EMPLOYMENT AND INCOME IMPACTS OF HIGHWAY EXPENDITURES ON BYPASS, LOOP AND RADIAL HIGHWAY IMPROVEMENTS

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

LENGTH

Symbol	When You Know	Multiply By	To Find	Symbol
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

Symbol	When You Know	Multiply By	To Find	Symbol
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)

Symbol	When You Know	Multiply By	To Find	Symbol
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

VOLUME

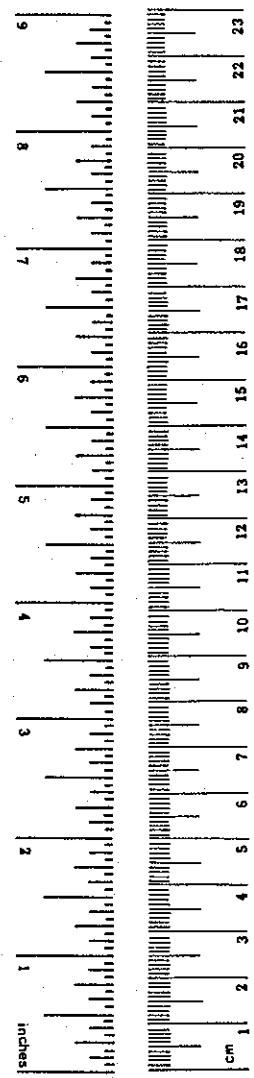
Symbol	When You Know	Multiply By	To Find	Symbol
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

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

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°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

LENGTH

Symbol	When You Know	Multiply By	To Find	Symbol
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

Symbol	When You Know	Multiply By	To Find	Symbol
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)

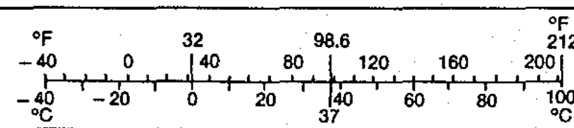
Symbol	When You Know	Multiply By	To Find	Symbol
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T

VOLUME

Symbol	When You Know	Multiply By	To Find	Symbol
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)

Symbol	When You Know	Multiply By	To Find	Symbol
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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

PREFACE

The authors are indebted to Messrs. Alvin Luedecke, Robert Cuellar and Thomas A. Griebel of the Texas State Department of Highways and Public Transportation (SDHPT) for their assistance in this study.

The Texas Transportation Institute staff assisting with this portion of the study includes Messrs. Lawrence Crane and Nat Pinnoi who assisted with the data base preparation. Mrs. Brenda Hazelwood and Mrs. Margaret Chui assisted in the report preparation.

The contents of this report reflect the views of the authors and do not necessarily represent the official views or policies of the Federal Highway Administration or the State Department of Highways and Public Transportation. This report does not constitute a standard, a specification, or a regulation.

SUMMARY OF FINDINGS

The objective of this study is to develop economic models that document significant growth and development in relation to highway expenditures. The results reported here are based on highway expenditures on specific highway improvements, such as, bypasses, loops and radials. Actual dollar amounts are not used in developing the relationship between key economic development variables, because it is difficult to establish the total cost of each highway improvement.

The data base is composed of 67 new location improvements constructed over the past 30 years as follows: (1) 40 bypasses, (2) 20 loops, and (3) 7 radials. Data are collected on 34 variables which are of the economic, highway system, geographic or locational, and time related type. Three key economic variables are studied in detail as follows: (1) number of manufacturing employees in a study city, (2) number of employees in a study county, and (3) the total actual or real wages in a study county. Four years of data are collected on each variable so that a cross-sectional and a combined cross-sectional and time-series analysis could be accomplished. The regression models used in the analysis are of the single linear equation type and are solved by the ordinary least squares method or the pooling method. Since at least one year of data represents both a "before or after construction" situation, a dummy "before versus after construction" variable could be used in the combined cross-sectional and time-series analysis.

Two models are developed for each of the key economic variables: one for the one-year cross-sectional analysis and the other for the four-year combined or pooled analysis. The three models based on the one-year cross-sectional analysis show statistically significant relationships between the key economic variables and highway improvement variables. However, the three models based on the four-year combined or pooled analysis show these effects more clearly and accurately than those based on the one-year cross-sectional analysis, because the "before versus after construction" approach could be used. Also, corrections could be made for serial correlation and heteroskedasticity.

Some of the more specific findings based on the above analysis are as follows:

(1) The "before versus after construction" variable is positive and statistically significant in the models estimating employment and real wages of study counties and is positive but not statistically significant in models estimating manufacturing employment of study cities.

(2) Bypass highway improvements have a statistically significant and positive influence on the number of employees of study counties and a positive but not quite statistically significant influence on a study city's manufacturing employment and a study county's real wages.

(3) Loop improvements have a statistically significant and positive influence on the number of employees and total real wages of counties.

(4) Radial improvements have a statistically significant and positive influence on a study city's manufacturing employment and a statistically significant and negative influence on a study county's employment and real wages.

IMPLEMENTATION STATEMENT

The research results presented in this report can be implemented by the Texas State Department of Highways and Public Transportation and by other highway and transportation agencies.

Procedures for Estimating Economic Impacts of Highway Expenditures

Regression models developed in the study can be used to estimate the employment and income impacts of highway expenditures for building bypass, loop and radial highways in urban areas. The equations that generate the most reliable estimates are those developed from the four data base using the combination cross-sectional and time-series procedure applied on a "before versus after construction" basis. Also, the estimates of other procedures, such as input-output multipliers applied to the actual dollars of proposed expenditures for highway bypasses, loops or radials, can be compared to these results.

Estimated Economic Impacts of Highway Expenditures

The estimated economic impacts presented in this report can be used by highway and transportation agencies to prepare environmental assessments and to inform the public of possible impacts of expenditures of tax dollars used for building major highway improvements as highway bypasses, loops and radials.

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INTRODUCTION

Objective of Study

This report is the third of four that presents findings of the study entitled "Impact of Highway Construction Expenditures on Economic Growth, Tourism, Planning Policies and Transportation." The general objective of this study is to develop economic models that document significant relationships between economic variables which measure growth and development and highway expenditures. This objective has three sub-objectives:

(1) To prepare economic models or techniques to analyze macro and micro effects of highway expenditures;

(2) To perform a case study analysis of the role of highway expenditures in the development of the tourism industry on the Texas Gulf Coast; and

(3) To examine how the highway planning and decision-making process can best incorporate economic development criteria and considerations into the policy and procedures of the State Department of Highways and Public Transportation (SDHPT).

This report presents an analysis of the employment and income impacts of highway expenditures on specific highway improvements, such as bypasses, loops and radials. The vast majority of all the highway bypasses and loops constructed in the state are used in this analysis. Due to the difficulty of establishing the total cost of each of these improvements, actual dollar amounts are not used in developing the relationship between key economic development variables and highway expenditures. Alternatively, the key economic variables are related to other economic, locational, highway system, geographic and time-related variables. The results show the average impact of a bypass, loop or radial highway improvement on the key economic variables of a city or county having such improvements.

Literature Review

The literature review reveals several references which deal with the problem of establishing the relationship between highway construction expenditures and economic growth and development. Several studies show a significant link between economic development and highway expenditures [1,2,3]. Other studies show a positive correlation between transportation expenditures and regional economic variables, such as employment growth rates, manufacturing activity, and population [4,5]. There are studies which indicate that transportation costs and accessibility can affect the number of job seekers in a particular area and thus affect the size of the labor force available for hiring by interested firms [1,6,7,8,9]. Even a significant relationship between highway expenditures and rural employment is established in one study [1]. Large scale models tend to show that positive relationships exist between economic activity and transportation expenditures [1,10,11].

Models and techniques used in estimating the overall and specific sector effects of changes in highway expenditures on U.S. output and employment are also reported in the literature [7,10,11]. The Chase macroeconomic model and input-output models are examples [10]. The Texas input-output model provides multipliers for estimating the impacts of highway construction on employment and income in Texas [11]. Finally, the literature reports various studies which estimate the local effects of highway construction on employment, income, and\or land use [12-17].

Stephanedes and Eagle [18] do a good job discussing the various types of models used to estimated the impact of highway expenditures on employment and income. They analyze the following procedures: (1) input-output, (2) cross-sectional, 13) time-series, and (4) pooled cross-sectional with time-series. These researchers conclude that the input-output models produce mixed results; cross-sectional models only determine the correlation between highways and development; times-series models differentiate the effects of highways on development from the effects of development on highways; and pooled cross-sectional and time-series models determine the correlation between highways and development and also determine the effects of development on highways. These researchers prefer using the pooled model which is described in detail by Kmenta [19] and computerized by White and Horsman [20].

EVALUATION TECHNIQUES AND DATA BASE

Evaluation Techniques Applied

After a thorough examination of the existing models and techniques reported in the literature, two basic types of models are applied as evaluation techniques in this part of the study as follows: (1) models using a cross-sectional data base and (2) models using a combination times-series and cross-sectional data base. Further, each model uses a single linear multiple regression equation and uses the ordinary least squares method to estimate it. Also, continuous and binary variables are used in each equation. The resulting equations show the statistically significant relationships between the selected economic impact variables and the various explanatory variables. No variable is used in these models to reflect general changes in the Texas economy over time. The models using only cross-sectional data do not need such a variable included to obtain results that can be used to make inferences with respect to highway expenditure impacts. Also, the results of models using one-year cross-sectional data confirm the results of models using multi-year combined cross-sectional and time-series data. Since the second set of models also use cross-sectionally based data, it does not seem critical to include a variable to reflect general economic conditions over time in the state.

The results generated by these models can be used to place an upper limit on estimates of the total economic impact resulting from expenditures for such highway improvements in a city or county. Also, these results can be compared with the estimates obtained by using multipliers generated by the Texas input-output model [11] with actual dollar amounts spent on such improvements.

Models Using Cross-Sectional Data

Models using cross-sectional data help to measure microrelationships between the key economic variables and the explanatory variables at one point in time. For example, it is helpful for the highway planner to know that the variable "distance to equal or larger city" explains a significant amount of variation in the employment of a county where a major highway improvement is constructed, no matter which data year is used to estimate the model. In other words, this variable is not time-related. However, the basic problem in using only cross-sectional data in these models is heteroskedasticity, a condition which violates the assumption that the error variances are constant[19]. In such cases, the ordinary least squares estimation places more weight on observations with large error variances than on those with small error variances, keeping the variances of estimated parameters from being minimum variances. The resulting estimated parameters are still unbiased and consistent but not efficient. The extent of this problem can be measured with appropriate statistical tests.

Models Using Combination of Cross-Sectional and Time-Series Data

Models based on a combination of cross-sectional and time-series data help measure microrelationships and macrorelationships between the key economic variables and the explanatory variables, because they are based on multiyear data. Time-series data are used primarily to development macrorelationships. However, the use of time-series data has a problem of causing serial correlation, a condition which violates the assumption that the errors of the different observations are uncorrelated. Therefore, these models have to deal with both heteroskedasticity and serial correlation. These problems are more pronounced in ordinary least squares models than in models using the pooling technique, because the pooling technique transforms the data before applying the ordinary least squares estimation. The transformation is made on each observation to adjust for heteroskedasticity and serial correlation. Again, the extent of these problems in a particular model can be measured with appropriate statistical tests.

The pooled model is a single multiple regression equation, as described by Kmenta [19], and is processed by SHAZAM, an economic computer program written by White and Horsman [20]. The Kmenta model requires that all years of each cross-section be arranged together in consecutive order, and SHAZAM, using the "SAME" option, restricts all cross-sections to have the same autoregressive parameter, as described in the Kmenta model. As a result, the model yields regression residuals that are nonheteroskedastic and nonautoregressive. Therefore, the regression coefficients are efficient, consistent and unbiased.

Data Base Developed

As indicated above, the data base is designed to establish the statistical relationship between key economic variables and explanatory variables for specific types of highway improvements. The data base is restricted to major highway improvements, such as bypasses, loops and radials. The data base contains 67 highway improvements which include 40 bypasses, 20 loops and 7 radials. The criteria for selecting these highway improvements are as follows: (1) be improved with at least one segment completed after 1955 and before 1984, (2) be located in a city of over 4000 population, and (3) be built on new location.

The data base sources are the following: <u>Texas Almanacs</u>, U.S. Bureau of Census <u>County and City Data Books</u>, Texas Employment Commission quarterly reports, Texas directories of manufacturers, city maps, and SDHPT highway road and traffic maps.

To conduct a combination cross-sectional and time-series analysis using a "before versus after construction" approach, more than one year of data is required for each highway improvement studied. Therefore, the data base contains four years of data for each of the 67 highway improvements. The first year of data is 1954, which is selected as the first "before construction" year for all 67 improvements. The last year of study is 1988, which is at least five years after completion of each improvement. Also, data are collected for two interim years. The first interim year, 1961, is a "before construction" year for some improvements and an "after construction" year for others. The second interim year, the map year, is considered a "before construction" year. It represents the year before the highway improvement shows up on the state highway map.

Some of the data for certain variables do not perfectly match one or more on of the above data years, but none are off more than three years. Where possible, the data is adjusted by extrapolating between two actual data years.

Table 1 gives a list of 34 basic variables which make up the data base. The variables are listed by type, name and location on the left side of the table. Also, the primary functional relationship of each variable is indicated on the right side. There are 13 economic variables, 14 highway system descriptive variables and 7 geographic and time variables. Only those of the economic type are used as dependent variables, because they are considered more or less dependent on the other variables making up the data base. All but two of the variables are considered continuous. The other two categories are expanded into four binary or dummy variables. These are defined as follows:

Type of new highway route, city - expanded to:

Bypass = 1, otherwise = 0,

Loop = 1, otherwise = 0, and

Radial = 1, otherwise = 0.

Before vs. after construction - expanded to:

After construction = 1, otherwise = 0.

Some of the other variables are combined in various ways or changed into log form and tried in one or more of the analyses or models. [See additional discussion on page 16.]

Table 1. Variables Used in Cross-Sectional and Combined Cross-Sectional and Time-Series Analysis

Variable by Type, Name and Location	Functional Relationship	
	Dependent	Explanatory
Economic Development		
Population, county		X
Population, city		X
Firms, commercial, city	X	
Firms, manufacturing, city	X	
Employed, county	X	
Employed, city	X	
Employed, manufacturing, city	X	
Employed, manufacturing, old route, city	X	
Employed, manufacturing, new route, city	X	
Wages, ths. of dollars, county**		X
Bank deposits, ths. of dollars, county**		X
Oil produced, barrels, county		X
Vehicles registered, county		X
Highway System Description		
Hubs, city		X
Continuous highways, city		X
Terminal highways, city	X	
State highways, city		X
U.S. highways, city		X
Interstate highways, city	X	
ADT (1985), incoming highways, city		X
ADT (1985), new highway route, city		X
Type of new highway route, city	X	
Shape of new route segments, city		X
Number of new route segments, city		X
Construction time, all new segments, city	X	
Length, new route, city		X
Length, old route, city		X
Distance, between old and new routes, city		
Geographic and Time		
Distance to nearest major city, state		X
Distance to equal or larger city, state		X
Distance to Gulf coast, state		X
Age of first new route segment, city		X
Age of last new route segment, city		X
Before vs. after construction, city		X

**In actual dollars in cross-sectional analysis and in constant 1954 dollars in the combined cross-sectional and time-series analysis.

RESULTS OF ANALYSES

The results of the cross-sectional analysis and the combined cross-sectional and time-series analysis are presented separately below. The final models of each analysis are described and discussed in detail, including the amount of explained variation, level of statistical significance of each variable, and the appropriate test results.

Cross-Sectional Analysis

The results of the cross-sectional analysis are presented separately for three selected economic variables, namely: (1) number of manufacturing employees in study city; (2) number of all employees in study county; and (3) total actual wages in study county. These three economic variables are considered the most feasible for indicating the employment and income impacts resulting from spending highway dollars to construct bypasses, loops and radials. As is evident in the study cities and counties over the state, many businesses locate or relocate along these new highway improvements. In some cases, so many firms locate along these new transportation arteries that they cause traffic congestion on them in just a few years.

Number of Manufacturing Employees in City

Table 2 shows Model 1 which uses one-year cross-sectional data to estimate the number of manufacturing employees in a city impacted by a highway improvement. For comparative purposes, the results are shown for two data years, 1954 and 1988, respectively. It should be recalled that 1954 is the true "before construction" year and 1988 is the true "after construction" year. Many combinations of variables are used in this model before deciding on the final sets shown in Table 2. Both of the data years have the same explanatory variables. Multiple collinearity is at a minimum, the signs of the regression coefficients are appropriate, and the variables used are expected to independently influence the variation in the number of manufacturing employees in a city with a highway

Table 2. Model 1. Coefficients for Estimating Number of Manufacturing Employees in City, Using Cross-Sectional Analysis

Explanatory Variable	1954 Data Base Regression Coefficient	1954 Data Base T-Ratio[a]	1988 Data Base Regression Coefficient	1988 Data Base T-Ratio[a]
Constant term	-1966	-0.92	-2098	-1.07
Number of U.S. highways	1792	2.95	1621	2.83
Number of State highways	1808	3.26	1404	2.68
Distance to equal or larger city[b]	-168.97	-10.89	-118.34	-7.87
Distance between old and new routes[b]	1124.49	1.52	1922.36	2.92
Population of City	0.1189	19.33	0.07622	35.66
Radial improvement	2977	0.62	6681	2.83
Bypass improvement	1597	1.01	544	0.37
R^2 statistic	0.98		0.99	
F statistic	341		736	
Durbin-Watson statistic	1.42		1.29	
Standard error of regression	4386		4147	

[a] T-ratios of 2.00 or greater are statistically significant 95% or more of time.
[b] In miles (00.00).

improvement. The standard error of regression is at or near the minimum for both data years and the amount of explained variation is very high, as indicated by the R-squares and confirmed by the high F-values. However, the Durbin-Watson statistic is a little low, indicating that some serial correlation is present in the model. A Durbin-Watson statistic of about 2 would indicate the presence of no serial correlation. No correction is made for serial correlation because it is not a relevant problem for the one-year cross-sectional analysis. No test is performed to determine if heteroskedasticity is a problem in this model, because such corrections are made in the combination or pooled analysis to be presented later. [For example, see results presented in Table 5 on page 17.]

Comparing the results of the two data years, Model 1 shows that the building of a radial highway in a city does have a statistically significant positive influence on the number of manufacturing employees in that city. Also, the distance between the old and new routes has a statistically significant influence. As the distance between these routes increases, the number of manufacturing employees increases. In the case of the type of highway improvement, building a bypass has a positive but not statistically significant influence on the number of manufacturing employees. The extent of a loop highway's influence cannot be shown explicitly in the model when the two other dummy variables describing the type of highway improvement are used as explanatory variables. Otherwise, the regression equation could not be solved. In this model, the influence of loops is included in the error term. Of the three, the loop dummy variable is the least correlated with the other independent variables in the different models. In many cases, it is not significantly related to the other independent variables. Therefore, its inclusion in the error term should not result in an autocorrelated error term.

All of the other explanatory variables in Model 1 have a statistically significant influence on manufacturing employment. Two of these are highway related, namely, the number of U.S. highways and the number of state highways. As the number of these highways increases, the number of manufacturing employees increases. The distance to an equal or larger city has a negative influence on the number of manufacturing employees. Of all the explanatory variables in the model, the population of the city has the greatest statistically significant influence on manufacturing employment. Also, the city population explains more variation and helps the model to be more consistent than some of the other variables which are highly correlated with manufacturing employment.

Number of Employees in County

Table 3 shows Model 2 which estimates the number of employees in a county with two one-year data bases. About the same results are obtained in Model 2 as in Model 1. The same explanatory variables are used to obtain the best statistical results. Model 2 explains a high amount of variation in the number of employees in a county containing one of these highway improvements, as evidenced by the high R-squares and again confirmed by the high F-values. About the same statistical relationships exist for Model 2 as exist for Model 1. The only exception is the change in the relationship between the two highway improvement variables and the number of employees in a county. In Model 2, a bypass improvement significantly affects the number of county employees, where in Model 1, radial improvements significantly affect the number of manufacturing employees in a city. Apparently, manufacturing firms prefer to locate along radial highways, whereas, other firms prefer to locate on bypass improvements.

By comparing the results of the two data bases used for Model 2, several differences are observed. The first is the varied level of statistical significance of the two highway improvement variables. The 1988 data base produces more highly significant regression coefficients than does the 1954 data base which is the expected result. Since none of the highway improvements had been built in 1954, the coefficients generated by the 1954 data base should be statistically significant. However, one being significant may result partially from the anticipatory effects of a planned highway improvement. It usually takes several years to plan and build such highway improvements. As soon as businesses know the location of a planned bypass or loop around a city, some will purchase adjacent sites, build the facilities and start operating before the highway improvement is built or opened for use, especially if the facility follows or intersects existing roads in the area. The second difference observed is the significantly higher standard error of regression obtained with the

Table 3. Model 2. Coefficients for Estimating Number of Employees in County, Using Cross-Sectional Analysis

Explanatory Variable	1954 Data Base Regression Coefficient	1954 Data Base T-Ratio[a]	1988 Data Base Regression Coefficient	1988 Data Base T-Ratio[a]
Constant term	-16614	-2.58	-134626	-5.49
Number of U.S. highways	2554	1.40	22476	3.12
Number of State highways	7500	4.50	37462	5.72
Distance to equal or larger city[b]	-306.99	-6.59	-837.64	-4.45
Distance between old and new routes[b]	2351.57	1.06	22973	2.78
Population of City	0.3581	19.39	0.6580	24.60
Radial improvement	-16742	-1.16	60452	1.20
Bypass improvement	10596	2.24	52059	2.80
R^2 statistic	0.97		0.98	
F statistic	277		377	
Durbin-Watson statistic	1.53		1.35	
Standard error of regression	13170		51889	

[a] T-ratios of 2.00 or greater are statistically significant 95% or more of time.
[b] In miles (00.00).

1988 data base compared to that obtained with the 1954 data base. The standard errors of regression for both data bases in Model 1 are about the same. Such results would suggest that for various reasons the number of county employees fluctuated more between 1954 and 1988 than did the number of city manufacturing employees. Total employment in some counties apparently grew much faster than did manufacturing employment in the corresponding cities. The third difference observed is the statistically significant variable "number of U.S. highways" obtained only with the 1988 data base. Such a result indicates that U.S. highways have become more attractive to businesses in recent years.

Total Actual Wages in County

Table 4 shows the Model 3 results from using one-year cross-sectional data bases to estimate the total actual wages in a county. Once again, the same explanatory variables, as used in Models 1 and 2, are also the most feasible to use in Model 3. Generally, the same results are obtained in Model 3, as in both the other models, especially Model 2. The only exception is the fact that the regression coefficient for the variable "distance between the old and new routes" in Model 3 is not quite statistically significant using the 1988 data base compared to Model l.

The effects of the highway improvement are not as clear-cut in Model 3 as in the other two models. It takes the combined cross-sectional and time-series analysis to clarify the effects of these types of highway improvements on the above three economic impact variables.

Combined Cross-Sectional and Time-Series Analysis

As discussed above, the combined cross-sectional and time-series analysis is performed by using a multiple regression technique described by Kmenta [19] and executed with a computer program written by White and Horsman [20]. Also, it should be recalled that the data base has four years of data, each year having 67 observations, resulting in a combined data base of 268 observations.

Table 4. Model 3. Coefficients for Estimating Total Actual Wages in County, Using Cross-Sectional Analysis

Explanatory Variable	1954 Data Base Regression Coefficient	1954 Data Base T-Ratio[a]	1988 Data Base Regression Coefficient	1988 Data Base T-Ratio[a]
Constant term	-65974	-2.13	-3568511	-4.89
Number of U.S. highways	12276	1.41	516093	2.42
Number of State highways	33608	4.21	1104246	5.66
Distance to equal or larger city[b]	-1597	-7.15	23544.51	-4.20
Distance between old and new routes[b]	10756.84	1.01	464529.64	1.89
Population of City	1.4319	16.18	16.4995	20.72
Radial improvement	-86500	-1.25	-43264	-0.03
Bypass improvement	45344	2.00	1495349	2.70
R^2 statistic	0.96		0.97	
F statistic	191		244	
Durbin-Watson statistic	1.49		1.45	
Standard error of regression	63123		1545318	

[a] T-ratios of 2.00 or greater are statistically significant 95% or more of time.
[b] In miles (00.00).

The same economic impact variables used in the cross-sectional analysis are also used in this analysis. The same explanatory variables listed in Table 1 are tried out in this analysis, except for adding the dummy variable which indicates the general "before versus after construction" effects. For comparative purposes, the analysis is run also on an ordinary (nonpooled) least squares basis. The results of the three economic impact variables are presented separately below.

Number of Manufacturing Employees in City

The results of Model 4, which estimates the number of manufacturing employees in a city, are presented in Table 5. All but two of the explanatory variables used in this model are used in Models 1, 2 and 3, and since time-series data are also included in the Model 4 data base, a "before versus after construction" variable is added. Again, many combinations (approximately 30) of explanatory variables were used in this analysis before obtaining the best overall sets for this model. Also, the dependent variable and several explanatory variables were tried in log form. In addition several explanatory variables were combined. For example the number of U.S. highways was combined with the number of state highways, and the average daily traffic(ADT) on incoming highways on one side of the city was combined with the same on the other side of the city. Multiple collinearity is at or near a minimum; the standard errors of estimate are near a minimum; and the amounts of explained variation are relatively high, as evidenced by the R-squares and confirmed by the F-values.

Table 5 shows the results of the ordinary least squares approach as well as the pooled approach. Compared with the ordinary least squares approach, the pooled analysis yields a lower R-square and F-value. However, the Durbin-Watson statistic is much higher for the pooled analysis, which properly corrects for serial correlation in the error term. Therefore, the regression coefficients of the pooled approach are more efficient, consistent and unbiased than those of the other approach.

The results of Model 4 generally confirm the results of Model 1 by indicating that manufacturing employment in an affected city is positively affected by highway

Table 5. Model 4. Coefficients for Estimating Manufacturing Employment in City, Using Combined Cross-Sectional and Time-Series Analysis

Explanatory Variable	Ordinary Least Squares Regression Coefficient	Ordinary Least Squares T-Ratio[a]	Pooled Regression Coefficient	Pooled T-Ratio[a]
Constant term	-3818	-2.34	-685	-0.98
Distance to equal or larger city[b]	-166.83	-13.48	-101.64	-9.15
Distance between old and new routes[b]	4979.20	10.05	2541.20	6.91
Before versus after construction	-1097	-1.10	210	1.19
Bypass improvement	3441	2.66	763	1.75
Radial improvement	26101	8.64	23467	7.49
Population of city	0.07793	31.35	0.0722	20.13
R^2 statistic	0.95		0.88	
F statistic	798		323	
Durbin-Watson statistic	1.11		1.72	
Standard error of regression	7268		0.84	

[a] T-ratios of 2.00 or greater are statistically significant 95% or more of time.
[b] In miles (00.00).

improvements, such as those included in the study. Even though it is not statistically significant, the "before versus after construction" variable is positively related to manufacturing employment. Also, the other variables directly related to the highway improvement are positively related to manufacturing employment, and two are statistically significant. Radial highway improvements influence manufacturing employment more than do bypass improvements, because some manufacturing firms prefer to locate along new routes leading directly into the central business district of a city. This is not to say that manufacturing firms don't locate along bypasses or loops. In fact, some do. Also, nonmanufacturing firms locate along radial improvements, but such firms are more attracted to bypasses and loops. The distance between the old and new routes significantly influence manufacturing employment in a positive way, which tends to confirm that manufacturing firms like to locate along all three types of improvements.

Finally, the regression coefficients of Model 4's pooled approach are more efficient, consistent and unbiased than those of Model 1, because correction is made for heteroskedasticity and autocorrelation. Also, the Model 4 results, as shown in Table 5, give more definite indications of the positive effects of such highway improvements on the number of manufacturing employees in an affected city than those indicated in Model 1, as shown in Table 2. For example, the explanatory variables "distance between old and new routes" and "radial improvement" are more highly significant in Model 4 than in Model 1. Also, the explanatory variable "bypass improvement" is almost statistically significant iyn Model 4, whereas in Model 1, this variable is nowhere near being statistically significant.

Number of Employees in County

Table 6 presents the results of Model 5 which estimates the number of employees in a county by using the ordinary least squares analysis and combined or pooled analysis with a four-year data base. Again, the same explanatory variables are used in this model as used in Model 4. About the same results are obtained for the two analyses. Even though the R-square and F-values are not quite as high, the pooled analysis yields more efficient and accurate regression coefficients than the ordinary least squares analysis. The critical

Table 6. Model 5. Coefficients for Estimating Number of Employees in County, Using Combined Cross-Sectional and Time-Series Analysis

Explanatory Variable	Ordinary Least Squares Regression Coefficient	Ordinary Least Squares T-Ratio[a]	Pooled Regression Coefficient	Pooled T-Ratio[a]
Constant term	-13662	-0.88	2249	0.26
Distance to equal or larger city[b]	-302.89	-2.58	-328.11	-4.05
Distance between old and new routes[b]	-5572.10	-1.18	-4090.90	-1.45
Before versus after construction	48812	5.18	11619	4.22
Bypass improvement	18857	1.53	12290	2.02
Radial improvement	-116990	-4.07	-171710	-4.32
Population of city	0.67218	28.46	0.7156	16.12
R^2 statistic	0.88		0.83	
F statistic	326		218	
Durbin-Watson statistic	1.65		1.80	
Standard error of regression	69045		0.61	

[a] T-ratios of 2.00 or greater are statistically significant 95% or more of time.
[b] In miles (00.00).

"before versus after construction" variable of Model 5 is highly significant and indicates that a highway improvement, such as one of those studied, positively impacts employment in the affected county. The results of Model 5 also show that bypass improvements have a statistically significant and positive effect on county employment, whereas, radial improvements have the opposite effect. Bypass improvements are usually longer and further away from congested downtown areas, thus providing access to new shopping centers and other developments on large and less expensive sites. On the other hand, radial improvements are probably the least desirable of the three types of improvements to attract county imployment. However, the authors cannot explain why radial improvements would reduce total county imployment.

When the results of Models 4 and 5 are compared, the effects of the two highway improvement variables are shown to be different for city manufacturing employment than for county employment. Also, this difference is supported by a change in the "distance between old and new routes" variable which is positively related to manufacturing employment and negatively related to general county employment. Firms other than those of the manufacturing type prefer to locate on highway improvements that are notso far removed from the old centers of business activity in a county. However, both manufacturing and other types of employment are negatively affected by the distance to an equal or larger city.

Again, the Model 5 pooled analysis, using a four-year data base, presents additional indications of the impact of new highway improvements on county employment not presented by the Model 2 ordinary least squares analysis, using a one-year base. Model 5 shows that radial improvements are significantly and negatively related to county employment, whereas Model 2 shows insignificant and mixed results for this variable. Also, the Durbin-Watson statistic is higher for Model 5 than for Model 2. Therefore, the Model 5 regression coefficients are more efficient than those of Model 2, being more free of heteroskedasticity and serial correlation.

Total Real Wages in County

Table 7 shows the Model 6 results of estimating total real wages in a county by using the ordinary least squares analysis and pooled analysis, both with a four-year data base. This final model uses the same explanatory variables as used by Models 4 and 5. The R-squares and F-values of this model are somewhat lower than those obtained for the two previous models. The Durbin-Watson statistic for the pooled analysis of this model is highest of the three models, indicating that its regression coefficients are the most efficient. In other words, all heteroskedasticity and serial correlation are removed. Model 6 also shows the same relationships for the variables used to estimate real wages as shown by Model 5, which estimates the number of county employees. Since county wages are highly correlated with county employment, the same relationships among the explanatory variables are expected to exist. Model 6 shows that the "distance between the old and new routes" variable is statistically significant, but Model 5 shows it to be insignificant. Also, Model 6 shows that the "bypass improvement" variable is not significant, whereas Model 5 shows this variable to be significant.

About the same results are obtained by the ordinary least squares analysis as obtained by the pooled analysis, with both using the same explanatory variables. The R-square and F-statistic are lower for the pooled analysis, but the Durbin-Watson statisticis larger, even approaching 2.00 which indicates a full correction for serial correlation and heteroskedasticity. Using the four-year data base is superior to using a one-year data base, because it allows for a "before versus after construction" analysis and for a pooled cross-sectional and time-series analysis, which yields regression coefficients that are nonheteroskedastic and nonautocorrelated. One reason for the difference in results may be due to the use of total actual wages in the one-year data base model and total real wages in the four-year data base model.

Table 7. Model 6. Coefficients for Estimating Total of Real Wages in County, Using Combined Cross-Sectional and Time-Series Analysis

Explanatory Variable	Ordinary Least Squares Regression Coefficient	Ordinary Least Squares T-Ratio[a]	Pooled Regression Coefficient	Pooled T-Ratio[a]
Constant term	-37236	-0.39	37100	0.68
Distance to equal or larger city[b]	-1779.30	-2.42	-1818.30	-3.30
Distance between old and new routes[b]	-58966	-2.01	-44576	-2.35
Before versus after construction	262530	4.46	55438	3.64
Bypass improvement construction	107770	1.40	70134	1.82
Radial improvement	-915230	-5.11	-1404600	-5.35
Population of city	3.7186	25.22	4.1724	14.17
R^2 statistic	0.84		0.74	
F statistic	228		126	
Durbin-Watson statistic	1.56		1.90	
Standard error of regression	430960		0.64	

[a] T-ratios of 2.00 or greater are statistically significant 95% or more of time.

SUMMARY AND CONCLUSIONS

The findings of the above analysis and the appropriate conclusions derived from these findings are presented below.

Summary

In an attempt to estimate the impact of highway expenditures on highway bypass, loop and radial improvements, two evaluation techniques are applied as follows: (1) regression models using a cross-sectional data base; and (2) regression models using a combination cross-sectional and time-series data base. The data base developed to conduct this evaluation contains several economic variables which can be impacted by highway expenditures. It also contains highway system, geographic and time variables which can independently impact these economic variables. The three economic variables chosen for detailed study are as follows: (1) number of manufacturing employees in a study city, (2) number of employees in a study county, and (3) the total actual or real wages in a study county.

The regression models used in the analysis are of the single linear equation type and are solved by the ordinary least squares method or the pooling method. Models 1, 2, and 3 estimate the above three economic variables, respectively, and use a one-year cross-sectional data base. Models 4, 5, and 6 also estimate the three economic variables, respectively, but they each use a four-year combination cross-sectional and time-series data base which is applied on a "before versus after construction" basis.

Briefly, the results of the study show: (1) that the above three economic impact variables are impacted significantly by expenditures for the highway improvements studied; (2) that the regression models developed from the combination cross-sectional and time-series analysis show these effects more clearly and accurately than those developed from the cross-sectional analysis, because a "before versus after construction" approach is used; and (3) that although the "before versus after" explanatory variable may capture other effects in addition to those of the highway improvement, it still can be reasonably inferred that a major portion of the effects are due to the highway improvement.

Conclusions

The following conclusions are derived from the above analysis, as presented below:

1. Models based on a combined cross-sectional and time-series data base produce more efficient and consistent estimates of highway expenditure impacts on employment and wages in a study city or county than models based on a one-year data base.
2. Highway expenditures for bypass, loop, and radial improvements produce statistically significant impacts on employment and wages in the affected city or county.

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