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TRANSPORTATION
(INDOT)**

**EconWorks Tools for Assessing Wider Economic
Benefits of Transportation – Purdue University
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FINAL REPORT

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Final Report

ECONWORKS TOOLS FOR ASSESSING THE WIDER ECONOMIC BENEFITS OF TRANSPORTATION IMPLEMENTATION ASSISTANCE

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TECHNICAL SUMMARY

Introduction

The Indiana Department of Transportation (INDOT) is undertaking efforts to assess the potential economic development benefits associated with highway corridor improvements at the middle-stage planning level. The primary objective of this research is to demonstrate and document the use of the EconWorks W.E.B. tools for assessing the wider economic benefits (reliability, accessibility, and intermodal connectivity) of transportation projects in the State of Indiana. A parallel analysis of selected projects using TREDIS was also conducted in order to compare the relative merit or synergies between the tools.

Overview of the EconWorks W.E.B. Tools and Case Study Results

The EconWorks Reliability tool, the first of EconWorks W.E.B.'s three tools, aims to measure the benefits of reducing the variability in travel times. This is achieved by calculating a buffer time (delays) per mode, which is then multiplied by the value of reliability to estimate the recurring and non-recurring delay costs. The tool requires data on traffic volumes and capacity of the facility as well as the expected reduction in incident frequency and duration. The tool was used in a case study in Marion County, IN. The project consisted of adding lanes on a 1.6-mile segment of the U.S. 36 corridor. The tool's outputs include metrics of annual recurring and nonrecurring delays as well as their economic value per passenger cars and trucks. The sensitivity of the delay costs with respect to key parameters such as traffic volume, reduction in incident frequency, and reduction in incident duration was also evaluated. The results showed that the delay costs increased rapidly for volume to capacity (v/c) ratios greater than 0.85. In this upper range of v/c ratios, the non-recurring delay costs could be up to one third of the recurring delay costs. Finally, the sensitivity analysis also revealed that the incident frequency and incident duration had a moderate to high effect on the non-recurring delay costs. However, non-recurring delay costs accounted for only a small portion of the reliability cost savings, which were mostly due to an increase in the corridor capacity.

The EconWorks Buyer-Supplier Market Access tool focuses on measuring economies of scale triggered by the expansion of the customer delivery market served from a certain business site and the expansion of supplier locations that can deliver to that business site in a day, due to a highway transportation improvement in the region. These economies of scale or "productivity" are estimated as a function of the change in accessibility, the regional economic output, and the assumed productivity elasticity. The SR-3 capacity improvement project was used to demonstrate this tool. The proposed

project includes adding at least one lane per direction to a 36-mile segment of SR-3 between I-70 and I-74 and constructing bypasses at Rushville and Spiceland. The total business productivity benefits in the analysis year 2035 due to the project were estimated to be around \$16 million. The EconWorks Specialized Labor Market Access tool estimates the changes in zone accessibility index and commuter costs due to a transportation improvement. The SR-3 project was used as a case study for this tool as well, but minimal changes in labor market access resulting from the project were found.

The EconWorks Connectivity tool uses an approach similar to the EconWorks Buyer-Supplier Market Access tool's. This tool calculates a connectivity index based on built-in data regarding the level of activity of the port or terminal under analysis. This index is multiplied by the project savings to calculate a weighted connectivity index for the no-build and build scenario. The percentage change in the weighted connectivity index from the base to build scenario is translated to monetary values using the concept of productivity elasticity. The Port Bridge over the National Rail Corridor (Burns Harbor port) was considered for evaluating this tool. An analysis of the sensitivity of productivity outputs showed that the weighted connectivity index varied linearly with the expected travel time savings.

Synergies between the EconWorks W.E.B. tools and TREDIS

In terms of travel time reliability analysis, the EconWorks Reliability tool generates a group of metrics based on the travel time index, while TREDIS incorporates reliability based on empirical estimates of the buffer time for a given level of congestion in the travel cost calculations. Theoretically, the travel time index from the EconWorks Reliability tool can be used to derive a buffer time index in TREDIS. Additionally, the EconWorks Reliability tool only considers weekdays in the delay costs estimation, while TREDIS considers weekends as well. For corridor level projects, the EconWorks Reliability tool presents some advantages over the TREDIS in terms of fewer data requirements.

In terms of market access and connectivity analysis, the measures of market access and connectivity used by TREDIS and the EconWorks W.E.B. tools are fundamentally different. TREDIS includes the evaluation of buyer-supplier market access, labor market access, and intermodal connectivity benefits in a single module (Market Access Module), while in the case of EconWorks W.E.B. tools, three separate tools were developed for the evaluation of the aforementioned benefits. The approach regarding individual estimation of wider economic impacts adopted by EconWorks W.E.B. tools may result in double counting of economic benefits, while the approach followed by TREDIS does not allow for benefits overlap. Furthermore, in the EconWorks W.E.B. tools, the change in market access and connectivity is translated into monetary terms with the use of productivity elasticities, which are retrieved from relevant literature. However, TREDIS model parameters (equivalent to productivity elasticities) are included in the software, which makes the analysis more convenient for the user. With respect to the ease

of use, it can be concluded that the Market Access Module in TREDIS is less data intensive and easier to use than the EconWorks W.E.B. Accessibility and Intermodal Connectivity tools.

Applicability of the Tools

Guidance for selecting the appropriate tool based on the project objective and relevant threshold values is summarized in Table 1.

Table 1. Selection of Analysis Tool Based on Project Objective and Relevant Threshold

<i>Project Objective</i>	<i>Threshold Factor</i>	<i>EconWorks W.E.B. Tools</i>	<i>TREDIS</i>
Travel time reduction (due to speed or distance change)	Annual Reduction in VHT > 80,000 hours	-	✓
Capacity improvement/congestion relief	LOS ≥ D	Reliability Tool	✓
Travel time reliability improvement (incident delay reduction due to congestion relief)	Travel Time Index > 1.3	Reliability Tool	✓
Metropolitan area accessibility improvement between housing and employment centers	Population > 50,000 and Density > 1,800/sq.mile	Specialized Labor Market Access Tool or Buyer-Supplier Market Access Tool	✓
Metropolitan or regional business delivery accessibility improvement	Trucks > 12% of all vehicles	Buyer-Supplier Market Access Tool	✓
Intermodal terminal connectivity improvement	Trucks > 12% of all vehicles	Connectivity Tool	✓

Adapted from Weisbrod, G., N. Stein, C. Williges, P.Meter, J. Laird, D. Johnson, D. Simmonds, E. Ogard, D. Gillen, & R. Vickerman. (2014). Assessing Productivity Impacts of Transportation Investments. NCHRP Report 786, Transportation Research Board of the National Academies, Washington, D.C.

Implementation

In the short term, the implementation of this study will consist of a set of training sessions for INDOT and MPOs. These sessions will cover the theoretical background as well as demonstrate the use of the EconWorks W.E.B. tools. In the long-term, INDOT plans to use the EconWorks Connectivity tool on projects that provide linkages to multimodal facilities. INDOT has also identified future studies where the economic impacts of recommended strategies can be estimated using the EconWorks W.E.B. tools. Available staff resources and staff training in economic modeling were indicated as key challenges to a wide implementation of these tools.

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GLOSSARY OF TERMS AND ABBREVIATIONS

AADT	: Average Annual Daily Traffic.
Buffer Time	: The amount of additional time budget to a trip to avoid late arrivals.
Buffer Time Index (BTI)	: The percentage of additional travel time assigned to a trip to avoid late arrivals.
Buyer-supplier Market Access Benefits	: Economies of scale triggered by the expansion of the customer delivery market served from a certain business site and the expansion of supplier locations that can deliver to that business site in a day, due to a highway
BAO	: Esri's Business Analyst Online.
Connectivity	: A measure of the degree of accessibility to ports or terminals from a given location.
Concentration Index	: Change in concentration of the labor pool for a specific industrial sector within a zone, relative to the share of that same industrial sector across zones.
Decay Parameter	: A behavioral parameter and a critical input to the EconWorks Buyer-Supplier Market Access tool. Higher decay values place more weight on markets closer to the project location by penalizing markets farther away.
Effective Density	: The measure of accessibility used by the EconWorks Buyer-Supplier Market Access tool. It assumes that economic activity is proportional to the regional employment (or population) and inversely proportional to the cost of travel.
Employment Accessibility	: The total employment for each zone that can be accessed within a given accessibility threshold.
Free-Flow-Speed (FFS)	: The desired speed under no-congested traffic flow conditions.
Gross Regional Product (GRP)	: The economic output of a county or a metropolitan area (equivalent to Gross Domestic Product for states).
HCM	: Highway Capacity Manual.
IDAS	: ITS Deployment Analysis System.
ISTDM	: Indiana Statewide Travel Demand Model.
ITS	: Intelligent Transportation Systems.
Labor Market Access Benefits	: Economies of scale triggered by the expansion of the labor market due to a transportation project.

Linked Area	: Counties which are influenced indirectly by the project, such as neighboring counties.
NCHRP	: National Cooperative Highway Research Program.
Non-recurring Delay	: Delay caused by unexpected events such as work zones, accidents, weather conditions, or similar.
Business Output	: The total value of business production.
Productivity Elasticity	: The percent change in productivity divided by the percent change in market access. It is a very critical input to the EconWorks Buyer-Supplier Market Access tool.
Reliability	: A measure of the variability in travel times for a given trip.
Reliability Ratio	: The ratio between the values of one unit of travel time reliability to one unit of travel time.
Recurring Delay	: Delay caused by expected events, such as peak hour congestion on a given link.
SHRP2	: Strategic Highway Research Program.
Study Region	: Counties influenced directly by the project, such as the location of the project.
Threshold Impedance	: Typical duration or distance of commuting trips to an employment center.
Travel Time Index (TTI)	: Defined by the ratio between the travel time under congestion and the travel time using free flow speed.
TIGER	: Transportation Investment Generating Economic Recovery.
TREDIS	: Transportation Economic Development Impact System.
Value Added	: The difference between the business output and the cost of “intermediate consumption” (e.g., non-labor inputs).
Value of Reliability (VOR)	: Also known as value of travel time variability refers to the monetary value of reducing one unit of travel time variability.
Value of Travel Time (VOT)	: The monetary value assigned to each unit of travel time spend in a given a trip.
Zone Accessibility	: The number of zones that are accessible from the employment centers for a given threshold impedance.

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

The Strategic Highway Research Program (SHRP2) is a federally funded program authorized in 2005 with the objective of complementing existing transportation research programs. There are four components in SHRP2: the first, Safety, aims to understand the causes of crashes and methods to prevent them by analyzing data on driver behavior. The second component, Renewal, addresses how rapid design and construction methods can be used to treat aging infrastructure. Reliability constitutes the third component and aims to alleviate congestion through incident reduction, management, response, and mitigation. The last component, which encompasses the tools studied in this report, is Capacity. It aims “to integrate mobility, economic, environmental, and community needs in the planning and designing of new transportation capacity” (SHRP2, 2014).

Within the SHPR2 Capacity program, two complimentary tools were developed to assist practitioners and policy makers in the early and middle stages of the project development processes: the EconWorks Case Studies and the Development of Tools for Assessing Wider Economic Benefits (W.E.B.) of Transportation. The former is based on a database of more than 100 case studies where the economic development impacts were evaluated using pre and post project study approaches. This tool can be used as a screening tool to assess the expected range of economic impacts associated with new transportation developments covering a wide range of projects from beltways and bypasses to freight and intermodal terminals. The economic development impacts reflected in the tool are employment, business outputs and income. The second set of tools was completed in 2013 with the objective to enable agencies to measure the economic impacts associated with transportation projects at a middle stage planning and make better informed decisions. This new set of spreadsheet-like tools aims to evaluate the wider economic benefits (W.E.B.) of transportation projects. W.E.B. are defined as the benefits derived from enhancements in businesses productivity that go beyond the traditional measures of users’ benefits such as safety, travel time, vehicle operating cost, and travel time. W.E.B. are measured as direct benefits in business productivity (efficiency) considering three main impact classes: Reliability, Market Access, and Connectivity.

1.2 MOTIVATION AND STUDY OBJECTIVES

State agencies, such as the Indiana Department of Transportation (INDOT), are undertaking efforts to expand the scope of their assessment of the potential economic development associated with highway corridor improvements. The primary objective of this project is to demonstrate and document the use of the spreadsheet-based tools for assessing *wider economic benefits* of transportation projects in the State of Indiana. The deliverables of this study will be used by INDOT for middle-stage transportation planning involving single projects and/or for transportation programming. To this end, three specific tasks were undertaken:

1. Overview of the EconWorks tools and discussion for potential use in analyzing policies, programs, and projects.
2. Parallel analysis of the case studies using TREDIS to compare the relative merit or synergies of the tools.
3. Opportunities for the implementation of the EconWorks W.E.B. tools in the project development process at INDOT.

The information provided herein aims to provide the following benefits for INDOT:

- Offer guidance to INDOT about using the EconWorks W.E.B. spreadsheet tools.
- Provide information to support the decision-making process when evaluating projects at the middle-stage transportation planning or transportation programming, or the early stages of project development.
- Assist INDOT with communicating with elected officials, the general public, and stakeholders.

1.3 ORGANIZATION OF THE REPORT

The structure of this report is as follows. Chapter 2 presents an overview of the economic development impacts associated with transportation investments, including wider economic benefits. This chapter also describes each of the EconWorks W.E.B. tools as well as their inputs and outputs. Chapter 3 provides an overview of the TREDIS software and describes its synergies with the EconWorks W.E.B. tools. Chapter 4 demonstrates the application of the EconWorks W.E.B. tools and TREDIS for two case studies in Indiana. This chapter also presents a sensitivity analysis of the results with respect to EconWorks W.E.B. key inputs. Finally, a summary of the key findings, lessons learned and opportunities for future research are presented in Chapter 5.

CHAPTER 2 OVERVIEW OF THE ECONWORKS W.E.B. TOOLS

The following sections present a brief discussion of the basic concepts related to economic impact assessment of transportation investments, including wider economic benefits (W.E.B.). Subsequently, an overview of the three EconWorks W.E.B. tools, the data inputs, internal processes, and outputs of each tool is presented.

2.1 BASIC CONCEPTS

ECONOMIC DEVELOPMENT AND TRANSPORTATION SYSTEMS

Transportation systems form the backbone of a nation's economy. The mutual relationship between transportation and economy has been examined extensively in the past. Assessing economic development impacts of transportation projects is vital at various stages of project planning or program development for three reasons. First, it predicts the future impacts of proposed projects. A good assessment of economic development impacts for a transportation project could help decision makers identify cost-effective projects, allocate funds efficiently, select the best project, and justify the investment. Second, it examines whether a completed project has achieved its objectives. Third, it assists decision makers in gaining approval from the public by showing positive economic impacts (Sinha & Labi, 2011).

ECONOMIC DEVELOPMENT IMPACTS

Economic development seeks to improve a community's economy by increasing employment, income, productivity, property values, and tax revenues. Economic development impact types can be summarized into two groups (Sinha & Labi, 2011):

- Impact types related to the regional economy, such as economic output, personal income, and employment.
- Impact types related to a particular aspect of economic development, such as productivity, capital investment, and tax revenues.

Economic development impacts can be closely related to one another. It is common that an economic development change is reflected by two or three types of economic development impacts (Sinha & Labi, 2011). The economic development impacts of transportation projects can be further placed into four groups: direct impacts, indirect impacts, induced impacts, and dynamic impacts. An

expanded definition for each of these impacts is given in Forkenbrock and Weisbrod (2001). Figure 2.1 illustrates these categories of economic development impacts.

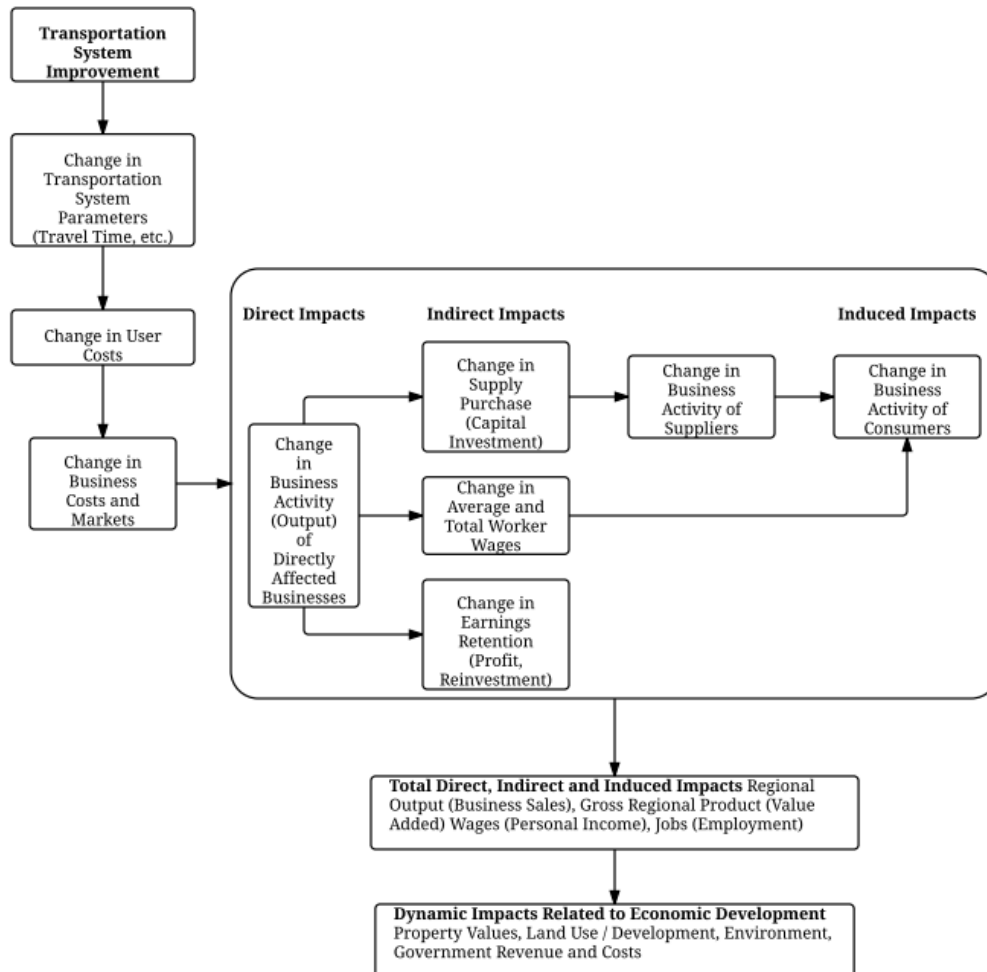


Figure 2.1 Categories of Economic Development Impacts (Source: Weisbrod, 2000)

Direct Economic Impacts

Cost savings result from changes in transportation system characteristics (such as travel time and safety) and changes in costs (such as vehicle operating costs). These make positive contributions to reductions in business costs and increased productivity in the region, which ultimately leads to increases in directly affected business activities in that region. Direct business activity outputs are considered as direct economic impacts. For example, reduced travel time to a supermarket results in user cost savings, which in turn, may result in more customers shopping there and generating more business outputs for the super market.

Indirect Economic Impacts

Indirect impacts from a transportation investment refer to the benefits to suppliers from changes in business output. For instance, a new highway improves the mobility of a freight company (increasing the business outputs of the company) in that corridor. The improvement enables the freight company to offer better service to markets. The employees of the freight company may also benefit by increased wages.

Induced Economic Impacts

Induced economic impacts happen when the people in a region spend more money on buying higher quality goods and services than before, because of their increased income.

Dynamic Economic Impacts

Dynamic economic impacts represent changes in business locations, land value and environmental conditions in the long run.

WIDER ECONOMIC BENEFITS

Wider economic impacts of transportation projects mainly concern the impacts on business productivity, which captures efficiency gains from business-related travel. Adjustments in a region's reliability of movements, accessibility to markets, and connectivity to intermodal facilities are major elements involved in wider economic impacts (NCHRP, 2014). *Reliability benefits* accrue when the duration of traffic incidents is reduced, especially under congested conditions. The enhancement of travel time reliability provides better assurance for on-time performance of freight pick-up and drop-off services as well as for employees' punctuality at their places of work (SHRP2, 2014). *Market access* could be defined as the degree of ease with which a business can access customers, suppliers, and labor markets from a given location. Some transportation projects could have significant effects on market access, for example, by enlarging the number of destinations that can be served from a single business location (SHRP2, 2014). *Intermodal connectivity* aims to reduce overall travel time from business locations to intermodal terminals (like airports, marine ports, rail terminals, and intermodal truck- rail facilities) (SHRP2, 2014). The following sections describe in more detail the three classes of benefits and their metrics considered in the EconWorks W.E.B. tools.

2.2 ECONWORKS RELIABILITY TOOL

The EconWorks W.E.B. tool aims to measure the benefits associated with the reduction of the variability of travel times. Traditionally, travel time evaluations have focused on the benefits gained from reducing the average travel times which have usually constituted the highest portion of the user benefits (Jenkins, Colella, & Salvucci, 2011). More recently, the consistency of travel times was perceived to be very important, especially for users who are highly sensitive to time variability when planning their departure and arrival times (i.e., commercial and business trips) (SHRP2, 2014). When dealing with high variable travel times, users add a “buffer” time to each trip to avoid late arrivals; high buffer times, in turn, are associated with a reduction in business productivity. The variability in travel times can be caused by predictable sources such as peak-hour congestion or unpredictable sources such as car crashes or inclement weather. In that sense, the EconWorks W.E.B. Reliability tool makes estimations of recurring delay (expected congestion) and non-recurring delay (unexpected congestion). Furthermore, SHRP2 identified seven sources of congestion that are associated with unreliable travel times: (a) incidents, (b) inclement weather, (c) work zones, (d) special events, (f) traffic control device timing, (g) demand fluctuations, and lastly, (f) inadequate base capacity (based on prevailing geometrics and traffic patterns). The relationships between these seven sources, called “anatomy of congestion”, were outlined by Cambridge Systematics & TTI (2005). Therefore, modifying one of the sources will have an impact on the other sources.

2.2.1 Defining and Measuring Reliability

There are various definitions for the term *reliability*. Moreover, it is used interchangeably with *unreliability* and *travel time variability* in the literature (Carrion & Levinson, 2012). In this report, the definition provided by the SHRP2 Report S2-L3-RR-1, Analytical Procedures for Determining the Impacts, will be adopted: “... *from a practical standpoint, travel-time reliability can be defined in terms of how travel times vary over time (e.g., hour-to-hour, day-to-day). This concept of variability can be extended to any other travel-time-based metrics such as average speeds and delay*” (SHRP2, 2013). In terms of the metrics, two groups can be distinguished, the first consists of simple and easy-to-communicate measures (performance-driven measures and user response measures), while the second group’s metrics are mainly used for modeling purposes.

Common measures of travel time reliability are based on statistics of travel time distributions, such as standard deviation, percentiles (50th, 80th and 95th), misery time, and the

buffer index (FHWA, 2013a; Pu, 2011; SHRP2, 2013, 2014). A slightly different definition of reliability uses the notion of the probability of failure. In this approach, failure is defined in terms of the number of times a threshold is not met (SHRP2, 2013). Additionally, the theoretical framework to assess reliability can be placed into three groups depending on the level of integration within the travel demand models. These methods are presented in three levels ranging from an initial post-processing measuring approach to a fully ideal integration approach that considers scheduled delay terms (De Jong & Bliemer, 2015). The reliability tool considered herein uses performance-driven measures and a post-processing approach; the reliability effects are not considered in the generalized cost (i.e., only travel time and/or travel cost are considered). Table 2.1 summarizes the main reliability metrics used in SHRP2 Project L03. The latter metrics, also reflected in the EconWorks Reliability tool, are based on functions derived from travel time distributions where the main parameter is the time index (TTI). TTI is defined as the ratio of the average travel time under congested conditions (TT_m) to travel time under free flow speed (FFS) conditions (TT_{FFS}) as seen in Eq. 2-1.

$$Travel\ Time\ Index\ (\%) = \frac{TT_m}{TT_{FFS}} \quad 2-1$$

Therefore, a TTI of 1.2 indicates that average users take 20% more time to travel through the route at FFS (NCHRP, 2014). It is important to note that the lowest possible value of TTI is 1 (i.e., users are traveling at free flow speeds) and the highest value is 6 (i.e., congested speeds are 1/6 of free flow speed or equivalent to 10 mph of the FFS is around 60 mph) (NCHRP, 2014). The reliability outputs for the EconWorks W.E.B. Reliability tool include TT95th, TT80th, TT50th, and trips occurring under 30 and 45 mph.

Table 2.1 Set of Reliability Metrics used in SHRP2 (2013)

PERFORMANCE METRIC	DEFINITION
Buffer Index	Difference between 95 th percentile TTI and average TTI, normalized by average TTI (%)
Failure and on-time measures	Percentage of trips with travel times <1.1 median travel time (MTT) and <1.25 MTT
	Percentage of trips with speeds less than 50, 45, and 30 mph
Planning Time Index	95th percentile TTI
95 th /80 th percentile of TTI	Self-explanatory
Skew statistic	(90 th percentile TTI - median) divided by (median - 10th percentile TTI)
Misery Index (modified)	Average of highest 5% of travel times divided by free-flow travel time

2.2.2 The Value of Travel Time Reliability

The value of travel time reliability refers to the monetary value that users assign to each unit of time reduced in the variability of travel time. The value reliability (VOR) can be determined using the reliability ratio (RR). According to SHRP2 (2014), the RR varies between 0.5 and 1.5. The RR will be different for each mode or purpose. For more details about the meta-analysis to derive this range, see De Jong & Bliemer (2015) which provides a summary of RR by modes, and Carrion and Levinson (2012) which provides a summary by year considering both stated and revealed preference data. The EconWorks Reliability tool provides default value of 0.8 for personal trips and 1.16 for commercial trips (trucks). However, a preferred approach would be to estimate values based on local data (De Jong & Bliemer, 2015).

2.2.3 Applying the EconWorks Reliability Tool

In order to estimate the recurring and non-recurring delay costs, a sequence of 13 steps was followed internally in the tools. These steps are summarized in **Error! Not a valid bookmark self-reference.**, while the corresponding inputs and outputs are discussed at the end of this section. The applicability of the tools is limited to individual road links where the project is expected to generate reliability benefits. Additionally, NCHRP (2014) recommends the use of this

tool on project segments that have volume to capacity ratios (v/c) greater than 0.85 and a TTI greater than 1.3.

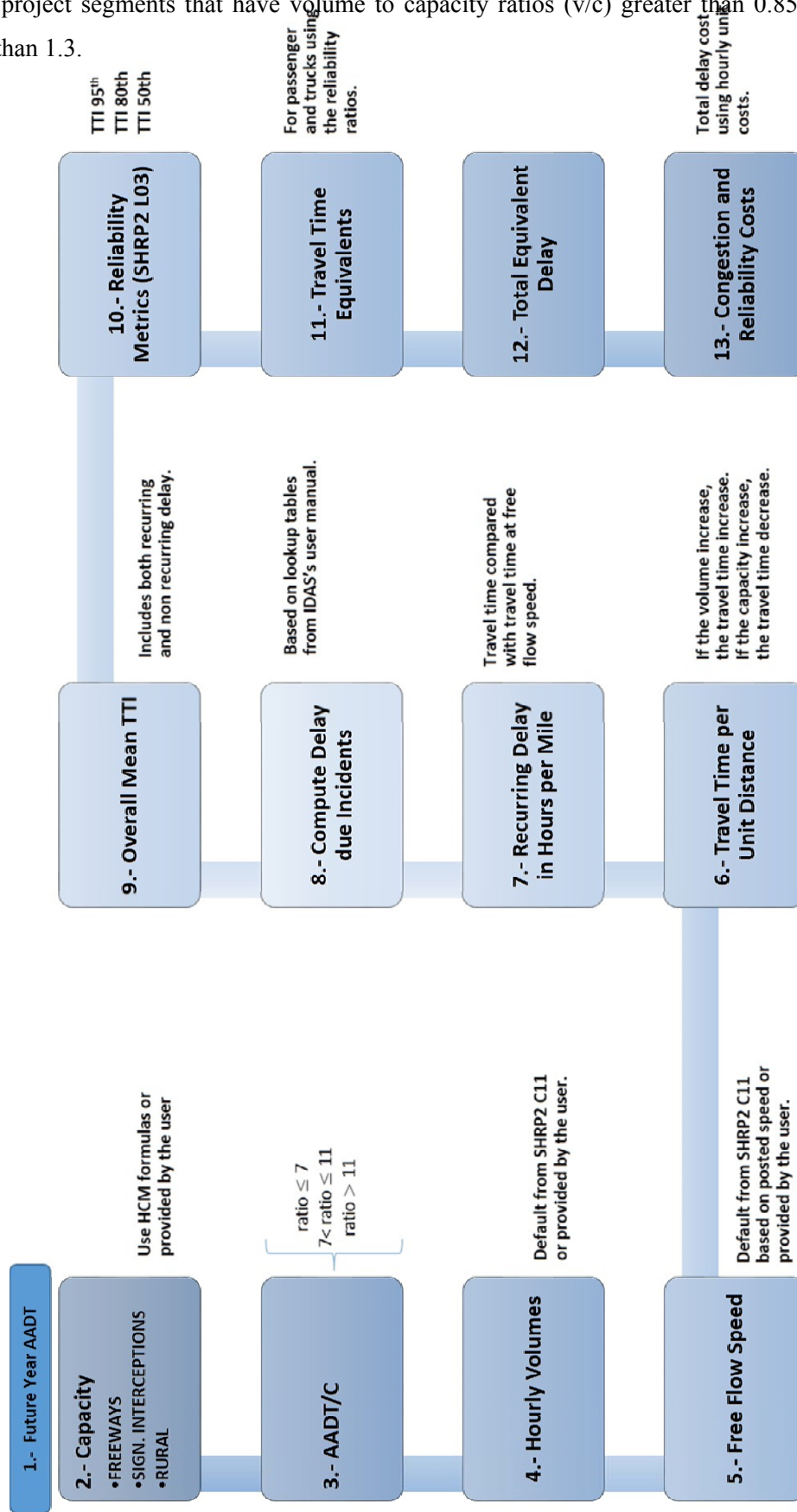


Figure 2.2 Steps for Evaluation of Productivity Impacts in the Reliability Tool. Adapted from SHRP2 (2014)

The inputs for the reliability tool are:

- *Traffic data*, Average Annual Daily Traffic (AADT) and annual growth rate (%).
- *Truck percentage*.
- *Link capacity*, which could be determined using the Highway Capacity Manual (HCM). In the case of signalized segments, this capacity is determined by the ratio of effective green and cycle length (SHRP2 provides 0.45 for arterials and 0.35 for other classes as default values).
- *Time horizon*, the period (years) in which the analysis applies.
- *Peak Capacity Period*, the period of time during the day for the analysis. The tool provides a set of different analysis (6 a.m. to 9 a.m., 9 a.m. to 3 p.m., 3 p.m. to 7 p.m., or 6 a.m. to 9 p.m.). In addition, the tool will distribute the AADT in hourly volumes using percentages that depend on the type of facility, the peak direction, and the ratio of AADT to capacity of the facility (see Appendix A).
- *Number of lanes*, in one direction (it does not apply for two-way rural roadways).
- *Highway Type*: freeway, signalized, or rural roadway. Depending on this value, the different set of capacity expressions can be used.
- *Free Flow Speed*, if available. Otherwise, FFS could be calculated based on the posted speed limit.
- *Reduction in incident frequency and/or duration*, the percentage by which the project is estimated to reduce the number of incidents occurring and/or their duration. This accounts for changes to an incident management strategy or program.
- *Travel Time Unit Cost*, for both personal and commercial vehicles. The 11EconWorks W.E.B. tools provide default values for personal and commercial trips. Alternatively, the TIGER Benefit-Cost Analysis Resource Guide (2014) can be used that suggest \$18.63 per hour for personal vehicles and \$27.75 for commercial vehicles.
- *Reliability Ratio*, for both personal and commercial vehicles. The default values in the tool are 0.80 and 1.16 for personal and commercial vehicles, respectively. A value of 1 means that one unit in travel time reliability is valued equally to one unit of travel time saved.

All these inputs are entered into the tool twice for the base scenario (no-build) and for the build scenario. The tool allows the addition of more scenarios to be compared simultaneously. More details about the calculations, inputs, and outputs can be found in SHRP2 (2014) and NCHRP (2014).

Table 2.2 Summary of the Primary Data and Sources for the EconWorks Reliability Tool

Data Input	Source
Time horizon	Project description provided by the state DOT
	ISTDM
AADT and traffic annual growth rate	Data retrieved from a Traffic-Count Database System such as from Modern Traffic Analytics (MS2) - indot.ms2soft.com ^a
Percentage of trucks	Same as AADT and traffic annual growth rate
Length and number of lanes	Project description provided by the state DOT
Peak hour period	Hourly traffic distributions provided in SHRP2 (2014)
FFS or Posted speed limit	Current posted speed limit on the highway segment
Reduction in incident frequency and/or duration	The reduction on frequency can be estimated based on a fraction of reduction in crash frequency. Crash modification factors or average crash rates can be used if available. The incident duration is mainly affected if incident management strategies are being implemented.
Travel Time Unit Cost and	TIGER Benefit-Cost Analysis Resource Guide (2014)
Reliability Ratio	Default values provided in SHRP2 (2014)

^a This source could be used alternatively if the analyst does not have access to a travel demand model.

The outputs of the reliability tool are tabulated for each scenario at both the beginning and the end of the analysis period. As more than one reliability metric is generated, this allows for

some flexibility in interpreting the results and facilitating further use of these metrics. The main outputs are:

- *Total annual weekday delay* for both *recurring and non-recurring delays*, measured in hours. The results are presented separately for passenger cars and trucks.
- *Total annual weekday congestion costs*, for both recurring and non-recurring delays, measured in dollars.
- *Travel Time Index TTI, overall, 95th and 80th percentiles.*
- *Percent of trips made at speeds less than 45 mph and 30 mph.*

The magnitude and value of reliability are reflected in the non-recurring delay section. The recurring delay section is estimated using standard travel benefits procedures. If travel time savings are estimated separately, the nonrecurring delay cost should not be reported to avoid double counting. The outputs present then the cost of delay by mode (commercial and passenger vehicles) and additional distinctions should be made between the trip purposes for passenger vehicles (businesses, commuting, and personal trips). In that sense, when evaluating the impact of the project on business productivity, only the business and commercial trips should be considered. The percentage of business trips can be estimated for local conditions or average values between 4.6 to 6.3 percent of passenger-car trips can be used (NCHRP, 2014).

2.3 ECONWORKS ACCESSIBILITY TOOLS

Numerous research studies have focused on the impact of transportation system improvements on the access between firms and their workers, suppliers and customers (NCHRP, 2014). It is now a widely accepted notion that some transportation projects could enhance market access and therefore contribute to business benefits and productivity gains. SHRP2 developed two tools for capturing the aforementioned economic benefits from transportation improvements: (1) EconWorks Buyer-Supplier Market Access tool, and (2) EconWorks Specialized Labor Market Access tool. NCHRP (2014) recommended the evaluation of buyer-supplier market access benefits when the percentage of trucks in the project area is over 12%. Similarly, the evaluation of labor market access benefits was suggested for areas with high population (more than 50,000) and high population density (more than 1,800 per square mile) (NCHRP, 2014). The EconWorks W.E.B. tools for market access are presented in detail and in the form of guidelines for implementation in the following sections.

2.3.1 EconWorks Buyer-Supplier Market Access tool

This tool was designed to provide preliminary assistance in estimating regional changes in market access from a transportation project for a base year (no-build scenario) and a reference year (build scenario) (SHRP2, 2014). The tool focuses on measuring economies of scale triggered by the expansion of the customer delivery market served from a certain business site and the expansion of supplier locations that can deliver to that business site in a day due to a highway transportation improvement in the region. Figure 2.3 presents a general overview of the tool’s inputs, analysis and results. Each element shown in Figure 2.3 is explained in the following sub-sections in detail.

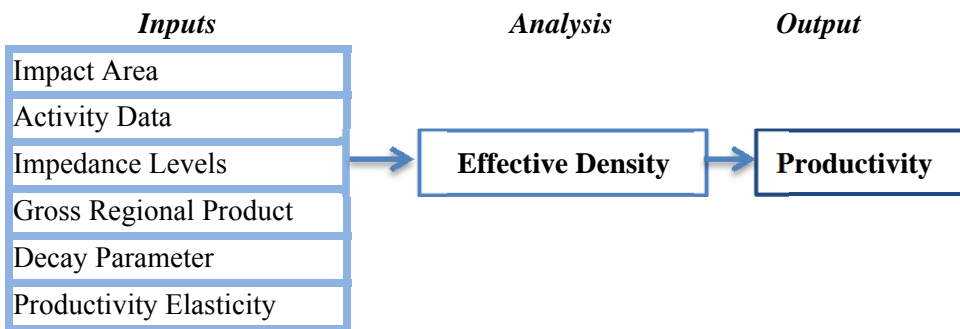


Figure 2.3 General Overview of the EconWorks Buyer-Supplier Market Access Tool

Input 1: Impact Area

The first step for the application of the tool is to define the area of impact (area within which the given project is expected to have measurable impacts). Typically, this area includes the region where the project is located and the adjacent regions. Also, origin-destination (O-D) matrices could be used to identify major centers of attraction in the greater region. These major centers have to be within a reasonable distance from the project that allows for same-day truck deliveries from one center to the other. The unit of analysis (traffic analysis zone (TAZ), metropolitan area, county) is chosen by the analyst and depends on the scale and nature of the project. However, the tool should not be used when the impact area consists of more than 30 zones or analysis units (SHRP2, 2014).

Input 2: Activity Data

The tool requires activity (population or employment) data for the base year (4 – Input Activity Data) and the reference year (5 – Input Activity Data) for each zone or analysis unit. Population

data is available from the U.S. Census Bureau for counties, metropolitan statistical areas (MSA), census tracts, block groups and blocks; this data can be aggregated to fit the chosen analysis unit. Employment data per county and per MSA is available from the Regional Economic Accounts of the U.S. Bureau of Economic Analysis (BEA). Future population or employment data (for the reference year) for the impact area also needs to be generated; appropriate growth rates based on historical data could be used to predict the future level of activity in the region. However, if the focus is to isolate the change in access, the employment or population level should be held constant for the base and the reference year. It should be noted that this tool does not estimate the growth of jobs (or jobs added) in the region related to a transportation improvement.

Input 3: Impedance Levels

O-D impedance matrices for the base year (6 – Input Impedance) and the reference year (7 – Input Impedance) need to be entered into the tool. Impedance could be measured in terms of travel time or generalized transportation cost (SHRP2, 2014). The Indiana Statewide Travel Demand Model (ISTDM) could be used for estimating the travel time between origins and destinations for the base and the reference year. Travel time could then be translated into cost using appropriate estimates for the value of time (VOT). Such estimates could be found in the TIGER Benefit-Cost Analysis Resource Guide, Table 1, page 4 (US DOT, 2012).

Input 4: Gross Regional Product (GRP)

The tool requires GRP estimates for each zone or analysis unit for the base year (8 – Input Gross Regional Product). GRP estimates for states and MSAs are available from the BEA Regional Economic Accounts. However, GRP data for smaller analysis units, such as counties, is only available from private providers such as the Economic Modeling Specialists International (EMSI). SHRP2 (2014) proposed a methodology for estimating a proxy for per capita GRP. As a first step, an adjustment factor is estimated as the ratio of state (or MSA-level) Gross Domestic Product (GDP) to total earnings. In the second step, this adjustment factor is multiplied by the zone-specific per employee earnings; the result represents a proxy for per employee GRP. It is important to maintain consistency between the activity data and the GRP proxy estimation. The GRP proxy estimation (and consequently the productivity impacts) is only valid when employment is used to represent activity in the region. If employment data is used as a measure of activity and assuming that a per-county analysis is conducted, the GRP proxy for county i is estimated as follows:

$$GRP\ proxy_i = \frac{State\ or\ MSA\ GDP}{State\ or\ MSA\ total\ earnings\ by\ place\ of\ work} \times \frac{(Total\ earnings\ by\ place\ of\ work)_i}{Employment_i}$$

2-2

where earnings by place of work is the sum of three components of personal income: wages and salaries, supplements to wages and salaries, and proprietors' income. Based on BEA, earnings by place of work are considered a good representation of the income that is generated from participation in current production. Finally, when zones from more than one state are included in the analysis, the income data needs to be adjusted based on the regional price parity deflators developed by BEA; this will ensure that price variations across states do not affect the analysis results.

Input 5: Decay Parameter

The decay parameter is a behavioral parameter entered into this tool by the user (3 – Parameters, 1st parameter). This parameter can be calibrated using data from ISTDM or a Metropolitan Planning Organization (MPO) travel demand model. Also, Graham et al. (2009) estimated that the decay parameter is on average equal to 1 for the manufacturing sector, 1.8 for the consumer and business sectors, and 1.6 for the construction sector. Sensitivity analysis could be used to investigate the effect of this parameter on the final results. It is suggested that the value of the decay parameter is between 0 and 5 (SHRP2, 2014). In general, higher decay values place more weight on markets closer to the project location by penalizing markets farther away (SHRP2, 2014). Lower values of the decay parameter are suggested for investigating the buyer – supplier access compared to labor market access, to reflect the shorter distance of commuting trips compared to truck delivery trips (SHRP2, 2014).

Input 6: Productivity Elasticity

The productivity elasticity, which is defined as the percent change in productivity divided by the percent change in market access, is a very critical parameter for this tool (3 – Parameters, 4th parameter). The value of the productivity elasticity depends on the type of the activity data chosen for the analysis (population, total employment, employment in a single sector) and the type of transportation improvement (new link, improved link), as shown in Table 2.3 (SHRP2, 2014). Sensitivity analysis could reveal the effect of this parameter on the outcome productivity. A more in-depth discussion on productivity elasticity can be found in the meta-analysis study conducted by Melo et al. (2009) and in NCHRP (2014).

Table 2.3 Suggested Productivity Elasticity Values (Source: SHRP2, 2014)

Activity	Productivity Elasticity		
	Range	Suggested Value for New Capacity	Suggested Value for Improved Capacity
Population	0.01 – 0.20	0.06	≤ 0.03
Employment			
Manufacturing Employment	Mean: 0.04 Median: 0.036	0.03	< 0.03
Other Sector Employment	Limited guidance available		

Analysis: Effective Density

Effective Density is a measure of accessibility first proposed by the United Kingdom Department for Transport (UK DOT, 2005), and constitutes an extension of the more widely used potential access measure. Effective density is comprised of two components: (i) a scale factor, which accounts for the intra-zonal accessibility of the origin zone i , and (ii) the potential access measure, which accounts for accessibility of the other zones (SHRP2, 2014). It is defined as follows:

$$Effective\ Density_i = \frac{E_i}{d_{ii}^a} + \sum_j^{i \neq j} \frac{E_j}{d_{ij}^a} \quad 2-3$$

where E_i is the activity (employment or population) in zone i , d_{ii} is the intra-zonal impedance, d_{ij} is the impedance between zone i and j , and a is the decay parameter.

The tool allows the user to choose if the analysis will be done on the basis of effective density or potential access (3 – Parameters, 5th parameter). However, based on the tool’s guidelines, effective density gives a more complete picture of regional change in access and should be preferred over potential access when the focus of the analysis is the estimation of productivity changes (SHRP2, 2014). Effective density is calculated for both the base and the reference year and its change serves as an input in the productivity estimation, which is described in the following sub-section.

Output: Productivity

The result of the tool analysis is the change in effective density (or potential access) between the base year and the reference year, and the productivity added to the impact area due to the

improvement in market access, which is a consequence of the transportation improvement (9 – Output). The total productivity for the reference year is given as follows (SHRP2, 2014):

$$P = \sum_i \left\{ \left[\left(\frac{E_b}{E_{nb}} \right)^\mu - 1 \right] \times GRP_i \times E_i \right\} \quad 2-4$$

where P is the productivity, E_b is the effective density for the reference year (built scenario), E_{nb} is the effective density for the base year (no built scenario), μ is the productivity elasticity, GRP_i is the per employee gross regional product in zone i , and E_i is the total employment in zone i .

Although the tool guidelines proposed the use of either population or employment data, as a measure of activity, productivity impacts can be estimated only when employment data is used. Therefore, employment data should be used in 4 – Input Activity (no-build) and 5 – Input Activity (Build), when the focus is productivity impacts, to guarantee meaningful results. A summary of the inputs with their respective sources is presented in Table 2.4.

Table 2.4 Summary of Inputs and Data Sources for the EconWorks Buyer-Supplier Market Access Tool

Input	Data Source	Data Type
Impact Area	ISTDM or MPO travel demand model	O-D tables can help the user identify major trip attractions/productions around the project
	Longitudinal Employer-Household Dynamics database (http://onthemap.ces.census.gov) ^a	Geo-coded employment estimates by industrial sector per county, MSA, or city
Activity Data	BEA Regional Economic Accounts	Employment per county or metropolitan area
	U.S. Census Bureau, American Fact Finder	Population per county, MSA, census tract, block group, or block
Impedance Levels	ISTDM or MPO travel demand model	O-D travel time matrix
	TIGER Benefit-Cost Analysis Resource Guide (U.S. DOT, 2014)	VOT by trip type
	Oak Ridge National Highway Network (2011) ^a	O-D impedance matrix
	ESRI Business Analyst Online ^a	O-D travel time matrix
	Google Earth ^a	O-D travel time matrix
GRP	BEA Regional Economic Accounts	GRP per state and MSA Income per state Per capita income per county Earnings by place of work per state Earnings by place of work per county
	Economic Modeling Specialists Intl. (Private Provider)	GRP per county
Decay Parameter	ISTDM or MPO travel demand model	Parameter used in the friction factor function
	Graham et al. (2009)	Parameter Value
Productivity Elasticity	SHRP2 (2014) (see Table 2.3), NCHRP (2014)	Elasticity values

^a These sources could be used alternatively if the analyst does not have access to a travel demand model.

2.3.2 EconWorks Specialized Labor Market Access Tool

This tool was designed to provide preliminary assistance for estimating changes in access of work sites and employment centers to specialized labor markets due to transportation improvements for a base year (no-build scenario) and a reference year (build scenario) (SHRP2, 2014). The tool focuses on measuring economies of scale triggered by the expansion of the labor market due to a transportation project. These transportation-induced economies of scale occur through the better

connection between specific business needs and worker proficiencies, as well as the better exchange of information among skilled labor (knowledge spillovers). The tool is mostly useful when the transportation improvement links a place of work to a place of residence and, simultaneously, the study area includes specialized industry sectors (SHRP2, 2014). Figure 2.4 presents a general overview of the tool’s inputs, analysis and results; each element shown in Figure 2.4 is explained in the following subsections. Because the main purpose of this report is to provide guidelines for use, the theory behind the estimation of these four outputs is not fully provided here; for the full theoretical background of this tool, please refer to SHRP2 (2014), Chapter 5.

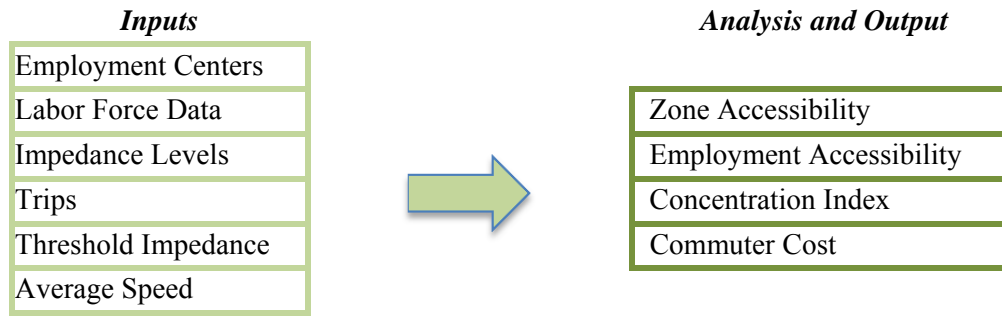


Figure 2.4 General Overview of the EconWorks Specialized Labor Market Access Tool

Input 1: Employment Centers

As previously explained for the EconWorks Buyer-Supplier Market Access tool, the first step is to define the area of impact. A list of zones as employment centers needs to be entered in this tool (7 – Input Employment Centers). The unit of analysis (TAZ, metropolitan area, county) is chosen by the analyst and depends on the scale and nature of the project (SHRP2, 2014). O-D trip matrices could be used to identify major centers of employment in the region. Moreover, the Longitudinal Employer-Household Dynamics database of the U.S. Census Bureau provides an online application (<http://onthemap.ces.census.gov>) that allows for the investigation of employment centers for cities, metropolitan areas, and counties.

Input 2: Labor Force Data and Parameters

This tool requires total as well as specialized labor force data. First of all, for the entire impact area, the user needs to specify the industry sector of interest. This is done in the list of tool

parameters by choosing the appropriate two-digit North American Industrial Classification System (NAICS) sector (3 - Parameters and Selections, 3rd parameter). Then, the labor force type of interest (employed or potential/population) needs to be selected (3 - Parameters and Selections, 4th parameter). For each employment center, the user needs to input total employment for all industry sectors and employment for the previously specified industry sector for the base and the reference year (4 – Input Labor Force Data). Employment data by sector is available from the BEA Regional Economic Accounts for each county and metropolitan statistical area (MSA). Future population or employment data (for the reference year) also need to be generated; appropriate growth rates based on historical data could be used to predict the future level of activity in the region.

The next labor-related parameter to be specified defines the reference point (“by place of work” or “by place of residence”) of the labor force data (3 - Parameters and Selections, 5th parameter). If data from the BEA Regional Economic Accounts were used in the previous step, the user needs to choose “by place of work” for this parameter; this is because BEA measures employment as number of jobs in each location (BEA, 2007). For the 6th parameter in 3 - Parameters and Selections, the user should choose “by industry sector” to denote the specialized labor category data type. Last, for the 7th parameter in 3 - Parameters and Selections, the user needs to choose the two-digit NAICS sector that matches the specialized labor data entered in 4 – Input Labor Force Data.

Input 3: Impedance Levels and Trips

As for the EconWorks Buyer-Supplier Market Access tool, O-D impedance matrices for the base year (5 – Input Impedance) and the reference year (6 – Input Impedance) need to be entered. Impedance could be measured in terms of travel time or generalized transportation cost (SHRP2, 2014). The Indiana Statewide Travel Demand Model (ISTDM) could be used for estimating the travel time between origins and destinations for the base and the reference year. Travel time could then be translated into cost using appropriate estimates for the value of time (VOT); such estimates could be found in the TIGER Benefit-Cost Analysis Resource Guide, Table 1, page 4 (US DOT, 2014). VOT in \$/hour needs to also be entered in the tool (3 - Parameters and Selections, 10th parameter). Apart from the impedance levels, this tool also requires O-D trip matrices for the base year (8 – Input Trip Table) and the reference year (9 – Input Trip Table). Home-based trips to work constitute the most appropriate entry here given this tool’s purposes. The period of analysis (entire day, peak or off peak) and its duration in hours need to be specified as well (3 - Parameters and Selections, 12th parameter).

The period of analysis and the O-D trip and impedance matrices need to be consistent. This means that, if the user chooses “peak” as the analysis period, the trips and impedance levels need to refer to that specific analysis period. For the 9th parameter of 3 - Parameters and Selections, the type of commuter trips (personal or business) and their corresponding percentage need to be specified. Last, the tool requests the user to specify the percentage of VOT (or wage rate) that will be used in the valuation of time costs. It is suggested to use the value of 50 (%) if the majority of trips are personal trips, and the value of 100 (%) if the majority of trips are business-related trips (SHRP2, 2014).

Input 4: Threshold Impedance

Threshold impedance is the typical duration or distance of commuting trips to an employment center (NCHRP, 2014). Regarding the EconWorks Specialized Labor Market Access tool, threshold impedance can be inserted in either miles or minutes (3 - Parameters and Selections, 8th parameter). SHRP2 (2014) suggested the use of American Community Survey (ACS) data for estimating threshold impedance. ACS provides data on the means of transportation and travel time to work by census tract or block group. Similar data can be found in the 2000 Census. This data would be more reliable, but is only available for one year (2000). The data from ACS and 2000 Census is available for download from the American Fact Finder website (<http://factfinder.census.gov>).

Input 5: Average Speed

The average speed of all links in the impact area network needs to be entered in the tool only if the threshold impedance is in miles (3 - Parameters and Selections, 13th parameter). In this case, the tool will use the average speed to convert impedance into hour units.

Output 1: Zone Accessibility

Zone accessibility is the first output provided by this tool (10 – Output - Labor Market Size). It is estimated as the number of accessible zones from the employment centers for a given impedance threshold for the base and the reference year (SHRP2, 2014). This measure represents how easily workers can access the work sites within given time (accessibility threshold). The difference in the number of accessible zones between the base and the reference year represents the change in zone accessibility attributed to the transportation improvement.

Output 2: Employment Accessibility

The second output (also located in 10 – Output - Labor Market Size) is called employment accessibility and is defined as the total employment for each zone that can be accessed in the base

and reference year within a given accessibility threshold (SHRP2, 2014). The difference in employment accessibility between the base year and the reference year expresses the possible expansion of the labor pool due to the transportation improvement.

Output 3: Concentration Index

The third output (also located in 10 – Output - Labor Market Size) is called concentration index (CI). It measures the change in concentration of the labor pool for a specific industrial sector within a zone, relative to the share of that same industrial sector across zones.

Output 4: Commuter Costs

SHRP2 (2014) proposed the use of commuter costs to approximate the monetary value of the change in labor market access. Therefore, the change in commuter costs is the saving for personal commute and business trips for all O-D pairs due to the transportation improvement. A constant equal to 1.2 is assumed for vehicle occupancy. Moreover, the costs are annualized, assuming 260 workdays in a year.

This output, which is located in 11 – Output - Commuter Costs, is estimated only when the analyst chooses the option “Click to compute zone accessibility & employment accessibility & concentration index with computer costs” to run the tool (2 – Data Entry). Finally, a summary of the inputs for the access to the labor markets tool with their respective sources is presented in Table 2.5.

Table 2.5 Summary of Inputs and Data Sources for the EconWorks Specialized Labor Market Access Tool

Input	Data Source	Data Type
Employment Centers	ISTDM or MPO travel demand model	O-D tables can help the user identify major trip attractions/productions around the project
	Longitudinal Employer-Household Dynamics database (http://onthemap.ces.census.gov) ^a	Geo-coded employment estimates by industrial sector per county, MSA, or city
Employment Data	BEA Regional Economic Accounts	Employment per county or metropolitan area
Impedance Levels	ISTDM or MPO travel demand model	O-D travel time matrix
	TIGER Benefit-Cost Analysis Resource Guide (U.S. DOT, 2014)	VOT by trip type
	Oak Ridge National Highway Network (2011) ^a	O-D impedance matrix
	ESRI Business Analyst Online ^a	O-D travel time matrix
	Google Earth ^a	O-D travel time matrix
Trips	ISTDM or MPO travel demand model	O-D trip matrix
Threshold Impedance	American Community Survey (ACS) 2000 Census	Means of transportation and travel time to work by census tract or block group
Average Speed	ISTDM or MPO travel demand model	Average network speed

^a These sources could be used alternatively if the analyst does not have access to a travel demand model.

2.4 ECONWORKS CONNECTIVITY TOOL

The connectivity tool aims to measure the productivity benefits for businesses when a project has the potential to improve their accessibility to intermodal ports, gateways, or terminals. The EconWorks Connectivity tool can be considered as an extension of the EconWorks Accessibility Tool in a sense that by improving the frequency of trips or reducing the impedance levels in the links to/from terminals this optimizes and generates movements. It might also improve the breadth of origins and destinations that could be reached for passengers and freight. The approach used in the tool is based on the gravity model, where the intermodal ports are nodes of trips' attraction. This port attractiveness, in turn, depends on the level of activity measured in terms of

the range of destinations served, the frequency of services, and the volumes handled. The impedance levels that reflect the accessibility to the ports are measured in terms of travel time (or generalized costs). The tool brings an in-built database in which all main airports, seaports, and rail terminals in the U.S. were included. The data also reflects the aforementioned activity levels as well as other characteristics such as the relative comparisons to other large facilities of the same type.

2.4.1 Calculations, Inputs and Outputs of the EconWorks Connectivity Tool

The tool generates an index (Eq. 2-5) that reflects the level of accessibility to any given terminal as well as the magnitude of services offered in that terminal (NCHRP, 2014).

$$WCI = \text{Connectivity Index} * \text{Project Savings} \quad 2-5$$

where WCI is the weighted connectivity index. The connectivity index reflects the connectivity value of the facility. Figure 2.5 shows the main parameters considered in the WCI calculation: level of activity in the port, value of the goods moved, and the number of locations served. Equations 2-4 to 2-6 show the corresponding calculations for each mode (marine port, air passengers, air cargo, freight rail, and passenger rail). When the connectivity index is further multiplied by the value of the travel time savings associated with the project, the weighed connectivity is obtained. The businesses' productivity benefits of improving the accessibility of businesses to/from these intermodal terminals are calculated by evaluating the changes in weighted connectivity index between the build and no-build situation. The latter change in magnitude is multiplied by an elasticity value in a similar fashion to the effective density in the Market Access tool. Therefore, the interpretation of the results as well as their limitations are also similar. An elasticity value of 0.010 is recommended for airport or marine port freight, and a value of 0.005 is recommended for Intermodal (truck/rail) freight (NCHRP, 2014). Additionally, SHRP2, (2014) reports that this elasticity could be as high as 0.04.

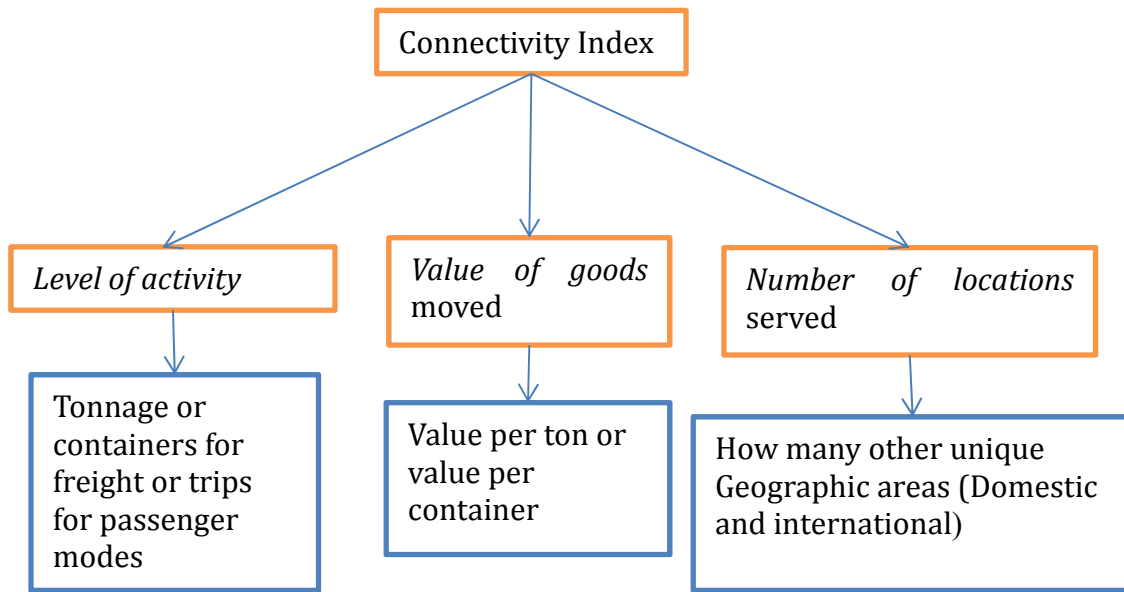


Figure 2.5 Default values for the connectivity index. Adapted from SHRP2 (2014)

The connectivity index is calculated as follows:

$$\begin{aligned}
 \text{Freight connectivity index} \\
 &= \text{Tons of freight} * \text{Average value per ton} * \text{Number} \\
 &\quad \text{of distinct locations served}
 \end{aligned}
 \tag{2-6}$$

Or

$$\begin{aligned}
 \text{Freight connectivity index} \\
 &= \text{Containers of freight} * \text{Average value per container} \\
 &\quad * \text{Number of distinct locations served}
 \end{aligned}
 \tag{2-7}$$

$$\begin{aligned}
 \text{Passenger connectivity index} \\
 &= \text{Number of passengers} * \text{Number of distinct locations served}
 \end{aligned}
 \tag{2-8}$$

Data Inputs

The tool calculates the connectivity index with the in-built information; therefore, the user inputs the parameters to calculate the travel savings:

- *Distance of the project to the intermodal port under analysis.*

- *Fraction of trucks associated with the facility (%)*.
- *Travel time per trip build and no-build scenario*.
- *Value per passenger hours saved*.

Table 2.6 List of Primary Data and Sources for the EconWorks Connectivity Tool

Data Input	Source
Facility type and location	Project description provided by INDOT
Connectivity index	Calculated using values provided in SHRP2 (2014)
Distance of improvement from facility (miles)	Indiana Statewide Travel Demand Model (ISTDM) Other geographic information system software ^a
Number of trucks within study area	ISTDM Estimations based on traffic station counts ^a
Hours saved per truck	ISTDM Estimations based on the change in capacity ^a
Default value per truck hour saved (travel time unit cost)	TIGER Benefit-Cost Analysis Resource Guide (US DOT, 2014)

^a These sources could be used alternatively if the analyst does not have access to a travel demand model.

Data Outputs

The outputs of the connectivity tool are explained below:

- *Total hours of vehicle travel time saved* in trips to the intermodal port.
- *Connectivity index*.
- *Weighted Connectivity Index*, product of the preceding two metrics (Equation 2-5), as an overall measure of the improvements relative to the intermodal terminal level of activity.

Improvements in accessibility could reduce travel times, and as such the final product (i.e., the weighted connectivity index) is expected to decrease.

2.5 ACCOUNTING FRAMEWORK

The accounting framework spreadsheet can be used for conducting a benefit-cost analysis (BCA) of the direct impacts (including wider economic impacts) of highway projects (SHRP2, 2014). Environmental, social, and indirect economic impacts are not included in this accounting framework, because its main focus is to demonstrate how reliability, market access and intermodal connectivity impacts could be incorporated into BCA (SHRP2, 2014). Figure 2.7 presents a general overview of the inputs and results. Each element shown in Figure 2.7 is explained in the following sub-sections.

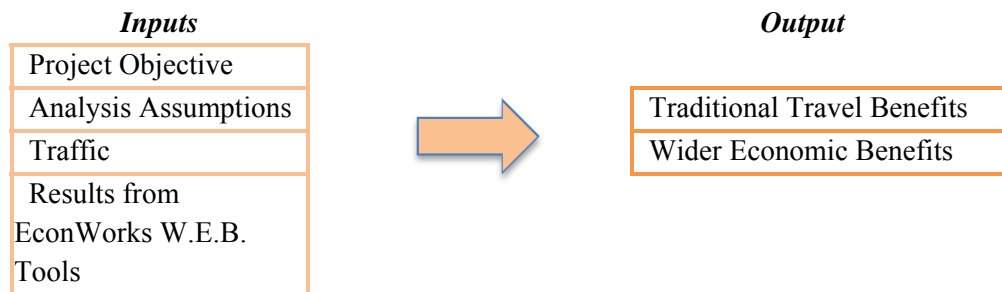


Figure 2.6 General Overview of the Accounting Framework

Input 1: Project Objective

In the accounting framework, the analyst is required to define the main project objectives or expected impacts (2 – Input). There are four categories of impacts to choose from: (a) traffic impact, (b) reliability tool, (c) effective density access tool, and (d) intermodal connectivity tool. More than one impact could be selected for a single project. The project type needs to be selected as well (2 – Input).

Input 2: Analysis Assumptions

The accounting framework includes a number of default parameters necessary for the estimation of direct impacts (3 – Forms). These parameters contain traffic characteristics and economic multipliers and need to be provided for each trip purpose (truck, commuting, personal and business travel). For the first group of assumptions, which is called “Standard Travel Benefit Analysis Assumptions”, the analyst needs to input information for the following parameters: (a) persons per trip, (b) vehicle operating cost per mile, (c) value of time per person, and (d) average cost per crash. For the second group of assumptions, which is called “Wider Benefit Assumptions”, the analyst needs to enter economic multipliers for each benefit type (labor market, delivery/customer market, air connectivity, marine port connectivity, rail connectivity).

The accounting framework includes default values for all the aforementioned parameters; the analyst has the option to modify these default values, if needed.

Input 3: Traffic

Traffic information related to the project in question needs to be entered as well (3 – Forms, (1) Traffic Impact). Specifically, the requested inputs are vehicle-miles of travel (VMT), vehicle-hours of travel (VHT), and crashes per 100,000 VMT for the “No project” and “With project” scenario (equivalent to no-build and build scenarios), and for each trip purpose (truck, commuting, personal and business travel). ISTD or an MPO travel demand model could be used for estimating this traffic information.

Input 4: Results from the EconWorks W.E.B. Tools

The resulting benefits from the individual tools (reliability, market access, and intermodal connectivity) are entered in the accounting framework to be taken into consideration in the overall BCA. If a tool was not used for analyzing the wider economic impacts of the project in question, the respective cells in the accounting framework should be left empty.

Regarding the reliability tool, the total equivalent delay (called “incident equivalent delay” in the accounting framework) and the total congestion cost (called “cost of unreliability” in the accounting framework) can be entered in the accounting framework (3 – Forms, (2) from the Reliability Tool). The effective density for the base and the reference year (called “No project” and “With project” in the accounting framework) from the EconWorks Buyer-Supplier Market Access tool can also be entered here (3 – Forms, (3) from the Effective Density Access Tool). Last, the weighted connectivity from the intermodal connectivity tool can be inserted in the accounting framework as well (3 – Forms, (4) from the Intermodal Connectivity Tool). It should be noted here that there is no option for entry of the results of the EconWorks Specialized Labor Market Access tool.

Although not clearly mentioned in the tools’ guidelines presented in SHRP2 (2014), the total GRP, which was previously estimated for the EconWorks Buyer-Supplier Market Access tool, can be inserted in the accounting framework, 4b – GRP conversion, cell F32. The total GRP has to be entered in the Accounting framework only if results from the EconWorks Buyer-Supplier Market Access tool or Connectivity tool are included as well.

Outputs

The accounting framework presents the analysis results per impact category (4a – Output). First, a total value of the traditional travel benefits (in dollars) is given. The traditional travel benefits

include vehicle operating cost, travel time and safety benefits. Second, a total value for the wider economic benefits (in dollars) for commercial and passenger trips is given. The accounting framework only provides information on the benefits side; therefore, additional work is needed for a complete BCA analysis.

CHAPTER 3 SYNERGIES BETWEEN TREDIS AND THE ECONWORKS W.E.B. TOOLS

In this chapter, first, a brief description on the TREDIS and its modules is provided. Subsequently, the synergies of TREDIS with each of the EconWorks W.E.B. tools are discussed.

3.1 INTRODUCTION TO TREDIS

TREDIS is a web-based Transportation Economic Development Impact System to measure the economic output of transportation projects at the project development stage of the transportation planning process. It is designed to help transportation planners conduct economic-related analysis of transportation projects, ranging from evaluating the economic impact and benefit-cost of a single transportation investment to assessing fiscal and public–private financial impacts of a set of project alternatives (EDRG, 2010). Appendix B shows all the features included in TREDIS version 4.0.

Comprehensiveness and flexibility are two key features of TREDIS. Comprehensiveness is represented by the coverage of transportation modes, scope of projects, and separation of trip purposes. Coverage on all transportation modes (car, bus, truck, train, aircraft, ship, and bike) makes it possible to analyze transportation projects, not only related to highway travel, but also to rail, aviation, marine, and pedestrian movement. With respect to the scope of transportation projects, TREDIS is capable of both investigating the economic value of a highway corridor across several states and studying the economic efficiency of a single contraflow lane covering a few miles. Separation of trip purpose allows TREDIS to calculate the economic benefits of a transportation project for different levels of detail for traffic data.

Flexibility is exhibited by compatibility and diversity. In terms of compatibility, there is no limitation in TREDIS on the types of models used to generate required traffic data input. TREDIS has been used with a variety of travel models and data sources, such as TransCAD, HERS, and IMPLAN. The matrix of mode and trip purpose inside TREDIS provides users various options for mode and trip purpose combinations.

3.1.1 Types of Analysis in TREDIS

TREDIS provides a detailed evaluation of economic values for various projects at each of the seven stages in the transportation planning process. Figure 3.1 indicates the seven types of analysis embodied in TREDIS.

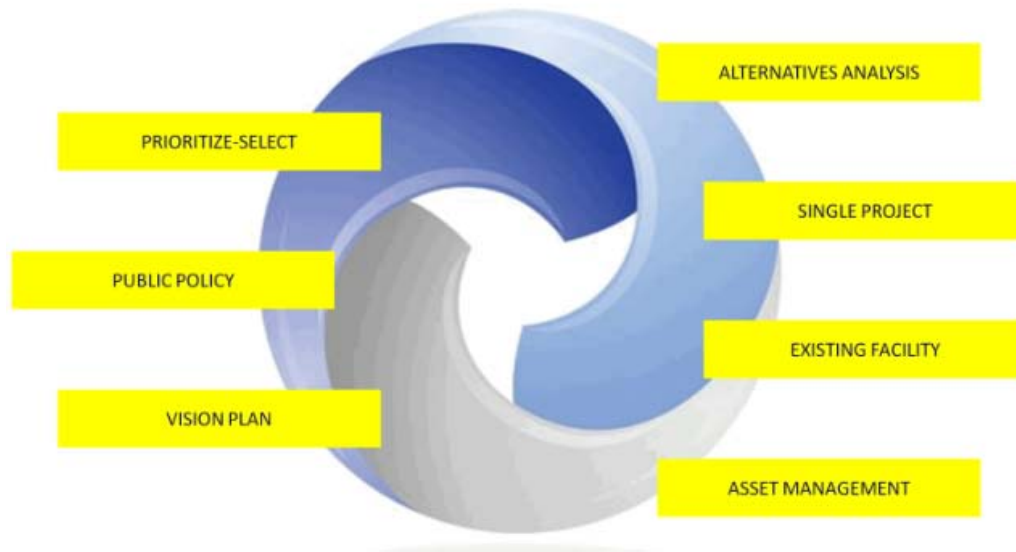


Figure 3.1 Seven types of analysis available in TREDIS (Source: TREDIS website, 2015)

Prioritize ranks a group of competing projects by comparing the base case of a specific project with its build alternative. The North Carolina Department of Transportation has employed TREDIS in the process of Project Prioritization 3.0 (North Carolina Department of Transportation, 2013).

Public policy estimates changes from alternative scenarios after implementing certain policies to a transportation infrastructure. The City of Fort Worth, Texas used TREDIS to investigate the anticipated economic impact on the planned transportation infrastructure by a number of policies such as increased impact fees (Willdan Financial Services, 2009).

Vision plan can be used for analyzing the economic impact of a long-term region plan or state development plan, like the Virginia Multimodal Transportation Plans (EDRG, 2009).

Alternative analysis appraises project alternatives regarding mode, costs, travel demand, market access and design details. The Ontario Ministry of Transportation in Canada adopted TREDIS to recognize specific effects of alternative future highway and railway investment

situations on market access and traffic flows on the Greater Toronto Area (GTA) West corridor and Niagara – GTA corridor (Ontario Ministry of Transportation, 2011).

Single project assesses the economic impact of completing a proposed project. The Indiana Finance Authority asked the Economic Development Research Group (EDRG) to apply its TREDIS product and conduct an economic impact analysis of the Ohio River Bridge in the Louisville area (EDRG, 2014). Appendix B provides step by step guidance on using TREDIS for single project evaluation.

Existing facility evaluates the economic value of current airports, ports, bus transfers and rail terminals to the local community. The City of Atlanta and Georgia DOT assessed the economic impacts of a new downtown transit terminal with the help of TREDIS (Bleakly Advisory Group et al., 2012).

Asset management estimates the economic benefit and impact of spending money on maintenance or rehabilitation of infrastructure and facilities.

3.1.2 Modules inside TREDIS

TREDIS has the following four interrelated modules: Travel Cost, Market Access, Economic Adjustment, and Benefit–Cost Modules. In addition to these basic modules, three optional modules are also included in TREDIS, which are the Finance Module, Freight Module, and Forecasting Module. Each module operates separately, but they can also work together. Figure 3.2 shows the internal relationship among modules.

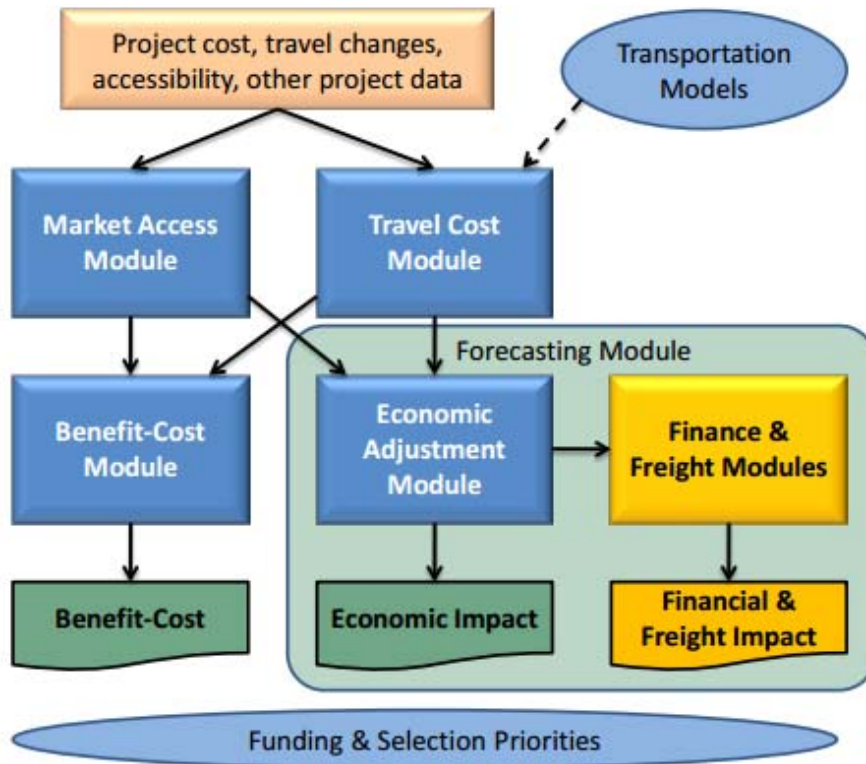


Figure 3.2 TREDIS Modules (Source: EDRG, 2010)

Travel Cost Module

The Travel Cost Module addresses changes in volume, speed or average trip distance, vehicle miles traveled (VMT), vehicle hours traveled (VHT), congestion levels, reliability, safety, and induced travel. It translates these changes into direct cost savings for estimating the benefits and economic impacts. For example, travel time savings for personal trips are defined as a social benefit value that would only make contribution to the benefit-cost ratio. Travel time savings for business trips are grouped as business operating cost changes that affect the benefit-cost ratio as well as economic impacts. Figure 3.3 illustrates the input and output factors of the travel cost module in TREDIS.

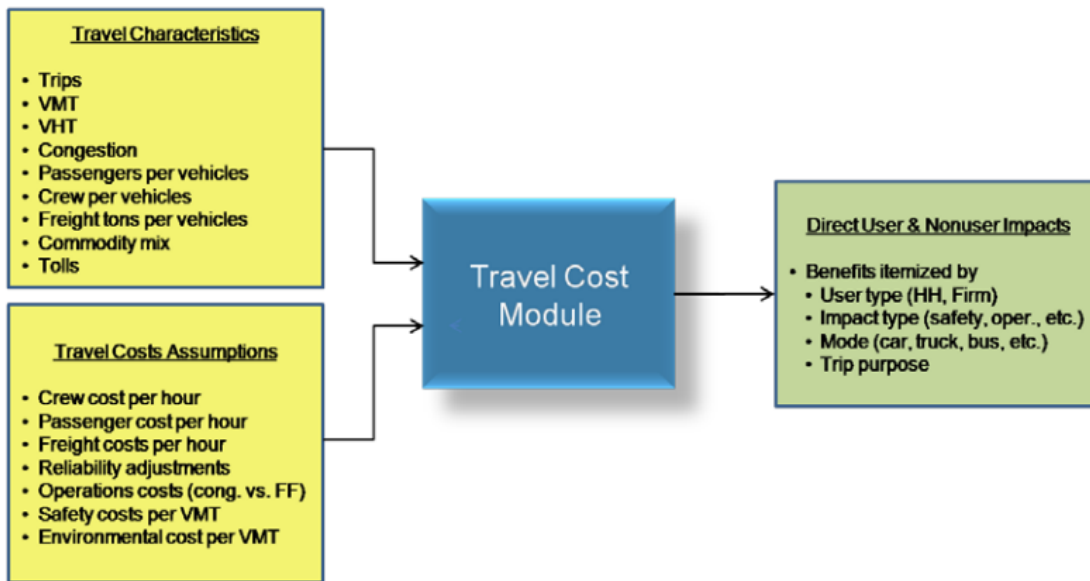


Figure 3.3 TREDIS Travel Cost Module Input and Output Factors (Source: EDRG, 2010)

The travel cost alternatively can include the benefits of improving the travel time reliability. These benefits are measured considering the notion of having extra time to avoid late arrivals. The value of the travel time reliability is given as follows:

$$ReliabilityCost = Veh.Trip \times BufferTimeVehTrip \times CostPerBufferHour \quad 3-1$$

where :

$$BufferTimeVehTrip = BTI(fractCong) \times \left(\frac{VHT}{VehTrips} \right) \quad 3-2$$

$BTI(fractCong)$ is the buffer time index as a function of the fraction of travel under congestion. The latter can be estimated for cars and trucks with an auto-fill option based on the level of congestion (see Figure 3.8). In that Figure, the BTI is expressed as percentage where, for example, if the fraction congested is 0.4, then the BTI is 15%. That is, if the average travel time is 10 minutes, then the users will add 1.5 minutes to avoid late arrivals.

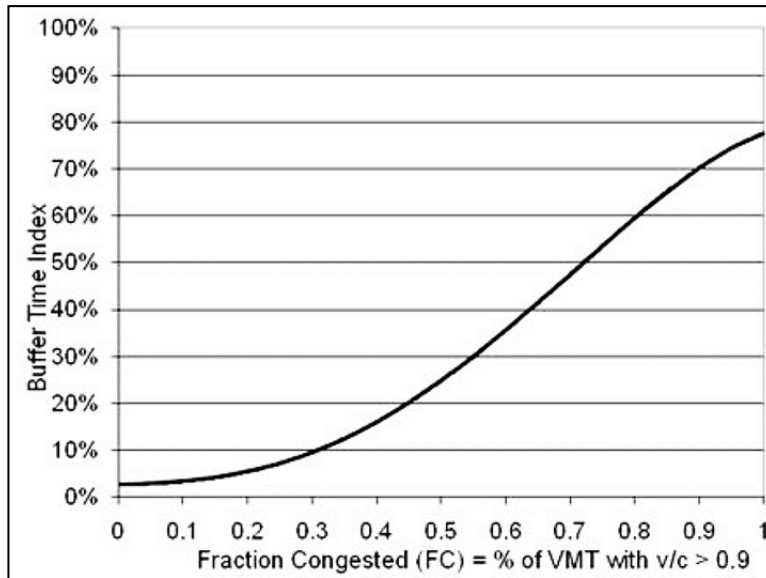


Figure 3.4 Relationship between Buffer Time and Congestion for Highway modes (EDRG, 2014a)

Market Access Module

The Market Access Module focuses on capturing the improvements of business production, labor productivity, and international exports in a study region by measuring access to labor, industrial suppliers and customers, intermodal facilities with domestic service, and international gateway facilities. Figure 3.5 shows the input and output factors of the Market Access module in TREDIS.

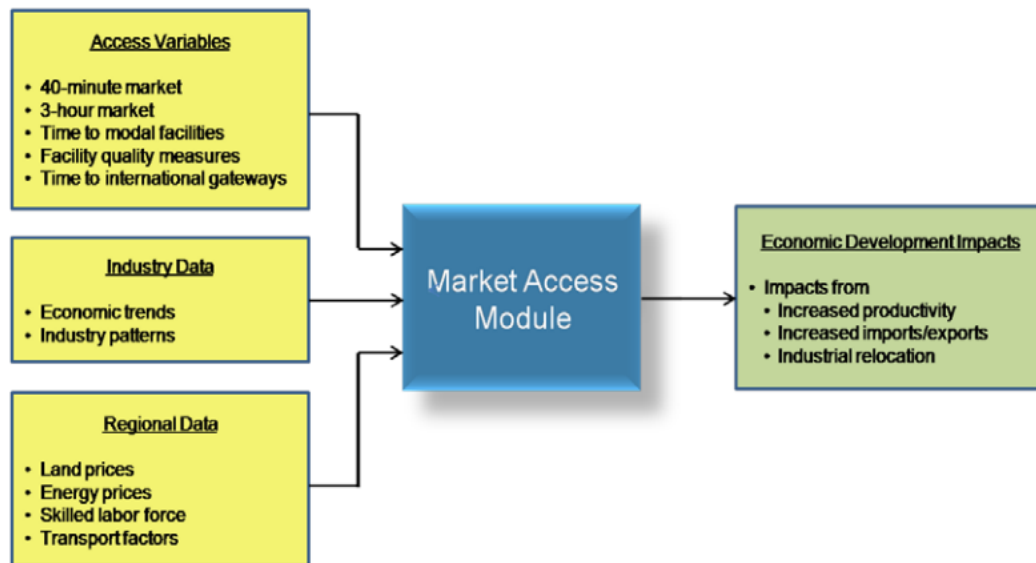


Figure 3.5 TREDIS Market Access Module Input and Output Factors (Source: EDRG, 2010)

The market access benefits calculated in TREDIS include the factors that have influence on enlarging the range of particular resources or demand that can improve business productivity. It is important to note that in order to avoid double-counting, the standard economic benefits (such as savings from vehicle operating costs, travel time, and safety) have been taken into consideration in the development of TREDIS. For example, the traditional benefits from travel time savings derived from the improvements of transportation projects are covered in the Travel Cost Module. The Market Access Module is mainly concerned with the benefits associated with the increase of business sales due to faster trips (EDRG, 2014b).

The objectives of the Market Access Module in TREDIS are summarized as follows. First, it measures the improved business productivity in a region caused by greater accessibility. Second, it estimates the improved labor productivity induced by knowledge spillovers or labor skill matching because of better accessibility. Third, it assesses the improved ability of international exports due to the enhanced accessibility and intermodal connectivity (EDRG, 2010). Therefore, the Market Access Module has been designed to evaluate the full impacts of market accessibility with the consideration of both the market accessibility factors and connectivity factors.

The outputs of TREDIS Market Access Module are the results from three regression models, which are in accordance with the aforementioned three objectives. The first model reveals how access affects the business productivity of an industry i in single county c by considering the population in industry i and county c , a changeable work skill variable, variables denoting market accessibility factors, and six variables denoting connectivity factors. The second model links access measure with work skill to illustrate the overall impacts on labor productivity through the coverage on employment in industry i and county c , a changeable work skill variable besides the market accessibility factors as well as connectivity factors. The third model illustrates the influence of increased access on the business sales due to international exported commodity from examining the total business output (sales) in industry i and county c and factors for measuring connectivity (EDRG, 2014b). Please refer to page 11 of TREDIS Market Access Module documentation (EDRG, 2014b) for the specific regression equations.

Population that can be reached within a 40-minute drive and employment that can be covered within a 3-hour drive are two factors involved to measure market accessibility. The market access benefits for the labor market access are characterized by measuring the size of

local markets that can be reached on a one-way trip from the weighed centroid of population of a county within a 40-minute drive. 40 minutes driving time is commonly regarded as an average travel time for commute trips in the U.S. The market access benefits for domestic industry supply chains are calculated by measuring total employment that can be accessed within a 180-minute drive from the center of weighed population of a county in U.S. The 3-hour driving time represents the estimated travel time for trips and reflects the market access benefits in terms of domestic supply chains because it is an appropriate approximation for “same-day deliveries”, according to industry surveys (Alstadt et al., 2012). These thresholds are calculated by a gravity model that denotes both the zonal market size (population or employment centered) and zonal access time (functions as a decay factor). Moreover, it is noted in the TREDIS user manual that employment can denote the access of considered industries better than the population with respect to regional business activities (EDRG, 2014b and 2014c).

For a project only in a single county in the study region, the default value (population reached within a 40-minute drive and employment covered within a 3-hour drive) in TREDIS for the base case can be obtained through the application of ESRI’s Business Analyst Online (BAO) (EDRG, 2013) by specifying the weighted population centroid for the county in a study region. For a study region containing more than one county, the corresponding default values were estimated by the method “population – weighted averages.” Esri’s Business Analyst Online (BAO) automatically generates reports regarding the values for these two variables along with other data analysis files for ease of use.

The factors for calculating the connectivity including airport activity level (annual operations), average drive time to domestic airport, average drive time to rail intermodal facility, average drive time to seaport facility, average drive time to international airport, and average drive time to international land border. Airport activity level and the average drive time to domestic airport together express the inter-region connectivity. Average drive time to rail intermodal facility is a substitution of prospective business productivity from rail shipments, and average drive time to seaport facility is a proxy of potential exported goods from marine freight. The list of rail facilities in the U.S. was obtained from the publication of Oak Ridge National Laboratory’s Center for Transportation Analysis (http://cta.ornl.gov/transnet/Intermodal_Network.html), and the list of airports was obtained from the Federal Aviation Administration (FAA) website (http://www.faa.gov/airports/airport_safety/airportdata_5010/). The average drive time to international airport captures the access to international supply chain. The 25 most active airports with a high ratio of international import activity to export activity based on the statistics

from WISER Trade (<http://www.wisertrade.org/home/portal/index.jsp>) are imported in TREDIS. The average drive time to an international land border represents the travel time to the 25 most active U.S. land border gateways from WISER Trade weighted by annual exported commodity. The default value of the aforementioned variables regarding connectivity was obtained by calculating the drive time from each county's weighed population weighted – centroid to the closest facility (EDRG, 2013).

Economic Adjustment Module

The Economic Adjustment Module takes the output from the Traffic Cost and Market Access Modules and incorporates data from project construction costs and operation and maintenance costs to predict the total impact of projects on the local region's economy. IMPLAN – CRIO, a dynamic input-output model estimates how many units of input one industry needs from all industries to generate a unit of output in the certain range of area, is employed in TREDIS. In conjunction with IMPLAN-CRIO, TREDIS converts the various cost savings and business productivity to economic development impact indicators (e.g., employment, income, etc.) by using robust economic multipliers with a cost – response elasticity from IMPLAN-CRIO. Figure 3.6 shows the input and output factors of the Economic Adjustment module in TREDIS.

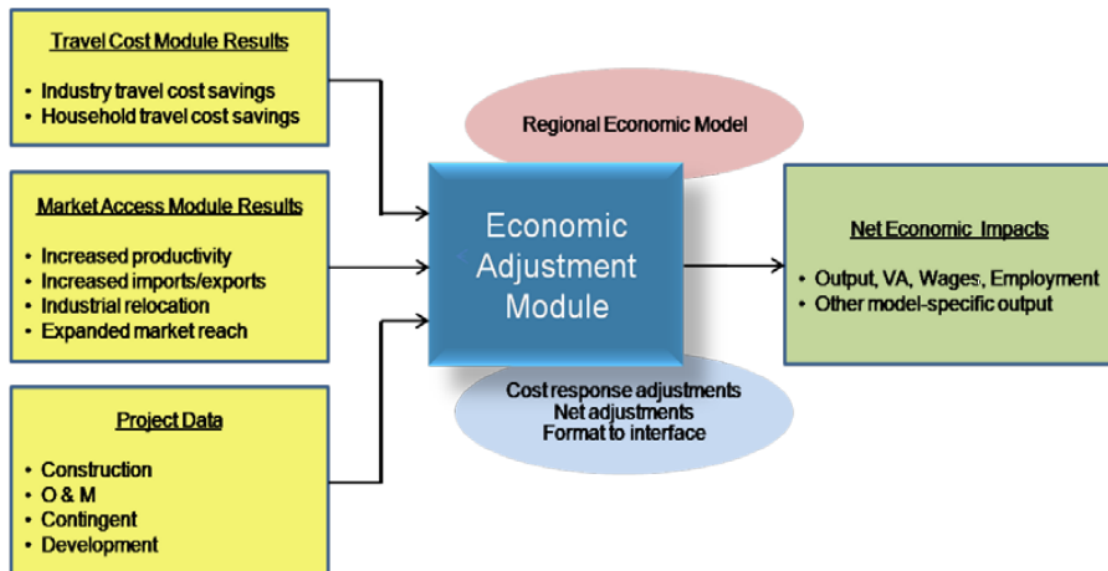


Figure 3.6 TREDIS Economic Adjustment Module Input and Output Factors (Source: EDRG, 2010)

Benefit-Cost Module

The Benefit-Cost Module collects the outputs from the Traffic Cost Module, Market Access Module, and Economic Adjustment Module in order to itemize and discount the economic efficiency of the projects, which includes calculating the benefit-cost ratio and net present value. The benefit-cost module cautiously avoids double counting the effects from economic impacts. For instance, travel time savings from personal trips or the improvement of air quality can be assigned with a dollar value, but these monetary values cannot necessary improve the local economy. Figure 3.7 shows the input and output factors of the TREDIS Benefit-Cost Module.

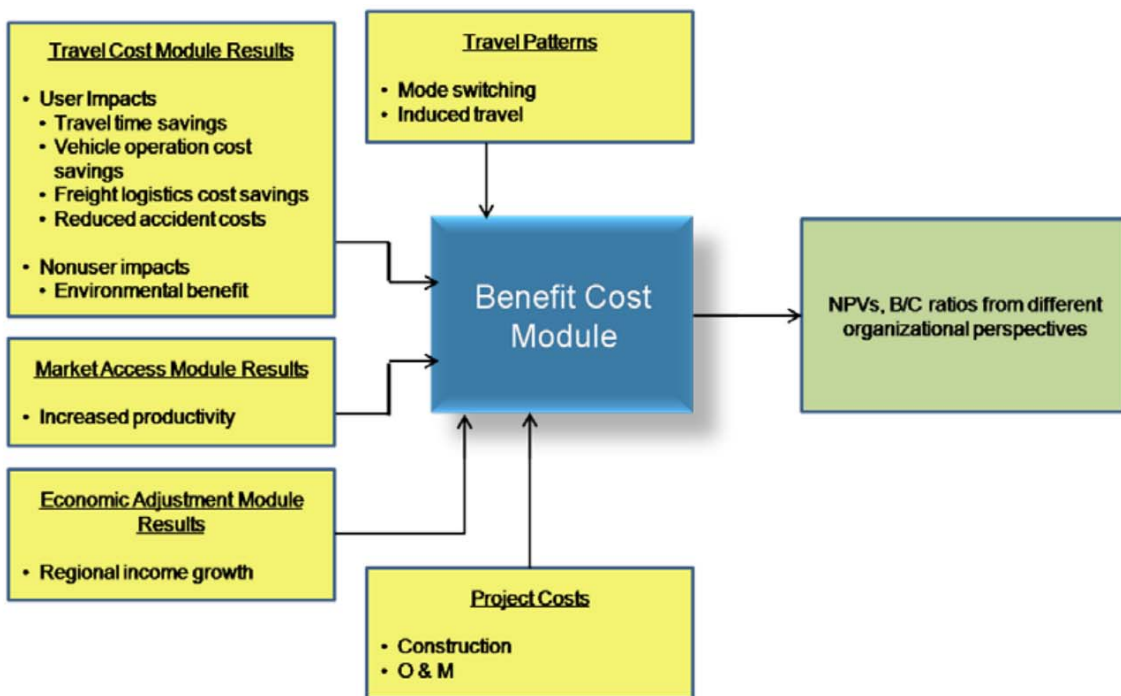


Figure 3.7 TREDIS Benefit - Cost Module Input and Output Factors (Source: EDRG, 2010)

The Finance Module displays the additional tax receipts related to the impacts of the project, while the freight module expresses how commodity flows are influenced. Finally, the Forecast Module works in conjunction with the economic adjustment, finance, and freight modules to predict the reference line of economic condition, tax receipts and freight flows.

3.2 COMPARISON OF TREDIS WITH THE ECONWORKS W.E.B. TOOLS

3.2.1 Overall Comparison

Although TREDIS and EconWorks W.E.B. are both tools for evaluating the economic value of transportation projects, they play distinct roles in investigating the bidirectional relationship between transportation investments and the local economy. In general, TREDIS is a more elaborate tool that dynamically covers broader aspects of assessing the economic value of transportation projects.

The EconWorks W.E.B. tools were designed to meet the needs of evaluating the wider benefits of transportation investments at the programming and prioritization stages. TREDIS was developed to satisfy the demand for measuring economic impacts of transportation projects at the project development or Environment Impact Study (EIS) stages.

In addition to the differences in purpose and timing, functionality is another area of difference. Four basic (Traffic Cost, Market Access, Benefit-Cost, and Economic Adjustment modules) and three optional modules (Finance, Freight, and Forecasting) within TREDIS provide possibilities for transportation planners to explore the economic value of a project with different emphasis, as well as to perform different types of economic impact analysis according to the specific requirements and unique features of projects. With respect to the exploration of the economic value of transportation projects, the Benefit-Cost Module of TREDIS can be used for any categories of transportation projects that require implementing benefit-cost analysis to justify an investment. The Economic Impact Adjustment Module is well suited to predict the economic development impacts of a transportation project, both in the short run and long run. In contrast to TREDIS, the EconWorks W.E.B. tools assess the wider economic benefit of transportation investments with a clear separation of reliability, market access, and connectivity analysis. Regarding the applicable types of analysis, TREDIS excels in single project evaluation, project prioritization, long-term vision plan, alternative selection, policy evaluation, infrastructure assessment, asset management and freight planning. The EconWorks W.E.B. tools do not have a specific characterization of the range of types of analysis, but the output from wider economic benefit evaluation might be useful for ranking a group of planned transportation projects in a multi-criteria analysis. Moreover, TREDIS requires more detailed engineering data and traffic data than the EconWorks W.E.B. tools to complete the evaluation of a single project.

Furthermore, TREDIS works with IMPLAN-CRIO to complete the conversion of direct, indirect, induced economic benefits and wider economic benefits into performance measures of

economic development impact. The EconWorks W.E.B. tools only capture the direct benefits in order to estimate the wider economic benefits.

Lastly, TREDIS is a web-based dynamic economic decision support system. The default values inside TREDIS were obtained through numerous data sources and methods. The licensing cost of TREDIS reflects these advanced features. By contrast, the EconWorks W.E.B. tools are free spreadsheets that can be downloaded from <http://www.tpics.us/tools/>. Table 3.1 summarizes the aforementioned discussion.

Table 3.1 Overall Comparison of TREDIS with the EconWorks W.E.B. Tools

Features	TREDIS	EconWorks W.E.B. Tools
Programing / Prioritization Stage		X
Project Development / EIS Stage	X	
Economic Development Impact	X	
Fiscal and Public – Private Financial Impacts	X	
Direct Economic Benefit	X	X
Indirect / Induced Economic Benefit	X	
Wider Economic Benefit	X	X
Benefit – Cost Analysis	X	
Single Project Evaluation	X	
Project Prioritization	X	
Long-term Vision Plan	X	
Alternative Selection	X	
Policy Evaluation	X	
Infrastructure Assessment	X	
Asset Management	X	
Freight Planning	X	
Free		X

3.2.2 Comparison in Terms of Reliability Analysis

In terms of measuring the improvements of travel time reliability, TREDIS does not provide a specific dedicated module for reliability analysis. Instead, it incorporates these benefits in the travel cost calculations. Following the approach to define Reliability, the comparison between EconWorks W.E.B. reliability tool and TREDIS reliability analysis lies on two dimensions: metrics of reliability and value of travel time reliability.

3.2.3 Comparison in Terms of Metrics of Travel Time Reliability

The EconWorks Reliability tool generates a group of metrics based on empirical travel time distribution functions using the travel time index as the main parameter. A conservative measure of the buffer time is derived from the 80th and 50th percentiles of TTI. On the other hand, TREDIS uses direct estimates of the buffer time as a primary indicator of travel time reliability. The user can provide an estimate of the buffer times, but the software provides an empirical relationship between the Buffer Time Index (BTI) and the fraction of travel under congested conditions. The latter is expressed as a percentage of the VMT with volume to capacity ratio greater than or equal to 0.90. This relationship was explained in the subsection 3.1.2 and it should be noted that it only applies to cars and trucks.

Theoretically, the metrics derived from the EconWorks Reliability (travel time index) can be used to derive a buffer time index in TREDIS. Although numerical differences might be found between the percentiles and average values and therefore the results, the underlying concept remains the same. Nevertheless, the analyst should pay attention to the period of analysis where the EconWorks W.E.B. tools allow the selection of different hours during the day including A.M., P.M, or both peak hours. Additionally, the delay costs in the EconWorks Reliability tool are derived considering only weekdays, which in a year is equivalent to 260 days. Finally, it should be noted that TTI and BTI are intrinsically related and can be used jointly for reliability assessments. Figure 3.8 shows an example of the relationship between the two metrics.

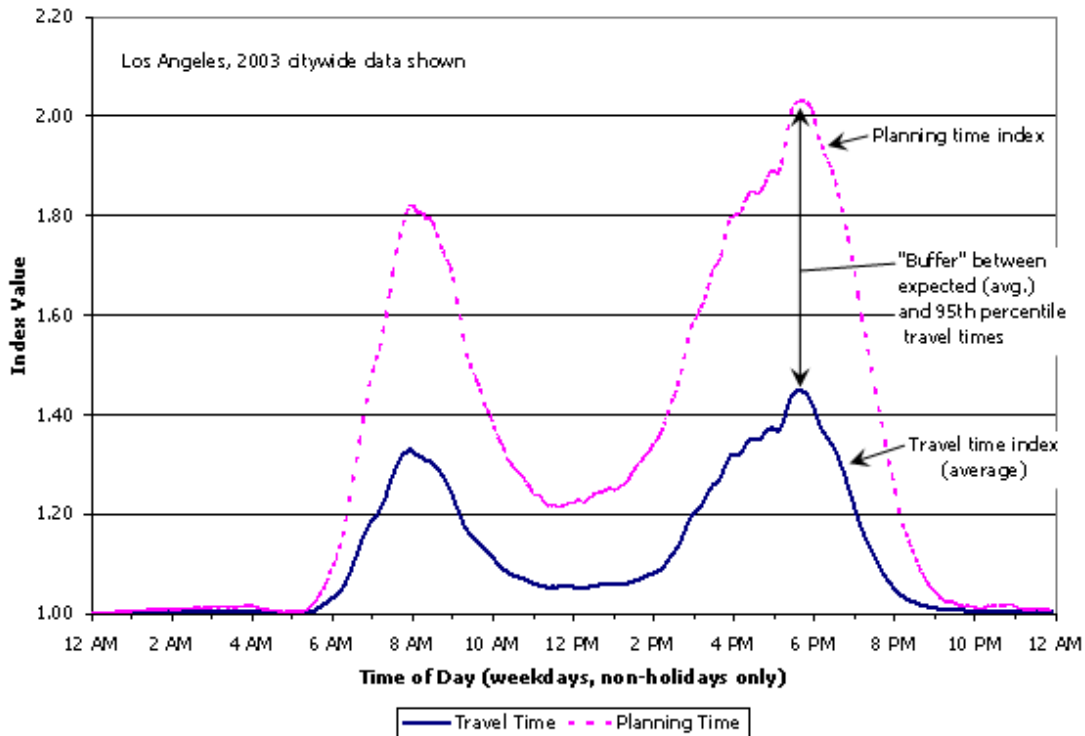


Figure 3.8 Reliability measures compared to average congestion measures
(Source: FHWA, 2013b)

3.2.4 Comparison of the Value of Travel Time Reliability

In terms of the value of each unit of travel time, the EconWorks Reliability tool uses the concept of reliability ratio to estimate the cost of reliability. If the reliability ratio is one, it means that one unit in travel time reliability is valued equally to one unit of travel time saved. TREDIS, on the other hand, provides default values that can be overridden. TREDIS suggests default buffer time values equivalent to the same unit of travel time for passenger vehicles and a range from \$0.79 to \$5.25 per hour for commercial vehicles. Finally, TREDIS also provides a tool where the calculations of reliability benefits can be overridden with the calculations from other sources such as the EconWorks W.E.B. tools. Table 3.3 summarizes the main differences between TREDIS and EconWorks W.E.B. for the evaluation of the reliability.

Table 3.2 Comparison of TREDIS with the SHRP2 EconWorks Reliability Tool

Criteria	TREDIS	EconWorks W.E.B. Tools
<i>Theoretical Background</i>	The value of reliability is calculated using the buffer time and its corresponding value assigned by the user. This calculation is included in the travel cost module.	The reliability is measured using functions based on the travel time index (TTI). The outputs of the tool include percentiles of TTI percent of trips, percent of trips under 30 and 45 mph, recurring delay, incident delay, and total delay.
	The buffer time can be directly provided by the user or it can be estimated using an empirical relationship between congestion and the buffer time index (only for cars and trucks).	The percentiles of TTI are estimated using the SHRP2 L03 “Data Poor” equations. The reliability space is measured as the difference between the 80 th and 50 th percentiles.
	The metrics of reliability do not consider the type of facility being analyzed.	The derivation of the metrics distinguishes between freeways, signalized highways, and rural roadways to calculate the capacity of the facility.
<i>Data Inputs</i>	The default values and empirical relationships facilitate the analysis.	The required data can be easily obtained or estimated. The tool does not require/offer calibration to local conditions.

3.2.5 Comparison in Terms of Market Access and Connectivity Analyses

The comparison of the TREDIS Market Access Module with the EconWorks W.E.B. tools is conducted herein on the basis of the tools’ methodological approaches as well as data inputs.

Regarding the tools’ methodological approaches, the following differences were identified:

- TREDIS includes the evaluation of buyer-supplier market access, labor market access, and intermodal connectivity benefits in a single module (Market Access Module), while in the case of the EconWorks W.E.B. tools, two separate modules (Accessibility and Connectivity) were developed for the evaluation of the aforementioned benefits. In addition, within the Accessibility Module, two different tools for market access are offered: (i) buyer – supplier market access tool and (ii) labor market access tool. The independent tools offered by SHRP2 allow the user to focus on the analysis of a single economic impact category. On the other hand, this individual estimation of wider economic impacts may result in double counting of economic benefits. This double counting of economic benefits could occur because the measure of one type of access

- (such as effective density in the EconWorks Buyer – Supplier Market Access Tool) could partly take into account the benefits related to another type of access (such as labor market access) as well. This overlap of benefits becomes problematic when both the EconWorks W.E.B. of the Accessibility module are used and their results are added. On the other hand, TREDIS developed a system of equations to describe employment concentration, labor productivity, and exports using data from 3,141 U.S. counties. This system of equations incorporates the different types of wider economic impacts as explanatory variables. Such an econometric approach does not allow double counting future benefits, as the parameter estimation for the market access and connectivity variables occurs simultaneously.
- The *measures of market access* used by TREDIS and the EconWorks W.E.B. tools are fundamentally different. TREDIS uses the change in employment reached within 3 hours of driving time as a proxy for measuring buyer- supplier market access variation due to a transportation improvement. On the other hand, the EconWorks Buyer-Supplier Market Access tool employs the notion of effective density to capture this variation in market access. Moreover, TREDIS uses the change in population reached within 40 minutes of driving time to represent labor market access variation, while the EconWorks Specialized Labor Market Access tool estimates the change in the concentration index (change in concentration of the labor pool of a specific industrial sector within a zone relative to the share of that same industrial sector across zones) given a threshold impedance.
 - The *measures of connectivity* used by TREDIS and EconWorks W.E.B. tools are fundamentally different. The EconWorks W.E.B. tools, in a similar approach to the accessibility tools, develop the idea of an indicator called “weighted connectivity” (equivalent to “effective density”). This indicator is made up of two parts, the connectivity index and the savings associated with the base and build scenario. The first factor incorporates information pertaining to the terminal being connected such as activity on the terminal, value of goods, and number of connections. Meanwhile, the second measures the value of travel time saved for users linked to the terminal. In TREDIS, the metrics used are travel times from the centroid of the county (based on population) to the intermodal ports. Ports and terminals include domestic and major airports, railroad facilities, major marine ports and major international borders with Canada and Mexico (not included in the EconWorks tool). Each port-connectivity is a

separate variable as part of the system of equations of market accessibility to estimate economic outcomes used in TREDIS

- In the EconWorks W.E.B. tools, the change in market access and connectivity is translated into monetary terms with the use of productivity elasticities, which are retrieved from relevant literature. SHRP2 (2014) suggested a range of values for each elasticity, while the selection of the appropriate value is left to the user. As previously mentioned, TREDIS estimated the effect of market access and connectivity on economic output using simultaneous equations. The estimated model parameters (equivalent to productivity elasticities) were developed by TREDIS for the given set of explanatory variables, which makes the analysis more reliable compared to adopting a range of productivity elasticities from past studies. Moreover, the model parameters are included in the software, which makes the analysis more practical for the user. On the other hand, the benefits estimated as part of the Market Access Module in TREDIS depend on the results of a single model, while SHRP2 (2014) incorporated a significant amount of past research into the EconWorks W.E.B. tools.
- The EconWorks Accessibility tools allow the user to investigate the impact of a transportation improvement on a single industry sector. The simultaneous equations developed by TREDIS were established for 54 industry groups. Although the software does not allow the user to estimate the benefits in a specific industry sector, it can provide results for each sector and all sectors together.

Regarding the *data inputs* required for running TREDIS and the EconWorks W.E.B. tools, it can be concluded that the Market Access Module in TREDIS is less data intensive compared to the EconWorks W.E.B. tools. As described in the previous section, the change in market access in TREDIS is captured by (i) the change in population reached within 40 minutes of driving time and (ii) the change in employment reached within 3 hours of driving time. The EconWorks Accessibility tools require the user to provide employment data, O-D impedance, O-D trips, GRP, decay parameter, productivity elasticity, and threshold impedance. The EconWorks Connectivity tool includes default values for the most important ports in the U.S.; this information is combined with the value of travel time saving that can be derived from the travel demand models or provided by the user. Additionally, the percentage of vehicles associated with the facility for trucks or buses is provided or derived using a decay function factor applied to the distance between the facility and the project. The tool must be run twice, one with the project and once without the project. For TREDIS, the market access module provides the default values

of travel time to surrounding ports from the population centroid of the county. The user has to evaluate how these values of travel time change in the built scenario, and the software calculates the economic benefits associated with that change. Table 3.3 summarizes the aforementioned discussion.

Table 3.3 Comparison of TREDIS Market Access Module with the EconWorks W.E.B.Tools

Criteria	TREDIS	EconWorks W.E.B. Tools
<i>Theoretical Background</i>	Buyer-supplier market access, labor market access, and intermodal connectivity benefits incorporated into a single module (Market Access Module).	Three separate tools for evaluating buyer-supplier market access, labor market access, intermodal connectivity benefits respectively.
	No double counting of economic benefits.	Possible double counting of economic benefits.
	Measure of buyer-supplier market access variation: change in employment reached within 3 hours of driving time.	Measure of buyer-supplier market access variation: change in effective density.
	Measure of labor market access variation: change in population reached within 40 minutes of driving time.	Measure of labor market access variation: change in concentration index for a given threshold impedance.
	Connectivity values (driving time) are measured from the centroid of the county to the location of the terminal/port.	Connectivity values are measured taking into account the geographical location of the project.
	Connectivity to different types of ports is measured concurrently.	Only one mode at a time. However, the tool could be run multiple times.
	Uses average driving times to each port/terminal and the activity level (annual operations) for air travel.	Uses a weighted index value for each port/terminal. The level of activity in each port or terminal is pre-loaded in the tool.
	The monetary benefits are calculated for each type of port/terminal.	All connectivity-related benefits (from different type of ports) are translated to monetary benefits using the same factor (elasticity).
	Elasticity values derived from a simultaneous equations model developed by TREDIS.	Range of elasticity values proposed based on past literature.
	Analysis for a specific industry sector is not possible.	Analysis for a specific industry sector is possible.
<i>Data Inputs</i>	Less data intensive.	High data requirements including O-D impedance and trip matrices, and GRP.

CHAPTER 4 CASE STUDIES

4.1 SELECTION PROCESS

The selection of the case studies took into account the parameters recommended in NCHRP (2014). Concurrently, INDOT provided an initial list of highway corridor projects that were selected and sorted according to their compatibility with the EconWorks W.E.B. tools. This selection process was undertaken in two stages the first stage included a focus group with SAC committee members where candidate projects were presented and discussed. The second stage included follow-up coordination with INDOT personnel to narrow down the list of candidate projects. Besides the NCHRP (2014) parameters, some additional considerations were also taken into account such as data availability, geographical location, and whether the project was being considered as a case study for the application of the SHRP2 C03 tool as well.

4.2 CASE STUDY 1: U.S. 36, INDIANA

4.2.1 Project Description

U.S. 36 goes through the state of Indiana and connects the borders with the state of Illinois and Ohio. The study area corresponds to a roadway segment of 1.6 miles located to the west of Indianapolis, between Transfer Dr. and Interstate I-465. Most of the traffic consists of passenger cars between Hendricks County and Marion County with an AADT of more than 40,000 vehicles per day. U. S. 36 consists of two lanes traveling in each direction where the peak hour period is between 5 p.m. and 7 p.m. (Indiana TCDS, 2014) with volume to capacity ratios (v/c) as high as 0.98 and TTI is as high as 2.05. The density of traffic lights is 1.8 intersections per mile and the segment presents high levels of congestion and associated unreliable travel times. In that sense, INDOT is considering adding travel lanes to relieve the high congestion levels on this segment.

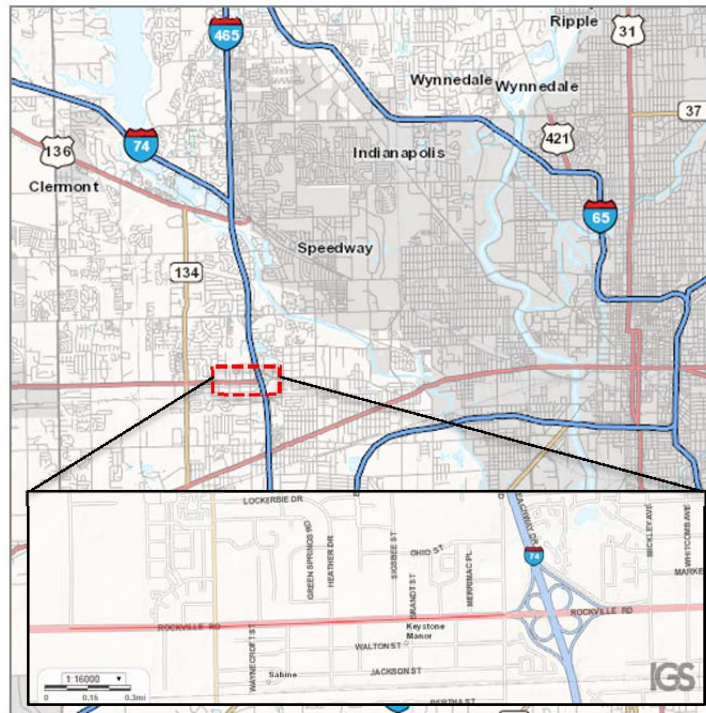


Figure 4.1. U.S.-36 from Transfer Dr. to I-465 (Source: IndianaMap.org)

4.2.2 Application of the EconWorks Reliability tool

The project is expected to reduce the levels of congestion and therefore, improve travel time reliability. The EconWorks Reliability tool was applied in order to measure the wider economic benefits associated with this improvement on businesses that use this highway segment. In order to do so, traffic data such as annual average daily traffic (AADT) and traffic growth factors (no-build scenario) were retrieved from the Indiana Travel Demand Model (ISTDM). The peak capacity was calculated according to the Highway Capacity Manual for signalized highways and the free flow speed was determined using the current posted speed of 45 mph. The default values of travel time unit costs for personal trips, commercial trips, and their corresponding reliability ratios (i.e., \$18.63 and \$25.75, 0.8 and 1.16) were used. For the build scenario, the same traffic demand and conditions were used and the expected reduction in incident frequency and duration was assumed to be zero; for the latter, a sensitivity analysis was also performed. It should be noted that the EconWorks Reliability tool report unique values for four scenarios: no-build (base) scenario and build scenario at the initial year of analysis (i.e., 2013) and at the end of the time horizon (i.e., 2033). Each scenario can be further extended to hourly reports for the time period chosen. Finally, the tool also offers a summary of all the intermediate calculations performed.

The EconWorks Reliability tool outputs (Table 4.1) for the no-build scenario (2013) show TTI percentiles that range from 1.17 to 1.70. The recurring and non-recurring delay costs reached \$0.93M and \$0.2M, respectively during the 6:00 a.m. – 7:00 p.m. period. For the build scenario in 2013, where the maximum v/c ratio is reduced to 0.76, the TTI percentiles ranged from 1.00 to 1.07 and the recurring and non-recurring delay costs were reduced to \$62K and \$2K, respectively. As discussed previously, these results were calculated using the default values for the reliability ratio (i.e., 0.8 and 1.16) and an incident reduction of 0%. The reduction in the percentage of trips with speeds lower than 30 mph reached a 90% reduction, and the incident delay (i.e., unreliability) was reduced almost by 100%. However, the incident costs, including those incurred by commercial and passenger cars, amounted to 19% of the total delay cost savings. Additionally, to measure the productivity benefits accruing to firms or businesses, only commercial and business trips (as a percentage of the passenger delay savings) were considered. The percentage of business trips was assumed to be 2%.

Table 4.1 Summary of Results-EconWorks Reliability Tool

Metric	US36 - Base scenario	US36 - Build Scenario
Overall mean TTI	1.24	1.02
TTI95	1.70	1.07
TTI80	1.35	1.02
TTI50	1.17	1.00
Percentage of trips less than 45 mph	24.79%	2.89%
Percentage of trips less than 30 mph	6.49%	0.65%
<i>Total Annual Weekday Delay (veh-hrs)</i>		
Total Equivalent Delay	59767	3408
Recurring Equivalent Delay	53282	3367
Passenger Delay	51023	3201
Commercial Delay	2259	165
Incident Equivalent Delay	6485	41
Passenger Delay	6113	38
Commercial Delay	372	3
<i>Total Annual Weekday Congestion Costs (\$)</i>		
Total Equivalent Delay	\$1,132,190	\$64,683
Recurring Equivalent Delay	\$931,093	\$62,179
Passenger Delay	\$878,941	\$58,084
Commercial Delay	\$52,152	\$4,095
Incident Equivalent Delay	\$201,097	\$2,504
Passenger Delay	\$185,499	\$2,276
Commercial Delay	\$15,599	\$228

Since the reliability costs increase with the level of congestion on a highway facility, an analysis of the change in delay costs with a variation in the v/c ratio was performed. Figure 4.2 depicts the relationships between v/c ratios and incident and recurring delays. It can be seen that, for v/c ratios over 0.85, the recurring delay costs increase rapidly with the v/c ratio. The same trend is seen in the non-recurring delay costs, in which the unreliability costs could be up to 1/3 of the recurring congestion costs. A similar analysis for the projected bypass in the State Road SR-03 around the city of Rushville, IN (see Section 4.3 for the description of the project) showed that for v/c ratios smaller than 0.80, the non-recurring delay costs tend to be zero (see Appendix C).

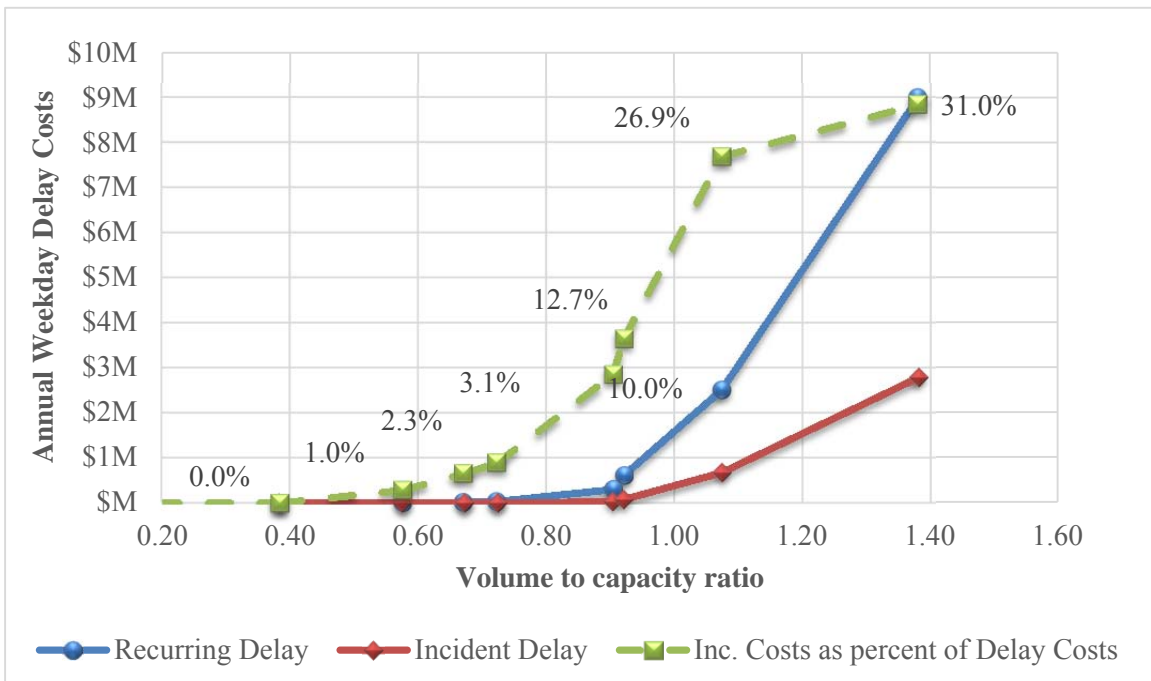


Figure 4.2 Sensitivity analysis with respect to the volume to capacity (v/c) ratio

The sensitivity related to the incident frequency was evaluated by keeping default input values for the build scenario (i.e., three lanes in each direction). Different increments in incident reduction were assumed and the results are depicted in Figure 4.3. The delay costs of both recurring and non-recurring delay decrease with an increase in the incident reduction parameter. The recurring delay costs decrease in linear proportion to the reduction in incident frequency (Figure 4.3a), while the incident delay shows a higher rate of reduction (i.e., for a reduction in incident frequency of 50%, the recurring delay is reduced by 55%; meanwhile, for a similar reduction in incident frequency, the incident delay is reduced by 65%). Similarly, if a reduction in

the duration of incidents reaches 50%, the cost of recurring delay (in the build scenario) is reduced by 76% and the incident delay is reduced by 88%. Although these reductions are significant, the change in incident frequency or incident duration had a minimal to moderate effect (3-10% change) on the total delay cost savings when compared to the no-build scenario in the initial and future year of analysis (2033). The latter occurs because most of the delay cost savings are due to changes in capacity. Additionally, given the v/c ratio of 0.76 in 2013 (build scenario), the incident delay costs with regards to the recurring delays decreased from around 4% to 3% for a 50% reduction in incident frequency, and to 3.4% for a 50% reduction in incident duration (Figure 4.3b).

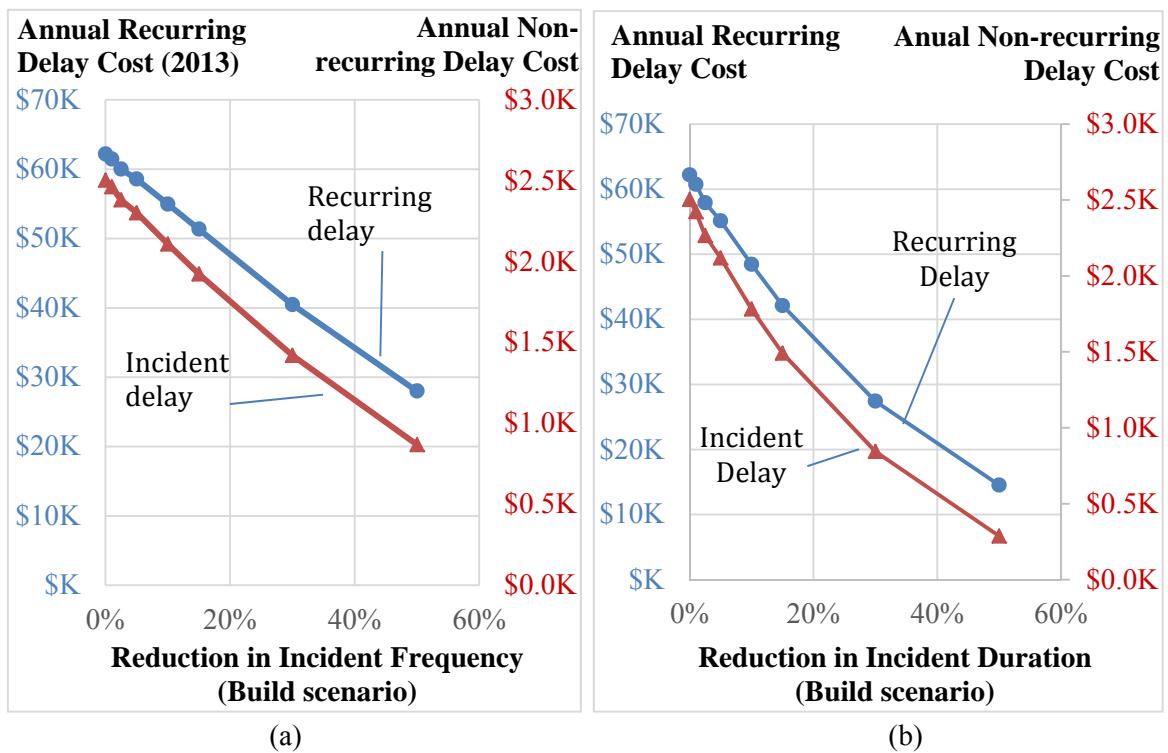


Figure 4.3 EconWorks Estimated Reliability Costs as a Function of the Reduction in Incident Frequency (a) and Reduction in Incident Duration (b) - Build scenario (2013)

4.2.3 Reliability Analysis in TREDIS and Comparison of Results

The reliability evaluation in TREDIS involves calculating the buffer time and reliability costs. Buffer time per vehicle trip combination in TREDIS is calculated as the product of buffer time index (based on the friction of congestion) and the ratio of vehicle hours traveled and vehicle trips for each vehicle trip combination (EDRG, 2014b). The vehicle hours traveled and vehicle trips for build and no-build scenarios are all imported at the annual level. Therefore, TREDIS

calculates the buffer time based on the annualized vehicle hours traveled for each vehicle trip combination. The reliability cost estimation in TREDIS is then conducted through the product of vehicle trip combination, buffer time per vehicle trip combination, and unit cost of buffer time per vehicle trip combination (EDRG, TREDIS Software Group, 2014b). Note that the reliability cost evaluation in TREDIS could be changed in the “Direct Cost Override” in the advanced mode of the Travel Characteristic Module (see Figure 3.3).

The reliability productivity benefits are triggered by the reduction in unreliable travel times for commercial and business trips. For the U.S. 36 case study, the business trips represent 2% of the personal trips, as shown in Table 4.1. Therefore, the EconWorks Reliability tool estimated incident delay cost savings for businesses to be \$19,034.81 that represents the difference between the build and no build scenarios in 2013 that were shown in Table 4.1. Meanwhile in TREDIS, the net reliability cost savings for commercial and business trips were estimated to be \$134,899. This difference is associated with the values of buffer times considered in each tool. The EconWorks Reliability buffer times (derived using the TTI metrics) are higher than those obtained in TREDIS (derived from the empirical BTI-congestion relationship). Moreover, the EconWorks Reliability tool only considers weekdays and a period of analysis between 6 a.m. and 7 p.m., while TREDIS quantifies the reliability benefits using annual vehicle trips (i.e., buffer time per trip is multiplied by the annual trips and the buffer time cost). This difference is associated with the values of buffer times considered in each tool. The EconWorks W.E.B. buffer times (derived using the TTI metrics) are higher than those obtained in TREDIS (derived from the empirical BTI-congestion relationship). Moreover, the EconWorks W.E.B. tool only considers weekdays and a period of analysis between 6 a.m. and 7 p.m., while TREDIS quantifies the reliability benefits using annual vehicle trips (i.e., buffer time per trip is multiplied by the annual trips and the buffer time cost).

4.3 CASE STUDY 2: SR 3, INDIANA

4.3.1 Project Description

The proposed project on SR-3 includes adding at least one lane per direction to the segment of SR-3 from I-70 to I-74, and constructing bypasses at Rushville and Spiceland. The purpose of the project is to enhance total as well as freight mobility and decrease travel time in the region. The capacity improvement in this project is 36 miles long and goes through three Indiana counties (Decatur, Rush, and Henry), as can be seen in Figure 4.4.

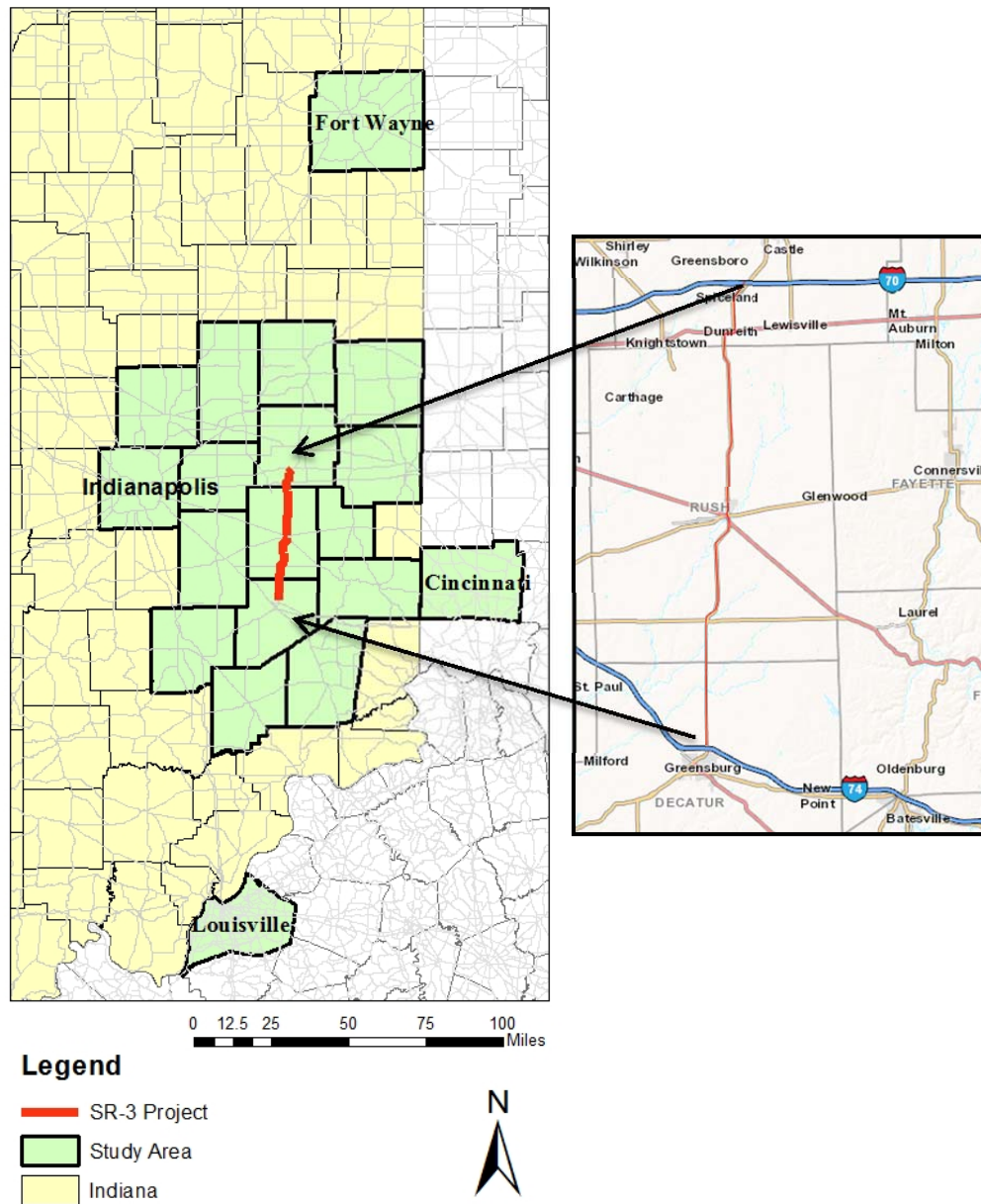


Figure 4.4 SR-3 from I-70 to I-74 - Impact Area for the EconWorks Buyer-Supplier Market Access Tool (Source: Indiana Maps <http://maps.indiana.edu/>, Ohio DOT <http://gis.dot.state.oh.us/tims/>, and Kentucky Geoportals <http://kygisserver.ky.gov/geoportal/catalog/main/home.page>)

The Blue Ribbon Panel (2014) investigated the economic impacts of this project and estimated that the project will create 460 new jobs and add \$44.6 million to the regional economy. Moreover, the travel time savings and vehicle operating cost savings were found to be \$7.2 million and \$0.3 million, respectively. Lastly, some negative impacts were identified in

terms of crashes and emissions. The Blue Ribbon Panel (2014) also indicated that the segment of SR-3 in question does not have congestion problems; AADT ranges from 4,700 to 6,700 vehicles per day in rural areas, while the most congested area is close to the intersection with I-74, where AADT reaches 9,400 vehicles per day. Therefore, although it was concluded that the project would improve the accessibility of manufacturing and distribution centers (such as the Greensburg Honda plant), no major improvements in travel time reliability were expected (see Appendix C). As such, the reliability tool was not used for evaluation of this project.

4.3.2 Application of the EconWorks Buyer-Supplier Market Access Tools for SR-3

The EconWorks Buyer-Supplier Market Access tool was used to estimate the possible productivity benefits of the SR-3 project. The analysis was conducted at the county level. The impact area, shown in Figure 4.4, is comprised of the three previously-mentioned counties, but also their neighbor counties (Bartholomew, Delaware, Fayette, Franklin, Hamilton, Hancock, Jennings, Madison, Randolph, Ripley, Shelby, and Wayne), as well as the major metropolitan centers that can be served by same day truck deliveries (Indianapolis, Fort Wayne, Cincinnati, and Louisville).

As the focus was to estimate productivity benefits from the buyer-supplier market access expansion, employment was used to represent the region's activity. Data on total employment for 2013 was retrieved from the BEA Regional Accounts for each county. Based on a discussion with the tool's developers, it was suggested to use the same employment data for the base and reference year. Regarding the O-D impedance for the base and the reference year, data from ISTDM was used. Specifically, for the base year, ISTDM was run using the base-case 2010 scenario, and the free-flow travel time from TAZ to TAZ for the state of Indiana was estimated. The matrix aggregation tool was then used to aggregate TAZs into county-level zones. The Federal Information Processing Standards (FIPS) was used as an identification code for each county (Table 4.2). The resulting free-flow travel time for the 2010 scenario is presented in Table 4.3. It should be noted here that if the impact area faces significant traffic congestion, the free-flow travel time may not be appropriate, and adjustments for congestion should be made. For the reference year, ISTDM was run using the 2035 scenario for traffic and a modified highway network, which was provided by INDOT and included the modifications for the new SR-3 project (bypasses and speed limit change). The free-flow travel time for the 2035 scenario including the new SR-3 project is shown in Table 4.4. It can be seen that, going from Decatur to Henry, the travel time was 64 minutes on average in 2010, while in 2035 with the new project, the travel

time reduced to 59 minutes, indicating 5-minute savings on average due to the network improvement.

Table 4.2 FIPS Codes for the Impact Area

County, State, (Metropolitan Center)	FIPS County Code
Allen, IN (Fort Wayne)	18003
Bartholomew, IN	18005
Decatur, IN	18031
Delaware, IN	18035
Fayette, IN	18041
Franklin, IN	18047
Hamilton, IN	18057
Hancock, IN	18059
Henry, IN	18065
Jennings, IN	18079
Madison, IN	18095
Marion, IN (Indianapolis)	18097
Randolph, IN	18135
Ripley, IN	18137
Rush, IN	18139
Shelby, IN	18145
Wayne, IN	18177
Jefferson, KY (Louisville)	21111
Hamilton, OH (Cincinnati)	39061

Table 4.3 O-D Free-Flow Travel Time Matrix, 2010 Scenario

	18003	18005	18031	18035	18041	18047	18057	18059	18065	18079	18095	18097	18135	18137	18139	18145	18177	21111	39061
18003	22	151	149	78	131	145	103	103	100	173	82	114	86	167	121	129	109	218	182
18005	151	20	40	96	76	71	72	64	82	37	84	55	115	59	61	41	96	83	105
18031	149	40	21	84	52	45	80	62	64	42	85	66	96	37	42	42	75	107	80
18035	78	96	84	18	67	83	51	49	35	111	32	60	37	102	58	74	49	164	125
18041	131	76	52	67	18	32	85	60	48	81	76	76	61	58	37	56	37	144	72
18047	145	71	45	84	32	24	96	72	64	71	90	85	76	42	46	61	52	131	59
18057	103	72	80	51	85	96	21	37	52	96	35	32	75	99	63	55	75	138	140
18059	103	64	62	49	60	72	37	20	36	85	37	34	69	81	40	40	54	133	117
18065	100	82	64	35	48	64	52	36	21	91	41	52	47	81	37	57	36	152	108
18079	173	37	42	111	81	71	96	85	91	21	107	78	124	43	69	61	103	77	92
18095	82	84	85	32	76	90	35	37	41	107	22	47	56	104	58	63	62	151	135
18097	114	55	66	60	76	85	32	34	52	78	47	20	82	86	55	41	70	120	127
18135	86	115	96	37	61	76	75	69	47	124	56	82	22	103	70	92	38	184	111
18137	167	59	37	102	58	42	99	81	81	43	104	86	103	22	59	61	79	103	65
18139	121	60	42	58	37	46	63	40	37	69	58	55	71	59	23	38	50	131	90
18145	129	41	42	74	56	61	55	40	57	61	63	41	92	61	38	24	73	111	102
18177	109	96	74	49	37	52	75	54	36	103	63	70	38	79	50	72	20	165	87
21111	218	83	107	164	144	131	138	133	152	77	151	120	184	103	131	111	165	27	117
39061	182	105	80	125	72	58	140	117	108	92	135	127	111	65	90	102	87	117	38

Table 4.4 O-D Free-Flow Travel Time Matrix, 2035 Scenario with SR-3 Project

	18003	18005	18031	18035	18041	18047	18057	18059	18065	18079	18095	18097	18135	18137	18139	18145	18177	21111	39061
18003	22	151	145	78	131	145	103	103	100	171	82	113	86	163	120	129	109	217	182
18005	151	20	40	95	75	71	72	64	79	37	84	55	112	59	60	41	93	83	105
18031	145	40	21	80	52	45	80	61	59	42	82	66	92	37	39	41	71	104	80
18035	78	95	80	18	67	83	51	49	35	106	32	60	37	98	57	73	49	163	126
18041	131	75	52	67	18	32	85	61	48	80	77	76	62	58	37	56	37	141	72
18047	145	71	45	83	32	24	96	72	64	71	90	85	76	42	46	61	52	130	58
18057	103	72	80	51	85	96	21	37	52	95	35	32	75	99	63	55	74	137	140
18059	103	64	61	49	61	72	37	20	36	85	37	34	69	80	39	40	54	133	117
18065	100	79	59	35	48	64	52	36	21	86	41	52	47	77	36	56	36	147	108
18079	171	37	42	107	80	71	95	84	86	21	105	78	119	43	67	61	99	77	91
18095	82	84	82	32	76	90	35	37	40	105	22	47	56	101	58	63	62	150	135
18097	113	55	66	60	76	85	32	34	52	78	47	20	82	86	55	41	70	120	127
18135	86	112	92	37	61	76	75	69	47	119	56	82	22	102	69	90	38	181	111
18137	164	59	37	98	58	42	98	80	77	43	102	86	102	22	57	61	79	102	64
18139	120	59	39	57	37	46	63	39	36	67	58	55	69	57	23	38	49	128	90
18145	129	41	41	73	56	61	55	40	56	61	63	41	90	61	38	24	71	111	102
18177	109	93	71	49	37	52	74	54	36	98	62	70	38	79	49	71	20	160	88
21111	217	83	104	163	141	130	137	133	148	77	150	120	181	102	128	111	160	27	117
39061	182	105	80	126	72	58	139	117	108	91	135	127	111	64	90	102	87	117	38

The GRP proxy was estimated for each county based on Equation 2-2 using 2013 data from the BEA Regional Accounts. First, an adjustment factor (GDP divided by total earnings by place of work) was estimated for each state included in the impact area, as shown in Table 4.5. Then, this adjustment factor was multiplied with the total earnings by place of work for each county and divided by the employment to yield the GRP proxy in 2013 dollars (Table 4.6). Last, this GRP proxy was multiplied by the relevant regional price parities (RPPs) to take into account the price differences across states; as the study area includes counties from three different states, this step was imperative for enabling productivity estimations from different states to be compared and summed into one final result.

Table 4.5 Adjustment Factor Estimation for Each State of the Impact Area

State	GDP in 2013 (\$2013)	Total Earnings by Place of Work in 2013 (\$2013)	Adjustment Factor
Indiana	\$311,188,000,000	\$181,296,867,000	1.7165
Kentucky	\$183,582,000,000	\$111,989,882,000	1.6393
Ohio	\$562,845,000,000	\$347,955,973,000	1.6176

Table 4.6 GRP Estimation for Each County in the Impact Area

FIPS County Code	Total Earnings by Place of Work in 2013 (\$2013)	Employment in 2013	Adjustment Factor	GRP Proxy in 2013 (\$2013)	Regional Price Parities (2013)	GRP Proxy in 2013 (\$2013 RPPs)
18003	10,885,791,000	225,997	1.7165	\$82,678	0.98	\$81,024
18005	3,236,762,000	58,027	1.7165	\$95,744	0.98	\$93,830
18031	801,797,000	16,869	1.7165	\$81,584	0.98	\$79,953
18035	2,533,636,000	59,099	1.7165	\$73,586	0.98	\$72,115
18041	351,332,000	9,176	1.7165	\$65,720	0.98	\$64,406
18047	237,313,000	7,316	1.7165	\$55,678	0.98	\$54,564
18057	9,451,471,000	187,089	1.7165	\$86,713	0.98	\$84,979
18059	1,470,326,000	39,448	1.7165	\$63,977	0.98	\$62,697
18065	677,199,000	17,893	1.7165	\$64,963	0.98	\$63,664
18079	403,230,000	10,284	1.7165	\$67,301	0.98	\$65,955
18095	2,045,449,000	50,399	1.7165	\$69,663	0.98	\$68,269
18097	42,547,315,000	674,177	1.7165	\$108,326	0.98	\$106,159
18135	520,513,000	10,461	1.7165	\$85,406	0.98	\$83,698
18137	730,740,000	14,440	1.7165	\$86,862	0.98	\$85,125
18139	368,182,000	6,784	1.7165	\$93,156	0.98	\$91,293
18145	1,042,678,000	22,169	1.7165	\$80,730	0.98	\$79,116
18177	1,570,164,000	36,692	1.7165	\$73,452	0.98	\$71,983
21111	30,151,414,000	539,746	1.6393	\$91,573	0.96	\$87,911
39061	39,980,262,000	608,746	1.6176	\$106,237	0.955	\$101,456

Following the guidelines provided in SHRP2 (2014), a productivity elasticity value of 0.03 (suitable for projects seeking to improve existing capacity) was selected for the analysis herein. The decay parameter was assumed to be equal to 1 based on the results reported in Graham et al. (2009) for the manufacturing sector; although this analysis does not focus on a particular sector, manufacturing was found to be the sector with the highest employment in most counties of the impact area. Table 4.7 shows the results from the EconWorks Buyer-Supplier Market Access tool analysis for SR-3. The total productivity benefits from the SR-3 project were found to be around \$16 million. Note that the estimated productivity is greater than zero when the effective density for the reference year is higher than the effective density for the base year; this could occur if there are travel time savings when traveling from one county to all the other counties in the study area and vice versa. The productivity gains in each county depend on the county's earnings per employee and change in effective density, as well as the productivity elasticity assumed.

Table 4.7 EconWorks Buyer-Supplier Market Access Tool Results for SR-3 Project

County	FIPS County Code	Effective Density, Base Year (2010)	Effective Density, Reference Year (2035)	Productivity Benefit (2013\$ RPPs)
Allen, IN (Fort Wayne)	18003	27,359	27,478	\$2,384,361
Bartholomew, IN	18005	35,919	36,012	\$422,381
Decatur, IN	18031	33,404	33,712	\$371,417
Delaware, IN	18035	34,987	35,063	\$277,443
Fayette, IN	18041	31,572	31,597	\$14,034
Franklin, IN	18047	31,696	31,723	\$10,197
Hamilton, IN	18057	46,986	47,485	\$5,039,462
Hancock, IN	18059	44,865	44,901	\$59,514
Henry, IN	18065	36,228	36,450	\$208,794
Jennings, IN	18079	31,065	31,267	\$131,901
Madison, IN	18095	38,897	38,983	\$227,974
Marion, IN (Indianapolis)	18097	57,133	57,262	\$4,842,611
Randolph, IN	18135	28,185	28,268	\$77,242
Ripley, IN	18137	31,252	31,429	\$208,280
Rush, IN	18139	35,333	35,579	\$128,924
Shelby, IN	18145	39,609	39,679	\$92,910
Wayne, IN	18177	31,724	31,882	\$393,683
Jefferson, KY (Louisville)	21111	36,311	36,350	\$1,520,141
Hamilton, OH (Cincinnati)	39061	31,942	31,933	-\$524,859
Total		684,467	687,053	\$15,886,410

A sensitivity analysis was conducted to determine the magnitude of the effect of the decay parameter and productivity elasticity assumptions on the estimated productivity. First, the tool was run for different values of the decay parameter (while keeping the productivity elasticity constant at 0.03). The resulting productivity estimates, which are presented in Figure 4.5, gradually increased for decay values between 1 and 2.5, while dramatic increases occurred for decay values higher than 2.5. The tool “crashed” for decay parameters higher than 3. The tool’s results were also sensitive to the productivity elasticity value assumed, although the pattern is different. While keeping the decay parameter constant and equal to 1, the tool was run for different productivity elasticity values (Figure 4.6). Results indicate that the tool’s estimate of total productivity is linearly proportional to the assumed elasticity value; a productivity elasticity increase of 0.01 increased the output by \$5M, on average.

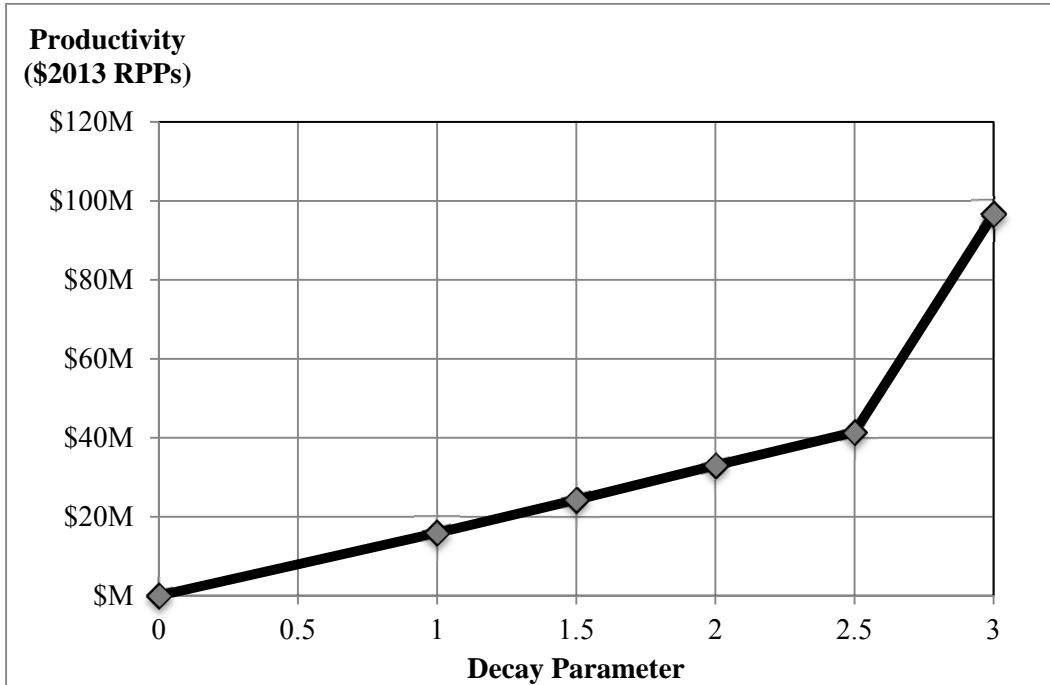


Figure 4.5 EconWorks Buyer-Supplier Market Access Tool, Sensitivity Analysis for the Decay Parameter

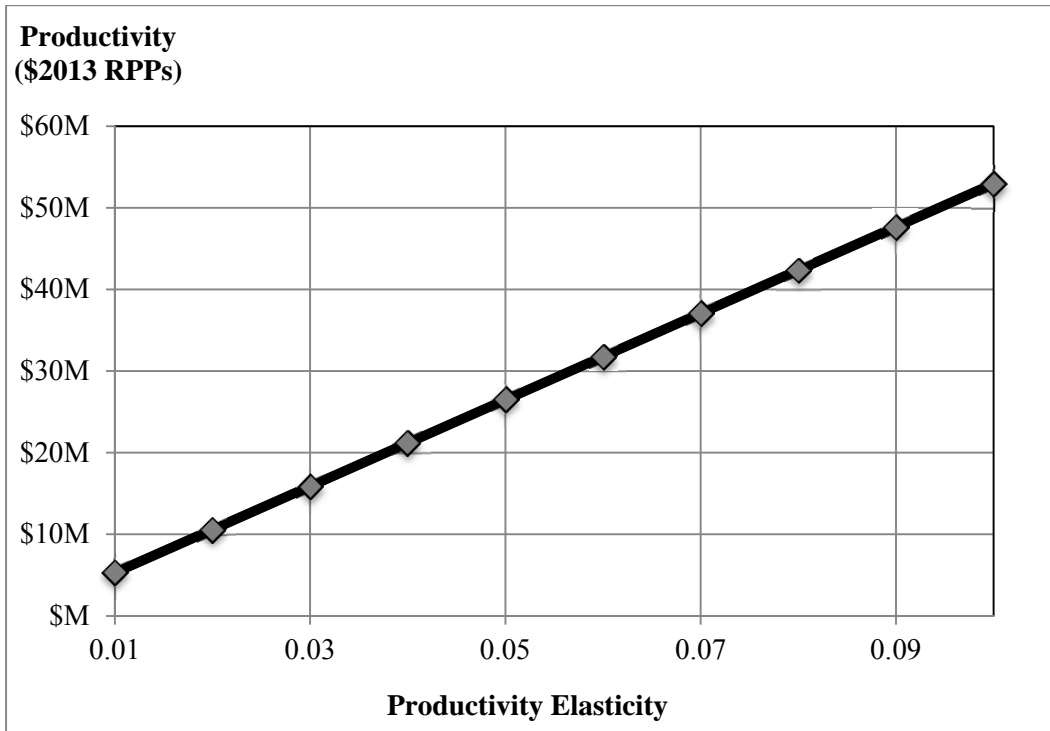


Figure 4.6 EconWorks Buyer-Supplier Market Access Tool, Sensitivity Analysis for the Productivity Elasticity Parameter

Last, the effect of the type of impedance used was investigated. The tool was run for three different impedance types: (i) free-flow travel time from ISTDM (results for this impedance type were shown in Table 4.6), (ii) travel time cost, which was estimated as free-flow travel time multiplied by VOT, and (iii) generalized cost of travel, which is also an ISTDM output. As can be seen in Table 4.8, the productivity estimates for the different impedance types do not differ significantly. We could conclude that the choice of impedance type is not critical and therefore, the user could select impedance type based on practicality.

Table 4.8 EconWorks Buyer-Supplier Market Access Tool Results for Different Impedance Types

Impedance Type	Productivity ^a (\$2013 RPPs)
Free-flow travel time (min)	15,886,410
Travel time cost ^b (\$)	15,945,778
Generalized cost (\$)	16,039,136

^a Productivity was estimated for decay parameter equal to 1, and productivity elasticity of 0.03

^b Travel time cost was estimated for VOT equal to \$25.75/hour, which corresponds to the VOT for truck drivers as presented in U.S. DOT (2014).

4.2.3 Application of the EconWorks Specialized Labor Market Access Tools for SR-3

The EconWorks Specialized Labor Market Access tool was used to estimate the possible changes in access of work sites and employment centers to specialized labor markets due to the SR-3 project. The analysis was conducted at the county level. The impact area, which is shown in Figure 4.7, is comprised of the counties that are within a reasonable commuting distance from the SR-3 project (counties that can be reached within 100 minutes approximately from the SR-3 project): Decatur, Rush, Henry, Bartholomew, Delaware, Fayette, Franklin, Hamilton, Hancock, Jennings, Madison, Marion, Randolph, Ripley, Shelby, and Wayne. Data on total as well as specialized employment for 2013 was retrieved from the BEA Regional Accounts for each county. This data served as input for the base year, while a 15% increase in total and specialized labor was assumed for the reference year (2035).

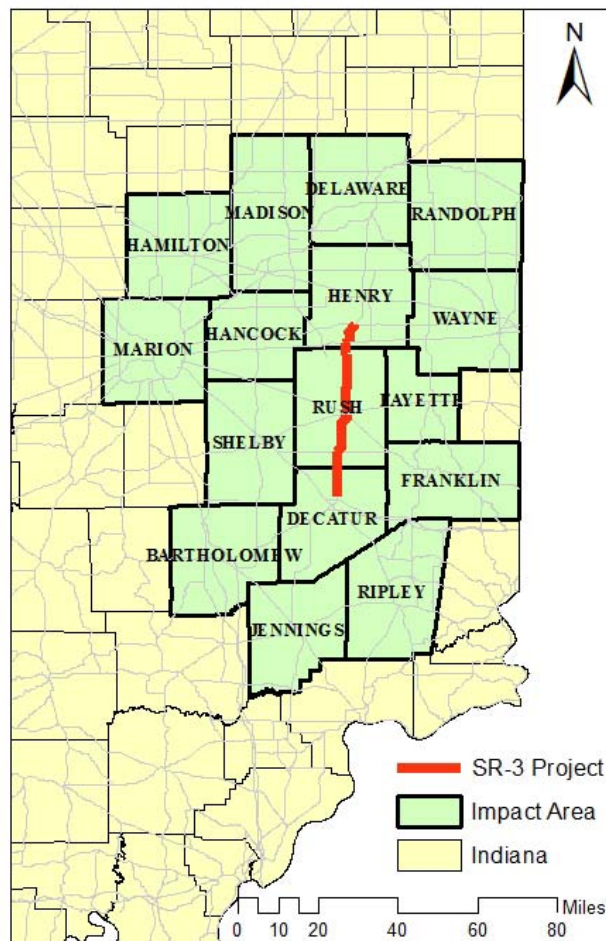


Figure 4.7 SR-3 from I-70 to I-74 - Impact Area Considered for the EconWorks Specialized Labor Market Access Tool (Source: Indiana Maps <http://maps.indiana.edu/>)

The employment data revealed that manufacturing is the sector with the highest employment in most of the counties included in the impact area. Therefore, the manufacturing sector was selected as the specialized sector to be analyzed by the tool; this was specified in the tool in 3 - Parameters and Selections, 3rd and 7th parameter, as shown in Figure 4.8. Employed labor force was chosen as the labor force type in 3 - Parameters and Selections, 4th parameter, to be consistent with the employment data collected. Last, “by place of work” was chosen as the reference point of the labor force data in 3 - Parameters and Selections, 5th parameter because the BEA Regional Economic Accounts data measures employment as number of jobs in each location (BEA, 2007).

PARAMETERS AND SETTINGS

1. Base Year (No-Build)	2010
2. Reference Year (Build)	2030
3. Classify the Site/Location by Sector	NAICS 31-33 : Manufacturing
4. Type of Labor Force	Employed Labor Force
5. Type of Data Source for Input 4.	By Place of Work
6. Select Sub-category of Data from Input 5.	By Industry Sector
7. Select Sub-category of Data from Input 6.	NAICS 31-33 : Manufacturing
8. Threshold Impedance (minutes/miles)	100
9. Select Type of Commuter Trips & Corresponding %	Business Trips
10. Wages per Hour/ Value of Time (VOT) Proxy (\$/hr)	\$18.90
11. Percentage (%) Wage Rate to be used for assessing VOT	50
12. Select Period of Analysis : Peak/Off-Peak/Entire Day	Entire Day

Figure 4.8 Screenshot from the EconWorks Specialized Labor Market Access Tool, 3 - Parameters and Selections

Regarding the O-D impedance and trip matrices for the base and the reference year, data from ISTDM was used. Specifically, for the base year, ISTDM was run using the base-case 2010 scenario, and the free-flow travel time as well as home-based trips to work from TAZ to TAZ for the state of Indiana was estimated. The matrix aggregation tool was used to aggregate TAZs into county-level zones. For the reference year, ISTDM was run using the 2035 scenario for traffic and a modified highway network, which was provided by INDOT and included the modifications for the new SR-3 project (bypasses and speed limit change). The O-D free-flow travel time for the 2010 and the 2035 built scenarios was previously shown in Tables 4.3 and 4.4, respectively. The O-D home-based trips to work for 2010 and 2035 are presented in Tables 4.9 and 4.10, respectively.

Table 4.9 O-D Home-Based Trips to Work, 2010 Scenario

	18005	18031	18035	18041	18047	18057	18059	18065	18079	18095	18097	18135	18137	18139	18145	18177
18005	44679	563	0	1	88	534	15	0	1574	1	1691	0	368	4	307	0
18031	562	6648	1	25	408	74	100	62	73	6	899	0	1697	456	447	1
18035	0	146920	112	3	445	24	1154	0	4918	696	1221	0	30	1	657	
18041	1	25	112	4537	435	5	36	344	0	16	144	15	27	431	119	361
18047	87	357	3	433	2372	1	16	59	2	1	50	2	1223	70	25	84
18057	505	72	431	5	190324	1099	224	0	3923	46280	75	0	29	237	44	
18059	15	116	24	36	20	1093	9131	724	0	654	8294	19	32	514	716	371
18065	0	63	1180	351	61	209	714	11311	0	1571	1362	89	17	395	6	2076
18079	1583	72	0	0	2	0	0	0	8932	0	102	0	144	0	9	0
18095	1	7	4902	17	1	3669	767	1527	0	42385	1813	175	0	35	50	95
18097	1578	993	692	146	66	47479	8117	1269	106	1902	429409	58	94	362	3762	456
18135	0	0	1302	14	2	74	19	89	0	188	57	3011	0	1	0	503
18137	379	1651	0	28	1215	0	29	17	145	0	91	0	9487	147	249	4
18139	4	464	30	430	77	28	513	391	0	33	343	1	141	3505	371	118
18145	295	377	1	118	27	253	698	6	9	46	3894	0	198	386	7921	7
18177	0	1	655	371	84	43	350	2078	0	99	456	486	4	117	8	14795

Table 4.10 O-D Home-Based Trips to Work, 2035 Scenario with SR-3 Project

	18005	18031	18035	18041	18047	18057	18059	18065	18079	18095	18097	18135	18137	18139	18145	18177
18005	47481	731	0	1	141	572	18	0	2012	1	1129	0	581	5	293	0
18031	730	7602	1	33	493	100	94	32	41	5	739	0	1788	403	377	3
18035	0	143520	13	0	896	58	947	0	4597	645	1384	0	11	1	388	
18041	1	33	13	5224	499	10	78	144	0	2	122	3	17	451	116	449
18047	140	438	0	497	3740	2	33	25	2	0	58	1	1590	75	34	75
18057	545	98	879	10	2145883	3403	560	0	6224	54253	173	1	42	275	117	
18059	18	109	59	78	36	3380	18113	942	1	807	11639	34	35	500	822	1102
18065	0	33	970	151	27	537	931	9440	0	1484	1435	84	13	360	13	1977
18079	2026	41	0	0	2	0	1	0	9082	0	135	0	163	0	7	0
18095	1	6	4566	2	0	5984	922	1445	0	37040	1536	242	0	10	33	122
18097	1032	827	643	123	77	55276	11500	1341	140	1613	407098	44	116	304	3586	487
18135	0	0	1473	2	1	171	34	84	0	256	43	1882	0	2	0	199
18137	592	1750	0	17	1586	1	32	13	164	0	115	0	10180	146	236	2
18139	5	409	12	450	81	40	498	357	0	9	285	2	142	3458	425	364
18145	280	322	1	117	37	291	804	13	7	30	3708	0	196	455	8465	16
18177	0	3	385	468	76	115	1074	1982	0	125	491	193	2	363	16	11131

As shown in Figure 4.8, the default percentage of business trips (50%) was used. The VOT estimate for intercity travel (for all purposes) from U.S. DOT (2014), \$18.90 per person-hour, and the suggested value (50%) for the percentage of VOT that will be used in the valuation

of time costs were entered as well. Last, since the travel time and trip tables are not for a specific period or time of day, “entire day” was selected in 3 - Parameters and Selections, 12th parameter.

The results from the EconWorks Specialized Labor Market Access tool, assuming threshold impedance (duration of commuting trips to an employment center) equal to 100 minutes, are presented in Table 4.11 (the default threshold impedance was used here; a sensitivity analysis of this parameter follows). The results indicated that the change in zone accessibility (change in the number of accessible zones from the employment centers) and the change in concentration index (change in concentration of the labor pool for the manufacturing sector within a zone) due to the SR-3 project were minimal. On the other hand, the change in employment accessibility (change in total employment that can be accessed) was around 16%. It should be mentioned here that SHRP2 (2014) does not provide a mathematical definition of zone and employment accessibility, which makes the interpretation of the results quite challenging. Moreover, although a mathematical definition for the concentration index is provided, the symbols used are not properly defined. The change in commuter cost represents the saving for personal commute and business trips for all O-D pairs due to the SR-3 project. These costs are annualized, assuming 260 workdays in a year. The software output includes the dollar amount of the change in commuter cost only, and therefore, it is not possible to estimate a percentage change and evaluate its magnitude. In general, it could be concluded that based on this tool, the SR-3 project will have a minimal impact on labor market access.

Table 4.11 EconWorks Specialized Labor Market Access Tool Results for SR-3 Project

Employment Center	FIPS County Code	Change in Zone Accessibility (%)	Change in Employment Accessibility (%)	Change in Concentration Index (%)	Change in Commuter Cost (\$ 2013)
Bartholomew, IN	18005	0.00	15.00	-0.11	\$0
Decatur, IN	18031	0.00	15.00	-0.11	\$167
Delaware, IN	18035	2.22	17.01	0.42	\$934
Fayette, IN	18041	1.64	15.00	-0.11	-\$1,912
Franklin, IN	18047	1.30	15.00	-0.11	-\$300
Hamilton, IN	18057	1.08	15.00	-0.11	\$559
Hancock, IN	18059	0.92	15.00	-0.11	\$3,144
Henry, IN	18065	0.80	15.00	-0.11	\$7,342
Jennings, IN	18079	1.46	21.18	1.75	\$0
Madison, IN	18095	1.32	15.00	-0.11	\$321
Marion, IN	18097	1.20	15.00	-0.11	\$369
Randolph, IN	18135	1.11	15.00	-0.11	\$22
Ripley, IN	18137	1.55	19.57	-1.43	\$24
Rush, IN	18139	1.44	15.00	-0.11	\$6,940
Shelby, IN	18145	1.33	15.00	-0.11	\$503
Wayne, IN	18177	1.67	16.82	0.61	-\$408
Total		1.31	15.85	0.00	\$17,705

A sensitivity analysis was conducted to determine the effect of the threshold impedance parameter on the labor market access results. The tool was run for different values of the threshold impedance while keeping all other inputs constant. To do that, the tool had to be re-downloaded and all inputs had to be re-entered for every run; otherwise, an error would appear and the tool would not give results. Figure 4.9 shows the results of the sensitivity analysis for zone accessibility, employment accessibility and the concentration index. Commuter cost does not depend on the threshold impedance parameter, and therefore remains constant when a change in this parameter occurs. It can be seen that the change in threshold impedance did not have a significant effect on the concentration index. At the same time, the change in zone and employment accessibility did not vary by more than 3% due to the change in threshold impedance. Last, the results for the 90-minute and 100-minute threshold impedance were similar.

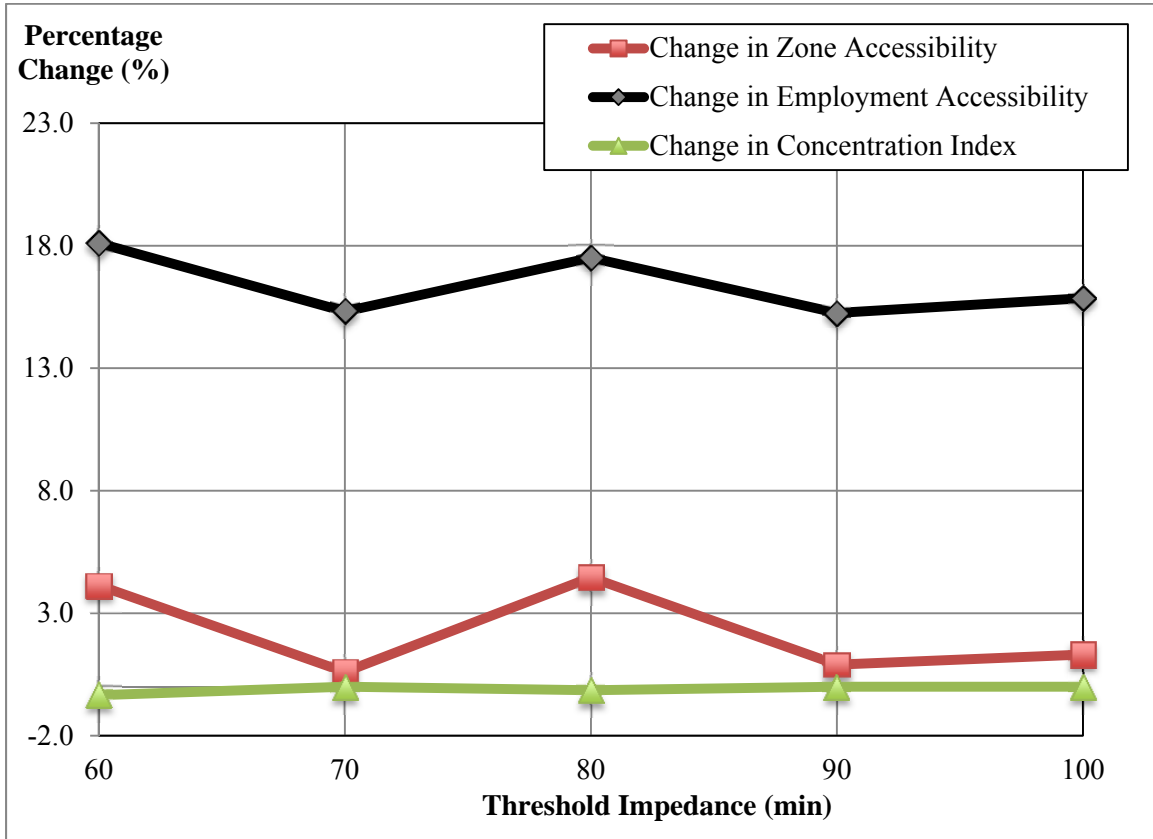


Figure 4.9 EconWorks Specialized Labor Market Access Tool, Sensitivity Analysis for Threshold Impedance

4.1.1 Market Access Analysis in TREDIS and Comparison of Results

Application of the TREDIS Access to Buyer-Supplier Markets Tool for SR-3

The Market Access Module inside in TREDIS was employed to evaluate the potential productivity benefits that would be generated by the SR-3 project. As aforementioned, employment that can be covered within a 3-hour drive was designed specifically for measuring buyer-supplier market access variation because of a transportation improvement. To conduct an analysis regarding buyer-supplier market access in the TREDIS Market Access Module, the tool needs inputs as follows: (a) transportation mode and trip purpose combination, (b) project timing information, (c) total construction costs of the project, (d) annual operation and maintenance costs of the project, (e) traffic data of the project for build and no-build scenarios, and (f) employment that can be reached with a 3-hour drive for build scenario. Table 4.12 indicates the main sources for these inputs.

Table 4.12 List of Primary Data and Sources for TREDIS Market Access Module

Input	Data source	Data type
Total Construction Cost ¹	Florida DOT Generic Cost Per Mile Model (Florida DOT, 2014)	Highway Project Construction Cost per Mile
	U.S. Army Corps of Engineers Civil Works Construction Cost Index System (CWCCIS) - Table A-3 (U.S. Army Corps of Engineers, 2015)	State Adjustment Factors
	U.S. Bureau of Labor Statistics	Producer Price Index
Maintenance Costs ²	21 st Annual Report on The Performance of State Highway Systems -Table 8 (Hartgen et al., 2014)	Maintenance Costs per State-Controlled Mile
Trip Purpose ³	2009 National Household Travel Survey	Trip Purpose by vehicle-mile traveled (VMT) or by Vehicle Trips per State
Vehicle Trips ⁴	MS2 Traffic Count Database (Indiana Department of Transportation, 2015)	Annual Average Daily Traffic (AADT)
Regional Market Size (Access to Buyer –Supplier Markets)	U.S. Census Bureau	County Population Centroid
	ESRI Business Analyst Online	Employment within a 3-hour drive from the Centroid of the Study County

^{1,2,3} These are not direct inputs for the market access module but required in TREDIS as preliminary data to run the market access module.

⁴ Alternative data source that can be used to calculate vehicle trips without the application of ISTDM.

Considering the nature of the SR-3 project, passenger cars consisted the major transportation mode involved in the analysis. Passenger car trips included business trips, personal trips, and commute trips. Truck – all for freight trips were also included in the transportation mode and trip purpose combination.

In terms of the construction start year of the SR-3 project, since the traffic data in this study was obtained from ISTDM by running the 2010 base scenario, the build and no-build scenarios in TREDIS should refer to that year as well. However, the earliest option for construction start year provided in the TREDIS version available is 2012, so construction was assumed to begin in 2012 and last for one year. To be consistent with the analysis in the EconWorks Accessibility tools, the analysis year was set in 2035. A 4% discount rate and a 1.5 % travel growth rate were also adopted per INDOT’s suggestions.

Rush, Decatur, and Henry were three counties chosen as study region for the SR-3 project because of the project location. Bartholomew, Delaware, Fayette, Franklin, Hamilton, Hancock,

Jennings, Madison, Randolph, Ripley, Shelby, and Wayne County were imported as the linked area. Jefferson County in Kentucky and Hamilton County in Ohio were not encompassed in the analysis because the purchased TREDIS license only incorporates counties in the state of Indiana.

The construction costs were calculated based on the following steps. First, the unit cost of the project was calculated from the Florida DOT Generic Cost per Mile Models. Second, the unit cost was adjusted to Indiana using the U.S. Army Corps of Engineers Civil Works Construction Cost Index System. Third, the Producer Price Index from U.S. Bureau of Labor Statistics was applied to convert the unit cost to the dollar value of the analysis year. The annual operation and maintenance costs were acquired from the 21st Annual Report on the Performance of State Highway Systems using the product of the unit cost in Indiana (\$44,371 per mile) and the length of the project (36 miles). The total construction costs and annual operation and maintenance costs were calculated to be \$78.03M and \$1.60 M, respectively.

In order to categorize the traffic volume, vehicle-miles-traveled (VMT), and vehicle-hours-traveled (VHT) and other required traffic data by trip purpose in the Travel Characteristic Module in TREDIS, the percentages of business trips, personal trips, and commute trips by annual vehicle trips and annual VMT in Indiana were obtained from the 2009 National Household Travel Survey. Table 4.13 shows the split of annual vehicle trips and VMT by trip purpose in Indiana.

Table 4.13 Shares of Annual Vehicle Trips and VMT by Trip Purpose in Indiana. (Adapted from: 2009 National Household Travel Survey, <http://nhts.ornl.gov/tables09/ae/TableDesigner.aspx>)

Trip Purpose	Annual Vehicle Trips	Annual Vehicle –Miles Traveled (VMT)
Business Trips	2%	4%
Personal Trips	84%	79%
Commute Trips	14%	17%

For the purpose of being comparable with the outputs from the EconWorks W.E.B. tools regarding the productivity benefits, the default values of time by trip purpose in TREDIS were replaced with those suggested in U.S. DOT (2014). Traffic data in the Travel Characteristics Module, such as annual vehicle trips, annual VMT, and annual VHT for the build and no-build scenarios were all acquired from ISTDM for the 2010 base year. The relationship between ISTDM outputs and TREDIS inputs is illustrated in Figure 4.10. The detailed traffic data inputs based on the year of 2010 for the build and no-build scenarios are shown in Table 4.14. It should be noted that the congestion level was not considered in the analysis since there were no

congestion issues on the SR-3. According to ISTDM, internal trips to the study region were 86.9% for passenger cars and 13.1% for trucks.

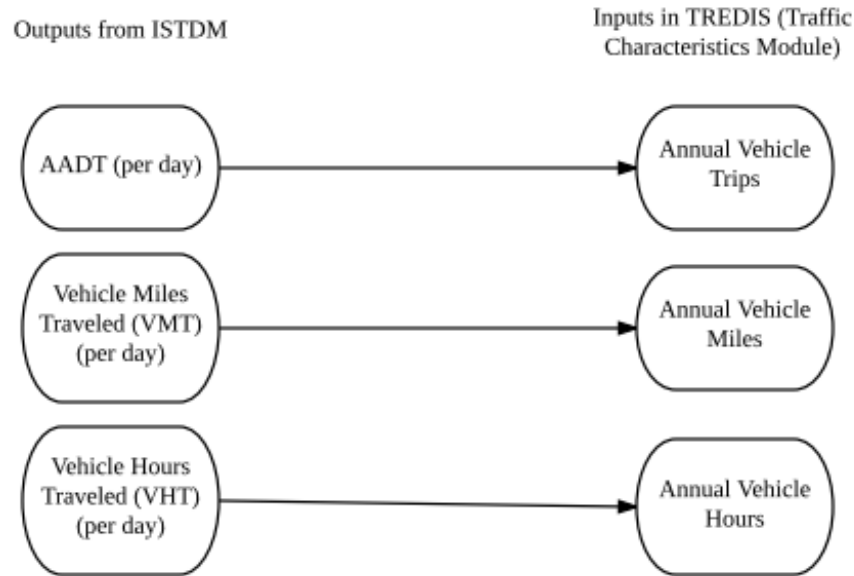


Figure 4.10 Relationship between ISTDM traffic data outputs and TREDIS inputs

Table 4.14 Traffic Data Inputs for the Build and No-build Scenarios in 2010

Trip Purpose – Mode	Vehicle Volumes (build & no-build)	VMT (no-build)	VMT (build)	VHT (no-build)	VHT (build)
Freight – Truck	322,055	122,607,894	36,339,824	376,523	618,138
Commuter – Passenger Cars	298,873	20,843,342	40,950,598	349,420	573,644
Personal – Passenger Cars	1,793,238	96,860,236	190,299,836	2,096,523	3,441,863
Business – Passenger Cars	42,696	4,904,316	9,635,435	49,917	81,949

Another approach for obtaining the annual vehicle trips, VMT and VHT (or travel speed) for the SR-3 project base case without the application of ISTDM is by employing the free online traffic data source MS2 (as listed in Table 4.12).

The employment that can be reached within a 3-hour drive was estimated by the application of ESRI’s Business Analyst Online. The data generation process for the no-build scenario involved three steps: first, downloading the 2010 geographical county center data in Indiana from the U.S. census and importing it to the Business Analyst Online; second, identifying the population centers of Rush, Decatur, and Henry counties and measuring the employment can be reached within a 3-hour (180 minutes) drive from the population center for each county; third, calculating the total employment for each county from the Business Summary report provided by Business Analyst Online. For the build scenario, the anticipated travel time savings from the project SR-3 for the aforementioned three counties were estimated to be 3 minutes, 4 minutes, and 4 minutes, respectively. As such, the employment that can be reached within a 183-minute drive for Rush county and within a 184-minute drive for Decatur county and Henry county was calculated under the build scenario. Table 4.15 shows the employment values for each county under the no-build and build scenarios. A sensitivity analysis of the access to buyer-supplier markets tool with respect to the employment that can be reached with a 3-hour drive is presented in Appendix D.

Table 4.15 Employment data from ESRI’s Business Analyst Online

County	Employment within a 3-hour drive (no-build)	Employment within a 3-hour drive (build)
Rush	6,808,907	6,911,588
Decatur	6,773,255	6,871,933
Henry	6,875,203	7,056,426

The ultimate value imported in the TREDIS as the proxy for access to buyer-supplier market for the build scenario was estimated through the additional two steps: first, using the population – weighed method, a single value of employment that can be reached within a 3-hour for both build and no-build scenarios was calculated; then, this value for the build scenario was adjusted by referring to the default value of employment can be reached within a 3-hour offered in TREDIS for the no-build scenario and using linear interpolation. The final value of employment that can be reached within a 3-hour drive for the build scenario that was imported in TREDIS was 7,486,525. The productivity benefits from the improvement of the access to buyer – supplier market were estimated in TREDIS as \$3.8M in the year of 2035, which expresses the value added because of the project SR-3.

The productivity benefits estimated by the EconWorks Buyer-Supplier Market Access tool are \$15.9M. A difference between the productivity benefits estimated by the two tools is expected. First of all, the measures of market access used by TREDIS and the EconWorks W.E.B. tools are fundamentally different. TREDIS uses the change in employment reached within 3 hours of driving time as a proxy for measuring buyer-supplier market access variation due to a transportation improvement. On the other hand, the EconWorks Buyer-Supplier Market Access tool employs the notion of effective density to capture this variation in market access. Second, in the EconWorks W.E.B. tools, the change in market access is translated into monetary terms with the use of productivity elasticities, which are retrieved from relevant literature. SHRP2 (2014) suggested a range of values for each elasticity, while the selection of the appropriate value is left to the user. On the other hand, TREDIS estimated the effect of market access and connectivity on economic output using simultaneous equations. The estimated model parameters (equivalent to productivity elasticities) were developed by TREDIS for the given set of explanatory variables, while for the EconWorks tools, a range of productivity elasticities was adopted from past studies. Moreover, the model parameters are included in the software, which makes the analysis more practical for the user. On the other hand, the benefits estimated as part of the Market Access Module in TREDIS depend on the results of a single model, while SHRP2 (2014) incorporated a significant amount of past research into the EconWorks W.E.B. tools. In summary, the two tools significantly differ in terms of methodological background, and therefore, it is expected that the estimated productivity benefits will differ. It would be of great interest to investigate how reliable and realistic these estimates are by conducting an ex-post evaluation study some years after the project implementation.

Application of the TREDIS Access to Labor Markets Tool for SR-3

To conduct an analysis with respect to labor market access in the TREDIS Market Access Module, the tool needs inputs as follows: (a) transportation mode and trip purpose combination, (b) project timing information, (c) total construction costs of the project, (d) annual operation and maintenance costs of the project, (e) traffic data of the project for build and no-build scenarios, and (f) population that can be covered with a 40-minute drive for build scenario. For the SR-3 project, same inputs from (a) to (e) as to the application of TREDIS to buyer-supplier markets were adopted. The only variable changed in this analysis was (f), population that can be covered within a 40-minute drive for the build scenario, which was obtained through the same process for

deriving the proxy of buyer-supplier markets mentioned in the previous section (see Table 4.16). The ultimate value of population that can be covered within a 40-minute drive for the build scenario that was imported in TREDIS was 50,681. The productivity benefits from the improvement access to labor market were estimated in TREDIS as \$64.9M in the year of 2035. These benefits are not directly comparable with the EconWorks Specialized Labor Market Access tool results. Based on the EconWorks Specialized Labor Market Access tool, the change in employment accessibility is equal to 16%. The tool does not translate this change into productivity benefits, and for this reason we cannot make a direct comparison with the results from TREDIS. Also, the EconWorks Specialized Labor Market Access tool provided an estimate for the change in commuter cost (equal to \$17,705). This estimate is the travel time savings for commuting among employment centers and does not represent productivity benefits.

Table 4.16 indicates the population data from ESRI’s Business Analyst Online. A sensitivity analysis of the access to labor markets tool with respect to the population that can be reached with a 40-minute drive is presented in Appendix D.

Table 4.16 Population data from ESRI’s Business Analyst Online

County	Population within a 40-minute drive (no-build)	Population within a 40-minute drive (build)
Rush	165,109	191,458
Decatur	151,508	198,146
Henry	342,184	426,618

4.3 CASE STUDY 3: PORT BRIDGE OVER NATIONAL RAIL CORRIDOR, INDIANA

4.3.1 Project Description

The two-lane bridge on the Indiana State Road 249 is the only roadway entrance to the Port of Indiana – Burns Harbor, which covers 15% of all U.S. steel trade with Europe as the only international port in Indiana. In addition to providing access to the Indiana – Burns harbor, the bridge is also close to several busiest rail lines in the county. However, currently the bridge is under heavy truck traffic because of its unique and critical location. Therefore, there is a need to build another bridge not only as an alternative in case that the existing one would fail, but also to ease the truck and commute traffic on the old bridge at peak hours. Beyond the above two benefits, the new build bridge would also improve the connectivity between five modes (road,

rail, river barge, lake vessel, and ocean ship) under operation around the Burns Harbor. The construction of the new bridge would roughly cost about \$18 million (Blue Ribbon Panel, 2014).

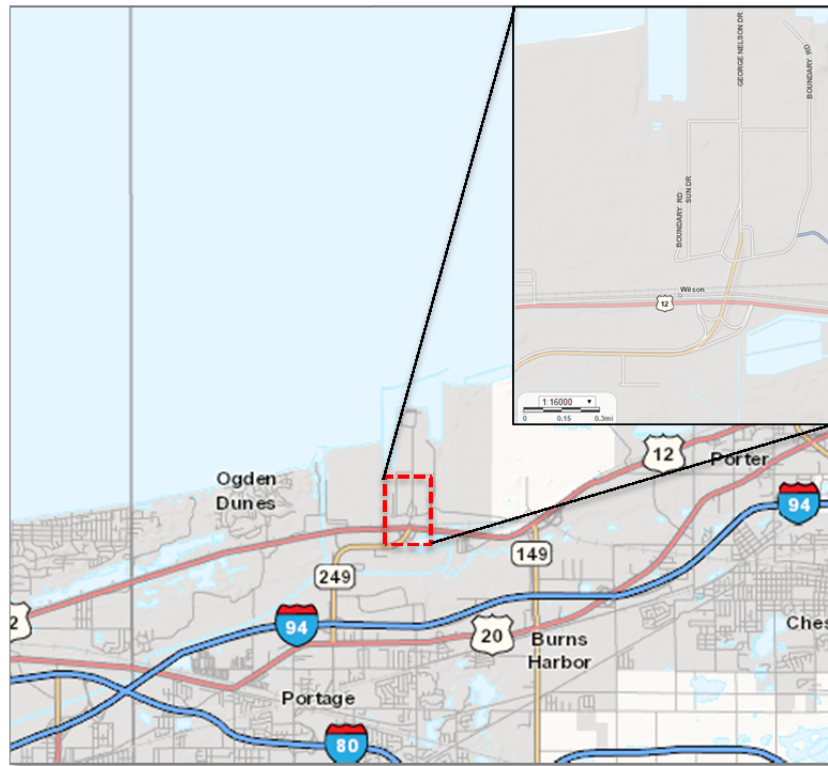


Figure 4.11 Port Bridge over National Rail Corridor (Source: IndianaMap.org)

4.3.2 Scenario Analysis

The specific location of the new bridge is currently under study and therefore, the travel time savings when traveling to the port are still uncertain. In that sense, the research team investigated the expected change in the weighted connectivity index (WCI) with respect to different levels of travel time savings. To do so, the *Freight Connectivity Index* for the port was located using built-in information from the Connectivity tool. This index was multiplied by the projected truck in 2035 and the travel time saving estimates. Additionally, the fraction of trucks associated with the port facility was assumed to be 1 (i.e. all trucks are arriving or departing the port facility) because the project location is next to the port. An important factor to take into account is the value per truck-hour saved which should reflect the crew cost and freight logistics costs; for this analysis, the default value of \$57 per hour was used.

The results of this analysis are shown in Figure 4.12. It should be noted that the values of WCI are translated to productivity benefits using the business impact elasticity factors. For marine ports, the elasticity value is 0.005. As such, for positive travel time savings of 0.17 hours (i.e., 10 min reduction in the travel time from 30 minutes to 20 minutes), the WCI would increase by 33.3%, and the corresponding change in business output would be 0.17%. Given that the Gross Regional Product for Porter County was estimated to be \$6,181,227,366, this change corresponds to a \$10,302,046 increase in business output.

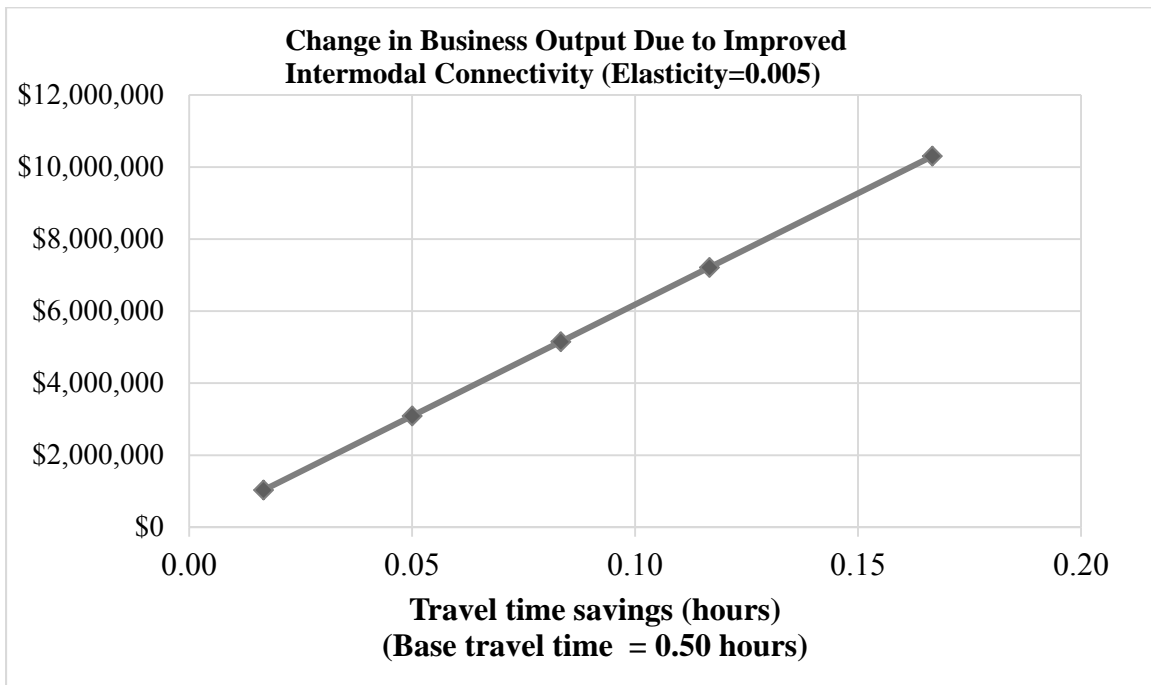


Figure 4.12 Expected change in the businesses' productivity for different values of expected travel time savings.

CHAPTER 5 SUMMARY AND CONCLUSIONS

5.1 SUMMARY OF RESULTS

5.1.1 EconWorks Reliability Tool

The EconWorks Reliability tool has been built to require minimum data and calibration in order to calculate the benefits of reducing the variability in travel times. These benefits are derived based on the evaluation of buffer times (delays) using statistical metrics from travel time distributions. The buffer time is the extra time that needs to be allocated to each trip to avoid late arrivals. The Future Strategic Highway Research Program defines seven primary sources of congestion that cause unreliability in travel times (SHRP2, 2013). The interaction of these sources causes a total congestion that is composed of recurring congestion (expected delay) and non-recurring congestion (unexpected delay). The EconWorks Reliability tool estimates both types of delays and their corresponding costs. Additionally, different metrics of reliability (travel time index, percentage of trips with 45 and 30 mph) are reported in four scenarios: build and no-build scenario at the initial and end year of the time horizon. It is at that point that the analyst can estimate the net benefits of improving reliability for the initial and end year of analysis or use the metrics as part of additional evaluations. The inputs of this tool include: (a) traffic and capacity data of the facility, (b) analysis period, and (c) strategies for reducing incident delays (frequency and duration of incidents). Default values for the value of travel time and values of reliability (reliability ratio) are provided, but they could be tailored to specific conditions or settings under study.

Section 4.2 presented the application of this tool to the U.S. 36 project, which involves the addition of travel lanes on a 1.6-mile segment where the v/c ratios approach 1. The current AADT is more than 40,000 vehicles per day, composed primarily of passenger cars. The results of the analysis showed that, for a period of analysis between 6 a.m. and 7 p.m., the total delay costs in the initial year (2013) reached \$1.78M, of which \$1.41M (78%) corresponded to recurring delay and \$0.37 (32%) to non-recurring delay or unreliability. For the build scenario, the v/c ratios were reduced to 0.76 and the total equivalent delay cost was reduced to \$64.68K, whereas the incident delay was reduced to \$2.5K. Furthermore, the mean travel time index was reduced from 1.34 in the base scenario to 1.02 in the build scenario. The latter value means that,

on average, users will be traveling at the estimated free flow speed after the project implementation. All the previous metrics were derived assuming default values for the reliability ratio, and reductions in incident frequency or duration of 0% due to incident delay strategies. Finally, the net incident benefits obtained by subtracting the delay costs in the build and no-build scenario resulted in 23% of the recurring total delay savings in 2013. This percentage increased to 32% at the end of the project horizon (20 years), where the traffic volume (AADT) increased by 22%.

The effect of certain important parameters on the results was investigated using a sensitivity analysis. It was found that the EconWorks Reliability tool outputs are highly sensitive to v/c ratios greater than 0.85. Below this threshold, the evaluation of incident delays decreased dramatically.

The sensitivity analysis results also indicated that incident frequency or incident duration had a moderate impact (3-24% change) on the total delay cost savings. Individually, the parameter indicating the incident duration had a higher effect on the incident (non-recurring) delay cost. For example, if the respective parameter is set to 50%, then the incident delay cost will reduce by 80%. Meanwhile, if the incident frequency is set to 50%, then the incident delay will be reduced by 62%.

Finally, in regards to the synergies between the Reliability tool and TREDIS for reliability analysis, it was found that both tools are compatible in terms of methodology and metrics and can be complementary. For example, the EconWorks Reliability tool outputs could be used for updating the buffer time index values in TREDIS. However, adjustments in the period of analysis and annual volumes considered might be needed. The incident delay costs for commercial and business trips, estimated in TREDIS were \$173,257, whereas EconWorks W.E.B. yielded \$23,018.

5.1.2 EconWorks Buyer-Supplier Market Access Tool

The EconWorks Buyer-Supplier Market Access tool was designed to provide preliminary assistance in estimating regional changes in market access from a transportation project for a no-build (base year) and a build scenario (reference year) (SHRP2, 2014). The tool focuses on measuring economies of scale triggered by the expansion of the customer delivery market served from a certain business site and the expansion of supplier locations that can deliver to that

business site in a day, due to a highway transportation improvement in the region. These economies of scale or “productivity” are estimated as a function of the change in accessibility, the regional economic output, and the assumed productivity elasticity. Effective density, which assumes that economic activity is proportional to the regional employment (or population) and inversely proportional to the cost of travel, is used for measuring accessibility. The tool requires the following inputs: (a) employment data for the base and the reference year, (b) O-D impedance matrices for the base and the reference year, (c) Gross Regional Product (GRP) estimates for the base year (d) decay parameter, and (e) productivity elasticity. The main sources for the previously-mentioned inputs were presented in Table 2.4.

Section 4.3.1 presented the application of this tool to the SR-3 capacity improvement project. The impact area is comprised of Rush, Decatur and Henry Counties, their neighbor counties (Bartholomew, Delaware, Fayette, Franklin, Hamilton, Hancock, Jennings, Madison, Randolph, Ripley, Shelby, and Wayne), as well as the major metropolitan centers that can be served by same-day truck deliveries (Indianapolis, Fort Wayne, Cincinnati, and Louisville). The total business productivity benefits in the impact area due to the project were found to be around \$16 million. These productivity gains depend on each county’s earnings per employee and change in effective density, as well as the productivity elasticity assumed.

A sensitivity analysis was conducted to determine the magnitude of the effect of the decay parameter assumption on the estimated productivity, because limited guidance is available on the choice of this parameter in SHRP2 (2014). Some guidance is provided by Graham et al. (2009) who estimated that the decay parameter is on average equal to 1 for the manufacturing sector, 1.8 for the consumer and business sectors, and 1.6 for the construction sector. SHRP2 (2014) suggested the calibration of the decay parameter based on state or MPO travel demand model friction functions, but the value should remain between 0 and 5. The sensitivity analysis revealed that productivity gradually increased for decay values between 1 and 2.5, and dramatically increased for decay values higher than 2.5.

The sensitivity of the productivity benefits to the productivity elasticity value, which is defined as the percent change in productivity divided by the percent change in market access, was also examined. The value of the productivity elasticity depends on the type of the activity data chosen for the analysis (population, total employment, employment in a single sector) and the type of transportation improvement (new link, improved link), as was shown in Table 2.3. Sensitivity analysis results indicated that the tool’s estimate of total productivity is linearly

proportional to the assumed elasticity value. Specifically, a productivity elasticity increase of 0.01 resulted in \$5M increase of productivity benefits on average.

Last, the effect of the type of impedance used was investigated. The tool was run for three different impedance types: free-flow travel time from ISTDM, travel time cost (free-flow travel time multiplied by VOT), and generalized cost of travel from ISTDM. It was found that the productivity benefits for the different impedance types did not differ significantly.

5.1.3 EconWorks Specialized Labor Market Access Tool

This tool was designed to provide preliminary assistance for estimating changes in access of work sites and employment centers to specialized labor markets due to transportation improvements for a base year (no-build scenario) and a reference year (build scenario). The tool estimates the changes in zone accessibility (change in the number of accessible zones from the employment centers), employment accessibility (change in total employment that can be accessed), concentration index (change in concentration of the labor pool for a given industry sector within a zone), and commuter costs (savings for personal commute and business trips) due to a transportation improvement. The tool requires the following inputs: (a) list of employment centers considered in the analysis, (b) total as well as specialized employment data for the base and the reference year for each employment center, (c) O-D impedance levels for the base and the reference year, (d) O-D home-based trips to work for the base and the reference year, and (e) threshold impedance (which is the typical duration of commuting trips to an employment center).

Section 4.1.2 presented the application of this tool to the SR-3 capacity improvement project. The impact area consists of the counties that are within a reasonable commuting distance from the SR-3 project (counties that can be reached within 100 minutes from the SR-3 project): Decatur, Rush, Henry, Bartholomew, Delaware, Fayette, Franklin, Hamilton, Hancock, Jennings, Madison, Marion, Randolph, Ripley, Shelby, and Wayne Counties. Manufacturing was selected as the specialized industry sector to be analyzed by the tool, based on the region's employment characteristics. Results indicated that the change in zone accessibility and the change in concentration index due to the SR-3 project were minimal. On the other hand, the change in employment accessibility was around 16%. The commuter cost savings were also relatively low (around \$18K for the entire region in the year 2035). It was therefore concluded that the SR-3 project would have a minimal impact on labor market access.

A sensitivity analysis was conducted to determine the effect of the threshold impedance parameter on the labor market access results, because no guidance on this parameter was provided in SHRP2 (2014). It was found that the change in threshold impedance did not have a significant effect on the concentration index. At the same time, the change in zone and employment accessibility did not vary by more than 3%, due to changes in threshold impedance. Commuter costs did not depend on threshold impedance, and therefore remained constant. Thus, it can be concluded that the tool's outputs are not particularly sensitive to variations of the threshold impedance parameter.

5.1.4 Market Access Analysis in TREDIS

Access to buyer-supplier markets and labor markets are captured in TREDIS by an indicator of employment that can be reached within 3-hour drive and an indicator of population that can be covered within a 40-minute drive from the population center of a county, respectively. TREDIS was used for the evaluation of market access benefits resulting from the SR-3 project. On the one hand, if one only takes into account the improvement in access to buyer-supplier markets, the productivity benefits in the year 2035 would be \$3.8 M. On the other hand, if one only considers the improvement in access to labor markets, the productivity in the corresponding year will be \$64.9M. TREDIS can also evaluate these two variables simultaneously to calculate the total productivity benefits in the analysis year 2035, which was estimated to be \$68M. Therefore, it is significant to note that the output of market access in TREDIS is highly sensitive to the population that can be covered within a 40-minute drive in the context of market access analysis. It is worth noting that the productivity benefits resulted from the improvement of access to buyer-supplier markets reflect effects on “manufacturing shipments, or same day delivery markets for just-in-time supply chains.” However, the productivity benefits generated by the improvement of access to labor markets mirror effects on “jobs within normal commuting and retail trip travel times.” Moreover, as aforementioned, buyer-supplier market size is estimated based on zonal employment but labor market size is assessed through zonal population (EDRG, 2014c). Connectivity factors in the Market Access Module inside TREDIS were not considered in the market analysis of the project SR-3.

5.1.5 Comparison between the EconWorks W.E.B. Tools and TREDIS – Key Findings

Comparison in terms of Reliability Analysis

In terms of measuring the improvements in travel time reliability, TREDIS does not provide a specific dedicated module for reliability analysis but incorporates these benefits in the travel cost calculations. The EconWorks Reliability Tool generates a group of metrics based on empirical travel time distribution functions using the travel time index as the main parameter. On the other hand, TREDIS uses direct estimates of the buffer time as a primary indicator of travel time reliability. The user can provide an estimate of the buffer time, but the software provides an empirical relationship between the Buffer Time Index (BTI) and the fraction of travel under congested conditions. Theoretically, the metrics derived from the EconWorks Reliability tool (travel time index) can be used to derive a buffer time index in TREDIS. Additionally, the delay costs in EconWorks Reliability tool are derived considering only weekdays (260 days in a year), while TREDIS considers weekends as well (365 days in a year). The EconWorks Reliability tool cannot be modified to consider the entire week. In terms of the value of each unit of travel time, the EconWorks Reliability tool uses the concept of reliability ratio to estimate the cost of reliability. TREDIS, on the other hand, provides default values that can be overridden.

In terms of the easiness of use, the EconWorks Reliability tool relies on data inputs that can be easily obtained from travel demand models or traffic count stations. The SHRP2 Reliability theoretical approach uses built-in functions of TTI and default hourly distributions (per type of facility and AADT to Volume ratios, see Appendix A) that facilitate the analysis and minimize the need to calibrate values. In the case of the reliability analysis in TREDIS, the data is taken from the traffic characteristics module which in turn relies on data that can be easily obtained from a travel demand model. However, TREDIS requires the estimation of a key parameter for the BTI calculation which is the percentage of VMT under congestion for each mode. The calculation of this value can be a little challenging if that information by mode is not available at the link level. In conclusion, it could be inferred that for this type of analysis, the EconWorks Reliability Tool presents some advantages over the TREDIS in terms of the data requirements.

Comparison in terms of Market Access and Connectivity Analysis

TREDIS includes the evaluation of buyer-supplier market access, labor market access, and intermodal connectivity benefits in a single module (Market Access Module), while in the case of EconWorks W.E.B. tools, three separate tools were developed for the evaluation of the

aforementioned benefits. The independent tools offered by SHRP2 allow the user to focus on the analysis of a single economic impact category. On the other hand, this individual estimation of wider economic impacts may result in double counting of economic benefits. This overlap of economic benefits could occur because the measure of one type of access (such as effective density in the buyer-supplier market access tool) could partly take into account the benefits related to another type of access (such as labor market access) as well; this could become problematic when both EconWorks W.E.B. tools of the Accessibility module are used and their results are added. On the other hand, the approach followed by TREDIS does not allow for benefits overlap. The measures of market access and connectivity used by TREDIS and EconWorks W.E.B. tools are fundamentally different. For example, TREDIS uses the change in employment reached within 3 hours of driving time as a proxy for measuring buyer-supplier market access variation due to a transportation improvement, while the EconWorks W.E.B. tools employ the notion of effective density to capture this variation in market access. Furthermore, in the EconWorks W.E.B. tools, the change in market access and connectivity is translated into monetary terms with the use of productivity elasticities, which are retrieved from relevant literature. However, TREDIS model parameters (equivalent to productivity elasticities) are included in the software, which makes the analysis more practical for the user.

Regarding the easiness of use, it can be concluded that the Market Access Module in TREDIS is less data intensive and easier to use compared to the EconWorks W.E.B. tools. Although TREDIS requires a lot of background project information, the Market Access Module does not require detailed data. On the other hand, the EconWorks W.E.B. tools require the user to provide employment data, O-D impedance, O-D trips, GRP and other not readily available data that could take significant time to collect, especially if a traffic demand model is used. Last, the EconWorks Specialized Labor Market Access tool has some functionality issues that appear in the form of incomprehensive pop-up error messages, which terminate the analysis process without results. These error messages appeared when trying to re-run the tool after the first successful run. To address this issue, the tool had to be re-downloaded and all inputs had to be re-entered for every run.

5.2 APPLICABILITY OF THE ECONWORKS W.E.B. TOOLS AND LESSONS LEARNED

The EconWorks W.E.B. tools can be used for the analysis of the wider economic impacts of projects related to new highway/road construction, highway capacity improvement, highway congestion relief, and accessibility improvement of intermodal facilities. The EconWorks W.E.B. tool selected for analyzing a specific project should match the main project objective. For example, if the principal goal of the project is the improvement of freight mobility in the region (as in the case of the SR-3 capacity improvement), the EconWorks Buyer-Supplier Market Access tool should be used. On the other hand, if the project focuses on relieving traffic congestion on a small highway segment, the EconWorks Reliability tool should be chosen. It is possible that a project could serve more than one purpose; in this case, the analyst should choose the tool that is more relevant to the project. Caution should be taken when benefits from more than one of the EconWorks W.E.B. tools are estimated for a single project, to avoid benefit overlap. The same, however, does not hold for TREDIS. TREDIS has incorporated the analysis of buyer-supplier markets access, labor markets access and intermodal connectivity into a single module, the Market Access module, which ensures that there will be no benefit overlap if all three previously-mentioned changes occur for the same project.

Table 5.1 presents a tool selection process based on the project objective and relevant traffic and activity-related thresholds, adopted from NCHRP (2014). The traditional benefit analysis includes the estimation of travel time, vehicle operating cost, safety and economic benefits related to the project, and is appropriate for all project objectives shown in Table 5.1. TREDIS is able to conduct traditional benefit analysis as well as wider economic impact analysis, while the EconWorks W.E.B. tools could only be used for the analysis of wider economic impacts. In contrast to the EconWorks Case Studies, which presents a range of values for the economic benefits measured, TREDIS and the EconWorks W.E.B. tools provide single values of the outputs. In addition, neither tool accounts for uncertainty in the analysis inputs (such as future traffic, travel time savings, future trips) as well as outputs. Lessons learned associated with each individual tool as well as TREDIS are presented in the following sections.

Table 5.1 Selection of Analysis Tool Based on Project Objective and Relevant Thresholds
(Source: NCHRP, 2014)

Project Objective	Threshold Factor	Traditional Benefit Cost Analysis ^c	EconWorks W.E.B. Tools	TREDIS ^e
Travel time reduction (due to speed or distance change)	Annual Reduction in VHT > 80,000 hours	x	-	x
Capacity improvement/congestion relief	LOS ^a ≥ D	x	Reliability Tool	x
Travel time reliability improvement (incident delay reduction due to congestion relief)	TTI ^b > 1.3	x	Reliability Tool	x
Metropolitan area accessibility improvement between housing and employment centers	Population > 50,000 and Density > 1,800/sq.mile	x	Specialized Labor Market Access Tool or Buyer-Supplier Market Access Tool ^d	x
Metropolitan or regional business delivery accessibility improvement	Trucks > 12% of all vehicles	x	Buyer-Supplier Market Access Tool	x
Intermodal terminal connectivity improvement	Trucks > 12% of all vehicles	x	Connectivity Tool	x

^a Level of Service Index

^b Travel Time Index

^c The “x” symbol in this column means that traditional benefit analysis is appropriate for the project in question

^d The EconWorks Buyer-Supplier Market Access tool could be used instead of the Labor Markets Tool for labor market access analysis, if population data is used instead of employment, and only the change in effective density is considered as final output (and not the productivity benefits)

^e The “x” symbol in this column means that TREDIS can be used for the analysis of the project in question

5.2.1 EconWorks Reliability Tool – Lessons Learned

In terms of the inputs, the Reliability tool brings a set of pre-built hourly volume distributions that cannot be adjusted to fit local conditions. For that reason, an analysis of the peak hour period might not reflect the real values. Additionally, the tool does not separate the benefits for each specific trip’s purpose. Moreover, the travel time unit cost for passengers might not be reflecting the cost of business trips or commuting trips. Also, despite the tool guidelines mentioning the range of Reliability ratios, there is no detailed explanation of how to estimate the value of reliability (VOR) for local conditions or specific type of traffic or industry being analyzed. Therefore, further research is necessary. Lastly, the thresholds of TTI>1.3 and v/c ratios over 0.85, which are recommended for the applicability of the tool, might not be sufficient to recognize projects in which reliability improvements are expected.

5.2.2 EconWorks Buyer-Supplier Market Access Tool – Lessons Learned

For the EconWorks Buyer-Supplier Market Access tool, the user needs to specify the unit of analysis or zone (TAZ, county, metropolitan area) and, consequently, the number of zones affected by the project in question. However, SHPR2 (2014) reports that the tool should not be used when the impact area consists of more than 30 zones. Therefore, it can be understood that the analysis cannot be conducted at the TAZ level (because only a maximum of 30 TAZs could be included, which are too few to capture wider market access benefits) and it should be conducted at a higher level (county or metropolitan area). Furthermore, SHRP2 (2014) suggests a process for the estimation of a proxy GRP for counties (presented in Section 2.3.1). This process results in an approximation of the regional economic activity; for more reliable GRP values, the user could consult with private providers.

With respect to the output provided, the tool estimates the change in effective density and the business productivity benefits from the market access expansion for given employment in the region. The tool does not provide estimates of new employment activity in the region or jobs added due to the transportation improvement. Moreover, the business productivity benefits refer only to the year specified for the build scenario (reference year) and not to the entire analysis period. Last but not least, the tool can provide productivity benefits for a single industry sector, if employment data for that sector is entered in the tool. However, the analysis of each industry sector needs to be conducted individually, and the tool is not able to provide productivity benefits across different sectors at once.

The EconWorks Buyer-Supplier Market Access tool was mainly designed to provide preliminary assistance in estimating regional changes in customer delivery and supplier market access from a transportation project. However, the tool can be used for the evaluation of labor market access benefits, if population data is used instead of employment. In this case, only the change in effective density can be used as a final output. The productivity benefits do not refer to labor market benefits and would not be a realistic output for this case.

5.2.2 EconWorks Specialized Labor Market Access Tool – Lessons Learned

The EconWorks Specialized Labor Market Access tool is mostly useful when the transportation improvement links a place of work to a place of residence and, simultaneously, the study area includes specialized industry sectors (SHRP2, 2014). The theoretical background associated with

this tool is difficult to evaluate, because SHRP2 (2014) did not provide mathematical definitions for all outputs. No mathematical definition was provided for zone and employment accessibility, and an incomplete definition was provided for the concentration index. Moreover, regarding the commuter costs, which represent savings for personal commute and business trips for all O-D pairs due to a certain project, the software output includes only the dollar amount of the change in commuter costs, and therefore, it is not possible to estimate a percentage change and evaluate the magnitude of the savings. Furthermore, the tool showed some functionality issues when the threshold impedance sensitivity analysis was attempted. Specifically, the tool had to be re-downloaded and all inputs had to be re-entered for every run; otherwise, an error would appear and the tool would not provide results.

As previously mentioned for the EconWorks Buyer-Supplier Market Access tool, the outputs of this tool as well refer only to the year specified for the build scenario (reference year) and not to the entire analysis period. Furthermore, the tool cannot provide labor market access benefits across different sectors at once; the analysis for each industry sector needs to be conducted individually.

5.2.5 TREDIS – Lessons Learned for Reliability and Market Access Analysis

Some important lessons were learned from evaluating the wider economic impacts of the U.S. 36 and SR-3 projects with TREDIS (version 4.0):

- When TREDIS measures reliability, the separation of recurring congestion (expected delays, like special events) and nonrecurring congestion (unexpected delays, like incidents) is not quite clear. Factors that can lead to unreliable travel times include incidents, inclement weather, work zones, special events, traffic control device timing, demand fluctuations, and inadequate base capacity (based on prevailing geometrics and traffic patterns) (SHRP, 2013). However, TREDIS estimates the reliability based on the Buffer Time Index (BTI) that only describes the overall relationship between the fraction of congested vehicle-miles-traveled (VMT) and fraction of additional time that should be budgeted to ensure an on-time arrival. Therefore, this Buffer Time Index (BTI) cannot indicate the source of the delay.
- TREDIS does not distinguish highways according to their functional classification for reliability analysis. The Buffer Time Index (BTI) adopted in TREDIS is a general

estimation for all highway modes, so users cannot calculate corresponding delay costs for different classes of highways, such as freeways, signalized arterials, and rural roadways.

- TREDIS takes into account the number of induced trips in the travel cost analysis, so it is important to balance the additional trips if the vehicle trips are different in the build and no-build scenario for the same analysis year.
- The default values for population and employment in the market access module of TREDIS are reference values that can be updated. The accuracy of the prediction in terms of the productivity benefits in the analysis year depends on the precision of the forecast estimates of population and employment from the no-build scenario to the build scenario.
- The “linked area” feature in TREDIS does not have explicit impact on the resulting estimates. Although the importance of the definition of the study area was stressed in the TREDIS technical documentation (Benefits Cost Module Version 4.0, page 6), the “linked area” feature cannot effectively capture the induced wider benefits from the project in the area surrounding the study region (the place where the project would take place).
- The business productivity from a specific industry sector cannot be estimated in TREDIS. TREDIS employs IMPLAN – CRIO, which is a dynamic input-output model. The industry sectors embedded in IMPLAN – CRIO are fixed for each county and are imported into the Economic Adjustment Module in TREDIS at the beginning of the analysis, so users can view the business productivity results by sector for all sectors aggregated, but users cannot customize the list of industry sectors.

5.3 IMPLEMENTATION

Integration in INDOT’s decision-making processes

The Indiana Department of Transportation (INDOT) is considering several avenues to discuss and enable the incorporation of the Econ Works W.E.B. tools in the decision making process at different stages. This set of actions is chronologically summarized in Appendix E.

INDOT also identified a few challenges in the wide implementation of these tools, such as staff training in economic modeling (need for in-depth knowledge to explain the process, answer tough questions, and defend the results), available staff resources (need for a dedicated person to take

on and sustain this activity over time), and time (need for marketing the tool and updating and adjusting the business rules as needed).

INDOT Reports

INDOT recognized three main types of reports. First, a system of economic analysis portfolios for key corridor improvements in a project-by-project basis will be used for communications with different agents in the decision-making making process, including the executive office, stakeholders, and general public. The portfolios will also be used for project discussions with asset teams in Indiana. Second, INDOT will also prepare ad-doc reports to respond to executive levels inquiries. Finally, INDOT will prepare reports showing aggregate statistics on INDOT's expenses on key corridors and the expected return on investment in terms of jobs, real income, business impacts, and system reliability, among others.

Agency and MPO Business Rules for Economic Analysis

There is a strong interest in the use of economic analysis in project decision-making, engaging stakeholders, and the general public, particularly with MAP-21 and performance base planning and asset management requirements. The issue is consistency. INDOT will need consistent definition, assumptions, approach between INDOT and the MPOs, and comparing the benefits of different modal analysis. The second issue will be working through disagreement if there is MPO and an INDOT economic analysis. There will be a need for a forum to discuss early coordination between the agencies for economic analysis to work out and agree upon assumptions, definitions, and approach. Business rules can be developed through Indiana Model User's Group (MUG) and documented in the joint INDOT/MPO Planning Roles and Responsibilities document. The MUG includes technical members from INDOT and the MPOs, consultants, and researchers. INDOT and MPOs will need to agree on and document the appropriate use of the tools, data input sources, default value assumptions, model availability and performance, and other related topics.

Agency and MPO Implementation Plan for Economic Analysis

INDOT has already developed a mechanism. The Model User's Group (MUG) will be used to discuss and develop an implementation plan and also to identify technical needs; staff resources, training, follow-up discussions, and potentially a statewide on-call consultant or FHWA Resource Center to answer complex questions and approaches. The INDOT/MPO Planning Roles and Responsibility Document will be used to reference the business rule. The document is a joint agreement with INDOT, the MPOs, and RPOs on how we carry-out coordinate basic to technical

transportation planning activities. Revisions to INDOT's scoring mechanism will start the summer of 2016 with implementation expected in early fall 2016, prior to the next statewide call for projects.

Future INDOT Studies and Indiana Specific Tools and Applications

INDOT plans to use the EconWorks Connectivity tool on projects that provide linkages to multimodal facilities. In addition, INDOT has prepared a list of future studies and documents for EconWorks and TREDIS. These include:

- New 2018 Long Range Transportation Plan, which supports new performance based requirement.
- New 2018 Statewide Corridor Vision Plan. This constitutes a good base for estimating and reporting economic impacts of various recommended strategies.
- Statewide Interchange Planning Study (potential use).
- Transportation Asset Management Plan (potential use).

Furthermore, INDOT is considering the Tool for Operations Benefit Cost Analysis (TOPS-BC) developed by the Federal Highway Administration (FHWA) as well as other tools for the economic analysis of transportation system management and operations strategies such as road diet projects and access management for a broader comparison of strategies. This tool is currently under development by the Purdue Research Team.

5.4 FUTURE RESEARCH

For the case studies conducted as part of this study, data from ISTDM was used, when appropriate. Although ISTDM is the most reliable source of traffic, trips, and travel time-related data for Indiana, it is also highly time consuming. Running the statewide model for a single scenario could take around 24 hours. If further analysis (such as selective link analysis or matrix aggregation) is necessary, the processing time for a single scenario could double. Therefore, ISTDM should be used only when a high level of detail in the analysis and results is required, while other sources (such as ArcGIS online for O-D travel time data) could be used for middle-stage planning. Future research could thus investigate the use of readily available data (for practicality purposes) as inputs in the EconWorks W.E.B. tools and how this could impact the tools' results in comparison to the results presented in this study. Moreover, the conclusions drawn from the sensitivity analysis are based on one case study per tool. Future research could

investigate how the results and sensitivity to certain parameters vary by project type. Furthermore, because TREDIS includes buyer-supplier market access, labor market access, and connectivity benefits into a single module (the Market Access Module), it would be interesting to apply all three market and connectivity-related EconWorks W.E.B. tools to a single project and compare the results with the TREDIS Market Access Module to investigate differences in the magnitude of total productivity benefits and the possibility of benefits overlap in the EconWorks W.E.B. tools. Last, this study limited its focus to evaluate the EconWorks W.E.B. tools and their synergies with TREDIS. In the future, a similar evaluation could be conducted for the EconWorks W.E.B. tools and MCIBAS or other commercial software such as REMI.

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APPENDICES

APPENDIX A

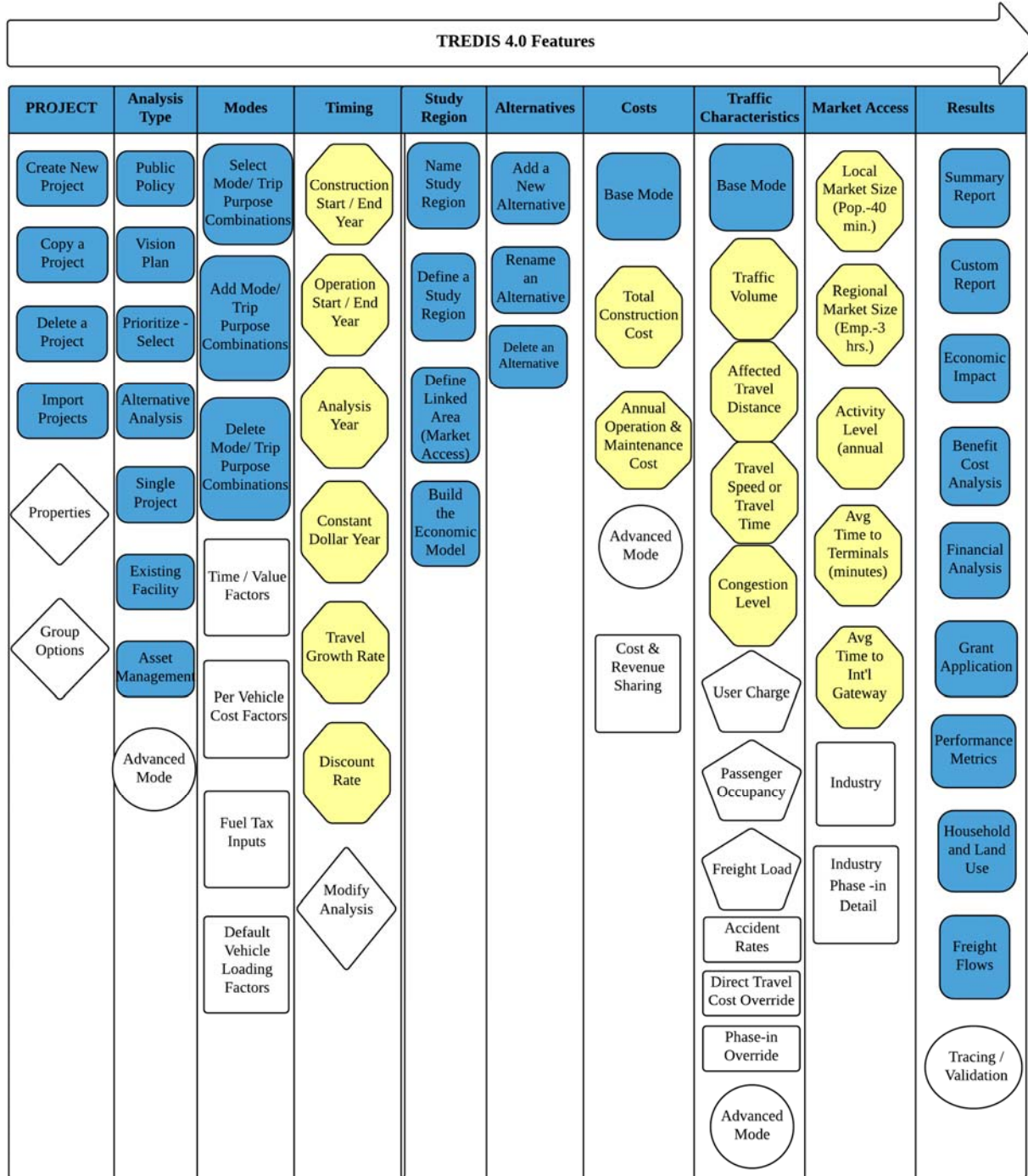
Hourly Volume Distribution Considered in the EconWorks Reliability Tool

Hour ending	Freeway, Weekday												Other, Weekday																							
	LE7						7.1-11.0						GT 11						LE7						7.1-11.0						GT 11					
	Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction		Peak Direction	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.				
	Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume		Percent of Daily Volume					
1	0.42	0.58	0.44	0.57	0.47	0.54	0.34	0.47	0.37	0.47	0.34	0.47	0.37	0.47	0.34	0.47	0.37	0.47	0.34	0.47	0.37	0.47	0.34	0.47	0.37	0.47	0.34	0.47	0.37	0.47	0.34	0.47				
2	0.27	0.33	0.27	0.34	0.27	0.32	0.21	0.28	0.23	0.28	0.21	0.28	0.23	0.28	0.21	0.28	0.23	0.28	0.21	0.28	0.23	0.28	0.21	0.28	0.23	0.28	0.21	0.28	0.23	0.28	0.21	0.28				
3	0.23	0.25	0.22	0.26	0.2	0.24	0.15	0.18	0.17	0.18	0.15	0.18	0.17	0.18	0.15	0.18	0.17	0.18	0.15	0.18	0.17	0.18	0.15	0.18	0.17	0.18	0.15	0.18	0.17	0.18	0.15	0.18				
4	0.23	0.22	0.21	0.21	0.18	0.18	0.14	0.14	0.16	0.14	0.14	0.14	0.16	0.14	0.14	0.14	0.16	0.14	0.14	0.14	0.16	0.14	0.14	0.14	0.16	0.14	0.14	0.14	0.16	0.14	0.14					
5	0.38	0.29	0.35	0.28	0.31	0.25	0.24	0.18	0.28	0.24	0.18	0.24	0.28	0.24	0.18	0.24	0.28	0.24	0.18	0.24	0.28	0.24	0.18	0.24	0.28	0.24	0.18	0.24	0.28	0.24	0.18					
6	1.17	0.68	1.12	0.69	1.06	0.72	0.74	0.42	0.81	0.74	0.42	0.74	0.81	0.74	0.42	0.74	0.81	0.74	0.42	0.74	0.81	0.74	0.42	0.74	0.81	0.74	0.42	0.74	0.81	0.74	0.42					
7	3.26	1.75	3.16	1.9	2.86	2.18	2.23	1.19	2.85	2.23	1.19	2.28	3.85	2.39	2.28	3.85	2.39	2.28	3.85	2.39	2.28	3.85	2.39	2.28	3.85	2.39	2.28	3.85	2.39	2.28	3.85					
8	4.83	2.9	4.59	3.05	3.9	3.27	4.11	2.18	4.11	2.18	2.18	4.11	2.18	4.11	2.18	4.11	2.18	4.11	2.18	4.11	2.18	4.11	2.18	4.11	2.18	4.11	2.18	4.11	2.18	4.11	2.18					
9	3.56	2.57	3.8	2.76	3.66	3.04	3.45	2.33	3.42	2.33	3.42	2.33	3.42	2.33	3.42	2.33	3.42	2.33	3.42	2.33	3.42	2.33	3.42	2.33	3.42	2.33	3.42	2.33	3.42	2.33	3.42					
10	2.58	2.24	2.75	2.3	2.94	2.53	2.64	2.29	2.69	2.29	2.64	2.29	2.69	2.29	2.64	2.29	2.69	2.29	2.64	2.29	2.69	2.29	2.64	2.29	2.69	2.29	2.64	2.29	2.69	2.29						
11	2.46	2.33	2.5	2.34	2.68	2.49	2.64	2.56	2.65	2.56	2.64	2.56	2.65	2.56	2.64	2.56	2.65	2.56	2.64	2.56	2.65	2.56	2.64	2.56	2.65	2.56	2.64	2.56	2.65	2.56						
12	2.56	2.56	2.61	2.61	2.73	2.69	2.9	3.02	2.9	3.02	2.9	3.02	2.9	3.02	2.9	3.02	2.9	3.02	2.9	3.02	2.9	3.02	2.9	3.02	2.9	3.02	2.9	3.02	2.9	3.02	2.9					
13	2.65	2.71	2.68	2.75	2.75	2.78	3.2	3.35	3.17	3.3	3.2	3.35	3.17	3.3	3.2	3.35	3.17	3.3	3.2	3.35	3.17	3.3	3.2	3.35	3.17	3.3	3.2	3.35	3.17	3.3						
14	2.7	2.77	2.75	2.81	2.82	2.86	3.14	3.24	3.14	3.24	3.14	3.24	3.14	3.24	3.14	3.24	3.14	3.24	3.14	3.24	3.14	3.24	3.14	3.24	3.14	3.24	3.14	3.24	3.14	3.24						
15	2.93	3.12	2.93	3.15	2.97	3.15	3.18	3.44	3.12	3.37	3.18	3.44	3.12	3.37	3.18	3.44	3.12	3.37	3.18	3.44	3.12	3.37	3.18	3.44	3.12	3.37	3.18	3.44	3.12	3.37						
16	3.26	4.01	3.21	3.87	3.21	3.6	3.4	4.13	3.35	3.93	3.4	4.13	3.35	3.93	3.4	4.13	3.35	3.93	3.4	4.13	3.35	3.93	3.4	4.13	3.35	3.93	3.4	4.13	3.35	3.93						
17	3.47	4.81	3.38	4.43	3.28	3.82	3.46	4.78	3.49	4.49	3.46	4.78	3.49	4.49	3.46	4.78	3.49	4.49	3.46	4.78	3.49	4.49	3.46	4.78	3.49	4.49	3.46	4.78	3.49	4.49						
18	3.42	4.85	3.32	4.39	3.29	3.77	3.31	4.83	3.45	4.55	3.31	4.83	3.45	4.55	3.31	4.83	3.45	4.55	3.31	4.83	3.45	4.55	3.31	4.83	3.45	4.55	3.31	4.83	3.45	4.55						
19	2.66	3.23	2.66	3.2	2.82	3.22	2.68	3.23	2.75	3.31	2.68	3.23	2.75	3.31	2.68	3.23	2.75	3.31	2.68	3.23	2.75	3.31	2.68	3.23	2.75	3.31	2.68	3.23	2.75	3.31						
20	1.95	2.23	1.97	2.25	2.12	2.36	2.14	2.41	2.18	2.53	2.14	2.41	2.18	2.53	2.14	2.41	2.18	2.53	2.14	2.41	2.18	2.53	2.14	2.41	2.18	2.53	2.14	2.41	2.18	2.53						
21	1.54	1.78	1.54	1.79	1.62	1.86	1.73	1.97	1.75	2.07	1.73	1.97	1.75	2.07	1.73	1.97	1.75	2.07	1.73	1.97	1.75	2.07	1.73	1.97	1.75	2.07	1.73	1.97	1.75	2.07						
22	1.4	1.63	1.44	1.69	1.54	1.74	1.49	1.71	1.5	1.77	1.49	1.71	1.5	1.77	1.49	1.71	1.5	1.77	1.49	1.71	1.5	1.77	1.49	1.71	1.5	1.77	1.49	1.71	1.5	1.77						
23	1.14	1.3	1.19	1.39	1.27	1.46	1.1	1.26	1.11	1.25	1.1	1.26	1.11	1.25	1.1	1.26	1.11	1.25	1.1	1.26	1.11	1.25	1.1	1.26	1.11	1.25	1.1	1.26	1.11	1.25						
24	0.79	0.98	0.83	1.05	0.89	1.07	0.74	0.94	0.75	0.9	0.74	0.94	0.75	0.9	0.74	0.94	0.75	0.9	0.74	0.94	0.75	0.9	0.74	0.94	0.75	0.9	0.74	0.94	0.75	0.9						
Total	49.87	50.13	49.92	50.08	49.84	50.16	49.36	50.64	49.67	50.33	49.36	50.64	49.67	50.33	49.36	50.64	49.67	50.33	49.36	50.64	49.67	50.33	49.36	50.64	49.67	50.33	49.36	50.64	49.67	50.33						

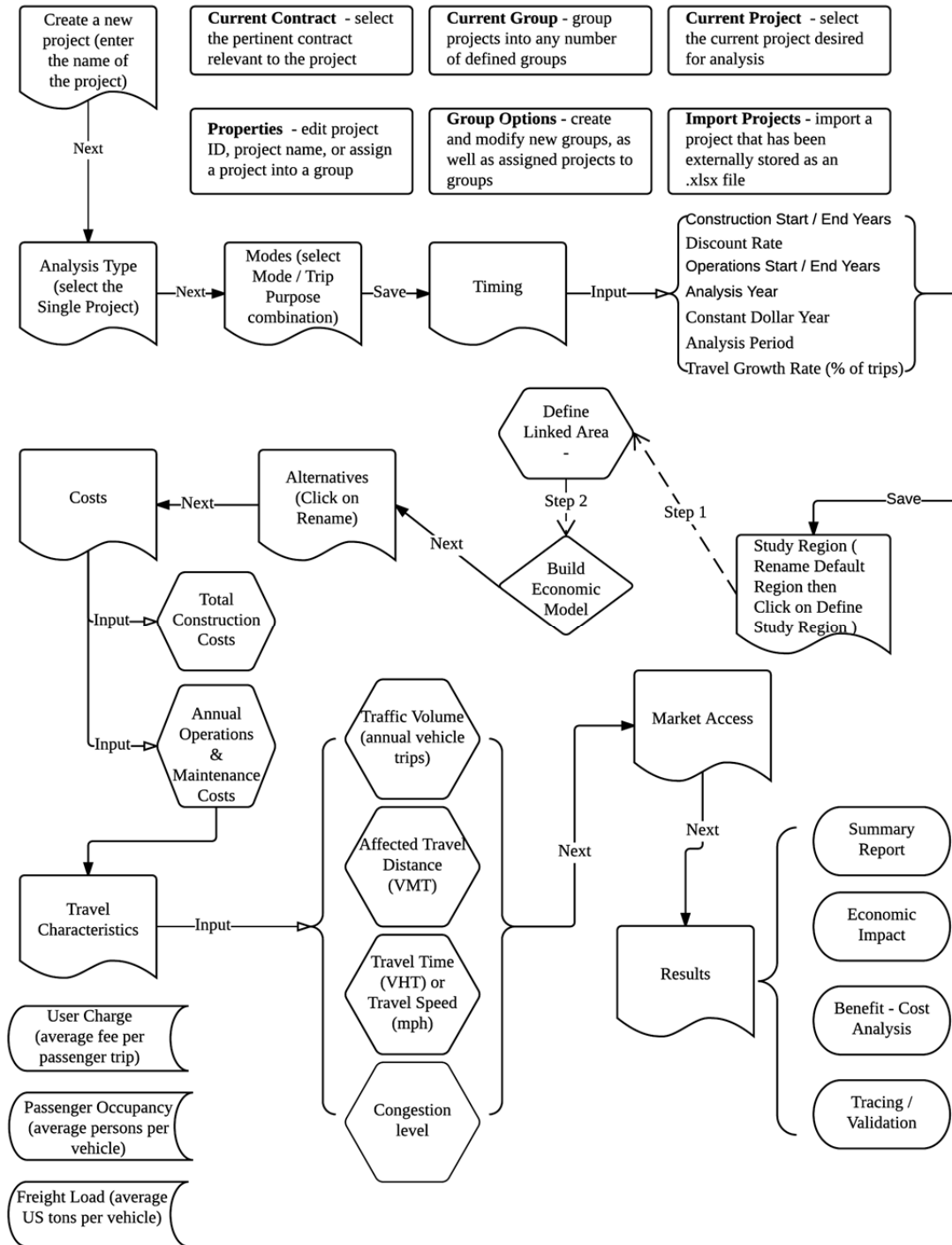
Figure A.1 Steps for Evaluation of Productivity Impacts in the Reliability Tool (Adapted from SHRP2, 2014)

APPENDIX B

TREDIS 4.0 Features



TREDIS 4.0 User Guidance – Single Project Flow Chart



APPENDIX C

Reliability Analysis for the SR-3, Rushville Bypass Segment

The SR-3 project also involves the construction of two bypasses along the cities of Spiceland and Rushville. In that sense, an analysis of the possible benefits from reducing travel time reliability was conducted for the Rushville segment. Since the volume to capacity ratios are smaller than the recommended threshold of 0.85 (recommended in NCHRP, 2014) for both bypasses, a sensitivity analysis of future traffic volumes was conducted. Table A.1 summarizes the main inputs used in the analysis, while Table A.2 and Figure A.1 depicts the results. It could be seen that for the existing projection of traffic volumes in 2035, there are no benefits due to improvements in reliability because the level of congestion is not high.

Table A.1 Reliability Inputs for the SR-3, Bypass of Rushville, IN

Metric	Value	Source
AADT	5900	indot.ms2soft.com
%Trucks	14%	Same as AADT
Time Horizon	20 years	
Number of Lanes	2 / 4	Indiana Blue Ribbon Panel (2014)
Peak Capacity Period	3:00 p.m. 7:00 p.m.	Same as AADT
Growth Rate	1.5%	Same as AADT
Travel time unit cost	\$19.86, \$36.055	(SHRP2, 2014)
Reliability Ratio	0.8, 1.1	Same as travel unit cost unit cost

Table A.2 Reliability Outputs for the SR-3, Bypass of Rushville, IN (2035)

Metric	SR03-Rushville - Base condition - Base scenario	SR03-Rushville - Base condition - Build scenario
<i>Congestion Metrics</i>		
Future year – 2035	1.00	1.00
TTI95	1.00	1.00
TTI80	1.00	1.00
TTI50	1.00	1.00
Pct. trips less than 45 mph	0.02%	0.00%
Pct. trips less than 30 mph	0.54%	0.53%
<i>Total Annual Weekday Delay (veh-hrs)</i>		
Total Equivalent Delay	0	0
Recurring Equivalent Delay	0	0
Passenger Delay	0	0

Metric	SR03-Rushville - Base condition - Base scenario	SR03-Rushville - Base condition - Build scenario
Commercial Delay	0	0
Incident Equivalent Delay	0	0
Passenger Delay	0	0
Commercial Delay	0	0
<i>Total Annual Weekday</i>		
<i>Congestion Costs (\$)</i>		
Total Equivalent Delay	\$0	\$0
Recurring Equivalent Delay	\$0	\$0
Passenger Delay	\$0	\$0
Commercial Delay	\$0	\$0

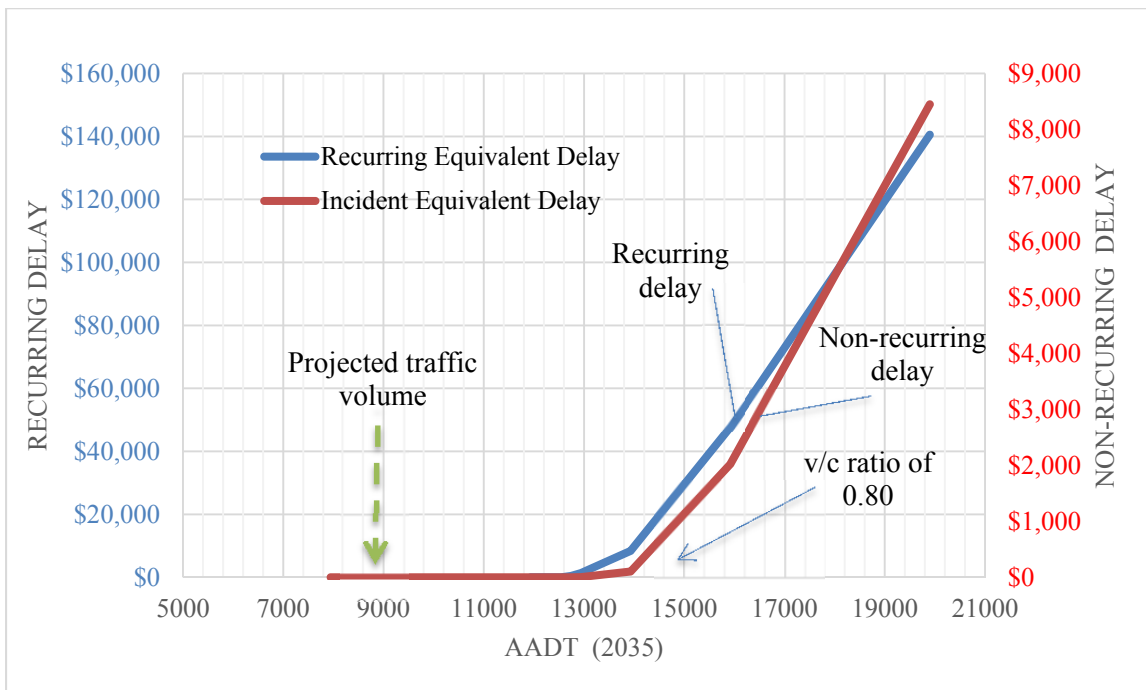
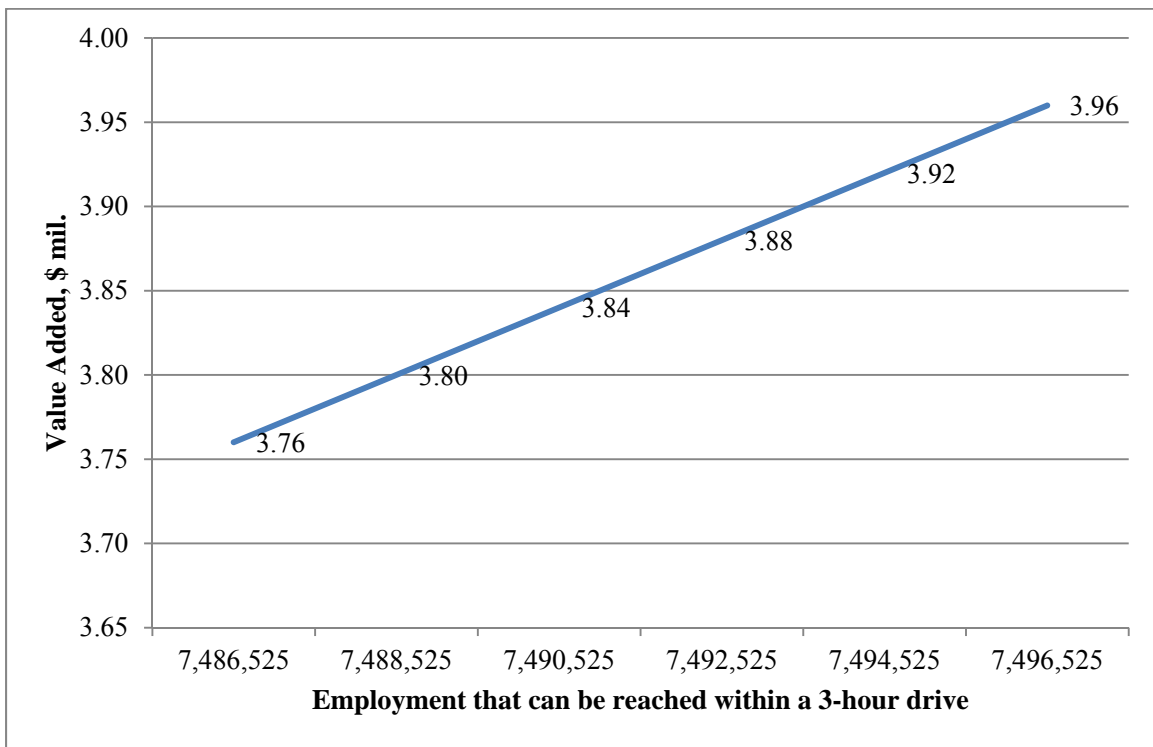


Figure A.2 Sensitivity analysis for the recurring and non-recurring delay in the SR-3, Bypass of Rushville, IN.

APPENDIX D

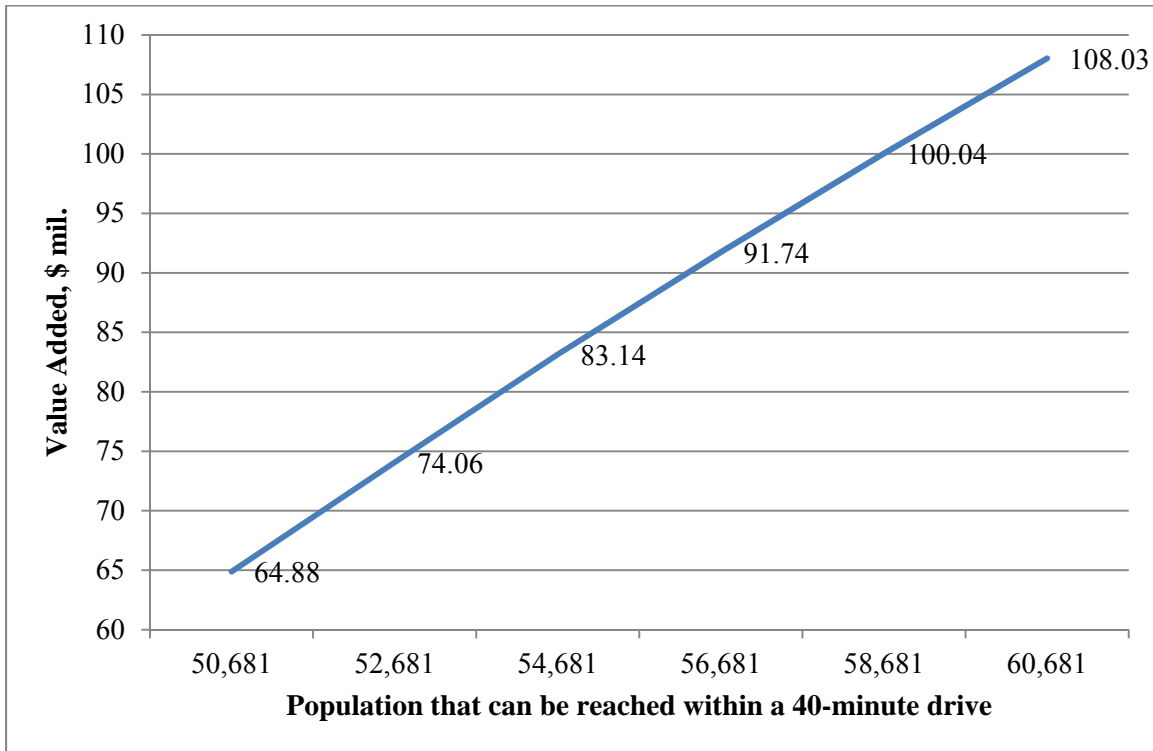
The employment and population data for the build case required in TREDIS are determined by measuring the employment that can be reached within a 3-hour drive and the population that can be reached within a 40-minute drive. A sensitivity analysis was conducted to inform analysts of the sensitivity of the results to these input parameters in the TREDIS Market Access Module.

Sensitivity Analysis of Access to Buyer-Supplier Markets in TREDIS for SR-3



The sensitivity analysis of buyer-supplier market access tool in TREDIS was conducted to explore the effect of the employment that can be reached within a 3-hour drive on the buyer-supplier market access results. The tool was run for a range of the employment data for the build case with an incremental rate of 2,000 while keeping all other inputs constant. It can be seen that change in employment caused a fixed increase on the value added. In another word, the value added increases \$0.2M for every 1,000 increase in employment.

Sensitivity Analysis of Access to Labor Markets in TREDIS for SR-3



A similar approach was adopted for the sensitivity analysis of labor market access tool in TREDIS to investigate the effect of the population that can be reached within a 40-minute drive on the labor market access results. The tool was also run for a range of the population data for the build case with an incremental rate of 2,000 while keeping all other inputs constant. Two conclusions can be drawn from the analysis. First, value added, as a proxy for the access to labor market or access to buyer-supplier market, is more sensitive to population changes than employment changes. Second, contrary to the previous analysis, changes in population did not cause a fixed increase in the value added.

APPENDIX E

Summary of Actions for the Incorporation of the EconWorks W.E.B. Tools in INDOT's Decision-Making Process

Date	Action Implemented/to Implement
October, 2015	Ongoing discussions with the Statewide Technical Services Director to ensure a representative from the technical planning or modeling team is at the table when the constrained list of major capacity adding projects scopes are being refined.
November, 2015	Employed the use of GIS to map projects. This will help visualize the project and proximity to multimodal facilities for use of the EconWorks Connectivity Tool.
December, 2015	Established annual district meetings with MPOs, RPOs, and each of the INDOT Districts to discuss existing projects, project coming in from the annual call, and future transportation needs. This will give the Team a head start to evaluate the constrained list of major capacity adding projects. INDOT discussed applying the tools for unconstrained projects, but resources are not available.
March-April 2016	INDOT and Purdue Researchers will conduct training sessions with the INDOT and the MPOs on EconWorks W.E.B.
April, 2016	The Technical Modeling Team will meet with select INDOT Executives, Indiana Economic Development Corporation Representatives, and Indiana Finance Authority to discuss the various economic and analysis tools, their capabilities and potential use. INDOT will then solicit this group for feedback on any additional usage.
May, 2016	The Technical Modeling Team will meet with interested MPOs to discuss incorporation of the EconWorks W.E.B. tools in their project development process. INDOT will ask that they document the process within 1-month of the discussion.
August, 2016	INDOT will have established a workflow to integrate the EconWorks Connectivity tool, TREDIS, and REMI into major capacity adding project development activities as well as preliminary analysis for the Executive Office. Need for dedicated staff is expected.
October-December 2016	Discussion with select asset teams, Freight Mobility Team, and MPOs on performance measures specific to the FAST Act and how these tools can assist with reporting performance results.
January-February 2017	Report the success of the tools and solicit for additional feedback, tool refinement, research assistance, MPO coordination, training needs, and refinement to business rules/work flow.