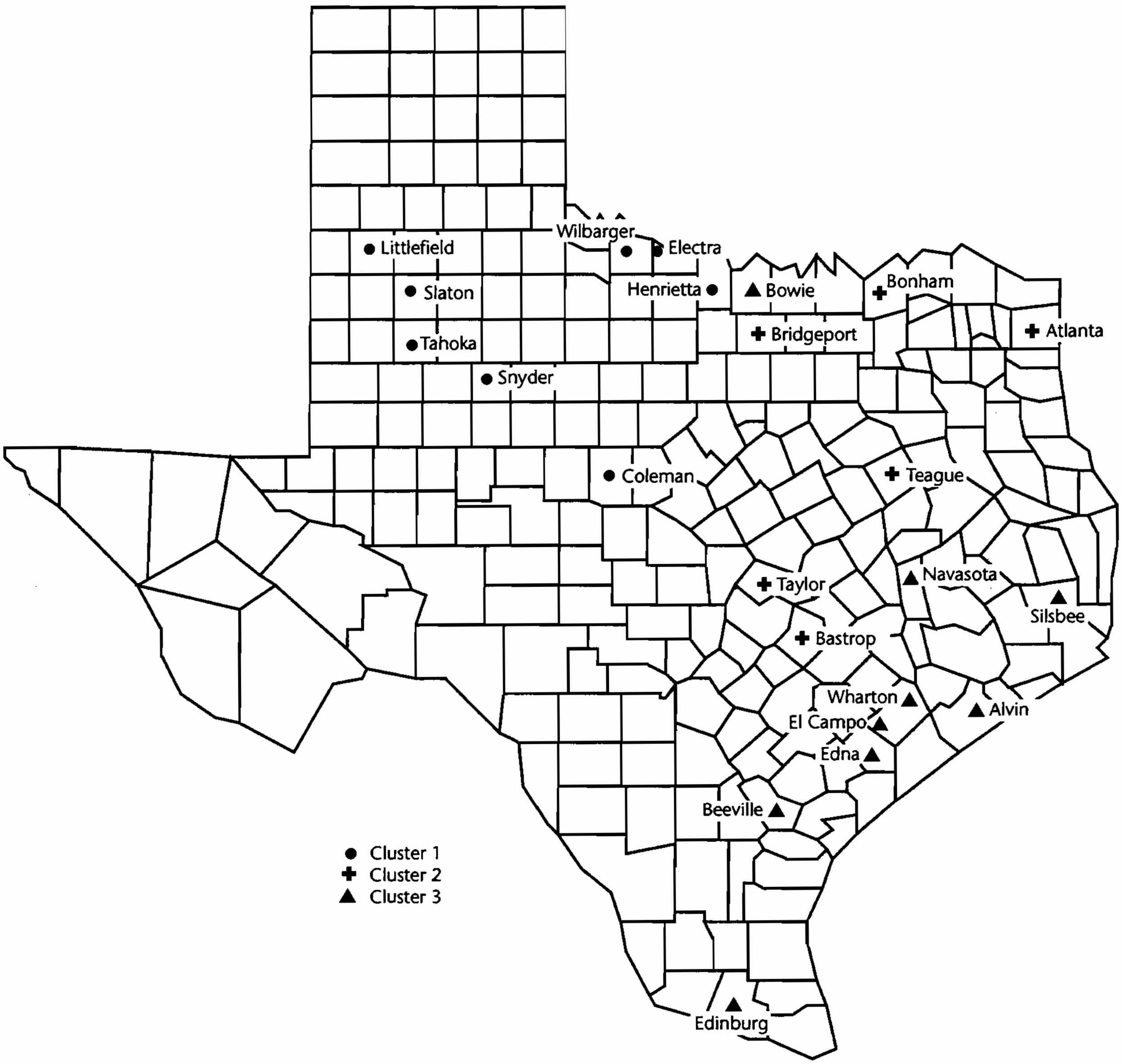

Figure 5.1 The geographic location of the clusters for the bypassed cities

CHAPTER 6. FINAL MODEL DEVELOPMENT

The final econometric models for the study are presented in this chapter, by combining results of the cluster analysis and econometric modeling from the previous chapter. The economic regions are introduced as explanatory variables in the final econometric models. By including these variables, instead of the city specific variables, the applicability of the econometric models becomes more general. This effort also shows the consistency between different approaches and ties together the results of the overall research effort.

FINAL MODELING PROCESS

The economic regions are introduced individually into the models as well as in subsets as suggested by the cluster analysis. These variables are binary indicator variables equal to 1, if a city falls in a specific region or group, and equal to 0 otherwise. Because the effect of an economic region is not necessarily additive, as location in a particular region may influence the effect of other factors on retail sales, various interaction variables are also introduced and tested, as discussed hereafter. All additional variables are defined in Table 6.1. Final regression models for the four business categories are compared with the initial models of Chapter 5 and presented in Table 6.2*a* and *b*. A brief discussion for each category follows.

Total Retail Sales

To test whether the type of access control on the bypass affected retail sales differently in the various economic regions, separate coefficients for the ACCESS variable were estimated for each economic region by including appropriate interaction terms in the specification. An F-test, with the restriction that all the coefficients of these interaction terms are equal, did not lead to rejection of the null hypothesis at the 5 percent level of significance. Similarly, interaction with different subsets of economic regions (corresponding to the clusters obtained earlier) did not support the existence of differential effects of the bypass across economic regions or groups. The coefficient for ACCESS is negative and statistically significant, suggesting that a bypass has a negative impact on retail sales in all regions.

POPULATION was also interacted with the geographic region, resulting in statistically significant

Table 6.1 Variables added to the data base

Explanatory Variables	Description
ACCREGION	interaction variable between ACCESS and any economic region (=1 if a city has limited access and falls within a specific geographic region; =0 otherwise)
POPGMC	interaction between POPULATION and the GULF, CENTRAL, and MPLEX-regions as a group (=POPULATION if city falls within any of these economic regions; 0 otherwise)
POPPLAINS	interaction between POPULATION and the PLAINS-region (=POPULATION, if city falls within PLAINS; 0 otherwise)
POPGC	interaction between POPULATION and the GULF and CENTRAL-regions as a group (=POPULATION if city falls within either of these two regions; 0 otherwise)
POPEAST	interaction between POPULATION and the EAST-region (=POPULATION if city falls within EAST; 0 otherwise)
ADTGC	interaction between ADTTOT and the GULF and CENTRAL-regions as a group (=ADTTOT if city falls within either of the two regions; 0 otherwise)

coefficients for POPPLAINS (a variable equal to the city's POPULATION if the city is in the PLAINS region, and equal to 0 otherwise) and POPGCM (similarly defined for the GULF, CENTRAL, and MPLEX regions taken as a group). This indicates that population size contributes differently to retail sales in different regions, possibly reflecting regional differences in purchasing power. The restriction that the parameters for POPPLAINS and POPGCM are equal was rejected, indicating that purchasing power in the PLAINS region appears to be significantly lower.

Note that the INCOME variable is not statistically significant, and thus is not included in the final model specification. This is likely due to the correlation between this variable and the regional variables, which capture varying income levels across the various regions.

By replacing the city-specific dummy variables with region-wide variables (without losing much explanatory power), the specification of the final model is conceptually improved and more generally applicable.

Gas Station Sales

An interactive effect between ADTTOT and the GULF and CENTRAL regions was captured in the interaction variable ADTGC. This variable is equal to the total ADT of the city if it resides in either the GULF or CENTRAL regions; it is equal to 0 otherwise. The statistically significant positive coefficient for this variable indicates the positive effect of daily traffic on gas station sales in these areas.

The bypass related variable, ADT-BYPASS, is statistically significant and negative, clearly indicating the negative effect of the bypass. When various restrictions were applied, no differential effect of this variable was observed across regions.

Restaurant Sales

Different behavior across geographic regions is also captured in the model for restaurant sales. Separate coefficients for POPULATION in the PLAINS region (POPPLAINS), and in the CENTRAL and GULF regions as a group (POPGC), were found to be significant. Several restrictions were applied to test various hypotheses regarding interaction with the geographic variable. The null hypothesis, that the parameters for POPULATION in the GULF region and POPULATION in the CENTRAL region are equal, was not rejected. As such, the restricted model containing the grouping of the two (POPGC) was obtained. On the other hand, the null hypothesis that the parameters for POPPLAINS and POPGC are equal was rejected, and both variables are retained in the final specification. The POPPLAINS variable is negative, showing that for the same population there is a lesser tendency to support restaurants in the Plains region.

Service Receipts

In estimating the model for service receipts, the geographic region played a less significant role than in previous models. Intuitively, this can be expected, since the number of services offered (and the corresponding number of service receipts) is probably more dependent on local characteristics than on regional characteristics. However, by interacting POPULATION with PLAINS (POPPLAINS), and also with EAST (POPEAST), some differential effects are observed. The significant positive contribution in the EAST region shows that more services are offered for a specific population when compared with services in other regions. This is probably due to the expansion, growth, and diversification of this region's economy. (*Texas Almanac 1990-1991.*) The significant negative interaction between POPULATION and PLAINS indicates that fewer services are offered in this predominantly agricultural region.

With this specification, the bypass-related variable is not significant. The only explanatory variable with a negative coefficient is POPPLAINS (apart from the effect captured in the intercept). This is an indication that bypass construction does not necessarily have a negative impact on service receipts; in this case the decreasing population in a mostly agricultural area appears to be the predominant negative factor.

Throughout the final modeling process, the importance of the geographic region is evident. The diversity and size of the State of Texas are thus better captured in these models. Also, in all the models, except the one for service receipts, the impact of the bypass remained statistically significant and negative. In all models, the city-specific dummy variables were replaced by variables related to the economic regions without any significant loss in explanatory power. As such, the final models are more general and improve the specification.

SUMMARY

In this chapter, the model development phase was concluded with the combination of results from cluster analysis and the econometric modeling process. It resulted in final econometric models that explain total retail sales, gasoline sales, restaurant sales, and service receipts as indicators of business activity. These models provide valuable insight into the evaluation of economic consequences of a highway bypass, by identifying the variables involved in the process. The models can now be applied as economic forecasting tools.

Table 6.2a Summary of the initial and final models

Variables	Total Retail Sales: Initial	Total Retail Sales: Final	Gas Station Sales: Initial	Gas Station Sales: Final
INTERCEPT	-14,495 (-5.99)	-8,437 (-4.613)	-4,390 (-5.74)	-4,632 (-5.947)
POPULATION	5.561 (22.84)	4.440 (17.665)	0.438 (15.05)	0.478 (22.470)
INCOME	0.576 (1.41)		0.205 (4.14)	0.229 (4.778)
ADT-TOTAL	1.305 (9.76)	1.349 (8.768)	0.054 (2.70)	
ADT-BYPASS			-0.131 (-2.98)	-0.67 (-1.822)
ACCESS	-12,402 (-4.91)	-15,760 (-5.50)		
YEAR'			4.596 (4.96)	4.656 (4.740)
HIGHWAYS			182 (2.37)	265 (3.427)
METRO-AREA				
LNPOP				
LNINCOME				
LNNEARBY				
LNADTTOT				
YEAR				
NEARBYCITY				
C6				
C118				
C119				
C22	31,470 (5.88)			
C23	-44,747 (-7.09)			
C101	15,186 (3.21)			
C13			2,344 (3.96)	
C112				
C113				
POPGMC		1.517 (6.161)		
POPPLAINS		1.227 (4.639)		
POPGC				
POPEAST				
ADTGC				0.036 (-1.822)
F	248	303	106	119
C.V.	23.2	26.1	34.4	34.9
Adjusted R^2	0.883	0.849	0.739	0.725
Durbin-Watson	1.167	0.918	1.407	1.394

Note: Every cell contains a corresponding estimated coefficient, with the t-statistic in parentheses

Table 6.2b Summary of the initial and final models

Variables	Restaurant Sales				Service Receipts			
	Initial		Final		Initial		Final	
INTERCEPT	-1,827	(-9.68)	-19,657	(-10.91)	-8.78	(-12.08)	-10.80	(-13.949)
POPULATION	0.336	(17.33)	0.355	(18.898)				
INCOME	0.062	(1.94)	0.151	(4.429)				
ADT-TOTAL	0.106	(8.57)	0.061	(5.101)				
ADT-BYPASS	-0.067	(-2.42)						
ACCESS			-439	(-2.246)	-0.116	(-1.54)		
YEAR'								
HIGHWAYS								
METRO-AREA	-296	(-1.77)	-575	(-3.649)				
LNPOP					1.022	(7.03)	1.191	(18.590)
LNINCOME					0.388	(4.35)	0.671	(6.213)
LNNEARBY					0.00303	(2.06)	0.003	(2.181)
LNADTTOT					0.315	(4.36)	0.154	(1.999)
YEAR					0.0243	(7.03)	0.019	(5.121)
NEARBYCITY								
C6					-0.671	(-4.34)		
C118					0.545	(3.55)		
C119					-0.870	(-5.08)		
C22								
C23	-1,704	(-3.54)						
C101								
C13								
C112	-1,022	(-2.75)						
C113	0.077	(4.51)						
POPGMC								
POPPLAINS			-0.040	(-1.885)			-0.014	(-1.915)
POPGC			1,745	(4.739)				
POPEAST							0.039	(3.265)
ADTGC								
F	193		226		215		228	
C.V.	37.1		36.7		4.1		4.5	
Adjusted R^2	0.855		0.855		0.881		0.855	
Durbin-Watson	1.060		1.035		1.248		1.165	

Note: Every cell contains a corresponding estimated coefficient, with the t-statistic in parentheses

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

This study concludes by presenting the final models of the study, which quantify the effects of a bypass and can be used as predictive tools. Conclusions drawn from the case study analysis and the modelling efforts described in the previous chapters are summarized. Finally, recommendations and thoughts on future research are discussed.

THE FINAL MODELS

The final model results of this study are summarized in Table 7.1. These models relate retail sales, restaurant sales, gasoline sales, and service receipts to the pertinent characteristics of bypassed cities.

CONCLUSIONS

The following conclusions are derived from the analyses made in this study:

(1) A highway bypass will be seen as a positive development by local citizens if the reduction in through traffic on major streets improves traffic flow and local access.
(2) A highway bypass may reduce business volumes in small cities in a rural setting. However, many other important local factors appear to affect business activities more significantly. Business communities will respond in various ways to a bypass, depending on the specific local characteristics.
(3) A combined cross-sectional and time-series data base can form the basis for the development of an econometric model that can predict total retail sales, gasoline station sales, restaurant sales, and service receipts.
(4) Cluster analysis highlighted the importance of the economic base of a city, as captured in the geographic regions. Also, inclusion of the regional cluster variables into the econometric models improved the specification of the models.
(5) A bypass changes activity patterns within a city. Traffic shifts away from the bypassed route. Increased traffic activity is found on the shortest connector from the bypass to the city center, resulting in increased development along this route.
(6) The various analyses indicate that a bypass may have a small, but negative, effect on the overall business activity of a small city in a rural setting.

RECOMMENDATIONS

The following recommendations complete the findings of this study:

(1) The econometric models developed for total retail sales, gasoline service station sales, and restaurant sales can be used as an economic forecasting tool. In the transportation planning process, these models should be useful in evaluating highway bypass alternatives.
(2) These econometric models contribute valuable economic insights to the study of highway bypass effects on a small city. These insights are critically important in evaluating the economic consequences of a highway bypass. For the community at large, these results can inform local citizens about the possible negative effects related to highway improvements, and can help the community develop strategies for economic positioning that could counteract the negative effects of the new highway facility.
(3) Future research should investigate the economic effects of highway bypasses on local businesses outside the sample of this study. Special attention should be given to very small cities with populations of 2,500 or less, which fell outside the scope of this study. Almost one-half of the non-interstate highway bypasses in Texas are near these cities.

Table 7.1 The Final models

Variables	Total Retail Sales	Gas Station Sales	Restaurant Sales	Service Receipts
INTERCEPT	-8,437 (-4.613)	-4,632 (-5.947)	-19,657 (-10.91)	-10.80 (-13.949)
POPULATION	4.440(17.665)	0.478(22.470)	0.355(18.898)	
INCOME		0.229 (4.778)	0.151 (4.429)	
ADT-TOTAL	1.349 (8.768)		0.061 (5.101)	
ADT-BYPASS		-0.67 (-1.822)		
ACCESS	-15,760 (-5.50)		-439 (-2.246)	
YEAR'		4.656 (4.740)		
HIGHWAYS		265 (3.427)		
METRO-AREA			-575 (-3.649)	
LNPOP				1.191 (18.590)
LNINCOME				0.671 (6.213)
LNNEARBY				0.003 (2.181)
LNADTTOT				0.154 (1.999)
YEAR				0.019 (5.121)
POPGMC	1.517 (6.161)			
POPPLAINS	1.227 (4.639)		-0.040 (-1.885)	-0.014 (-1.915)
POPGC			0.077 (4.739)	
POPEAST				0.039 (3.265)
ADTGC		0.036 (-1.822)		
F	303	119	226	228
C.V.	26.1	34.9	36.7	4.5
Adjusted R^2	0.849	0.725	0.855	0.855
Durbin-Watson	0.918	1.394	1.035	1.165

Note: Every cell contains a corresponding estimated coefficient, with the t-statistic in parentheses

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