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16. Abstract

This study investigates the determinants of total highway construction and maintenance expenditures in the state of Texas, and how these expenditures on transportation infrastructure affect the personal income and employment levels. Pooled time series and cross-sectional time series linear regression models were used to measure economic and political relationships to highway expenditures. Research results indicate that there is a positive relationship between total employment, personal income, expenditures on transportation, and expenditures on transportation lagged. The length of the lags vary among the economic sectors and major industries of the state. There is a difference between the highway districts as to the amount of effect transportation expenditures have on employment and income. The political influences as defined in this study were not significant in determining the level of public funds spent on highway infrastructure.

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ECONOMIC EFFECTS OF TRANSPORTATION EXPENDITURES ON EMPLOYMENT AND INCOME LEVELS WITHIN HIGHWAY DISTRICTS

by

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Research Report 1106-4F
Research Study Number 2-10-87-1106
"Impact of Highway Construction Expenditures on Economic Growth, Tourism, Planning Policies and Transportation"

Sponsored by

Texas State Department of Highways
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Federal Highway Administration

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Texas Transportation Institute
The Texas A&M University System

College Station, Texas

METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

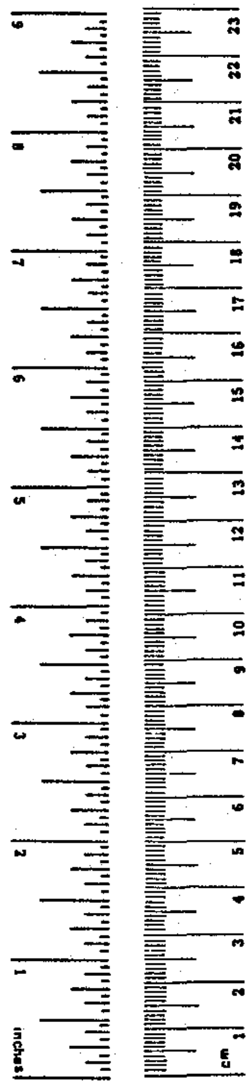
Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
	AREA			
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.0929	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
mi^2	square miles	2.59	kilometres 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 (2000 lb)	0.907	megagrams	Mg
	VOLUME			
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

TEMPERATURE (exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* SI is the symbol for the International System of Measurements

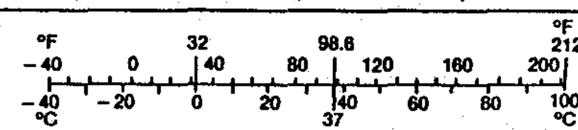


APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
	AREA			
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
km^2	kilometres squared	0.39	square miles	mi^2
ha	hectores (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	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres 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.

PROJECT SUMMARY

Previous research studies have shown significant linkages between economic development and transportation expenditures. The need for an understanding of the timing and strengths of these linkages has recently become more pronounced. As the various economic sectors of the country, including the economic and geographic sectors in the state of Texas, rebound from the severe recession in the agriculture and mining sector, various agencies and political bodies have become more vocal in advocating a move towards so-called economic diversification. The effect transportation expenditures have on a specific area is becoming increasingly interesting to governmental and administrative bodies, as are all public expenditure programs. In the future, agencies are also going to need to justify their budgets in an economic development and diversification context more so than they have been required to do in the past.

Improvements in understanding the determinants of highway expenditures should enhance the capacity of highway planning, economic development, tourism, planning policies, and transportation in the state of Texas. Texas' ability to maintain its existing network of roads in good condition and to increase capacity in time to prevent bottlenecks are important to all highway users, as well as to ensure strong economic growth.

The purpose of this study was to investigate the determinants of total highway expenditures in the State of Texas and how these expenditures on transportation infrastructure affect the state's economy; therefore, both economic and political variables were used in the analysis. Certainly, there is controversy about the influence and/or the amount of influence that political variables play in determining public policy. Highway policy is too important to the continued economic development of Texas for this area of public policy to be ignored in this analysis. To simply dismiss pluralist politics as not important could result in leaving out essential variables that determine highway policy in Texas.

A series of linear regression models were used to test the structural relationships developed in the analysis. Analysis of the data was done using both pooled cross-sectional time series procedures, and pooled time series techniques. Research results indicate that

there is a positive relationship between total employment and expenditures on transportation. This impact is felt over several years, as indicated by the significance of the lagged variables. The length of the influence defers among the economic sectors and industries of the state. There is also a difference between the highway districts as to the amount of effect that expenditures on transportation have on employment and income. The political variables as defined in this study were not significant in determining the level of public state funds spent on highway construction and maintenance.

IMPLEMENTATION

The following recommendations are offered for consideration by the SDHPT regarding implementation of the findings of this study.

1. In funding decisions regarding mutually exclusive projects, the impacts on employment should be estimated and considered for inclusion into project ranking, rating, and assessment techniques.

2. The differential effects on employment across industries can be estimated and included in strategic planning and policy formation regarding statewide economic diversification.

3. Future research should be initiated to further investigate the impacts of highway policy and transportation expenditure decisions on the economic climate of the districts. Both inter- and intradistrict comparisons by industry could prove enlightening.

ACKNOWLEDGEMENTS

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DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Texas State Department of Highways and Public Transportation or of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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INTRODUCTION

Problem Statement

Transportation investment has long been an important factor contributing to the economic infrastructure base of Texas. The State Department of Highways and Public Transportation's (SDHPT) expenditures for construction, maintenance, and rehabilitation of the transportation network create direct, secondary, and tertiary benefits to the state. The relationships between these benefits and transportation expenditures, and the variables that determine the level of public expenditure on transportation facilities need to be examined.

Study Background

Expenditures for public highways support the third largest function of state and local governments; expenditures for education and welfare are first and second. Texas has over 72,000 miles of highways, including 3200 miles of interstate highways, over 27,000 miles of primary (U.S. or state-numbered) roads, about 41,000 miles of secondary (farm-to-market) roads, over 100 miles of recreational roads, and about 20,000 bridges [1]. Highway policy outcomes are of interest to diverse groups. These groups range from the automotive and construction industry to the agriculture industry, real estate investors, municipal and regional transportation planners, tourism industry, large and small businesses, and almost anyone who utilizes the state's highways.

Policy outcomes express the value allocations of a society, and these allocations are the chief output of the society's political system [2]. As stated above, this study investigate's the determinants of total highway expenditures in the State of Texas and how these expenditures on transportation infrastructure affect the state's economy. An understanding of these relationships will be of value to highway policy makers as they act to meet the simultaneous goals of the different state agencies.

Policy makers are faced with difficult choices to provide adequate transportation facilities, fund education and other competing state programs, and increase economic activity, all within the bounds of a limited budget and limited resources. As some sectors within the state economy grow, and as others decline, policy makers are faced with the difficult task of being able to target programs that are not only geographically specific, but economically specific as well.

This difficult task involves governmental decisions affecting the use of public resources. Noted political theorist Thomas R. Dye states, "public policy regulates conflict within societies; distributes a great variety of symbolic awards and material services to members of the society; and extracts money from society, most often in the form of taxes" [3]. While Davis and Frederick define public policy as "a plan of action undertaken by government to achieve some broad purpose affecting a large segment of the citizenry" [4].

Texas' ability to maintain its existing network of roads in good condition and to increase capacity in time to prevent bottlenecks is important to all highway users and ensures strong economic growth. A recent Federal Highway Administration study shows that merely halting deterioration in the nation's highway network would improve economic growth for the economy as a whole, with national income 3.2 percent higher by 1995, employment 2.2 percent higher, and inflation 8 percent lower than if road conditions were allowed to continue to deteriorate, as in the late 1970's [5].

Another important aspect of public policy is an understanding of its formation. Scholars of public policy are not harmonious concerning whether socioeconomic variables, political variables, or both determine public policy. Dye and Gray provide a premise for policy analysts to consider before commencing investigations into public policy [6]. Policy analysts, they posit, must be willing to look at several disciplines to find determinants of public policy by putting good theory first and must be willing to accept ideals and theories from other academic disciplines.

Since the purpose of this study is to investigate the determinants of total highway expenditures in Texas and how these expenditures on transportation infrastructure affect the state's economy, both economic and political variables will be used in this analysis. There is a great deal of conflict as to the influence and/or the amount of influence that political variables play in determining public policy. Highway policy is too important to the continued economic development of Texas for this area of public policy not to be included in this analysis. To simply dismiss pluralist politics as not important could result in leaving out essential variables that determine highway policy in Texas.

Fundamentally pluralist politics indirectly affect SDHPT policy decisions in the following manner. The SDHPT is in charge of highway construction and maintenance in Texas; however, a three-member commission appointed by the governor with the concurrence of the Senate oversees the SDHPT.

Study Objective

The general objective of this study is to improve the understanding of how economic and political determinants of highway policy can enhance the effectiveness of highway planning, promote economic development, and improve transportation policy in Texas.

Study Approach

Political and economic variables may affect total highway expenditures in the state of Texas in one or more of the following manners:

(1) Political Competition, Party Affiliation, and Participation may influence the level of highway expenditures.

(2) Membership of the Texas House of Representatives Committee may influence the level of highway expenditures.

(3) Employment, income, and the price of oil may influence the level of highway expenditures.

(4) The amount of expenditures on transportation may impact the income and employment level of the citizens.

The economic variables that will be used in this study are per capita personal income in a highway district, total employment, and employment by economic sector within a highway district. Also, expenditures on transportation construction and maintenance, and the average price for crude oil for each year in the period 1969-1986 are included.

The political variables used are voter participation, partisanship, intra-party competition, and representation on the House of Representatives Committee on Transportation. The first three political variables are the same variables that Dye used in his study of highway policy in the American states in the early 1960's [2]. The fourth political variable, membership on the Texas House Committee on Transportation, is included here to determine the effect of committee members, if any, on highway expenditures in those districts they represented. The data was collected on a county basis where available and then aggregated into highway district aggregates. Figure 1 is a map showing the geographical location of the highway districts in the state of Texas and the counties they include.

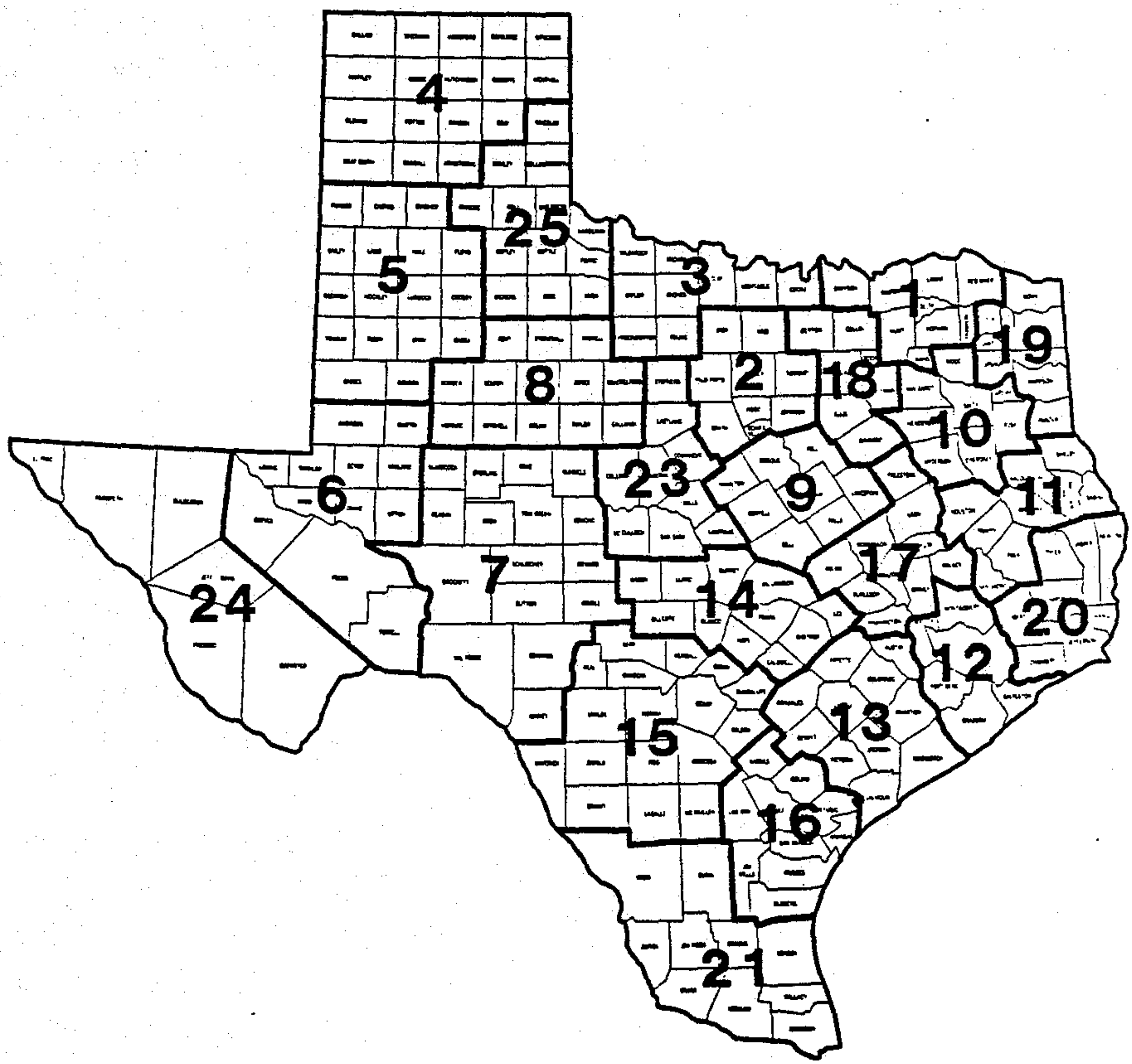

Figure 1. Texas Highway Districts and Counties.

LITERATURE REVIEW

Previous research has shown significant linkages between economic development and transportation expenditures [7,8,9,10]. The need for an understanding of the timing and strengths of these linkages has recently become more pronounced. As the various economic sectors of the country, including the economic and geographic sectors in the state of Texas, rebound from the severe recession in the agriculture and mining sector, various agencies and political bodies have become more vocal in advocating a move towards so-called economic diversification [11]. Understanding and documenting the effects transportation expenditures have on a specific area are increasingly important to governmental and administrative bodies, as are all public expenditure programs [10]. In the future, agencies are also going to need to justify their budgets in an economic development and diversification context more so than they have been required to do in the past.

Expansion of economic activity is a leading priority of state governments [11]. As a means of promoting and sustaining economic development activity, state governments are increasing their levels of support for various growth strategies, including, for example, casino bus transportation to Atlantic City [12] as well as promotion of market expansion through manufacturing export promotion [13]. There has been practically no statistical analysis of the effects of state expenditures promoting manufacturing exports to other states and countries. Furthermore, the funding of these growth and diversification strategies and the funding of their transportation requirements, needs to be analyzed in an economic as well as a political framework [14].

Several states have passed legislation creating enterprise development areas or zones [15]. The enterprise zone concept is founded on the belief that the formation of new business activity that will create employment opportunities can be fostered through incentives and innovative projects. However, very little is known about the factors that influence where new business location will occur and how much employment will be generated.

Location theory has been used in various studies to examine the relationship between transportation costs and level of service and regional economic development [16]. This was done in an attempt to determine whether public transportation infrastructure and freight subsidies can be expected to stimulate industrial development in a region.

Carlton simultaneously modeled both the location and employment choice of new branch plants [17]. He found energy costs and existing concentrations of employment to have a surprisingly large effect on plant location decisions, whereas taxes and state incentive programs do not seem to have major effects. For highly sophisticated industries, the available technical expertise, specialized resources such as labor skills and education, and factors that help attract and maintain a skilled labor force such as state and local taxes are important [18]. Less technical industries are influenced more by the traditional location factors of market access and transportation. Population migration and growth are affected by the economic employment climate of the state. For employment, differences in county growth are most often determined by the economic and demographic conditions [19].

The Federal Highway Administration issued administrative criteria for the selection of economic growth areas as they relate to transportation facilities and needs [20]. The effects of highway improvements on development pass through three different stages. In the first, it is not developed to a level at which it is capable of encouraging regional development. In the second stage, it acts as a vehicle for development, and in the third stage, it becomes an agent for personal mobility [21]. That is, as the highway network becomes saturated, it exhibits less of a developmental effect and begins to act as an agent to increase personal mobility.

Economic development is also increasingly being used by state departments of transportation as a criterion and justification for highway funding decisions. Past studies of the interactions between highway expenditures and economic development have provided little evidence supporting this funding justification criterion [16,22]. However, it has been found in recent econometric studies that highway expenditures lead to temporary increases in employment during the construction stage [23,24,25].

The determinants of general economic growth have been modeled in a whole menu of theories [26,27]. The project and/or regionally specific models are of more practical use to the highway department personnel [28]. There is a need however for further research at the project, district, and state level in all areas of transportation management, administration and policy planning [29].

The published literature also offers many diverse theories, models, and conclusions on the determinants of public policy. There are few published articles that include both economic and political variables in determining highway policy outputs; however, many of the findings of public policy studies presented in the published literature include highway policy outputs as one of the policy variables.

Presumably, the decision process of the public policy makers should be based on rational procedures. However, often when complex problems arise that government or governmental departments are to solve, the decision process becomes less than rational [30]. There is disagreement on many critical values and objectives; citizens disagree, congressmen (legislators) disagree, and public administrators disagree because of different values and mores [31]. Conflict among individuals, groups, and departments leads to what Lindblom describes the "muddling through" process [30]. The concept of muddling through is based on the premise that conflicting values of what is good policy will not allow for a rational and comprehensive decision-making process. Thus changes in governmental decision making will therefore be incremental.

The relationship between economics, politics, and public policy is complex. In 1963 Dawson and Robinson found that interparty competition correlates with the activity within the system (process). Further they found that socioeconomic factors and process variables, in turn, are statistically related to socioeconomic conditions [32]. However, when per capita income is controlled, there is no relationship between the process variables and interparty competition. Their findings left questions as to the relationship between socioeconomic factors and policy because both were so highly correlated with interparty competition.

In 1970 Fry and Winters asked the question, "Does politics make a difference in the policy formation process in the American state" [33]? They included both economic and political variables in their study. They found that economic and political variables were able to explain 55 percent of the variance in fiscal redistributive policies in the 48 continuous states. Thirty-eight percent of the total variance was attributable to political variables, while socioeconomic variables explained 17 percent of the total variance. However, the authors recognized that their study did not utilize any longitudinal analysis which may have an impact on the outcome of their findings.

Sharkansky and Hofferbert, in 1969, also inquired into the determinants of public policy in the American states [34]. They found that there is a relationship among political, economic, and policy factors. Welfare and education policies are significantly dependent upon political competition and voter participation and affluence of the state's economy. A wealthy state that has a high level of political competition and voter participation is likely to spend more on welfare and education. Although Sharkansky and Hofferbert admit that their research was not able to determine if political variables or socioeconomic variables are more important in the determination of public policy in the American state, they are able to show the multidimensionality in state economics, politics, and public policy.

Focusing more closely on the impacts of economic and political variables on highway policy, Salisbury and Heinz argue that "political system variables of the kind to have little impact on the amount of expenditures may still have a significant effect on the kind or the distribution of the amount" [35]. That is, political variables do not determine the amount spent, but have important implications for the "rules of structure of authority" that will guide allocations. Economics will determine the amount dispensed, but political actors will respond to pressure that is applied in structuring the redistribution process. Policy outcome then is determined by the interactions of "pattern of demand" and the "decisional structure." The authors present an excellent example of Lowi's distributive topology [36] in the highway decision-making process.

Lowi's distributive topology is one where there are no perceived losers [36]. These policies have the perception that no individual or group is gaining at the expense of another group. He puts the true "pork barrel" type policies in this group, although not all distributive policies are pork barrel. On the other hand, Lowi's redistributive topology is where there are gainers and losers. These policies are welfare in nature and Lowi believes that in the long run all policies become redistributive.

Public policy outputs that fit the distributive policy arena occur when a highly fragmented demand pattern, such as counties within states, interact with a fragmented decisional system, such as a state legislature. Again the political actors do not determine the amount of money available, but they do determine the "rules" by which it will be reallocated. For example, expenditures allocated for highways and roads can be disaggregated and dispensed in each county according to the rules and structures that the political actors (patronage or merit) are tied. Each individual county's request for expenditures for roads is independent of the amount that other counties may request [35].

In 1980 Dye examined the differences in taxing and spending among the American states and their impact on economic growth and development [37]. He investigated why the rates of growth for some state economies are larger than rates of growth for other state economies. Dye specifically asked, "What public policies of the states are likely to be influential determinants of variation in growth in income, employment, and productivity in the 1970's?" Dye developed a time lagged taxing and spending model, since taxing and spending are two areas which can be manipulated by (elected) decisionmakers. He examined the period between 1967-1970 for taxing and spending policies and its lagged effect on economic development in the period between 1972-1976.

Dye found that there was little association between taxing policies and economic growth. However, the spending policies of a state were strongly correlated to economic development in a state. The strongest relationship was between highway spending and economic development. Spending in the late 1960's correlated with economic development in the early and mid 1970's. He concludes that the data suggest investment in all areas of a state's infrastructure--highways, energy, water, mass transit, etc.,--promotes economic development. Tax incentives did not have a significant impact in the development of a state's economy [37].

Forkenbrock and Plazak found that the impact highways would have on economic development played a significant role in highway planning [38]. Economic development is becoming a major goal of highway planning in most states. Many states have created programs designed to find the economic impact of highway development. For example, Iowa's RISE program (Revitalize Iowa's Sound Economy), administered by the Iowa DOT, investigates the impact that highway construction and maintenance expenditures will have on economic development. In the current time of fiscal austerity, taxpayers are demanding the most effectiveness of publicly financed programs, including highway construction and maintenance expenditures.

Altshuler stated in 1977: "Nearly 90 percent of urban transportation spending is for goods and services produced in the private sector" [39]. That means only 10 percent of spending for transportation is for services provided by the government. He found the public to be fickle in what they expect government to do about transportation problems. On one hand, they collectively have signaled for urban governments to create mass transit, but on the other hand, refuse to use it. Altshuler also states, "American (all levels) governments can spend great sums to provide 'carrots,' even when they appear to be relatively ineffective" [39]. Restated, Americans do not want to be bothered using public transportation, but they expect the governments to make it available.

METHODOLOGY

Data

The data consist of annual observations for the 254 counties of Texas covering a time period from 1969 through 1986. The political variables include participation, partisanship, competition, and membership on the Texas House Committee on Transportation. The political variables are measured in the following manner:

1. Participation - the percentage of registered voters that participated in the gubernatorial election (1966-1982);
2. Partisanship - the percentage of voters voting Democrat (1966-1982);
3. Competition - the percentage difference between the winner and loser in the general election for governor (1966-1982); or the lower the percentage, the higher the competition;
4. Membership - the number of legislative representatives from the counties within a given highway district that hold membership on the Texas House Transportation Committee.

Although this study examines a period from 1969-1986, the gubernatorial election in 1966 was included so that data is available for 1969 and 1970. The results of a gubernatorial election are held constant for four years or until the next gubernatorial election. The Texas Almanac was the source of the data for the first three political variables [40].

The fourth political variable, membership, is a variable that will be used to investigate variation in highway expenditures according to membership on the Texas House Transportation Committee. The data for this variable is collected every biennium. Before 1973, the Texas House Committee on Transportation did not exist, thus for the years 1969-1972, membership is measured according to membership on the Texas House Committee on Common Carriers and the Texas House Committee on Highways and Roads [41].

The data for the economic variables are personal income and employment values as collected by the U.S Department of Commerce by major industry, expenditures for transportation (maintenance and construction), and crude oil prices [42]. Oil prices were used as a surrogate variable to measure the general health of the Texas state economy.

Because the oil industry in Texas is a dominate industry, general economic conditions could be measured from it. A major source of state revenue is from the oil industry and its related businesses.

To exclude the effects of inflation, the nominal dollar values were deflated into real dollars using the GNP implicit price deflators (1982=100) in the Economic Report of the President [43]. Table 1 is a listing of the components of the employment and personal income data categories by major industry.

Table 1. Personal Income by Major Source and Earnings by Major Industry; and Full-Time and Part-Time Employment by Major Industry.

COMPONENT TITLE
TOTAL PERSONAL INCOME
NONFARM PERSONAL INCOME
FARM INCOME
POPULATION (THOUSANDS)
PER CAPITA PERSONAL INCOME (DOLLARS) AND TOTAL EMPLOYMENT
FARM
NON-FARM
PRIVATE
AG. SERV., FOR., FISH., AND OTHER
MINING
CONSTRUCTION
MANUFACTURING
TRANSPORTATION AND PUBLIC UTILITIES
WHOLESALE TRADE
RETAIL TRADE
FINANCE, INSURANCE, AND REAL ESTATE
SERVICES
GOVERNMENT AND GOVERNMENT ENTERPRISES
FEDERAL, CIVILIAN
MILITARY
STATE AND LOCAL

For use in the statistical analysis for highway districts, the individual county employment data and the total personal income data are aggregated annually within each highway district. The transportation expenditure data is likewise aggregated. However, for the per capita personal income data, and the price of crude oil, the mean values (calculated from the counties within each district) are used.

The annual price for crude oil used in this study are those reported in the Texas

Railroad Commission Report [42]. The highway construction and maintenance expenditures are those reported by the Texas State Department of Highways and Public Transportation in their biennial reports.

Statistical Analysis

The study objectives outlined above were fashioned into three basic structural models as follows:

1. Total Employment = f(transportation expenditures both current and lagged, oil prices both current and lagged, and per capita personal income).
2. Per Capital Personal Income = f(transportation expenditures both current and lagged, oil prices both current and lagged, and total employment).
3. Transportation Expenditures = f(political variables, oil prices both current and lagged, per capita personal income and total employment).

A series of linear regression models were used to test the above structural relationships. These regression models were of two types: (1) time series models using dummy variables to pool the data, and, (2) cross-sectional time series models with dummy variables. Pooled data provides more observations than nonpooled cross-sectional or time series alone, and thus increases the degrees of freedom available in the analysis [23,44]. By pooling the data, we were able to use more lagged terms as variables than otherwise would have been possible with only 18 annual observations.

Pooling refers to the process of combining data. When time series data is pooled using dummy variables it is assumed that the cross-sectional parameters are constant over time. This assumption means that the cross-sectional differences between the districts have stayed the same during the study years. When the cross-sectional parameters shift over time, it is appropriate to pool with both cross-sectional and time series explanatory variables. However, when this procedure is followed, the structure of the error term in the regression equation becomes more complex. The complexity arises because the error term consists of time series related disturbances, cross-sectional disturbances, and a combination of both error components [45]. There are different techniques available to pool the data, and the one used reflects the assumptions made about the structure and components of the error or disturbance term [46].

There are 24 highway districts in Texas, districts 1-21 and districts 23-25. District 22, which no longer exists, was integrated into districts 7 and 15. Twenty three dummy variables were used to pool the data in the time series models and to measure the differences between highway districts within each model. There is one less dummy variable than there are districts allowing the dummy variable coefficients in the regression analysis to be interpreted with respect to the omitted district. In this study, district 1 was the omitted district and is the one from which the difference in the other districts is based.

Aggregating the data within each district and pooling the data using dummy variables made it possible to make interdistrict comparisons of the effects of the independent variables on the dependent variables. It was assumed that district aggregates would give a more realistic representation of the actual relationships between economic activity, expenditures on transportation, and the political process. Intuitively, the effects of the independent variables on the dependent variable are felt over a wider range than just within the immediate county. Aggregating within districts had the effect of capturing these inter county relationships within districts. For example, this assumption means that when a highway is constructed, the economic benefits of this expenditure are felt in the surrounding geographic area and not only in those counties that it intersects. That is, the economic effects are felt in a more general area than just in the immediate counties. Intradistrict comparisons between counties were not attempted as part of this study.

The particular pooled cross-sectional time series procedure used is the TSCSREG procedure available in the Statistical Analysis System (SAS) computer program [47]. PROC TSCSREG allows use of three different methods to model the statistical characteristics of the error components in a pooled cross-sectional time series regression model. The three methods are the Parks, Da Silva, and Fuller and Battese model approaches.

The Parks method is a first-order autoregressive error structure model that assumes contemporaneous correlation between cross-sections and is solved using a two-stage generalized least squares procedure. The Da Silva method is a mixed variance component moving average error process used to estimate a suitable estimator to replace the unknown covariance matrix. The regression parameters are estimated using a two-stage generalized least squares procedure. The Fuller and Battese method was selected for use in this analysis and assumes a "variance component model error structure similar to the common two-way random effects model with covariates" [48]. The variance components are estimated by the "fitting of constants" method, rather than by creating dummy variables, and estimates of the regression parameters are made using generalized least squares. Dummy variables are then used to test the differences between districts. Another reason for selecting the Fuller and Battese method is that the computer core storage needed in performing the analysis is smaller than for the Parks and for the Da Silva methods.

Dummy variables are used in the economic analysis to measure the differences in effects between highway districts. The null hypothesis (Ho: B=0) tested is that the effect of the independent variables on the dependent variable is not different between districts. By pooling the data for all districts with dummy variables we can isolate the differences between districts. The dummy variables whose t-statistics from the regression analysis are significant, are the ones for which we can reject the null hypothesis that there is no difference and conclude that there is a difference. The amount of difference is measured by adding the coefficient for the dummy variable to the intercept term in the regression equation.

Statistical Results

Using the two pooled procedures discussed above, two equations for estimating total employment were developed, as outlined in the first structural relationship where:

Total Employment = f(transportation expenditures both current and lagged, oil prices both current and lagged, and per capita personal income).

. Equation (1) was developed using ordinary least squares (OLS) time series regression, and equation (2) was developed using the previously discussed PROC TSCSREG cross-sectional time series procedure. These two equations are:

$$\begin{aligned}(1)\quad \text{TOTES} = & -337926.49\\ & + 0.1452\ \text{RTES}\\ & + 0.1058\ \text{RTE2S}\\ & + 0.0909\ \text{RTE4S}\\ & + 3797.81\ \text{RPCPIM}\end{aligned}$$

and,

$$
(2) \quad TOTES = -11645.0 + 0.0241\ RTES + 0.0674\ RTE2S + 0.0324\ RTE4S + 3921.96\ RPCPIM
$$

where the variables are defined as:

TOTES	= total employment
RTES	= real transportation expenditures
RTE2S	= real transportation expenditures lagged two years
RTE4S	= real transportation expenditures lagged four years
RPCPIM	= real per capita personal income

It is apparent from these two equations that the estimates of the effects of transportation expenditures, oil prices, and per capita income on total employment using time series techniques are similar to those estimates when using the cross-sectional time series technique. The same coefficients are significant in both models, and the transportation expenditure lags appear to follow a two-year pattern. However, there is a difference in this pattern between the two models. In equation (1) the effect of transportation expenditures on employment follows a decreasing linear function. In equation (2) a second order polynomial would more closely resemble the lagged impact. For example, the coefficients could be viewed as multipliers having an effect of 0.0241 in the immediate year, increasing to a peak of 0.0674 two years later, and then declining to 0.0324 four years after the initial impact. This difference between the two models is most likely attributable to some characteristic of the data that is captured when cross-sectional affects are accounted for in this model. This could be interpreted to mean that the cross-sectional affects on total employment regarding coefficient significance have not shifted through time but have remained relatively constant during the years of this study, whereas the pattern of impact, resulting from structural changes, may have changed over time.

These models indicate that expenditures on transportation, in the lag patterns described above, do positively affect the amount of total employment. Table 2 shows the standard errors, t-statistics, and the significant dummy variable coefficients for the time series equation, equation (1). This is the equation that one would use to estimate effects

TABLE 2. Time Series Regression Estimates with Total Employment as the Dependent Variable.

SOURCE*	B VALUES	STD ERR B	T FOR H:B = 0	PROB>{T}
$INT	-337926.49	24308.83	-13.901	0.0001
RTES	0.1452	0.0177	8.185	0.0001
RTE2S	0.1058	0.0221	4.773	0.0001
RTE4S	0.0909	0.0221	4.107	0.0001
RPCPIM	3797.81	255.30	14.876	0.0001
DUM2	152657	22889.92	6.669	0.0001
DUM4	-116702.53	19945.03	-5.851	0.0001
DUM6	-70719.82	18895.64	-3.743	0.0002
DUM7	-56112.02	18190.81	-3.085	0.0022
DUM9	96396.28	18278.42	5.274	0.0001
DUM10	49657.31	18192.68	2.730	0.0066
DUM12	745981.23	47199.06	15.805	0.0001
DUM13	-51333.55	18291.77	-2.806	0.0052
DUM14	135902.67	18464.83	7.360	0.0001
DUM15	226025.93	26283.75	8.599	0.0001
DUM16	66715.81	18304.74	3.645	0.0003
DUM18	580747.01	32539.82	17.847	0.0001
DUM21	166222.93	19416.79	8.561	0.0001
DUM24	106618.70	18331.66	5.816	0.0001
DUM25	-51533.48	1.8787.31	-2.743	0.0064

Degrees of Freedom for T-Statistics = 412
Model F Value = 521.019
Prob > F = 0.0001
Adjusted R Square = 0.9582
Mean Square Error = 5343435969
Durbin-Watson D = 0.462

*Where:

- $INT = Intercept
- RTES = Real Transportation Expenditures
- RTE2S = Real Transportation Expenditures Lagged Two Years
- RTE4S = Real Transportation Expenditures Lagged Four Years
- RPCPIM = Real Percapita Personal Income
- DUMi = Intercept Dummy Variable for District i

on total employment assuming no cross-sectional shifts. The dummy variables in equation (1) for which we failed to reject the null hypothesis that there is no difference between these districts and district 1, are districts 3, 5, 8, 11, 17, 19, 20, and 23.

The dummy variable coefficients listed in Table 2 are for those districts that were found to be statistically different from district 1. A positive coefficient indicates that the effects of the independent variables on total employment were greater than in those districts listed above. This means that the employment affects of a dollar spent in districts 2, 9, 10, 12, 14, 15, 16, 18, 21, and 24 are greater than for a dollar spent in districts 1, 3, 5, 8, 11, 17, 19, 20, and 23. A negative coefficient indicates that the effect on total employment would be less than in the nonsignificant districts. This means that the employment affects of a dollar spent in districts 4, 6, 7, 13, and 25 are less than for a dollar spent in districts 1, 3, 5, 8, 11, 17, 19, 20, and 23.

Figure 2 graphically shows these differences in effects between districts by the direction of shift on the regression estimate of total employment. The amount of the difference for any particular significant district can be calculated be adding the dummy variable coefficient for that district to the intercept term in equation (1). For example, to find the effect on employment in district 2, one would add the district 2 dummy variable (DUM2) coefficient value of 152657 from Table 2 to the intercept value of -337926.49 in equation (1).

The Durbin-Watson statistic of 0.462 in this time series model suggests the presence of auto-correlation. Auto-correlation is a condition where the stochastic disturbance terms are not independent of one another but are serially correlated through time leading to an incorrect measure of the true error variance. One result of auto-correlation is that the standard errors are biased downwards leading to the conclusion that the parameter estimates are more precise than they really are. Generally this problem occurs because of the way the model is specified. For example, the auto-correlation in this model is apparently due to the inclusion of lagged variables, and the exclusion of other relevant variables from the model. As a result the regression estimates and their corresponding significance statistics in this time series model are possibly overstated. However, the size of the significance statistics are sufficiently large for the overall model, and for most all of the variables, to

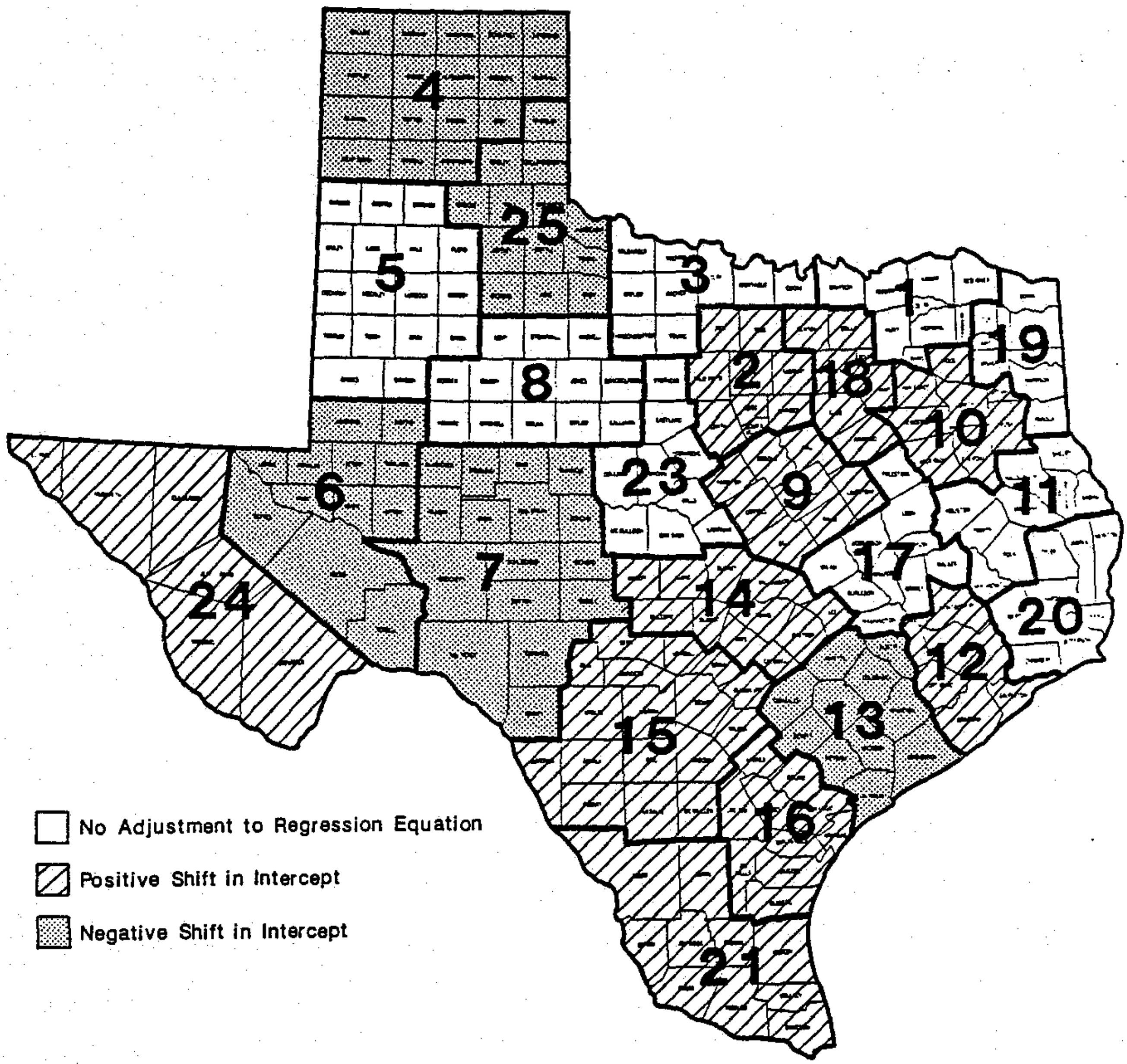

Figure 2. District Differences in Effect on Total Employment.

overcome most reasonable questions concerning validity of the results.

Furthermore, to correct for auto-correlation in this study, the number of lagged variables used in the model specification was minimized. Preliminary models were tested excluding the lagged transportation expenditure variable. As one may expect, with these model specifications the Durbin-Watson statistic indicated a decrease in auto-correlation. However, a lagged transportation variable was included in the attempt to capture the important time pattern of the effects of transportation expenditures on employment, as has been demonstrated by other studies [16,24,26].

Moreover, an effort was made to include all of the relevant variables in the specification of the model. Because the analysis was done on a county basis, with the county data being aggregated at the district level as explained above, only variables for which county data was available over the 18 year study period were possible candidates for inclusion.

Table 3 presents the Fuller and Battese estimates from the pooled cross-sectional time series model. The differences between districts can be seen by looking at the dummy variables for which there was significant evidence to reject the null hypothesis that there is no difference in effects between the districts. In this model dummy variables were used to also test the slope of the regression equation and not just the intercept. These slope dummies identify the source of the difference. For example, the dummy variables in Table 3 that are coded as STEDUMi are the districts for which the expenditures on transportation have differing affects, and the STIDUMi dummies are measuring the differing affects of personal income.

To evaluate if this positive effect on total employment was universal across the different industries in the state, the time series model developed in equation (1) was tested on a sector basis. The five industries tested were the construction, manufacturing, mining, services, and wholesale trade sectors. Only OLS time series models were developed at the sector level.

Equations (3) through (7) were estimated for the five industries. In each of these models the dependent variable was total employment within that industry.

TABLE 3. Time Series Cross-Sectional Regression Estimates with Total Employment as the Dependent Variable.

FULLER AND BATTESE METHOD ESTIMATES

SOURCE	B VALUES	T FOR H:B=0	PROB>{T}	STD ERR B
$INT	-11645.0	-0.68434	0.4941	17016
RTES	0.0241	2.1574	0.0316	0.011196
RTE2S	0.0674	8.4449	0.0000	0.0079833
RTE4S	0.0324	4.1900	0.0000	0.0077348
RPCPIM	3921.96	3.3725	0.0008	11.629
DUM12	-558945.	-9.8536	0.0000	56725.
DUM18	-905027.	-12.997	0.0000	69633.
SPIDUM2	479.039	11.721	0.0000	40.870
SPIDUM6	61.9934	2.8558	0.0045	21.708
SPIDUM9	194.508	4.2806	0.0000	45.440
SPIDUM10	212.226	5.4445	0.0000	38.980
SPIDUM12	1930.59	40.974	0.0	47.118
SPIDUM14	340.013	11.971	0.0	28.404
SPIDUM15	358.087	13.813	0.0	25.924
SPIDUM17	80.3471	2.4852	0.0133	32.330
SPIDUM18	2157.01	48.759	0.0	44.238
SPIDUM20	128.613	3.1417	0.0018	40.938
SPIDUM21	280.610	5.5870	0.0000	50.226
SPIDUM24	366.810	5.4041	0.0000	67.876
STEDUM2	0.0614248	2.5351	0.0116	0.024229
STEDUM12	0.0625535	4.6244	0.0000	0.013527
STEDUM14	0.0770131	2.1340	0.0334	0.036089
STEDUM18	0.118575	6.0162	0.0000	0.019709

Degrees of Freedom for T-Statistics = 409

*Where:

$INT	=	Intercept
RTES	=	Real Transportation Expenditures
RTE2S	=	Real Transportation Expenditures Lagged Two Years
RTE4S	=	Real Transportation Expenditures Lagged Four Years
RPCPIM	=	Real Per Capita Personal Income
DUMi	=	Intercept Dummy Variable for District i
SPIDUMi	=	Personal Income Slope Dummy for District i
STEDUMi	=	Real Transportation Expenditures Slope Dummy for District i

The construction sector employment was modeled as shown in equation (3):

(3) CONSES = - 24500.00
+ 0.0090 RTES
+ 0.0073 RTE1S
+ 254.83 RPCPIM

Table 4 summaries the statistical results and dummy variable coefficients of equation (3). Graphically, Figure 3 shows the district differences in impact on construction sector employment for a given change in the independent variables in equation (3).

For the manufacturing sector, employment was modeled in equation (4) as:

(4) MANUES = -10973.66
+ 0.0083 RTES
+ 0.0098 RTE1S
- 0.0116 RTE3S
- 14150.45 ROILP4M
+ 430.38 RPCPIM

Likewise, Figure 4 shows by district the different effects on manufacturing employment for a given change in transportation expenditures. Table 5 presents in detail the statistical results for equation (4).

The mining sector employment was modeled in equation (5) as:

(5) MINEES = - 28714.49
+ 0.0074 RTES
+ 0.0114 RTE1S
+ 0.0073 RTE2S
+ 0.0034 RTE3S
- 8355.80 ROILP4M
+ 233.70 RPCPIM

The mining sector employment impacts on employment are shown by district in Figure 5. Table 6 presents the dummy coefficients, and the significance statistics for equation (5).

For the services sector, employment was modeled in equation (6) as:

(6) SERES = - 77852.74
+ 0.0303 RTES
+ 0.0230 RTE2S
+ 0.0244 RTE4S
+ 738.41 RPCPIM

TABLE 4. Time Series Regression Estimates with Construction Sector Employment as the Dependent Variable.

SOURCE*	B VALUES	STD ERR B	T FOR H:B = 0	PROB>{T}
$INT	-24500.00	2184.77	-11.214	0.0001
RTES	0.0090	0.0018	4.947	0.0001
RTE1S	0.0073	0.0021	3.424	0.0007
RPCPIM	254.83	22.9934	11.083	0.0001
DUM2	7939.37	2032.31	3.907	0.0001
DUM4	-6512.40	1814.84	-3.588	0.0004
DUM9	4135.38	1691.35	2.445	0.0149
DUM12	85022.48	3789.73	22.435	0.0001
DUM14	8722.88	1704.34	5.118	0.0001
DUM15	14436.94	2201.33	6.558	0.0001
DUM16	8437.38	1696.14	4.974	0.0001
DUM18	30189.23	2600.47	11.609	0.0001
DUM20	5908.66	1710.58	3.454	0.0006
DUM21	9960.70	1806.82	5.513	0.0001
DUM24	7002.72	1700.54	4.118	0.0001

Degrees of Freedom for T-Statistics = 417
Model F Value = 427.377
Prob > F = 0.0001
Adjusted R Square = 0.9327
Mean Square Error = 47099515.67
Durbin-Watson D = 0.415

*Where:
$INT = Intercept
RTES = Real Transportation Expenditures
RTE1S = Real Transportation Expenditures Lagged one year
RPCPIM = Real Per Capita Personal Income
DUMi = Intercept Dummy Variable for District i

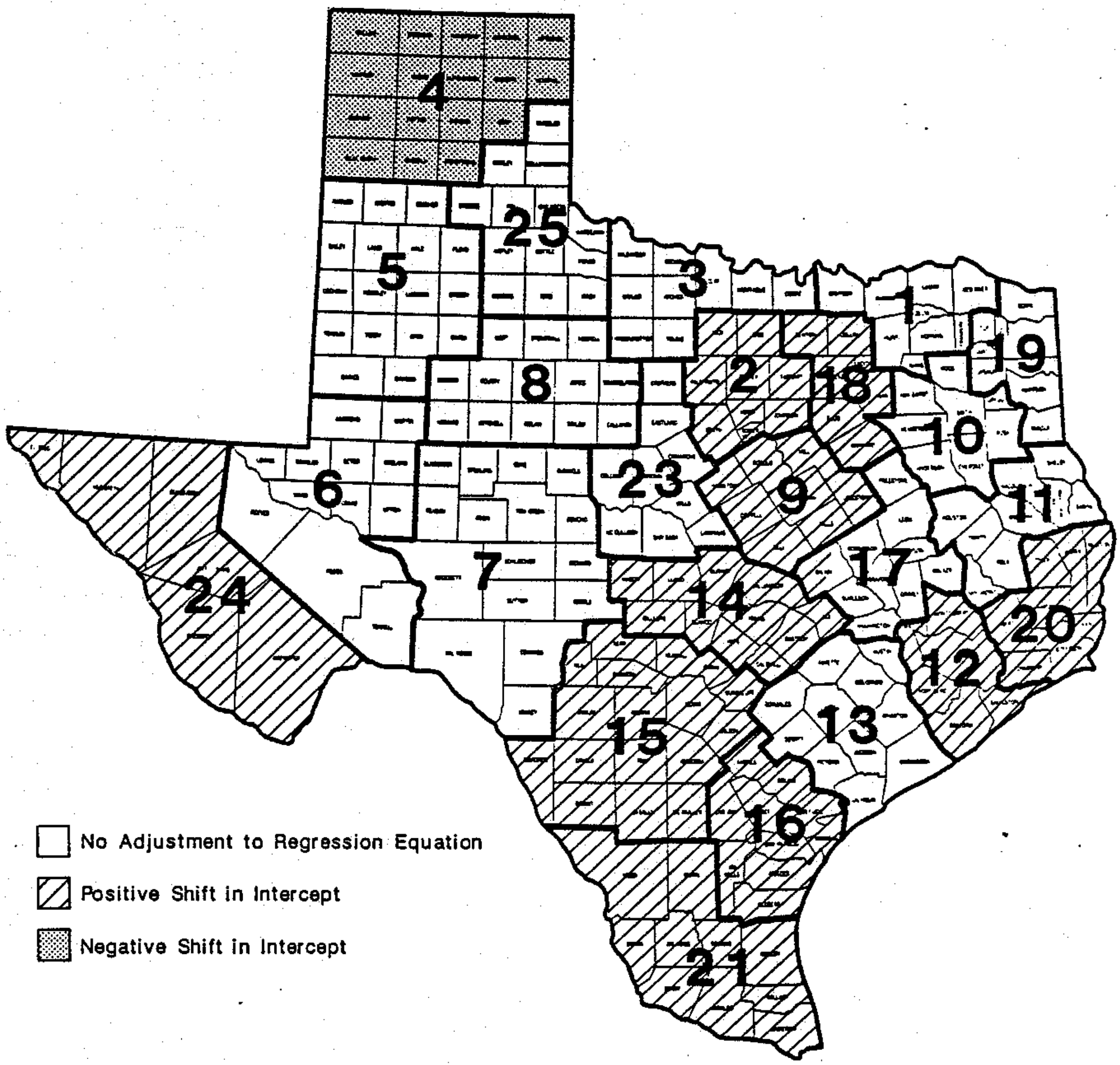

Figure 3. District Differences in Effect on Construction Sector Employment.

TABLE 5. Time Series Regression Estimates with Manufacturing Sector Employment as the Dependent Variable.

SOURCE*	B VALUES	STD ERR B	T FOR H:B = 0	PROB>{T}
$INT	-10973.66	3012.19	-3.643	0.0003
RTES	0.0083	0.0023	3.598	0.0004
RTE1S	0.0098	0.0028	3.474	0.0006
RTE3S	-0.0116	0.0025	-4.548	0.0001
ROILP4M	-14150.45	6891.57	-2.053	0.0407
RPCPIM	430.38	37.01	11.627	0.0001
DUM2	62323.92	2719.79	22.915	0.0001
DUM3	-19204.79	2322.23	-8.270	0.0001
DUM4	-24007.79	2587.30	-9.279	0.0001
DUM5	-15627.37	2228.80	-7.012	0.0001
DUM6	-26667.74	2382.48	-11.193	0.0001
DUM7	-21799.83	2212.58	-9.853	0.0001
DUM8	-20954.94	2259.71	-9.273	0.0001
DUM11	-5334.86	2232.13	-2.390	0.0173
DUM12	155506.37	5573.77	27.900	0.0001
DUM13	-17520.95	2212.71	-7.918	0.0001
DUM15	20237.65	2981.07	6.789	0.0001
DUM16	-12779.37	2192.88	-5.828	0.0001
DUM17	-15731.46	2191.24	-7.179	0.0001
DUM18	148802.47	3830.64	38.845	0.0001
DUM19	-4496.37	2192.82	-2.050	0.0410
DUM20	13502.56	2231.47	6.051	0.0001
DUM23	-19046.92	2289.98	-8.317	0.0001
DUM24	8082.76	2196.40	3.680	0.0003
DUM25	-27057.52	2329.21	-11.617	0.0001

Degrees of Freedom for T-Statistics	= 407
Model F Value	= 689.611
Prob > F	= 0.0001
Adjusted R Square	= 0.9760
Mean Square Error	= 49590525585
Durbin-Watson D	= 0.514

*Where:

$INT	= Intercept
RTES	= Real Transportation Expenditures
RTE1S	= Real Transportation Expenditures Lagged One Year
RTE3S	= Real Transportation Expenditures Lagged Three Years
ROILP4M	= Real Oil Price Lagged Four Years
RPCPIM	= Real Per Capita Personal Income
DUMi	= Intercept Dummy Variable for District i

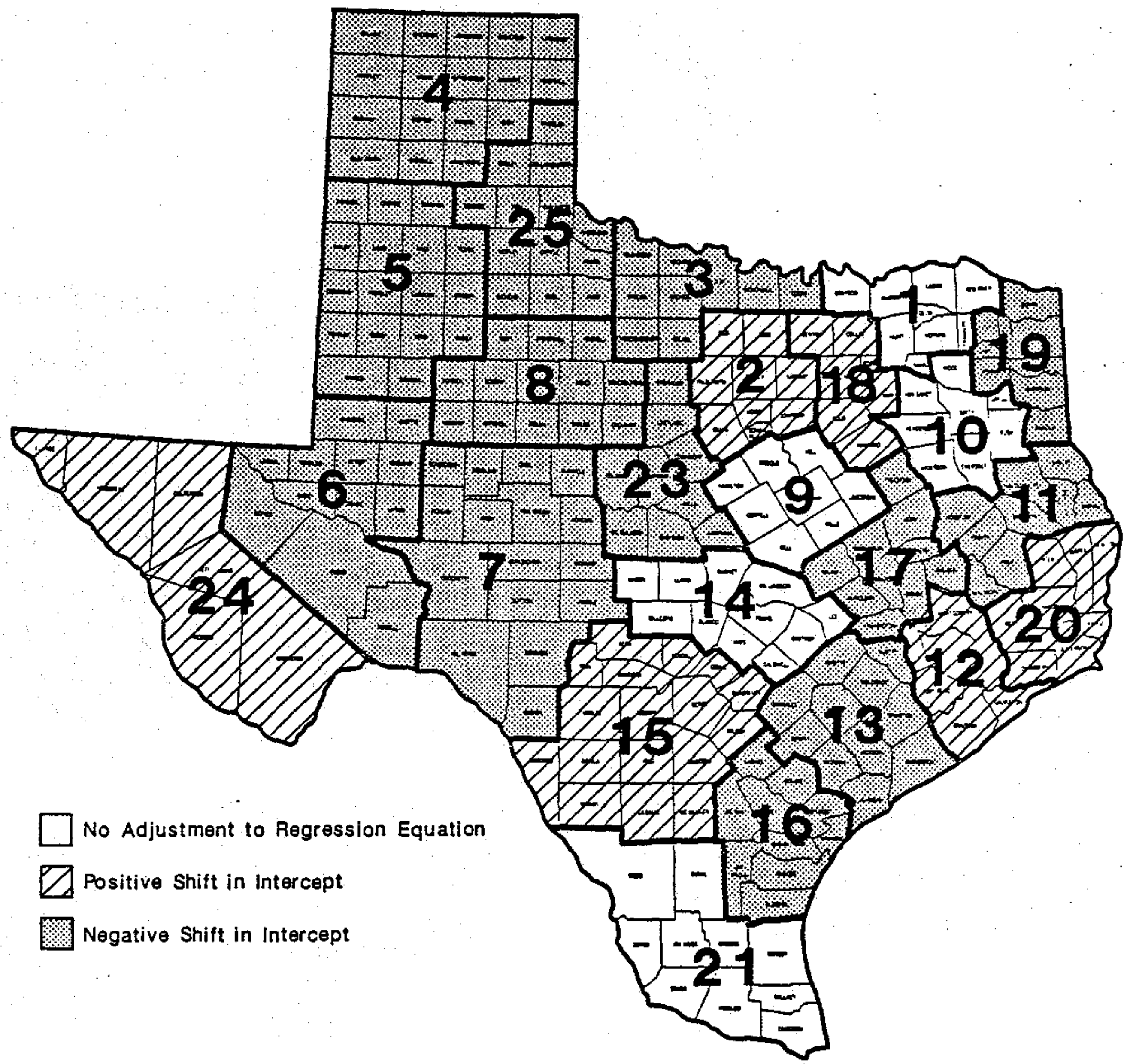

Figure 4. District Differences in Effect on Manufacturing Sector Employment.

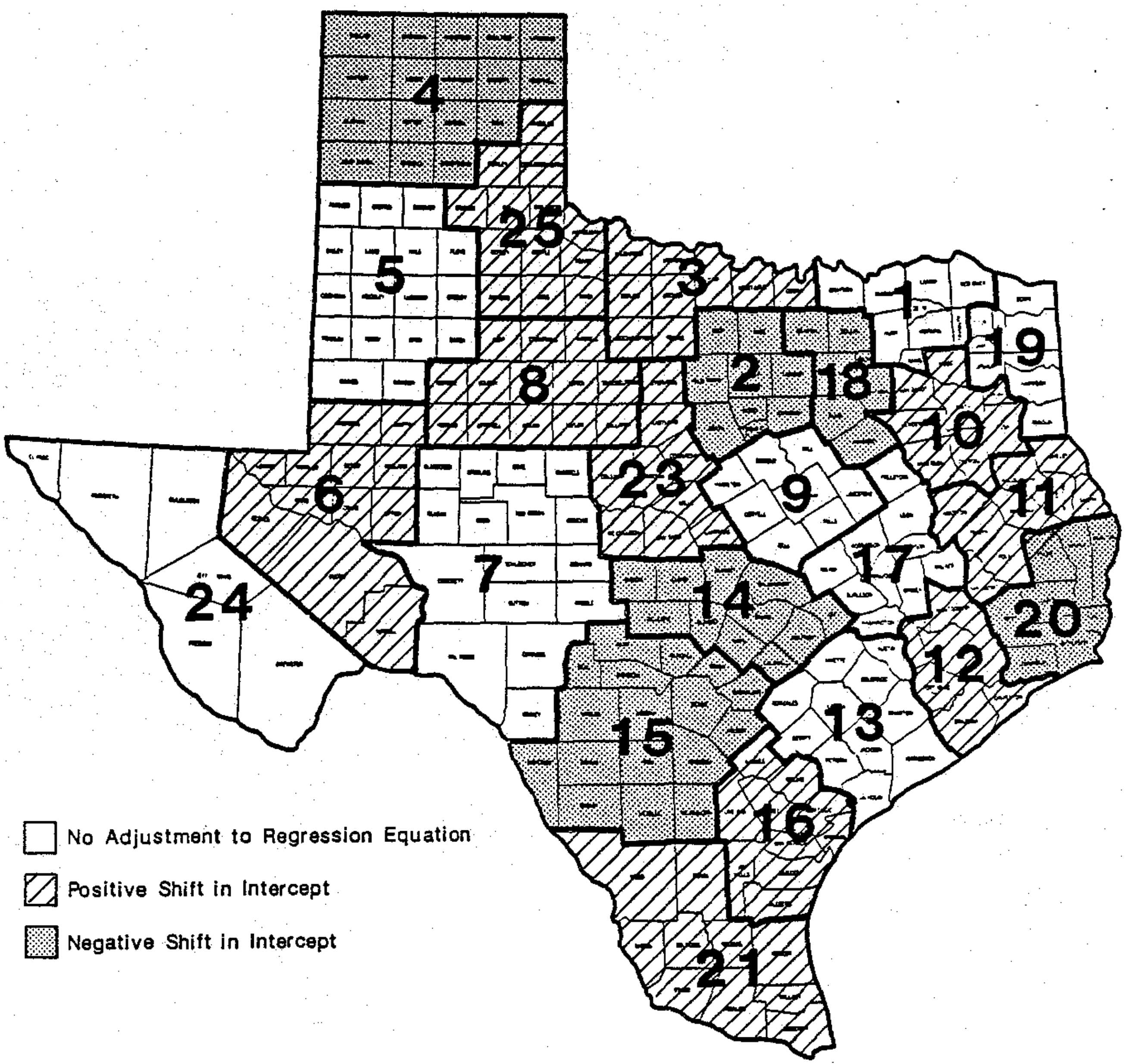

Figure 5. District Differences in Effect on Mining Sector Employment.

TABLE 6. Time Series Regression Estimates with Mining Sector Employment as the Dependent Variable.

SOURCE*	B VALUES	STD ERR B	T FOR H:B = 0	PROB>{T}
$INT	-28714.49	1704.67	-16.845	0.0001
RTES	0.0074	0.0012	6.196	0.0001
RTE1S	0.0114	0.0017	6.567	0.0001
RTE2S	0.0073	0.0016	4.503	0.0001
RTE4S	0.0034	0.0013	2.514	0.0123
ROILP4M	-8355.80	3748.47	-2.229	0.0263
RPCPIM	233.70	20.6990	11.291	0.0001
DUM2	-14647.59	1413.10	-10.366	0.0001
DUM3	3613.89	1151.36	3.139	0.0018
DUM4	-4388.38	1301.91	-3.371	0.0008
DUM6	16901.99	1184.54	14.269	0.0001
DUM8	4454.14	1118.70	3.982	0.0001
DUM10	5449.02	1096.08	4.971	0.0001
DUM11	3848.14	1125.70	3.418	0.0007
DUM12	8114.05	3100.92	2.617	0.0092
DUM14	-4362.09	1109.34	-3.932	0.0001
DUM15	-16042.54	1600.83	-10.021	0.0001
DUM16	7963.15	1091.93	7.293	0.0001
DUM18	-20035.88	2117.46	-9.462	0.0001
DUM20	-2356.74	1110.54	-2.122	0.0344
DUM21	6475.91	1191.74	5.434	0.0001
DUM23	5686.42	1151.75	4.937	0.0001
DUM25	3304.63	1164.94	2.837	0.0048

Degrees of Freedom for T-Statistics	= 409
Model F Value	= 195.598
Prob > F	= 0.0001
Adjusted R Square	= 0.9132
Mean Square Error	= 19012939.21
Durbin-Watson D	= 0.542

*Where:

$INT	= Intercept
RTES	= Real Transportation Expenditures
RTE1S	= Real Transportation Expenditures Lagged One Year
RTE2S	= Real Transportation Expenditures Lagged Two Years
RTE4S	= Real Transportation Expenditures Lagged Four Years
ROILP4M	= Real Oil Price Lagged Four Years
RPCPIM	= Real Per Capita Personal Income
DUMI	= Intercept Dummy Variable for District I

For equation (6), Figure 6 shows the district differences on employment in the services sector, and Table 7 lists the statistics and coefficients.

And for the wholesale trade sector, employment was modeled in equation (7) as:

$$(7) \quad WTES = -19813.27 + 0.0102\ RTES + 236.33\ RPCPIM$$

And finally, Figure 7 and Table 8 show, for the wholesale trade sector, the different impacts by district that transportation expenditures and per capita income have on total employment.

The results of the industry analysis are quite uniform across the sectors. With one exception, transportation expenditures showed a positive relationship to the level of total employment. That exception is in the manufacturing sector where there is a negative relationship between manufacturing employment and expenditures on transportation three years earlier. This counter-intuitive result is likely an idiosyncrasy of the data, or perhaps is a result of the auto-correlation introduced through the inclusion of the lagged variables as was discussed earlier.

Moreover, in all other sectors and in all years that had statistically significant lagged expenditure variables, the relationship between employment and expenditures on transportation, the relationship was positive. The wholesale trade sector was the only sector where there was not also a lagged positive relationship. Only in the manufacturing and mining sectors was total employment affected by oil prices, and in both cases it was a negative relationship with the price four years previous. In all models the level of per capita personal income was the dominant independent variable determining total employment.

The impacts on the various sectors differ across districts as one may expect. This is evident by looking at the dummy variables in the tables that were found most often to be significant in one or more of the models. Some interesting observations can be made from viewing the figures showing the district differences. For example, there appears to be a difference in effect between urban and rural districts as indicated by general district groupings. For instance, the districts that include the larger metropolitan concentrations of the state, districts 2 (Fort Worth), 12 (Houston), 14 (Austin), 15 (San Antonio), and 18 (Dallas) are often grouped together.

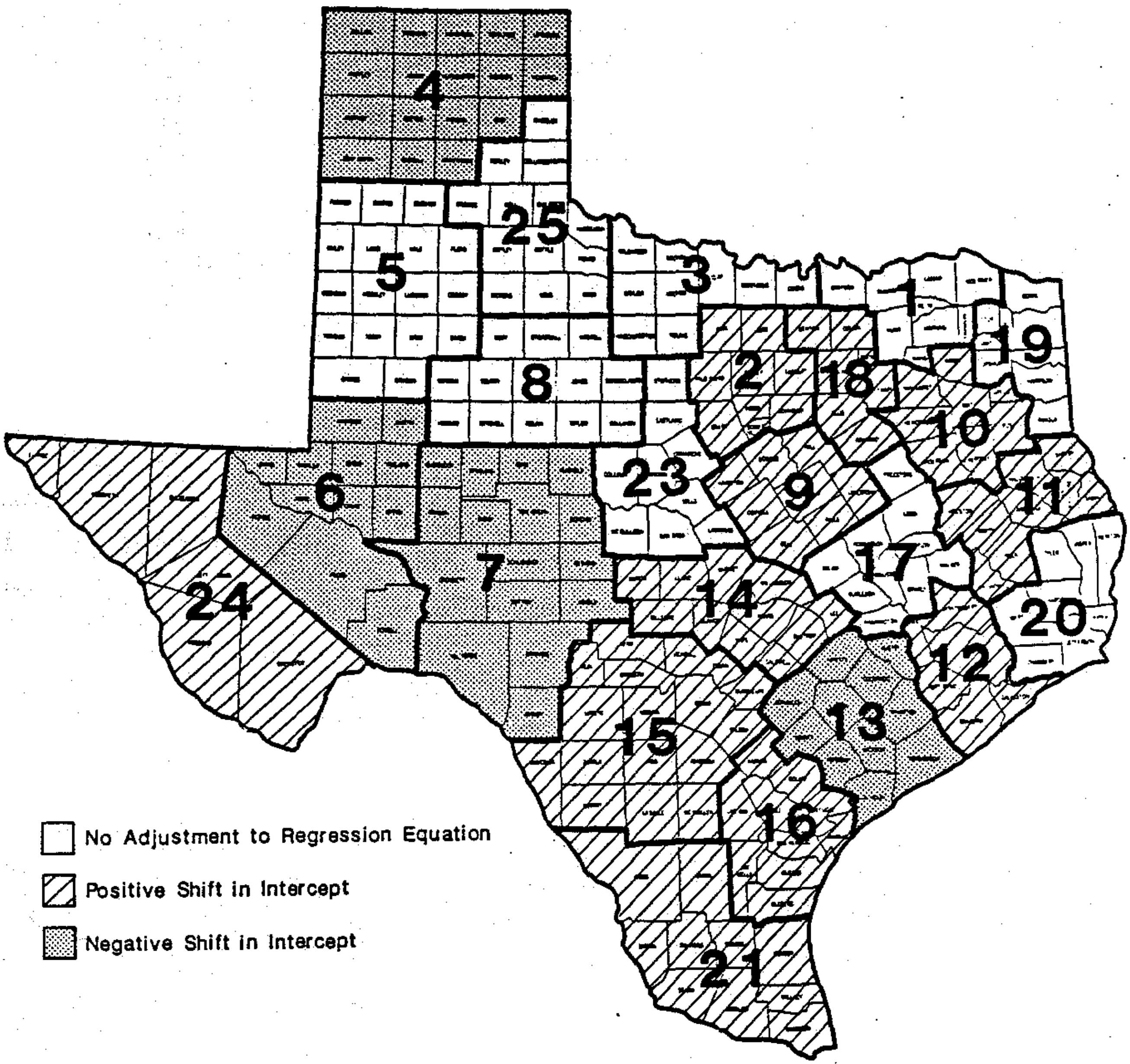

Figure 6. District Differences in Effect on Service Sector Employment.

TABLE 7. Time Series Regression Estimates with Services Sector Employment as the Dependent Variable.

SOURCE*	B VALUES	STD ERR B	T FOR H:B = 0	PROB>{T}
$INT	-77852.74	5367.68	-14.504	0.0001
RTES	0.0303	0.0038	8.000	0.0001
RTE2S	0.0230	0.0047	4.854	0.0001
RTE4S	0.0244	0.0047	5.175	0.0001
RPCPIM	738.41	55.353	13.340	0.0001
DUM2	16055.90	4902.22	3.275	0.0011
DUM4	-24934.89	4261.84	-5.851	0.0001
DUM6	-14997.06	4038.91	-3.713	0.0002
DUM7	-8256.18	3903.41	-2.115	0.0350
DUM9	13495.53	3934.14	3.430	0.0007
DUM10	10179.11	3904.36	2.607	0.0095
DUM11	8828.68	3966.63	2.226	0.0266
DUM12	125282.83	9962.97	12.575	0.0001
DUM13	-8311.39	3929.55	-2.115	0.0350
DUM14	26544.74	3966.97	6.691	0.0001
DUM15	29039.42	5605.17	5.181	0.0001
DUM16	12879.28	3939.38	3.269	0.0012
DUM18	91008.51	6921.68	13.148	0.0001
DUM21	27295.69	4206.26	6.489	0.0001
DUM24	17898.58	3949.86	4.531	0.0001

Degrees of Freedom for T-Statistics	= 412
Model F Value	= 403.886
Prob > F	= 0.0001
Adjusted R Square	= 0.9467
Mean Square Error	= 246083140
Durbin-Watson D	= 0.422

*Where:

$INT	= Intercept
RTES	= Real Transportation Expenditures
RTE2S	= Real Transportation Expenditures Lagged Two Years
RTE4S	= Real Transportation Expenditures Lagged Four Years
RPCPIM	= Real Per Capita Personal Income
DUMi	= Intercept Dummy Variable for District i

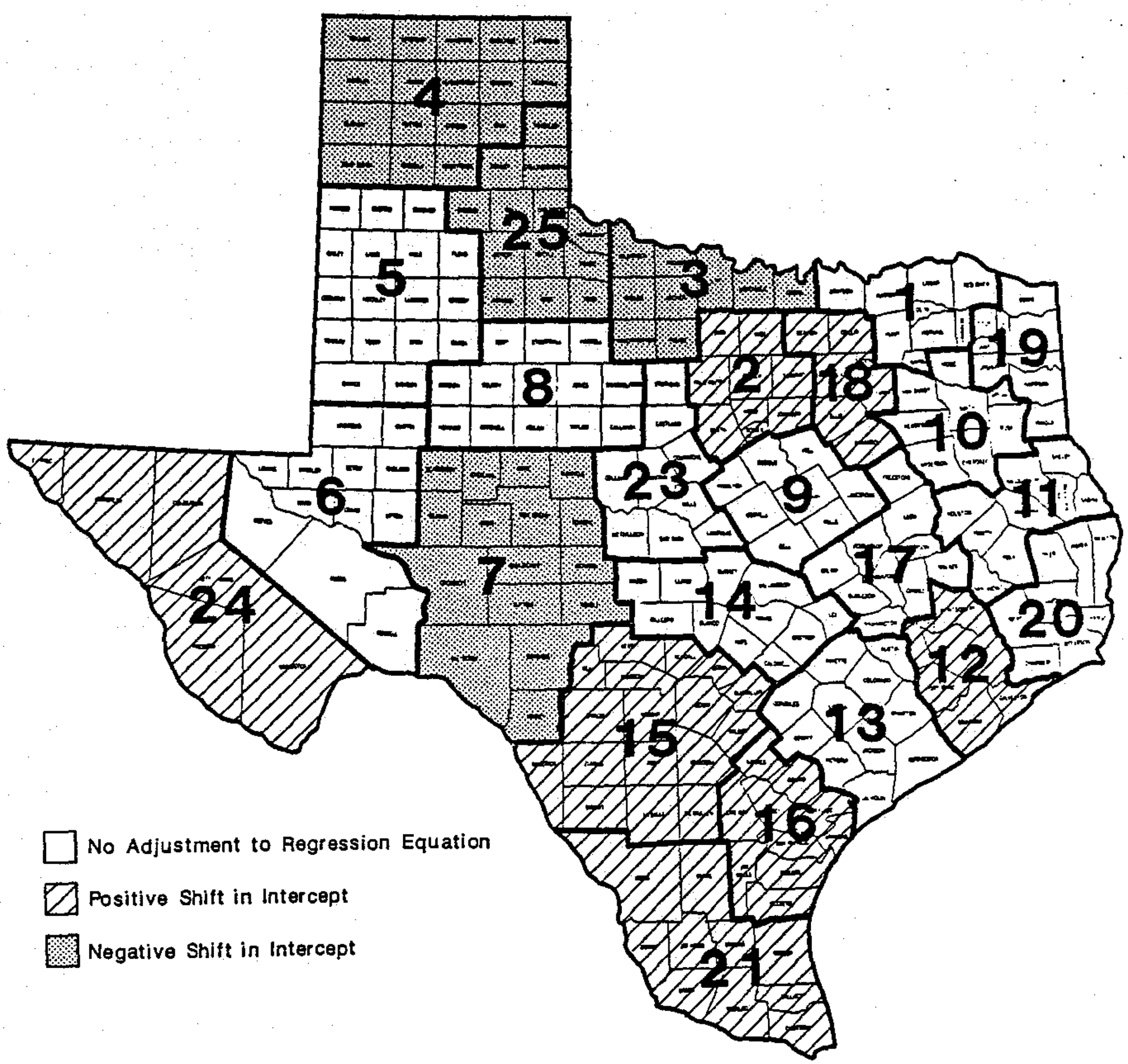

Figure 7. District Differences in Effect on Wholesale Trade Sector Employment.

TABLE 8. Time Series Regression Estimates with Wholesale Trade Sector Employment as the Dependent Variable.

SOURCE*	B VALUES	STD ERR B	T FOR H:B = 0	PROB>{T}
$INT	-19813.27	1727.88	-11.467	0.0001
RTES	0.0102	0.0012	8.056	0.0001
RPCPIM	236.33	18.77	12.585	0.0001
DUM2	10986.95	1532.30	7.170	0.0001
DUM3	-3390.61	1381.60	-2.454	0.0145
DUM4	-3467.65	1470.93	-2.357	0.0189
DUM7	-3345.44	1355.58	-2.468	0.0140
DUM12	76176.46	2577.77	29.551	0.0001
DUM15	13798.29	1624.09	8.496	0.0001
DUM16	2934.00	1359.82	2.158	0.0315
DUM18	73121.72	1832.48	39.903	0.0001
DUM21	11321.61	1445.17	7.834	0.0001
DUM24	6233.79	1367.24	4.559	0.0001
DUM25	-3404.58	1384.79	-2.459	0.0144

Degrees of Freedom for T-Statistics = 418
Model F Value = 744.162
Prob > F = 0.0001
Adjusted R Square = 0.9573
Mean Square Error = 30664914.82
Durbin-Watson D = 0.421

*Where:

$INT = Intercept
RTPIS = Real Transportation Expenditures
RPCPIM = Real Per Capita Personal Income
DUMi = Intercept Dummy Variable for District i

This means that when money is spent on transportation, it increases the level of employment in the highway districts. There is a difference however between the districts in the amount of employment that is generated. Also there is a difference in the economic sectors regarding the timing of the employment effects and the length of those effects. This is important because as highway planners and SDHPT personnel go through the process of deciding where to construct roads, they can better estimate the timing and amount of economic growth as measured by total employment. This result also provides information that can be helpful to district personnel in promoting growth in specific industries within their districts.

Again using the two pooled procedures discussed above two equations for estimating personal income were developed, as outlined in the second structural relationship where:

Per Capital Personal Income = f(transportation expenditures both current and lagged, oil prices both current and lagged, and total employment).

Equation (8) was developed using ordinary least squares (OLS) time series regression. However, when the PROC TSCSREG procedure was used to estimate the above structural relationship, correcting for shifts in the cross-sectional parameters, total employment was the only statistically significant independent variable. This was interpreted to mean that when the cross-sectional differences were accounted for in this model structure, transportation expenditures had no impact on per capita personal income.

Even though per capita personal income is the preferred measure, equation (9) was estimated using total personal income (rather than per capita personal income) as the dependent variable. This was done because a personal income measure is often used to measure the productivity or output of an industry or geographic area [49,50,51]. A per capita personal income measure is preferred because it accounts for population changes, however, because it was found to be not significant, the second best choice of total personal income was used as the dependent variable.

Equation (9) was estimated using the previously discussed PROC TSCSREG cross-sectional time series procedure. The parameter estimates from equation (8) are not directly comparable to the estimates from equation (9) because the dependent variables are not the same as was the case in the previous equations. These two equations were developed as follows:

$$(8) \quad RPCPIM = + 65.1775 - 0.000014\, RTE2S + 62.1043\, ROILPM + 29.5012\, ROILP2M + 44.3733\, ROILP4M + 0.000036\, TOTES$$

and,

$$(9) \quad RTPIS = - 6012.46 + 0.0528\, RTES + 0.0327\, RTE2S + 0.0300\, RTE4S - 4703.89\, ROILPS$$

where the variables were defined as:

RPCPIM = real per capita personal income
RTPIS = real total personal income
RTES = real transportation expenditures
RTE2S = real transportation expenditures lagged two years
RTE4S = real transportation expenditures lagged four years
ROILPS = real oil prices
ROILP2M = real oil prices lagged two years
ROILP4M = real oil prices lagged four years
TOTES = total employment

This model was used to provide information on the effects of highway expenditures, oil prices, and total employment on personal income in the state of Texas. Note that in the time series model oil prices have a positive impact on per capita income, and transportation expenditures a negative impact. However this relationship is reversed when total rather than per capita income is the dependent variable in the cross-sectional time series model. There also appears to be an every other year lag effect for these variables as indicated by the significance of the two- and four-year lags.

Table 9 and Table 10 summarize the t-statistics and standard errors for equations (8) and (9) respectively. These tables also report the coefficients for the significant dummy variables. Figure 8 shows the groupings of districts according to the direction of shift in regression equation (8). These models provide evidence that transportation expenditure do have a statistically significant impact on total personal income within a highway district, and that the impact differs from district to district.

Using the pooled procedures discussed above, two equations for estimating the structural relationship of transportation expenditures were developed where:

- Transportation Expenditures = f(political variables, oil prices both current and lagged, per capita personal income and total employment).

Equation (10) was developed using time series regression, and equation (11) was developed using the cross-sectional time series procedure. These two equations are:

$$(10)\quad RTES = +\ 599267.72 - 2405.63\ PSHIPM - 1172986.88\ ROILP3M + 1013660.16\ ROILP4M - 1849.33\ RPCPIM + 0.904\ TOTES$$

and,

$$(11)\quad RTES = +\ 284525 + 8.35629\ RTPIS - 1.01402\ TOTES$$

where the variables were defined as:

RTES	=real transportation expenditures
PSHIPM	=degree of partisanship
ROILP3M	=real oil price lagged three years
ROILP4M	=real oil price lagged four years
RPCPIM	=real per capita personal income
RTPIS	=real total personal income
TOTES	=total employment

Equation (10) shows that there is a positive relationship between total employment and transportation expenditures while equation (11) indicates a negative relationship. Similar conflicting results exist between the two equations for the relationships between income and transportation expenditures. The reason for the apparent lack of harmony between the two models is that equation (11) has been corrected for shifts over time in the cross-sectional parameters. As part of that process total income was used in equation (11) rather than per capita income for the reasons discussed in regards to equations (8) and (9).

TABLE 9. **Time Series Regression Estimates with Per Capita Personal Income as the Dependent Variable.**

SOURCE*	B VALUES	STD ERR B	T FOR H:B = 0	PROB>{T}
$INT	65.1775	1.2375	52.665	0.0001
RTE2S	-0.000014	.0000021	-6.732	0.0001
ROILPM	62.1843	6.1635	10.089	0.0001
ROILP2M	29.5012	8.4436	3.494	0.0005
ROILP4M	44.3733	7.4633	5.946	0.0001
TOTES	0.000036	.0000025	14.172	0.0001
DUM2	7.8074	1.8553	4.208	0.0001
DUM3	16.3307	1.8787	8.692	0.0001
DUM4	36.0941	1.8686	19.315	0.0001
DUM5	7.2849	1.8611	3.914	0.0001
DUM6	24.2462	1.8700	12.965	0.0001
DUM7	8.8272	1.8878	4.676	0.0001
DUM8	11.7975	1.8746	6.293	0.0001
DUM10	4.9167	1.8641	2.638	0.0087
DUM11	-6.0032	1.8827	-3.189	0.0015
DUM13	8.9619	1.8862	4.751	0.0001
DUM14	4.0487	1.8571	2.180	0.0298
DUM15	-8.8804	1.9004	-4.673	0.0001
DUM20	6.6896	1.8635	3.590	0.0004
DUM21	-23.5190	1.8582	-12.657	0.0001
DUM24	-7.2181	1.8629	-3.875	0.0001
DUM25	9.4774	1.9013	4.984	0.0001

Degrees of Freedom for T-Statistics = 410
Model F Value = 102.493
Prob > F = 0.0001
Adjusted R Square = 0.8318
Mean Square Error = 54.2049
Durbin-Watson D = 1.341

*Where:

- $INT = Intercept
- RTE2S = Real Transportation Expenditures Lagged Two Years
- ROILPM = Real Oil Price
- ROILP2M = Real Oil Price Lagged Two Years
- ROILP4M = Real Oil Price Lagged Four Years
- TOTES = Total Employment
- DUMi = Intercept Dummy Variable for District i

TABLE 10. Time Series Cross-Sectional Regression Estimates with Real Total Personal Income as the Dependent Variable.

FULLER AND BATTESE METHOD ESTIMATES

SOURCE*	B VALUES	T FOR H:B=0	PROB>{T}	STD ERR B
$INT	-6012.46	-1.0624	0.2886	5659.2
RTES	0.0528	9.0029	0.0000	0.0058664
RTE2S	0.0327	4.4949	0.0000	0.0072801
RTE4S	0.0300	4.2376	0.0000	0.0070968
ROILPS	-4703.89	-2.1252	0.0342	2213.4
DUM2	27167.2	2.8511	0.0046	9528.7
DUM12	139399.	9.5840	0.0000	14545.
DUM14	22865.3	2.5843	0.0101	8847.7
DUM18	99535.1	8.7391	0.0000	11390.

Degrees of Freedom for T-Statistics = 423

*Where:

$INT	= Intercept
RTES	= Real Transportation Expenditures
RTE2S	= Real Transportation Expenditures Lagged Two Years
RTE4S	= Real Transportation Expenditures Lagged Four Years
ROILPS	= Real Oil Prices
DUMi	= Intercept Dummy Variable for District i

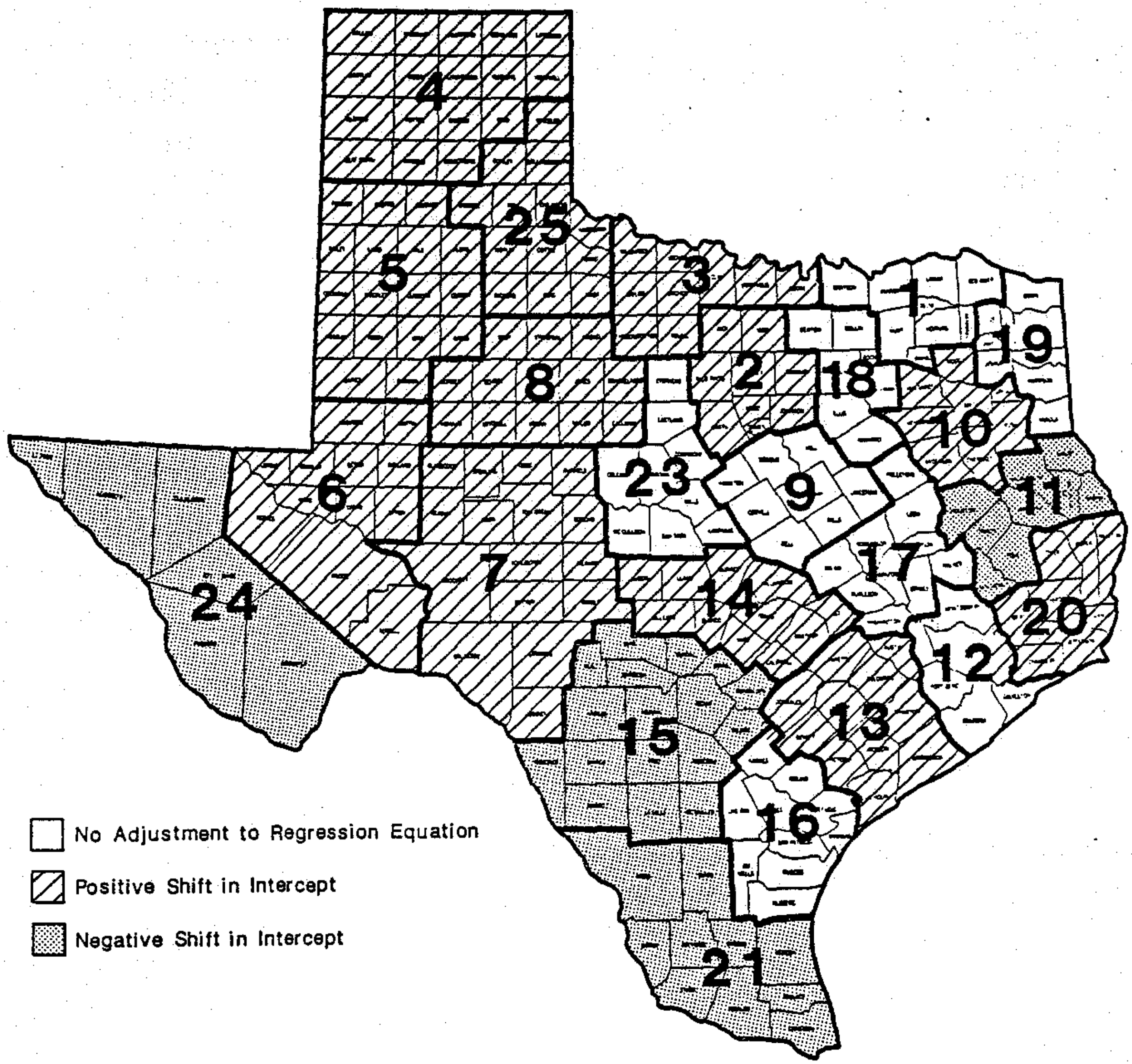

Figure 8. District Differences in Effect on Per Capita Personal Income.

With this understanding then, the two models can be interpreted independent of each other.

The standard errors for the parameter estimates and their corresponding t-statistics are presented in Table 11 for the time series regression estimates in equation (10). The coefficients for the significantly different dummy variables, districts 2, 5, 12, 15, and 24, are also presented in the table. Figure 9 shows pictorially these differences in the districts.

Table 12 contains the same information for the equation (11) time series cross-sectional Fuller and Battese estimates. When this statistical approach was used, the effect of the independent variables on transportation expenditures in districts 2, 5, 12, 15, 18, 23, and 25 were found to be statistically different from the other highway districts, as indicated by the dummy variables.

It should be noted when comparing these two models that partisanship in equation (11) was the only statistically significant political variable. This statistic suggests that total expenditures for highways are greater when the governor of Texas belongs to the Republican party than when the governor is a Democrat. However, it is important to point out, there has been only one Republican governor in Texas since the Civil War and that was within the time period of this study, from 1979-1982. Since there has been only one Republican governor, it would be premature to conclude, based only on this data, that when a Republican is governor total highway expenditures will increase more than when a Democrat is governor. Also it is important to note that when adjustments to cross-sectional shifts are made this variable is no longer significant as shown in equation (11).

TABLE 11. Time Series Regression Estimates with Transportation Expenditures at the Dependent Variable.

SOURCE*	B VALUES	STD ERR B	T FOR H:B = 0	PROB>{T}
$INT	599267.72	112933.88	5.306	0.0001
PSHIPM	-2405.63	988.29	-2.434	0.0153
ROILP3M	-1172986.88	265754.90	-4.414	0.0001
ROILP4M	1013660.16	273111.42	3.712	0.0002
RPCPIM	-1849.33	744.86	-2.483	0.0134
TOTES	0.9405	0.0436	21.588	0.0001
DUM5	-1274908.30	530391.70	-2.404	0.0167
SEDUM2	0.5337	0.0909	5.871	0.0001
SEDUM5	6.8846	2.6901	2.559	0.0108
SEDUM12	0.3310	0.0461	7.169	0.0001
SEDUM15	0.4906	0.0860	5.702	0.0001
SEDUM24	-0.5043	0.2236	-2.255	0.0246

Degrees of Freedom for T-Statistics	= 420
Model F Value	= 222.946
Prob > F	= 0.0001
Adjusted R Square	= 0.8500
Mean Square Error	= 33364469977
Durbin-Watson D	= 1.482

*Where:

$INT	= Intercept
PSHIPM	= Degree of Partisanship
ROILP3M	= Real Oil Price Lagged Three Years
ROILP4M	= Real Oil Price Lagged Four Years
RPCPIM	= Real Percapita Personal Income
TOTES	= Total Employment
DUM5	= Intercept Dummy Variable for District 5

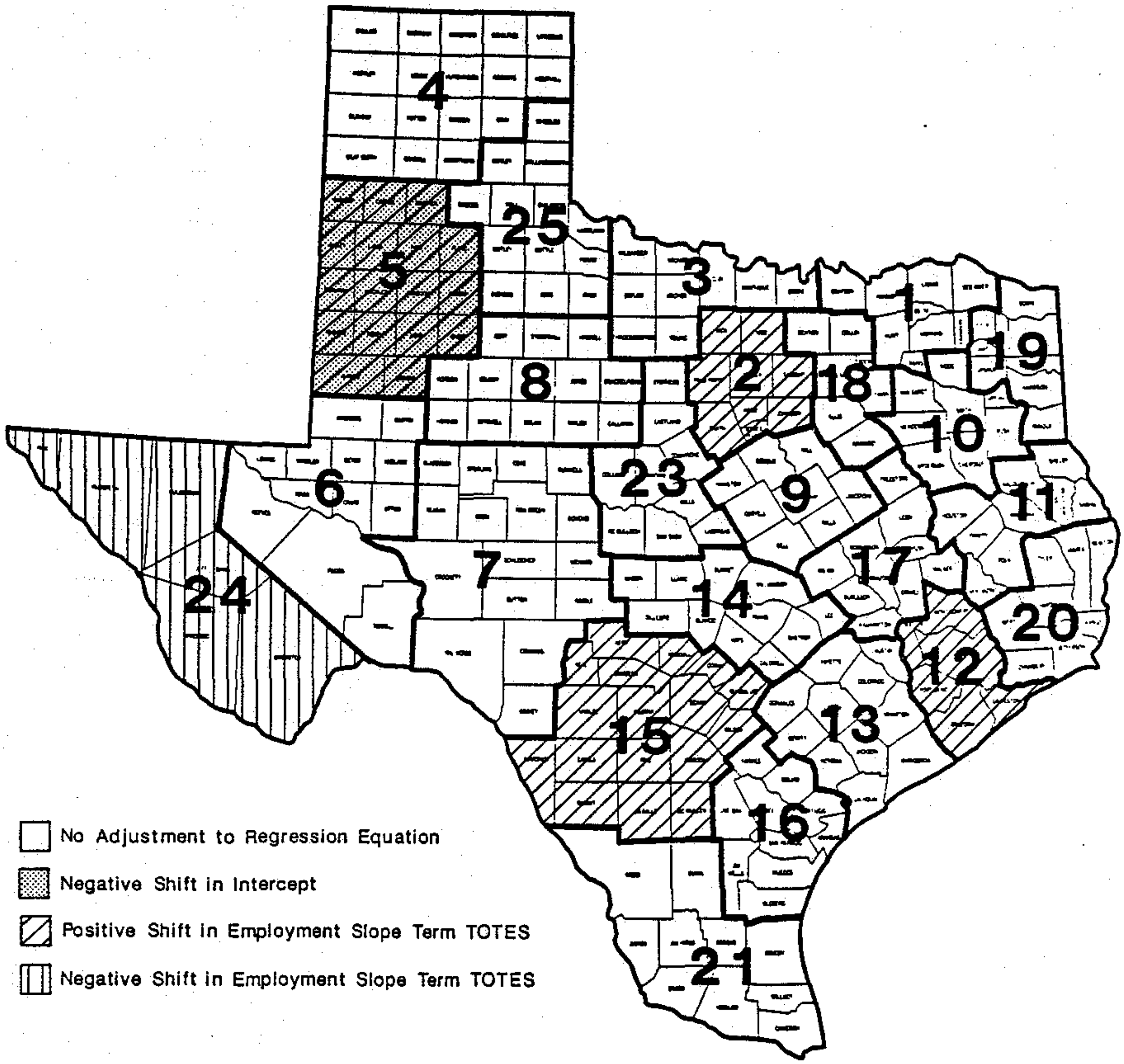

Figure 9. District Differences in Effect on Transportation Expenditures.

TABLE 12. Time Series Cross-Sectional Regression Estimates with Transportation Expenditures as the Dependent Variable.

FULLER AND BATTESE METHOD ESTIMATES

SOURCE*	B VALUES	T FOR H:B=0	PROB>{T}	STD ERR B
$INT	284525	8.1390	0.0000	34958.
RTPIS	8.35629	3.9838	0.0001	2.0976
TOTES	-1.01402	-2.0674	0.0393	0.49047
DUM2	186616.	-2.6728	0.0078	69821.
DUM5	-1421809.	-3.4601	0.0006	410917.
DUM12	2626277.	3.1384	0.0018	836811.
DUM15	385400.	5.1645	0.0000	74626.
DUM23	-126043.	-2.5845	0.0101	48769.
DUM25	-126094.	-2.5153	0.0123	50130
SIDUM12	29.7713	2.7618	0.0060	10.779
SIDUM18	-38.7568	-9.9172	0.0000	3.9080
SEDUM5	7.72355	3.7202	0.0002	2.0761
SEDUM12	8.64307	-2.7673	0.0059	3.1233
SEDUM18	-8.53968	9.8471	0.0000	0.86723

Degrees of Freedom for T-Statistics = 418

*Where:

$INT	= Intercept
RTPIS	= Real Total Personal Income
TOTES	= Total Employment
DUMi	= Intercept Dummy Variable for District i
SIDUMi	= Real Total Personal Income Slope Dummy for District i
SEDUMi	= Total Employment Slope Dummy for District i

STUDY FINDINGS

A series of linear regression models were used to test the three structural relationships:

1. Transportation Expenditures = f(political variables, oil prices both current and lagged, per capita personal income and total employment)
2. Per Capital Personal Income = f(transportation expenditures both current and lagged, oil prices both current and lagged, and total employment)
3. Total Employment = f(transportation expenditures both current and lagged, oil prices both current and lagged, and per capita personal income).

Analysis of the data was done using both pooled cross-sectional time series procedures, and pooled time series techniques. The first two relationships where transportation expenditures and personal income were the dependent variables, the results between the time series, and the cross-sectional time series models exhibited contradictory results.

The only political variable that was significant is partisanship. This statistic suggests that total expenditures for highways are greater when the governor is Republican. Since there has been only one Republican governor during the study period, it would be premature to conclude that when a Republican is governor, total highway expenditures would increase. Most likely this is a spurious relationship, and if so, can conclude that the political variables as they were defined and included in this study have no statistically significant relationship to public expenditures for transportation construction and maintenance.

The third structural relationship where total employment is the dependent variable, practically identical results were achieved from a cross-sectional time series model and from the pooled time series model. From these model results it can be concluded that transportation expenditures positively effect the amount of total employment. This impact appears to follow a two-year cycle lasting four years. Per capita personal income is also highly significant in determining the level of employment.

Twenty-three dummy variables were used to pool the data in the time series models and to measure the differences between highway districts within each model. There appears to be a difference between urban and rural districts; that is to say, for a given level of expenditures on transportation, the impact on employment is different between urban and rural districts. As expected for total employment, the effect is stronger in the more populated districts.

There is also a difference in effects of transportation expenditures on employment between economic sectors within the state. Current expenditures were significant in the construction, manufacturing, mining, services, and wholesale trade sectors. The impact was lagged as long as three years in the manufacturing and mining sectors, and four years in the services sector.

RECOMMENDATIONS

The following recommendations are offered for consideration by the SDHPT regarding the findings of this study.

1. In funding decisions regarding mutually exclusive projects, the impacts on employment should be estimated and considered for inclusion into project ranking, rating, and assessment techniques.
2. The differential effects on employment across industries can be estimated and included in strategic planning and policy formation regarding statewide economic diversification.
3. Future research should be initiated to further investigate the impacts of highway policy and transportation expenditure decisions on the economic climate of the districts. Both inter- and intra-district comparisons by industry could prove enlightening.

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