FINAL REPORT

SHRP2 EconWorks: Wider Economic Benefits Analysis Tools

Connecticut Department of Transportation

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Section 1: Introduction

CDM Smith has completed an evaluation of the EconWorks Wider Economic Benefits (W.E.B.) Analysis Tools for Connecticut Department of Transportation (CTDOT). The intent of this evaluation was to compare the results of the outputs of this toolkit to ostensibly similar results derived from the TREDIS economic impact model. As the review of the W.E.B. analysis tools progressed, it became evident that the detailed analysis completed by the project team using TREDIS and the statewide travel demand model and the W.E.B. analysis tools were not comparable. The reasons for this are:

- The W.E.B. tools do not produce benefit cost calculations but rather attempt to capture dimensions of impacts which are relatively new to practitioners, without regard to a comparison of benefits and costs or a complete economic impact analysis.
- The W.E.B. tools analyze reliability, accessibility and productivity, but the implementations of these impacts (the specific formulas used) are different than those found in TREDIS.
- In order to complete the evaluation of the W.E.B. tools in a timely manner and to cover as many of tools as possible, the project team limited the analysis to one or at most two time periods, and a single year evaluation. TREDIS produces discounted year by year results as part of the benefit/cost analysis; EconWorks W.E.B. does not apply a discount factor.

The team completed the review for several of the tools and several projects, focusing on the ease of use, utility and functionality of the tools. This report documents this review.

Section 2: Study Overview

The Strategic Highway Research Program 2 has deployed a suite of spreadsheet tools and guidebooks for assessing the broader implications of transportation investments. These tools and guidebooks provide analysis frameworks to understand the relationships between the interactions of transportation supply and demand as interpreted in measures of effectiveness that, previously, have not been explicitly and broadly considered in transportation impact and alternatives analysis. These tools offer the potential to broaden the range of factors and considerations taken into account when measuring and explaining the benefits and impacts of transportation investment or disinvestment.

There is a need to broaden and improve the understanding of a transportation project's effectiveness, through better conceptualization of transportation investment impacts (for policy makers and analysts), and better communication techniques and tools (for the general public and for decision-makers). The EconWorks W.E.B. program has proposed to address the first of these two needs.

For decades, analysts and policy makers have relied on a relatively static range of impact dimensions and techniques to estimate and describe transportation impacts in economic terms. For the past 50+ years, transportation *benefit cost analyses* have compared impacts to users and some non-users to a project's capital and operating costs. The range of impacts has included travel time, vehicle operating costs, out of pocket costs, safety costs and possibly the value of emissions impacts (noise, air) to the capital and operating costs of a project. *Economic impact analyses* translate the dollar value of the transportation impacts into broader societal impacts, using numerical relationships between transportation, spending and economic production, and between industries, households and government. These broader impacts include gross regional product, employment, and income.

The concepts that the EconWorks W.E.B. have introduced into the mainstream via the suite of tools are challenging to measure, and in some cases challenging to understand. Each is at a different level of maturity in terms of marketplace awareness and acceptance:

- Reliability, a measure of travel time predictability or variability. Relatively mature and accepted. With good travel time data, easy to measure. Difficult to forecast reliably, yet procedures exist to do so. The concept is easy to understand. There are multiple ways of measuring reliability, which can lead to confusion.

- Connectivity, a measure of how direct a transportation connection is between two areas between which there are economic interactions. Model formulation is based on travel time changes and interactions between a subject intermodal facility and other intermodal facilities. This tool presents a different perspective and way of measuring an idea that is well understood. With good travel time data, easy to measure. Relatively easy to forecast, and easy to understand.

- Labor markets accessibility, how an economy benefits when employers have better access to workers, especially skilled workers, in employment centers. A measure that has been part of the mainstream for years, without the economic impact dimension. Model application requires travel time and economic data, and if available, easy to measure. Relatively difficult to forecast, and moderately challenging to explain and understand.

- Supplier markets accessibility, how an economy benefits when producers have better access to labor inputs or consumer markets to create or sell their products, especially specialized inputs. A measure that is not as mature as connectivity/reliability and not broadly accepted. Model formulation is based on trip distribution concepts, and not firmly established. Productivity elasticity (a parameter) is difficult to understand and derive appropriately. Model application requires travel time and economic data, and if available, easy to measure. Relatively difficult to forecast, and difficult to understand.

Section 3: Summary of Findings

3.1 Reliability Tool

- The reliability tool was implemented successfully and appeared to produce reasonable and understandable results. The tool and more generally the approach could be considered for project alternatives analysis.

- The reliability tool could be adapted for multimodal analysis, including passenger rail, air passenger and bus transit analysis. It's possible that the tool can be adapted easily for these purposes; demonstrating how to make those adaptations in the user manual would be helpful.

- With HERE and INRIX vehicle speed probe data widely available, transportation agencies can develop their own reliability measures for forecasting in modeling applications.

- For ease of use, the reliability tool accepts a single volume for both directions of travel. On a typical corridor, there are many changes in volume in both directions of travel.

3.2 Connectivity Tool

- The connectivity tool was implemented successfully and appeared to produce reasonable and understandable results. The tool and more generally the approach could be considered for intermodal project alternatives analysis.

3.3 Buyer-Seller Market Access Tool

- The tool results show that a re-orientation of trips from employment destinations to park and ride lots in the rail analysis led to negative results for several zones. The team has considered resolving the problem by constraining the build congested travel times to be no greater than times in the no-build.

- The documentation notes that the tool is flexible in that in can accept different representations of activity data, including population, employment sectoral employment or a ratio of sectoral to total employment. It's unclear though what the tool is measuring in the case of population versus total employment inputs. Also, the documentation could be clearer in the explanation of some subscripts and in the explanation of elasticity. The documentation does not clearly explain what the elasticity means in practical terms and provides no guidance about how to select or determine one that would be appropriate for a particular industry.

3.4 Labor Market Access Tool

- The tool focuses on impacts to employment centers, which are generators of economic activity, and allows the user to specify sub-categories of employment.

- Additional guidance on interpreting the results would be welcomed.

- The analysis is built to compare a build and no-build, and these should correspond to the same year of analysis. A multi-year analysis capability within the tool would be welcomed.

3.5 General

- Like any software, the W.E.B. tools require some time to understand how to use them properly. However, the workbooks can crash without explanation, and they are lacking error trapping that are standard for professional applications. The workbooks have an unfinished feel to them.

- CTDOT has more refined tools at its disposal for impact analysis than are offered by the EconWorks W.E.B., namely the statewide travel demand model and the TREDIS economic impact model.

- Building in-house modeling and economic analysis capabilities would help CTDOT leverage the software and data resources of CTDOT.

Section 4: Analysis Context

In 2013, CTDOT initiated an update to the statewide strategic long range transportation plan (SLRP). The STP describes a long term portfolio of transportation investments and policies designed to achieve goals and objectives concerning mobility, safety, infrastructure condition, economic development, livability, quality of life and agency responsiveness and capacity. CTDOT reached out to the public, stakeholders, and partners (a broad spectrum of elected officials, industry advocates, and businesses) through large and small events, work sessions, surveys, webinars, and online interaction. Based on technical analyses and extensive public outreach, CTDOT developed a 30 year Let's GO CT vision plan identifying all critical preservation and enhancement needs. For this analysis, the following three projects were identified and selected from the Let's GO CT vision document.

4.1 I-95 between NY State Line and New Haven (I-95)

I-95 between the New York State Border and New Haven is the most congested corridor in Connecticut in terms of the severity, extent and duration of congestion experienced by motorists on a daily basis. This highly congested corridor constructed in the early 1950s has outgrown its ability to serve the region and current operations present significant congestion and safety issues. To address the congestion and operational issues, it has been proposed to add an additional operational lane in each direction along with congestion management practices, starting with the most congested segment i.e. between Bridgeport and Stamford. These projects are anticipated to enhance vehicular capacity, increase operational safety, and provide a significant benefit to the economic environment, as well as the ability of the coastal route to support tourism and recreation. The estimated cost of the I-95 improvements is $9.0 billion ($2013)

4.2 Metro-North Railroad Transit System Improvements

Metro-North Railroad (MNRR) is a suburban commuter rail service operated by the Metropolitan Transit Authority that runs service between New York City and suburbs of New York and Connecticut. Within Connecticut, it runs the New Haven line which is operated through a partnership between Metro-North and the State of Connecticut. The New Haven Line consists of three branch lines- New Canaan, Danbury and Waterbury branch lines. As part of the 30-year vision plan, CTDOT plans to improve operations on the New Haven and Branch Lines by expanding high frequency, fast service to/from New York City; expanding station access through parking, bike, shuttle, bus and pedestrian improvements and adding new equipment, upgrading stations, parking and equipment storage.

Between New York and New Haven, along the New Haven Line and Branch Lines, CTDOT has identified the following improvements as part of Let's GO CT:

- Restore rail infrastructure, including bridges, track, catenary
- Improve safety and reliability of service
- Expand and enhance service for more frequent and more express service
- Upgrade all 4 tracks to support high-frequency local service and express service
- Add and modernize stations
- Improve station access through parking expansion, bus connection, local shuttle service, and bike and pedestrian access

The estimated cost of the mainline improvements (excluding branch line improvements is $2.9 billon ($2013).

4.3 New Terminal B Passenger Facility and Associated Improvements at Bradley International Airport

CTDOT proposes to construct a new passenger terminal in the area occupied by the existing Terminal B at Bradley International Airport (BIA) in Windsor Locks, CT. The existing Terminal B complex, which includes the two attached concourses, the old International Arrivals Building, the grade-separated roadway, short-term parking and the airfield lighting substation, will be demolished for construction of a new terminal complex that will be designated as Terminal B. Key elements of the program include a new terminal building with concourses, a modified roadway system to access the terminal, new approach roadway alignments, and new parking facilities. The current plan is to build the terminal and concourses in phases as the demand for gates increases. The entire project, including the construction of the new terminal, is estimated to cost $574.5 million.

The proposed improvement includes the demolition of Economy Lot 1 and Economy/Employee Lot 2, which would be replaced by the new Terminal Arrivals & Departures Roadway, a realigned Schoephoester Road, and the Consolidated Rental Car (ConRAC) parking garage facility. A ConRAC facility is built to accommodate numerous rental car agencies. They are typically found at airports and may include on-site offices, fueling and maintenance services and also rental vehicle pick-up/drop-off areas. Currently, rental car facilities at Bradley Airport are located along Schoephoester Road between Postal Road and Light Lane.

The new parking garage would provide approximately 3,500 spaces, replacing 1,500 at-grade spaces in Lots 1 and 2. Approximately 2,250 of those spaces would be dedicated to the ConRAC facility, while the remaining 1,250 spaces would be used for short and long-term parking for Terminal B. This would result in an overall reduction of on-airport parking of 300 spaces. This facility is anticipated to be fully completed by 2018, and its availability for parking is anticipated to lead to an increase in vehicular traffic in the study area by 2018. Some additional traffic volume associated with the parking garage/ConRAC facility and other infrastructure improvements would also occur between 2018 and 2028, as use and occupancy rates rise.

CTDOT commissioned a traffic study to evaluate the potential transportation-related impacts of the proposed roadway alignment and ConRAC facility construction under existing, future No-Build and a future Build (Alternative) conditions. The planned improvements are expected to attract several hundred new trips during the peak hours of adjacent street traffic. With the addition of new spaces dedicated to the ConRAC facility, traffic circulation patterns are also anticipated to change between the No Build and Build conditions.

For the W.E.B. analysis, the project team considered the effect of moving the rental car facility from its current off-site location to the existing parking garage directly across from the terminal. In this analysis, the reduction in rental facility access times is somewhat offset by the increase in volume and delay at intersections leading to the airport.

Section 5: Tools and Projects

The project team tested four of the five tools produced by the EconWorks W.E.B. initiative. **Table 5-1** below shows which tools were used for which purpose. A brief description of each tool follows.

Table 5-1: EconWorks W.E.B. Tools Used by Project

Project	Labor	Supplier	Reliability	Connectivity
I-95	●	●	●	
MNRR	●	●		
BIA				●

5.1 Reliability Tool

The EconWorks W.E.B. reliability tool produces a sketch-level estimate of the value of travel time variability, for the non-signalized sections of roadways. The documentation that accompanies the tool provides a thoughtful and well-written explanation of reliability and summary of the research that preceded the creation of the tool.

5.1.1 Outputs and Calculations

The reliability tool produces travel time-based reliability indices, trip-based outputs, travel times and cost-based outputs for a future year of analysis, as shown in **Table 5-2**.

Table 5-2: Reliability Tool Outputs

Indices	Time-based	Trip-based	Cost-based
Travel time index (TTI)	Hours of recurring delay	Percentage of trips <45 mph	Total congestion cost
95th percentile TTI	Hours of incident delay	Percentage of trips <305 mph	Cost of recurring delay
80th percentile TTI			Cost of non-recurring delay
			Cost of unreliability

The Travel Time Index is the ratio of the peak-period travel time and the free-flow travel time. All time-based measures are sensitive to the definition of free-flow time. Some agencies use the speed limit as the free-flow time, while others use a percentile of speed during the overnight hours.

The reliability tool develops a distribution of hourly traffic volumes from a two-way look up table that varies by AADT (Average Annual Daily Traffic)/Capacity ratio. The distribution is based on an analysis of data and traffic simulations from 1994. The tool decomposes the hourly volumes into recurring and incident delay, based on formulas developed for other FHWA analysis tools. The 95th 80th, and 50th, percentile Travel Time Index formulas are based on curves fit to data in prior SHRP2 research (LO3, data rich and data poor analyses). Congestion is the sum of recurring and non-recurring delay, as calculated by equations that combine TTI values, free flow speeds and vehicle miles traveled. Travel time costs are simply the product of values of time and travel times (reliability- and non-reliability based).

5.1.2 Inputs

The reliability tool minimizes data requirements because it employs reliability relationships that have been estimated from meta-analyses or other, non-local research. The primary inputs and their sources are listed in **Table 5-3**. The added cost of unreliable time is set as a default to 0.8 times the recurring congestion time for personal travel and 1.5 for commercial travel, based on prior research (Stogios et al. 2013) as documented in the manual.

Table 5-3: Reliability Tool Inputs

Inventory Data	Traffic Data	Other	Cost-based
Mileage	Base year AADT	Peak capacity, using Highway Capacity Manual procedures	Auto and truck value of time
Roadway type	Annual traffic growth rate	Green time/cycle length ratio (for roads with signalized intersections)	Added cost of unreliable time (factor applied to congested time).
Number of lanes	Truck percentage	Terrain	
Free flow speed		Analysis time horizon (years)	

5.2 Access to Buyer-Seller Market Access Tool

The buyer-seller access tool estimates the value of transportation cost reductions (or increases) in travel to businesses, which depend on transportation for access to labor and for access to customer markets. Transportation cost savings can lead to higher business productivity for both forms of access.

5.2.1 Outputs and Calculations

Effective Density is an estimate of accessibility to employment in a given industry in a given location. It is measured by factoring the employment in a given location (employment zone) by the travel time between it and each zone from which a commute trip can originate. The values between the employment zone and each originating zone are summed. A scale factor is then applied to that result. The scale factor accounts for the relative size of the employment zone.

Potential Access is nearly identical to effective density. It is an estimate of accessibility to employment in a given industry in a given location. However, no scale factor is applied.

Productivity measures the economic output per worker, summed over all workers. The productivity measure relies on an elasticity factor (μ) which is expressed as a power (x^{μ}). The elasticity of productivity expresses the sensitivity of an area or an industry to changes in travel times. Prior research on this topic found that employers using more specialized occupations were more sensitive to changes in travel times than employers who could easily replace workers.

5.2.2 Inputs

The principal inputs needed for the buyer-seller market access tool are travel times between origins and destinations, trips between origins and destination socio-demographic data. The socio-demographic data is available from the US Census. To analyze a project and its future benefits, forecasts of the corresponding inputs must be acquired or developed. A summary of the inputs needed is shown in **Table 5-4**.

Table 5-4: Inputs for Supplier-Buyer Market Access Tool

Activity Data	Impedance	Economic Data
Employment (or population) by area	Congested travel times between commuter origins and employment destinations	Per Capita Gross Regional Product (or proxy)

Labor inputs. Commuter cost savings may lead to higher labor productivity or increases in personal disposable income. The fundamental idea underlying this tool is that highly specialized labor is hard to find and relatively expensive, and that transportation improvements can decrease that cost by increasing the market shed that is accessible to an employer per unit of time. The less specialized a labor market is, the lower the potential benefit of transportation improvements, from this tool's perspective. Thus, the labor market tool considers the underlying economic structure of a region from an employer's perspective in valuing transportation impacts.

Supplier inputs. Firms rely on raw materials and intermediate inputs for the goods that they produce. The more specialized the good, the harder it is to find a substitute when input prices rise. The less specialized the good, the easier it is for consumers or suppliers to find a substitute when input prices rise. Lowering transportation costs in regions whose businesses and regions depend on specialized inputs can produce a greater economic impact than in areas using less specialized inputs, all other things being equal.

5.3 Labor Market Tool

The labor market access tool estimates the value of transportation cost reductions (or increases) to commuters traveling to designated employment centers. To generate impacts, the commuters are considered as labor inputs for economic outputs. The labor market access tool uses a travel time threshold to determine whether to measure an employment area and the economic activity within it as accessible to commuter points of origin (i.e., household locations).

5.3.1 Outputs and Calculations

Labor Market Area is a count of the number of employment areas or zones that are accessible from commuter origins within a user defined threshold.

Workforce Market Area is a count of the number of employees in employment areas that are accessible from commuter origins within a user defined threshold.

Concentration Index is a measure of the relative competitiveness of a zone as measured by its accessibility as an employment center within a time threshold, to a particular industry, and compared to other employment centers.

Commuter Cost is the monetized value of in-vehicle times for all commuters traveling to an employment center.

5.3.2 Inputs

The two principal inputs needed for the labor market access tool are travel times between origins and destinations and detailed, industry-specific employment data. The employment data is available from the US Census or proprietary data sources. To analyze a project and its future benefits, forecasts of the corresponding inputs must be acquired or developed as well. A summary of the inputs needed is presented in **Table 5-5**.

Table 5-5: Inputs for Labor Market Access Tool

Activity Data	Impedance	Economic Data	Cost-based
Employment centers and employment	Congested travel times between commuter origins and employment center destinations	Per Capita Gross Regional Product (or proxy)	Wages/values of time
Number of trips between areas			

5.4 Connectivity Tool

The connectivity tool analyzes the benefits of improved transportation connections between origins and destinations that connect to an intermodal facility, namely an airport or a port. The tool focuses on the facility as the unit of analysis and generates impacts using information about: 1) the level of activity at the facility; 2) the number of connections between the facility and similar facilities in the United States and 3) changes in roadway access conditions to the facility. The tool is primarily designed for freight-focused analysis, but it can accommodate passenger analysis as well.

5.4.1 Outputs and Calculations

The connectivity tool estimates the level of connectivity of an intermodal port and the value of changes in access to the port.

Unique Origins/Destinations is a count of the number of destinations served by the facility, based on information from (in the case of airports) data from the Federal Aviation Administration (FAA). This information is independent of the roadway access improvement.

Facility Connectivity Raw Value is based on the product of the number of passengers served (from FAA data) and the number of cities served. This information is independent of the roadway access improvement.

Relative Activity compares the connectivity raw value of the facility to the facility with the highest value from the FAA data.

Relative Value compares the value of freight shipments to/from the facility with the highest value from the FAA data. The Bradley analysis considers passenger travel only, and the tool generates no value for this metric.

Relative Origins and Destinations compares the number of cities served by the facility to the facility with the highest value from the FAA data.

Relative Facility Connectivity Index is calculated as the product of the number of passengers served (from FAA data) and the number of cities served.

Number of Annual Passenger Vehicles Served is an input required of the user and is simply copied to the output page.

Associated Vehicles Served Factors vehicles served by the percentage of affected vehicles that use the facility.

Total Passenger Vehicle Hours Saved/Associated VHT is the product of the vehicles served and the time saved per vehicle.

Associate Passenger Vehicle Hours Saved factors the hours saved by the percentage of affected vehicles that use the facility.

Total Value applies the value of time to the time saved.

Total Associated Value factors the total value by the percentage of affected vehicles that use the facility.

5.4.2 Inputs

The inputs needed for the connectivity tool are:

1. The level of roadway activity related to the project
2. The level of activity associated with the airport
3. A distance sensitivity factor that disproportionately discounts improvements, the further away from the facility they are
4. The travel time savings produced by the improvement
5. The distance of the improvement from the facility and,
6. The value of time.

Section 6: Development of Inputs

The EconWorks W.E.B. tools require that decisions be made about certain input parameters and study parameters. This section focuses on the study parameters that are common to each of the three analyses. The analysis year for all projects is 2040.

6.1 Derivation of Project Impacts

The CTDOT statewide model, blended with impacts derived from prior analyses, was the primary evaluation tool used to create inputs for the W.E.B. tools. The research team adapted the statewide travel demand model for an economic impact analysis of expansion projects associated with Connecticut DOT's long-range statewide strategic transportation plan. The statewide travel demand model had been validated to match base year travel conditions for 2013. It produces impact assessments for four time periods: am, mid-day, pm and off-peak. For this analysis, 2040 pm peak outputs were used, unless otherwise indicated.

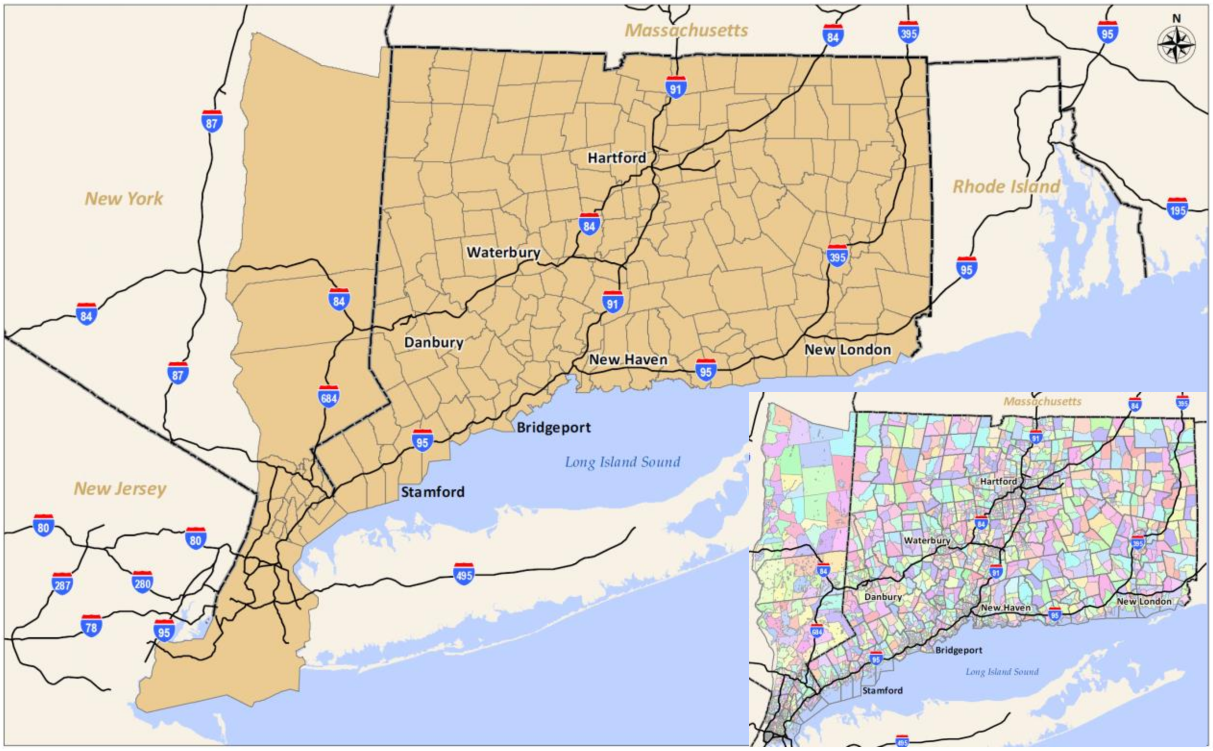
To overcome some of the limitations of the spreadsheet-based accessibility tools, the project team reduced the number of traffic analysis zones from 2240 to 184, and aggregated results for the use in the W.E.B. tools accordingly. The 184 zone system and the original 2240 zone system are shown in **Figure 6-1**.

- The impacts of the **I-95 widening** were analyzed directly from an application of the statewide travel demand model. The build forecast represents year 2040 conditions.

- The impacts of the **Metro North expansion** were built from a rail ridership forecast developed for the Northeast Corridor Coalition. The project team translated the rail ridership forecast into reduced auto trip by time period. The impacts of reduced auto trips in the build case were analyzed with the statewide travel demand model for the year 2040.

- The impacts of the **Bradley airport expansion** were based on a SYNCHRO analysis conducted for the airport as part of an airport expansion study. The project team converted the simulation analysis into a set of changes in travel time for passengers entering and leaving the airport. The project team traced the trips entering and leaving the airport and created an origin/destination table of 2040 vehicle trips and congested travel times by conducting a select zone analysis with the statewide travel demand model. The team also compared the distance from the main terminal building to the rental counter in the build and no-build condition as the primary impact for the analysis.

Figure 6-1: EconWorks W.E.B. Traffic Analysis Zones and Original Zones (colored in inset)



6.2 Derivation of Socio-Economic Inputs

The labor and supplier market access tools require forecasts of various types of socio-economic information. To generate this information, the project team:

1. Extracted population, total employment, sectoral employment and wage information at the township level for the base year from US Census
2. Calculated the contribution of each town (zone) to the total for the county in which it resides
3. Extracted the county-level future year forecast from Woods and Poole, and
4. Applied the factors from Step 2 to the county level forecasts from Woods and Poole, to produce forecasts of the socio-economic data at the 184 zone level.

The team also analyzed US Census and Woods and Poole data to understand the degree and type of labor specialization in the I-95 corridor. Employment in health care and in the finance industry showed relatively high concentrations of employment. The team proceeded with the FIRE (finance, insurance, real estate) sectors as the focal point of the labor and buyer-seller access analysis.

Section 7: Analysis Results

7.1 I-95 Additional Lane of Travel

The project team applied the reliability, supplier access and labor market access tools to analyze the addition of a lane in each direction between New Haven and New York.

7.1.1 Reliability Tool

The reliability tools offer reliability estimates for four time periods, two of which (morning and evening peak) correspond to the statewide model analysis time periods. The input requirements for the analysis, as shown in **Table 7-1** rely mostly on existing engineering and design information for a single representative highway section. The build and no-build conditions differ by the addition of one lane in each direction, and the analysis assumes that the mainline capacity is 2,000 vehicles per hour per lane in each direction.

Table 7-1: Input Parameters for I-95 Reliability Analysis

Scenario Data	No Build Inputs	Build Inputs
Time Horizon	25 years (2040)	25 years (2040)
Analysis Period	AM Peak (6 am-9 am) / PM Peak (3 pm- 7 pm)	AM Peak (6 am-9 am) / PM Peak (3 pm- 7 pm)
Highway Type	Freeway	Freeway
Mileage	50 miles	50 miles
Number of Lanes	3	4
Free flow Speed	55 mph	55 mph
AADT	135,000	135,000
Truck Data	11 percent	11 percent
Capacity	6000 vphpl	8000 vphpl
Terrain	Flat	Flat

The results of the analysis are shown in **Table 7-2**. The build reduces delay by 80 percent in the am and by 73 percent in the pm, by the year 2040. The no-build TTI95 values are high, and indicate a large disparity between the highest speeds and the average speeds. The PM delay is greater than the AM delay, which corresponds to the statewide travel demand analyses conducted previously.

Table 7-2: Summary of I-95 Reliability Tool Results for 2040

Scenario Data	No Build AM	Build AM	No Build PM	Build PM
Mean TTI	1.58	1.08	1.62	1.12
TTI95	2.44	1.28	2.64	1.40
TTI80	1.90	1.11	1.95	1.16
TTI50	1.50	1.05	1.52	1.07
Pct. trips less than 45 mph	43.48%	10.89%	52.54%	15.72%
Pct. trips less than 30 mph	27.26%	1.28%	24.59%	1.58%
Total Delay (vehicle hours)	4,597,037	678,238	5,998,020	1,191,207
Total Equivalent Delay	$77,527,657	$11,535,289	$101,233,567	$20,244,222

7.1.1.1 Observations and Conclusions

- The reliability tool is easy to use and easy to set up and run. This workbook stimulates thought about transportation performance in new ways by introducing measures about the distribution of speeds in a given time period.
- There are a few minor glitches in the printed outputs. For example, a table forecast result year header (2022) does not correspond to the analysis period entered in the input screen (25 years). For the forecast year, the “Mean TTI” table header is overwritten by the “2022” analysis year. The same issue was observed in the user guide. Also inserting a blank sheet between the inputs and results sheets (for additional calculations outside of the protected sheets) causes the scenario names to disappear, until the blank sheet is deleted.

7.1.2 Labor Market Access

The team analyzed access to traffic analysis zones as destinations for workers in the FIRE sectors and configured the analysis for the pm peak period, year 2040. The input parameters are shown in **Table 7-3.**

The results of the labor market access application are shown in

Table 7-4**.** The results indicate that the I-95 improvement would produce a 25.6 percent increase in accessible zones (within 45 minutes), a 24.1 percent increase in accessible employment for the FIRE sectors and a 24.5 percent improvement in the concentration index. The travel time savings of $27,497 represents the monetized average weekday evening peak 2040 travel savings for commuters destined for the designated employment centers, which lie along the I-95 corridor. These travel time impacts are one of a number of impacts that would be considered in a full benefit cost analysis. The larger set of impacts includes travel time savings over all years and times of day and for non-commute travel. A benefit-cost analysis conducted as part of a briefing to a Governor-appointed finance panel found that the project would produce $8.2 billion in total statewide benefits over the lifetime of the project.

Table 7-3: Inputs for Labor Market Access Tool, I-95 Analysis

Scenario Data	Inputs
Base Year	2040
Reference Year	2040
Specialized Labor Category (sector of location)	Finance, Insurance and Real Estate
Type of Labor Force	Employed Labor Force
Type of Data	Place of Work
Sub-category of Data Source (1)	Industry Sector
Sub-category of Data Source (2)	NAICS 52: Finance, Insurance and Real Estate
Type of Commuter Trips and Corresponding Percentage	Trips to Place of Business, not Personal Trips (Business Trips) (25% of trips)
Value of Time	$38.27
Percentage of Wages per Hour for Analysis	50
Period of Analysis	Peak
Input Labor Force Data	FIRE employment for 17 cities/towns (employment centers) along I-95 corridor
Impedance Data	Build and no-Build congested travel times from application of statewide travel demand model, aggregated to 184 traffic analysis zone system
Input Trip Table	Build and no-Build from statewide travel demand model pm peak forecast vehicle trips

Table 7-4: Results of I-95 Labor Market Access Analysis for 2040

Scenario Data	No Build PM	Build PM
Zones Accessible Within Threshold	17,941	18,409
Sectoral Employment Accessible Within Threshold	2,946,372	3,784,288
Concentration Index	19.8	24.6
Commuter Costs (savings)		($27,497)

7.1.2.1 Observations and Conclusions

- Accessibility is an important component of transportation impact analysis because it combines transportation performance with the way land use and economic activities are organized.

- While the labor force accessibility results show that the investment improves accessibility, it is hard to know the significance of the results or how to interpret them. It's unclear, for example, what a concentration index of 24.6 versus 19.8 is as part of a justification for making the investment. Additional guidance on interpreting the results would be welcomed.

- The analysis is built to compare a build and no-build, and these should correspond to the same year of analysis. A multi-year analysis capability within the tool would be welcomed.

- The tool works very slowly to complete the analysis for the 184 zone system. Some relatively simple programming changes can probably address the issue.
- The commuter cost savings for 2040 are much lower than travel time savings analyzed in the STP economic impact analysis. Tracing the cause will require additional effort.

7.1.3 Buyer-Seller Market Access

The constant decay factor (alpha, α) registers the sensitivity of the model to distance. In effect, the greater the travel time or distance between zones, the more the accessibility measure is discounted. The factor is applied as a power $(\frac{Ej}{dij\alpha})$[1]. By using a value of 1.0 for alpha, no additional discount is applied. The application uses the default productivity elasticity value (0.3), since the documentation provides no explicit guidance on how the value chosen relates to any specific labor market, or how it relates to the level of diversity or concentration in a traffic analysis zone. The inputs for the analysis are presented in **Table 7-5**.

Table 7-5: Inputs for I-95 Buyer-Seller Market Access Analysis

Scenario Data	Inputs
Base Year	2040
Reference Year	2040
Constant Decay Factor (α)	1
Productivity Elasticity	0.3
Impedance	Build and no-Build congested travel times from application of statewide travel demand model, aggregated to 184 traffic analysis zone system
Input Activity	2040 Employment (184 zones)
Analysis Type	Effective Density (no activity growth) – accessible employment per unit
Gross Regional Project	2040 forecast GRP (184 zones, represented by income)

As **Table 7-6** shows, the impacts of the I-95 improvements in terms of buyer-seller market access are relatively modest. The effective density (a factor that measures the cumulative number of employees within access to employment areas) in the build increases by less than one-hundredth of one percent, and the increase of productivity in the PM peak totals about $27M.

Table 7-6: Results of I-95 Buyer-Seller Market Access Analysis for 2040

Scenario Data	No Build PM	Build PM
Effective Density	3,821,179,631	3,821,355,328
Productivity Change		26,821,581

7.1.3.1 Outcomes and Conclusions

- The buyer-seller results are modest and by themselves do not demonstrate a compelling justification for the project.

7.2 Metro North (Four Track Service)

The project team applied the labor and buyer-seller market access tools to the Metro North project analysis. The pm peak analysis used the outputs of the statewide travel demand model application that was completed as part of a broader economic impact analysis related to development of CTDOT's long-range strategic transportation plan.

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[11] The equation produces a lower accessibility result the further in time an origin and destination are, and the higher the level of employment is. The relationship is disproportional or non-linear, meaning that, for example, a 10 percent increase in travel time produces more than a 10 percent decrease in accessibility when the value of alpha is not 1.0).

The Metro North investment encourages a re-orientation of auto travel to a commuter park and ride lot rather than a work place. Therefore, some origin-destination pairs see a slight rise in trips, vehicle miles of travel and vehicle hours of travel. However, the net effect is a reduction in VMT and VHT, and the biggest effects are seen where the baseline levels of congestion are the greatest.

7.2.1 Labor Market Access

The labor market access input is shown in **Table 7-7**. As shown for the I-95 widening, the team configured the access analysis to focus on employment in the finance, insurance and real estate sectors. The team also identified 17 towns encompassing the project corridor as employment centers.

Table 7-7: MNRR Labor Market Access Inputs

Scenario Data	Inputs
Base Year	2040
Reference Year	2040
Specialized Labor Category (sector of location)	Finance, Insurance and Real Estate
Type of Labor Force	Employed Labor Force
Type of Data	Place of Work
Sub-category of Data Source (1)	Industry Sector
Sub-category of Data Source (2)	NAICS 52: Finance, Insurance and Real Estate
Type of Commuter Trips and Corresponding Percentage	Trips to Place of Business, not Personal Trips (Business Trips) (25% of trips)
Value of Time	$38.27
Percentage of Wages per Hour for Analysis	50
Period of Analysis	Peak (from the tool's parameters, we selected 8 hrs of peak)
Input Labor Force Data	FIRE employment for 17 cities/towns (employment centers) along I-95 corridor
Impedance Data	Build and no-Build congested travel times from application of statewide travel demand model, aggregated to 184 traffic analysis zone system
Input Trip Table	Build and no-Build from statewide travel demand model pm peak forecast vehicle trips

According the results of the labor market tool application, the MNRR investment produces a 2.9 percent increase in accessible zones, a 10.1 percent increase in accessible FIRE employment and an 18.2 percent increase in the concentration index (**Table 7-8**).

Table 7-8: MNRR Labor Market Access Results

Scenario Data	No Build PM	Build PM
Zones Accessible Within Threshold	17,941	18,471
Sectoral Employment Accessible Within Threshold	2,946,372	3,244,783
Concentration Index	19.8	23.4
Commuter Costs (savings)		($87,982)

The results for commuter cost savings show a cumulative savings of $87,982 relative to the no-build. The savings results are limited to a fraction of the impacts considered in a benefit cost analysis. While this analysis estimates impacts to commuters for evening peak travel based on travel times and values of time, a typical benefit cost analysis considers all time periods, all travelers (including on-the-clock travel) and a more comprehensive range of impacts including vehicle operating, safety and environmental costs. A benefit-cost analysis conducted as part of a briefing to a Governor-appointed finance panel found that the project would produce $2.29 billion in total statewide highway travel time benefits over the lifetime of the project.

7.2.1.1 Observations and Conclusions

- The estimated travel time impact for the rail line is $2.3B over the study period
- The results of the labor market analysis are slightly lower than the results produced for the I-95 analysis for accessibility and higher for commuter costs (the commuter percentage for rail is assumed to be double that of the highway analysis). The analysis is limited to the pm peak and does not capture effects during other times of the day.
- The results from a prior test must be cleared from the results worksheet, otherwise the program will crash.

7.2.2 Buyer-Seller Market Access

The team configured buyer-seller market access analysis to account for the shifts in auto trips from employment destinations to commuter rail park and ride lots. However, the tool has produced illogical, negative results for several zones. Additional review is needed to determine whether adjustments are needed, such as constraining the build impedance to be no greater than the no-build impedance, for each O/D pair. A summary of the inputs and parameter is shown in **Table 7-9**.

Table 7-9: Inputs for MNRR Buyer-Seller Market Analysis

Scenario Data	Inputs
Base Year	2040
Reference Year	2040
Constant Decay Factor (α)	1
Productivity Elasticity	0.3
Impedance	Build and no-Build congested travel times from application of statewide travel demand model, aggregated to 184 traffic analysis zone system
Input Activity	2040 Employment (184 zones)
Analysis Type	Effective Density (no activity growth) – accessible employment per unit
Gross Regional Project	2040 forecast GRP (184 zones, weighted by income)

The buyer-seller market access analysis shows a very slight increase in effective density, similar to the result obtained for the I-95 analysis. The productivity change is slightly higher than the result obtained for the I-95 analysis. The assumption of 50% commuters using Metro North influences this result**.**

Scenario Data	No Build PM	Build PM
Effective Density	3,821,179,631	3,821,355,328
Productivity Change		34,136,598

Table 7-10: Results of MNRR Supplier-Buyer Access Analysis for 2040

Scenario Data	No Build PM	Build PM
Effective Density	3,821,179,631	3,821,355,328
Productivity Change		34,136,598

7.3 Bradley Airport Access

Before engaging the connectivity tool, the project team completed an access impact analysis of the airport road network. Using the simulation results from the prior airport study as a starting point, the team developed a profile of traffic circulation patterns, examined the difference in travel time before and after the rental car facility relocation and, using the select zone feature of the statewide travel demand model, estimated the number of trips accessing the airport. The traffic analysis is outlined further below.

7.3.1 Changes in Traffic Circulation and Travel Time Savings

The construction of the ConRAC facility by 2018 is anticipated to result in changes in traffic patterns along with reductions in travel times for passengers using the existing rental car facilities located along Schoephoester Road between Postal Road and Light Lane.

The following is a list of assumptions made to traffic patterns for rental car facility passengers dropping off/picking-up vehicles on their way to the airport/from the airport

- **Traveling to the Airport**
  - <u>No-Build Condition</u>-Travelers dropping off rental cars are assumed to travel east-bound along Schoephoester Road as they make their way to the rental car located on Postal Road and Light Lane. After the rental car has been returned, passengers assumed to ride the Shuttle from the parking lots to the Airport.
  - <u>Build Condition</u>- With the construction of the parking garage/ConRAC facility near the Airport Terminal Roadways, passengers traveling to the airport are estimated to save time while experiencing less delay in dropping off rental cars. It is assumed that travelers dropping off cars in the Build condition, gain access to the ConRAC facility via the Airport Jughandle Road as they drive EB along Schoephoester Road.
- **Traveling from the Airport**
  - <u>No-Build Condition</u>-Travelers picking-up rental cars from the lots are assumed to ride the shuttle from the Airport to the rental car facilities located between Postal Road and Light lane. Once the rental car has been picked up, it is assumed that drivers exit the lot and travel west-bound along Schoephoester Road on-route to their final destinations.
  - <u>Build Condition</u>- With the construction of the parking garage/ConRAC facility near the Airport Terminal Roadways, passengers save time in rental car pick-up and are also assumed to experience less delay as they exit along the Airport Terminals Roadway towards Schoephoester Road WB.

Based on the travel pattern assumptions highlighted above and using the delay analysis results from the prior traffic study commissioned by CTDOT, travel time savings were estimated for trips going to and from the airport under the no-build and build conditions. Under the no-build condition passengers driving to/from the airport to drop-off and pick-up rental cars experience a total travel time of approximately 11.5 minutes and 17.7 minutes respectively. With the construction of the parking facility and consolidation of parking spaces in the ConRAC facility the total travel time experienced by passengers dropping off and picking up rental vehicles is anticipated to be approximately 3.5 minutes and 2.3 minutes, respectively. Overall, the planned development is anticipated to save approximately 8 minutes and 15.4 minutes, respectively for rental car drivers/airport passengers traveling to and from the airport. Assuming that approximately only 25% of the total airport passengers experience the travel time benefits of building the new parking garage/ConRAC facility, the weighted travel time savings for drop off and pick-up is estimated to be approximately 2 minutes and 3.9 minutes, respectively. A summary of the traffic analysis is shown in **Table 7-11**.

Table 7-11: Bradley Airport Traffic Analysis for Connectivity Tool

Traffic Data	To Airport			From Airport		
	No-Build	Build	Diff	No-Build	Build	Diff
Route Delay (secs)	87	32	55	132	132	117
Free Flow Time (secs)	420	180	240	480	480	360
Wait Time (sec)	180	0	180	450	450	450
Total Time (sec)	687	212	475	1062	135	927
Time Associated with Airport Passenger Travel	172	53	119	266	34	232

7.3.1.1 Inputs and Results

The project team configured the connectivity tool for a pm peak analysis of travel. The inputs are shown in **Table 7-12**. The connectivity tool requires information about the location of the traffic improvements, the travel time savings and the value of time. The value of time was set slightly higher than that for other types of travel, because the income profile of air travelers is generally higher than travelers using cars or transit as the primary means of travel.

Since the select zone analysis captured only pm trips from and to the airport, there was no need to discount the number trips affected by the airport investment. However, total travel time savings, derived from the prior traffic analysis, were discounted by an assumption that 25% of local travel would correspond to airport passenger traffic. This result is shown in the last row of **Table 7-11**.

Table 7-12: Inputs for Connectivity Analysis

Scenario Data	Inputs
Distance of Improvement from Facility	1 mile
Number of Annual Passengers within Study area	4,561,200 (from select zone analysis)
Hours Saved per Passenger Vehicle	0.05 (one way, 25% of all trips - airport access trips only)
User Specified Average Value per Passenger Hour Saved	$40 (assume higher wage rate)
User Specified Fraction	1.0 (25% accounted for previously)

The results of the 2040 analysis are shown in **Table 7-13**. The value of the travel time savings to airport users in the pm peak is $8.9 million, which corresponds to nearly a quarter of a million hours of travel time saved in 2018. The balance of the results relies on the FAA database and confirms that Bradley is in the lower half of airports in terms of connections to other cities.

Table 7-13: Results of Bradley Airport Connectivity Analysis for 2040

Scenario Data	Outputs
Activity	5,311,192 passengers
Value	N/A no freight impact
Unique Origins/Destinations	149
Connectivity Raw Value	7.9
Relative Activity	6.1%
Relative Value	N/A no freight impact
Relative Origins and Destinations	41%
Relative Facility Connectivity Index	2.5%
Number of Associated Annual Passenger Vehicles	4,561,200
Time Savings (hours)	222,359
Value of Time Savings	$8,894,340

7.3.1.2 Observations and Conclusions

- The connectivity tool appears to represent a means of demonstrating how local traffic improvements can benefit national connections.
- The data from which the national flight data are derived come from FAA and need to be updated each year, because flight connections between each airport in the U.S. change constantly. Typically, maritime data are more stable.
- Rail data are in private hands but an expansion of the tool for rail intermodal access, including access to ports, would be beneficial.
- The tool appears to produce results for one year only. Expanding the tool's capability for multi-year analysis would be beneficial.
- Completion time is instantaneous; most or all of the calculations are embedded in formulas.

Section 8: Recommendations

Due to the difficulties in using the tools and the availability of tools such as TREDIS, CTDOT was not able to find a way to integrate the EconWorks tools into its project prioritization methodology. CTDOT and its stakeholders were not able to validate the results of the tools with other methods of economic analysis that uses for project selection or performance measurement. The recommendations below outline some of the changes that could be made to the tools that would allow CTDOT and its stakeholders to more easily integrate them into prioritization and analysis frameworks:

- Develop a consolidated tool as a one-stop analysis that combines the multiple sets of impacts addressed by these tools.
- Develop multi-year and discounting capability for estimating cost effects.
- Develop a travel time curve rather than a fixed and binary threshold for accessibility analysis.
- Improve error trapping in workbooks.
- Improve speed of workbooks by reading data into memory before initiating operations (for Access workbooks).