Economic Impact of Highway Bypasses

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The economic effects of bypasses are addressed from several methodological perspectives. A data base for bypassed cities in the state of Texas was developed. A control city was chosen for each bypassed city in the sample to control for the effect of the bypass. Econometric models were developed to relate retail sales, gasoline sales, restaurant sales, and service receipts to the pertinent characteristics of the area. The models showed that a bypass generally brought a small, but statistically significant, decrease to business volumes in bypassed cities. Cluster analysis, a multivariate statistical procedure, was used to explore a possible grouping of cities that can help predict the economic impact of bypasses. Cluster analysis emphasized the importance of the economic base of a city, as captured in the geographic regions in which the city is located. Inclusion of the regional cluster variables in the econometric models improved the specification and predictive abilities of the models. Beyond formal analysis, individual case studies showed that local communities might not necessarily perceive bypasses as negative but as one of many factors contributing to the overall performance of a city in a rural setting.

Highway bypasses have long provided a practical approach to improving transportation levels of service through small cities in primarily rural settings by rerouting through traffic around such cities.

Road investment in highway bypass construction normally produces benefits for road users in the form of reduced journey times and vehicle operating costs and an improvement in safety. It reduces environmental nuisance from traffic to residents and pedestrians along the bypassed roads. In addition, highway transportation projects such as bypass construction normally produce local economic impacts of the following nature: (a) the creation of jobs and subsidy revenue from facility planning, construction, and operations; (b) the indirect impact of increased production because of reduced transportation costs and delays; and (c) the indirect impact of all of the above on nonusers because of the multiplier effect.

The construction of bypasses, however, has not always met with unanimous approval. Communities have feared that their economies would be adversely affected by the 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. In voicing their concern, communities have raised the following questions: Does the economy of the bypassed city suffer from these 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?

Several methodological perspectives are used in this paper to address the economic effects of bypasses. A case study analysis of several Texas cities provides insights that form a basis for more formal analyses with greater applicability. A data base is established, containing data on pertinent variables for both bypassed cities and control cities. Control cities are introduced 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.

BACKGROUND REVIEW

Historically, transportation has been a vital component in almost every aspect of economic development. The traditional view in the literature has been that the improvement of the 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 1970s and 1980s generally concludes that many other factors besides highway improvements come into play to affect regional growth (*1*). In well-integrated economic systems, the effects of transportation improvements are complex and difficult to predict.

Several highway bypass studies have explored the economic effects on small communities (*2–5*). These effects can take many forms, such as a drop or increase in retail sales, employment, or personal income. Highway bypasses have been reported to have seriously affected highway-oriented businesses (i.e., those providing fuel, food, and accommodations for travelers). To remain competitive, service stations and restaurants often have successfully adjusted their merchandise and their methods of operation to attract local trade. In a review of several Texas highway bypass studies, Skorpa et al. (*6*) found it difficult to draw a relationship between highway bypass construction and changes in local business volumes. In almost all cases, the non-traffic-oriented businesses had experienced increases in annual gross sales, whereas many traffic-serving businesses, such as service stations and motels, showed large decreases.

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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 centralization of trade and economic and social relationships has diminished the importance of many small towns (*7*). The ability of a community to retain its residents is largely dependent on its economic base (*8*). For instance, agricultural communities have experienced a nearly steady loss of population over the past two decades as a result of increased mechanization and a shift to corporate-owned farms.

It is evident that the effects of bypass construction are neither conclusive nor uniform across locations. Many factors influence the economy in a given area, severely complicating one's ability to establish simple cause-and-effect relationships and limiting the ability of any one methodological approach to uncover reliable results. Several methodological perspectives are often necessary to obtain robust results and form conclusions with a reasonable level of confidence. In this study, results from econometric modeling, cluster analysis, and exploratory data analysis are combined with the findings of more qualitative case studies to obtain insights into the economic effects of bypasses as well as into the factors likely to influence the direction and magnitude of these effects.

DEFINING THE SAMPLE

Highway bypasses in Texas were inventoried and categorized to identify those bypasses relevant to the study's objectives. Highway bypasses in Texas can be categorized according to highway characteristics, geographical location, population characteristics, and year of construction. The segment of a new highway intended to reroute through traffic around a central business district constitutes, for this study, the working definition of a bypass. A sample of 23 Texas cities, with bypasses conforming to this definition, was obtained (*9,10*). Interstate bypasses are excluded from this analysis, because 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 using other highways.

It was decided to compare changes in the economies of the bypassed city with the changes (over the same period) in selected control areas. A control city was selected for each bypassed city so that both cities would ideally share the following common characteristics: highway district, proximity to a larger city, economic base, magnitude and trend of retail sales, population size category and growth trend, and highway network characteristics.

DATA BASE

A data base was established by assembling data on pertinent variables for all cities to form the basis for further analysis. Distinction is made between dependent and explanatory variables.

Several measures were used as dependent variables intended to capture the changes in business activity. Typically, total retail sales is used as a short-term indicator reflecting the economic viability of a city. Service receipts are also used as a short-term indicator, representing a sector providing a variety of services for individuals, businesses, and government establishments. Also, it is expected that a bypass should specifically affect highway-oriented businesses. To this effect, data for gasoline sales, restaurant sales, and hotel/motel receipts are pertinent. However, data on hotel receipts were available only when there were more than three hotel/motel establishments in the city, which was rarely the case with this sample of small cities.

The explanatory variables in the data base reflect the demographic, geographic, economic, and highway characteristics of each city. Influential explanatory variables cited in earlier studies include the population of the bypassed city, the distance to a comparably sized city or a larger city, the distance between the old and the new routes, and the number of state and U.S. highways (*11*). Explanatory variables, together with the dependent variables, are given in Table 1.

Summary descriptive statistics were calculated for the variables in the data base to examine the overall similarity of bypassed and control cities (see Table 2). Several tests were performed (*9*), including tests of the differences in the means of the key variables between the bypassed cities and the control cities before the opening of the bypass. The differences between bypassed and control groups are minor and insignificant except for the variable ADT-TOTAL (average daily traffic on incoming highways). Higher traffic volumes in the bypassed cities were, presumably, one of the reasons to construct the bypass in the first place. Descriptive statistics confirmed the similarities of bypassed and control cities in the period preceding the opening of a bypass.

The pertinence of variables and their importance in establishing a relationship between highway bypasses and business activity are explored further in the rest of the paper by following several methodological approaches.

CASE STUDY METHODOLOGY

The case studies involve six cities in Texas (Navasota, Grapeland, Taylor, Alvord, Bowie, and Littlefield) with different population and economic characteristics. The study methodology included the following: a review of each city's history and economy; the tracking of changes in the spatial distribution of highway-oriented businesses in the city; and a site visit including interviews with local business people. The interviews focused on the following topics: economic viability of the city, effect of the bypass on businesses, adjustment to the bypass, opinions regarding the desirability of the bypass, downtown improvement programs, land use changes, and traffic characteristics. A full account of the case studies is presented by Helaakoski et al. (*9*) and Andersen et al. (*10*).

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

1. In general the bypass is not perceived by local residents to have had a devastating impact on any of the communities that were visited. The case studies do not suggest a strong

TABLE 1 Variables in the Data Base

Variable Name	Description
Dependent Variables	
SALES	Total Retail Sales within city, in 1987 dollars
GAS STATION SALES	Gas Station Sales within city, in 1987 dollars
RESTAURANT SALES	Restaurant Sales within city, in 1987 dollars
SERVICE RECEIPTS	Value of Services provided to city, in 1987 dollars
Explanatory Variables	
POPULATION	within city boundaries
DLARGER	distance in miles to a city of larger size
METRO-AREA	=1, if the city is located in a metropolitan area, otherwise 0
INCOME	average personal income per capita in the county in 1987 dollars
GROWTH1	the growth rate per capita of real GNP in the USA during the period between year t and t-1
GROWTH5	the growth rate per capita of real GNP in the USA during the period between year t and t-5
US	number of incoming US highways to the city
STATE	number of incoming state highways to the city
YEAR'[a]	overall trend in gas station sales
ADT-TOTAL	average daily traffic volumes on incoming highways
LENGTHOLD	length of the old bypassed route in miles
LENGTHNEW	length of the bypass in miles
DISTANCE	the average distance in miles between a bypass and a bypassed route
C1 through C24	city specific dummy variables for bypassed cities
C101 through C124	city specific dummy variables for control cities
CLASS	classification of the bypass (US highway=1, state =0)
ADT-BYPASS	Average daily traffic volumes on the bypass
ACCESS	access type for the bypass (=1, if a bypass has limited access and grade separation, otherwise 0)

[a] YEAR' = -3074 + 111.5*YEAR - 0.8283*(YEAR)^2

relationship between a bypass and economic growth. Other factors, such as fluctuation in the agriculture or oil business, continuing urbanization trends, and establishment of large discount stores within the market area, have a much stronger effect on local businesses.

2. Local business and political leaders can exert a strong influence on a local community and businesses and their evolution after bypass opening.

3. Spatial changes are often confined to increased activity toward and at the point at which another highway intersects the bypass. Few establishments were found at the split between the bypass and the bypassed route.

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

5. Downtown businesses have typically experienced a drop in sales after the opening of the bypass. However, this drop was in many cases temporary, as business owners restructured their stores or reoriented their businesses. Many gas stations have closed on the bypassed route, corresponding to general declining trends as a result of industry restructuring nationally.

The case study findings agree to a large extent with those from previous case studies (*5*) and others referenced by Helaakoski et al. (*9*) and Andersen et al. (*10*).

ECONOMETRIC MODELING

One of the purposes of this research is 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 the relative effects of various such determinants. Multivariate regression models are developed 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:

$$Y_{it} = bX_{it} + e_{it}$$

TABLE 2 Means, Standard Deviations, and Medians for Dependent and Key Explanatory Variables Before Bypass Was Opened

	BYPASSED CITIES			CONTROL CITIES		
Variables	Mean	Std Dev	Median	Mean	Std Dev	Median
Total Retail Sales / Person	6,783	2,165	6,249	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, all incoming highways	13,630	5,660	13,490	10,220	4,440	9,040

where

Y_{it} = measure of business activity (total retail sales, gas station sales, restaurant sales, or service receipts) for a city in year t;
X_{it} = vector of explanatory variables for city i in year t;
b = vector of parameters to be estimated; and
e_{it} = 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 and shown in Table 1. It may also include city-specific binary variables that capture city-related differences in culture, such as base of economy and geography, that change very slowly over time and that are not captured well by the other explanatory variables in the model. The vectors of parameters b were 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):

$$\begin{aligned}\text{SALES} = {} & -14{,}495 + 5.561\text{POPULATION} \\ & (-5.99) \qquad (22.84) \\ & + 0.576\text{INCOME} + 3{,}027\text{LARGERCITY} \\ & \quad (1.41) \qquad (1.81) \\ & + 1.305\text{ADT-TOTAL} - 12{,}402\text{ACCESS} \\ & \quad (9.76) \qquad (-4.91) \\ & + 31{,}470\text{C22} - 44{,}747\text{C23} + 15{,}186\text{C101} \\ & \quad (5.88) \qquad (-7.09) \qquad (3.21)\end{aligned}$$

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 may not entirely reflect buying power in a small city within the county.

The distance between a given city and the nearest city of equal or larger size (DLARGER in Table 1) 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 mi 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 LARGERCITY is a binary indicator variable equal to 1 if the distance to a larger city is 20 mi or more; 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 in which 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 in which 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 (*9*). Ten cities in the sample have bypasses with limited access.

To decrease autocorrelation and to control for intercity differences, the most significant dummy variables were included in the model. City-specific dummy variables C22 (Silsbee), C23 (Edinburg), and C101 (Clarksville) were found to be statistically significant. With these dummy variables, it was possible to determine part of the intercity differences not captured by other explanatory variables in the model.

Highway-Oriented Business

Gas Station Sales

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

$$\begin{aligned}\text{GAS STATION SALES} = {} & -4{,}390 + 4.596\text{YEAR}' \\ & (-5.74) \qquad (4.69) \\ & + 0.438\text{POPULATION} + 0.205\text{INCOME} \\ & \quad (15.05) \qquad (4.14) \\ & + 182\text{HIGHWAYS} + 0.0544\text{ADT-TOTAL} \\ & \quad (2.37) \qquad (2.70) \\ & - 0.131\text{ADT-BYPASS} + 2{,}344\text{C13} \\ & \quad (-2.98) \qquad (3.96)\end{aligned}$$

As expected, POPULATION and INCOME are 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.

An overall gas station sales trend (YEAR′) was included as an explanatory variable and proved to be statistically significant. It captures exogenous influences unrelated to bypass effects or other local factors. The trend was calibrated for the control cities to avoid contamination by bypass effects. For the cities studied, gas station sales reached a peak in the late 1960s. A reversal of the trend is caused mainly by more energy-efficient automobiles.

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 var-

iable indicates, in principle, that the more traffic that 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, on the basis of the mean values of the variables and the corresponding estimated coefficients, that a highway bypass causes on the average about a 15 percent decrease in gasoline station sales in a small city.

Restaurant Sales

The model for restaurant sales is as follows:

$$\begin{aligned}\text{RESTAURANT SALES} = {} & -1{,}827 + 0.366\text{POPULATION} \\ & (-9.68) \qquad (17.33) \\ & + 0.062\text{INCOME} - 296\text{METRO-AREA} \\ & \quad (1.94) \qquad (-1.77) \\ & + 0.016\text{ADT-TOTAL} - 0.0674\text{ADT-BYPASS} \\ & \quad (8.57) \qquad (-2.42) \\ & - 1{,}704\text{C23} - 1{,}022\text{C112} + 1{,}745\text{C113} \\ & \quad (-3.54) \qquad (-2.75) \qquad (4.51)\end{aligned}$$

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; 0 otherwise. Apparently, a greater variety of restaurants in a nearby large metropolitan area reduces sales in small cities for reasons similar to 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 the average with a 10 to 15 percent decrease in 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 hereafter.

$$\begin{aligned}\ln(\text{SERVICE RECEIPTS}) = {} & -8.78 + 0.0243\text{YEAR} \\ & (-12.08) \qquad (7.03) \\ & + 1.022\ln(\text{POPULATION}) + 0.388\ln(\text{INCOME}) \\ & \quad (15.99) \qquad (4.35) \\ & + 0.00303\ln(\text{NEARBYCITY}) \\ & \quad (2.26) \\ & + 4.36\ln(\text{ADT-TOTAL}) - 0.116\text{ACCESS} \\ & \quad (4.36) \qquad (-1.54) \\ & - 0.671\text{C6} + 0.545\text{C118} - 0.870\text{C119} \\ & \quad (-4.34) \qquad (3.55) \qquad (-5.08)\end{aligned}$$

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 mi, otherwise, it is set to the value of the variable DLARGER, 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 mi away. With longer distances, the positive effect still increases gradually. Furthermore, service receipts also apparently are a traffic-related phenomenon, as can be seen from the significance of the ADT-TOTAL variable. Also, 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 in which 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 (*9*). It was concluded that the negative effect of a highway bypass on total retail sales and highway-oriented sales has about the same significance for cities of less or more than 6,000 inhabitants. 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 (*9*).

CLUSTER ANALYSIS

Cluster analysis, a multivariate statistical procedure, involves the grouping of entities that are similar to one another. This problem 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 (*12*). 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.

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, 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 that 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 given in Table 1 are utilized as variables for the clustering procedure, with the following additions: (a) variables representing prebypass growth and (b) the economic region each city is located in. These regions are the Plains, Metroplex, East Texas, Gulf Coast, Central Corridor, and the Border (*13*). Their locations are shown in Figure 1. The cluster variables as input to the cluster procedure are summarized as follows: population, growth in population, income, growth in income, distance to a larger city, total incoming traffic, growth in traffic, economic regions of Texas (Plains, East Texas, Border, Metroplex, Gulf Coast, and Central Texas), and access control.

Cluster Analysis Results

Results from the cluster analyses for both groups (bypass and control groups) appear to be very similar. Three clear clusters emerge for both groups. The geographical variable is the most important clustering variable. 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; whereas 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, whereas 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 prebypass 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 prebypass trend is extended for the postbypass period to yield the projected trend. Actual data points for the postbypass trend are then compared with the projected trend,

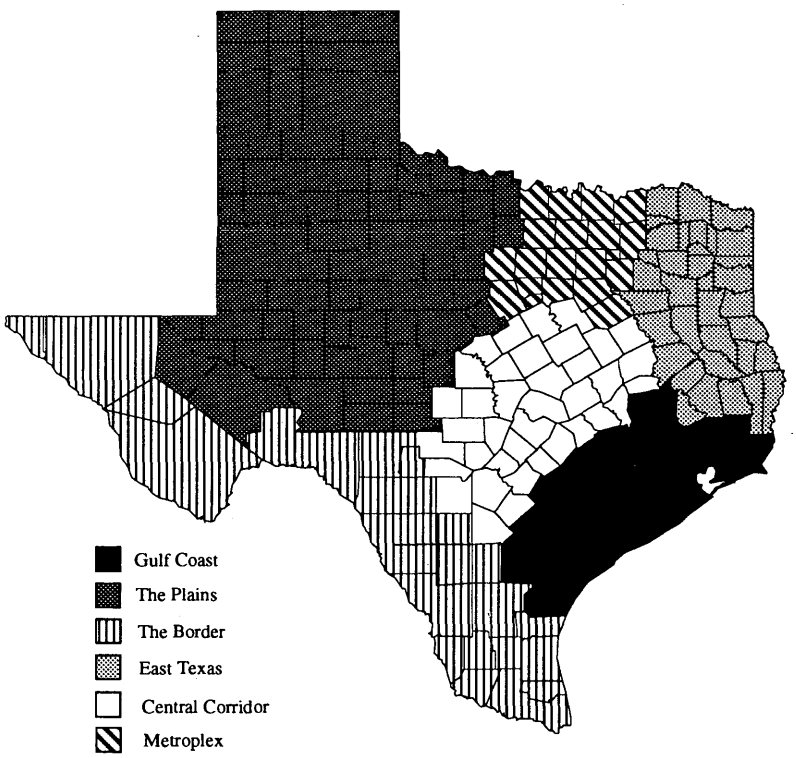

FIGURE 1 Economic regions of Texas.

and the difference is determined. The differences for the two groups are summarized by informal descriptive statistics [see Andersen et al. (*10*) 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 the sales volumes of a small city.

The cluster does not detect any new phenomena that might have been generated by the introduction of a bypass that will drastically change the characteristics of a city. The similarity between the clustering of the bypassed and control groups suggests that the control cities were, in most cases, well chosen. A comparison of 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.

FINAL MODEL DEVELOPMENT

Results of the cluster analysis and econometric modeling are now combined by introducing indicators for the economic regions as explanatory variables in the econometric model. 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 various approaches and ties together the results of the overall research effort.

The economic regions were 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; 0 otherwise. The effect of an economic region is not necessarily additive, because location in a particular region may influence the effect of other factors on retail sales, so various interaction variables were also introduced and tested, as discussed hereafter. All additional variables are defined in Table 3. Final regression models for the four business categories are compared with the initial models and presented in Table 4. A brief discussion of each category follows.

Total Retail Sales Model

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 of 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 various 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 coefficients for POPPLAINS (a variable equal to the city's POPULATION if the city is in the PLAINS region, 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 differences in purchasing power in the various regions. 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 because of 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 regionwide variables (without losing much explanatory power),

TABLE 3 Variables Added to Data Base

Variable Name	Description
Explanatory Variables	
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)

TABLE 4 Summary of Initial and Final Models

VARIABLES	TOTAL RETAIL SALES INITIAL	TOTAL RETAIL SALES FINAL	GAS STATION SALES INITIAL	GAS STATION SALES FINAL	RESTAURANT SALES INITIAL	RESTAURANT SALES FINAL	SERVICE RECEIPTS INITIAL	SERVICE RECEIPTS FINAL
INTERCEPT	-14495 (-5.99)	-8437 (-4.613)	-4390 (-5.74)	-4632 (-5.947)	-1827 (-9.68)	-19657 (-10.91)	-8.78 (-12.08)	-10.80 (-13.949)
POPULATION	5.561 (22.84)	4.440 (17.665)	0.438 (15.05)	0.478 (22.470)	0.336 (17.33)	0.355 (18.898)		
INCOME	0.576 (1.41)		0.205 (4.14)	0.229 (4.778)	0.062 (1.94)	0.151 (4.429)		
ADT-TOTAL	1.305 (9.76)	1.349 (8.768)	0.054 (2.70)		0.106 (8.57)	0.061 (5.101)		
ADT-BYPASS			-0.131 (-2.98)	-0..67 (-1.822)	-0.067 (-2.42)			
ACCESS	-12402 (-4.91)	-15760 (-5.50)				-439 (-2.246)	-0.116 (-1.54)	
YEAR'			4.596 (4.96)	4.656 (4.740)				
HIGHWAYS			182 (2.37)	265 (3.427)				
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	31470 (5.88)							
C23	-44747 (-7.09)				-1704 (-3.54)			
C101	15186 (3.21)							
C13			2344 (3.96)					
C112					-1022 (-2.75)			
C113					1745 (4.51)			
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	248	303	106	119	193	226	215	228
C.V.	23.2	26.1	34.4	34.9	37.1	36.7	4.1	4.5
Adjusted R^2	0.883	0.849	0.739	0.725	0.855	0.855	0.881	0.855
Durbin-Watson	1.167	0.918	1.407	1.394	1.060	1.035	1.248	1.165

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

the specification of the final model is conceptually improved and more generally applicable.

Highway-Oriented Business

Gas Station Sales

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

The bypass-related variable, ADT-BYPASS, is statistically significant and negative, clearly indicating the negative effect of the bypass. By applying various restrictions, 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 for the PLAINS region (POPPLAINS, as defined before), and for the CENTRAL and GULF regions as a group (POPGC, defined similarly for the CENTRAL and GULF regions as a group), were 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. 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 the other 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, defined similarly to POPPLAINS, but for the EAST region), some differential effects are observed. The significant positive contribution in the EAST region shows that more services are offered for a specific population compared with what is offered in other regions. This is probably because of the expansion, growth, and diversification of this region's economy (*12*). 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. The final models are thus more general and improve the specification.

CONCLUSIONS

The economic impact of highway bypasses on small cities in a rural setting is not uniform across cities and in most cases appears to be rather minor. The way in which a social and business community responds to a highway bypass is complex and involves the interaction of several factors. Several approaches were used in this study to address this issue.

Econometric models showed that a bypass generally brought a small, but statistically significant, decrease to business volumes in bypassed cities. These models were developed to relate total retail sales, gasoline service receipts, restaurant sales, and service receipts to the pertinent characteristics of the area. Cluster analysis highlighted the importance of the economic base of a city, as captured in the geographic regions. Cities in rural settings in Texas were clustered according to their characteristics, resulting in similar clusters for both the bypassed and the control cities. Inclusion of the regional cluster variables into the econometric models improved the specification of the models.

Beyond the formal models, individual case studies show that local communities might not necessarily perceive bypasses as negative. Rather, the construction of a bypass is seen as one of many factors contributing to the overall economic performance of a city in a rural setting. The initial decreases in certain types of sales were often counteracted by reorientation of local stores. Political and business leadership in a given area seems to play an important role in the evolution of the city after bypass opening.

ACKNOWLEDGMENT

Financial support for this study was provided by the Texas Department of Transportation.

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The views and findings expressed and described in this paper are the authors' and do not necessarily reflect those of the Texas Department of Transportation or the Center for Transportation Research at the University of Texas.

Publication of this paper sponsored by Committee on Social and Economic Factors of Transportation.