TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-91/1228-2F		

4. Title and Subtitle	5. Report Date / 6. Performing Organization Code
Economic Development Impacts of Expenditures for State Highway Improvements in Texas: Preliminary Findings	5. Report Date: August 1991 6. Performing Organization Code:
7. Author(s)	8. Performing Organization Report No.
R.W. Stokes, N. Pinnoi, E.J. Washington	Research Report 1228-2F
9. Performing Organization Name and Address	10. Work Unit No. / 11. Contract or Grant No.
Texas Transportation Institute Texas A&M University System College Station, Texas 77843-3135	10. Work Unit No.: 11. Contract or Grant No.: Study No. 2-10-90-1228
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered / 14. Sponsoring Agency Code
Texas Department of Transportation Transportation Planning Division P.O. Box 5051 Austin, Texas 78763	13. Type of Report and Period Covered: Final: September 1989 August 1991 14. Sponsoring Agency Code:

15. Supplementary Notes

Research performed in cooperation with DOT, FHWA.
Research Study Title: Role of SDHPT in Statewide Economic Development.

16. Abstract

This research project focuses on the economic development impacts of expenditures for state highway improvements. While the scope of this investigation should be viewed as preliminary and largely exploratory in nature, the results indicate that the economic development impacts of expenditures for state highway improvements can be substantial. This research project utilizes a modified version of the Regional Economic Impact Model for Highway Systems (REIMHS) to estimate the economic development impacts of proposed highway improvements in a rural highway corridor in Texas. Based on a review of previous research findings and preliminary testing of the modified REIMHS model, it does not appear to be unreasonable to assume that the monetary value of the economic development impacts resulting from highway investments are at least equal to the direct user benefits which have traditionally been the focus of highway economic analyses. This research report also presents several general recommendations concerning: (1) preliminary guidelines for estimating the economic development impacts of expenditures for state highway improvements, (2) additional refinement and testing of the modified REIMHS model, and (3) future research the Department should conduct and/or sponsor in the area of transportation and economic development.

17. Key Words	18. Distribution Statement
Economic Development, Highway Development, Cost-Benefit Analysis, Economic Development Funds/Bonding, Highway/Transportation Expenditures, Economic Development/Impact Models	No restrictions. This document is available to the public through the National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	65	

ECONOMIC DEVELOPMENT IMPACTS OF EXPENDITURES FOR STATE HIGHWAY IMPROVEMENTS IN TEXAS

Preliminary Findings

by

Robert W. Stokes
Associate Research Planner

Nat Pinnoi
Research Associate

and

Earl J. Washington
Assistant Research Planner

Research Report No. 1228-2F
Research Study No. 2-10-90-1228
Role of TxDOT in Statewide Economic Development

Sponsored by

Texas Department of Transportation

in cooperation with the
U.S. Department of Transportation
Federal Highway Administration

Texas Transportation Institute
The Texas A&M University System
College Station, TX 77843-3135

August 1991

METRIC (SI*) CONVERSION FACTORS

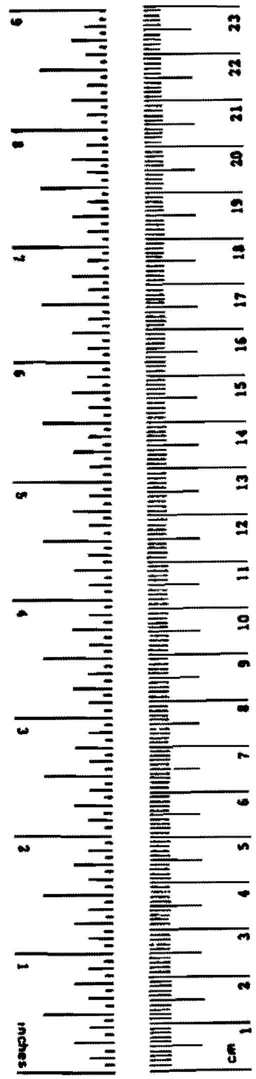
APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	2.54	centimetres	cm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
	AREA			
in²	square inches	645.2	centimetres squared	cm ²
ft²	square feet	0.0929	metres squared	m²
yd²	square yards	0.836	metres squared	m²
mi²	square miles	2.59	kilometres squared	km²
ac	acres	0.395	hectares	ha
	MASS (weight)			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
	VOLUME			
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft³	cubic feet	0.0328	metres cubed	m³
yd³	cubic yards	0.0765	metres cubed	m³

NOTE: Volumes greater than 1000 L shall be shown in m³.

TEMPERATURE (exact)

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

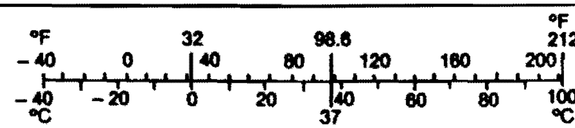


APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
	AREA			
mm²	millimetres squared	0.0016	square inches	in²
m²	metres squared	10.764	square feet	ft²
km²	kilometres squared	0.39	square miles	mi²
ha	hectores (10 000 m²)	2.53	acres	ac
	MASS (weight)			
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
	VOLUME			
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m³	metres cubed	35.315	cubic feet	ft³
m³	metres cubed	1.308	cubic yards	yd³

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.

* SI is the symbol for the International System of Measurements

ABSTRACT

This research project focuses on the economic development impacts of expenditures for state highway improvements. While the scope of this investigation should be viewed as preliminary and largely exploratory in nature, the results indicate that the economic development impacts of expenditures for state highway improvements can be substantial. This research project utilizes a modified version of the Regional Economic Impact Model for Highway Systems (REIMHS) to estimate the economic development impacts of proposed highway improvements in a rural highway corridor in Texas. Based on a review of previous research findings and preliminary testing of the modified REIMHS model, it does not appear to be unreasonable to assume that the monetary value of the economic development impacts resulting from highway investments are at least equal to the direct user benefits which have traditionally been the focus of highway economic analyses. This research report also presents several general recommendations concerning: (1) preliminary guidelines for estimating the economic development impacts of expenditures for state highway improvements, (2) additional refinement and testing of the modified REIMHS model, and (3) future research the Department should conduct and/or sponsor in the area of transportation and economic development.

Key Words: Economic Development, Highway Development, Cost-Benefit Analysis, Economic Development Funds/Bonding, Highway Transportation Expenditures, Economic Development/Impact Models

IMPLEMENTATION STATEMENT

This research project focuses on the economic development impacts of expenditures for state highway improvements. While the scope of this investigation should be viewed as preliminary and largely exploratory in nature, the results indicate that the economic development impacts of expenditures for state highway improvements can be substantial. The results of this study should be useful to the Department in developing a more comprehensive approach to evaluating various state highway improvement programs and projects.

DISCLAIMER

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

TABLE OF CONTENTS

Abstract v

Implementation Statement vi

Disclaimer vi

I. Introduction 1

Background 1
Study Objectives 3

II. State-of-the-Art 5

Literature Review 5
Transportation and Economic Development Programs in Other States 8
Transportation and Economic Development Impact Models 11

III. The Regional Economic Impact Model for Highway Systems (REIMHS) 17

Overview 17
Data Requirements 20
Data Sources 21
Model Structure 22
Previous Applications in Texas 31
Limitations of REIMHS 32
The Modified REIMHS Model 35

IV. Preliminary Analysis of Economic Impacts of Highway Expenditures in Texas 43

Overview 43
Study Corridor 43
Summary of Test Application of the Modified REIMHS Model 45

V. Conclusions and Recommendations 49

Conclusions 49
Recommendations 50

References 55

I. INTRODUCTION

Background

In recent years, the Texas Department of Transportation (TxDOT) has begun to expand its mission to include the use of highway improvements to encourage economic growth and development in the state. Highway improvements, either in the form of a new highway or the upgrading of an existing one, can generate changes in the functioning of an economy. Economic effects can be beneficial, where accessibility is improved, travel time and costs are reduced, or land values rise; or they can be adverse, where land values decrease or congestion on feeder roads increases. It is important to identify, to the extent possible, where highway improvements are likely to be most beneficial, who or what groups realize the gains, and who or what groups bear the costs (including the costs of foregoing one project in favor of another).

The Department frequently receives requests to conduct intercity route studies. The requests for these studies frequently come from local governments and/or the private sector and are typically promoted on the basis that the new routes would result in improved movement of people and goods and produce economic benefits. The proposed new roadway in the Austin-San Antonio corridor, for example, has been advocated as a means to accommodate recent and projected traffic growth in the I-35 corridor between Austin and San Antonio. The proposed roadway would also improve the accessibility of thousands of acres of undeveloped land and foster additional development and economic growth in the corridor. Similarly, the proposed new roadway in the Austin-College Station corridor is being promoted on the basis of its ability to improve the quality of the highway system serving the two cities and to stimulate additional cooperative efforts between Texas A&M University and the University of Texas.

At the present time, TxDOT is developing a State Highway Trunk System but does not currently have procedures to systematically assess the traffic and economic development impacts of proposed intercity highways. As a result, requests for intercity route studies are addressed on a case-by-case basis. At the present time, it is difficult to anticipate the timing and scope of these requests and incorporate them into the state's transportation planning and programming process. This approach to responding to these requests requires a great deal of TxDOT staff time and resources. There is a need to develop procedures and/or policies to evaluate these requests for highway route studies within the Department's statewide transportation planning process.

The state-of-the-art in modeling the relationships between transportation and its physical, social, and economic environments is largely "one-dimensional." For example, the number of trips produced and attracted by an area can be estimated from information describing the socioeconomic characteristics of the area. However, the problem of estimating the nature and magnitude of the socioeconomic impacts that result from improvements in the transportation system is much more complex and is not understood nearly as well as the relationships between economic activity and travel demand. As a result, the various interest groups that may be involved in highway improvement projects that are intended to promote economic growth and development often have very different perceptions of the potential magnitude of the economic impacts of highway improvements.

Transportation planners and engineers can employ a number of "standard" procedures (e.g., benefit-cost analysis) to assess the relative cost-effectiveness of alternative transportation improvements. However, benefit-cost analysis, and most of the other traditional economic analysis procedures, typically does not address the complete spectrum of social and economic impacts of highway improvements. In addition, there are several methodologies which can be used to examine the relationships between transportation and economics at the regional level. However, there are no widely accepted procedures for quantifying the economic development potentials of transportation improvements within individual travel corridors.

This research report focuses on the relationships between the state's transportation expenditures for intercity highways and economic development. *The relationships between* *economic development and changes in accessibility, travel time, or land values that result from intercity highways are not explicitly addressed.* However, the results of this research could provide a useful point of departure for future research efforts directed at quantifying the relationships between changes in accessibility, travel time or land values, and economic development.

Study Objectives

The overall goal of this research effort is to develop procedures and/or guidelines to assess the economic impacts of intercity highways. Specific study objectives are:

1) Review procedures used by other states to identify, prioritize, and select intercity highway improvements that are intended to foster economic development.

2) Identify current analytical techniques for assessing the economic development impacts of expenditures on intercity highways.

3) Develop the data bases needed to calibrate and implement these procedures for use in selected travel corridors in Texas.

4) Develop guidelines for use in assessing the economic development impacts of expenditures on intercity highways in Texas.

5) Develop procedure(s) for incorporating these guidelines into the state's existing planning and decision-making process.

A previous research report (1) presented a review of the literature, a survey of current practices in other state departments of transportation to foster economic development through highway improvements, and the identification of analytic techniques for assessing the economic impacts of expenditures for highway improvements. Specifically, that report addressed study objectives 1 and 2. The key findings of the previous research report are briefly summarized in the following chapter of this report.

The principle focus of this report is on those phases of the research directed at the primary study objectives; e.g., objectives 3, 4, and 5. The scope of this investigation should be viewed as exploratory and, therefore, preliminary in nature, as the findings are based on the results of using a single model to estimate the economic development impacts of highway expenditures in a very limited number of rural highway corridors. This study provides preliminary, planning-level guidelines which could be used to estimate the monetary magnitude of the economic development impacts of various highway investment programs. The results do indicate that the economic development impacts of expenditures for highway improvements can be substantial.

II. STATE-OF-THE-ART

Literature Review

The connection between highway improvements and economic development is both obvious and elusive. Conventional wisdom holds that ample, well maintained highways, streets, and roads are important to an area's development potential because they provide access to resources, goods, and markets. In any form of economic activity, accessibility is a critical need. However, the precise impact of a particular transportation improvement is often times difficult to assess. Also, a variety of external factors complicate an understanding of this linkage. Some of these are availability and cost of land, labor, and capital; relative tax rates; environmental and general life quality; and the presence of needed services and other types of infrastructure. A reasonable supposition is that good transportation is a necessary but not sufficient condition for economic development to occur. Put another way, transportation facilities contribute significantly to a competitive advantage of an area. The stronger the overall competitive advantage an areas has, the more likely employment - generating investment is to occur (2).

The role of highway development in economic growth has been the subject of considerable analysis. Briggs (3) demonstrated, using regression analysis, that the location of interstate highways has a positive effect on economic growth through population migration and employment change. Siccardi (4) documents the legislative history of federal attempts to stimulate growth through transportation improvements. Siccardi concludes that economic growth is promoted by increasing accessibility to meet specific objectives, such as improving access to airports, hospitals, and other community service functions. Additionally, he points out that population receives beneficial growth effects from highway improvements, and this will, in fact, become a positive stimulus to prosperity.

Lichter and Fuguitt (5) concur in their examination of demographic response to the interstate highways in non metropolitan areas stating:

> The presence of good transportation appears to be a necessary part of any adequate explanation of nonmetropolitan population growth generated by inmigration. This effect is posited to operate through employment change in manufacturing, non local trade and services, and tourist related activity.

The effect of highway development on improved accessibility also has a positive impact on property values. Miller (6) discussed the concept of accessibility and the resulting appreciation of property. He asserts that the relative location of a piece of property is a key factor in enhancing property values. Using time series and regression techniques, Langley (7) and Palmquist (8) demonstrate how proximity to major thoroughfares increases adjoining property values. Specifically, Palmquist predicts a 15 to 17 percent increase in property values resulting from being directly accessible to a highway segment. Grossman and Levin (9) examined the effects of highways on distressed or redevelopment areas and suggest that good highway transportation is at least as important in distressed manufacturing centers as in any other urban area; in addition, there are a number of instances of smaller urban centers so located that their economies can be directly stimulated by an improvement of their connections to a nearby, larger metropolitan area with a stronger, more diversified economy. Improved highway transportation is a potentially vital factor in combating the effects of economic decline in a major distressed area. Grossman and Levin (9) also suggest that high quality highways are one of the most important elements in economic development in modern American communities. Although good highways alone are not sufficient to insure economic improvement in competition with other areas, they are a necessity to any area to insure its attractiveness to new industry, its ability to retain existing industry, and its overall efficiency as a place to live and work.

A National Cooperative Highway Research Program (NCHRP) study (10) points out that highway improvements, either in the form of a new highway or the upgrading of an existing one, unquestionably generate changes in the functioning of an economy. To some extent the welfare and/or income position of some individuals and/or firms will be altered. Economic effects can be beneficial (positive), where travel time and cost are reduced or land values rise; or they can be adverse (negative), where land values decrease or congestion on feeder roads increases. Rarely is an economic impact clearly all beneficial or all harmful within a community.

Some research results minimize the significance of the role of transportation facilities in the promotion of economic development. For example, Mills (11) examined the effects of beltways on the location of residences and selected work places and reported that beltways and probably transportation facilities in general are, at most, one of many influences on the pattern of urban development, and policies to support revitalization of central cities might be better implemented by using beltways or other transportation facilities to support measures such as land use controls that bear more directly on urban development.

Eagle and Stephanedes (12) addressed the causality relationship between highway improvements and economic development and concluded:

> Increases in highway expenditures do not in general lead to increases in employment other than temporary increases in the year of construction. However, in locations that are economic centers of the state, highway expenditures do have a positive long term effect, that is, employment increases more than it would for the normal trend of the economy.

Baird and Lipsman (13) have contested the significance of the relationship between highway transportation and economic development stating:

> Clearly, major highway system changes promote change in local and regional economies, but whether transportation infrastructure investment causes long-term economic development remains in question.

Wilson et al. (14) report similar findings in an examination of the role of transportation in regional economic growth. The authors concluded:

> Transportation improvements have been cited as having important effects on political unity, social cohesion, economic growth, specialization, and price stability, as well as an attitudinal change. Yet . . . precisely opposite effects are equally plausible.

Transportation and Economic Development Programs in Other States

Many states simply incorporate economic development objectives into their normal programming process and do not have special funds or programs for the specific purpose of fostering economic development. The nature of involvement in economic development-related activities by state transportation agencies is presented in Table 1. Thirty-six states explicitly take economic development into account in their highway programming activities. Of these states, 14 incorporate economic development objectives into their normal programming process but do not have special funds or programs for the specific purpose of fostering economic development. The methods used range from informal petitions on the part of local governments for priority programming to point systems for ranking projects.

A surprisingly large number of states, 22, have categorical funding or bonding authority for economic development. Iowa, for example, has a dedicated two-cent motor fuel tax, the proceeds of which flow into a special fund. Programs vary in scale from Maine's $400,000 industrial park matching program (to supplement private sector funds) to more extensive efforts, such as those in Florida, Iowa, Massachusetts, Michigan, and Washington (see Table 2).

Eleven states' programs are oriented primarily toward making industrial parks more accessible. These programs supplement local and private funding sources in financing the construction of such improvements as interchanges, frontage roads, or other access roads. In their industrial park programs, some states specify funding limitations based on the amount of local or private funds contributed or on the number of jobs created. South Dakota, for example, requires:

- A commitment to actual construction of the industrial facility in the near future.
- A committed capital investment of at least five times the required state participation costs.
- Total employment for all facilities in the industrial park of at least 50.

Table 1. Summary of State DOT Involvement in Economic Development Programs

State	Economic Development Objectives in Programming[1]	Special Economic Development Funds/Bonding[2]	Industrial Park Road Program[3]	Quick-Response Capabilities[4]
Alabama	*	*	*	
Alaska		*		
Arizona				
Arkansas	*	*	*	
California	*			
Colorado	*			
Connecticut	*			
Delaware	*			
Florida		*		
Georgia	*			
Hawaii	*			
Idaho	*			
Illinois	*	*	*	
Indiana	*			
Iowa	*	*		*
Kansas	*	*	*	
Kentucky	*	*		
Louisiana	*	*		*
Maine	*	*		
Maryland			*	
Massachusetts	*	*		
Michigan	*	*		*
Minnesota	*	*		
Mississippi			*	*
Missouri				
Montana				*[5]
Nebraska				
Nevada	*			
New Hampshire				
New Jersey				
New Mexico	*			*
New York	*	*		
North Carolina	*	*		
North Dakota				
Ohio	*			
Oklahoma	*	*	*	
Oregon	*			
Pennsylvania	*			
Rhode Island				
South Carolina				
South Dakota	*	*	*	
Tennessee	*		*	
Texas	*			
Utah	*			
Vermont				
Virginia	*	*		
Washington	*	*		
West Virginia	*	*	*	*
Wisconsin	*	*		*
Wyoming	*	*	*	

Sources: (1,2).

Notes:

1. "Economic Development Objectives in Programming" means that the state specifically takes economic development into account in its capital programming process or has special highway programs to encourage economic development.
2. "Special Economic Development Funds/Bonding" means that the state has a categorical funding source or bonding authority for economic development or industrial park roads.
3. "Industrial Park Program" means that the state has a special program dedicated to constructing this type of road.
4. "Quick-Response Capabilities" means that the state has the ability to expedite economic development-related road projects.
5. Expedites environmental review for economic development projects.

Table 2. Details of Special State Highway Economic Development Programs

State	Approximate Annual Budget ($ Million)	Program Name/Description
Alabama	No annual budget	Single-bond issue of $25 million
Alaska	No annual budget	State economic development program
Arkansas	Not reported	Industrial access roads
Florida	$10.0	Economic Development Transportation Fund
Illinois	$4.4	Five-year average. Part of "Build Illinois"
Iowa	$7.5	Six-year average. "RISE" program
Kansas	$3.0	Economic Development Fund
Kentucky	No fixed budget	Industrial access road program
Louisiana	No fixed budget	Discretionary funds
Maine	$0.4	Federal funds
Massachusetts	$10.00	Public Works and Economic Development Program
Michigan	$13.3	Three-year average. Economic Development Program
Minnesota	No annual budget	Municipal bonding, reimbursed by state
New York	$5.0	Industrial Access Program
North Carolina	$2.0	State Economic Development Program
Oklahoma	$1.6	Industrial Access Road Program
South Dakota	$0.5	Industrial Park Construction Program
Virginia	$3.0	Industrial Access Fund
Washington	$10.0	Community Economic Revitalization Board
West Virginia	No fixed budget	Contingency funds
Wisconsin	$4.9	Proposed "AHEAD" Program
Wyoming	$1.0	Industrial Road Program

Sources: (1,2).

- Local participation in funding of industrial park roads of at least 20 percent of the approved state project construction budget.
- Dedication of the roadway and adjacent right-of-way to public use.
- State participation limited to roads within the industrial park that are one mile or less in length.

Similarly, Virginia stipulates that unmatched state highway funding shall not exceed 10 percent of the total private capital investment in the assisted development. Florida requires that for expansions of existing facilities, at least 100 new positions must be created if the initial grant request is $100,000 or more. The motivation for specifying match rates is to use limited state funds to leverage as much local and private funding as possible. Even states that do not have specific percentage limits have indicated that they place considerable emphasis on the relative size of the non-state funding share.

Because private sector development decisions often are made in a compressed time frame, eight states' programs include the capability for a "quick response" to funding requests for development-related highway projects. Quick-response program features apply when a development is being negotiated between a local government and private sector investors and highway facilities are a significant issue. The nature of these quick-response capabilities varies from expedited environmental review procedures in Minnesota to readily-available capital, as in Florida and Iowa and in Wisconsin's proposed program.

Because most states only recently have established transportation programs intended to bolster economic development, limited information on impacts is available. In their responses, however, three states noted specific impacts. In North Carolina, road improvements costing $4.5 million were instrumental in attracting a major office headquarters with an initial investment of over $50 million that will employ 2,000 persons. Over the past three years, Michigan has invested $40 million in economic development-related projects; it is believed that these improvements have been instrumental in retaining 18,000 jobs and attracting 6,300 new jobs (1).

Transportation and Economic Development Impact Models

Public investment, economic development, and their relationship have long been recognized as one of the premier economic issues. The principal question addressed in this study is how economic development and transportation investment are related to each other. Facing limited resources, it is crucial for a policy maker to undertake the most efficient investment project. In recent years, economists and engineers have attempted to address this issue from their individual perspectives.

This section of this chapter provides an overview of the basic approaches to economic modeling. The review focuses on the models which have been successfully calibrated and applied in studies of the relationship between transportation investment and economic development (see Table 3). Additional information on these models can be found in Reference 1.

Table 3. Summary of Selected Economic Development Impact Models

	TRIM[a] (15)	Aschauer (16)	Cambridge Sys. Inc. (17)	Eagle & Stephanedes (12)	Lemmerman (18)	Liew & Liew (19)	REIMHS[b] (20)
Year of Publication	1988	1989	1989	1987	1984	1985	1989
Model Characteristic	I/O Model	Econometrics	Econometrics & I/O	Time-Series	Cost-Benefit	I/O Model	I/O Model
Calibrated Area	Ontario	National Level	Wisconsin	Minnesota	New York	Arkansas & Regional	Dallas/Ft. Worth Area
Type of Transportation Infrastructure	Various Highways	General Transportation	Freeway & Expressway	General Highways	Various Highways	Navigation System	Various Highways
Data Type	I/O Table	Macro Data	I/O Table Cross-Section	Time-Series	Cross-Section	I/O Table & Cross Section	I/O Table
Years of Available Data	1979	1949-1985	1986	1964-1982	Case Dependent	1972	1986
Endogenous Variables	GDP[c] & Employment	Productivity & Output/Capital	Disposable Personal Income	Employment	Operating Cost Savings & Travel Time Savings	Industrial Outputs, Prices & Trade Coefficients	Total Output, Earnings, & Employment
Exogenous Variables	I/O Coefficients & Highway Expenditures	Nonmilitary Govt. Expenditures	I/O Coefficients and Project Costs	Transportation Expenditures	Typical Traffic Data and Project Cost	I/O Coefficients and Final Demand	I/O Coefficients & Project Costs
Results	GDP Multiplier Equals to 1.4	1% Increase in Govt. Exp. = 0.49% Increase in Productivity	Economic development benefits = 50% of total benefits	$1 Mill. Increase in Highway Exp. = 108 New Jobs	Benefit-Cost Ratio was 0.5477	5% Decrease in Trans. Cost = 2.989% Increase in Output	$10 Mill. Proj. = $17.6 Mill. in Total Output
Practicality	Very Practical	Very Practical for National Data	Practical if the model is made available	Practical	Practical	Not Practical	Very Practical
Comments	Frequently Update I/O	Disaggregate Data	Include Opp. Cost	Simultaneity Problem	Include Econ. Benefit	Frequently Update I/O	Include Long-Term Effects

[a]Transportation Impact Model

[b]Regional Economic Impact Model for Highway Systems.

[c]Gross Domestic Product.

Classes of Economic Models

A study of the relationship between transportation investment and economic development should begin with a description of these two variables. The transportation investment can be clearly defined as an investment that improves, maintains, or adds transportation infrastructure. However, the concept of economic development is not universally agreed upon. One may think of increased employment as economic development whereas others may consider expanded total industrial output as the development of the economy. Hence, economic development should be perceived as the total improvement of a given economy in terms of output, employment, earnings, and standard of living of its inhabitants. An economic model, explaining the relationship between transportation investment and economic development, should take this information into account.

Transportation and economic development impact models can be classified according to the following four basic forms: econometric base model, input-output base model, time-series analysis, and cost-benefit framework. A brief summary of each of these model forms is presented below. Table 3 provides a summary of representative examples of these models as applied to a range of transportation improvement projects.

Econometric Models

The collection of economic theory and statistical inference is included in the econometric base model. For example, the question of how transportation investment and economic development relate to one another can be answered with the assistance of economic theory. The estimation of a single equation and a system of simultaneous equations is often utilized in order to obtain empirical results. In the past, an econometric model was capable of analyzing only time-series or cross-section data. However, thanks to advancements in econometric modeling, both time-series and cross-section data can be combined and explained by the econometric method, regardless of the type of equations at hand (e.g., a single equation or a system of equations).

Input-Output Models

The input-output framework has been applied in many different economic fields, ranging from econometrics to urban planning. Input-Output (I/O) models were initially intended to be used at the national level to analyze the interdependency among industries in an economy; however, I/O models have been extended to cope with smaller units of the economy. For example, regional and multiregional economic issues can be analyzed using an I/O framework.

The I/O methodology can be separated into two major forms: simple I/O models, variable I/O models. In *simple* input-output models, total outputs of all industries can be computed from the final demand, and technical and trade coefficients, which are assumed to be constant. This simple model is best suited for analyzing a short-term impact of policy change. With *variable* I/O models, information on changes in output and input prices are taken into consideration. Therefore, the values of the multipliers can be updated upon receiving the price signals.

One of the more promising I/O models is the Regional Economic Impact Model for Highway Systems (REIMHS), developed by Politano and Roadifer in 1988 (20). *As discussed in a previous research report (1), the REIMHS model was selected for test applications in Texas.* The REIMHS model, and the results of test applications of the model in Texas, is discussed in detail in the subsequent chapters of this report.

Autoregressive Time-Series Analysis

The basic idea of autoregressive time-series analysis is that the future behavior of a variable of interest will be governed by its history. The model was made famous by Box and Jenkins (21). Autoregressive Moving Average (ARMA) and Vector Autogression (VAR) models are parts of such analysis. The ARMA models assume that a variable in question depends on its past values and past random errors. The VAR models, on the other hand, assume that a column vector of the combined dependent and independent variables is a linear function of a column vector of this past value and an error term. Thus, the VAR model is capable of forecasting a column vector of variables consisting of responding variables and driving variables.

Cost-Benefit Analysis

Most transportation projects are evaluated in terms of their costs and benefits to assist the policy maker in identifying the most efficient project. The cost-benefit framework relies basically on the measurement of costs and benefits of a given project. However, a good cost-benefit analysis must take into account the importance of an opportunity cost of the project in question. The opportunity cost is the cost of forgoing the best alternative program in which available funds may be invested. A fundamental shortcoming of cost-benefit analysis is that it considers only those variables which can be assigned a monetary value.

The Department currently uses a computerized Highway Economic Evaluation Model (HEEM II) to calculate a benefit/cost ratio for proposed highway improvement projects (22). The HEEM II model is capable of evaluating a range of standard rural highway improvements, as well as several special classes of highway improvement projects (e. g., high occupancy vehicle (HOV) projects, and two-corridor projects). However, like most benefit-cost models, the HEEM II model does not consider economic impacts other than the direct highway user benefits which result from highway improvement projects.

III. THE REGIONAL ECONOMIC IMPACT MODEL FOR HIGHWAY SYSTEMS (REIMHS)

Overview

The overall goal of this research effort was to attempt to quantify the relationships between expenditures for transportation improvements and economic development in Texas. This chapter describes the basic model used to perform the preliminary analyses directed at accomplishing this goal.

The preliminary analyses were performed using the Regional Economic Impact Model for Highway Systems (REIMHS). As discussed in a previous report (1) published to document the first year of this research effort, the REIMHS model was selected primarily because it allows a more comprehensive assessment of the economic impacts of highway investment programs than other economic evaluation models such as HEEM (22). The REIMHS model uses data which is routinely collected by the Department or which is readily available from widely accepted secondary sources. The REIMHS model is reasonably tractable and is built around a fairly straightforward operating logic.

Like HEEM, the REIMHS model evaluates the following benefits associated with highway improvements:

(1) Operating Efficiency Savings (savings in vehicle maintenance and repair costs, oil and fuel consumption, vehicle depreciation, and tire wear);

(2) Mobility Savings (monetary value of time saved by motorists before and after the highway improvement); and

(3) Safety Savings (accident costs before and after the improvement).

In addition to these three factors, the REIMHS model assesses the regional economic impacts of highway investments. These regional economic impacts consist of the following three components:

(1) Estimated monetary value of all goods and services produced by the regional industries involved in implementing the highway improvement project;

(2) Estimated monetary value resulting from the employment of workers in the regional industries involved in implementing the highway improvement project; and

(3) Estimated total employment generated within the regional industries involved in implementing the highway project.

The REIMHS model, then, focuses on the employment impacts of highway investments. It does not provide estimates of the economic impacts of new land developments or increased interregional trade flows that can result from highway investments. The literature review (1) did not reveal any suitably tractable and/or reliable procedures for modeling these more comprehensive impacts of transportation investments.

It was hoped that by applying the REIMHS model in several highway corridors, a reasonably consistent relationship between expenditures for highway improvements and economic development would emerge. Such a relationship, if one exists, could be used by the Department to formulate preliminary, planning-level estimates of the economic development impact potentials of various highway improvement programs and projects.

The Regional Economic Impact Model for Highway Systems was developed by Politano and Roadifer in 1988 (20). The main objective of the REIMHS model is to estimate the economic impacts of investments in highway systems. Expenditures for transportation improvements provide not only direct user benefits, such as mobility savings, operating efficiency savings and safety savings, but direct and induced regional economic benefits as well. The direct economic benefits consist of lower transportation costs and increases in construction income, both for labor and the suppliers of construction materials. The direct auto user benefits and the direct economic benefits can be estimated by REIMHS provided that information concerning the cost of the project and general transportation data are available. Additionally, the induced economic benefits of transportation investments can also be estimated by REIMHS. The induced economic effects are the additional economic impacts brought about by increases in spending by the recipients of the direct economic benefits. The size of the induced economic effects, or multiplier effects, depends on the multipliers obtained from the regional interindustry analysis (input-output table). Using the Bureau of Economic Analysis' multipliers for regional industrial output (23), along with employment and income estimates, REIMHS estimates the aggregate value of the induced economic impacts in terms of industrial output and the earnings and employment impacts of undertaking or not undertaking a given highway project.

The REIMHS model procedures go one step farther than a conventional cost/benefit analysis. While traditional cost/benefit analyses typically evaluate only the direct automobile users' benefits and the project costs, the REIMHS model takes into account the economic effects of highway investments. For example, the Highway Economic Evaluation Model (HEEM) (22) currently used by the Department computes the present value of benefits including safety, travel time, and operating savings and the present value of total project costs. A benefit-cost ratio is then calculated to permit a ranking of the prospective highway improvement projects under consideration. Furthermore, REIMHS and HEEM share many of the same basic data sources, such as the AASHTO value of travel time and traffic data from HPMS. With the REIMHS model, the analyst can not only rank the prospective projects according to their benefit-cost ratios but can also evaluate projects on the basis of their regional economic impacts.

A PC-compatible version of the REIMHS model written in MS QuickBasic has been developed by Garcia-Diaz and Freyre (24). This interactive program requires the same data as the original REIMHS. The PC version of REIMHS has been developed to estimate the economic impacts of highway expenditures in each of the following five states: Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. Six types of highway systems can be modeled by the PC version of the REIMHS model. These are interstate, primary, and urban highways in urban areas and interstate, primary and secondary highways in rural areas.

Data Requirements

The basic data requirements of the REIMHS model are outlined below.

1. *General Transportation System Data*

   - Facility Type: urban interstate, urban primary, urban, rural interstate, rural primary, and rural secondary.

   - Year of Analysis.

   - General Traffic Data: percentage of traffic experiencing congestion (level of service C or worse), average annual daily vehicle of miles of travel, percentage trucks, running speed before improvement, running speed after improvement, number of passengers per car, fatal accidents (victims/million veh-mi), injury accidents, property damage accidents (vehicles/million veh-mi), and pavement condition index.

   - Distribution of Vehicles: small, medium and large autos, pick-up trucks, 2A-SU trucks, 3A-SU trucks, 2S-2 trucks, and 3S-2 trucks.

2. *Project Cost Data*: this information can be obtained from the FHWA Form No. 47.

   - Project Type: new construction or improvement of in an existing highway.

- Type of Improvement: bridge widen/modify, bridge replacement, widen traveled way, lanes added, roadway realignment, and skid resistent overlay.

- Year the project was completed.

- Project Costs: final construction cost, total cost of all materials and supplies, final contract amount for signs, final contract amount for lighting, and total labor cost.

- Materials Used: type, quantity and price per unit.

3. *Input Industry Information* (for each of the following materials):

- Chemical and petroleum refining,
- Lumber and wood products and furniture,
- Stone, clay, and glass products, and
- Primary metal industries.

Data Sources

The data required by the model on highway construction material and labor costs must be provided by the user. It is recommended that these data be obtained from FHWA Form No. 47. Type of highway system, project type and length of the project are also available from this form.

The efficiency savings, consumption data for maintenance and repair, fuel, tire, oil and depreciation costs are estimated by REIMHS using data from a 1982 FHWA-sponsored study (25) on vehicle operating costs.

The data on running speeds needed to estimate mobility savings must be provided by the user. These speed data are available from the Highway Performance and Monitoring System (HPMS) Analytical Process, Version 2.1 (26).

The monetary value of time in the REIMHS model for both trucks and automobiles is from the American Association of State Highway and Transportation Officials' (AASHTO) manual on user benefits (27) [updated to represent current prices by using the consumer price index and the wholesale price index for industrial commodities].

Data from a Federal Highway Administration (FHWA) publication, entitled Alternative Approaches to Accident Cost Concepts: State-of-the-Art (28), is used by REIMHS to calculate the accident savings resulting from highway improvements.

Model Structure

As shown in Figure 1, the REIMHS model consists of five basic modules as outlined below.

Module 1: Distribution of Project Costs. The method used by REIMHS to distribute project costs is illustrated in Figure 2. The basic procedures used to calculate the individual components of the project cost are outlined below.

The initial step in Module 1 is to update the five costs given in FHWA Form No. 47 from the completion date (e.g., 1980) to the year of analysis (e.g., 1986). As outlined earlier in this chapter, the five costs are: final construction cost, labor cost, total cost of all materials and supplies, final contract amount for signs, and final contract amount for lighting. For example, the updated labor costs are calculated as shown below.

$$\textit{Labor Cost}(1986) = \textit{Labor Cost}(1980) \times \textit{Price Index}(1986) \, / \, \textit{Price Index}(1980)$$

Where the *price index* is obtained from Price Trends for Federal-Aid Highway Construction (29).

The REIMHS model also calculates the costs of the materials used in the project. The individual material costs are calculated by simply multiplying the *quantity of material* by its *unit price*. The total material cost is the sum of the individual material costs. Table

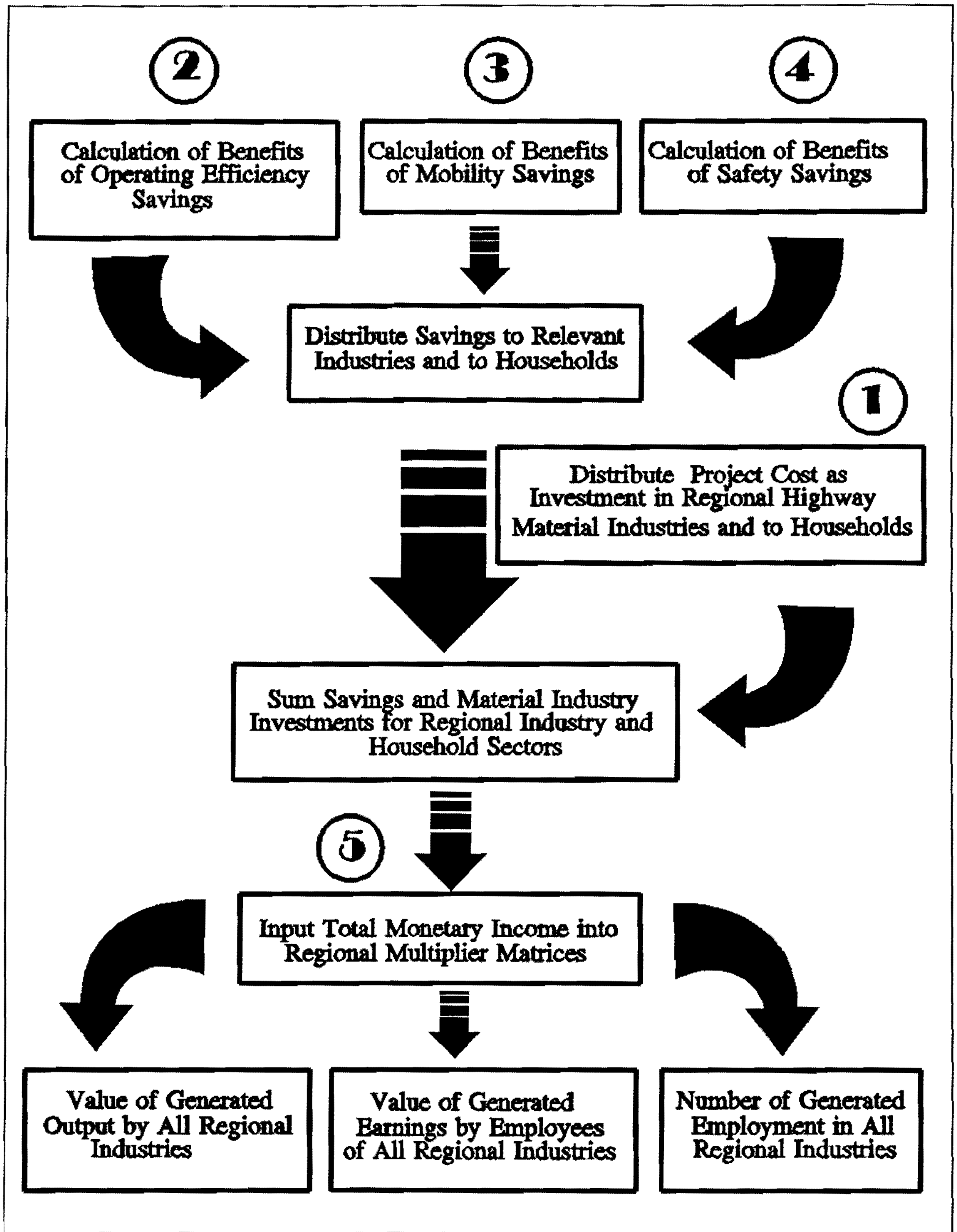


Figure 1. Basic Structure of the REIMHS Model

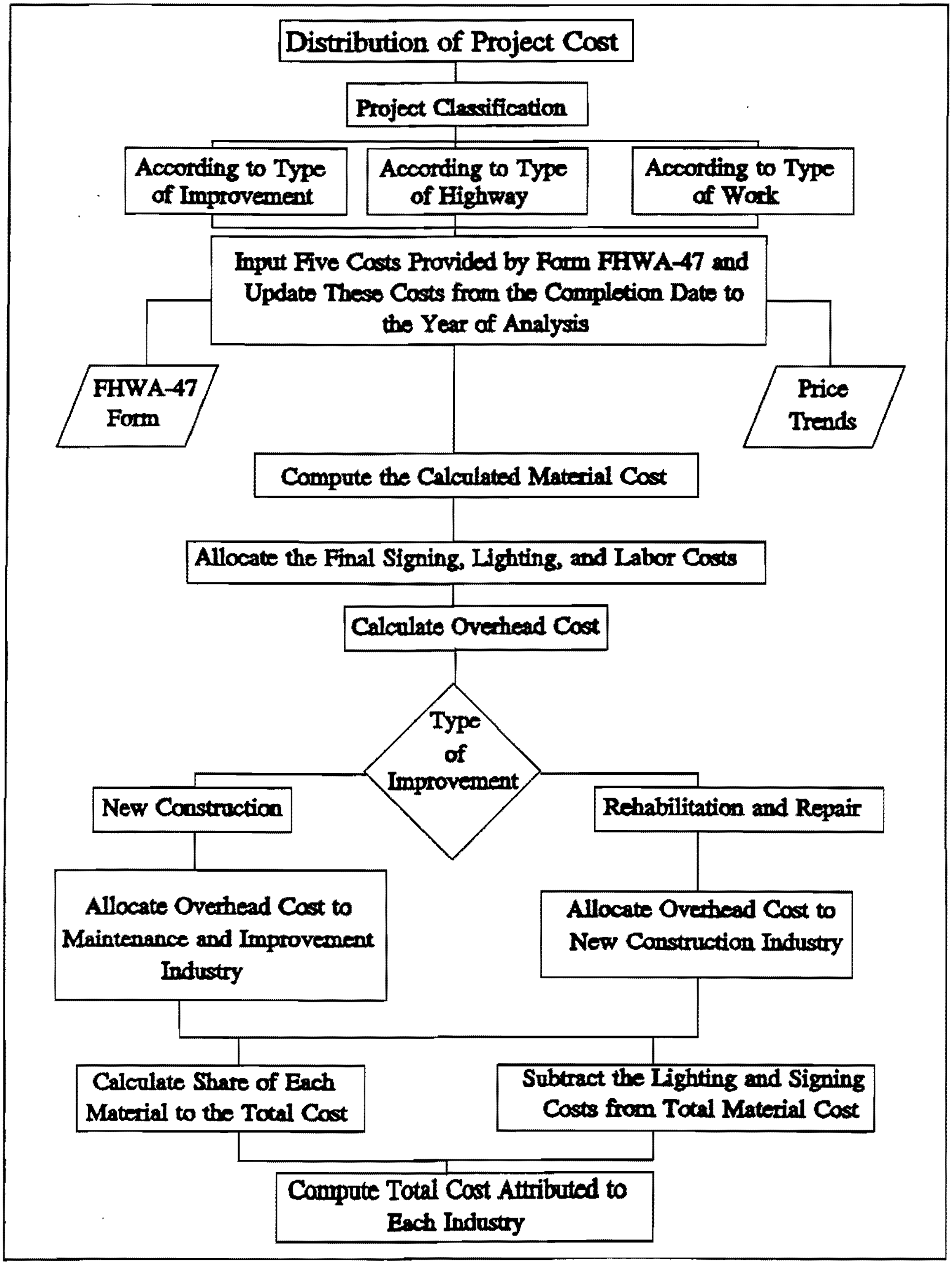


Figure 2. Distribution of Project Costs in the REIMHS Model

4 shows the categories of materials used in FHWA Form No. 47 and their corresponding industries.

Table 4. Categories of Materials and Industries in FHWA Form No. 47

Materials	Industries
Cement	Stone, Clay, and Glass Products
Bituminous Materials	Chemicals and Petroleum Refining
Aggregate Materials	Stone, Clay, and Glass Products
Structural Steel	Primary Metal Industries
Concrete Pipe	Stone, Clay, and Glass Products
Clay Pipe and Tile	Stone, Clay, and Glass Products
Lumber	Lumber and Wood Products and Furniture
Timber Piling	Lumber and Wood Products and Furniture
Petroleum Products	Chemicals and Petroleum Refining
Explosives	Chemicals and Petroleum Refining
Fencing	Primary Metal Industries
Guardrail	Primary Metal Industries
Bridge Rail	Primary Metal Industries
Corrugated Aluminum	Primary Metal Industries
Cast Iron Pipe	Primary Metal Industries
Signs	Miscellaneous Manufacturing Equipment
Lighting	Electric and Electronic Equipment
Overhead (or Profit)	
New Construction	New Construction
Repair	Maintenance and Improvement Construction

Because FHWA Form No. 47 does not provide the costs of individual materials used in the project, the cost of each material is calculated by REIMHS as follows:

Share of Material X Cost (%) = Cost of Material X/Total Material Cost

Material Cost (1986) = *Total Material Cost (1986) - Signing Cost (1986) - Lighting Cost (1986)*

Cost of Material X = Share of Material X Cost (%) x Material Cost

As indicated in Table 4, the total cost attributed to a given industry (e.g., Chemicals and Petroleum Refining) is the sum of all the corresponding material costs. For example:

Total Cost = *Cost of Bituminous Material + Cost of Petroleum to Petroleum Industry Products + Cost of Explosives + Cost of Premix Bituminous Materials to Petroleum Industry*

In addition, the material cost shares by industry are calculated as:

Material Cost Share by Industry Y (%) = Total Cost of Industry Y / Final Cost(1986).

The REIMHS model assigns the overhead costs (or profit) to either the new construction industry or the maintenance and improvement construction industry, as shown in Table 4. This component is calculated as:

Overhead (1986) = Final Cost (1986) - Labor Cost (1986) - Total Material Cost (1986)

Module 2. Calculation and Distribution of Operating Efficiency Savings. The Operating Efficiency Savings (OES) refers to the differences in maintenance and repair costs, oil and fuel consumption, depreciation for trucks and automobiles, and tire wear before and after the highway improvement. The OES are computed for traffic experiencing congestion (defined as roadways with a volume to capacity ratio greater than 0.77 for all urban roads and 0.18 for all rural roads). These changes translate into savings in vehicle operating costs. Such savings realized by households and relevant industries are assumed to be spent in the regional economy. Figure 3 outlines the procedure used in REIMHS to calculate OES. The OES for automobile users are allocated to the households, while OES

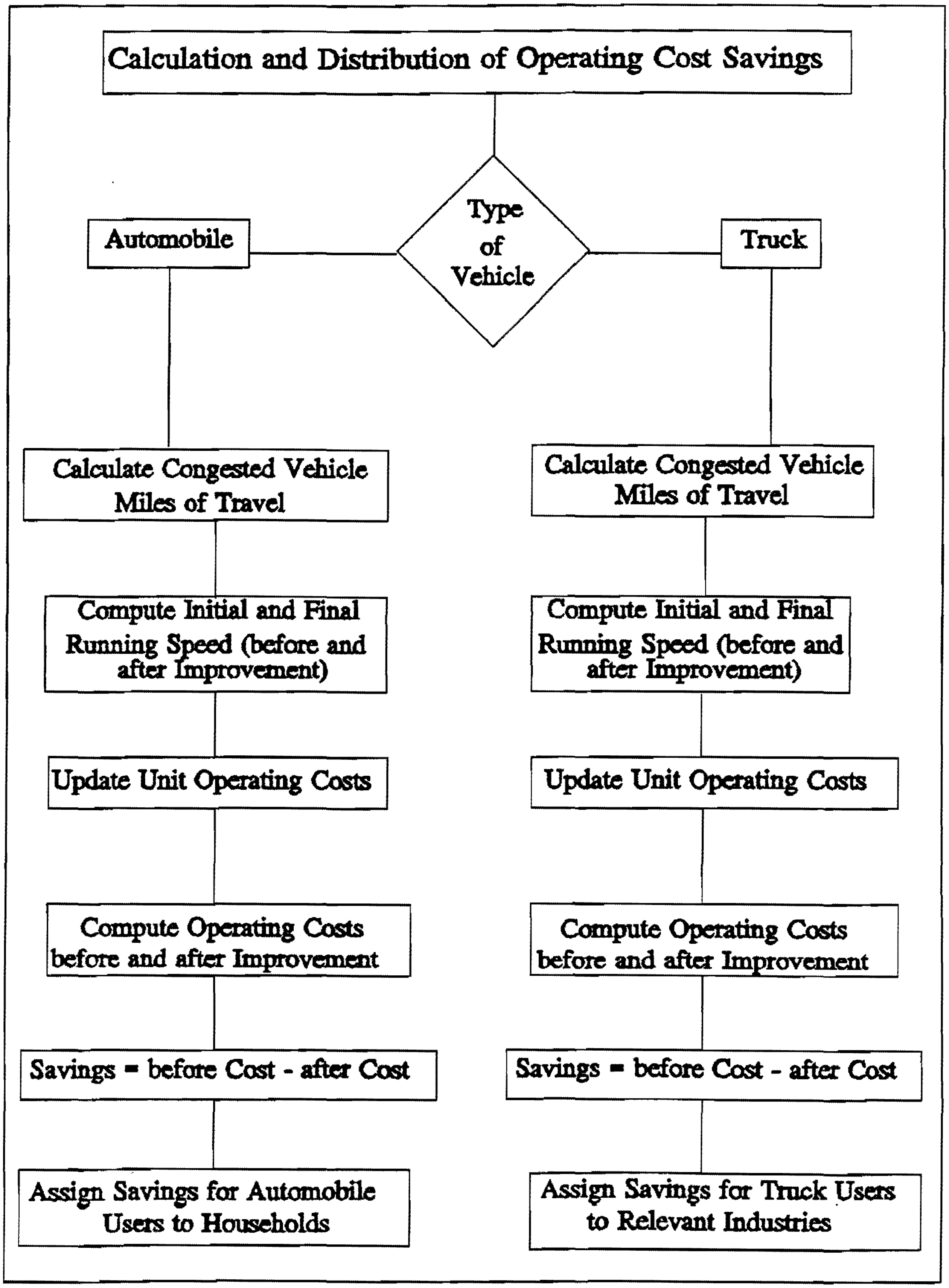


Figure 3. Calculation and Distribution of Operating Cost Savings in REIMHS

for trucks is assigned to the corresponding industries. Data from the 1982 Census of Transportation: Truck Inventory and Use Survey, United States(30) is used to calculate truck vehicle-miles of travel for various trip purposes and to calculate the percentage of truck vehicle-miles of travel for each industry. The OES are then allocated to the relevant industries by the percentage of truck vehicle-miles of travel for those industries.

Module 3. Calculation and Distribution of Mobility Savings. The Mobility Savings (MS) is the monetary value of time saved after the improvement by traffic which experienced congestion before the highway improvement. The MS calculation procedures performed by REIMHS are depicted in Figure 4. The value of time saved refers to the difference between the average running speed before and after the improvement. The AASHTO Manual on User Benefits of Highway and Bus-Transit Improvements (27) provides the values of time used in REIMHS ($8.20/hour for automobiles and $13.98/hour for trucks). The MS for automobile users are allocated to the households and the MS for trucks are distributed among the relevant industries as described in Module 2 (Calculation and Distribution of Operating Efficiency Savings).

Module 4. Calculation and Distribution of Safety Savings. The Safety Savings (SS) of motor vehicles are the differences between the accident costs before and after the roadway improvement. The SS are computed by REIMHS as summarized in Figure 5. The accident costs are separated into fatal, injury, and property damage costs. Ten percent (10%) of the total SS are assigned to households, and 90% of the savings are assigned to the insurance industry.

Module 5. Calculation of Regional Economic Impacts. The estimated Regional Economic Impacts (REI) can be disaggregated into three components: total estimated monetary value of all goods and services produced by the regional industries, total estimated monetary value of all workers employed by the regional industries, and total estimated employment generated within the regional industries. These estimates are calculated by first summing all the investments calculated in Module 1 and all the savings from Modules 2 - 4 for each industry in the region. Second, the total investments and savings available in

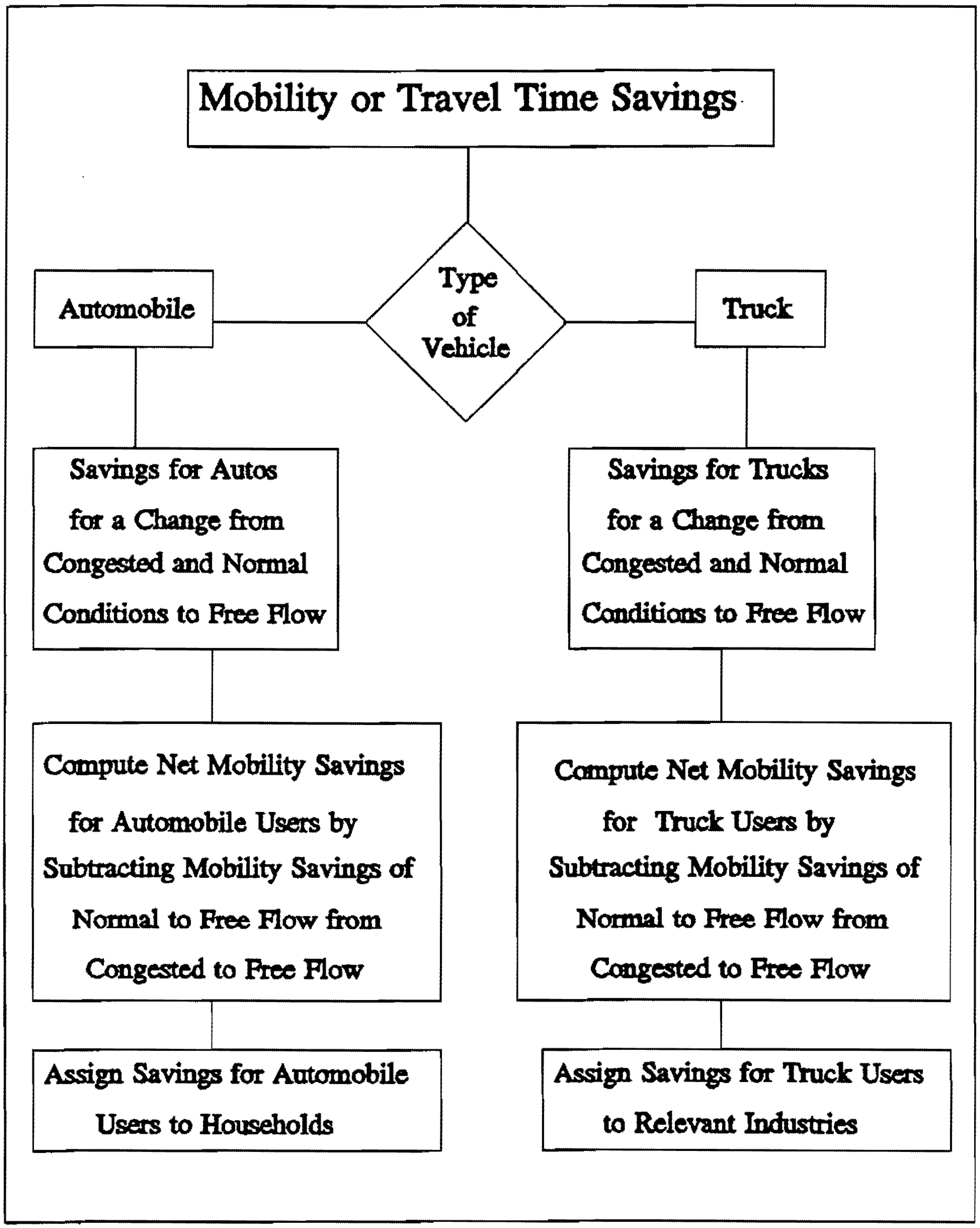


Figure 4. Calculation and Distribution of Mobility Savings in REIMHS

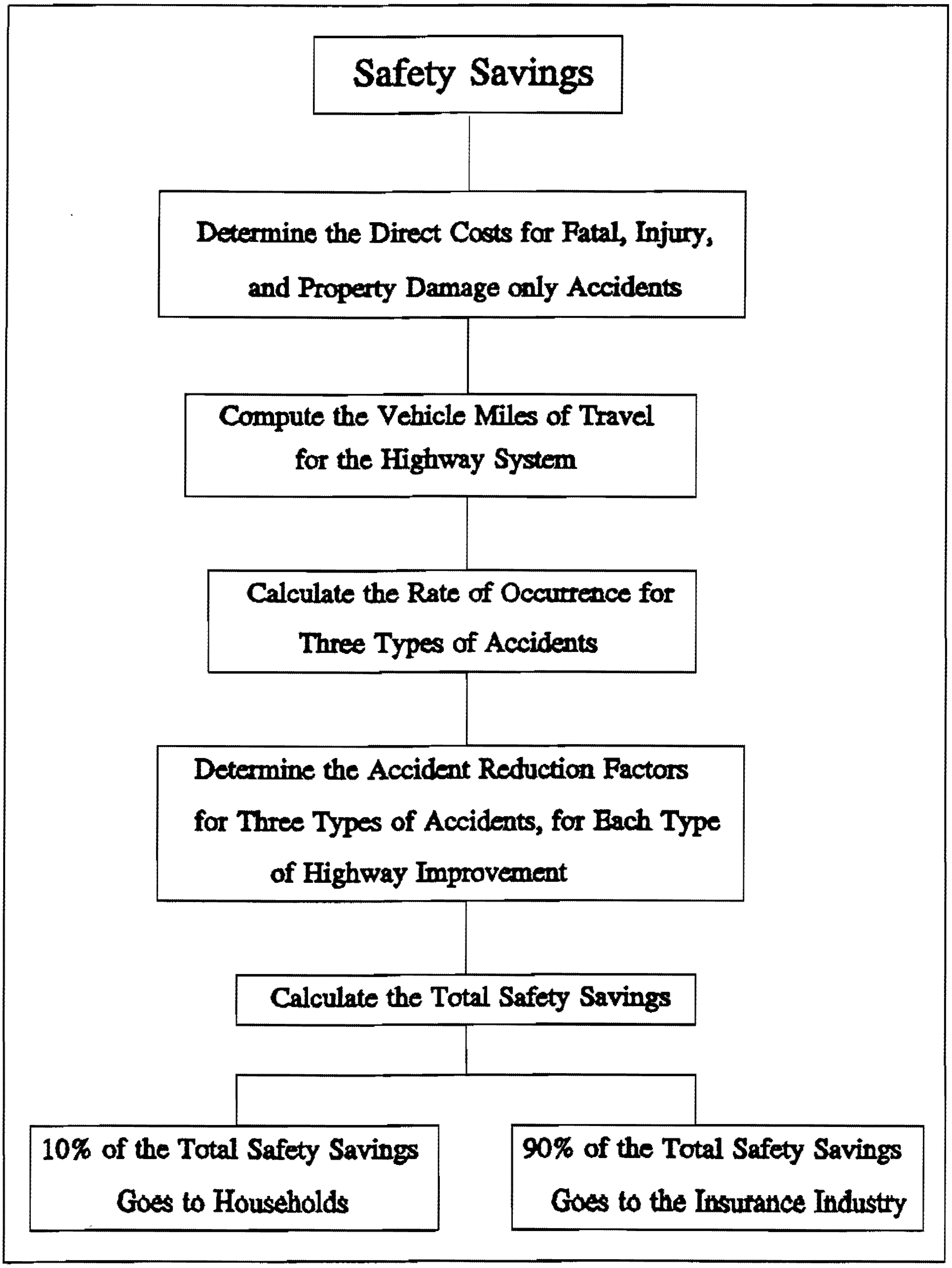


Figure 5. Calculation and Distribution of Safety Savings in REIMHS

each industry are represented as a row vector. Then, the Bureau of Economic Analysis' multipliers for all regional industrial output (23), earnings of employees in all industries, and employment (which are available in column vector forms) are used to compute the REI as illustrated in the following example. Earnings and employment effects are calculated in a similar manner.

$$\begin{array}{ccccc} \textbf{Total Investment and Savings} & & \textbf{Output Multipliers} & & = \textbf{Output Effects} \\ \textit{Industry 1} \quad \textit{Industry 2} & & & & \\ [\,100 \qquad 200\,] & \times & \begin{array}{l} \textit{Industry 1} \\ \textit{Industry 2} \end{array} \begin{bmatrix} 1.5 \\ 1.8 \end{bmatrix} & & \begin{array}{l} (100\times1.5)+(200\times1.8) \\ = \$510 \end{array} \end{array}$$

Previous Applications in Texas

A case study application of the REIMHS model in a 16-county area surrounding Dallas/Fort Worth was performed by Politano and Roadifer in 1989 (20). Their study evaluated the impacts of a $10 million highway improvement project. As shown in Table 5, the average benefits over several types of improvements resulting from efficiency, mobility, and safety savings (or losses) were estimated to be $0.13 million, $1.05 million, and $0.50 million, respectively for urban areas, and -$0.01 million, $0.10 million, and $0.03 million, respectively for rural areas. Total direct highway user benefits were estimated to be $1.68 million for urban areas and $0.13 million for rural areas. In addition, the REIMHS model estimated that this investment would generate $16.08 million and $4.56 million in total regional output and total regional earnings, respectively for urban areas, and $17.22 million and $4.43 million in total regional output and earnings, respectively for rural areas.

Table 5. Impacts of a $10 Million Highway Improvement Investment on Dallas/Fort Worth Region as Reported by Politano and Roadifer

Area Type	Average Efficiency ($ Millions)	Average Mobility ($ Millions)	Average Safety ($ Millions)	Average Output ($ Millions)	Average Earnings ($ Millions)	Average Employment (Jobs)	Benefit-Cost Ratio
Urban	0.1328	1.048	0.502	16.08	4.56	202	1.61
Rural	-0.0054	0.104	0.0317	17.22	4.43	194	1.72

Source: Reference 20 and authors' calculations.

The results of the Politano and Roadifer study indicate that every $1 invested in highway improvements produces an estimated $1.61 and $1.72 in total regional output for urban and rural areas, respectively. Also, the $10 million highway investment would create a total of nearly 400 jobs (an average of 202 urban jobs and 194 rural jobs).

Garcia-Diaz and Freyre (24) have used the REIMHS model to estimate the economic development impacts of highway expenditures in each of the following five states: (1) Arkansas, (2) Louisiana, (3) New Mexico, (4) Oklahoma, and (5) Texas. For the state of Texas, they investigated the impacts of five different facility types with a total cost of $36.5 million. The results of their analyses for the state of Texas are summarized in Table 6 for various facility types and improvement projects. The principal findings for the state of Texas are summarized below.

(1) The total output of regional industries due to a $9.1 million investment, and corresponding savings in efficiency mobility and safety is equal to $28.07 million.

(2) The total earnings of workers in these regional industries, receiving a $9.1 million highway investment, and corresponding savings in efficiency mobility and safety is equal to $7.43 million.

(3) The total (directed and generated) number of jobs created by the investment of $9.1 million in the urban interstate highway system is about 410.

(4) Benefits from mobility savings were the greatest ($2.89 million). Benefits from the savings in safety improvements were next in order of significance ($0.75 million). The least significant benefits were those associated with efficiency savings ($0.176 million).

Limitations of REIMHS

Although the REIMHS model has the ability to incorporate both economic and direct automobile user benefits into the analyses of highway investment programs in a straightforward manner, the model suffers from the following basic shortcomings:

Table 6. Total Regional Impact of Highway Investments in State of Texas as Reported by Garcia-Diaz and Freyre

Facility Type	Type of Work	Highway Investment ($ millions)	User Benefits ($ millions)			Economic Development Impacts		
			Efficiency	Mobility	Safety	Output ($ millions)	Earnings ($ millions)	Employment
Urban Interstate	New Construction Roadway Realignment	9.1	0.176	2.898	0.752	28.072	7.431	410
Urban Primary	New Construction Roadway Realignment	6.9	-0.003	0.084	0.176	15.337	4.185	223
Rural Interstate	New Construction Roadway Realignment	16.4	-0.055	0.725	0.050	36.883	9.756	516
Rural Primary	Skid Resistant Overlay	3.4	0.002	0.034	0.030	7.817	2.123	114
Rural Primary	Bridge Widening	0.8	0.002	0.034	0.034	1.860	0.570	31

Source: Ref. (24).

(1) The REIMHS model cannot be used to evaluate a *proposed* highway improvement project. This is because the project cost data required by REIMHS is available only after the completion of the project (e.g., from FHWA Form-47).

(2) REIMHS does not take into account the *length of the project* in calculating the direct user benefits attributable to safety savings, operating cost savings, and travel time savings -- each of which directly depends on the length of the highway construction project.

(3) Because most highway improvements have a long life, the benefits (at least the direct user benefits) resulting from these improvements should be computed over the entire life of the project and represented in terms of the discounted present value of the costs and benefits. This option is not currently available in the REIMHS model. The HEEM model, on the other hand, computes the discounted present value of the stream of user benefits and costs over the life of the improvement.

(4) The structure of the current REIMHS program makes it difficult to update the key variables in the model (e.g., to use data from other sources that are updated on a regular basis).

In an attempt to remedy these basic shortcomings, a Modified Regional Economic Impact Model for Highway Systems (MREIMHS) was developed and tested as part of this research effort. The basic structure of the current REIMHS model was retained. However, in MREIMHS the distribution of the cost of highway construction projects is calculated using data from Highway Statistics (31). The data in Highway Statistics is frequently updated and can be easily incorporated into MREIMHS. Finally, by combining the Highway Statistics data with the (discounted) direct user benefits available from HEEM, the MREIMHS model can calculate regional economic impacts as well as the benefit-cost ratio of proposed highway investment programs.

The proposed MREIMHS model is described in detail in the following sections of this chapter. The results of a preliminary test application of the MREIMHS model in an intercity highway corridor in Texas are presented in the following chapter of this research report.

The Modified REIMHS Model

The MREIMHS has been designed to extend the basic REIMHS model to permit the evaluation of proposed highway improvement projects in terms of their contributions to the regional economy. The general structure of MREIMHS is shown in Figure 6. The MREIMHS utilizes the output from an existing computerized cost-benefit model (HEEM), which is currently employed by TxDOT to rank proposed highway projects. The MREIMHS model uses annual project cost information from Highway Statistics (31) and the direct user benefits from the HEEM model to estimate the regional economic impacts of proposed highway investments. The results of the MREIMHS model can be used to calculate a benefit-cost ratio which can then be used to rank highway projects. The key components of the MREIMHS model are described in the following subsections of this chapter.

Distribution of Project Costs in MREIMHS

Table 7 presents a general summary of the annual construction cost data contained in Highway Statistics (31). The MREIMHS model assigns the total construction cost to the following nine industries:

1. new construction,
2. repair and maintenance construction,
3. primary metal industry,
4. stone, clay, and glass products,
5. petroleum refining industry,
6. lumber, wood, and furniture products,
7. electric and electronic equipment,
8. miscellaneous manufacturing, and
9. households.

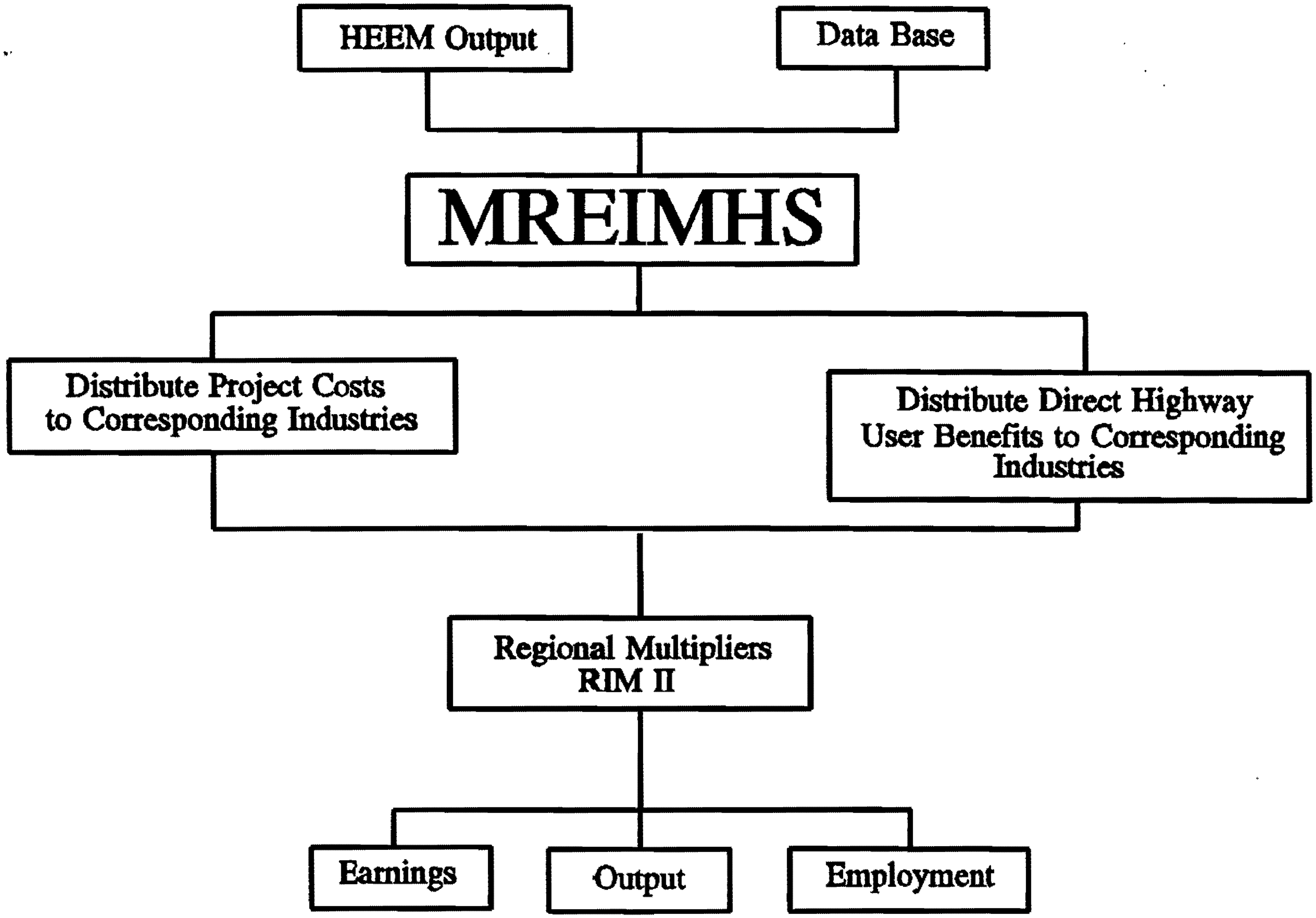


Figure 6. General Structure of the Modified REIMHS Model

Table 7. Distribution of Costs on Federal Aid Highway Construction Contracts over $500,000 (Excluding All Secondary Projects)

Distribution of Construction Costs	Percent	Industry	Percent
Overhead	31.5	New or Repair	31.5
Wages	20.3	Households	20.3
Materials	48.2		
Aggregates	11.5	Stone, Clay	25.62
Portland Cement	4.8	Metal	8.53
Steel	5.5	Petroleum	13.49
Bituminous	8.7	Lumber, Wood	0.36
Others[a]	17.7	Elec. Equip.	0.10
Lumber and Wood	0.230	Misc. Manuf.	0.10
Explosive	0.216	Total	100
Signs	0.100		
Lighting	0.100		

[a]17.505% allocated to industries 4-6; balance allocated as shown.

Source: Derived from Reference 31.

The procedure employed by MREIMHS to assign total construction costs to their relevant industries is illustrated in Figure 7. As outlined in Figure 7, the overhead costs are allocated to either the new or repair construction industries, according to the project type (new construction or rehabilitation). Households (owners of labor input) receive the wages and salary portions of the total construction cost. Material costs are distributed among the remaining six industries (e.g., industries 3-8) on the basis of the cost distribution information provided by Highway Statistics. As a result, the MREIMHS model enables the user to evaluate proposed highway projects without detailed project cost information (e.g., the only information needed is the total construction cost).

Distribution of Direct Highway User Benefits in MREIMHS

The present values of road user benefits (delay savings, operating cost savings, maintenance costs, and accident cost savings) are computed by HEEM as a part of the initial process of evaluating proposed highway projects. The MREIMHS disaggregates these user benefits into automobile user and truck user benefits, using percent of truck vehicle miles traveled as a guideline. The basic procedure is illustrated in Figure 8.

Both the REIMHS and the proposed MREIMHS model assume that 90 percent of the accident cost savings is assigned to the insurance industry, and the remaining 10

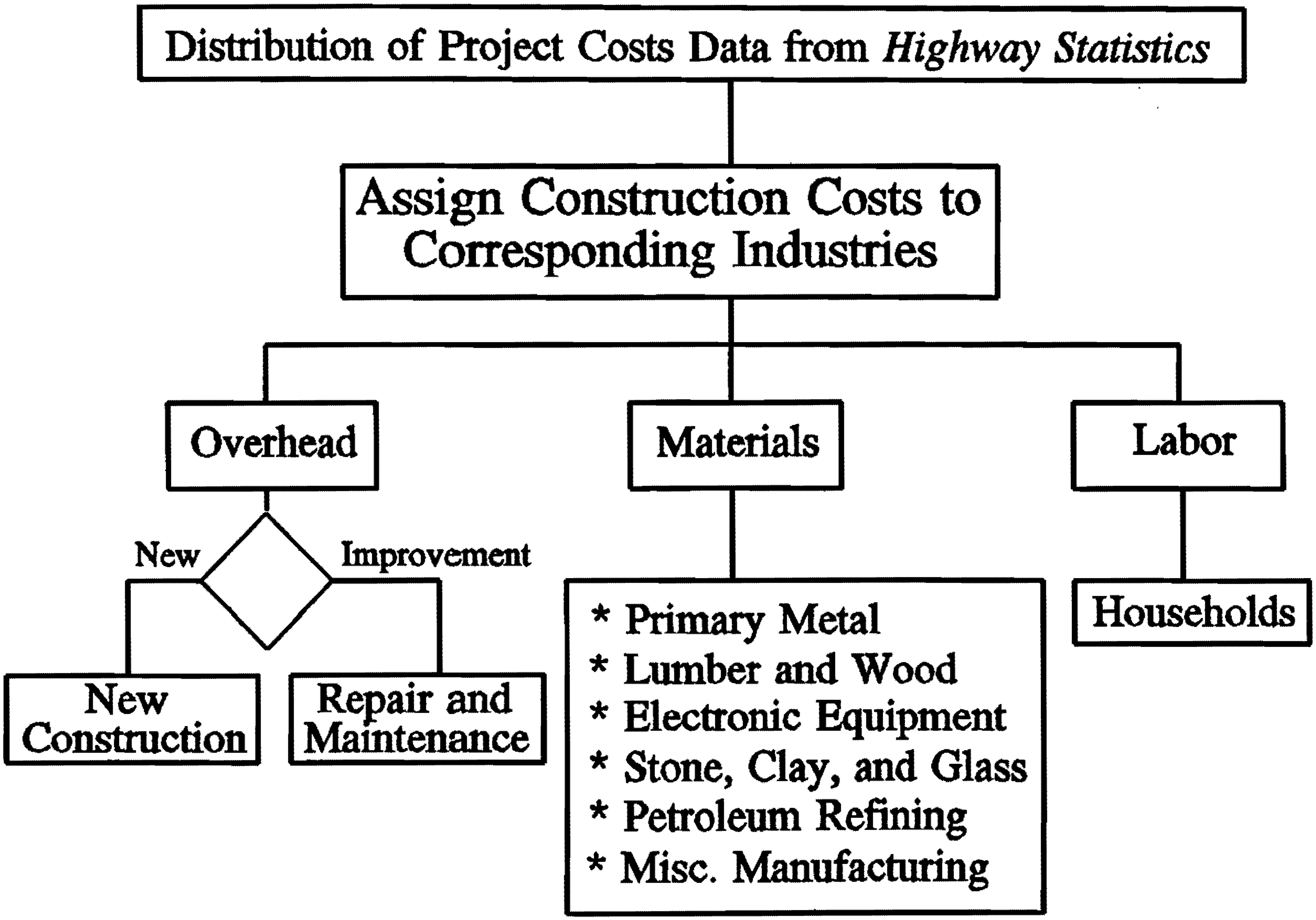


Figure 7. Distribution of Project Costs in the Modified REIMHS Model

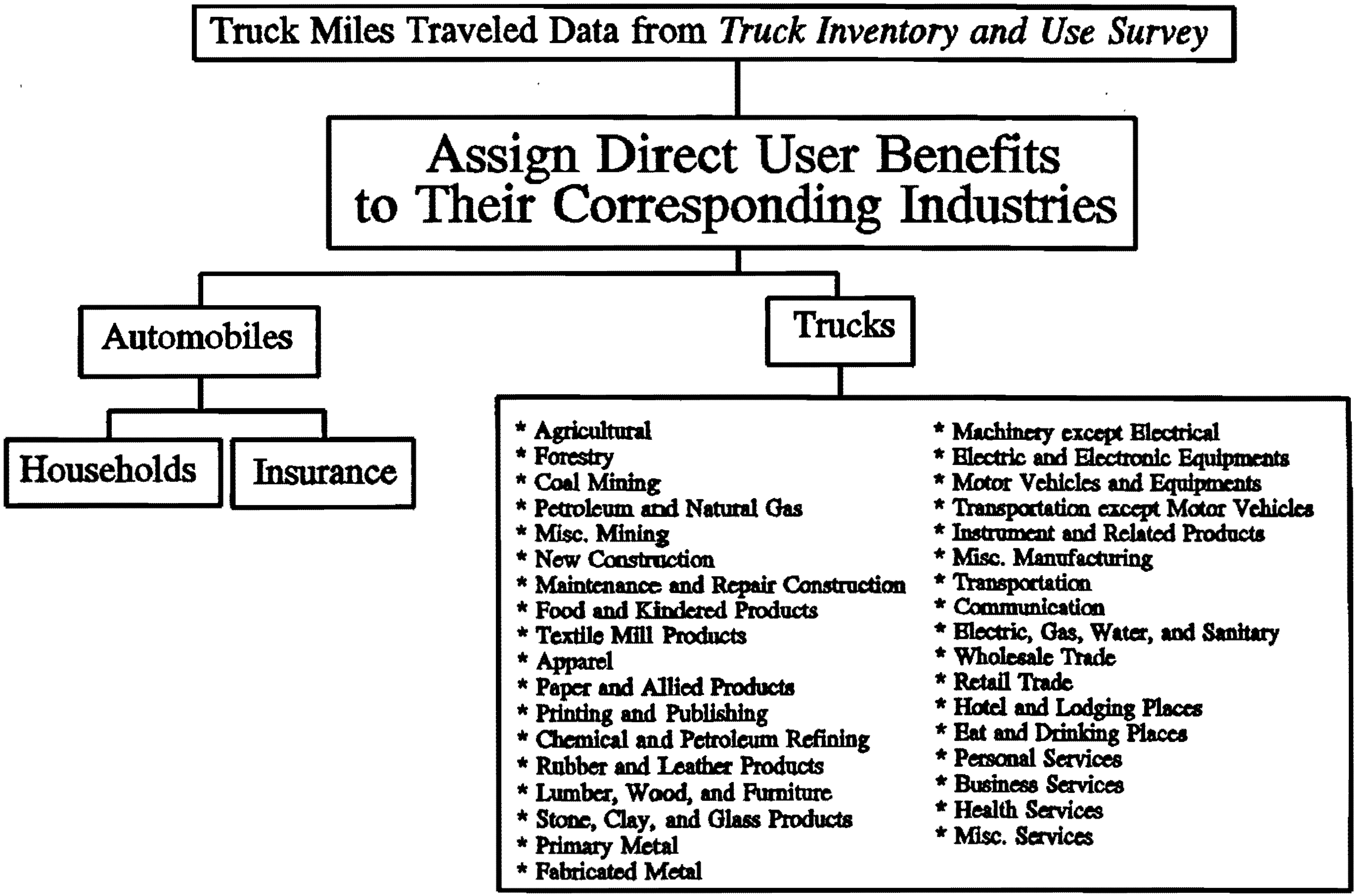


Figure 8. Assignment of Direct User Benefits in the Modified REIMHS Model

percent is assigned to households. The sum of operating cost savings, maintenance costs (negative or positive), and delay time savings for automobile users is allocated to the households.

The total truck user benefits are distributed to their corresponding industries according to the percent of truck miles in each industry. The required truck travel data are available for every state in the U.S. from Reference 30. The truck vehicle miles traveled (VMT) for the state of Texas by industry are shown in Table 8. Unfortunately, the industries represented in Table 8 do not conform with the aggregation of industries used by the Bureau of Economic Analysis (source for the regional multipliers used in this study). The MREIMHS model uses the employment share of each industry to allocate truck VMT to all industries except the construction industry. The industry employment and truck VMT data used in this study are summarized in Table 9.

For the construction industry, distribution factors are computed from capital and maintenance outlays for the state of Texas using data from Highway Statistics. Based on these analyses, the MREIMHS model assigns 79 percent of truck VMT for construction to the new construction industry and 21 percent to the repair and maintenance industry.

Table 8. Texas Truck VMT by Industry, 1987

Industry	Truck Miles (millions)
Agricultural	2,867.3
Forestry	450.9
Mining	354.3
Construction	6,120.5
Manufacturing	1,452.6
Wholesale Trade	1,650.9
Retail Trade	2,544.2
For-Hire Transportation	2,765.1
Utilities	883.1
Services	1,812.3
Daily Rental	98.3
One Way Rental	87.4
Personal Transportation	31,000.2
Transportation	2,950.8

Source: Ref. 30.

Table 9. Employment and Truck VMT Data for Texas, 1987

Industry	Number of Employees	Percent of Total	Truck Miles (Millions)	Percent Trucks
Manufacturing	934,841			
Food and Kindred	88,365	9.45	137.31	0.68
Textile Mill	4,262	0.46	6.62	0.03
Apparel	49,307	5.27	76.62	0.38
Printing and Publishing	71,451	7.64	111.02	0.55
Paper and Allied Products	22,777	2.44	35.39	0.17
Chemical and Petroleum	95,172	10.18	147.88	0.73
Rubber and Misc.	32,184	3.44	50.01	0.25
Lumber, Wood, etc.	30,379	3.25	47.20	0.23
Stone, Clay, Glass	38,101	4.08	59.20	0.29
Primary Metals	26,295	2.81	40.86	0.20
Fabricated Metals	72,216	7.72	112.21	0.55
Machinery, ex. Electric	97,846	10.47	152.04	0.75
Electric Equipment	107,977	11.55	167.78	0.83
Motor Vehicles	11,168	1.19	17.35	0.09
Transportation Equipment	66,479	7.11	103.30	0.51
Instruments and Related	20,655	2.21	32.09	0.16
Misc. Manufacturing	15,059	1.61	23.40	0.12
Services	1,443,412	-	-	-
Hotel and Lodging	74,792	5.18	93.91	0.46
Business Services	323,737	22.43	406.47	2.00
Personal Services	83,883	5.81	105.32	0.52
Health	394,467	27.33	395.28	2.44
Misc. Services	104,418	7.23	131.10	0.65
Mining	169,828	-	-	-
Coal and Other	3,844	2.26	8.02	0.04
Petroleum and Gas	118,882	70.00	248.02	1.22
Misc. Mining	7,427	4.37	15.49	0.08
Construction	-	-	-	-
New	-	-	4842.70	23.88
Repair and Maintenance	-	-	1277.80	6.30
Transportation	-	-	2950.80	14.55
Agriculture	-	-	2857.30	14.09
Forestry	-	-	450.90	2.22
Utilities	114,861	-	-	-
Communication	624,927	54.54	481.62	2.37
Electric, Gas, and Sanitary	520,934	45.46	401.48	1.98
Retail Trade	-	-	1736.70	8.56
Eating and Drinking Places	394,055	31.74	807.50	3.98
Wholesale Trade			1650.90	8.14
Total			20282.60572	100.

Calculation of Regional Economic Impacts in MREIMHS

By combining the distribution of project costs and the direct highway user benefits, an input vector (e.g., a row of data) can be formed. The MREIMHS model utilizes the regional multipliers (for Texas) provided by U.S. Department of Commerce, Bureau of Economic Analysis (23) to calculate the regional economic impacts of a proposed highway improvement project. The economic impacts include the value of total changes in regional output, the earnings that regional industries pay to households, and the number of jobs that regional industries provide. By multiplying the input vector by the regional multipliers matrix, the regional economic impacts resulting from investment in a highway improvement project are obtained.

IV. PRELIMINARY ANALYSIS OF ECONOMIC IMPACTS OF HIGHWAY EXPENDITURES IN TEXAS

Overview

This chapter presents the results of a preliminary, test application of the MREIMHS model in an intercity highway corridor in Texas. The scope of this investigation should be viewed as exploratory and, therefore, preliminary in nature, as the findings are based on test applications in a single highway corridor. The results do, however, indicate that the economic development impacts of highway investments can be substantial and that additional research and model testing should be pursued by the Department.

Study Corridor

The Pinehurst corridor (Figure 9) was selected for the sample application of the modified REIMHS model in Texas. This corridor is situated northwest of the greater Houston area between U.S. Highway 290 and Interstate Highway 45 and is one of the most rapidly developing areas in Harris and Montgomery Counties. According to 1980 census data, Montgomery County experienced a 160 percent increase in population during the 1970s.

Land use within the general highway corridor between Pinehurst and Houston is closely associated with the economic characteristics of the area. Land use is divided primarily between the economic interest of agriculture, mineral production, and residential/commercial/industrial development. The residential/commercial/industrial development in this corridor is located within and adjacent to the larger cities. Examples include a research and development center located in the Woodlands and the new Compaq computer plant near Tomball.

The economy of this corridor is based on agriculture, mineral production, tourism, and a wide range of manufacturing activities. Additionally, this corridor has the potential to become a new "high-tech" research and development area within the state.

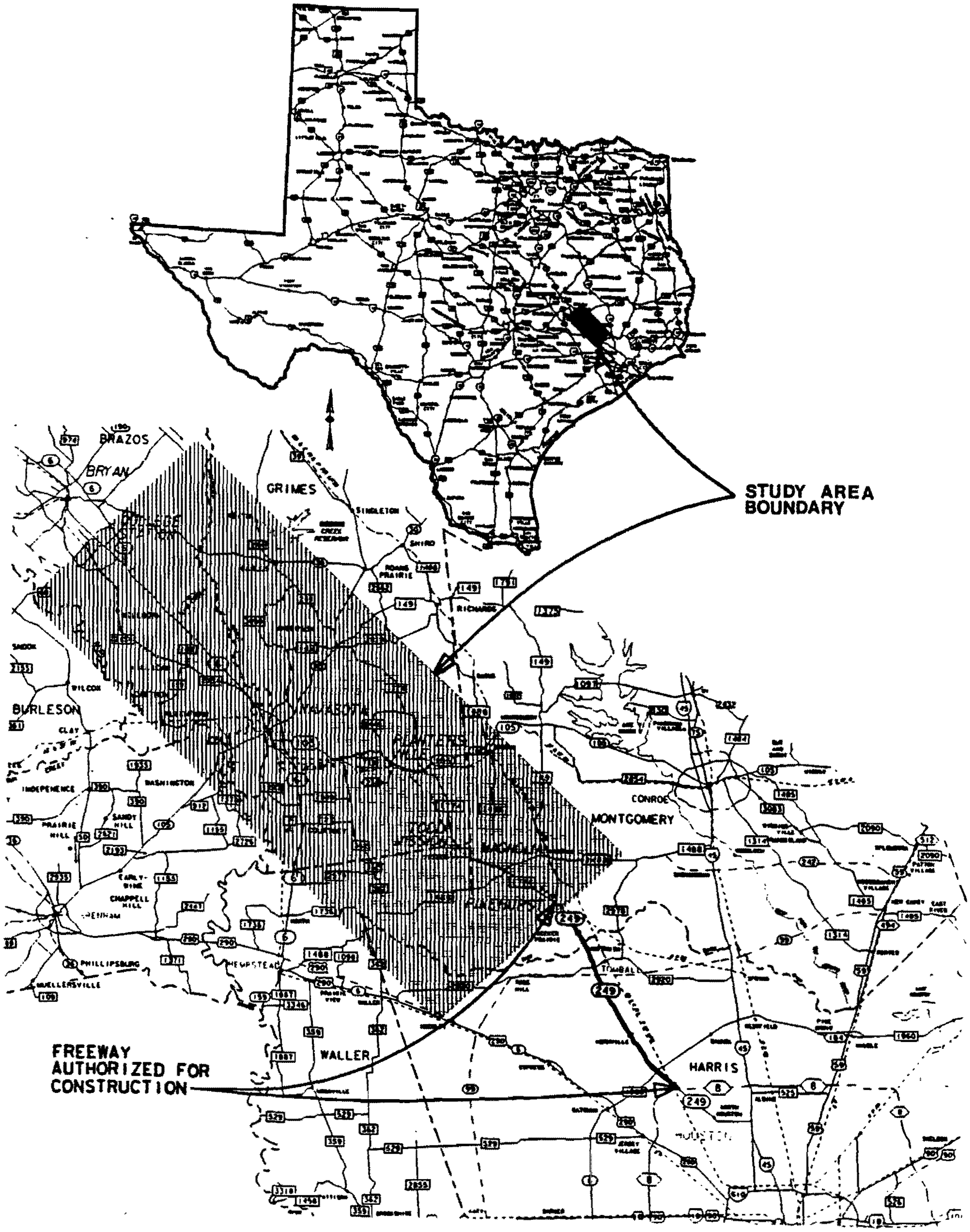


Figure 9. Bryan-College Station to Pinehurst Study Area

The Department has used the HEEM model to evaluate the *direct user benefits* resulting from a number of new highway improvements in the study corridor. The Department's analyses focused specifically on the feasibility of a new roadway in the corridor. The new roadway would follow State Highway (SH) 6 from Bryan-College Station to approximately 2.9 miles south of Navasota. From this point, the route would follow a new southeastwardly alignment across Grimes County, north of Todd Mission, into Montgomery County, north of Magnolia, and intersect Farm to Market (FM) Road 1774 and SH 249 just south of Pinehurst. The proposed route includes approximately 26.9 miles of SH 6 and approximately 26.5 miles on a new alignment.

The Department evaluated the following three highway improvement alternatives (32):

(1) A four-lane freeway along the proposed new alignment with the necessary right-of-way (ROW) acquired in accordance with Departmental policies.

(2) A four-lane freeway along the proposed new alignment with partial donation of the necessary ROW.

(3) Upgrade existing roadways in the corridor to four-lane freeways.

The estimated total costs (construction plus ROW) for alternatives 1, 2, and 3 are $163.3 million, $125.9 million, and $167.4 million, respectively (32).

Summary of Test Application of the Modified REIMHS Model

The modified REIMHS model was used to estimate the economic development impacts of the three improvement alternatives described in the previous section of this chapter. The results of the test application of MREIMHS in the Pinehurst Corridor are shown in Table 10. The results of the preliminary analyses in the Pinehurst corridor indicate that the that each of the highway investment alternatives would bring approximately $200 million of total regional output, approximately $60 million in total earnings, and generate over 3,000 jobs. It is clear that alternative 2 is the most effective improvement, with a benefit-cost ratio of 1.84 (i.e., each $1 spent yields $1.84 worth of total regional output and user benefits 1 year after the completion of the project). Alternatives 1 and 3 yield benefit-cost ratios of approximately 1.4. This conclusion is similar to the results of the Department's study (32) of the Pinehurst corridor using the HEEM model.

Table 10. Impacts of Highway Investments in Bryan-College Station to Pinehurst Corridor

Alternatives	Direct User Benefits from HEEM ($ Millions)	Total Project Cost ($ Millions)	Economic Impacts of Highway Projects			Benefit Cost Ratio[a]
			Output ($ Millions)	Earnings ($ Millions)	Jobs	
1. New Alignment	14.1676	163.3	216.9017	59.0764	3181	1.41
2. New Alignment with Donated Right-of-Way	14.1676	125.9	216.9017	59.0764	3181	1.84
3. Existing Alignment	14.4718	167.4	225.1563	61.346	3301	1.43

[a]Benefits consist of direct user benefits plus regional output.

Note: The benefits and cost used in this table, are based on 1 year after the completion of the project.

It should be noted that the benefit-cost ratios shown in Table 10 do not include the benefits resulting from the creation of new jobs. As shown in Table 10, the employment potentials of highway construction projects can be substantial. In the future, it may be useful to incorporate these benefits into the analyses. This could be achieved on the basis of an assumed regional average wage rate.

In terms of the reasonablness of the estimate of the number of jobs created by the proposed Pinehurst corridor highway improvements, a 1980 study by the FHWA (29) estimated that 10 on-site, full-time jobs would result from each one-million dollars invested in highway construction. The MREIMHS model estimates that approximately 19 jobs would be created per one million dollars invested in the Pinehurst corridor highway project. This estimate is somewhat larger than the FHWA estimate because the MREIMHS model estimates not only on-site jobs but off-site and construction and service related jobs as well.

A Bureau of Labor Statistics study (23) reported that for each million dollars invested in highway construction generates an average of 22 new jobs. Similarly, Politano and Roadifer (20) have estimated that each one million dollar investment in highway construction results in from 16 to 23 new jobs. Garcia-Diaz and Freyre (24) estimate a somewhat higher job creation rate of from 28 to 45 new jobs per million dollars invested in highway construction. The number of jobs estimated by the MREIMHS model, then, appears to comparable to the findings of other studies.

V. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Public investment, economic development, and their relationship have long been recognized as important economic issues. In recent years, there has been a flurry of research directed at addressing the question of how economic development and transportation investment are related to each other. There appears to be a general consensus that ample, well maintained highways, streets, and roads are important to an area's development potential. However, due to a variety of external factors, there is considerable controversy concerning the precise nature of the linkage between transportation improvements and economic development. Some of the external factors which complicate an understanding of this linkage include availability and cost of land, labor, and capital; relative tax rates; environmental and general quality of life; and the presence of needed services and other types of infrastructure. In short, it appears that good transportation is a necessary but not sufficient condition for economic development to occur.

The results of this investigation of the relationship between economic development and expenditures for transportation improvements indicate that while the economic benefits can be substantial, additional research will be needed to quantify the precise nature of this relationship. Despite the uncertainty concerning the nature of the relationship between transportation and economic development, many states consider the economic development impacts of expenditures for transportation facilities and services in the development of transportation improvement programs. Specifically, 36 states explicitly consider economic development potentials in their highway programming activities. Of these states, 14 (including Texas) incorporate economic development *objectives* into the programming process but do not have special transportation funds or programs for the specific purpose of fostering economic development. The remaining 22 states have categorical funding or bonding authority for transportation improvements which is intended to promote economic development. Because most of these economic development programs are relatively new, data on the impacts of these programs are extremely limited.

As more and more states institute programs to increase the effectiveness of transportation improvement programs, it appears likely that the economic development potentials of various transportation investment options will become increasingly important. Consequently, there is a need to quantify the potential economic development impacts of transportation improvements, and to identify those situations which are most likely to benefit from investments in new or expanded transportation facilities and services. The following section of this chapter presents several general recommendations for achieving these ends in Texas.

Recommendations

The recommendations drawn from this research project are presented in the following subsections of this chapter. The recommendations focus on the following aspects of this research topic area: (1) preliminary guidelines concerning the economic development impacts of expenditures for state highway improvements; (2) additional refinement and testing of the modified REIMHS model; and (3) future research the Department should conduct and/or sponsor in the area of transportation and economic development.

<u>Economic Development Impact Guidelines</u>

A summary of the economic development impacts of expenditures for transportation improvements, as estimated as part of this research effort and by other researchers, is presented in Table 11. As indicated by the limited data summarized in Table 11, economic development benefits as a percent of total benefits range from a low of 48 percent to a high of 98 percent. Based on these limited data, *it does not appear to be unreasonable to assume that the monetary value of the economic development benefits resulting from highway investments are at least equal to the direct user benefits which have traditionally been the focus*

Table 11. Summary of Economic Development Impacts of Highway Expenditures

Project Description and Source	Project Cost ($ Millions)	Model/Procedure Used	Estimated Benefits		Economic Development Benefits as % of Total Benefits
			User ($ Millions)	Economic Development ($ Millions)	
• Construction of new 4-lane rural highway in Wisconsin.	$550	Regional Economic Model (input/output)	$480	$438	48%
• General urban/rural highway improvements in Dallas/Ft. Worth Area (20).	$10	REIMHS (Regional Input/Output)	$1.68	$16.08	91%
• General urban/rural highway improvements in Texas (24).		REIMHS (Regional Input/Output)			
- New Urban Interstate	$9.1		$3.8	$28.1	88%
- New Urban Primary	$6.9		$0.3	$15.3	98%
- New Rural Interstate	$16.4		$0.7	$36.9	98%
- Overlay of Rural Primary	$3.4		$0.07	$7.8	99%
- Bridge Widening on Rural Primary	$0.8		$0.07	$1.9	96%
• New four-lane rural highway in Pinehurst Corridor (Texas).	$163.3	MREIMHS (Regional Input/Output)	$14.2	$216.9	94%

of highway economic analyses. As long as the tentative basis for this assumption is recognized, the Department should find this guideline useful in preliminary, planning-level assessments of various highway investment options.

The Modified REIMHS Model

Although the MREIMHS model is intended to address several of the shortcomings of the basic REIMHS model, some caution must be exercised in applying MREIMHS. Like other economic impact models which use input-output tables and multipliers, one crucial assumption in REIMHS and MREIMHS is that the structure of the economy represented by the input-output table (compiled in 1977 in the case of RIMS II) remains stable over time. Because regional wage and salary data are frequently revised, this is probably a reasonable assumption. However, if there is evidence that the structure of the current regional economy differs substantially from the structure represented by the input-output tables, the results from REIMHS, MREIMHS or other economic impact models should be used with caution.

None of the existing economic development impact models and techniques reviewed in this study explicitly takes into account the costs of right-of-way acquisition. In many cases, these costs can be substantial. Future versions of the MREIMHS model should incorporate right-of-way costs into the analysis.

The MREIMHS model incorporates the results (e.g., direct highway user benefits) computed by HEEM. The HEEM model has recently undergone a critical reevaluation by TTI researchers. It has been shown that some key assumptions in HEEM should be updated and revised; thus, HEEM II (a revised version of HEEM) has been developed. The improved procedures in HEEM II for estimating direct highway user benefits should be incorporated into subsequent versions of MREIMHS.

It is the recommendation of this study that the revisions outlined above should be incorporated into the MREIMHS model. The MREIMHS model should then be tested in additional highway corridors in Texas. Following the implementation and testing of these revisions, the appropriate Department personnel should be trained in the maintenance and application of the MREIMHS model. Such a program would be similar to current training programs concerning the Department's use of the HEEM model.

Future Research

The Department's future research efforts should focus on the following three general aspects of the relationship between transportation and economic development: (1) quantification of the economic development potentials of various transportation investment programs; (2) identification of the physical, economic, and sociodemographic environments in which investments in transportation facilities and services offer the greatest potential for promoting economic development; and (3) identification and evaluation of special transportation funds and/or programs for promoting economic development. The general nature of the Department's future research efforts in these three areas is outlined in the following recommendations.

(1) The Department should continue to monitor economic development programs in other states. This could provide useful guidance concerning the relationship between transportation improvements and economic development. This effort could also be useful in identifying and evaluating special transportation funds and/or programs the Department may wish to consider for promoting economic development in Texas.

(2) The Department should pursue additional research directed at quantifying the relationship(s) between economic development impacts and transportation improvement project type and setting (e.g., how, for a given type of improvement, do economic development impacts vary by physical, economic, and sociodemographic environments). The modified REIMHS model described in this research report should be used to conduct this investigation.

(3) The Department should evaluate the need to develop special funds and/or programs for using transportation improvement expenditures to promote economic development in the state. The initial phases of this investigation should focus on the basic policy question of whether the Department's mission should include using transportation investment to promote economic development in the state. If it is determined that this is an appropriate role for the Department, the types of funds and programs necessary to accomplish this element of the Department's mission should then be identified, evaluated, and implemented.

REFERENCES

1. Washington, E. J., N. Pinnoi and R. W. Stokes. *State Highway Investment and Economic Development: State-of-the-Art Review*. Research Report No. 1228-1 (Draft), Texas Transportation Institute, College Station, TX, Oct. 1990.

2. Forkenbrock, D.J. and D.J. Plazak. *State Transportation Programs to Foster Economic Development, RISE Technical Report II*. Office of Advance Planning, Planning and Research Division, Iowa Department of Transportation, Feb. 1986.

3. Briggs, R. Interstate Highway System and Development In Non-metropolitan Areas. *Transportation Research Record 812*, TRB, Washington, DC, 1981, pp. 9-12.

4. Sicardi, A.J. Economic Effects of Transit and Highway Construction and Rehabilitation. *Journal of Transportation Engineering*, Vol. 112 (1), 1986, pp. 63-75.

5. Lichter, D.F. and G.V. Fuguitt. Demographic Response to Transportation Innovation: The Case of the Interstate Highway. *Social Forces*, Vol. 59 (2), 1980, pp. 493-512.

6. Miller, S.F., Jr. Effects of Proposed Highway Improvements on Property Values. *National Cooperative Highway Research Program Report 114*, TRB, Washington, DC, 1971.

7. Langley, C.J., Jr. Highways and Property Values: The Washington Beltway Revisited. *Transportation Research Record 812*, TRB, Washington, DC, 1981, pp. 16-21.

8. Palmquist, R.B. Impact of Highway Improvements on Property Values. *Transportation Research Record 887*, TRB, Washington, DC, 1982, pp. 22-29.

9. Grossman, D.A. and M.R. Levin. Area Development and Highway Transportation. *Highway Research Record 16*, TRB, Washington, DC, 1963, pp. 24-31.

10. Gamble, H.B. and T.B. Davinroy. Beneficial Effects Associated with Freeway Construction: Environmental, Social, and Economic. *National Cooperative Highway Research Program Report 193*, TRB, Washington, DC, 1987.

11. Mills, F. Effects of Beltways on the Location of Residences and Selected Workplaces. *Transportation Research Record 812*, TRB, Washington, DC, 1981, pp. 26-33.

12. Eagle, D. and Y.J. Stephanedes. Dynamic Highway Impacts on Economic Development. *Transportation Research Record 1116*, TRB, Washington, DC, 1987, pp. 56-62.

REFERENCES (CONT.)

13. Baird, E.A. and M.A. Lipsman. *The Role of Non-Interstate Highway Transportation in Enhancing Economic Development in Iowa: Development of an Economic-Based Methodology for Programming Highway Improvements,* Iowa Department of Transportation, prepared for presentation at the International Conference on Transportation and Economic Development, Colonial Williamsburg, VA, Nov. 1989.

14. Wilson, F.R., A.M. Stevens and T.R. Holyoke. Impact of Transportation on Regional Development (Abridgement). *Transportation Research Record 851*, TRB, Washington, DC, 1982, pp. 13-16.

15. Allen, B.L., D.W. Butterfield, A. Kazakov, M.L. Kliman, A.A. Kubursi, and J.D. Welland. Measuring Economic Stimulation from Capital Investment in Transportation. *Transportation Research Record 1197*, TRB, Washington, DC, 1988, pp. 49-55.

16. Aschauer, D.A. Is Public Expenditure Productive? *Journal of Monetary Economics*, March 1989, pp. 177-200.

17. Cambridge Systematics, Inc., Donohue and Associates, Inc., and Regional Economic Models, Inc. *Highway 29/45/10 Corridor Study: Economic Development Benefits and Cost-Benefit Evaluation*, Final Report, March 1989.

18. Lemmerman, J.H. Quick Benefit-Cost Procedure for Evaluating Proposed Highway Projects. *Transportation Research Record 984*, TRB, Washington, DC, 1984, pp. 11-22.

19. Liew, C.K. and C.J. Liew. *Regional Economic Development Impact Model: Phase I Study*, Report No. 1 WR-CR-85-C-4, Oklahoma University, Norman, OK, Nov. 1985.

20. Politano, A.L. and C.J. Roadifer. Regional Economic Impact Model for Highway Systems (REIMHS). *Transportation Research Record 1229*, TRB, Washington, DC, 1989, pp. 43-52.

21. Box, G.E. and G. Jenkins. *Time-Series Analysis*. Holden-Day, San Francisco, CA, 1970.

22. Memmott, J.L. and J.L. Buffington. *Revised Highway Economic Evaluation Model (HEEM-II)*. Research Rept. 225-28F, Texas Transportation Institute, College Station, TX, Nov. 1983.

23. U.S. Department of Commerce, Bureau of Economic Analysis. *Regional Multipliers: A User's Handbook for the Regional Input-Output Modeling System (RIMSII)*. U.S. Government Printing Office, Washington, DC, 1986.

REFERENCES (CONT.)

24. Garcia-Diaz, A. and G. Freyre. *Relationship between Economic Development and Transportation Investment*. Unpublished Manuscript, Department of Industrial Engineering, Texas A&M University, College Station, TX, Nov. 1989.

25. U. S. Department of Transportation, Federal Highway Administration. *Vehicle Operating Costs, Fuel Consumption, Pavement Type, and Congestion Factors*. Unpublished Report, June 1982.

26. U. S. Department of Transportation, Federal Highway Administration. *The Highway Performance Monitoring System Analytical Process, Vol. II, Technical Manual Version 2.1*. Office of Planning, Washington, DC, Dec. 1986.

27. American Association of State Highway and Transportation Officials. *A Manual on User Benefit Analysis of Highway and Bus Transit Improvements*. Washington, DC, 1977.

28. Miller, T. R., K. A. Reinert, and B. E. Whiting. *Alternative Approaches to Accident Cost Concepts: State-of-the-Art*. Federal Highway Administration, Safety and Design Division, Washington, DC, Jan. 1984.

29. U. S. Department of Transportation, Federal Highway Administration. *Price Trends for Federal-Aid Highway Construction*. Office of Engineering, Federal-Aid Division, Washington, DC, various issues.

30. U. S. Department of Commerce, Bureau of the Census. *1982 Census of Transportation: Truck Inventory and Use Survey, United States*. Government Printing Office, Washington, DC, 1986.

31. U. S. Department of Transportation, Federal Highway Administration. *Highway Statistics*. Government Printing Office, Washington, DC, 1987.

32. Texas Department of Transportation. *Bryan - College Station to Pinehurst Feasibility Study*. Transportation Planning Division, Austin, TX, May 1990.