Highway District and Economic Sector Employment Effects of Transportation Expenditures

Laurence M. Crane, Dock Burke, and Clay Hanks

The determinants of total highway construction and maintenance expenditures in the highway districts of Texas and how these expenditures on transportation infrastructure affect employment levels are described. 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 lag varies among the economic sectors and major industries of the state. Some lag patterns of transportation expenditures and employment follow a decreasing linear function, whereas others more closely resemble a second order polynomial. There is a difference between the highway districts as to the amount of effect transportation expenditures have on employment. The impacts are greatest in the more urban districts, and least in the more rural districts. The political influences as defined in this study were not significant in determining the level of public funds spent on highway infrastructure.

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. 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.

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 mi of highways, including 3,200 mi of Interstate highways, over 27,000 mi 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 uses 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*). This study investigates the determinants of total highway expenditures in 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 (*3*) 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." On the other hand, Davis and Frederick (*4*) define public policy as "a plan of action undertaken by government to achieve some broad purpose affecting a large segment of the citizenry." 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 1987 study indicates 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 1970s (*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 (*6*) provide a premise for policy analysts to consider before commencing investigations into public policy. 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.

Both economic and political variables will be used in this analysis; however, there is conflict as to what influence and the amount of influence that political variables play in determining public policy. 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

Economics and Planning Division, Texas Transportation Institute, Texas A&M University, College Station, Tex. 77843-3135.

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.

The general objective 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. Specifically, it is to improve the understanding of how expenditures for transportation construction and maintenance promote and impact economic activity.

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 on Transportation 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 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 to 1986 are included.

The political variables used are voter participation, partisanship, intraparty competition, and representation on the House Committee on Transportation. The first three political variables are the same variables that Dye (*2*) used in his study of highway policy in the American states in the early 1960s. The fourth political variable, membership on the 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 were collected on a county basis where available and then aggregated into highway district aggregates.

LITERATURE REVIEW

Previous research has indicated significant linkages between economic development and transportation expenditures (*7–10*). 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 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 need 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, little is known about the factors that influence where new business locations 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*). It was used in an attempt to determine whether public transportation infrastructure and freight subsidies can be expected to stimulate industrial development in a region.

Carlton (*17*) simultaneously modeled both the location and employment choice of new branch plants. 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 FHWA 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*). The effects of transportation expenditures on employment and income have also been shown to be distributed differently between urban and rural areas (*25*).

The determinants of general economic growth have been modeled in a whole menu of theories (*26,27*). The project and regionally specific models are of more practical use to the highway department personnel (*28*). However, there is a need for further research at the project, district, and state levels 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 (*30–32*). Few published articles 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 (*33–36*).

In 1980. Dye (*37*) examined the differences in taxing and spending among the American states and their impact on economic growth and development. 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 1970s?" Dye developed a time-lagged taxing and spending model, because taxing and spending are two areas that can be manipulated by (elected) decision makers. He examined the period between 1967 and 1970 for taxing and spending policies and its lagged effect on economic development in the period between 1972 and 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 1960s correlated with economic development in the early and middle 1970s. He concludes that the data suggest investment in all areas of a state's infrastructure—highways, energy, water, mass transit, etc.—promote economic development. Tax incentives did not have a significant impact in the development of a state's economy.

Forkenbrock and Plazak (*38*) found that the impact highways would have on economic development played a significant role in highway planning. 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, the Revitalize Iowa's Sound Economy (RISE) program, 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 (*39*).

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 to 1982);
2. Partisanship—the percentage of voters voting Democrat (1966 to 1982);
3. Competition—the percentage difference between the winner and loser in the general election for governor (1966 to 1982); or the lower the percentage, the higher the competition; and
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 to 1986, the gubernatorial election in 1966 was included so that data are available for 1969 and 1970 (*40*). The results of a gubernatorial election are held constant for 4 years or until the next gubernatorial election. 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 are collected every biennium. Before 1973, the Texas House Committee on Transportation did not exist; thus for the years 1969 to 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 dominant industry, general economic conditions could be measured from it. A major source of state revenue is from the oil industry and its related businesses.

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. To exclude the effects of inflation, all nominal dollar values were deflated into real dollars using the GNP implicit price deflators (1982 = 100) (*43*).

Statistical Analysis

The study objectives were fashioned into two basic structural models as follows:

1. Total employment as a function of transportation expenditures both current and lagged, oil prices both current and lagged, and per capita personal income); and
2. Transportation expenditures as a function of (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: (a) time series models using dummy variables to pool the data, and (b) 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, more lagged terms could be used 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 are 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 it is assumed that 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 to 21 and Districts 23 to 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 intercounty relationships within districts. 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.

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 procedures. 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 (*48*) 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." The variance components are estimated by the "fitting of constants" method, rather than by creating dummy variables, and estimates of the regression parameter 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 (H_0: $B = 0$) 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, the differences between districts can be isolated. The dummy variables whose *t*-statistics from the regression analysis are significant are the ones for which the null hypothesis that there is no difference can be rejected, with the conclusion 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

The statistical results are presented in the following three sections. The first section is for models having total employment as the dependent variable. The second section is for models developed at the sector level where sector employment is the dependent variable. The last section is for models in which the amount of expenditures on transportation maintenance and construction is the dependent variable.

Total Employment Models

Using the two pooled procedures, two equations for estimating total employment were developed, as outlined in the first structural relationship, total employment as a function of 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

$$\begin{aligned} \text{TOTES} = &- 337926.49 + 0.1454\ \text{RTES} \\ &+ 0.1058\ \text{RTE2S} + 0.0909\ \text{RTE4S} \\ &+ 3797.81\ \text{RPCPIM} \end{aligned} \tag{1}$$

and

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

Figure 1 shows the definitions of all model variables appearing in the equations and in the tables.

DUMi = **Intercept dummy variable for District *i*,**
$INT = **Intercept,**
ROILP4M = **Real oil price lagged 4 years,**
RPCPIM = **Real per capita personal income,**
RTES = **Real transportation expenditures,**
RTE1S = **Real transportation expenditures lagged 1 year,**
RTE2S = **Real transportation expenditures lagged 2 years,**
RTE3S = **Real transportation expenditures lagged 3 years,**
RTE4S = **Real transportation expenditures lagged 4 years,**
RTPIS = **Real total personal income,**
SEDUMi = **Total employment slope dummy for District *i*,**
SIDUMi = **Real total personal income slope dummy for District *i*,**
SPIDUMi = **Personal income slope dummy for District *i*,**
STEDUMi = **Real transportation expenditures slope dummy for District *i*, and**
TOTES = **Total employment.**

FIGURE 1 Definitions of model variables.

From these two equations, 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 2-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 2 years later, and then declining to 0.0324 4 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 effects 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 1 presents the standard errors, *t*-statistics, and significant dummy variable coefficients for the time series equation, Equation 1. This equation would be used to estimate effects on total employment assuming no cross-sectional shifts. The dummy variables in Equation 1 for which the null hypothesis (that there is no difference between

TABLE 1 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

these districts and District 1) was not rejected, are Districts 3, 5, 8, 11, 17, 19, 20, and 23.

The dummy variable coefficients presented in Table 1 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 earlier. This means that the employment effects 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 effects of $1 spent in Districts 4, 6, 7, 13, and 25 are less than for $1 spent in Districts 1, 3, 5, 8, 11, 17, 19, 20, and 23.

The amount of the difference for any particular significant district can be calculated by 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 152,657 from Table 1 to the intercept value of $-337{,}926.49$ in Equation 1.

The Durbin-Watson statistic of 0.462 in this time series model suggests the presence of autocorrelation. Autocorrelation is a condition in which 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 autocorrelation 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 autocorrelation in this model is apparently caused by 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 overcome most reasonable questions concerning validity of the results.

In order to correct for autocorrelation, the number of lagged variables used in the model specification was minimized. Preliminary models were tested excluding the lagged transportation expenditure variable. As expected, with these model specifications the Durbin-Watson statistic indicated a decrease in autocorrelation. 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 earlier, only variables for which county data, for all 254 counties, was available over the 18-year study period were possible candidates for inclusion.

Table 2 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

TABLE 2 TIME SERIES CROSS-SECTIONAL REGRESSION ESTIMATES (FULLER AND BATTESE METHOD) WITH TOTAL EMPLOYMENT AS THE DEPENDENT VARIABLE

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	0.0000	47.118
SPIDUM14	340.013	11.971	0.0000	28.404
SPIDUM15	358.087	13.813	0.0000	25.924
SPIDUM17	80.3471	2.4852	0.0133	32.330
SPIDUM18	2157.01	48.759	0.0000	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 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 2 that are coded as STEDUMi are the districts for which the expenditures on transportation have differing affects, and the SPIDUMi dummies are measuring the differing affects of personal income.

Sector Employment Models

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 for five industries. OLS time series equations were estimated for the construction, manufacturing, mining, services, and wholesale trade sectors. In each of these models, the dependent variable was total employment within that industry. The results of these sector models are presented in Tables 3–7.

Table 3 presents the statistical results and variable coefficients for the construction sector, indicating the district differences in impact on construction sector employment for a given change in the independent variables. Likewise, Table 4 presents the statistical results and variable coefficients for the manufacturing sector, and shows by district the different effects on manufacturing employment for a given change in the independent variables. Coefficients and significance statistics for mining sector employment impact are presented by district in Table 5. Table 6 presents the district differences on employment in the services sector, with the corresponding statistics and coefficients. Finally, Table 7 presents the different impacts by district that transportation expenditures and per capita income have on total employment for the wholesale trade sector.

The results of the industry analysis are uniform across the sectors. Transportation expenditures exhibited a positive relationship to the level of total employment, with one exception. That exception is in the manufacturing sector where, as indicated in Table 4, there is a negative relationship between manufacturing employment and expenditures on transportation 3 years earlier. This counterintuitive result is likely an idiosyncrasy of the aggregated data, or perhaps is a result of the autocorrelation introduced through the inclusion of the lagged variable, or the exclusion of other relevant variables.

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, presented in Table 7, was the only sector where there was not also a lagged positive relationship. Only in the manufacturing and mining sectors, Tables 4 and 5, was total employment affected by oil prices, and in both cases it was a negative relationship with the price of 4 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 expected. This variation 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. Likewise, the more rural districts in the state, Districts 4 (Amarillo), 6 (Odessa), 7 (San Angelo), and 13 (Yoakum) are similarly grouped with smaller employment impacts.

TABLE 3 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

TABLE 4 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

TABLE 5 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

TABLE 6 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

TABLE 7 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

Thus, when money is spent on transportation, it increases the level of employment in the highway districts. However, there is a difference 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.

Total Transportation Expenditures

Using the pooled procedures discussed earlier, equations for estimating the structural relationship of transportation expenditures were specified and tested in which transportation expenditures were a function of political variables, oil prices both current and lagged, per capita personal income and total employment.

The parameter estimates and standard errors for these estimates and their corresponding *t*-statistics are presented in Table 8 for the cross-sectional time series regression model. The coefficients for the significantly different dummy variables, Districts 2, 5, 12, 15, and 24, are also presented in the table. The variables representing oil prices in the current period and in the lagged periods were not significant in any of the expenditure models. Additionally, all of the political variables were found not to be significant. 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.

CONCLUSIONS AND RECOMMENDATIONS

A series of linear regression models was used to test structural relationships between total employment, expenditures on transportation construction and maintenance, and selected economic and political variables. Current and lagged variables were used in the analysis of the data using both pooled cross-sectional time series procedures, and pooled time series techniques. For the structural relationship in which 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 affect the amount of total employment. This impact appears to follow a 2-year cycle lasting 4 years. Per capita personal income is also highly significant in determining the level of employment.

There is 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 3 years in the manufacturing and mining sectors, and 4 years in the services sector. 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. For employment, the effect is stronger in the more populated districts.

For the model in which transportation expenditures is the dependent variable, only economic variables were found to be significant. 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.

As a result of this research, it is recommended that 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. Also, the differential effects on employment across industries can be estimated and included in strategic planning and policy formation regarding statewide economic diversification. Additional research should be initiated to further investigate the timing of impacts of highway policy and transportation expenditure decisions on the economic climate of the highway districts.

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TABLE 8 TIME SERIES CROSS-SECTIONAL REGRESSION ESTIMATES (FULLER AND BATTESE METHOD) WITH TRANSPORTATION EXPENDITURES AS THE DEPENDENT VARIABLE

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

REFERENCES

1. J. E. Anderson, R. W. Murray, and Edward L. Farley. *Texas Politics*. Harper & Row, New York, 1984.
2. T. R. Dye. *Politics, Economics, and the Public: Policy Outcomes in the American States*. Rand-McNally, Chicago, 1966.
3. T. R. Dye. *Understanding Public Policy*, 5th ed. Prentice-Hall, Englewood Cliffs, N.J., 1984.
4. K. Davis and W. C. Frederick. *Business and Society*. McGraw-Hill, New York, 1984.
5. *The National Economic Impact of No Federal Highway Funding*. The Road Information Program (TRIP), Washington D.C., 1987, 34 pp.
6. T. R. Dye and V. Gray. *The Determinants of Public Policy*. Lexington Books, Mass., 1980.
7. Y. J. Stephanedes and D. M. Eagle. Highway Expenditures and Non-Metropolitan Employment. *Journal of Advanced Transportation*, Vol. 20, No. 1, 1986, pp. 43–61.
8. *Barriers to Urban Economic Development*. U.S. Congress, Congressional Budget Office, Washington, D.C., 1978.
9. F. R. Wilson, A. M. Stevens, and T. R. Holyoke. Impact of Transportation on Regional Development. In *Transportation Research Record 851*, TRB, National Research Council, Washington, D.C., 1982, pp. 13–16.
10. E. C. Sullivan. Transportation and Economic Development on the Pacific Coast. *Institute of Transportation Studies Review*, Vol. 12, No. 1, Nov. 1988, p. 4.
11. J. Dewitt, S. S. Batie, and K. Norris. *A Brighter Future for Rural America? Strategies for Communities and States*. National Governors' Association, Center for Policy Research, Washington, D.C., 1988, 120 pp.
12. W. Cherwony. Casino Bus Transportation System. In *Transportation Research Record 984*, TRB, National Research Council, Washington, D.C., 1985, pp. 51–56.
13. C. C. Coughlin, and P. A. Cartwright. An Examination of State Foreign Export Promotion and Manufacturing Exports. *Journal of Regional Science*, Vol. 27, No. 3, 1987, p. 439.
14. I. Hock, K. Beron, D. Merriman, J. Gilbert, R. Straton, and W. Dixon. *Funding Transportation Needs in the North Central Texas Area*. Center for Applied Research, Report 88-34, No. 10, University of Texas at Dallas, Jan. 1987, 167 pp.
15. R. J. Roggenburk and R. K. Mufti. Transportation Planning for Enterprise Development Areas. In *Transportation Research Record 1046*, TRB, National Research Council, Washington, D.C., 1985, pp. 15–17.
16. C. J. Frederich and A. Weber. *Theory of Location of Industries*. University of Chicago Press, Chicago, Ill., 1929.
17. D. Carlton. The Location and Employment Choices of New Firms: An Econometric Model With Discrete and Continuous Endogenous Variables. *The Review of Economics and Statistics*, Vol. 65, 1983, pp. 440–449.
18. H. W. Herzog, A. M. Schlottmann, and D. L. Johnson. High-Technology Jobs and Worker Mobility. *Journal of Regional Science*, Vol. 26, 1986, pp. 445–460.
19. G. A. Carlino and E. S. Mills. The Determinants of County Growth. *Journal of Regional Science*, Vol. 27, No. 1, 1987, p. 39.
20. A. J. Siccardi. Economic Effects of Transit and Highway Construction and Rehabilitation. *Journal of Transportation Engineering*, Vol. 20, No. 1, Jan. 1986, pp. 63–75.
21. F. R. Wilson, G. M. Graham, and M. Aboul-Ela. Highway Investment as a Regional Development Policy Tool. In *Transportation Research Record 1046*, TRB, National Research Council, Washington, D.C., 1985, pp. 10–14.
22. R. Briggs. The Impact of the Interstate Highway System on Nonmetropolitan Development, 1950–80. *Beyond the Urban Fringe*, R. H. Platt and G. Machinko, eds., University of Minnesota Press: Minneapolis, 1983, pp. 83–105.
23. D. M. Eagle and Y. J. Stephanedes. Dynamic Highway Impacts on Economic Development. In *Transportation Research Record 1116*, TRB, National Research Council, Washington, D.C., 1987, pp. 56–62.
24. Y. J. Stephanedes and D. M. Eagle. Highway Impacts on Regional Employment. *Journal of Advanced Transportation*, Vol. 21, Spring 1987, pp. 369–389.
25. L. M. Crane and D. J. Leatham. *The Distributed Lag Between Transportation Expenditures and Rural Income and Employment*. Texas Agricultural Experiment Station Technical Article 25261, Texas A&M University, College Station, 1990, 20 pp.
26. B. F. Hoselitz, J. J. Spengler, J. M. Letiche, E. McKinley, J. Buttrick, and H. J. Bruton. *Theories of Economic Growth*. The Free Press, Glencoe, Ill., 1960.
27. M. L. Jhingan. *The Economics of Development and Planning*. Vikas Ltd., New York, 1975.
28. A. L. Politano and C. J. Roadifer. Regional Economic Impact Model for Highway Systems (REIMHS). In *Transportation Research Record 1229*, TRB, National Research Council, Washington, D.C., 1989, pp. 43–52.
29. E. Weiner and W. C. Graeub. The Current Need for Research in Transportation Management, Administration, and Planning. *TR News 127*, 1986, pp. 11–14.
30. C. E. Lindblom. The Science of "Muddling Through." *Public Administration Review*, Vol. 19, 1959, pp. 69–88.
31. S. Krislov and D. H. Rosenbloom. *Representative Bureaucracy and the American Political System*. Praeger Publishers, New York, 1981.
32. R. E. Dawson and J. A. Robinson. Inter-Party Competition, Economic Variables, and Welfare Policies in the American States. *Journal of Politics*, Vol. 25, 1963, pp. 265–289.
33. B. R. Fry and R. F. Winters. The Politics of Redistribution. *The American Political Science Review*, Vol. 64, 1970, pp. 508–522.
34. I. Sharkansky and R. I. Hofferbert. Dimensions of State Politics, Economics, and Public Policy. *American Political Science Review*, Vol. 63, 1969, pp. 867–879.
35. R. Salisbury and J. Heinz. A Theory of Policy Analysis and Some Preliminary Applications. *Policy Analysis in Political Science*, I. Sharkansky, ed. Markham, Chicago, Ill. 1968, pp. 151–175.
36. T. J. Lowi. American Business, Public Policy, Case-Studies, and Political Theory. *World Politics*, Vol. 16, 1963, pp. 677–715.
37. T. R. Dye. Taxing, Spending, and Economic Growth in the American States. *The Journal of Politics*, Vol. 42, 1980, pp. 1085–1107.
38. D. J. Forkenbrock and K. J. Plazak. Economic Development and State-Level Transportation Policy. *Transportation Quarterly*, Vol. 40, 1986, pp. 143–157.
39. A. A. Altshuler. Changing Patterns of Policy: The Decision-Making Environment of Urban Transportation. *Public Policy*, Vol. 25, 1977, pp. 171–203.
40. *Texas Almanac and State Industrial Guide*. Dallas Morning News, Dallas, Tex., 1988–1989.
41. *Texas State Legislative Handbook, 71st Session*. Texas State Directory Press, Inc., Austin, Tex., Jan. 1989.
42. *Texas Railroad Commission Annual Report*. Texas Railroad Commission, Oil and Gas Division, Austin, Tex., 1986.
43. *Economic Report of the President*. U.S. Government Printing Office, Washington, D.C., Feb. 1988, 374 pp.
44. D. N. Gujarati. *Basic Econometrics*. McGraw-Hill, New York, 1988.
45. R. S. Pindyck and D. L. Rubinfield. *Econometric Models and Economic Forecasts*. 2nd ed., McGraw-Hill, St. Louis, Mo., 1981, 630 pp.
46. J. Johnston. *Econometric Methods*. 2nd ed., McGraw-Hill, St. Louis, 1972, 437 pp.
47. D. J. Drummond and A. R. Gallant. The TSCSREG Procedure. *SUGI Supplemental Library User's Guide*, SAS Institute Inc., Cary, N.C., 1983.
48. W. A. Fuller and G. E. Battese. Estimation of Linear Models with Crossed-Error Structure. *Journal of Econometrics*, Vol. 2, 1974, pp. 67–78.

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