EMPLOYMENT IMPACT ANALYSIS FOR HIGHWAY OPERATIONS

Prepared for

Federal Highway Administration
Department of Transportation

Prepared by

MacroSys Research and Technology
Washington, DC

July 18, 2003

EXECUTIVE SUMMARY

In national and state legislative debates, job creation is one of the major arguments made for highway investments. Models have been developed to estimate the number of jobs created by spending on highway construction. In contrast, highway operations have received far less attention, although operations and maintenance have become relatively more important than construction since the interstate system has been largely completed, and the number of jobs, by type of skill and income level, created by spending in highway operations is very likely to differ significantly from jobs created by new construction. A new model is therefore needed to incorporate distinctive features of highway operations and to provide policymakers with specific information on highway operations.

The research presented in this report aims to develop such a model. At the core is the Transportation Satellite Accounts, an input-output model extended to provide more details on transportation. A wide variety of source data were analyzed to develop the spending structure and the average employee compensation for major categories of highway operation activities. The total employment impact estimated includes the direct hire of highway operations and the direct and indirect employment impact of the purchases of commodities and services for highway operations.

In 2000, the expenditure on highway operations accounted for more than 15 percent of the total expenditure on state-administered highways and generated a total of 184,854 full-time job equivalents, or 17,810 jobs per billion dollars spending on average. In terms of the number of jobs, traffic supervision, toll collection, and snow and ice removal are the three largest job-creating activities of highway operations. They account for about 65 percent of the total jobs created by highway operations.

Comparison of Employment Impact of Highway Operations and Construction Spending (full-time job equivalents per billion dollars*)

	Highway Operations	Highway Construction (FHWA)	Highway Construction (BLS)	JOBMOD (version 1.1)
Direct employment	12,231	7,250	NA	NA
Indirect employment	5,579	18,080	NA	NA
Total employment	17,810	25,330	16,298	21,219

FHWA: Federal Highway Administration; BLS: Bureau of Labor Statistics. JOBMOD is a software program for estimating the economic impact of highway construction.
*All estimates are based on 2000 dollars, except for that of JOBMOD for which the information of a specific year cannot be found in the materials available.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EMPLOYMENT IMPACT ANALYSIS FOR HIGHWAY OPERATIONS

I. INTRODUCTION

In national and state legislative debates, job creation is one of the major arguments made for highway investments. Models have been developed to estimate the number of jobs created by spending on highway construction either directly through the contracts for construction labor and supplies, or indirectly through the increased spending of the hired labor and through productivity gains to society from the new transportation facility.[1] These models do not represent spending on operational improvements, except as a minor component of new construction.

The number of jobs, by type of skill and income level, created by spending in operations is very likely to differ significantly from jobs created by new construction. Operations are more electronics based, less dependent on the use of heavy equipment, and more personnel intensive. The skill set required for staff of a traffic operations center open 24 hours a day, 7 days a week is fundamentally different from the skill set of a construction crew, and the ratio of payroll to expenditures on physical materials is probably also quite different, resulting in significant differences in the number and type of jobs created per level of expenditure.

A new model is therefore needed to incorporate these distinctive features of highway operations and to provide policymakers with specific information on highway operations. This need was demonstrated in 2001 when the U.S. Federal Highway Administration (FHWA) Operations Office had the opportunity to propose spending

[1] See Weisbrod (2000) for a comprehensive review of the literature on the impact analysis of transportation investment.

initiatives as part of an economic recovery package. The key policy issue was how many jobs would be created by spending targeted on operations compared to traditional, construction-based highway spending for economic stimulation. Only crude estimates could be made, and the credibility of those estimates would have been easily challenged since they were not based on accepted methods and data such as the national accounts.

The new model for highway operations can be readily developed with the Transportation Satellite Accounts (TSA) as its basis. The TSA is an extension by the Bureau of Transportation Statistics and the Bureau of Economic Analysis (BEA) of the input-output tables of the United States. It identifies and measures transportation activities by establishments engaged in transportation as a secondary activity (i.e., in-house transportation) as well as those engaged in transportation as a primary activity (i.e., for-hire transportation). The TSA's more detailed view of the structure of the U.S. economy identifies detailed expenditure flows with their commensurate material and labor flows. Expenditures on labor, material, and other components for operations can be extracted from the TSA by industry and translated into jobs. Since the TSA has been developed through BEA and vetted as consistent with other components of the system of national accounts, the resulting estimates of labor impacts can be made with methods and data that are consistent with those used by FHWA for job creation of construction expenditures.

This research aims at developing such a new model for evaluating employment impact of highway operations, and this report presents a summary of the research methods, data sources, and results. The remainder of the report is organized as follows: Section II defines highway operations and its components. Section III provides an outline of major approaches to employment impact analysis. Section IV defines the model for the current research. Section V discusses the data sources of the research. Section VI presents key steps of data processing. Section VII describes the methods and procedures for the development of the spending structure and employment compensation of highway operations activities and employment-output ratios. The final section provides results. Some technical details are provided in an appendix.

II. DEFINITION OF HIGHWAY OPERATIONS

Expenditures on highway operations are recurrent expenses that are required to administer and operate the nation's highway facilities (AASHTO, 1999; U.S. Bureau of Census, 2000a; U.S. Federal Highway Administration, 2000). Highway operations are categorized into three major categories, namely, administration and research, highway and traffic services, and highway law enforcement and safety. The activities covered under each of these operations components are discussed below. Some examples of highway operations are provided in Table 1.

Administration and Research

This category includes the administration of federal, state and local highway agencies and programs that are not assignable to a specific capital, maintenance or any other highway activity. Also included are highway planning, research and development, investigation, staff education and training, highway litigation, highway publication, and other related highway activities.

Table 1. Examples of Highway Operations by Type

Administration and Research

Administration: Administration of highway programs by federal, state and local highway agencies such as the Federal Highway Administration, National Highway Traffic Safety Administration, and their corresponding state and local level agencies. Examples of operations expenditure for these agencies include salaries and benefits of employees; office expenses such as supplies, rent, communication, travel, insurance, utilities and miscellaneous expenses; and contractual services and supplies; etc.

Research and Planning: Highway planning, staff training, research and development, and investigation, including laboratory and field research in road and bridge materials and design, traffic research, and technical and financial studies, etc.

Highway and Traffic Services

Traffic control operations: These include operations of intelligent and other traffic control and surveillance systems that are designed to monitor and control traffic by managing vehicle flow on streets and highways. These systems consist of traffic signal control; freeway, tunnel and bridge surveillance and control; electronic message boards; video monitoring; traffic information radio stations; motorist aid; and toll-free drawbridges, tunnels and ferries; etc.

Snow and ice removal: Removal of snow and ice from roadway, roadside, and shoulders; sanding and chemical applications; erection and removal of snow fences; and opening of inlets clogged with snow and ice, etc.

Other services: Highway beautification; junkyard control and roadside cleaning operations; control of outdoor advertising; litter pickup, mowing, and tree trimming; air quality monitoring; vegetation management; and erosion control programs; etc.

Highway Law Enforcement and Safety

Traffic supervision: This covers highway patrol activities providing traffic supervision: enforcement of traffic laws, supervision and direction of traffic, accident investigation, and incidental service functions, etc.

Highway traffic and driver safety: These include safety programs and similar activities related to the promotion of highway safety and traffic accident prevention, whether conducted by the state or local highway agency, the highway patrol, a traffic safety commission or other state agency. These also include such activities as driver education and driver awareness, motorcycle safety, drunk or impaired driving, accident reduction, and emergency medical services for highway accident victims, etc.

Vehicle inspection: Inspecting vehicles, operating inspection stations, and other activities related to periodic motor vehicle inspections programs; motor vehicle emissions inspection; and motor carrier safety inspection; etc.

Vehicle size and weight enforcement: Operating truck-weighing stations, operating other devices involved in the enforcement of vehicle, and equipment and size and weight limitations on highways, etc.

Highway and Traffic Services

Highway and traffic services include activities designed to improve the efficiency of highway operations, safety, fuel economy, air quality, and appearance of the roadway. Highway and traffic services are classified into four major activities. The first type of highway and traffic services is traffic control operations monitoring and controlling traffic flows. The second type is snow and ice removal. The third includes toll collection services. The fourth type covers other miscellaneous highway services, which include highway beautification, litter control, vegetation management, erosion control, and air quality programs.

Highway Law Enforcement and Safety

Highway law enforcement and safety cover law enforcement and safety activities of federal, state and local highway agencies. In addition, highway related functions of state and local police, departments of public safety, and other agencies are also included. Law enforcement and safety cover traffic supervisions and enforcement, highway traffic and driver safety programs, motor vehicle inspection programs, and enforcement of vehicle size and weight limitations.

III. GENERAL APPROACHES TO EMPLOYMENT IMPACT ANALYSIS

Key Measures of Employment Impact

Employment impact of highway operations is defined for this project as the total effect on the level of employment caused by spending on highway operations. The key to this definition is the cause and effect relationship between highway operational spending and changes in the level of employment. Identifying and quantifying this relationship is the essence of any impact assessment effort.

Total employment impact has its underlying details. The total effect on employment level is traditionally considered as the combination of direct, indirect, induced, and enabling effects on the variable. These different types of effects are distinguished according to the ways through which they are linked to the original cause. Take as an example the output impact of a highway investment project. It is easy to understand that the project will require direct purchases of, say, concrete, steel, asphalt, etc., and generate extra income for, say, construction workers. It can also be assumed that the project will lead to improvements in the highway network. Accordingly, the direct effect is the additional output required to satisfy the direct purchases for the highway project; the indirect effect is the additional output required to produce the additional output for the direct purchases; the induced effect is the additional output required to satisfy new consumption purchases induced by extra incomes from the highway project; and the enabling effect is the additional output produced in response to an improved highway network due to the highway project. In other words, the direct, indirect, and induced effects relate to the highway project as the original source of additional purchases, while the enabling effects relate to the highway project as the original cause of an improved highway system. The former three are demand-side effects and the latter one is a supply-side effect. Demand-side effects inhere in spending money on any public projects but supply-side effects are limited to those that cause direct improvement in broadly defined productive factors and processes. For example, projects in public housing, socially beneficial as they arguably are, are unlikely to have big supply-side effects, although they have all the demand-side effects.[2] Since supply and demand both change in response to the highway project, the output impact of the project is then the total output increase due to the four types of effects.

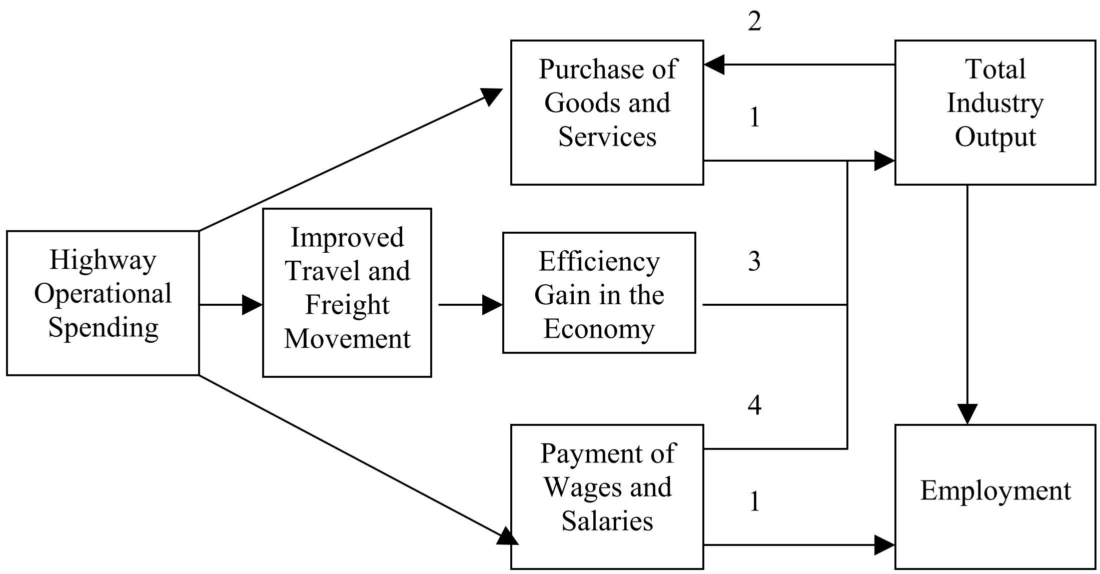
Highway operations are different from highway investment projects in terms of their initial spending or purchase patterns. For example, more operational spending may go to labor while more investment spending may go to materials. Nevertheless, highway operations have similar types of impacts on labor and output as highway investment projects. First, highway operational spending entails direct purchase of materials such as computers, phones, and other office supplies. Labor is needed to produce these materials. More important, the spending on labor for highway operations results in direct increases in employment. These are all direct impacts on labor. Second, additional goods and services have to be produced to facilitate the production of materials directly purchased for highway operations. The production of such additional goods and services needs

[2] Good illustrations can be found among ancient relics such as the Pyramids and the Great Wall. While it is hard to count the Pyramids as productive inputs in ancient times, the Great Wall was probably the most important input without which the normal production of anything was hard to carry out at least in Northern China. Of course, both the Pyramids and the Great Wall are having great supply-side effects today in connection with tourism industries, but the Pharaohs and the First Emperor must have correctly ignored these effects due to discounting even if their planning horizon had extended to today. It is also interesting to note that the induced effects of building the Pyramids and the Great Wall were probably very small because the construction workers were mostly slaves and slaves were not paid. Naturally, that must have made the direct effects larger.

more labor, which is the first round of the indirect impact on labor. Further indirect impacts come forth as more indirect responses occur throughout the economy. Third, the increased employment for highway operations leads to more consumption spending on goods and services. The labor employed in producing these goods and services is counted as induced employment impact. Fourth, highway operations facilitate travel and movement of freight, resulting in more efficient resource allocation and utilization. The efficiency gain affects productive activities within the entire economy that in turn affect the level of employment. Figure 1 provides an overview of these effects for the employment impact of highway operations.

The direct effect works through two channels: direct purchase of goods and services and direct hire of labor (arrows labeled "1" on figure 1). Except for the direct hire, all employment impact works through industry output. Purchase of goods and services, efficiency gain, and consumption spending all lead to increased industrial output, which in turn results in additional employment of labor.

Figure 1. Employment Impact of Highway Operations



1: Direct Effect; 2: Indirect Effect; 3: Enabling Effect; 4: Induced Effect

Alternative Methods

Researchers and analysts have utilized three broad sets of methods to estimate economic, including employment, impact of highway investments. They are the input-output (IO) approach, structural model approach, and aggregate production/cost function approach. Different approaches require different input data and provide different output details. These approaches can be adapted for highway operations. [3]

Input-Output Analysis

The standard IO approach lends itself most readily to the measurement of direct, indirect, and induced effects. Actually, these effects are very often defined as inherent IO concepts since each effect corresponds exactly to one IO quantity. Because employment impact is determined through output impact, except for direct hire as shown in figure 1, we use output impact to illustrate these IO quantities. The direct effect is the vector of goods and services on which the initial spending is made; the indirect effect is the sum of total commodity multipliers for industries minus the direct effect; and the induced effect is the sum of total commodity multipliers for households. Commodity multipliers here refer to all multipliers except for income multipliers in the IO system with an endogenous household sector. A commodity multiplier is the additional output of the commodity that is produced in response, directly and indirectly, to one dollar's worth of initial spending. Since the initial spending triggers a chain of reactions that affects all commodity production, all commodity multipliers must be summed up to measure the total effect corresponding to each category of the spending. Because a total multiplier includes both

[3] A general discussion of these approaches is provided below for conceptualization purpose. This report will only provide estimates of traditional impact measures based on IO approach.

direct and indirect effect, the direct effect must be taken out to identify the indirect effect. Also, only the commodity multipliers are counted for output impact.[4]

Other than the availability of an IO table suitable for the purpose, the most important step for the IO approach is the estimation of the direct output effect, which is often presented as a vector of goods and services directly purchased with the total spending. Multiplying a standard input structure or spending structure with the total spending on goods and services gives the vector of direct output effect. Obviously the spending structure differs among different types of operations. With the direct output effect vector, the standard Leontief equation can be used to estimate the indirect effect. To capture the induced effect through the same procedure, the usual commodity and industry-based IO tables have to be extended with a household sector and labor commodity in the intermediate section, and the direct effect vector has to include an element for household income, which is equal to the direct spending on labor for highway operations.

A supply-side IO approach can be used to estimate a different type of effect. Imagine an upstream and a downstream industry. While the increased demand by the downstream industry certainly will stimulate more production by the upstream industry, more production by the upstream industry may also stimulate more production by the downstream industry. For example, an improved highway system may stimulate certain industries to grow faster, which will in turn facilitate the growth of other industries. This is particularly true in a supply-constrained economy. To the extent that the production of the upstream industry facilitates the production of the downstream industry, this supply-

[4] Going from output impact to employment impact and handling direct employment impact through direct hire require more technical steps outside the IO framework. More discussions are provided in section IV.

side effect may be called the enabling effect. As the following discussion will show, this supply-side measure does not reveal the full magnitude of the enabling effect.

Structural Model

The IO approach focuses on the linkages among industries in the form of input and output relations. An industry increases its production in response to the increase in the demand for its product. Likewise, an industry increases its production by the additional amount of input it receives. Although this type of interaction among industries is important, industries do not only respond to demand and supply from consumers and from each other. They may all respond in different ways to a technological breakthrough, to the opening of a new market, and to a change in the pattern of inter-regional comparative advantages, etc. This type of response, another form of enabling effects, is particularly important for highway impact assessment because an improvement in the highway network and its operations tends to be closely associated with market widening and deepening such as more and better access to inputs and more and better outlets for output. The IO approach does not capture this type of enabling effects.

A structural model, with sufficient details on the underlying interactive mechanism within the economy, is a more appropriate approach. Compared to the IO model, a structural model makes possible the simultaneous determination of a much wider variety of variables and it provides far greater flexibility for model specification on the underlying economic relations. For example, a better-operated highway system may result in a reduction in transportation costs. Industries may respond to the cheaper transportation services by producing more or producing different output mix. The increased output and changed output mix both lead to changes in employment. A structural model can be designed to capture this effect by including equations relating highway operational characteristics with a variable on transportation cost and a transportation cost variable with an output variable. Specifying and estimating valid structural equations among these variables are not easy tasks, but a structural modeling approach is taken whenever such efforts are made.

A structural model can be designed for the whole economy or for a part of it: a computable general equilibrium (CGE) model is of the former kind, and a partial equilibrium model for the transportation sector is an example of the latter. A CGE model is needed to capture the full magnitude of an impact felt throughout the entire economy. A CGE model may include the full set of IO relations as its components. The specification of other components of a CGE model depends on specific issues at hand, data availability, and modeling strategies.

Production/Cost Function

A production function relates total output to total inputs such as labor, private capital, and public inputs such as transportation infrastructure services; while a cost function relates total cost to total output, factor prices, public inputs. In the case of highway operations, highway service has to be quantified and related to highway operational spending. Both production and cost functions are essentially single equation approaches, relating a variable affected by highways with highway operational spending through highway service along with a set of common economic variables in one equation. Aggregate production functions are often used to examine private output growth and productivity changes. In contrast, cost functions are often used to estimate cost reduction and productivity effects and to derive factor demand.[5]

Both production and cost functions can be estimated for the whole economy or for an individual industry. The key to the assessment of highway employment impact is the inclusion of the highway operational spending or highway service as an independent variable in these functions. Other than the usual technical obstacles such as model specification and data development, using production and cost functions as an approach for employment impact assessment has two particular challenges. First, the questions of what the highway service is and what the relationship is between the total highway service and highway operations must be answered for the production and cost function approach to be applicable. Second, one must answer the question of how the output increase and cost reduction relate to the level of employment.

Three supplemental procedures are needed. The first is for estimating highway service, the second is for relating highway operations with highway service, and the third is for relating output and cost with employment. The production function or cost function is of course the core.

IV. MODEL FOR THE ANALYSIS OF THE EMPLOYMENT IMPACT OF HIGHWAY OPERATIONS

We use a modified IO model for estimating the employment impact of highway operations (Figure 2). There are two reasons for choosing an IO model as the approach to our analysis. First, the model facilitates the estimation of direct, indirect, and induced

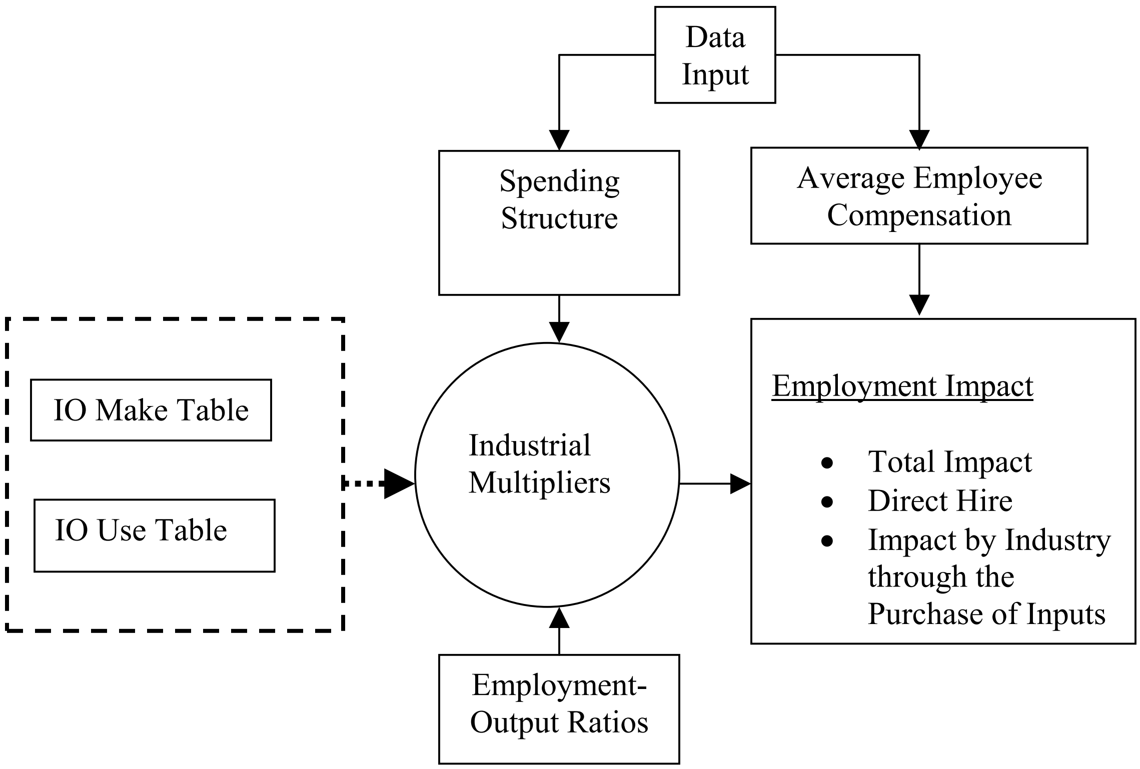
[5] One important disadvantage for both production and cost function approaches is that neither models the underlying mechanism relating the highway investments and cost reductions or productivity increase. Factors such as mobility, accessibility, and business inventory management are intuitive elements within that mechanism. However, solid conceptual and empirical understanding is currently lacking.

effects of highway operations on employment. Second, the IO model has several advantages in that it facilitates consistent estimates within an integrated system, it provides industry-level details, and it serves as an information base as well as a set of analytical tools. The IO model is one of the most frequently used methods in economic impact analysis and has been widely used in the impact analysis of highway-related investment. Numerous impact assessments developed for transportation investments are often based on IO models. Among the widely used comprehensive regional IO models are the BEA RIMS II multipliers (U.S. Bureau of Economic Analysis, 1992a), the Minnesota IMPLAN Group, Inc. (MIG) IMPLAN Pro model (Minnesota IMPLAN Group (MIG) Inc., 1999), the Regional Science Research Corporation (RSRC) PC I-O model (Regional Science Research Corporation, 1996), and the Regional Economic Models, Inc. REMI Policy Insight model (Treyz, Rickman, and Shao, 1992). IO models are often used for both the assessment of an existing highway system (Babcock and Bratsberg, 1997; Keane, 1996a; Politano and Roadifer, 1989; RESI, 1998; Stokes, Pinnoi, and Washington, 1991; and Texas Department of Transportation, 1998) and the analysis of proposed projects (Burgess and Niple Ltd, 1998; Liew and Liew, 1984; Stokes, Pinnoi, and Washington, 1991; Wilbur Smith Associates, 1995; Texas Transportation Institute, 1991; Thompson et al., 1997; and University of North Carolina at Charlotte, 1991, 1999). They are also used by the FHWA in highway investment impact analysis (Keane, 1996b; BUCTS and Battelle, 2001). Therefore, an IO model for highway operations has another advantage in terms of producing estimates of employment impact that are conceptually comparable with those for highway investment projects.

Model Structure

As shown in Figure 2, the IO model consists of five interrelated components. First, an IO make table provides information on goods and services produced by each and every industry in the U.S. economy. Second, an IO use table presents the information on goods and services used by each and every industry in the U.S. economy. The make and use tables provide a complete characterization of the inter-industry relationship and serve as the basis for all IO analyses including employment impact assessment. Third, the spending structure vector contains information on purchase or spending patterns for highway operations. This vector consists of the same number of commodities as the IO use table, with each value as the share of purchase of the corresponding commodity for highway operation purposes. Fourth, the employment-output ratios vector provides information on employment impact per unit output for each and every industry. The vector has the same number of elements as the number of industries in the IO use table (thus industrial multipliers) with each element's value as the unit employment level for the corresponding industry. Fifth, average employee compensation provides single or multiple parameters for converting payment to employees including wages or salaries and benefits into employment provided in highway operations through direct hiring.

Figure 2. Model Structure



The left-most box and arrow are displayed with dotted lines to highlight the feature in our model design that the basic input data from the underlying IO tables will not be visible to the end users of the model. Making these data and processes invisible is justified on the following considerations. First, the basic IO make and use tables do not have direct use to the end users except for providing input data to derive multipliers. Second, deriving multipliers from basic IO tables involves complicated matrix manipulations. Third, multipliers do not fluctuate very much over time provided that the analytical period is not too far away from the IO base period. Nevertheless, we believe that IO tables should be provided along with other components in Figure 2 to enforce data consistency and facilitate data updating.

Research Scope and Data Requirements

The above model includes all aspects of employment impact of highway operations and provides a general guidance for our analysis. Because of the limit of current resources and time, however, we have to leave out the induced and enabling effects in our analysis. Most previous studies of similar kind also do not capture these effects. The employment impact estimated in our analysis includes the employment impact through direct hire and the employment impact from the purchases of goods and services for highway operations. In addition, our analysis is limited to highway operations expenditures on state-administered highways.

Based on the basic model and the research scope, the following data are required for the estimation of employment impact of highway operations.

- Industrial multipliers
- Spending structure of highway operations activities
- Employment-output ratios by industry
- Average employee compensation in each of highway operations activities
- Expenditures on highway operations

Except for industrial multipliers, which are available from the Transportation Satellite Accounts, there are no readily available data for other required items. Therefore, the spending structures of highway operation activities, employment-output ratios by industry, and average employee compensations in highway operations activities need to be developed from a variety of data sources.

The biggest challenge is the development of the spending structures of highway operations activities, and the major obstacle is how to determine what inputs of goods and service are used in those activities defined in Section II. There may be two ways to overcome the obstacle. One is to conduct a survey of spending structure in highway operations activities across states. But this approach is time consuming and is impractical given the constraints of current resources. The other way to overcome this difficulty is to borrow the spending structures of similar industries from BEA input output analysis. The latter approach is adopted in our analysis.

Another challenge is that the employment-output ratios by industry need to be developed. While the output impact comes directly from the analysis within an IO model, additional data are needed to link such output impact to employment. Since IO models produce output impact at the industry level, it is highly preferable to build the output-employment links at the industry level as well. The data on industrial output and employment are available for the development of employment-output ratios.

Finally, average employee compensation is required for the model implementation. It is independent of the underlying IO model and is necessary for the estimation of the number of jobs directly generated by the payment of employee compensation.

V. DATA SOURCES

This section states the types and sources of the data used in our analysis:

- Expenditures on highway operations by activity: U.S. Federal Highway Administration (2001) *Highway Statistics*.
- Industrial multipliers (2-digit IO industry level): U.S. Bureau of Transportation Statistics and Bureau of Economic Analysis (2000) *Transportation Satellite Accounts for 1996*.
- Spending structure in highway operations: U.S. Bureau of Economic Analysis (1992b) Input-Output Tables; and U.S. Federal Highway Administration (1998)

Test and Evaluation Project No. 28: Anti-icing Technology, Field Evaluation Report (Publication No.: FHWA-RD-97-132).

- National employment by industry: U.S. Bureau of Labor Statistics: *National Employment, Hours, and Earnings* (Employees on Nonfarm Payroll by Industry (2-digit SIC) in 1996, seasonally adjusted).
- Industrial output (2-digit IO industry level): U.S. Bureau of Economic Analysis (2000) *Transportation Satellite Accounts for 1996*, The Make of Commodities by Industry table.
- Average annual wage by occupation: U.S. Bureau of Labor Statistics, *Occupational Employment Statistics: 2000 National Occupational Employment and Wage Estimates*.
- Average annual wage by industry: U.S. Bureau of Labor Statistics, *Occupational Employment Statistics: 2000 National Industry-Specific Occupational Employment and Wage Estimates* (2000 National 3-digit SIC Estimates for SICs 071 to 903*)*.
- Benefit-compensation ratios: U.S. Bureau of Labor Statistics, *National Compensation Survey: Employer Cost for Employee Compensation*.
- State and local government expenditure: U.S. Bureau of the Census, *State and Local Government Finance Data*.
- State and local government employment: U.S. Bureau of the Census (2000b) *State and Local Government Public Employment and Payroll Data*.
- Full-time sworn state police officers: U.S. Bureau of Justice Statistics (2000) *Law Enforcement Management and Administrative Statistics, 1999: Data for Individual State and Local Agencies with 100 or More Officers*.
- Average employee compensation in toll collection: Illinois State Toll Highway Authority (2000) *Alternatives for Restructuring the Tollway System: A Report to the Governor*.

VI. KEY STEPS OF DATA PROCESSING

This analysis includes the direct employment impact of spending on labor cost and the total employment impact of input purchases on other industries. The number of jobs derived in this analysis is the number of full-time job equivalents rather than full-time job positions. The temporal scope of data used in this analysis is about 10 years. It is assumed that no changes in technology have affected the practice of highway operations occurs.

The major procedures of the analysis are as follows:

- Convert SIC-based industrial employment into two-digit IO level industrial employment.
- Develop the employment-output ratios by industry.
- Adjust the industrial multipliers from TSA for 1996 in order to match the developed employment-output ratios by industry.
- Develop the spending structure, i.e., the input structure of each activity including traffic control operations, snow and ice removal, toll collection, other services, traffic supervision, highway safety and driver education, vehicle inspection and vehicle size and weight enforcement, general administration, and research and planning.
- Then, disaggregate the total U.S. highway operations spending in each activity into corresponding categories of inputs.
- Determine the average annual employee compensation in each activity.
- Calculate direct hiring based on the derived labor cost and average annual employee compensation in each activity.

- Calculate the indirect impact of each activity: First, calculate the impact of input purchases on industrial output. Second, multiply the industrial output change with employment-output ratios to obtain the number of jobs created through the purchases of commodities and services.
- Obtain the number of total jobs by the summation of the number of direct hiring and the number of jobs created through the purchases of goods and services.

VII. SPENDING STRUCTURES, AVERAGE EMPLOYEE COMPENSATION, AND EMPLOYMENT-OUTPUT RATIOS

The development of the spending structure, employee compensation, and employment-output ratios is the key to our analysis. The following describes the methods and procedures in the process of data processing and analysis.

Spending Structure

No data are readily available for spending structure in highway operations activities. Therefore, proxies have to be used to approximate the spending structure for each of highway operations activities. The major data source is the BEA 1992 Input-Output data from which some similar industries are selected as proxies for eight of nine highway operation activities. The exception is snow and ice removal whose spending structure is developed based on the data from the "Anti-icing Technology, Field Evaluation Report" published by FHWA in 1998. The use of these data to obtain the proxies for the spending structure of highway operations activities is based on the assumption that technological relationships between commodity inputs in each of highway operations activities have been stable.

The calculation of spending structure includes all commodity inputs and employee compensation. For the selected industries that have data on both commodity inputs and employee compensation, the derivation of their spending structure is straightforward. The share of each input is the ratio of the value of the input to the sum of all commodity inputs and employee compensation. For industries without data on employee compensation, the share of employee compensation is developed on the basis of estimated employee compensation. At the lack of employee compensation in the IO data, the estimation of the employee compensation is specifically stated.

Highway operations activities fall into three categories: highway and traffic services, administration and research, and highway law enforcement and safety. The following describes how the spending structure of each activity is determined.

Highway and Traffic Services

There are four types of highway and traffic services: traffic control operations, snow and ice removal, toll collection facility, and other services (e.g., beautification, erosion prevention, litter control).

- Traffic control operations: Two IO industries are selected and then combined to be the proxy for traffic control operations. They are Electric Utilities Repair and Maintenance and Construction, and Computer Programming, Data Processing, and Other Computer Related Services.
- Toll collection: IO industry State and Local Government Toll Highways is used as a proxy for toll collection.
- Other services: IO industry Landscape and Horticultural Services is used as a proxy for "Other Services."

- Snow and ice removal: The spending structure of snow and ice removal is derived with the data from the report on "Anti-icing Technology" (Appendix I).

Administration and Research

This includes two categories of activities: general administration, and research and planning. The expenditures on the two categories in *Highway Statistics* are not exclusively for highway operations but for highway construction, maintenance, and operations. Prior to further analysis, the portion of the expenditures on highway operations has to be separated. The expenditures on administration and research for highway operations are separated from the total expenditures on administration and research according to the share of total highway operations expenditure in the total expenditure of highway construction, maintenance, and operations, which is 15.26 percent in 2000. Table 2 shows the expenditures and their percentages on highway construction, maintenance, operations; the total expenditures on administration and research; and the expenditures on administration and research for highway operations.

The spending structure of state and local government including government enterprises (98C, 99C, and 79) is used as a proxy for the commodity input structure of general administration. However, there is no data on employee compensation for state and local government in the BEA 1992 Input-Output tables.

The share of employee compensation in state and local government is estimated with the data on state and local government finance and public employment and payroll published by U.S. Bureau of the Census and with the data on employee compensation from U.S. Bureau of Labor Statistics (BLS). In state and local government finance, the

Table 2. Highway Operations Expenditure for State-Administered Highways

	Expenditure (Thousands of Dollars)	Percentage Of Total Highway Expenditure
Capital outlay	44,069,138	70.44%
Acquisition of right-of-way	3,115,876	
Preliminary and construction engineering	6,470,094	
Highway construction and system preservation	34,483,168	
Physical Maintenance	8,945,942	14.30%
Highway Operations Expenditure	9,543,848	15.26%
Traffic control operations	939,604	
Snow and ice removal	1,139,028	
Other services	479,972	
Toll collection facility	1,289,969	
Traffic supervision	4,243,549	
Highway safety and driver education	706,608	
Vehicle inspection and vehicle size and weight enforcement	744,918	
Total expenditure of capital outlay, physical maintenance, and highway operations	62,558,928	100%
Total general administration and research & planning	5,473,540	
General administration	4,669,474	
Research and planning	804,066	
General administration and research for highway operations	835,262	*
General administration expenses	712,562	*
Research and planning	122,700	*

Data Source: U.S. Federal Highway Administration (2001) *Highway Statistics 2000*, page IV-56. Washington, D.C.: U.S. Department of Transportation.
*Note: General administration and Research & Planning expenses for highway operations are separated from their total expenses based on the share of highway operations in the total expenditure of capital outlay, physical maintenance, and highway operations.

total expenditure of current operations includes general administration of state and local government and government enterprises. Government enterprises accounted for 13.33% of the total commodity purchases by state and local government and government enterprises in 1992. For the consistency of the data analysis, the data on state and local government and government enterprises in the IO data were combined to approximate the spending structure of general administration.

Total employee compensation needs to be estimated in order to obtain the share of employee compensation in the current operations in state and local government. The Census Bureau provides the data on full-time employment equivalent and the total expenditure of current operations and wages and salaries of state and local government. Unfortunately, the Census Bureau's definition of "wages and salaries" is not the same as employee compensation because it does not include some of the employee benefits. Nevertheless, it is broader than the definition of wage used by BLS.

The average annual employee compensation of state and local government is estimated with the average wages of state and local government and the benefit-compensation ratios of state and local government from BLS. First, an average annual wage of state and local government is computed based on the data from the 2000 National Industry-Specific Occupational Employment and Wage Estimates (2000 National 3-digit SIC estimates for SICs 071 to 903) published by BLS. The average annual wage for state and local government employees is a weighted average of the industry total average wages of state government and local government. Then, the average annual wage of state and local government is adjusted with a benefit-compensation ratio of 29.2% in 2000 into the average annual employee compensation. Third, the total employee compensation of state and local government is the product of the average annual employee compensation and the full-time equivalent employment of state and local government. The share of employee compensation is the ratio of the estimated total employee compensation to the total expenditure of current operations of state and local government. The estimated share of employee compensation is 59.15% based on the data in 2000.

A preliminary analysis shows that the share of "wages and salaries" in the expenditure of current operations has been quite stable over the period from 1992 to 2000, ranging from 43 to 46%. Meanwhile, the data from BLS shows that the benefit-compensation ratio has been in the neighborhood of 30% with a deviation of less than one percentage point. This suggests that the share of employee compensation in state and local government is also quite stable. Therefore, it is reasonable to apply the estimated share of employee compensation in 2000 to the BEA 1992 Input-Output data for state and local government to form a spending structure of state and local government.

The IO industry Noncommercial Research Organization is used as a proxy for the function of research and planning in highway operations.

Highway Law Enforcement and Safety

Four types of activities are included in this category of highway operations: traffic supervision, highway safety and driver education, vehicle inspection, and vehicle size and weight enforcement. State and Local Government - Police is used as a proxy for the structure of commodity purchases in traffic supervision. Similarly, no data on employee compensation are available for state and local government police. There are no statistics on the number of police who are engaged in traffic supervision. Generally, the state police are responsible for state highway patrol. It is assumed that all full-time sworn police officers who are in field operations are involved in traffic supervision. In 1999, 51,260 full-time sworn police officers were in field operations (U.S. Bureau of Justice Statistics, 2000). Total employee compensation in traffic supervision in 2000 is calculated using the adjusted average annual compensation for a police officer. The share of total compensation in the expenditure of state highway traffic supervision is combined with the data on State and Local Government Police Consumption to derive the spending structure of traffic supervision.

IO industry Social Services is selected as a proxy for highway safety and driver education. Vehicle inspection and vehicle size and weight enforcement is combined and treated as one activity. Fixed Facilities and Inspection and Weighing Services for Motor Vehicle Transport industry is selected as a proxy for the combined activity.

Average Annual Employee Compensation

Two steps are involved in estimating average employee compensation. The first step is to identify an appropriate proxy occupation or industry for each of highway operations activities. The second is to adjust an average wage with an appropriate benefit-compensation ratio into average compensation. Table 3 provides a summary of the estimation of average annual employee compensation for all of highway operations activities.

With an exception of toll collection, the average employee compensation for all of highway operation activities is based on the *2000 Occupational Employment and Wage Estimates* (U.S. Bureau of Labor Statistics) or *2000 National Industry-Specific Occupational Employment and Wage Estimates* (U.S. Bureau of Labor Statistics). An occupational average wage is used when an occupation is identified in regard to a highway operation activity. Otherwise, the average wage of a corresponding industry is used for a highway operations activity. As indicated in Table 3, occupational wages are used as proxies for average wages in snow and ice removal, traffic supervision, and vehicle inspection and vehicle size and weight enforcement. Industrial average wages are used as proxies for average wages in traffic control operations, other services, general administration, research and planning, and highway safety and driver education.

Table 3. Wage and Compensation Data

Activities	Sources of Wages	Proxy Occupation or Industry Wage	Wage ($)	Benefit-Compensation Ratio (%) (4)	Average Annual Compensation
Traffic control operations	(1)	Weighted Average Wage of SIC 173 and 737, industry total	52,105	25.5	69,940
Snow and ice removal	(2)	Highway maintenance workers	27,480	25.5	36,886
Other services	(1)	SIC 078 Landscape and horticultural services, industry total	24,120	25.5	32,376
Toll collection	(3)	Illinois Toll Industry Average	37866 (5)		52244 (6)
General administration	(1)	Weighted average wage of State and Local Government (SIC 902 and 903), industry total	35,793	29.2	50,555
Research and planning	(1)	SIC 873 Research, development, and testing services, industry total	48,450	29.2	68,432
Traffic supervision	(2)	Sheriff and police's patrol officers	40,590	29.2	57,331
Highway safety and driver education	(1)	SIC 839 Social Services, not elsewhere classified, industry total	30,690	25.5	41,195
Vehicle inspection	(2)	Automotive service technicians and mechanics	30,780	25.5	41,315

Sources: (1). U.S. Bureau of Labor Statistics: 2000 National Industry-Specific Occupational Employment and Wage Estimates (3-digit). (2). U.S. Bureau of Labor Statistics: 2000 Occupational Employment and Wage Estimates. (3). The average wage and compensation are estimates based on The Report by Illinois Toll Highway Authority (2000). (4) Benefit-compensation ratio is from U.S. Bureau of Labor Statistics: Employer's Cost for Employee Compensation in 2000. In 2000, benefit-compensation ratio for state and local government is 29.2% and for service-producing industries 25.5%. (5) This number is the average payment to employees, exclusive of FICA/Retirement and Insurance benefits. (6) Weighted average payroll (including FICA/retirement)+ average insurance benefits = 46127 + (7633922/1248) = $52,244.

The average wage is adjusted into average employee compensation with appropriate benefit-employee compensation ratios published by BLS. The benefit-compensation ratio of state and local government is applied to general administration, research and planning, and traffic supervision. The benefit-compensation ratio of private sector service-producing industry is applied to traffic control operations, snow and ice removal, other services, highway safety and driver education, and vehicle inspection.

The average employee compensation in toll collection activity is derived from the data in the report by Illinois Toll Highway Authority (2000). It is an average across occupations in Illinois Toll Highway Authority. The national average wage or compensation for toll highway employees is not available.

Employment-Output Ratios

The employment-output ratios are employment per unit industrial output. They are developed with the industrial output data from U.S. Transportation Satellite Accounts for 1996 (U.S. Bureau of Transportation Statistics and Bureau of Economic Analysis, 2000) and the seasonally adjusted nonfarm employment data in 1996 from U.S. Bureau of Labor Statistics. The industrial output is based on two-digit input-output industry codes. The industrial employment is based on two-digit SIC codes. The annual employment is an average of the seasonally adjusted monthly employment. In order to compute employment-output ratios, the two data sets are adjusted correspondingly so that they are compatible with each other.

VIII. RESEARCH RESULTS

The total expenditure of highway operations on state-administered highway is \$10,379,110 thousand in 2000, which accounts for 15.26% in the total expenditure on state-administered highway (Table 2). As shown in Table 4, the expenditure on highway operations generates a total of 184,854 full-time job equivalents (jobs hereafter), which equals 17,810 jobs per billion (2000) dollars spending on average. In terms of the number of jobs, traffic supervision creates 78,500 jobs, accounting for 42.47% of the total jobs created by highway operations. Toll collection is ranked the second, generating 21,021 jobs. Snow and ice removal is the third largest provider of jobs in highway operations, creating 20,446 jobs. The three aforementioned activities account for about 65% of the total jobs created by highway operations. A detailed breakdown of the employment impact by activity and industry is provided in Table 5.

In terms of job creation per billion dollars, the category of other services is ranked the highest, generating 22,130 jobs per billion (2000) dollars. The second and third highest are vehicle inspection and vehicle size and weight enforcement, and general administration, generating 19,288 and 18,978 jobs per billion (2000) dollars, respectively. In a descending order, other activities are traffic supervision, highway safety and driver education, toll collection, snow and ice removal, traffic control, and research and planning.

The results of three other comparable impact studies on highway construction are presented below, and they are compared with the results of this study. Table 6 shows the adjusted estimates of employment impacts of federally aided highway investment from a FHWA study in 1996 (Keane, 1996b). Original estimates are based on 1995 dollars. After adjustment for inflation, the total of direct and indirect employment is 25,330 jobs per billion (2000) dollars.[6] Table 7 shows the estimated employment impacts of a number of construction-related activities by the Bureau of Labor Statistics (BLS) (Keane, 1996b). The original estimates are based on 1982 dollars. Table 7 provides the adjusted

[6] Induced employment was also estimated in the FHWA study but is excluded here for comparison purposes.

estimates of total direct and indirect employment impacts based on 2000 dollars. Investment in federally aided highways created 16,298 jobs per billion (2000) dollars. JOBMOD, a software program developed by BUCTS and Battelle (2001), generates an estimate of 21,219 jobs from the direct and indirect impact of highway construction. A comparison of these studies is provided in Table 8. The average estimated total direct and indirect employment created by the expenditure on highway operations is 17,810 per billion (2000) dollars. It is smaller than the employment impact of the investment in federally aided highway estimated by the FHWA study (25,330) and by JOBMOD (21,219), but it is greater than the employment impact of the investment in federally aided highway estimated by BLS (16,298). Also, highway operations spending generates more direct employment but much less indirect employment than does highway construction investment in terms of employment per billion dollars. Almost 70% (68.7%) of employment generated in highway operations is direct hiring. In contrast, more than 70% (71.4%) of employment generated in highway construction is indirect employment. This suggests that highway operations is more labor intensive but has less linkage with other industries than highway construction.

There are several caveats in our analysis, mainly due to severe data constraints. First, our analysis does not include all employment impact of highway operations because of current resource constraints. As stated in Section IV, our analysis of the employment impact of highway operations is limited to the direct employment impact of spending on labor and the direct and indirect employment impact of spending on input purchases. The induced effect through household spending and enabling effect through the improvement of transportation networks are not included in our analysis. The employment impact would be larger if the induced effect and enabling effect were captured. Therefore, the numbers of full-time job equivalents in our analysis are conservative estimates.

Second, the spending structures of highway operations except for snow and ice removal are borrowed from proxy industries. Because of the constraints of data availability on highway operations spending structures, similar industries are used as proxies for activities in highway operations. Though we believe the use of the proxies is justified, the real spending structure of highway operations might be quite different. Third, average employee compensations are also estimates based on proxy occupations or industries. Similarly, real compensation in highway operations might also be very different.

Finally, the employment-output ratios are based on the data in a single year. It is assumed that these ratios reflect the relationship between employment and output in an average year and do not change significantly over time. In reality, employment-output ratios change over time because of the change of economic conditions. Because of the above caveats, the estimated number of full-time job equivalents should be used with caution.

Table 4. Summary of the Analysis of the Employment Impact of Highway Operations (full-time job equivalents)

	Total Spending ($1,000)	Average Annual Employee Compensation	Direct Hiring	Employment Impact from spending on materials and services	Total Employment Impact	Employment Per Billion Dollars
Highway and traffic services						
Traffic control operations	$939,604	$69,940	7,066	5,995	13,061	13,901
Snow and ice removal	$1,139,028	$36,886	17,510	2,936	20,446	17,950
Other services	$479,972	$32,376	9,029	1,593	10,622	22,130
Toll collection facility	$1,289,969	$52,244	15,145	5,876	21,021	16,296
Administration and research						
General administration	$712,562	$50,555	8,337	5,186	13,523	18,978
Research and planning	$122,700	$68,432	779	829	1,608	13,105
Highway law enforcement and safety						
Traffic supervision	$4,243,549	$57,331	51,260	27,240	78,500	18,499
Highway safety and driver education	$706,808	$41,195	6,633	5,072	11,705	16,560
Vehicle inspection and vehicle size and weight enforcement	$744,918	$41,315	11,191	3,177	14,368	19,288
Total	$10,379,110		126,950	57,904	184,854	17,810

Table 5. Employment Impact of Highway Operations by Activity and Industry (full-time job equivalents)

	Traffic Control	Snow and Ice Removal	Other Services	Toll Highway	General Administration	Research and planning	Traffic Supervision	Highway Safety	Vehicle Inspection	Total
Agricultural, forestry, and fishery services	33	12	112	51	19	5	16	24	15	287
Metallic ores mining	4	14	1	5	1	0	1	1	1	28
Coal mining	4	6	1	21	6	1	2	4	2	48
Crude petroleum and natural gas	18	110	27	116	28	4	12	39	109	464
Nonmetallic minerals mining	4	67	8	45	4	1	3	3	5	140
Construction	92	59	53	1,513	162	18	29	99	256	2,281
Fabricated metal products and transportation equipment	91	39	30	123	25	7	136	58	27	537
Food and kindred products	9	23	4	7	16	2	28	9	9	107
Tobacco products	0	0	0	0	0	0	1	0	0	1
Textile and apparel products	13	10	11	51	15	3	37	13	7	159
Lumber and wood products	32	17	13	177	22	8	12	35	33	350
Furniture and fixtures	2	1	0	2	0	0	1	2	1	10
Paper products	59	33	16	29	16	33	32	110	19	347
Printing and publishing	191	29	34	50	35	99	24	640	109	1,211
Chemicals and allied products	36	892	71	140	25	10	58	33	19	1,282
Petroleum refining and related products	5	23	8	40	8	1	2	12	42	139
Rubber and miscellaneous plastics products	78	48	19	94	16	8	169	47	19	499
Footwear, leather, and leather products	1	0	0	1	1	0	48	4	0	56
Stone, clay, and glass products	30	349	6	106	13	6	17	11	17	555
Primary metal industries	77	33	12	86	13	3	20	23	16	283
Industrial machinery and equipment	506	46	20	219	25	13	35	41	22	927
Electronic and other electric equipment	571	17	21	114	20	10	31	42	22	849

Table 5. Employment Impact of Highway Operations by Activity and Industry (full-time job equivalents), cont.

	Traffic Control	Snow and Ice Removal	Other Services	Toll Highway	General Administration	Research and planning	Traffic Supervision	Highway Safety	Vehicle Inspection	Total
Instruments and related products	24	9	4	12	11	3	18	19	5	105
Miscellaneous manufacturing	12	5	3	21	8	2	17	33	7	107
Railroad, pipelines, state and local transit, and transportation services	44	44	47	102	22	8	35	46	38	386
Motor freight transportation and warehousing	76	124	72	146	29	15	44	89	33	629
Water transportation	3	4	2	5	3	1	17	6	2	42
Air transportation	76	20	93	27	18	13	16	52	76	391
Communications	159	19	29	65	25	12	49	150	73	580
Electric, gas, and sanitary services	37	60	14	182	38	6	22	43	22	424
Wholesale trade	514	241	207	327	79	41	138	222	198	1,966
Retail trade	106	24	19	253	33	8	13	99	50	605
Finance	136	41	49	196	48	13	56	111	86	736
Insurance	36	19	31	108	7	5	23	47	144	420
Real estate	66	17	25	27	9	16	13	95	86	353
Hotels and lodging places	130	41	33	52	14	18	189	107	184	769
Personal and repair services (except auto)	38	14	11	15	16	4	13	25	10	145
Business services	2,199	329	368	1,161	238	336	291	2,225	1,155	8,303
Eating and drinking places	150	42	39	54	-24*	19	140	115	179	715
Automotive repair and services	61	20	43	28	13	7	118	49	15	353
Amusements	48	12	15	19	-8*	5	12	213	40	357
Health services	1	1	1	2	-387*	1	2	3	2	-375
Educational and social services, and membership organizations	221	23	21	83	-238*	63	84	71	26	355
General government industry	0	0	0	0	4,766	0	25,214	0	0	29,979
Direct hire	7,066	17,510	9,029	15,145	8,337	779	51,260	6,633	11,191	126,950
Total	13,061	20,446	10,622	21,021	13,523	1,608	78,500	11,705	14,368	184,854

*Note: Negative numbers indicate that the services of these industries are provided rather than purchased by general government industry, which is used as a proxy for general administration for highway operations. Then, a negative employment impact is generated.

Table 6. Employment Impacts of Investment in Federally Aided Highway

Type of Employment	Jobs Created Per Billion (2000) Dollars*
Direct	7,250
Indirect	18,080
Subtotal	25,330
Induced	13,308
Total	38,638

Source: Keane (1996b) The Economic Importance of the National Highway System. *Public Roads*, Vol. 59, No. 4 (available online).
*Note: These are adjusted numbers for which the BEA gross domestic product implicit price deflators are used. The original employment numbers are based on 1995 dollars. It is assumed that the same employment is required for the same work. However, one billion 1995 dollars spending is inflated into 1.0896 billion 2000 dollars. The employment numbers in this table are derived through the division of the original employment numbers by 1.0896.

Table 7. Employment Impacts of Construction-Related Activities

Type of Activities	Total Direct and Indirect Employment Impacts Per Billion (2000) Dollars*
Private multi-family housing	15,362
Private single-family housing	13,512
General Hospitals	15,688
Elementary and Secondary Schools	14,761
Federally Aided Highway	16,298
Sewer-Line Work	14,615
Sewer-Plant Work	14,225
College Housing	14,520
Civil Work, Land	12,960
Civil Work, Dredging	14,109
Public Housing	15,133
Federal Office Building	15,265
Commercial Office Building	13,734

Source: Keane (1996b) The Economic Importance of the National Highway System. *Public Roads*, Vol. 59, No. 4 (available online).
*Note: These are adjusted numbers for which the BEA gross domestic product implicit price deflators are used. The original employment numbers are based on 1982 dollars. It is assumed that the same employment is required for the same work. However, one billion 1982 dollars spending is inflated into 1.6134 billion 2000 dollars. The employment numbers in this table are derived through the division of the original employment numbers by 1.6134.

Table 8. Comparison of Employment Impact of Highway Operations and Construction Spending (full-time job equivalents per billion dollars*)

	Highway Operations		Highway Construction (FHWA)		Highway Construction (BLS)	JOBMOD (version 1.1)
	Employment	%	Employment	%	Employment	Employment
Direct employment	12,231	68.7	7,250	28.6	NA	NA
Indirect employment	5,579	31.3	18,080	71.4	NA	NA
Total employment	17,810	100	25,330	100	16,298	21,219

NA, not available.

*All estimates are based on 2000 dollars, except for that of JOBMOD for which the information of a specific year cannot be found in the materials available.

REFERENCES

AASHTO (American Association of State Highway and Transportation Officials) (1999) *Maintenance Manual: The Maintenance and Management of Roadways and Bridges*. Washington, D.C.

Babcock, M.W. and Bratsberg, B. (1997) *Economic Impacts of the Kansas Comprehensive Highway Program*. Report Prepared for Kansas Department of Transportation, Department of Economics, Kansas State University.

Burgess and Niple, Ltd., et al. (1998) *Final Report: I-71 Corridor Transportation Study*. Prepare for Ohio-Kentucky-Indiana Regional Council of Governments.

BUCTS and Battelle (Boston University Center for Transportation Studies and Battelle Memorial Institute) (2001) *JOBMOD, A Model for Estimating Federal-aid Highway Program Income and Employment Impacts*. Washington, D.C.: Federal Highway Administration.

Keane, T. (1996a) *Highway Infrastructure Investment and Job Creation*. Publication No. FHWA-PL-96-015. Federal Highway Administration, U.S. Department of Transportation. Washington, DC.

Keane, T. (1996b) The Economic Importance of the National Highway System. *Public Roads*, Vol. 59, No. 4. Retrieved from: http://www.tfhrc.gov/pubrds/spring96/p96sp16.htm, on May 4, 2003.

Liew, C.K., and C.J. Liew. (1984) Measuring the development impact of a proposed transportation system. *Regional Science and Urban Economics*, Vol. 14, 175-98.

Illinois State Toll Highway Authority (2000) *Alternatives for Restructuring the Tollway System: A Report to the Governor*. Retrieved from: http://www.illinoistollway.com/News/Documents/GovernorsReport.pdf, on February 5, 2003.

Minnesota IMPLAN Group (MIG), Inc. (1999) *IMPLAN Professional Users Guide*. Stillwater, Minn.

Politano, A.L. and C. Roadifer. (1989) Regional Economic Impact Model for Highway Systems. *Transportation Research Record 1229*. Transportation Research Board, National Research Council. Washington, DC.

RESI – A Research Institute of Towson University (1998) *The Economic Impact of Maryland highway Investment*. Prepared for the Maryland State Highway Administration. Baltimore, MD.

Regional Science Research Corporation (1996) *PC I-O User's Manual*. Hightstown, N.J.

Stokes, R.W., N. Pinnoi, and E.J. Washington. (1991) *Economic Development Impacts of Expenditures for State Highway Improvements in Texas*. Texas Transportation Institute, Texas A&M University for the Texas Department of Transportation. Austin, T.X..

Texas Transportation Institute (1991) *Economic Assessment of the Proposed Improvement of US Highway 287 in Wichita Falls*. Texas Department of Transportation. Austin, TX.

Texas Department of Transportation (1998) *Economic Impact of Developments of the Texas trunk System*. Austin, TX.

Thompson, E., E. Berger, D. Black, A. Chanra, and K. Gitings. (1997) *Economic Impact Assessment of a Southern Kentucky Corridor (I-66)*. Center for Business and Economic Research, University of Kentucky. Lexington, KY.

Treyz, G., D. Rickman, and G. Shao. (1992) The REMI economic-demographic forecasting and simulation model. *International Regional Science Review*, Vol. 14, No. 3, 221-53.

University of North Carolina at Charlotte (1991) *Interstate 40 Economic Impact Study: Technical Report*. North Carolina Department of Economic and Community Development. Raleigh, NC.

University of North Carolina at Charlotte (1999) *Economic Impacts of the Monroe-Gastonia Connector*. North Carolina Department of Economic and Community Development. Raleigh, NC.

U.S. Bureau of Census: *State and Local Government Finance Data*. Retrieved from: http://www.census.gov/govs/www/financegen.html, on March 11, 2003.

U.S. Bureau of the Census (2000a) *Government Finance and Employment Classification Manual*. Retrieved from: http://www.census.gov, in November 2002.

U.S. Bureau of Census (2000b) *State and Local Government Public Employment and Payroll Data*. Retrieved from: http://www.census.gov/govs/apes/00stlall.xls, on March 18, 2003.

U.S. Bureau of Economic Analysis (1992a) *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II), 2nd edition*. U.S. department of Commerce, Washington, D.C.

U.S. Bureau of Economic Analysis (1992b) Input-Output Tables.

U.S. Bureau of Justice Statistics (2000) Law Enforcement Management and Administrative Statistics, 1999: Data for Individual State and Local Agencies with 100 or More Officers. Washington, D.C.: U.S. Department of Justice.

U.S. Bureau of Labor Statistics: *National Employment, Hours, and Earnings* (Employees on Nonfarm Payroll by Industry in 1996, seasonally adjusted). Retrieved from: http://www.bls.gov/webapps/legacy/cesbtab1.htm, on January 21, 2003.

U.S. Bureau of Labor Statistics: *Occupational Employment Statistics: 2000 National Occupational Employment and Wage Estimates*. Retrieved from: http://www.bls.gov/oes/oes_dl.htm, on January 27, 2003.

U.S. Bureau of Labor Statistics: *Occupational Employment Statistics: 2000 National Industry-Specific Occupational Employment and Wage Estimates (*2000 National 3-digit SIC Estimates for SICs 071 to 903*)*. Retrieved from: http://www.bls.gov/oes/oes_dl.htm, on March 6, 2003.

U.S. Bureau of Labor Statistics: *National Compensation Survey: Employer Cost for Employee Compensation*. Retrieved from: http://www.bls.gov/ncs/home.htm, on March 31, 2003.

U.S. Bureau of Transportation Statistics and Bureau of Economic Analysis (2000) U.S. Transportation Satellite Accounts for 1996. Retrieved from: http://www.bea.gov, on January 23, 2003.

U.S. Federal Highway Administration (2001). *Highway Statistics 2000*. Washington, D.C.: U.S. Department of Transportation.

U.S. Federal Highway Administration (2000) *Guide to Reporting Highway Statistics*. Retrieved from: http://www.fhwa.dot.gov/, in November 2002.

U.S. Federal Highway Administration (1998) *Test and Evaluation Project No. 28: Anti-icing Technology, Field Evaluation Report* (Publication No.: FHWA-RD-97-132). Washington, D.C.: U.S. Department of Transportation.

Weisbrod, G. (2000) *Current Practices for Assessing Economic Development Impacts from Transportation Investments, A Synthesis of Highway Practice*. National Cooperative Highway Research Program (NCHRP) Synthesis 290. Washington, DC.: Transportation Research Board, National Research Council.

Wilbur Smith Associates (1995) *Economics Impact Study of CSX Intermodal's New Atlanta Terminal*. CSX International. Richmond, VA.

APPENDIX I. SPENDING STRUCTURE OF SNOW AND ICE REMOVAL

The analysis of the spending structure of snow and ice removal is based on the data from the report on anti-icing technology (U.S. Federal Highway Administration, 1998), which provides data on spending on snow and ice removal for five of the 15 participating states in the test and evaluation of anti-icing technology. The five states are California, Nevada, New Hampshire, New York, and Wisconsin. Three types of information in the report are useful to our analysis: spending on labor, equipment, materials, and total costs in snow and ice removal; information on prices of some inputs; and information on total amount of materials and volume ratios of chemicals to abrasives in materials.

The data are available for both test and control sections of highways. The major difference between test and control sections is in the materials used during the tests. New materials were used in test sections but conventional ones such as salt and sand or other abrasives were used in control sections. Online research shows that the use of conventional technology is still a normal practice in snow and ice removal. For example, both Virginia and Montgomery County of Maryland are still using a salt/sand mix in snow and ice removal. Therefore, the data on control sections are used in our analysis because they are based on conventional technology in snow and ice removal.

Procedures of the Analysis

First, spending patterns in labor, equipment and materials across five states are calculated based on the data in Tables 59-63 of the 1998 U.S. Federal Highway Administration report. Due to the differences in the number of observations across the five states, state averages for each category are calculated and then summed by category. The average percentages of spending on labor, equipment and materials are then calculated (Table A1).

To be consistent with the data for California, New Hampshire, Wisconsin and Nevada, data on materials in New York were adjusted to eliminate the cost for clean up (see discussion below). Nevada has data with and without clean-up cost.

Second, spending on materials is separated into two categories: salt and abrasives (Table A2). Third, a spending structure of snow and ice removal was obtained with four categories: labor, equipment, salt, and abrasives (Table A3).

Table A1. Average Spending Structure of Snow and Ice Removal with Three Categories

	California Average	Nevada Average	New Hampshire Average	New York Average	Wisconsin Average	Total	%
Labor	$127.79	$221.31	$70.52	$2,044.51	$161.65	$2,625.78	56.70%
Equipment	$59.57	$151.90	$59.88	$426.51	$136.60	$834.47	18.02%
Materials	$60.74	$347.08	$96.23	$609.05	$57.41	$1,170.51	25.28%
Total	$248.11	$720.30	$226.63	$3,080.08	$355.66	$4,630.77	100.00%

Table A2. Average Structure of Spending on Materials

	California Average	Nevada Average	New Hampshire Average	New York Average	Wisconsin Average	Total	%
Salt	$27.94	$241.12	$89.86	$572.32	$57.41	$988.66	84.47%
Abrasives	$32.80	$105.96	$6.37	$36.64	$0.00	$181.77	15.53%
Total	$60.74	$347.08	$96.23	$608.96	$57.41	$1,170.43	100.00%

Table A3. Average Spending Structure of Snow and Ice Removal

	Average	Average
Labor	56.70%	56.70%
Equipment	18.02%	18.02%
Materials	25.28%	
Salt		21.35%
Abrasives		3.93%
Total	100.00%	100.00%

Spending on Materials

Materials used in snow and ice removal include two major categories: salt (different types) and abrasives (sand or cinders). The amount and price of and spending on each category is provided in Tables 59-63 in the 1998 U.S. Federal Highway Administration report. According to the ratio of salt/sand ratios for each state (Table A2), spending on materials is separated into two sub-categories: salt and abrasives.

Four of the five states have data on spending on materials that do not include clean-up cost. New York's spending on materials, however, does include clean-up cost. The costs for salt and sand is calculated based on the ratio of salt to sand and the price information for salt and sand.[7] Then, the sum of costs for salt and sand is deducted from total spending on materials. The remainder is the cost for cleanup of sand. In order to be comparable across state, the cleanup cost is deducted from the spending for materials and from the total spending for snow and ice removal. The final data for the five states does not include clean-up costs, and they are comparable in terms of the composition of spending.

[7] There is no price information for New York in the 1998 U.S. Federal Highway Administration report. The average price of abrasives in California and New Hampshire ($7.58/t) are used in the analysis. This may bring error into the computation because the price of sand in New York could be quite different from the average. The difference between the price of abrasives in California and New Hampshire is $7.44, which is substantial.

In the case of Nevada, there is no price information for salt or sand. The price for salt in California ($55.00/t) is used to separate spending on salt from total spending on materials.