AN EVALUATION OF THE BUSINESS ATTRACTION MODULE IN MONTANA'S HIGHWAY ECONOMIC ANALYSIS TOOL

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16. Abstract

Montana's Highway Economic Analysis Tool (HEAT) was created to forecast the economic benefits of highways projects, including possible growth in employment. Of particular interest is the business attraction module in HEAT, which estimates the direct employment gains within counties by many industrial sectors owing to improvements in accessibility. This study investigates the transferability of HEAT to other locales by implementing essential aspects of HEAT's business attraction module for five candidate highway projects in Wisconsin. HEAT's business attraction module gives plausible results, but the impacts of these five candidate highway projects were each estimated to be very small. HEAT's business attraction module, for the most part, uses readily-available national data, so any agency with access to a statewide travel forecasting model could implement a similar economic forecast.

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Table of Contents

An Evaluation of the Business Attraction Module in Montana's Highway Economic Analysis Tool

Executive Summary

Project Summary

Montana's Highway Economic Analysis Tool (HEAT) was created to forecast the economic benefits of highways projects, including possible growth in employment. Of particular interest in Wisconsin is the business attraction module in HEAT, which estimates the direct employment gains within counties by many industrial sectors owing to improvements in accessibility by highways. This study investigates the transferability of HEAT to other locales by implementing essential aspects of HEAT's business attraction module for five candidate highway projects in Wisconsin.

Background, Process

Many states, including Wisconsin, have long sought a valid method of forecasting the economic development benefits of highway projects. Local communities and business interests have routinely advocated highway projects on the basis of claimed economic development potential. The Wisconsin Department of Transportation (WisDOT) is similar to most state DOTs who do not possess an automated method of including economic development as a factor in long-range transportation plans or in the highway project selection process.

Recently, Montana DOT commissioned the development of the Highway Economic Analysis Tool (HEAT), one of the more sophisticated configurations of computer programs for estimating the economic benefits of highway investments. However, it is unclear whether HEAT can be effectively transferred to another state. This project tested HEAT's business attraction module in a suitably modified form on five Wisconsin highway corridors. An emphasis was placed on executing HEAT-like concepts in a way that is within the capability and resources of a typical state DOT.

Business attraction in HEAT is directly influenced by highway travel and indirectly by the presence of air cargo and railroads. Total industrial growth is the sum of the influences of improvements in highways on each mode and on suppliers, customers and the labor market. The HEAT business attraction module, as implemented for the case studies, essentially performs two tasks.

- *Growth Constraints.* Growth constraints for a county consist of limits on how fast any industry can grow, based on the industry's historic grow rate in a multistate region, and limits as to the ultimate employment gains, based on how much an industry is currently below its regional average within a county.
- *Growth by County and Industrial Group*. Growth in employment in any industry, within the constraints, is calculated from improvement in accessibility from a highway project and the degree to which transportation is an input factor in the production of products for that industry.

There are a total of seven sources of employment growth in HEAT.

- Highway Access for Airports
- Highway Access to Rail Terminals
- General Highway Accessibility
- General Highway Accessibility to Canada
- Expanded Customer Markets
- Expanded Labor Markets
- Better Accessibility to (from) Suppliers

Each of these growths in employment are proportional to (a) fractional improvements in accessibility, (b) the fraction of product production that is transportation of a particular mode, (c) the current level of employment in an industry, and (d) various other modifiers that depend upon the mode or market. One such modifier, which appears in the "access" growths is an index of relative business costs for a county.

A business attraction model was created on a spreadsheet that adopted national parameters from Montana's HEAT and various local sources. Accessibility indexes were principally functions of travel times, which were obtained for both before and after cases from WisDOT's statewide travel forecasting model. The model was tested on five rural highway projects for which funding decisions have not yet been made. None of the project improved travel times sufficiently to realize important economic impacts.

Finding and Conclusions

The business attraction model produces plausible results. The model is appropriately constrained to avoid overly optimistic forecasts of employment impacts.

The only transportation inputs to the business attraction model are highway travel times, so the model is not sensitive to any other manifestations of transportation investment, such as increases in airport capacity, faster rail service, or highway safety improvements.

The business attraction model evaluates every project using exactly the same methodology. Thus, it is suitable for ranking the economic development potential of many candidate projects.

The business attraction model requires a substantial amount of local data. However, if national data are used to construct certain parameters, the start-up costs of the model can be minimized.

There were no unusual difficulties in interfacing a statewide travel forecasting model with the business attraction model. Montana's implementation of HEAT in a GIS package was particularly convenient, but the spreadsheet developed for this study is certainly adequate for the task and it is much easier to maintain. Once a business attraction model is set up for any highway project, it becomes immediately usable for any other project, large or small.

Although the five projects tested yield little economic development impact, the business attraction model will show large impacts if there are significant speed improvements from multiple highway projects or a major policy change, such as increasing speed limits on rural highways.

Recommendations for Action

Wisconsin and other states with concerns about the economic development potential of highway projects should consider implementing a business attraction model, similar to HEAT, to aid evaluation of highway projects and other policies. However, planners need to recognize that not all economic impacts of transportation projects are captured by such a business attraction model.

The business attraction model in HEAT should be scrutinized for redundancies and overly broad assumptions. For example, some of the accessibility measures created for HEAT could be inaccurate indicators of transportation costs. The availability of a statewide travel forecasting model in Wisconsin and many other states allows for better estimates of transportation cost savings.

A county-level unit of analysis works well for rural highway projects. Analysis of projects within urban areas would require much smaller traffic analysis zones. In addition, highway projects that occur within large urban areas would require the use of an urban travel forecasting model and should include an evaluation of secondary land-use impacts.

Introduction

There is a clear historical relationship between governmental expenditures on transportation infrastructure and economic growth (Nadiri and Mamuneas, 1996) of the whole US economy. Many states, including Wisconsin, have long sought a valid method of forecasting the economic development benefits of highway projects. Local communities and business interests have routinely advocated highway projects on the basis of claimed economic development potential. The Wisconsin Department of Transportation (WisDOT) is similar to most state DOTs who do not possess an automated method of including economic development as a factor in long-range transportation plans or in the highway project selection process. Staff at WisDOT from its Economic Development Section has a painstaking process for use on selected highway corridors to profile current business patterns and then estimate the potential for additional business attraction. However, that process involves manual data collection/tabulation for each corridor rather than an automated, systematic model such as HEAT. For its corridor selection process WisDOT mainly relies on a computer program (their Meta-Manager) that identifies highway segments and corridors in need of project funding, but that program is insensitive to economic development potential. It is widely recognized that economic development benefits are principally tied to the ability to move freight between points of production and points of consumption within the state.

Recently, Montana DOT commissioned the development of the Highway Economic Analysis Tool (HEAT) (Wornum et al., 2004), one of the more sophisticated configurations of computer programs for estimating the economic benefits of highway investments. While attractive on paper, there are several issues related to adapting HEAT to another state. First, while HEAT was calibrated for Montana, it has not yet been subjected to a convincing degree of validation. Second, the data requirements for HEAT, while manageable in a small-population state such as Montana, may become unwieldy in larger states. Third, HEAT works as a framework that automates the integration of several computer packages (state-level freight forecasting, GIS and economic model systems) so that the user does not need special expertise to operate any of them; however, each component would require special expertise for properly understanding and interpreting the results. Fourth, HEAT contains proprietary software code that is not easily transferable to another agency. Finally, the HEAT implementation in Montana included a laborious screening of industries by locale, though that is optional and not absolutely required for operating the system. The information generated from the industrial screening was primarily intended to provide Montana DOT officials with sufficient knowledge about market conditions in general and specific industries in particular. This knowledge would help those without a background in economics or ready access to such information interpret results and provide more informed responses when results from HEAT entered the public debate. Montana DOT directed the consultants to collect empirical data from Montana businesses about their market conditions and needs for transportation investment. This information was intended to address the original goal of the Reconfiguration Study. According to the consultants,[1] this information was critical in countering some of the extreme advocacy on the part of some local leaders that highway widening would reverse economic decline in their communities. To a

[1] Christopher Wornum, Glen Weisbrod, and Daniel Hodge, Personal memorandum to Alan Horowitz, September 21, 2007.

limited degree, the information gave Montana officials timely knowledge they should not be expected to have but was eventually needed during their outreach activities.

The need for embedding economic development considerations in the statewide project prioritization process is not new. In the 1990's New Jersey implemented the Transportation Economic and Land Use System (TELUS) (Pignataro, Burchell, and Wen, 1998), which provides project-level economic impacts to its Transportation Improvement Program. Oregon and Ohio have sought to include economic development as an essential core feature of their statewide travel forecasting models. These states actually implement a particular land-use model (PECAS) statewide (Hunt, Abraham and Weidner, 2004; Hunt and Abraham, 2003), which simulates the transfer of goods and services between zones, establishes exchange prices of land and commodities, and allows economic activity to move, grow or decline. Within these two statewide forecasting models, business and household locations are a function of transportation supply, and consequently business and household activities create transportation demands, both freight and passenger travel. After multiple revisions, the Oregon model is just now maturing into a useful tool. The Ohio model is still undergoing testing. The construction of each model required many years and many millions of dollars.

The most recent national study of state DOT practices in evaluating economic potential of transportation projects was NCHRP Synthesis #290, *Current Practices for Assessing Economic Development Impacts from Transportation Investments* (Weisbrod, 2000). This synthesis found a wide acceptance of the need for economic impact assessment. The synthesis concluded that there has been a "significant increase in the number and sophistication level of economic development impact studies conducted or commissioned by public agencies in the last decade." However, problems remain. The study cited three limitations of current efforts: inadequate data, lack of expertise, and less-than-fully-trusted methods,

Utah DOT recently commissioned an objective review (Schultz, et al., 2006) of economic development assessment tools. This review, based only on published documents, included REMI/TransSight, HEAT, HERS-ST, RIMS-II and IMPLAN. HEAT received positive comments, but its cost, complexity and required level of expertise were considered by those authors to be serious drawbacks. The review also included a survey of local practices and a complete summary of relevant literature. Furthermore, the review incorporated findings from NCHRP Synthesis #290. The Utah study found that there were only sporadic implementations of economic development analysis, despite its high importance to transportation decision-making. The Utah study concluded that economic impact analysis is essential. However, because of the difficulty of conducting economic impact analysis, the study recommended that only major highway projects with a strong potential for funding be subjected to a full economic impact analysis.

Potentially, certain concepts of HEAT, particularly its business attraction module, can be strapped onto conventional statewide travel forecasting models with freight components; these are available in about one-fourth of the states (Horowitz, 2006), including Wisconsin, thereby providing them with much of the capabilities found in Oregon and Ohio at a far more reasonable cost.

This project tested HEAT's business attraction module in a suitably modified form on five Wisconsin corridors. An emphasis was placed on executing HEAT-like concepts in a way that is within the capability and resources of a typical state DOT.

There are other innovative aspects to HEAT, beyond its business attraction module, that are not reviewed here, particularly in the way a geographic information system (GIS) was used to fully integrate the project evaluation process. Persons interested in many of the details of HEAT can find them described by Wornum and coauthors (2004).

Prominent Methods of Assessing Economic Development Impacts of Highways

Given the number of recent reviews of literature on the economic impacts of highways, this section focuses its attention on the most promising methods that have seen recent implementations by state departments of transportation.

Transportation projects can possibly affect economic development in four aspects, both short-term and long-term (CSI, 1998):

- *Construction impacts* refer to the buying of materials and hiring of workers directly caused by the construction project.
- *Business expansion* results from the reduced business costs because of the improved travel time and vehicle operating costs. It also includes the increased household buying ability due to time and cost savings on travel.
- *Business attraction* captures the effects of expanded market size for labor and suppliers beyond direct business cost benefits. It may also cause geographic shifts in population and employment.
- *Tourism impacts* primarily refer to the increase in visiting trips due to improved transportation access and the increase in business sales due to increased visitor spending.

Many studies have been conducted and software products have been developed to examine and quantify the relationship between transportation projects and the economy. Regardless of the different concepts, models and data sources they use, there is a common procedure that is followed.

- First, calculate the direct user benefits. These may include time saving, vehicle operating cost saving, incident improvement or other travel-related costs.
- Second, measure business cost benefits of the industries that are significantly affected by highway movement. These benefits may include improved reliability, reduced cost of shipping goods or services, reduced cost of worker commuting, increased productivity and competitiveness, and business expansion.
- Third, calculate the indirect benefits of the affected businesses and residences that lead to broader impacts on the economy through interactions among industries and residential spending.

This study primarily contrasts two economic impact assessment tools: REMI's (Regional Economic Model, Inc) TranSight, and HEAT (Highway Economic Analysis Tool). REMI's TranSight and its companion, Policy Insight, are fairly complex and comprehensive economic forecasting models that together simulate the effects of public or private programs on the economy. HEAT is a highly customized toolbox developed for Montana to examine the relationship between highway improvement projects and economic development.

REMI's Policy Insight functions as a dynamic input-output model in that it tracks the inter-industry dollar flows and estimates the associated economic effects (INDOT, undated). A multiregion version of Policy Insight, as implemented in Montana, will show different economic impacts in different parts of the state[2]. TranSight uses outputs from the travel demand model (VHT and VMT), translates them into policy variables (transportation cost matrix) and passes them into Policy Insight, where the impacts on economic and demographic trends are simulated (REMI, 2004).

Overview of HEAT

Montana Department of Transportation was required to conduct a study with the initial goal of examining the economic impact of reconfiguring the state's two-lane highways into four-lane highways. The resulting toolbox is the Highway Economic Analysis Tool (HEAT), which combines six modules to identify, quantify, and estimate the relationship between specific scenarios of highway reconfiguration and economic development.

HEAT aims to estimate the full economic benefits of a particular highway improvement project on industries. Figure 1 presents the three basic components of the methodology for estimating the benefits. First, the affected classes of passenger travel and the freight commodities are all identified and their origins and destinations are located. The second component identifies 13 industry sectors and creates profiles of each industry indicating their performance and dependence on freight transportation. Direct benefits for each industry are estimated including travel time reductions and operating cost savings, based on the profiles and the changes in shipping and receiving generated by the proposed improvement. New businesses that could be attracted if conditions are improved are also identified. Finally, the direct benefits and the new business attraction are input to a multi-regional economic model, along with estimates of additional tourism visitor attraction, to determine the full economic benefits, including job increases, personal income increases and gross product increases.

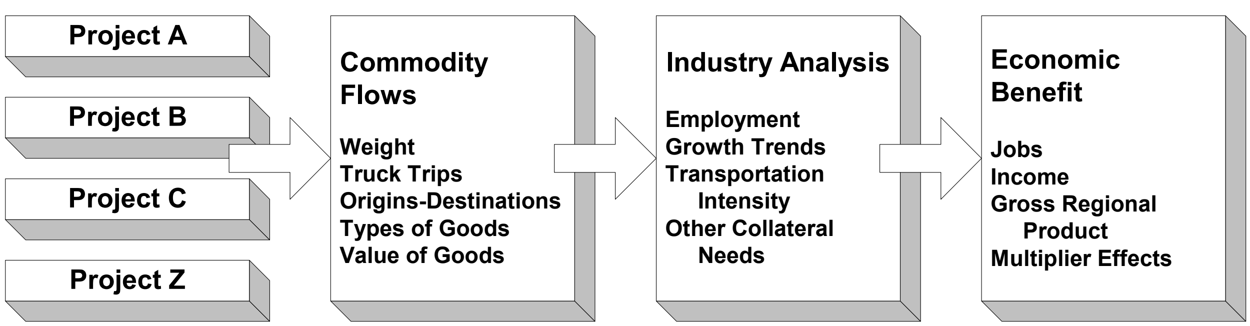

FIGURE 1 Basic Methodology for Estimating Economic Benefits of Transportation Investments (Source: Wornum, et al., 2004)

Six modules are combined in HEAT to accomplish the estimation of the economic benefits and costs associated with highway improvements. Figure 2 shows the six automated and linked modules, followed by a brief description of the data used.

[2] Adam Cooper, REMI, personal correspondence, August 29, 2007.

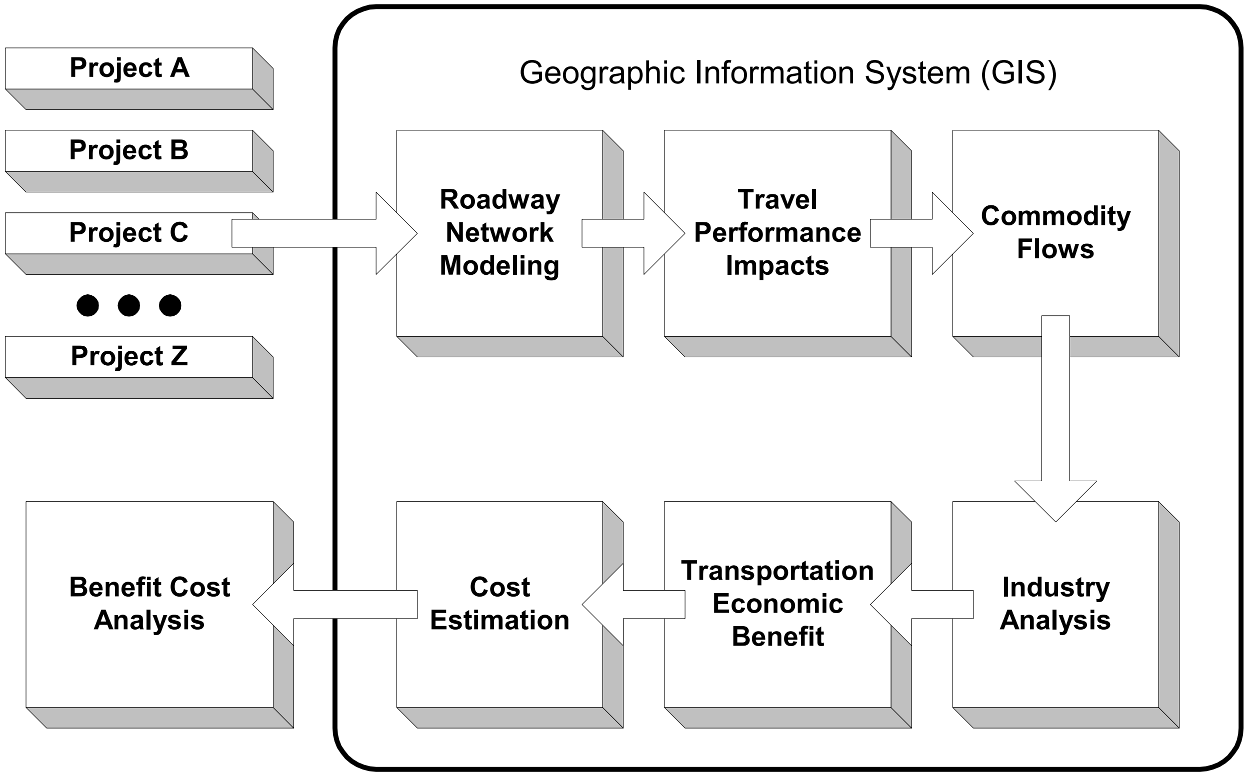

FIGURE 2 Analytical Modules in HEAT (Source: Wornum, et al., 2004)

Commodity flow data, 2001 TRANSEARCH, were purchased from Reebie. Other sources of data were used to verify the Reebie data. Freight Analysis Framework (FAF) data were used to estimate and allocate commodity percentage growth to each county based on employment. Regions outside of Montana (the rest of U.S. and western Canada) are divided into five external regions based on the five major interstates into and out of the state.

Industry profiles were created through interviews, literature and statistics. Thirteen industry sectors were identified in Montana based on the two-digit standard industrial classification (SIC) codes. Three types of background information were of interest: (*1) industry trends, (2) non-transportation local advantages and disadvantages, and (3) transportation access or mobility issues*.

Five data sources and commercial analysis tools used in HEAT need to be purchased and periodically updated: (1) Reebie commodity flow data, (2) REMI's Policy Insight, (3) Woods & Poole county-level economic forecasts, (4) MISER international trade data, and (5) IMPLAN county-level industry employment data at the two-digit SIC level.

A detailed explanation of HEAT's business attraction model, which is the core of the "transportation economic benefit" box in Figure 2, is found in a later section of this report. The business attraction model was singled-out for intense investigation because of its critical position in determining the economic benefits of highway projects.

Congestion and Accessibility Modeling

Weisbrod, et al. (2001) suggested a six-step procedure to estimate the economic impacts of congestion as shown in the Figure 3 flowchart. Weisbrod and his coauthors argue that both a HEAT-like model and model like REMI's TranSight, although they seem to be doing many of the same things, are relevant to analyses of economic development in urban areas because they focus on different mechanisms for estimating economic growth benefits from expanding labor markets and truck delivery markets. TranSight is based on this 2001 study, but does not implement all of the methodology.

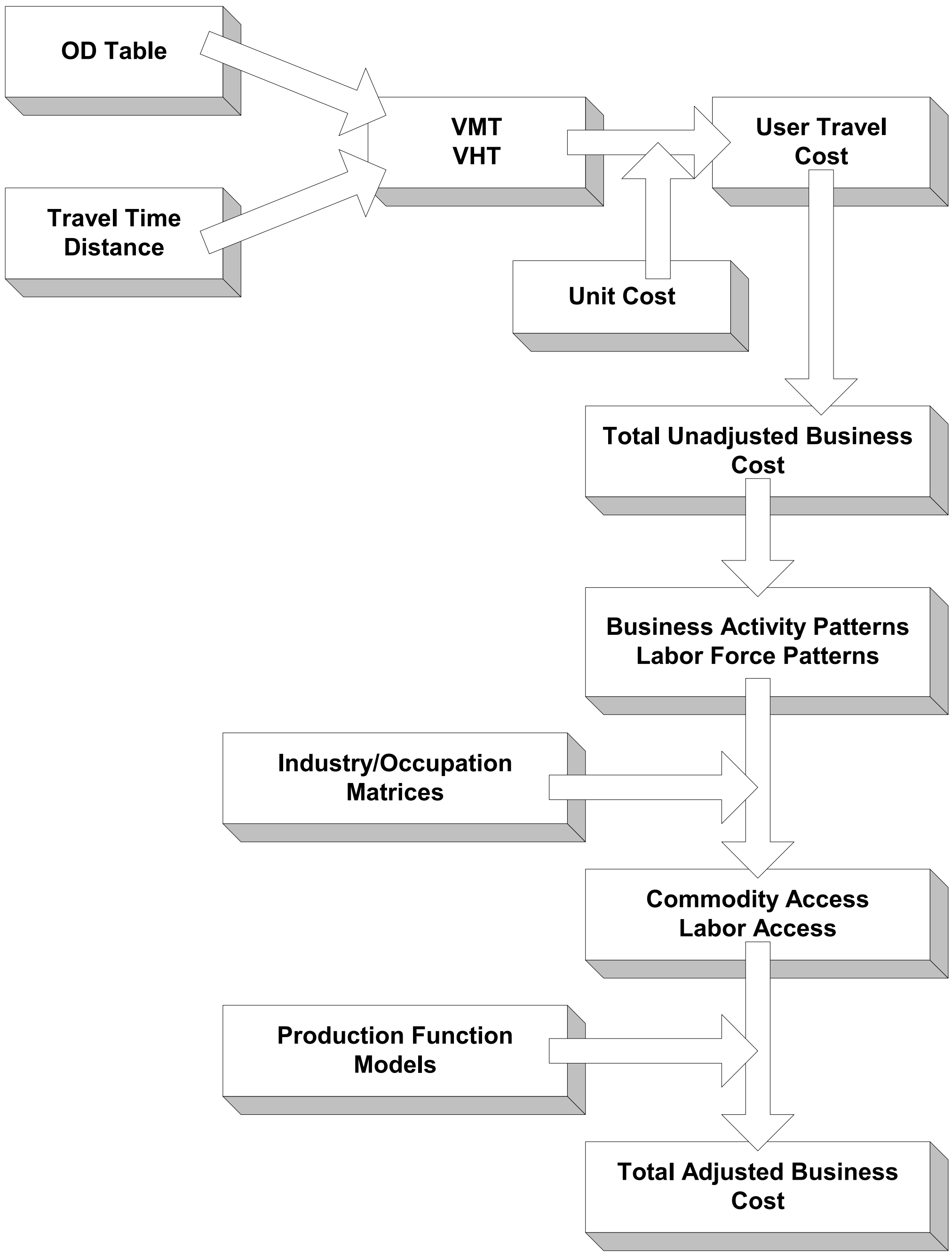

FIGURE 3 Framework for Measuring Economic Cost of Congestion (Source: Weisbrod, et al., 2001)

The first step is to separately obtain zonal trip data for commuting trips and delivery trips. Commuting trips include home to work trips as a weighted average of car, commuter rail, bus, and nonmotorized modes. Delivery trips include regional/interregional delivery and regional service delivery trips. These trip tables are further disaggregated by economic sectors (SIC groups). Personal travel (home-based non-work trips) was not discussed in the report; it may be covered by leisure time cost in TranSight.

Second, travel time and distance data are derived from travel demand models at TAZ level. These data together with trip data are then used to calculate VMT and VHT by businesses in different industries and commuters in different occupation groups.

Third, the total travel cost (driver time and vehicle operating expenses) is calculated by industry sector for each origin-destination pair. The US DOT recommended values (shown in the Table 1 below) are used to estimate user's value of time.

TABLE 1 US DOT Recommended Values of Travel Time for Surface Modes ($1995 Per Person Hour) (Source: Weisbrod, 2001)

Category	*Percent of Wage Rate*	*Hourly Earnings Rate*	*Value of Travel Time*	*Plausible Ranges*
Local Travel				
Personal	50%	$17.00	$8.50	$6.00-$10.20
Business	100%	$18.00	$18.80	$15.00-$22.60
All Purposes			$8.90	$6.40-$10.70
Intercity Travel				
Personal	70%	$17.00	$11.90	$10.20-$15.30
Business	100%	$18.00	$18.80	$15.00-$22.60
All Purposes			$12.20	$10.40-15.70

The following equations are used to calculate shipping costs for delivery travel,

$$cc_{ij}^{l} = \frac{1.1 \times \left[Dir\_Cost_{ij}^{l} + JIT\_FAC^{l} \times PHR\_REL^{l} \times \frac{\sqrt{\mathrm{var}_{ij}}}{60} \right]}{Trk\_val_{ij}^{l} \times LD\_FAC_{ij}^{l}}$$

where

cc_{ij}^{l} = the shipping cost from zone *i* to zone *j* for an average shipment of industry *l* (expressed as a percentage of shipping-free value of shipment),

$Dir\_Cost_{ij}^{l}$ = the direct shipping cost in dollars from zone *i* to zone *j* for industry *l*,

JIT_FAC^{l} = an adjustment factor for a firm engaged in just-in-time manufacturing for industry *l*,

PHR_REL^{l} = the per hour value of reliability in dollars for industry *l*,

$Trk\_val_{ij}^{l}$ = the shipping-free value of shipment from zone *i* to zone *j* for industry *l*,

$LD\_FAC_{ij}^{l} =$ a load factor that reflects the fact that not all deliveries are truck load shipments for industry l.

For all industries except the services industry,

$$Dir\_Cost_{ij}^{l} = \frac{(t_{ij} + t_{ji})}{60} \times Uni\_Cost^{l}$$

where

$t_{ij} =$ the shipping time by truck from zone i to zone j, and

$Uni\_Cost^{l} =$ the shipping cost in \$/h for industry l.

For the services industry,

$$Dir\_Cost_{ij}^{l} = w^{l} \times \frac{(t_{ij} + t_{ji})}{8} + 1.3 \times w^{l} \times \sqrt{\frac{\mathrm{var}_{ij}}{1000}} + \frac{\left(0.25 \times \left(d_{ij} + d_{ji}\right)\right)}{2.5}$$

where

$w^{l} =$ \$108.75 as the average of the median daily compensation for technicians and related support (\$139.20) and services (excluding private households) (\$78.30),

$d_{ij} =$ the shipping distance by truck from zone i to zone j, while $d_{ii} = \sqrt{A_i}/3$.

The estimated truck shipping costs based on the Chicago and Philadelphia case studies are presented in Table 2.

TABLE 2 Unit Shipping Cost by Industry (Source: Weisbrod, 2001)

Delivered Product	*Direct User Cost Per Hour*	*Reliability Cost Per Minute*	*Value of Shipment*
Agriculture	\$25.07	\$7.00	\$16,764.55
Mining	\$25.04	\$0.83	\$5,469.32
Manufacturing	\$25.66	\$11.20	\$34,681.55
Service/Other	\$0.00	\$0.00	\$135.00

For commuting trips, the direct travel cost, including car depreciation and gasoline cost, is assumed to be 16.67 cents per minute. The unit cost factors estimated for commuting trips based on the two case studies are presented in Table 3.

TABLE 3 Unit Cost Factors for Commuting Delay (Source: Weisbrod, 2001)

Occupation	*Average Hourly Wage*
Precision production and crafts	$16.20
Transport and material moving	$15.08
Executive, administrative, managerial	$21.90
Technicians	$17.40
Machine operators	$12.25
Protective services	$9.79
Helpers and laborers	$11.03
Sales occupations	$15.65
Professional Occupations	$22.39
Clerical occupations	$12.64
Private household occupations	$4.57

Next, the total unadjusted business cost (beyond direct user travel cost) is estimated. For delivery/service trips, this total includes travel time reliability cost (logistics, scheduling, and just-in-time processing costs). For commuting trips, the total business cost also includes worker compensation for the excess delay. The authors assumed the value of commuting delay to be 50 percent of the wage rate. Travel time reliability is defined as the standard deviation of incident-related travel time delay. The following equations were used to estimate the mean delay per mile of road, as adopted from Cohen and Southworth (1999):

Freeways with two lanes in each direction

$$D = 0.0154(V/C)^{18.7} + 0.00446(V/C)^{3.93}$$

Freeways with three lanes in each direction

$$D = 0.0127(V/C)^{22.3} + 0.00474(V/C)^{5.01}$$

Freeways with four or more lanes in each direction

$$D = 0.00715(V/C)^{32.16} + 0.00653(V/C)^{7.05}$$

where

D = average delay per mile due to incidents (h/mi), and
V/C = volume to capacity ratio.

Then, the business activity pattern (employment levels) and workforce pattern (workers by place of residence) data at the TAZ level are obtained to *calculate the proximity or availability of labor markets and supplier market alternatives for businesses*. It is useful to note that HEAT differs from TranSight by using highway skims to calculate this proximity, while TranSight uses a concept of "effective distance" to measure proximity[3].

Finally, the production function model is applied to calculate the adjusted total business costs, since businesses can adjust to offset the changes in costs instead of just absorbing the

[3] Glen Weisbrod, personal correspondence, October 7, 2007.

costs. The production function model indicates how business activities respond to changes in access costs for supplies and labor. The ability of businesses to adjust to the costs is measured by substitution elasticity. Generally speaking businesses with more specialized input requirements have lower elasticity, which means they will benefit relatively more from congestion reduction.

Table 4 and Table 5 below show the calibrated coefficients of the production function model for delivery travel and commuting travel respectively. *An elasticity of substitution of 12 means that a one percent increase in total product cost (due to congestion) leads to a 12 percent decrease in sales for the supplier of that product*.

TABLE 4 Estimated Elasticity of Supply Substitution Coefficients (Source: Weisbrod, 2001)

Category	*Elasticity of Substitution*	*Standard Deviation*	*t-statistic*
Chicago			
Agriculture	14.51	0.41808	34.7
Mining	4.62	0.27627	16.7
Manufacturing	7.44	0.04913	151.8
Service/other	10.61	0.01042	1018.2
Philadelphia			
Agriculture	15.00	0.33072	45.4
Mining	10.10	0.20507	49.0
Manufacturing	6.81	0.00786	866.4

TABLE 5 Estimated Elasticity of Labor Substitution Coefficients (Source: Weisbrod, 2001)

Occupation Category	*Elasticity of Substitution*	*Standard Deviation*
Precision production, crafts and repair	11.27	0.017
Transportation and material moving	11.35	0.028
Executive, administrative, and managerial	12.25	0.016
Technicians and related support	12.83	0.031
Machine operators, assemblers, and inspectors	13.04	0.024
Protective services	13.21	0.043
Handlers, cleaners, helpers and laborers	13.75	0.031
Sales	13.05	0.018
Professional specialty	14.57	0.018
Administrative support	14.66	0.016
Private household services	16.02	0.140
Services (excluding household and protective)	16.49	0.024

Based on Weisbrod's theory, the TranSight system implements each of these three cost categories as an index of generalized opportunities based on a coarse county level zone system: commuter cost, transportation costs of goods and services and access costs to labor and intermediate inputs. Through a labor access and commodity access index, infrastructure improvements have secondary impacts on the region's economy as shown in Figure 4, which gives a good sense of how TranSight differs from HEAT in overall structure. *TranSight measures the change in these costs by comparing the ratio of VMT to VHT between the alternative and baseline scenarios. As these three cost matrices already have counterparts in Policy Insight, TranSight passes them directly into EDFS-70, where they impact economic and demographic trends through different channels.* The causal underpinning of this approach is based on empirical research regarding the economies of agglomeration in labor, product assembly and delivery markets (e.g., see Weisbrod and Treyz, 1998). It is worth noting that HEAT also follows the Weisbrod's approach by having two categories of cost (commute cost and truck delivery cost), while TranSight has three cost categories (splitting truck delivery cost into different measures for delivery of final goods and intermediate inputs)[4].

Additional discussion of Weisbrod's theory is reflected in a series of recent professional publications (Weisbrod, 2005, 1997). Of course, the elasticity coefficients of the REMI TranSight, like many models with coarse zonal systems, is open to spurious correlations and the effects of common trends on the computed elasticities. Specifically, it is unclear from the documentation whether the model is simply duplicating activity relocation processes that are explicitly covered by conventional urban land-use models.

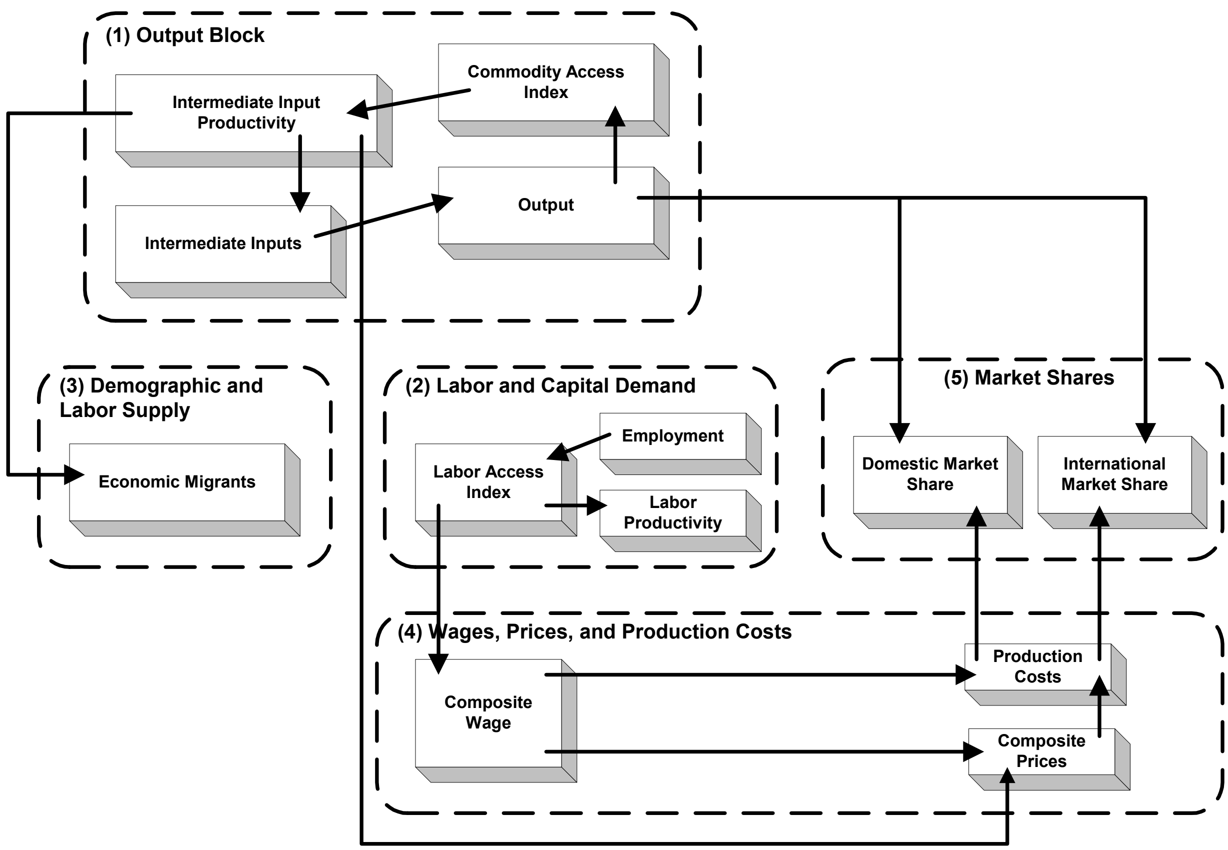

FIGURE 4 Impact of Economic Geography within EDFS-70

[4] Glen Weisbrod, personal correspondence, October 7, 2007.

Other impacts of transportation projects that are considered in TranSight include:

- Emissions – Cost per gram for five pollutants (volatile organic compounds, nitrogen oxides, carbon monoxide, sulfur oxides, and particulate matter) for each model region;
- Value of Time – Value of leisure time ($US) for each model region;
- Government Funding – Percent amenity loss due to the reduction in other government services needed to fund the transportation project.

Technical Summary of the HEAT's Business Attraction Module

The HEAT business attraction module is functionally similar to LEAP, Local Economic Assessment Package, from the Economic Development Research (EDR) Group. While there are published reports and articles that explain in qualitative terms what HEAT or LEAP does, these reports lack certain technical details that would be necessary to independently verify the assumptions and results. Therefore it was necessary to build a deeper understanding of the HEAT through direct observation of the source code, supporting data files, and implementations of LEAP elsewhere. For example, a spreadsheet version of LEAP-like analysis was used in a study of North Country, New York (Hodge, Weisbrod and Hart, 2003), and that spreadsheet was obtained by this project team. LEAP is a proprietary software package belonging to Economic Development Research Group, Inc.

The HEAT business attraction module organizes industries to 2-digit SICs. The spatial units of analysis are counties. Thus, it is possible (though not necessarily desirable) to obtain growth estimates for any 2-digit SIC for any county in the state. Business attraction is directly influenced by highway travel and indirectly by the presence of air cargo and railroads. Total industrial growth is the sum of the influences of improvements in highways on each mode and on suppliers, customers and the labor market.

The HEAT business attraction module essentially performs three tasks.

Task 1. Growth Constraints

HEAT develops maximum growth constraints for each industry in each county. There are two separate calculations for maximum growth; HEAT uses the lower of the two possible values. One value is created from the "location quotient", which is calculated as an industry's share of employment in a county divided by the industry's share of employment nationally or regionally. Industries are allowed to grow only to the extent that their location quotient does not exceed 1.

A second possible maximum growth value is set proportionally to the national or regional growth rate for a particular industry over the forecast period. In HEAT, the proportionality constant was set to 1.25 for certain SICs[5] (1, 2, 8, 9, 10, 12, 13, 14) of particular importance to Montana and at 1.00 for all other SICs. In other words, if an industry previously grew by 5% in Montana, but 10% in the U.S., the maximum forecasted of that industry's growth is capped at 10%.

[5] Agricultural production of crops or livestock; forestry; fishing, hunting and trapping; all mining.

Task 2. Growth by County and SIC Code

HEAT calculates total growth for each county and for each SIC in proportion to changes in accessibility by highways to various modes, employment and population. Accessibility indexes are estimated in Montana for each highway project simulated in HEAT, and were customized within GIS using travel demand model output. Accessibility indexes measure the change in travel time for local businesses, suppliers, customers and workers to key destinations and markets. The estimates are at the county-level, but the accessibility calculations track to sub-county areas (thus allowing for refined estimates of accessibility). The accessibility indexes used in Montana at the county level were[6]:

Delta_Air: Change in time to closest airport
Delta_Rail: Change in time to closest intermodal freight rail terminal
Delta_Population_Center: Change in accessibility to population in the five closest cities, where accessibility is calculated as:

$$\text{Population\_Accessibility} = \sum_i \left[P_i / t_i^2 \right]^{0.5}$$

where P_i is the population in city i (i = 1 to 5) and t_i is the travel time to city i.

Delta_Border: Change in travel time to nearest border crossing with Canada.

Delta_Employment: Change in accessibility to employment in the five closest cities, where accessibility is calculated as:

$$\text{Employment\_Accessibility} = \sum_i \left[E_i / t_i^2 \right]^{0.5}$$

where E_i is the employment in city i (i = 1 to 5) and t_i is the travel time to city i.

Delta_Population: Change in population within 60 minutes.

All of the growths by mode (i.e., highway, air and rail) by county and by industry are calculated using three principle terms, which include the "delta" accessibility indexes, and some adjustment factors.

Modal_Growth = (Fractional_change_in_accessibility)*(Base_Year_Employment)*(Economic Impact_Factor)*(Various Adjustments)

The various adjustments differ across modes, as will be described later. The growth rates for suppliers, customers and labor market are calculated differently.

The Economic_Impact_Factor is the fraction of all industrial expenditures on transportation for that specific mode, as determined from the Transportation Satellite Accounts (TSA). TSA is a national dataset that would be assumed to apply locally, with some modest

[6] Variable and parameter names are expanded from those in HEAT.

adjustments. Without any further adjustments, the factors imply that transportation savings are fully captured in revenue growth for the industry and that employment growth is proportional to revenue growth.

Adjustment for TSA Sensitivity. Three separate sets of "sensitivities" were used in Montana to modify the TSA factors for each mode and for each industry. They are constant across counties. These sensitivities deal with the fact that not all travel cost savings will directly cause more employment. Presumably, these sensitivities should be adjusted for local conditions, but doing so would require more economic data than are readily available.

Adjustment for Relative Business Costs. HEAT further adjusts the growths with the reciprocal of a business cost index for each county. That is, high cost counties would have proportionally less employment growth. From inspection of the North Country spreadsheet, the business cost index would likely include three major business cost item: electricity prices, wage rates and business taxes.

Other Adjustments. Other adjustments apply to specific market segments. There are adjustment factors for retail effects, pass through trips, tariffs on imported and exported goods, and skill levels for both industries and workers within counties.

Agglomeration. The HEAT specification allows for adjustments for economic agglomeration, but agglomeration effects were not actually implemented in Montana to avoid any real or perceived potential double-counting with the industry transportation cost savings effects or REMI multiplier effects[7].

Basic/Non-Basic Effects. Induced employment by basic industries in the non-basics sectors are not included in the business attraction model of HEAT, because it is assumed that the results would be further processed by software that contains appropriate input-output analysis.

Summation of Growths. The separate effects of each mode and of each market segments are summed to obtain an overall employment growth for each industrial sector and for each county.

Applications of Constraints. HEAT reduces the growth in industrial sectors within counties to the maximum growths values obtained in step 1. In addition, HEAT significantly reduces industry growth potential in locally-serving industries that are likely to either be covered by potential visitation effects, or result in replacement of existing firms. For example, effects on retail trade and local services are greatly reduced thus focusing business attraction effects on industries such as manufacturing, farming, warehousing/distribution, and other export-based industries.

There are a total of seven sources of employment growth in HEAT.

- Highway Access for Airports
- Highway Access to Rail Terminals
- General Highway Accessibility
- General Highway Accessibility to Canada
- Expanded Customer Markets
- Expanded Labor Markets

[7] Per conversation with Dan Hodge of CSI, March 28, 2007

- Better Accessibility to (from) Suppliers

Each source of growth is related to several variables or constants. Below, variables are shown in italics; locally derived constants are shown in large/small caps; and nationally derived constants that are assumed to hold at a local level are shown in bold type. Each variable or constant is a component in a version of the Modal_Growth equation that was presented earlier in this section.

Growth Due to Highway Access for Airports:

Delta_Air;
BASE_YEAR_EMPLOYMENT;
Economic_Impact_Factor_Air_Cargo_Proportion;
RELATIVE_BUSINESS_COST;
AIR_CARGO_ADJUSTMENT

Growth Due to Highway Access to Rail Terminals:

Delta_Rail;
BASE_YEAR_EMPLOYMENT;
Economic_Impact_Factor_Railroad_Proportion;
RELATIVE_BUSINESS_COST;
RAILROAD_ADJUSTMENT

Growth Due to General Highway Accessibility:

Delta_Population_Center;
BASE_YEAR_EMPLOYMENT;
Economic_Impact_Factor_Truck_Proportion;
PERCENT_CANADIAN**;**
RELATIVE_BUSINESS_COST;
TRUCKING_ADJUSTMENT

Growth Due to General Highway Accessibility to Canada:

Delta_Population_Center_Canada;
BASE_YEAR_EMPLOYMENT;
Economic_Impact_Factor_Truck_Proportion;
PERCENT_CANADIAN**;**
Tariffs_Adjustments

Growth Due to Expanded Customer Markets:

Delta_Population;
BASE_YEAR_EMPLOYMENT;
FRACTION_LOCAL_SALES_INDUSTRY;
FRACTION_PASS_THROUGH_SALES_INDUSTRY

Growth Due to Expanded Labor Markets:

Delta_Population;
BASE_YEAR_EMPLOYMENT;
FRACTION_EMPLOYMENT_INDUSTRY;
RELATIVE_BUSINESS_COST;
Industry_Need_for_High_Skilled;
Industry_Need_for_Low_Skilled;
Skill_Level_Industry;
SKILL_LEVEL_LOCAL

Growth Due to Better Accessibility to (from) Suppliers:

Delta_Employment;
BASE_YEAR_EMPLOYMENT;
Intermediate_Goods_Sensitivity_Air_Cargo;
Delta_Air;
Intermediate_Goods_Sensitivity_Trucking;
Delta_Rail;
Intermediate_Goods_Sensitivity_Railroad

Notes. Skill levels are measured in terms of the proportion of workers (needed by industries or supplied locally) with high school education, relative to the national average. Tariffs are used to penalize trade to Canada. While Air_Cargo_Adjustment, Raiload_Adjustment and Trucking_Adjustment are presumably derived locally, it is more efficient to borrowing these parameters from elsewhere.

Assumptions. HEAT assumes that there are no environmental, regulatory or land constraints on the growth of any industrial sector in any county. HEAT does not consider variations in traffic reliability that might impact JIT deliveries or business location decisions.

Task 3. Redistribution within State

The third step of the HEAT business attraction model is to adjust the results for possible redistributions from other parts of the state. This step is a simple process of applying a reduction factor to employment growth to account for drawing away employment from nearby "regions" as defined for the REMI model. There 5 such regions in Montana.

Observations Related to a Wisconsin Implementation of HEAT

Because HEAT was built for Montana in particular, there are local issues that would not necessarily translate well to Wisconsin. However, there is extensive use of national data, in lieu of local data, which should translate well to Wisconsin. There are four principal considerations that standout when transferring the HEAT concept to Wisconsin.

1. *Accessibility Index:* In HEAT employment growth is linearly related to market accessibility calculations. This implies that reductions in travel time are linearly related to accessibility. Thus, accessibility indexes that are reasonably accurate predictors of travel time to markets should be custom created for Wisconsin.
2. *Trade with Canada:* Equations involving trade with Canada are likely to have little effect on employment growth estimates for most locations in Wisconsin. Thus, trade with Canada should be dropped from the model, wherever it appears, for the Wisconsin application, ideally based on the results of travel demand model runs.
3. *Various Local Parameters Derived from National Data.* As an expedience, certain data in HEAT that could be locally determined have been taken from national data sources. This same expedience is recommended for the Wisconsin application. These data items are:

   FRACTION_LOCAL_SALES_INDUSTRY;
   FRACTION_PASS_THROUGH_SALES_INDUSTRY;
   TRUCKING_ADJUSTMENT;

RAILROAD_ADJUSTMENT;
AIR_CARGO_ADJUSTMENT.

Some tweaking of these parameters might be necessary in a true planning application; however, these parameters should suffice for testing and sensitivity analysis purposes.

4. *Agriculture:* HEAT has special provisions for agriculture, such as the location of grain elevators, which may not transfer well to other locations outside Montana.

Specifics of the Wisconsin Implementation of HEAT

The business attraction parts of HEAT were implemented on an Excel spreadsheet. None of the HEAT source code was used. In general, an attempt was made to exploit existing or otherwise inexpensive databases to execute the business attraction model, in order to create the most cost-effective, but reliable, way of estimating the employment impacts of highway projects.

Accessibility Indices from the Wisconsin Statewide Travel Forecasting Model

All of the accessibility indices in the business attraction model are built from origin-to-destination (OD) travel times, as calculated by the Wisconsin Statewide Travel Forecasting Model for each alternative. Alternatives are differentiated from each other only by their OD travel times. Consistent with Montana's implementation of HEAT, travel times were obtained county-to-county. Some counties in Illinois, Iowa and Minnesota were included in the travel time matrices. Intra-county travel times were calculated with the traditional nearest-neighbor rule. That is, travel times within a county were taken to be one-half of the average travel time between the county and its two nearest neighboring counties. Using the nearest neighbor rule gives the model sensitivity to improvements in travel times on major highways. This rule is preferable to ways of setting intra-county from the area of the zone that do not directly include travel time improvements. An alternate method of computing intra-county times from interzonal times (between small traffic analysis zones) within a single county was not explored because it would be expected to give comparable results to the nearest neighbor rule.

Both population and employment accessibility were calculated from the same formula as in Montana, except that all counties in the model were used.

Converting between Industrial Classification Systems

HEAT and its business attraction module were originally developed using the Standard Industrial Classification (SIC), but employment data are now reported in the North American Industry Classification System (NAICS). In order to preserve the original HEAT parameters that were developed from national data sources, it was necessary to convert those parameters from SIC to NAICS. This interpolation was accomplished by using factors developed by the Bureau of Labor Statistics with 2001 data.[8] Two-digit SICs were converted to three-digit NAICS, thereby increasing the number of industrial sectors in the business attraction model from 72 to 89. Because of the increase in the number of industrial sectors, the results of the business attraction model are reliable, at best, only at the two-digit NAICS level.

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[8] Ratios of Employment from SIC to NAICS, Bureau of Labor Statistics, http://www.bls.gov/ces/cesratiosemp.htm, January 6, 2004, accessed on August 14, 2007.

Location Quotients and Growth Rates

Sets of location quotients and historical employment growth rates both were calculated from County Business Patterns. Employment data for location quotients for Wisconsin counties were taken from 2005 and referenced to employment totals in a four-state region consisting of Illinois, Iowa, Minnesota, and Wisconsin. Where possible, location quotients were calculated at the three-digit NAICS level; however, data suppression required that some location quotients for some counties be calculated at the two-digit NAICS level. Historical employment growth rates were calculated between 2000 and 2005 for the four-state region.

Redistribution within the State and Negative Impacts

The method in HEAT for accounting for redistribution within the state was specific to Montana and is not well documented. Thus, this step was omitted from the business attraction model.

HEAT allows for the possibility of negative growth, should travel times increase. Negative employment growth would be a reasonable possibility only if highway infrastructure failed to keep pace with traffic demand or if something was done to reduce speeds in a corridor. Negative growth in any county or industrial sector was allowed to occur.

Educational Attainment

Education attainment by county was measured as the fraction of the population in the 2000 census which has a high school diploma or more.

Air Cargo and Intermodal Rail Terminals

According to the Wisconsin State Airport System Plan 2020, the primary air cargo airports in Wisconsin are: General Mitchell International Airport (Milwaukee); Austin Straubel International (Green Bay); Central Wisconsin (Mosinee); Dane County Regional (Madison); Outagamie County (Appleton); and Rock County (Janesville/Beloit). There are also several air cargo feeder airports in Wisconsin, which are not considered in the business attraction model.

The airports in adjacent states serving the Wisconsin include Greater Rockford airport, Chicago O'Hare International Airport and Minneapolis-St Paul International Airport. Airports, both instate and out-of-state, are recognized as being important to business travelers as well as to shipping.

With regard to intermodal facilities, the business attraction model just considers terminals with rail and highway access. Within the state, Arcadia (Ashley Furniture) and Milwaukee (Port of Milwaukee) are the two primary intermodal facilities. It was also necessary to account for intermodal facilities in adjacent states. These include Minneapolis - Canadian Pacific, St. Paul – BNSF, Chicago Area - Canadian Pacific (two facilities); Canadian National (one facility); Union Pacific (four facilities); BNSF (four facilities); Norfolk, Southern (five facilities); CSX (two facilities), East Peoria, Il - Canadian National and Rochelle, IL - Union Pacific.

Given that the travel times for some facilities out of Wisconsin are not available in the travel time matrix for each alternative, the travel time was approximated by assuming that all the trips to or from these facilities must pass the listed county which is closest to them. For example, all trips to and from the Chicago O'Hare International Airport are assumed to pass through Lake County, Illinois. Since we already have the travel times to and from Lake County for all other counties, this assumption simply adds the extra travel time between Chicago O'Hare and Lake County to the times found in the appropriate row and column of the travel time matrix.

Commercial Cost Index

In this project, the Commercial Cost Index in for the business attraction model is estimated from a linear combination of four indices: wage cost index, tax burden index, electricity cost index and a rent index. Each index is referenced to the statewide average, so the average value of an index is 1.0. An alternative approach, not tested, would be to reference the cost index to national values. Specifically, wage cost measures the average annual wage per employee in all industries. The tax burden includes property tax and sales tax rates of each county. Electricity cost measures the cost of industrial electricity cost in cents per kilowatt-hour. Because it is difficult to find the specific industrial and office rent for each county, the business attraction model used the relative housing value per unit as a substitute.

To determine the Commercial Cost index in HEAT, the above indexes are weighted as follows:

Commercial Cost index = 50% Wage Cost index + 10% Property Tax index + 10% Sales Tax index + 15% Electricity Cost index + 15% Rent index

The indexes and weights are consistent with the approach used by Milken Institute in determining its well-regarded Cost-of-Doing-Business index.[9]

Electricity Cost. Figure 5 shows the electric utility service territories of the energy companies in Wisconsin. Beyond the nine major energy companies listed in Table 6, there are about 70 minor cooperative companies, which mainly offer electric utility service for a local rural area. Since rural areas have very limited impacts on the employment growth, the minor cooperative companies were ignored. Instead, the index used the major electric company that served the main cities in each county. The industrial electric rate of each company was determined by dividing the total industrial operating revenues to the total megawatt-hours-sold for industrial use (Table 6). These data were obtained from annual report of each company, which is available on the Public Service Commission of Wisconsin website.[10]

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[9] 2005 Cost of Doing Business Index, Milken Institute, August 11, 2005, http://www.milkeninstitute.org/research/research.taf?cat=indexes&function=detail&ID=26&type=CDB, accessed August 14, 2007.

[10] Public Service Commission of Wisconsin, http://psc.wi.gov, accessed August 14, 2007.

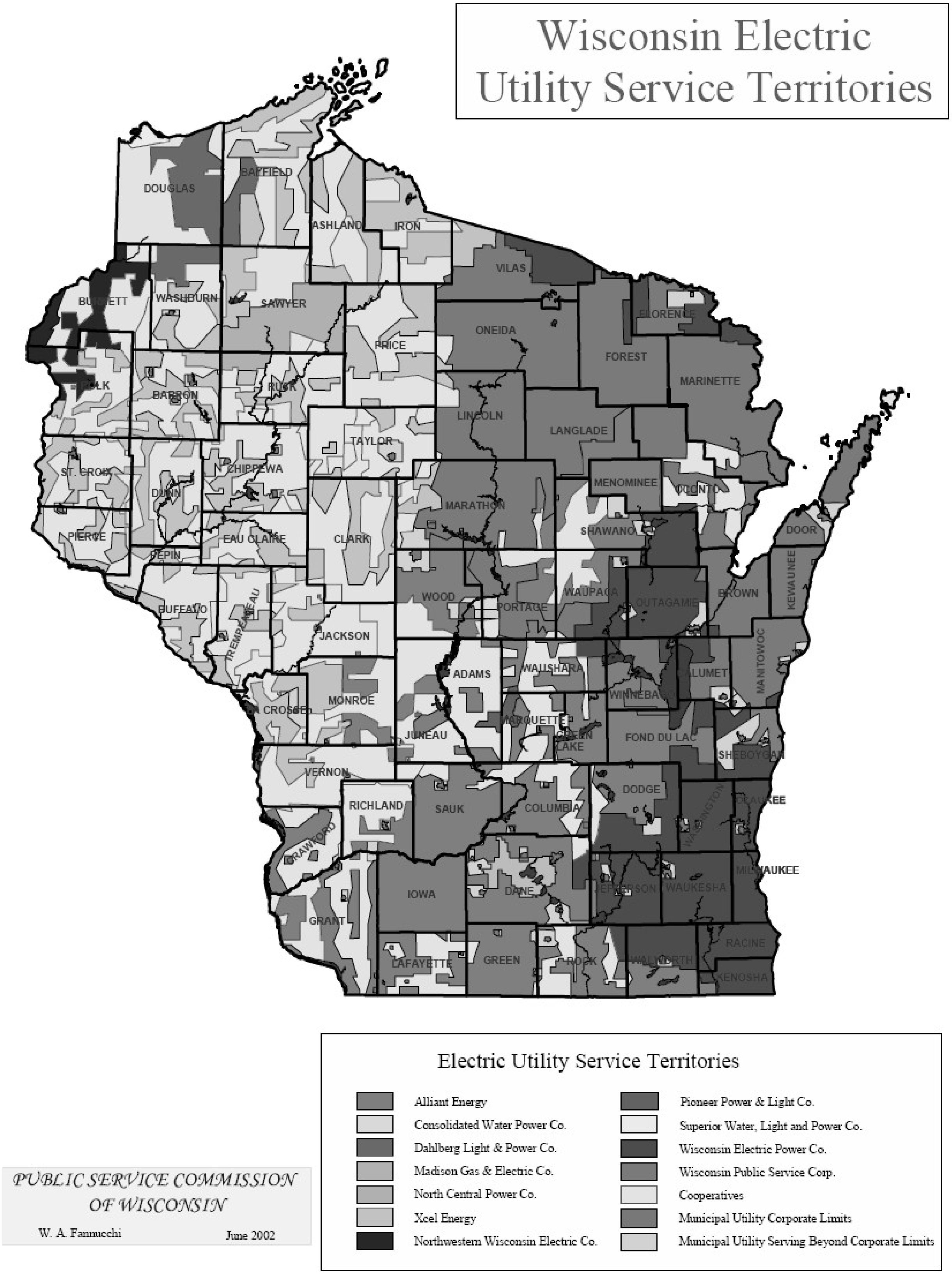

FIGURE 5 Electric Utility Service Territories in Wisconsin (Source: Public Service Commission of Wisconsin)

TABLE 6 Industrial Electric Rate of Major Energy Companies Serving the Wisconsin

Electric Utility Service Company	Operating Revenues	Megawatt Hours Sold	Industrial Electric Rate
We Energies	536,028,931	8,567,899	0.0626
We Public Service	194,300,372	4,031,318	0.0482
Dahlberg Light and Power	1,465,501	19,400	0.0755
Northwestern Wisconsin Electric	3,618,793	43,673	0.0829
Madison Gas & Electric	91,709,971	1,214,824	0.0755
North Central Power	122,669	1,278	0.0960
Superior Water, Light and Power Co.	24,328,092	551,243	0.0441
XCEL Energy (North States Power - Wis)	80,402,805	1,500,333	0.0536
Alliant Energy (Wisconsin Power and Light)	318,737,777	4,858,709	0.0656
Total	**1,250,714,911**	**20788677**	**0.0602**

Source: Annual report 2006 of each energy company
Note: All the data are for the industrial use in the service areas within Wisconsin's borders.

Discussion. Wages dominate the business cost index, so it is important that this data item be as accurate as possible. As will be seen by the case-study results contained in the next section, there is little to be gained for this study by a highly refined commercial cost index. Provided it is warranted by a suitable sensitivity analysis, another state might consider minor improvements over what was done here. For example, a more accurate electricity cost might be obtained by including all electric utilities serving a county. If available, data that might be a closer indicator of business rent should be substituted for residential housing values. Property tax rates, which can vary substantially across municipalities and school districts, should be separately calculated for the locations in counties where industrial development is most likely to happen, rather than for the whole county.

The commercial cost index and its components do not vary much in Wisconsin. The standard deviation of the commercial cost index over all Wisconsin counties is just 9% of its mean. The wage index has a standard deviation of just 14% and the electricity rates have a standard deviation of just 15%.

Tests

Five separate corridor improvements were tested in the business attraction model. All of these corridors are of rural character.

1. I-39/90 from Beloit to Madison: This corridor is runs north-south through southern Wisconsin. The project would upgrade this facility to a six-lane freeway with a free speed of 70 mph from a four-lane freeway with a free speed of 70 mph. The project is 46 miles long.
2. STH 21 from Coloma to Oshkosh: This corridor runs east-west through central Wisconsin. The project would upgrade this facility to a four-lane expressway with a free speed of 65 mph from a two-lane principal arterial road with a free speed of 60 mph. The project is 51 miles long.
3. USH 8 from Minnesota border to USH 53: This corridor runs east-west through west-central Wisconsin. The project would upgrade this facility to a four-lane expressway

with a free speed of 65 mph from a two-lane principal arterial road with a free speed of 60 mph. The project is 43 miles long.

4. USH 14 from Spring Green to Middleton: This corridor runs east-west in southwest Wisconsin. The project would upgrade this facility to a four-lane expressway with a free speed of 65 mph from a two-lane principal arterial road with a free speed of 60 mph. The project is 31 miles long.
5. USH 10 from Menasha (or Kimberly) to intersection with I-43 in Manitowoc County: This corridor runs east-west in eastern Wisconsin. The project would upgrade this facility to a four-lane expressway with a free speed of 65 mph from a two-lane principal arterial road with a free speed of 60 mph. A good existing alternative route between Menasha and Manitowoc involves only part of this corridor and I-43. The project is 37 miles long.

The locations of these projects are shown in Figure 6.

Each corridor was implemented separately in the Wisconsin Statewide Model. The base-network consisted of all existing and committed facilities, which excludes the five corridor improvements listed above. The origin-destination flow table was a 2030 forecast.

Results

Direct Employment Impacts

The results of the test corridors are easily summarized in Table 7. Employment impacts are given in units of employees, showing that none of the corridors would have much of an impact on total employment in the state.

TABLE 7 Growth in Number of Employees Statewide for Corridor Improvements

Corridor	*Employment Growth*
I-90	0.0
STH 21	11.9
USH 8	4.8
USH 14	2.8
USH 10	4.8
10% Speed Improvement	27323.2

These small employment impacts, when traced backwards to their root causes within the spreadsheet, are a result of very small changes in travel times between the “no-build” condition and the build alternatives. For example, adding two lanes to I-90 had the effect of decreasing just 32 of 8836 OD times in the matrix by no more than 0.01 minutes. This change is only about a one part in 5.3 million of total of all travel times in the matrix. The other alternatives were only slightly more interesting.

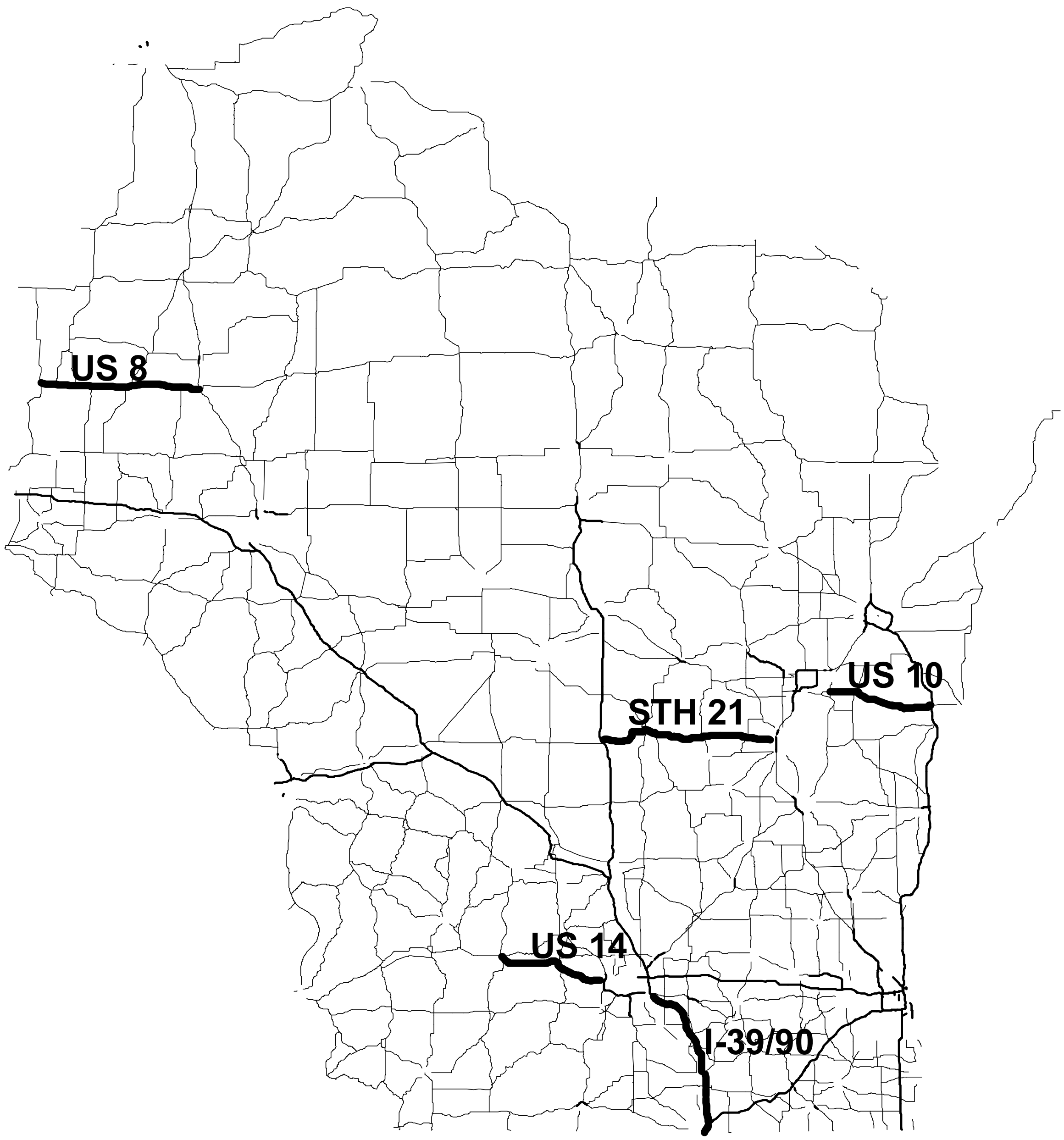

FIGURE 6 Case-Study Projects Relative to Major Wisconsin Highways

To get a sense of the small impact from these corridors, Table 7 also lists the direct employment impact of a uniform 10% improvement in speed, systemwide, without indicating how such speed improvements can be accomplished. A 10% improvement in speeds would result in more than 27,000 new jobs, implying a speed elasticity of employment of about 0.11, which is of reasonable magnitude given the results of Nadiri and Mamuneas (1996), who found an historical elasticity of 0.18 between public investment in highways and industrial productivity. The counties gaining the most new jobs on a percentage basis were scattered and relatively small in population: Douglas, Winnebago, Price, Dodge, Bayfield, and Florence.

It should be noted that these employment impacts were not further processed through REMI or an input-output model, as was done in Montana's HEAT, so the total net employment impacts should calculate to a higher value in each case.

In every case, the industries that were most strongly affected by the corridor improvements were transportation and warehousing.

Effects of Constraints

The business attraction model limits growth in an industry within a county to the multistate region's historical growth rate. It also limits growth such that the location quotient for an industry and a county does not exceed 1.0. Certain exceptions were made for key industries in Montana. The Wisconsin tests described here made no exceptions. These constraints imbue conservatism in the model. They will allow growth only in places and in industries where they are underperforming relative to the rest of the economy.

Table 8 shows the effects of relaxing each constraint individually. It is seen that relaxing the location quotient constraint increases estimates of employment impacts by a factor of 2 to 3, depending upon the project. Relaxing the regional growth limits increases estimates of employment by roughly a factor of 2.

TABLE 8 Effect of Constraints on Growth by Relaxing Constraints

Corridor	*% Increase in Impact without LQ*	*% Increase in Impact without Regional Growth Limits*
I-90	320%	234%
STH 21	292%	216%
USH 8	255%	167%
USH 14	244%	170%
USH 10	202%	172%

Discussion of the Structure of the Business Attraction Model

There are aspects of HEAT's business attraction module that seem to be highly refined but do very little within the model for the Wisconsin case studies. Given some of the bold assumptions made, there would be very little advantage to any feature of a business attraction model that would change the results by only a few percent. A business attraction model could be made somewhat simpler without significantly affecting the quality of its results in states such as Wisconsin. For example, some parts of the business attraction model (such as relative business costs and skill levels) are intended to give a slight advantage to poorer or lower-cost areas in the state, but are having very little effect in Wisconsin. These features would likely show more impacts in states where there are economically-depressed counties. Simplifications would help make the business attraction model more transparent, as well as easier to maintain.

Accessibility measures in the business attraction model are serving as proxies for transportation costs. There is only a weak theoretical justification for these accessibility measures serving as cost proxies. The developers of HEAT have argued that the accessibility measures do, however, serve as a direct representation of how improved travel speeds result in increased market accessibility, defined in terms that are of importance to business.

Given the existence of a statewide travel forecasting model with a good freight component, it would have been possible to calculate more precise measures of transportation cost savings. For the case studies, all accessibility indexes improved, so negative growths were not observed.

HEAT did not include a convincing way to determine how businesses might relocate within a state given a specific highway project, as compared to the models developed in Oregon and Ohio. Some business relocation was allowed in HEAT, but the mechanisms did not closely follow conventional land-use theory. Therefore, the business attraction model tested in this Wisconsin study omitted relocation effects. The absence of business relocation does not necessarily undermine the results from the model, but it limits its utility for certain types of decision making. Also, the business attraction module does not include agglomeration effects.

Epilogue

In the few years since HEAT was implemented, a number of refinements have been made to the concept by its developers. HEAT has evolved successively into LEAP, which has been incorporated into TREDIS (Transportation Economic Development Impact System). TREDIS addresses many of the limitations of HEAT by using NAICS for industrial categorization, encapsulating many national and local-level parameters, has a step to handle agglomeration, and uses census tracks to achieve a finer estimation of accessibility. LEAP or TREDIS have been used in Tennessee, Pennsylvania, New York, Mississippi, and the Appalachian region. LEAP/TREDIS has also been used alongside a statewide land-use model in Oregon. LEAP, as applied in the Appalachian Region, includes input variable representing terminal size and service levels for aviation, rail and marine modes.

Conclusions and Recommendations

Conclusions

The business attraction model, based on the similar module in Montana's HEAT, produces plausible results. The model is appropriately constrained to avoid overly optimistic forecasts of employment impacts. The only transportation inputs to the business attraction model are highway travel times, so the model is not sensitive to any other manifestations of transportation investment, such as increases in airport capacity, faster rail service, or highway safety improvements. Travel times are taken from a statewide travel forecasting model, which is an accepted way to evaluate rural highway projects.

The business attraction model evaluates every project using exactly the same methodology. A model such as HEAT, when applied to many projects in a state, has considerable advantages over a case-by-case manual analysis, which would likely be more expensive and potentially uneven. Thus, it is suitable for ranking the economic development potential of many candidate projects. Because the business attraction model is based on a consistent set of economic principles, it is useful for validating or debunking claims of large economic benefits that may be made on behalf of a particular highway project.

The business attraction model requires a substantial amount of local data. However, if national data are used to construct certain parameters, the start-up costs of the model can be minimized. This study adopted parameters from Montana wherever possible. Wisconsin specific data were limited to employment totals by county and industry, educational attainment by county, population by county, real estate values by county, electric rates by county, wages by county, property and sales taxes by county and the locations of airports and truck/rail intermodal terminals.

There were no unusual difficulties in interfacing the statewide travel forecasting model with the business attraction model. Montana's implementation of HEAT in a GIS package was particularly convenient, but the spreadsheet developed for this study is certainly adequate for the task and it is much easier to maintain. Once a business attraction model is set up for any highway project, it becomes immediately usable for any other project, large or small.

Although the five projects tested yield little economic development impact, the business attraction model will show large impacts if there are significant speed improvements from multiple highway projects or a major policy change, such as increasing speed limits on rural highways.

Recommendations

Wisconsin and other states with concerns about the economic development potential of highway projects should consider implementing a business attraction model, similar to HEAT, to aid evaluation of highway projects and other policies. However, planners need to recognize that not all economic impacts of transportation projects are captured by such a business attraction model.

A business attraction model, like HEAT's, could be simplified and thereby clarified. Reducing a business attraction model to its essential elements would likely help planners understand the reasons why a project might have a particularly high impact or a particularly low impact.

The business attraction model in HEAT should be scrutinized for redundancies and overly broad assumptions. For example, some of the "delta" variables in HEAT could be inaccurate indicators of transportation cost savings. The availability of a statewide travel forecasting model in Wisconsin and many other states allows for better estimates of transportation cost savings.

A county-level unit of analysis works well for rural highway projects. Analysis of projects within urban areas would require much smaller traffic analysis zones. In addition, highway projects that occur within large urban areas would require the use of an urban travel forecasting model and should include an evaluation of secondary land-use impacts.

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