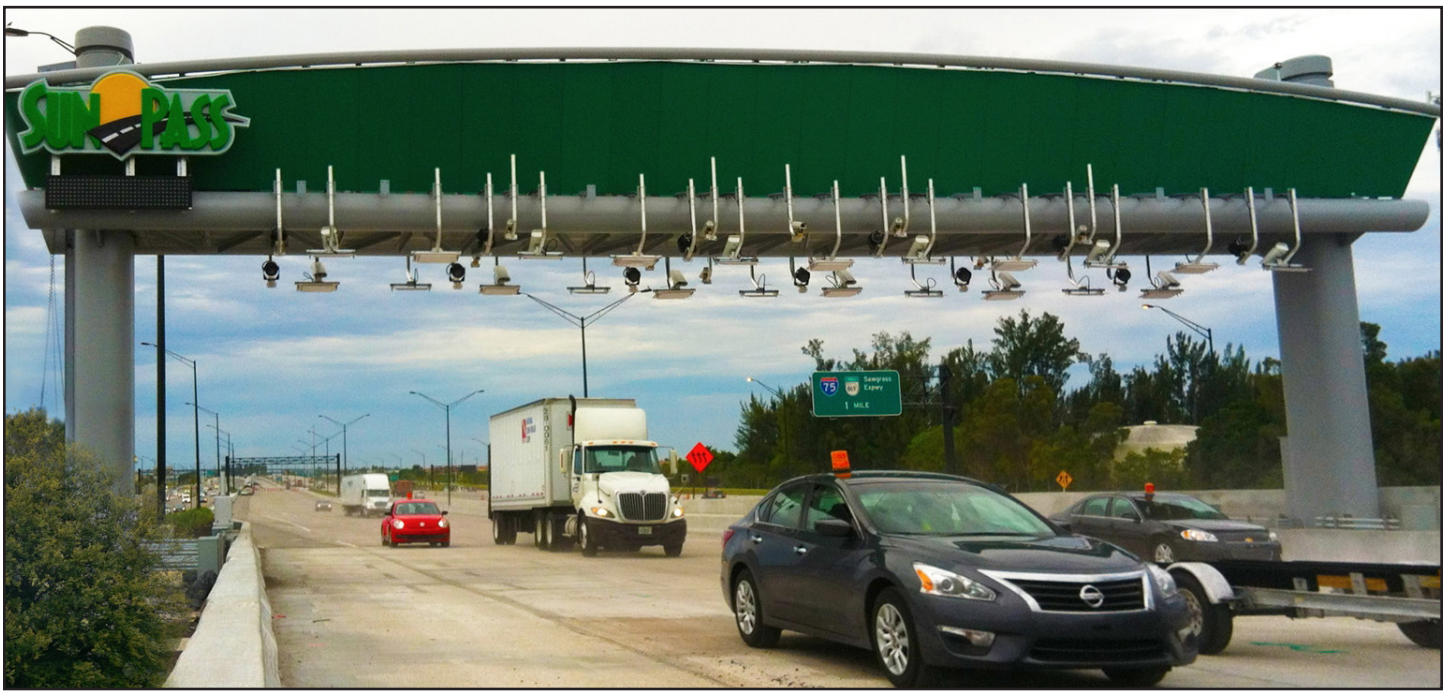
Florida Department of
TRANSPORTATION

Macroeconomic Analysis of Florida's Transportation Investments



January 2015

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Macroeconomic Analysis of Florida's Transportation Investments

FDOT Work Program, Fiscal Years 2014-2018

Florida Department of Transportation
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Executive Summary

The Florida Department of Transportation (FDOT) has estimated the economic effects of its Work Program for fiscal years (FYs) 2013/2014 through 2017/2018. The analysis covers almost all of Work Program spending, including highway, rail, seaport and transit modes. The primary results are shown in Table ES.1. Economic benefits of the Work Program consist of:

- **Personal user benefits**, which arise from personal travel via highways or transit, including commuting, recreational and social trips; and
- **Increased personal income**, which stems from business travel including person trips for business purposes and freight trips via truck, rail and water.

With adjustments for the present value of future benefits, total benefits will be $141.7 billion. Costs reflect the Work Program budget in 2014 dollars[1]. Economic benefits are projected 25 years past the completion of the Work Program, to FY 2043. The ratio of total benefits to costs is 4.4. This means, on average, every dollar invested in the Work Program will yield about $4.40 in economic benefits for Florida from the beginning of the Work Program to FY 2043.

Table ES.1 Benefits and Costs of the FDOT Work Program*
(Billions of 2014 Dollars, 2014-2043)

Present Value of Personal User Benefits	$76.0
Present Value of Increased Personal Income	$65.7
Total Economic Benefits	$141.7
Present Value of Work Program Budget (Costs)	$32.1
Estimated Benefit-Cost Ratio	4.4

* July 1, 2014 Adopted Work Program

Study results were compared with results from prior analyses from 2003, 2006 and 2009. All three studies apply a similar methodology, but some changes in the results are caused by changes in underlying data, changes in a few computational procedures, and the addition of an analysis of the Highway Safety Improvement Program (HSIP).

Although the new benefit-cost ratio of 4.4 is slightly lower than the 4.9 ratio from the 2009 study, the minor change reflects the consistent and positive effect of the Work Program.

Contributing factors to the slight decline likely include higher costs for highway construction, and less growth than expected in personal and business travel. The long and deep recession of recent years has clearly influenced the results. At this point, however, it is difficult to tell

[1] Calculation of a benefit-cost ratio requires discounting all benefits and costs to the present day. Both costs and benefits were discounted to 2014 dollars to reflect the time value of money.

whether the recession heralded long-term structural changes in the economy, or whether its effects will entirely disappear over the coming years.

In any case, these results continue to demonstrate that high quality transportation for persons and freight will be essential for economic success in the 21st century. The results of this study do not include the short-term stimulus effects of construction spending. It is important to realize that virtually all Work Program expenditures produce two streams of benefits – short-term and long-term – and this report is focused on measuring long-term benefits relative to costs. This is discussed further in Chapter 1, Section 6.

Future updates to this report are anticipated to expand the analysis to include aviation investments, and further refine the methodologies used for evaluating highway, rail, seaport and transit investments, among other enhancements to the modeling system. In conclusion, Work Program investments in Florida's transportation system yield significant benefits to both business and personal travel. With continued emphasis on economic growth and employment, Florida will invest heavily in transportation to support and improve the global competitiveness of our economy.

1.0 Background

The purpose of this study is to analyze the long-term economic benefits of the Florida Department of Transportation (FDOT) Work Program, specifically the Work Program for fiscal years 2014 to 2018. This report includes income growth as a major benefit of transportation investment. Therefore, analysis of specific benefits and costs and of broader economic effects is merged into a single set of quantitative estimates. This chapter provides a general introduction and describes the Florida legislative mandate which this study fulfills. It reviews the Department's five-year Work Program analyzed here. It also summarizes previous study results from 2003, 2006, and 2009. Lastly, there is a brief discussion of how this study relates to economic short-term stimulus proposals and policies.

1.1 Introduction

Transportation infrastructure is one of the pillars of the Florida economy or of any modern economy. The call-out box to the right describes "A Transportation Vision for 2060," as defined in the Florida Transportation Plan (FTP). Florida's continued investment in transportation to address safety, security, reliability, efficiency and choice across modes continues to move the state toward meeting these goals. A transportation system in this vision will allow:

- workers to commute to their jobs and travel inter-regionally and internationally for business;
- shippers to deliver raw materials and supplies to construction sites and manufacturers and farm products to markets;
- visitors to travel to tourist destinations; and
- consumers to patronize retail establishments.

The multi-modal transportation system is complex and provides connections for different types of travelers going to different types of destinations with a choice of modes. The state's economic health and its ability to remain competitive in the globalized economy depend on the efficient transport of people and goods.

The five-year Work Program, which covers fiscal years (FYs) 2013/2014 through 2017/2018, accounts for $38.2 billion in transportation investments. One of the main purposes of the Work Program is to enhance the efficiency of the

A Transportation Vision for 2060

The state of Florida in 2060

- A globally competitive economy serving as a hub for international and domestic trade and investment, and attracting and retaining skilled workers.
- Vibrant urban and rural communities where Floridians have greater choices about where to live, work, learn, play, and shop.
- A healthy environment with improved air and water quality, as well as conservation of critical lands, waters, wildlife, habitats, energy, and other natural resources.

Florida's transportation system in 2060

- Safe and secure travel, as Florida moves toward eliminating fatalities on the transportation system.
- A reliable, efficient, and well maintained transportation system.
- Multiple options for moving people and freight within and among Florida's urban and rural areas, working together as an integrated transportation system.
- Enhanced stewardship of transportation resources through effective planning, efficient decision making, wise investments, proper accountability, and rigorous performance measurement and reporting.

transportation system. This macroeconomic analysis establishes the link between Work Program investments in highways (i.e., bridge, pavement, capacity, and safety), seaports, transit and rail over the next five years, and economic growth due to these investments in Florida over the following 25 years.

Economic effects include increases in employment, business output, value-added (as measured by gross state product) and personal income. In addition, this study measures the return on investment of FDOT's Work Program by conducting a benefit-cost analysis to compare the magnitude of benefits and costs over time. In order to make sound projections for these economic performance measures, direct user benefits experienced by travelers and freight carriers were determined first. The benefits to businesses function as inputs to the regional economic model used in this study. The economic model estimates the long run benefits. The conceptual methodology of the macroeconomic analysis framework is illustrated in Figure 1.1. A more detailed discussion of the specific methodologies for each modal analysis is provided in the coming chapters.

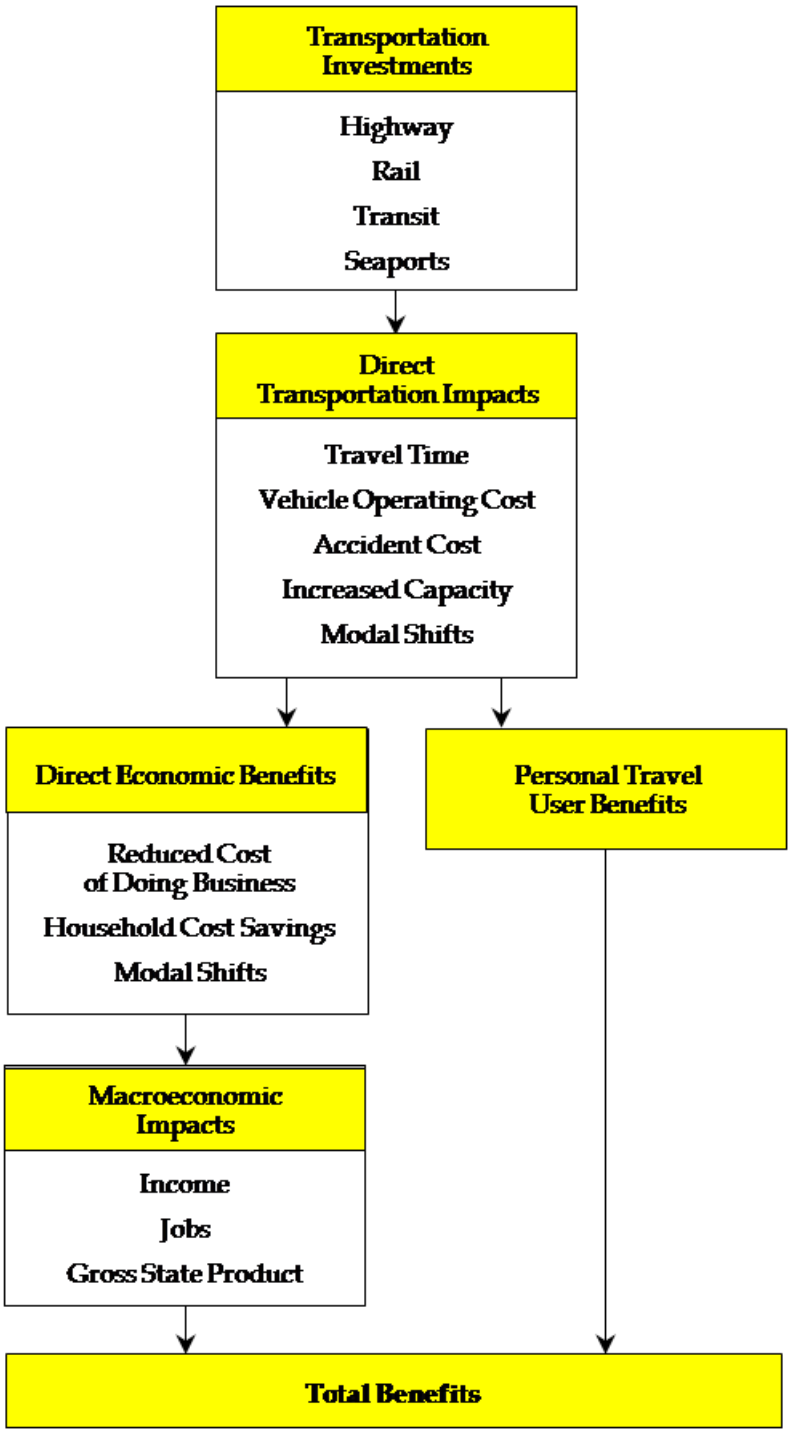
As described in Chapter Six, recent work on integrating Aviation, Spaceport and Intermodal Logistic Center (ILC) investments into the framework of this study has produced new information and innovative analysis to measure the economic effects of these programs. However, because of some remaining inconsistencies and difficulties, it is not yet possible to integrate these results into the overall Work Program benefit-cost ratio.

Florida's multimodal network of roads and highways, commercial and general aviation airports, spaceports, seaports and waterways, passenger and freight rail corridors and terminals and public transit services has evolved as a result of continuous investment. The improvement and expansion of this system depends on public and private expenditures on new and improved infrastructure, technology and services. These investments have direct benefits, including travel time savings for commuters and reduced shipping costs for manufacturers, distributors and retailers as well as reduced vehicle operating and accident costs and broader economic effects. These transportation benefits lead to long-term macroeconomic effects such as higher employment, greater gross state product (GSP), more personal income, more new enterprises and possible beneficial effects for the national and world economies.

1.2 Response to Legislative Mandate

The catalyst for this series of studies is a Florida legislative requirement, passed in 2000, to analyze the macroeconomic implications of transportation investments and to provide an understanding about how transportation effects the state's competitive position. A more thorough listing of the relevant legislative mandate(s) can be found in Sections 334.046(4) (b) of Florida Statutes, shown in Appendix A. In addition, the 2060 Florida Transportation Plan (FTP) includes "Invest in transportation systems to support a prosperous, globally competitive economy" as one of six long-range goals.

Figure 1.1: Macroeconomic Analysis Framework



This study is required so "the state has a clear understanding of the economic consequences of transportation investments…" The method for reaching this goal is to "develop a macroeconomic analysis of the linkages between transportation investment and economic performance."

In response to this legislative mandate, FDOT has developed and evolved a macroeconomic analysis methodology to evaluate the long-term economic benefits of FDOT's Work Program. These benefits are based on an understanding of how transportation investments save time, reduce costs and enhance economic competitiveness and opportunities. Consistent with economic theory, an improved transportation system makes Florida more attractive to productive assets, primarily skilled workers, successful businesses and capital stock. These assets enable the state to produce more at competitive prices. As the state's economy becomes more productive, Floridians' incomes, opportunities and lifestyles will improve over the long run.

The legislation specifically requires the analysis to assess the following:

1. The state's economic performance relative to the competition. Investments in transportation can improve travel time, reduce vehicle-operating costs, and lessen economic costs associated with crashes. The macroeconomic approach developed by FDOT directly analyzes the impact of Work Program investments on travel conditions in the state on a mode-by-mode basis. The model quantifies the benefit of Work Program investments reducing transportation costs, and then translates those benefits into cost savings for the state's businesses. For example, investments in highway infrastructure can lessen congestion and travel time delay, which subsequently can reduce the time and cost spent throughout a company's supply chain.

The reduced cost of doing business in Florida allows businesses to be more competitive and increase market share in national or global markets. Specific business benefits are increased output (sales), hiring additional workers and ultimately increasing the personal income of Florida's residents. These benefits spread from the direct users of the transportation infrastructure to the broader Florida economy.

2. The business environment as viewed from the perspective of companies evaluating the state as a place to do business. The Regional Economic Models, Inc. (REMI) economic simulation model, used in the macroeconomic analysis, accounts for the expansion and attraction of firms due to a reduced cost of doing business from transportation investments. In other words, by providing efficiencies in the transportation system, the state reduces business costs and becomes more attractive to employers of all sizes.

REMI estimates economic expansions, as well as an influx of workers who would move to the state to take advantage of new employment opportunities and the improved business environment. Over a 25-year period, the improved business environment would support a significant number of new long-term jobs. These economic effects have been a focus of policy and planning efforts for Florida for over a decade. Recent related work has been performed by

the Florida Chamber Foundation and the Florida Department of Economic Opportunity Strategic Plan.[2]

3. The state's capacity to sustain long-term growth. The emphasis of this analysis is on long-term economic effects of transportation improvements rather than short-term, temporary benefits. Short-term impacts are briefly discussed in Section 1.6.

Over a 25-year period, Work Program investments will reduce the cost of doing business in the state, and these cost savings are projected to produce a substantial increase in personal income for Florida residents. The full results of this study can be seen in Chapter 7 of this report. The FDOT Work Program includes a large percentage, but not all, of the total investment being made in the state's transportation system by all levels of government, the private sector and other entities. Analysis of all transportation investments would require the collection and processing of considerably more data and the cooperation of many more agencies, companies and others.

1.3 Florida Department of Transportation Work Program

This macroeconomic analysis assesses the effects of the transportation investments in the FDOT Work Program. Investments include activities such as upgrades to existing highways (widening, interchange improvements, etc.), new highway or interchange construction, resurfacing/reconstruction, right-of-way purchases, safety improvements, and capital expenditures applicable to transit, rail and seaports. These activities are found in the "Product" category within the 10- year Program and Resource Plan, which includes a summary of Work Program investments over the next five years.

In addition to Product expenditures, the Florida DOT's Program and Resource Plan includes categories for other activities, including Product Support, Operations and Maintenance, and Administration. These support activities are essential and the Product expenditures could not occur without them. Consequently, these three support activities, with expenditures of over $11.5 billion, were included as part of the cost of delivering the Work Program investments.

[2] Please see http://www.flchamber.com/six-pillars/overview/, http://www.flchamber.com/wp-content/uploads/MadeForTrade-FINAL-Single-1.pdf and http://www.floridajobs.org/office-directory/division-of-strategic-business-development/florida-strategic-plan-for-economic-development.

Product Investments within the Work Program

Table 1.1 presents the proposed expenditures by Product and other investment categories contained in the 2013/2014 to 2017/2018 Work Program in year-of-expenditure dollars. For consistency with the 2003, 2006, and 2009 analyses, these amounts do not include "roll forward" amounts from prior years. As the table shows, over 75 percent of the Work Program Product investments are focused on product categories which are primarily highway related. However, significant investments are also made in a variety of other modes. For example, investments in transit infrastructure and services amount to nearly $2 billion, and rail investments comprise $784 million of FDOT's Work Program.

Table 1.1: FDOT Work Program, FY 2014-2018

In Year of Expenditure Dollars

PROGRAM AREAS	13/14	14/15	15/16	16/17	17/18	TOTAL
I. PRODUCT	7545.1	5582.1	4449.3	4761.8	4212.6	26,550.8
A.SIS/Intrastate Highways	3,812.5	2,522.5	2,170.4	1,926.8	1,730.5	12,162.8
B. Other Arterials	426.7	247.2	226.5	195.3	222.0	1,317.7
C. Right Of Way	775.5	799.5	326.2	230.9	278.0	2,410.1
D. Aviation	185.3	167.6	168.4	171.5	198.9	891.7
E. Transit	641.8	383.5	309.1	324.1	322.7	1,981.3
F. Rail	250.9	341.5	192.5	222.4	193.6	1,200.9
G. Intermodal Access	84.6	33.9	21.1	34.2	28.6	202.5
H. Seaports	278.1	100.9	51.0	78.3	85.3	593.7
I. Safety	161.0	119.2	107.9	133.2	132.8	654.2
J. Resurfacing	553.7	611.8	735.7	743.3	777.5	3,422.0
K. Bridge	374.9	254.6	140.4	701.6	242.6	1,714.0
II.PRODUCT SUPPORT	1,741.2	1,241.4	990.1	920.5	840.7	5,733.8
III.OPERATIONS & MAINTENANCE	999.2	1,006.2	1,025.1	1,055.1	1,062.5	5,148.1
IV. ADMINISTRATION	138.0	165.0	158.3	154.8	177.2	793.4
TOTALS	10,423.4	7,994.7	6,622.9	6,892.2	6,293.0	38,226.2

Source: Florida Department of Transportation Work Program Summary, 13/14 through 17/18.

A variety of analytic tools were used to assess macroeconomic effects. Similar to past studies, three of the principle tools were the Highway Economic Requirements System (HERS), the National Bridge Investment Analysis System (NBIAS) and the Regional Economic Models, Inc. (REMI) economic effect forecasting model. The effects of rail and transit investments were analyzed using spreadsheet models and appropriately integrated into the HERS and REMI analyses. The economic effects from seaport investments and the HSIP highway safety program were estimated separately based on other studies done in Florida and elsewhere and integrated into the results for highways, rail and transit. All tools are described in more detail in Chapters 3, 4 and 5. Tools and data to assess the incremental benefits from new investments in the aviation, spaceport and Integrated Logistics Centers modes are being developed, but were not available for inclusion in this analysis.

Understanding Work Program Expenditures

Work Program expenditures are presented in three ways in this report: year of expenditure dollars, constant dollars and discounted costs. The expenditure concept used depends on the specific analysis. In this report, Work Program expenditures are analyzed using the following concepts:

- **Year of Expenditure Dollars.** Year of expenditure dollars (sometimes called nominal dollars) reflect the actual Work Program investments expected to occur in future years. Since some degree of inflation is expected to continue, year of expenditure amounts will always be greater than constant amounts to build a particular facility. This is consistent with how FDOT presents investments in its Work Program summary documents, and is reported here for comparison and reference purposes only. Within the context of this analysis, we analyzed Work Program Product investment totaling $26.5 billion in year of expenditure dollars. Work Program Product Support, Operations and Maintenance, and Administration expenditures are $11.7 billion, and the total Work Program entails $38.2 billion in expenditures.
- **Constant Dollars.** Year of expenditure dollars are adjusted for inflation in order to reflect the extent of expenditures in each future year. These constant dollars (sometimes called real dollars) have been used as inputs into several of the economic models, including HERS and REMI. For the purposes of this study, the final results also are reported in 2014 constant dollars.[3]
- **Discounted Costs.** In order to provide a consistent basis for a comparison of dollar concepts over time, the value of future Work Program investments and benefits are discounted to reflect a present value at 2014 levels. Essentially, discounting Work Program expenditures accounts for the time value of money. A dollar today is worth more than a dollar next year since it can be invested and earn interest (above inflation). Discounted Work Program expenditures and benefits are utilized in the benefit-cost analysis section of this report. Please see Appendix D, Glossary, for broad definitions of several of these terms.

[3] The HERS and NBIAS models currently are calibrated for 2010 dollars, so their results were converted to 2014 dollars for consistency.

1.4 Florida Results of Previous Macroeconomic Analyses

Previous evaluations of the Work Program showed significant economic benefits from these large-scale investments. The results of those analyses are presented below.

2003 Analysis of Work Program

The five-year Work Program evaluated in the 2003 analysis included total capital expenditures of $26.2 billion (in 2002 dollars). The results of the analysis showed a very strong correlation between the transportation investments and economic benefits. Key findings of the study included:

- Work Program investments in highway, transit and rail over the five-year period were projected to result in an increase of $44 billion in personal income for Florida residents and support 88,000 new jobs over the following 25 years. Work Program investments also were projected to yield significant direct user benefits to personal travel in terms of reduced travel time, vehicle operating costs and accident costs. Specifically, the direct user benefits for personal travel over the 25-year time frame were estimated to be $74 billion.
  - From a benefit-cost perspective, macroeconomic business benefits and personal travel benefits were estimated as $5.50 worth of economic benefits for every $1.00 invested in the transportation Work Program.

2006 Analysis of Work Program

Similar to the previous study, the 2006 analysis showed transportation investments have significant economic benefits for Florida businesses and residents. The 2006 study reached the following conclusions:

- The Work Program was likely to generate a steady escalation in the number of jobs in the state, with 60,000 more jobs than in the Base Case for the period from 2016 to 2035.
- The Work Program investments would generate over $147 billion in 2006 dollars in user and economic benefits to Florida residents and businesses through the year 2030.
  - These benefits, compared to total costs of approximately $26 billion in 2006 dollars, produce a projected benefit-cost ratio of 5.6.

2009 Analysis of Work Program

- The Work Program was expected to support an additional 50,000 jobs every year from 2016 to 2038, and an additional 60,000 jobs for the years 2023 to 2033.
- The Work Program investments would generate over $139 billion in present value in user and economic benefits to Florida residents and businesses through the year 2038.
- These benefits, compared to total costs of approximately $28.3 billion, would produce a benefit-cost ratio of 4.92.

1.5 Comparison of Previous Results

It is instructive to consider some of the changes in approach and results among the 2009 and previous studies especially in light of the current research presented in this report. As shown in Table 1.2, the summary statistics across the three studies are quite similar. The value of Auto User benefits in the 2009 study was somewhat lower than for the previous two studies. This was mostly due to higher construction costs for the latter Work Program, resulting in less productivity in terms of travel time savings.

Table 1.2: Comparison of Analysis Results*

	2003	2006	2009
Benefits			
Discounted Value of Personal Income	54.2	57.9	60.2
Discounted Value of Non-business Auto User Benefits	91.1	99.8	80.6
Total Discounted Benefits	145.3	157.7	140.7
Total Discounted Costs	26.4	28.1	28.6
Net Present Value (Benefits minus Costs)	119.0	129.6	112.1
Benefit-Cost Ratio (Discounted benefits divided by discounted costs)	5.5	5.6	4.9

* All dollar values shown are in billions of 2014 dollars. The Benefit-Cost Ratio has no units. It is a simple ratio.

The 2006 study made updates to analytic methods for estimating benefits from investments in seaports. The study results were influenced by expected increases in transit ridership, additional freight rail investments and dramatic increases in construction costs during the 2004 to 2007 period.

The 2009 study included enhanced transit analysis, reformatted the macroeconomic base case, and applied sensitivity analysis to estimate the range of potential effects given different policy assumptions:

- **Enhanced Transit Analysis.** The methodology was enhanced by considering user surplus benefits to transit riders. Previous analyses had only considered the effect of transit improvements on highway congestion. The 2009 analysis incorporates the effects on transit consumers themselves. As with highway improvements, improved transit service for commuters enables them to reach their place of work more quickly and reliably. If workers can reach more places of employment by transit, this improves the flexibility of labor markets and ultimately makes Florida a more attractive location for business. Also, as with the highway side, transit improvements tend to provide value to transit users by saving them time.
- **Change in Base Case Assumption.** The 2008/09 analysis was technically different from prior analyses in the way REMI was run. Previously, it had been assumed that the Work Program would constitute a set of improvements in addition to those assumed in the REM base case. Upon discussion within the project team and with a few outside experts, there was a consensus that the REMI default values include infrastructure investments to maintain the transportation network. Consequently, we assume that the essence of the Work

Program is incorporated into the REMI Regional Baseline Forecast. Therefore, the absence of the Work Program would result in a reduction in the growth anticipated in the REMI baseline forecast. The change in Base Case assumption did not affect the results very much, but it made the REMI analysis more realistic and put the study on a sounder conceptual footing.

- **Sensitivity to Alternative Assumptions.** An additional objective of the study was to understand the range of potential effects given different policy assumptions. The results of this study were intended to enable FDOT to evaluate a variety of scenarios in the future. Given the state's economic and fiscal conditions, there was significant uncertainty about future work program levels and construction cost inflation. As a practical matter, the Sensitivity Analyses were not useful for decision making when the Work Program budget was cut during the 2008 to 2010 period.

Otherwise, the 2009 study used the same methodology applied in previous studies, and it found a lower Benefit-Cost Ratio. The main reasons for the decline were:

- The dramatic increase in highway and other transportation construction costs during the period from 2000 to 2007;
- A parallel increase in auto and truck operating costs; and
- Relatively limited growth in general inflation and real wages – the value of travel time savings hardly changed from prior analyses, in contrast to the rapid increase in costs.

1.6 Relationship with Short-Term Jobs

This study, *Macroeconomic Analysis of Florida's Transportation Investments*, does not address implication for construction jobs or other short-term stimulus impacts of transportation spending. It documents the economic benefits of transportation facilities themselves, not short-term benefits related to construction.

During recessions, public attention focuses on jobs in the short-term. The need for additional jobs was especially acute in the wake of the housing crash of 2008 and the ensuing recession, which had significant effects on the economy well into 2012.[4] With favorable timing, public works programs can have a noticeable short-term impact on GSP and unemployment during recessions.

However, in line with the long-term nature of highway and other transportation infrastructure investments, FDOT seeks to enhance economic prosperity in the long run. This analysis projects these long-run effects, which are likely to persist though temporary economic booms and recessions. Important as short-term effects in a recession can be, long-term economic growth stimulated by infrastructure investments will have a greater effect on a larger number of people.

[4] According to the widely quoted National Bureau of Economic Research (NBER), the recession ended in July 2009. However, the NBER definition typically only applies to the 1st phase of a recession, and additional phases, particularly the "bottom of the trough" can prevent full recovery for years, as was the case from 2009 and 2012.

2.0 Study Improvements

This year's macroeconomic analysis study combines established methods and new techniques to provide more extensive information on the economic effects of the Work Program. The major changes in the analysis from prior versions are as follows:

- **Highway Safety Benefits –** FDOT has a longstanding policy that safety is a top priority.[5] With every major improvement to a highway segment, we try to add specific features and make changes that will improve safety. It is clear that the efforts of FDOT and numerous other parties to improve highway safety have yielded major dividends. Highway fatalities for the United States have dropped from 1.7 per 100 million vehicle miles traveled in 1994 to 1.1 in 2012, with an even greater decrease for the State of Florida, from 2.3 in 1995 to 1.3 in 2012.[6]

  Originally, it was challenging to project future reductions in fatalities and other adverse outcomes from specific changes arising from FDOT projects on the State Highway System (SHS). In prior versions of this study, such safety benefits with specific links to actual projects were not estimated. As research and analysis has advanced, the Safety Office has developed comprehensive estimates of benefits from the Highway Safety Improvement Program (HSIP), a federally sponsored program, and those estimates are included as benefits of the Work Program in this report.

  The HSIP consists of hundreds of relatively small projects which include a significant safety component. HSIP projects fall into dozens of different categories, with some of the more prominent categories including:

  a. New signal at channelized intersection
  b. Add 2nd left turn lane in same direction at existing intersection
  c. Skid hazard overlay (i.e. increased friction road surface)
  d. New roadway segment lighting

  For each category of HSIP project, conservative estimates were generated of reductions (or in a few cases increases) in fatalities, serious injuries and property damage per year likely to be generated. In turn, the expected life of the improvement, in years, was used to generate the expected total safety benefits. As with all costs and benefits in this study, these benefits were discounted at the real discount rate of 4 percent per year. This analytic produced a present value of $3.9 billion in benefits. This equates to a reduction of 407 fatal crashes, 2,603 incapacitating injury crashes, 6,658 other injury crashes, 9,769 possible injury crashes, and 21,466 property damage only crashes. No equivalent number was included in the benefit compilations of the prior macroeconomic studies.

  While the HSIP is a significant part of FDOT's safety program, there are substantial additional safety benefits likely to be generated by other components of the FDOT 5-Year

[5] Specifically, the Mission Statement reads "The department will provide a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity and preserves the quality of our environment and communities." http://www.dot.state.fl.us/publicinformationoffice/moredot/mvv.shtm, accessed July 16, 2014.
[6] Florida Department of Highway Safety Motor Vehicles (DHSMV) 2012 Crash Facts

Work Program, particularly highway construction. Some very large FDOT projects, such as the I-4 Ultimate Project, expected to initiate construction in 2015, or the series of projects currently in progress on Krome Avenue in Miami-Dade County, may generate over $100 million in safety benefits by themselves. The FDOT Safety Office is working on totaling benefits from all projects explicitly funded for safety purposes; developing a complete accounting of all safety benefits from the Work Program is a major long-term goal. (CONFIRM). But until more complete analyses are available, analysis of the HSIP provides a partial and conservative measure of the expected value of the Department's ongoing efforts to improve transportation safety for all Floridians and visitors.

- **Change In Discount Rate –** Previous macroeconomic studies used a real discount rate of 7 percent to bring all costs and benefits to a common present value. The real discount rate is a critical parameter for FDOT macroeconomic studies and for virtually all studies comparing economic costs and benefits. In transportation, costs tend to come up front. The design and construction of a major facility can take 10 years, but the public and the Florida economy can derive benefits from that investment for more than 30 years.[7]

  Because most of the costs tend to come early in the life cycle of major transportation facilities, higher discount rates have relatively little effect on the present value of the costs and a much greater effect on the present value of benefits. In general, the higher the discount rate, the lower the BCR of most transportation capacity projects. The Federal government requires a 7 percent real discount rate, with provision for a sensitivity analysis using a 3 percent rate, for TIGER grant applications and other analyses of Federal programs.[8]

  One of the major rationales for setting a public sector rate, the Social Rate of Time Preference (SRTP), currently suggests a real discount rate of 3 percent. The other rationale, the Social Opportunity Cost of capital (SOC) would suggest a somewhat higher rate, but estimates vary widely. The 4 percent rate was chosen because it is consistent with the rate in FDOT economic analysis of major capacity projects. Please see Appendix B-6, Determining an Appropriate Discount Rate, for further discussion of this issue.

[7] In order to apply the analysis consistently, this study covers 5 years of capital expenditures in the Work Program and projects benefits and costs 25 years out, for a total of 30 years of projections. This is conservative for major capital construction projects for the highway, seaport and passenger rail modes.

[8] TIGER BCA Guidance (2014). It notes that applicants may also provide an alternative analysis using a real discount rate of 3%. See http://www.dot.gov/sites/dot.gov/files/docs/TIGER%20BCA%20Guidance%202014.pdf, p. 13, accessed July 24, 2014.

3.0 Methodology: Highway Analysis

3.1 Introduction

This chapter describes the overall methodology and the specific approach chosen to analyze the economic effects of highway investments. Chapter 4 outlines the technical methodologies applied to all other modes. Later chapters provide analytic results including benefit-cost ratios for the Work Program.

3.2 Overview of Analytic Methodology

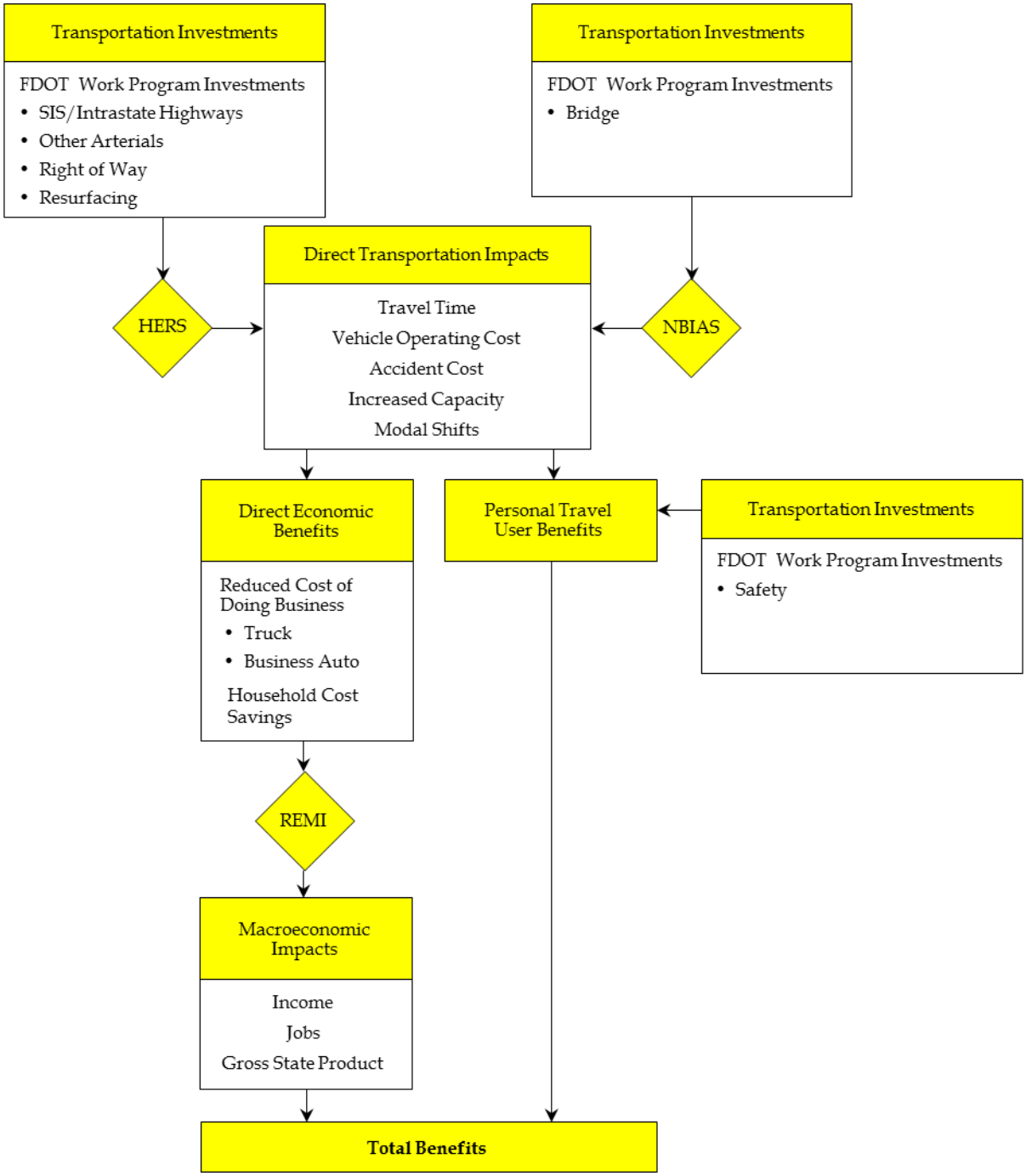
The general analytic framework is shown in Figure 3.1. As shown, investments in highways have a direct impact on auto and truck travel time, vehicle operating cost and accident costs. These cost savings represent direct economic benefits to both personal travel and business-related travel including freight. For the business-related portion of these benefits, the resulting reduction in the cost of doing business leads to economic benefits measured by increases in personal income for Florida residents, employment and GSP.

Several software tools to operationalize the analytic method are shown in Figure 3.1. The key tools are two models developed and maintained by the Federal Highway Administration: the Highway Economics Requirements System – State Version (HERS-ST) and the National Bridge Investment Analysis System (NBIAS). A brief description of these tools as well as the selected methodology is provided here.

HERS-ST - The Highway Economic Requirements System-State Version (HERS-ST) estimates the highway user benefits from investment programs affecting either highway system performance or usage. The model has been used in a number of states, and at the national level, to estimate the direct economic benefits of highway investments. FHWA uses HERS, in conjunction with NBIAS to prepare its biennial report on the conditions and performance of U.S. highways, bridges and transit. The U.S. Government Accountability Office (GAO) has evaluated the models in HERS and found it an appropriate tool to estimate highway program investments at both the federal and state level.

- **Travel Time Savings.** Travel time savings reflect the dollar value of the reduction in vehicle-hours of travel associated with improved highway conditions. Travel time savings result from reduced congestion due to increased highway capacity or reduced vehicle miles of travel (i.e., from diversion to transit and rail), improved roadway geometry and improved pavement condition. The model assigns different values of time for personal auto, business auto and truck trips. Reduced inventory holding costs and the time savings from reductions in non-recurring incident delay are also captured.
- **Vehicle Operating Cost Changes.** Vehicle operating costs include fuel, tires, lubricants and maintenance. These costs are affected both by travel time and the general wear and tear on vehicles from substandard pavement conditions.

Figure 3.1: Highway Analysis Approach



- **Safety Effects.** Investment can reduce the crash rate on a highway system by reducing congestion and improving roadway geometry. Conversely, improving highway conditions could increase the number of crashes by inducing more total travel on the highway network or increase crash severity if speeds increase significantly. HERS estimates the effects of capacity investments on the overall crash rate by type of crash (fatality, injury and property damage only), calculates the total number of crashes by category based on vehicle miles traveled and assigns a monetary value to these changes in crashes. In this report, the safety results of the HERS analysis do not show any net reduction in crashes from the Work Program, are folded into the overall HERS results. However, as indicated above, the analysis of HSIP was conducted outside the HERS model.

Detailed review of the HERS inputs revealed some structural changes in Florida transportation since 2009, including:

- **Slower growth in vehicle miles traveled (VMT).** The 2006 and 2009 studies indicated relatively fast growth in overall VMT. This study indicates much slower growth. The growth envisioned for 2012 never was realized.
- **Decrease in vehicle occupancy.** The HERS inputs suggest that fewer people are driving together in personal vehicles. Because the value of time is expressed in person-hours, any reduction in people per vehicle creates a reduction in the value of each vehicle-hour traveled.
- **Decrease in truck VMT.** There was a significant decrease in truck VMT compared to the projections of the 2009 study. This drop in truck volume likely is due to the downturn in the construction industry.[9] Freight Office data indicate that truck growth is expected to accelerate in the near term while continuing to recover in the long-term.
- **No growth in the value of time (VOT).** FHWA based the 2008 HERS value of time estimates on a US Department of Transportation study completed in 2000. They anticipated that the value would continue to grow over time. That growth was never realized. An updated study produced in 2009 found that the value had not changed demonstrably over time. In line with long running economic trends, VOT is anticipated to resume growth of 1.08% per year in the future.

NBIAS - The National Bridge Investment Analysis System (NBIAS) simulates conditions of highway bridges, predicting direct transportation benefits resulting from performing preservation and/or functional improvement work on existing bridges. As in the case of HERS-ST, the model has been used to project bridge investment needs in several states, and FHWA uses the system for its bridge investment modeling.

[9] The Federal Bureau of Labor Statistics releases estimates of total Florida construction jobs monthly. These statistics show a peak of 691,800 jobs in June 2006, followed by a mostly steady drop to 309,300 in July 2012. The most recent estimate shows a recovery to 414,600 construction jobs as of September 2014. The estimates can be accessed at http://data.bls.gov/timeseries/SMS12000002000000001?data_tool=XGtable.

Safety - Safety effects analyzed in HERS do not address the full range of safety benefits supported by the Work Program. Safety improvements are included routinely in pavement and bridge improvement projects but data specifically identifying safety improvements to support analysis do not yet exist. The Highway Safety Improvement Program (HSIP) and High Risk Rural Roads Program (HRRRP) funds and project tracking efforts do provide data for assessing economic benefits of work accomplished in these programs. The benefits of these programs in terms of reduced costs to society and the value of a human life have been estimated outside the HERS model.

Please see Appendix B-1, HERS and NBIAS, Analysis Steps for further details concerning the conduct of the analysis for highways and bridges.

4.0 Methodology: Other Modes

The previous chapter discussed the methodology applied to analyze the highway portion of the Work Program. Significant investments are also made in other transportation modes. This chapter covers the methodology used for the estimation of benefits and economic effects for investments in seaports, transit service and rail systems. The following Chapter discusses a few modes that are not included in the final Benefit-Cost Ratio, but for which economic analysis has been performed by the Department.

4.1 Transit/Passenger Rail Analysis

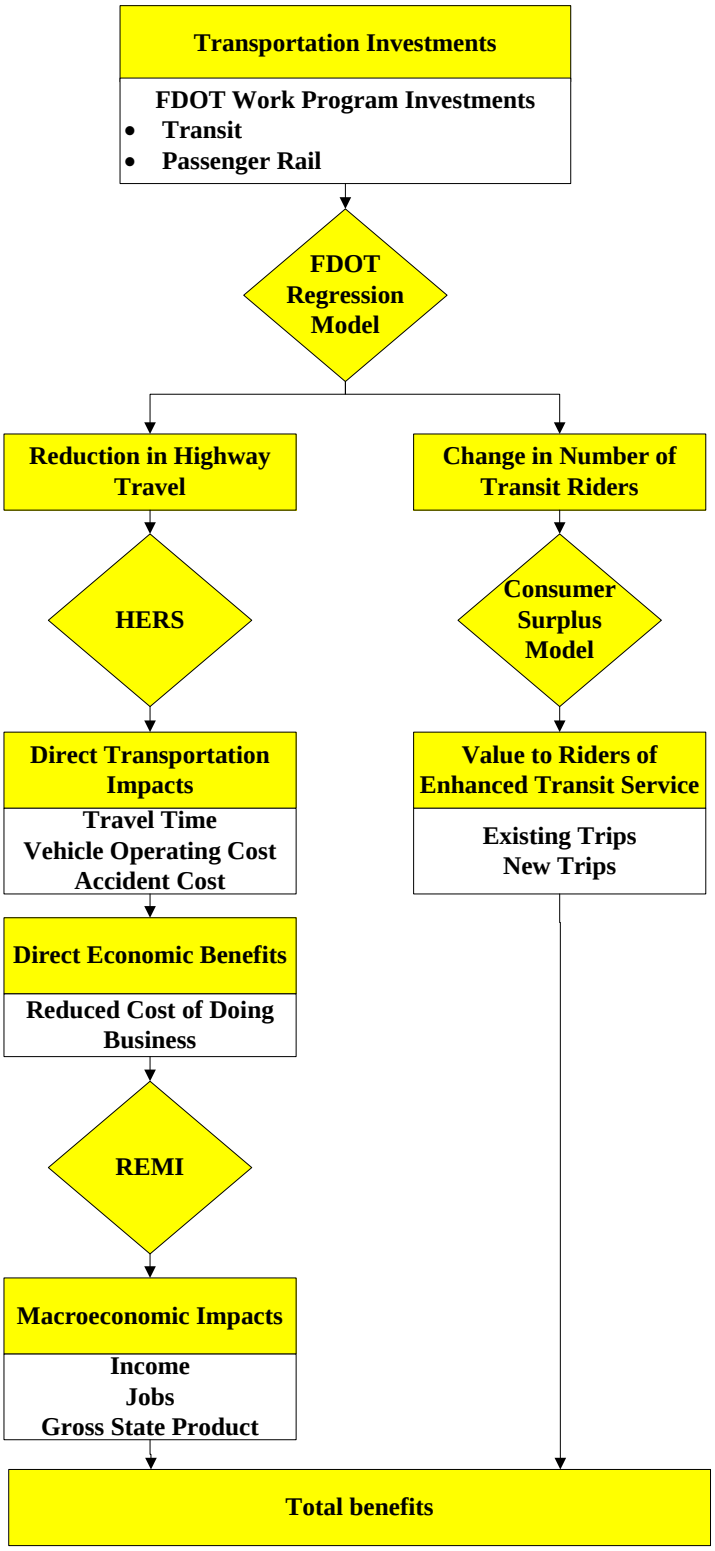
The analysis of the Transit Work Program includes analysis of fixed route bus service and rail transit, which in Florida consists primarily of commuter rail and heavy rail. The macroeconomic effects of transit have been captured by performing two separate analyses:

1. Travel efficiency benefits are generated by the reduction in highway traffic. Remaining highway users enjoy less congested facilities as a result of a small percentage of automotive trip takers switching to transit. These benefits can be applied to the HERS model, which generates estimates for travel time savings, vehicle operating cost savings and accident cost reductions.

2. Additionally, all transit riders benefit from transit improvements, typically through the reduction of door-to-door trip time. This is roughly analogous to highway users benefiting from reductions in congestion or from the opening of new road facilities. It is sometimes referred to as increases in consumer surplus. Consumer surplus can be defined as the difference between a person's willingness to pay for a service and the actual price paid.

Figure 4.1 shows the approach used to calculate total benefits from transit investment. First, a regression model based on historical data on transit investment and transit ridership is used to forecast future reductions in highway auto vehicle miles traveled (VMT). The left-hand side of the diagram shows that these changes in VMT become part of the HERS analysis, and through HERS subsequently enter REMI to calculate macroeconomic effects. The right-hand side of the diagram shows how the regression output is used to forecast changes in consumer surplus. The change in consumer surplus is not part of REMI inputs. It is added directly to other benefits in the estimation of total benefits. See Appendix B-3, Transit Analyses, for further details concerning the methodology used in both analyses.

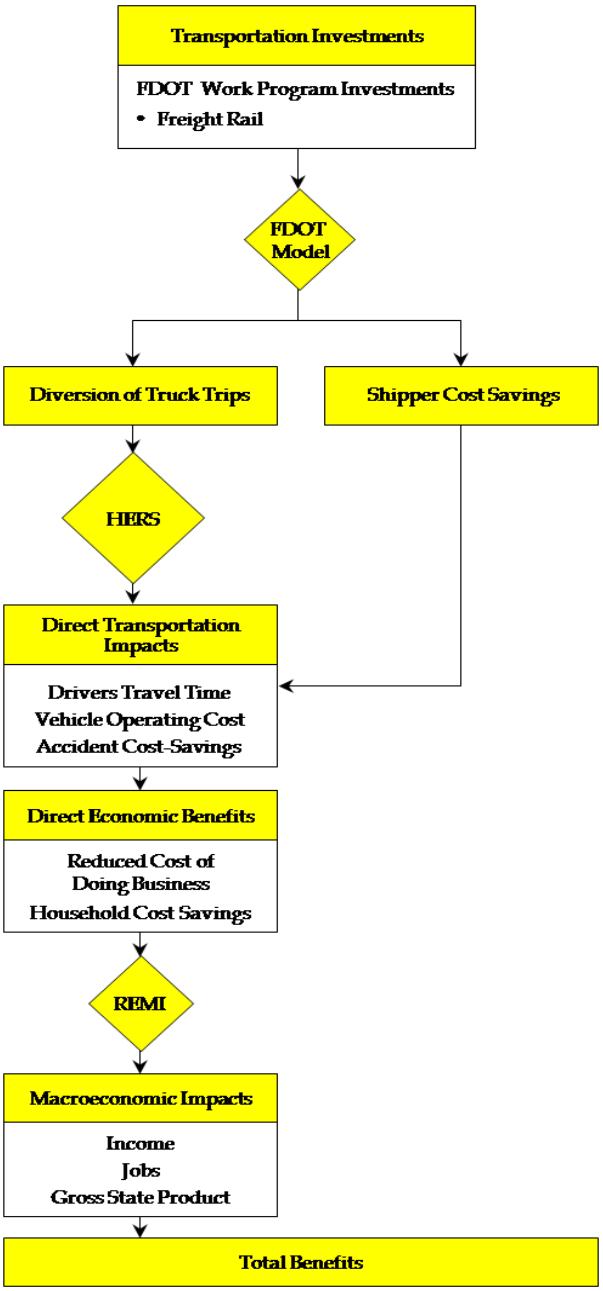
Figure 4.1: Transit/Passenger Rail Analysis Approach



4.2 Freight Rail Analysis

The benefits stemming from freight rail investments were estimated based on data provided by the FDOT Rail Office. The method is shown diagrammatically in Figure 4.2. The analysis depends on constructing estimates of the number of truck trips that will be diverted to rail and of the savings to shippers that result from freight rail improvements.

Figure 4.2: Freight Rail Analysis Approach



A representative sample of ongoing and future projects was used for the analysis. This sample, including the total estimated cost and the SIS share of cost, is shown in Table 4.1. Most freight rail projects are supported by the FDOT Strategic Intermodal System (SIS) program, with the exception of some minor investments in shortline railroads and rail-highway crossings. The Freight Rail Work Program has increased over the years, and it is higher for the FY 2014-18 Work Program than for any of the previous macroeconomic analyses. The SIS program pays for at least 50 percent of all projects in the sample.

Table 4.1: Freight Rail Projects in the Adopted Work Program

FY	Railroad	Project	Total $	SIS $	Railroad $
14	AN	Bridge Upgrades	5,000,000	3,750,000	1,250,000
14	BAYL	Track Upgrade	8,578,006	6,433,504	2,144,502
14	FEC	Railex FEC Rail Spur	1,136,363	1,136,363	-
14	JaxPort	ICTF Rail Improvements	15,000,000	10,000,000	5,000,000
15	FCRR	Line Upgrade	2,023,500	1,517,625	505,875
15	FEC	Bowden Intermodal Yard Improvements	14,360,000	7,180,000	7,180,000
15	FEC	Spruce Creek Siding Extension	3,351,902	1,675,951	1,675,951
15	FEC	Sunbeam-Bayard Double Track	9,491,852	4,745,926	4,745,926
15	FEC	Villa Rica Siding Extension	2,441,983	1,220,991	1,220,992
15	FEC	New Smyrna Siding Extension	2,833,592	1,416,796	1,416,796
15	FEC	Holly Hill Siding Extension	2,804,518	1,402,259	1,402,259
15	FEC	Scottsmoor Siding Extension	3,731,562	1,865,781	1,865,781
15	FEC	C-15 Hidden Valley Canal Bridge	213,195	106,597	106,598
15	FEC	Eau Gallie River Bridge	1,704,386	852,193	852,193
15	FEC	Goat Creek Bridge	574,521	287,260	287,261
15	NS	Intermodal Facility @ Soutel Rd.	29,300,000	14,650,000	14,650,000
15	SCFE	Bridge Upgrades	5,213,000	3,909,750	1,303,250
15	SCFE	Cane Block	21,750,000	16,312,500	5,437,500
16	SWFRC	Southwest Florida Rail Corridor ROW	3,062,003	3,062,003	-
17	SCFE	Interchange Tracks	5,000,000	3,750,000	1,250,000
		Total	148,237,050	93,275,499	54,961,551

Abbreviations: AN – Apalachicola Northern, BAYL – Bay Line Railroad, FCRR – Florida Central Railroad, FEC – Florida East Coast Railway, JaxPort – Port of Jacksonville, NS – Norfolk Southern Railway, SCFE – South Central Florida Express, SWFRC – Southwest Florida Rail Corridor.

Freight rail improvements generate economic benefits in two ways: by reducing shipping costs and by reducing highway congestion.

1. Cost savings. Rail capacity improvements reduce the cost of shipping by rail, and also enable more shippers to start using rail to move their products instead of trucks. Rail shipments are on average lower cost than their counterparts on the roads especially when the supply lines cover long distances. The sum of these cost savings within Florida makes up one portion of the total economic benefits. The current analysis follows the approach used for the 2006 and 2009 studies.
2. Highway travel benefits. By removing trucks from highways, the flow of traffic is improved as highway travel is reduced. This in essence leads to travel time savings, vehicle operating cost reductions and a decrease in accidents. Dollar values have been assigned to these benefits using HERS unit costs. The portion of the HERS outputs accounted for by business travel were then input into the REMI analysis.

In order to generate the projected economic benefits of the freight rail improvements, the analysis completed in 2006 and applied in 2008 was leveraged and used to extract the main assumptions and parameters. Based on previous analysis, one dollar spent on rail improvements generates roughly a 0.11 mile reduction in truck travel. Similarly, based on the number of trucks diverted from the roads and trucks loads now carried by rail, cost savings could be estimated. It is expected that this methodology will be revisited and revised the next time the macroeconomic analysis is updated.

The project-specific results were then scaled to the size of the current Work Program for freight rail improvements. Based on the Adopted Work Program, $316.3 million are scheduled to be spent on such improvements over the next five years. Additionally, only 50 percent of the cost savings for projects involving the large national railroads (referred to as Class I, including CSX and Norfolk Southern) are assumed to be incurred within the State of Florida. Investments in regional and local rail operations incur all of their benefits within the state.

Rail benefits were estimated for year 2013, and allocated among the first four years of the Work Program based on the proportion of investments occurring in each year. The highway travel reductions and shipping cost savings as estimated based on the Adopted Work Program are shown in Table 4.2.

Table 4.2: Impact of Freight Rail Improvements on Truck Miles Traveled and Shipping Costs

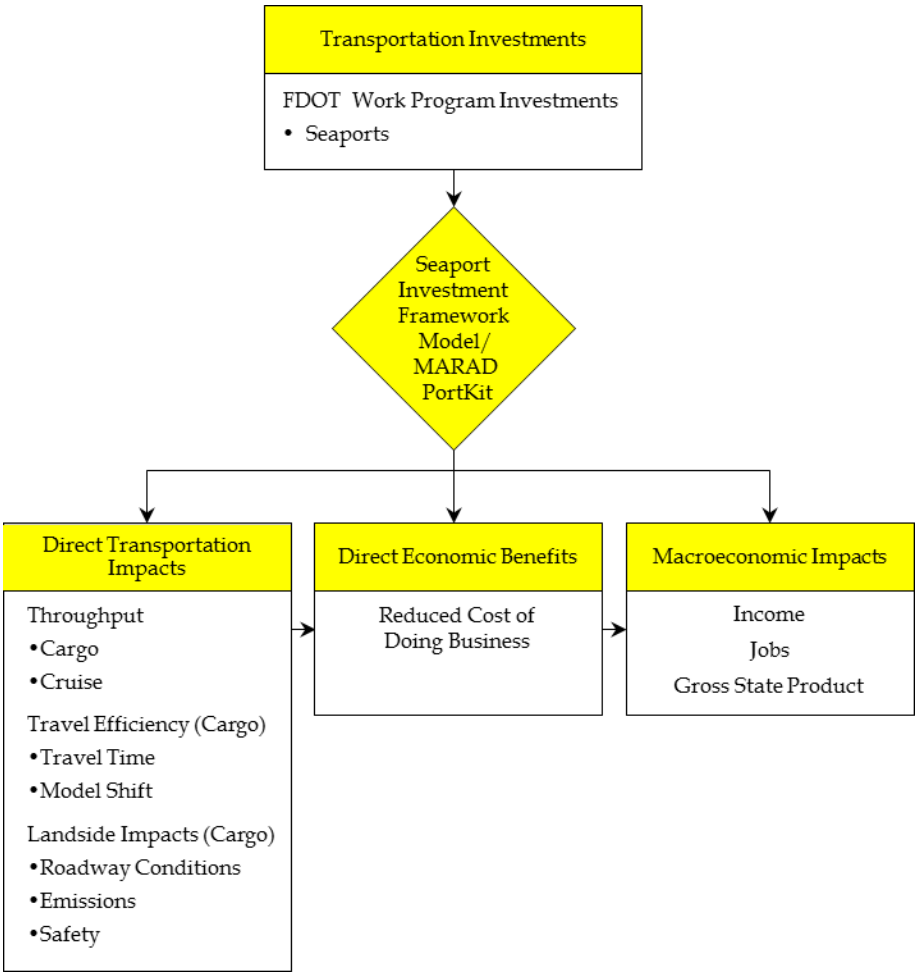
	Reduced truck-miles traveled in Florida (millions)	Shipping cost savings accrued to Florida businesses (million $)
2014	3.4	$37.4
2015	14.8	$163.1
2016	15.1	$167.0
2017	15.7	$173.2
2018	15.7	$173.2
Totals	64.7	$713.9

4.3 Seaport Analysis

The seaport Work Program analysis used the benefit-cost tool developed for FDOT as part of the Seaport Investment Framework. This tool was originally designed to quantify the benefits and costs of a specific improvement project related to economic competitiveness and mobility factors. In order to evaluate the entire seaport Work Program, data from a sample of projects deemed representative of the current Work Program was analyzed. This is consistent with standard social science theory.[10] The results from these sample projects were then proportionally expanded to represent the entire seaport Work Program budget.

As shown in Figure 4.3, the seaport analysis tool contains structural relationships capturing the economic consequences of investments in different aspects of seaport infrastructure. The seaports supplied the data for this analysis, and the FDOT Seaport Office checked the data for reasonableness compared to prior analyses.

Figure 4.3: Seaport Macroeconomic Analysis Approach



[10] Babbie, Earl, The Practice of Social Research, 11th ed. Belmont, CA, Wadsworth, 2006.

The tool was employed to evaluate throughput impacts for cargo (containers and tonnage) and cruise activity using multipliers from the U.S. Maritime Administration (MARAD) Portkit model, which is used to estimate the economic effect of seaport investments. These multiplier relationships capture the extent of the increase in regional economic activity as a result of an increase in cruise terminal capacity, for example. Similarly, freight-specific benefits are assumed to directly affect the regional economy depending on the types of goods and commodities targeted. Therefore, the seaport analysis, unlike the highway analysis, was not entered into the REMI model to analyze further economic effects. Such REMI analysis would have been redundant to the multiplier and regional effects already captured by the model. The seaport model also used an existing analysis to evaluate travel efficiency impacts typically associated with on-port roadway projects.

Along with the benefits obtained from the MARAD Portkit model and the travel efficiency benefits, the seaport tool estimated negative impacts generated by projects in terms of roadway maintenance, railway maintenance, emissions and safety/accidents. These negative impacts were subtracted from the benefits to obtain "net benefits" which in turn were compared to costs. The use of the MARAD model for Seaport improvements is conceptually and practically consistent with the use of HERS and REMI for the highway mode and with the methodologies applied to other modes.

Please see Appendix B-4 for additional document of the methodology for macroeconomic analysis of Seaport investments.

5.0 Methodology: Economic Benefits

The Regional Economic Models, Inc. (REMI) TranSight model was used to estimate the indirect and induced economic effects of the Work Program investments within the state of Florida. The REMI model used in this study is a statewide model, with 66 industry-sector detail. REMI generates control forecasts and simulates policy changes based on a series of linked socioeconomic variables representing industry output, demand for goods and services, labor supply, wages and prices, and industry market shares.

Key features of the REMI model include:[11]

- **Input-output structure.** At the core of the REMI model is an input-output model which captures inter-industry linkages and multiplier effects.
- **Econometrically estimated relationships**. Econometric and advanced statistical techniques are used to estimate many of the key relationships in REMI, such as costs, market shares and business output.
- **Dynamic time series.** The model estimates economic and demographic changes over time, which allows for firms and individuals to respond to changing economic conditions. These mechanisms allow for changes in the demand for labor and the prices of goods over time.
- **Demographic influences.** The model includes a detailed cohort component model (age, race and gender) estimating population trends and movements including how the labor force and population respond to changes in employment opportunities.

For this study, the estimates of direct business travel benefits (business auto and truck) generated by the HERS and NBIAS models, and by the freight analysis were translated into reductions in the cost of doing business and input into REMI to estimate macroeconomic effects. The direct user benefits in terms of travel time, operating cost were input into REMI as:

1. **Trucking benefits.** Businesses using, owning or operating trucks are the major direct recipient of these user benefits. These are largely the shippers and receivers of motor freight. Truck user benefits were allocated to industries based on relative industry size and demand for trucking services.

2. **Business auto benefits.** Businesses whose employees drive "on-the-clock" for business purposes, such as sales meetings, also experience a direct benefit from reduced travel times and costs. Business auto user benefits were allocated to industries based on each industry's share of total private sector jobs in the economy.

3. **Rail shipping costs.** Businesses relying on shipping and receiving goods by rail experience a direct benefit from improved rail capacity and speed. For example, freight rail investments allow for a greater share of freight to move by rail (compared to highway) and thus result in lower per ton mile shipping costs. Rail shipping cost savings were allocated to industries based on relative industry size and demand for freight rail services.

[11] For more information see: www.remi.com

It is worth noting that economic effects due to seaport investments, while not captured through the REMI analysis, are included in total economic effects and the benefit-cost analysis. Seaport investments are estimated using FDOT's Seaport Office benefit-cost analysis tool, which includes the MARAD port kit economic effect or impact model. The MARAD model estimates the same types of economic benefits projected by REMI.

All Work Program scenarios were modeled in a theoretical analysis to estimate the effects of the Work Program compared to zero investments by FDOT.[12] The difference between the control forecast and the simulated effects of the Work Program reflects the estimated positive economic benefits of the Work Program.

Transportation Cost Savings

There are three input elements to the REMI model: the freight rail analysis results, HERS highway analysis results (which includes traffic congestion relief benefits of transit[13] and freight rail) and NBIAS bridge analysis results. Other benefits estimated in this study (e.g. seaports, safety impacts and transit user benefits[14]) while not included in the REMI analysis, are included in the benefit-cost analysis. The inputs to REMI strictly represent benefits to businesses and do not include any personal travel benefits.[15] The cost savings, in dollars, estimated by the HERS, NBIAS and the freight rail analysis enter REMI as industry cost savings for Florida businesses. As businesses realize lower transportation costs, these savings increase their competitiveness and market share, and therefore output (or sales) are estimated to increase.

Please see Appendix B-2, REMI Projections, for further details concerning the distribution of transportation benefits among various industries.

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[12] In practice, however, because we assume that the Work Program expenditures are built into the REMI baseline forecast, the inputs into REMI are specified as *increases* in the cost of doing business in the absence of the Work Program.

[13] Congestion relief is modeled in HERS as reductions in auto vehicle miles traveled due to increased use of transit, as described in Chapter 4.

[14] Transit user benefits are the change in consumer surplus created by transit investments. This is described in Chapter 4.

[15] Personal auto and transit benefits are included directly within the benefit-cost analysis, without going through REMI.

6.0 Analysis: Modes Not Included

Since the first study was conducted in the early 2000's,[16] the Department has incrementally expanded the scope of this study, and cautiously made other changes in methodology to improve the usefulness and realism of the findings.

The most recent changes are discussed in Chapter 2 of this report. The primary goal is to analyze as much of the FDOT 5-Year Work Program as possible, especially all capacity enhancing programs, regardless of mode. However, the Work Program includes thousands of capacity projects and project phases in dozens of project categories in at least 10 different modes. The variety and complexity of modes, categories and projects has prevented the quantitative analysis from being absolutely comprehensive to this point.

In particular, analytic capacity for the aviation mode, though far more advanced than when the Department began its efforts over 12 years ago, is not sufficient for a definitive measurement of the contributions of the FDOT Aviation Work Program. This chapter summarizes the analysis thus far performed by the FDOT Aviation Office and outlines plans to further develop this method. The situation is similar with respect to Intermodal Logistics Centers (ILCs) and Spaceport; in both cases, the Department has initiated funding support programs within the past few years. Inclusion of economic analysis for Bicycle, Pedestrian and Intercity Passenger modal work programs remains a long-term goal. As time and resources become available, these modes will be the subject of further analysis, and they are likely to be included in future Macroeconomic studies.[17]

6.1 Aviation

The Aviation Office prepared the Florida Airport BCA Tool in 2013. By focusing on airside capacity of seven large airports throughout the state,[18] this tool lays the ground work for a comprehensive assessment of the benefits and costs of much of the FDOT Aviation Work Program. The basic method is to analyze each airport's capacity and demand for the near future, generating a Demand/Capacity Ratio for the year 2020.

The Florida Airport BCA Tool yields estimates for Benefit-Cost Ratios for potential Work Program capacity expansion projects at each airport. It facilitates the generation of estimates of the benefits and costs of expanding capacity in the selected airports in future years, such as 2040 and 2060. Another module of the Florida Airport BCA Tool performs a specialized form of break-even analysis. This module simulates the benefits of a typical airside capacity project for a range of levels of airside traffic demand. The module output estimates what level of airport demand would be required for the project to yield sufficient economic benefits to the State of

[16] "Macroeconomic Impacts of the Florida Department of Transportation Work Program" February 2003, http://www.dot.state.fl.us/planning/Policy/economic/macroimpacts2003.pdf

[17] Please note All Aboard Florida is a private intercity rail initiative not funded out of the FDOT Work Program.

[18] The 7 airports included are Fort Lauderdale-Hollywood International (FLL), Tampa International (TPA), Southwest Florida International (RSW), Seminole-Orlando Sanford International (SFB), Northwest Florida Beaches International (ECP), Cecil Airport (VQQ) and Marathon Airport (MTH).

Florida to justify a capacity expansion. The break-even approach is likely to be advantageous because of the uncertainty of forecasts of airport volume. Rather than relying on forecasts which tend to have substantial error rates, planning and programming for facility expansion can be accelerated when the volume approaches the break-even level.

The new tool developed by the Aviation Office constitutes remarkable progress in analyzing the economic benefits of many aviation projects. However, further research and analysis is needed before the Department can generate a reliable BCR for the capacity component of the Aviation Work Program. Development of a comparable methods and tools for other types of projects would be desirable. Overall, the progress made in the last few years is encouraging, and we anticipate including much of the Aviation Work Program in the next Macroeconomic Analysis.

6.2 ILC and Spaceport

Since the first study in 2003, FDOT policy has increasingly focused on Intermodal Logistics Centers (ILCs). ILCs facilitate the handling of freight into and out of seaports. Under Florida Statute (s.311.101, F.S.), the Department recently initiated the ILC Infrastructure Support Program, providing at least $5 million a year in matching funds to public or private entities for projects which facilitate shipment of goods between seaports and ILCs. The ILC program utilizes economic and financial analysis to help select the specific projects that receive matching funds. At this time, it is not possible to aggregate the economic benefits and costs of the program in a way that is consistent with the methods used in this study. However, as with the aviation mode, the Department expects to develop a complete method and generate such analysis in future years.

Current FDOT policy provides for funding within the Work Program for Spaceport projects in cooperation with Space Florida. Space Florida conducts financial and economic analysis of specific Spaceport projects before requesting funding from FDOT. As with ILCs, it is not possible at this time to aggregate the economic benefits and costs of the program in a way that is consistent with the methods used in this study. Spaceport projects in particular entail a high degree of uncertainty concerning future utilization and economic effects. However, work continues on improving and systematizing the study of such economic effects, and it is expected that additional analysis will be available in future years.

* * *

FDOT looks forward to including more modes in the macroeconomic analysis in coming years. For now, the most important requirement for this analysis is to match the benefits numerator with the costs denominator. As long as all costs that produce the benefits analyzed are included in the denominator, the analysis will be consistent and sound.

7.0 Results and Findings

The overall efficiency of transportation investments can be assessed by comparing the appropriate economic benefits against the economic costs. This Chapter presents the summary of economic benefits and costs, and the benefit-cost ratio, of investments in the FDOT Work Program. Consistent with previous macroeconomic analyses, this approach includes economic effects related to competitiveness and economic growth in addition to the direct user benefits. The cost analysis follows a traditional benefit-cost approach by including all of the Work Program's expenditures such as the costs to build, operate and maintain infrastructure, as well as associated administrative and support costs. The following is a description of the components of the costs and benefits included in the economic analysis of the Work Program:

Table 7.1: Components of Benefit-Cost Analysis

Benefits	Costs
• Change in Personal Income • Change in Personal Auto Benefits • Change in Transit Rider Benefits (i.e., Consumer Surplus)	• Capacity Spending • Costs for Operations and Maintenance • Costs for Administration and Support

7.1 Benefits and Costs

The benefits attributable to the FDOT Work Program include the macroeconomic effects measured by changes in real personal income, which result from improved transportation performance and the effect of these improvements on business productivity and expansion. In other words, investments reduce the cost of doing business for firms in Florida and this increases employment growth, business sales, and personal income. Direct highway and transit user benefits for personal travel are considered as well. Highway user benefits include the travel time savings, vehicle operating cost reductions and accident cost reductions created by improved travel conditions. Transit consumer surplus benefits are described in Chapter 4 and Appendix B-3. Highway safety benefits are described in Chapters 2, 3 and 7.

This approach avoids double-counting because user benefits of a direct business nature are used as inputs to the broader macroeconomic benefits analysis. Excluded from the benefits estimation are short-term construction benefits, including construction jobs, operational expenditures and any environmental impacts.

Costs considered in the analysis include the Work Program itself with investments in highways, highway safety, transit, seaports and rail between the fiscal years 2013/14 and 2017/18. Also added to the total cost for the analysis are expenditures for investment support, operations and maintenance, and administration. Excluded from the analysis are airport program investments, spaceport investments and most intermodal access investments. As noted in Chapter 6, the Department is working on methodologies to incorporate these types of investments into future analyses.

7.2 Analytic Assumptions

As a general guideline, the analysis examined a period of 30 years, including 5 years of capital expenditures in the Work Program, and 25 years of projected benefits and macroeconomic effects. The final year for which quantitative results were generated was 2043, so 25 years of benefits and macroeconomic effects are included for projects completed in 2018. Costs and benefits are expressed in constant dollars of 2014, and discounted to present value terms. The present value of costs and benefits occurring in future years was estimated with a real discount rate of 4 percent, the rate selected by FDOT for the benefit-cost analysis of capital projects. Use of the discounted "present value" of future costs and benefits provides a consistent basis for comparing costs and benefits accruing at different times in the future.

In keeping with the convention for transportation infrastructure projects and programs, the primary measure of effectiveness is the benefit-cost ratio. The benefit-cost ratio is defined as the discounted stream of future benefits divided by the discounted stream of future costs. In some cases, the net present value is used to supplement or replace the benefit-cost ratio. The net present value is defined as the difference between the discounted stream of benefits and the discounted stream of costs (see Appendix D, Glossary). In virtually all cases, these two terms are simply different ways of expressing the same set of mathematical relationships. The information used to calculate the benefit-cost ratio can be used to calculate the net present value.

7.3 Methodology

Estimating Benefits

User Benefits (Personal Travel)

User benefits are the result of time savings from infrastructure improvements resulting in benefits to Florida residents. Also referred to as non-business benefits, they accrue to individuals using the transportation system to commute to work or school, or for recreational and social travel. These include personal auto benefits from highway and bridge improvements, transit user benefits, and highway safety benefits.

Personal Auto Benefits: The personal auto benefits were calculated within the HERS and NBIAS analyses. The personal time savings are due to improvements to highways and bridges, as well as reduced congestion from increased transit ridership or the diversion of truck trips to other modes. These personal time savings estimates are multiplied by the value of time to determine the aggregate personal auto benefits for Florida residents. In addition, HERS also estimates the personal auto benefits resulting from lower vehicle operating costs and reduced accidents. Both categories are included in the total estimate for personal auto benefits.

Transit Consumer Surplus: Improvements to transit infrastructure will reduce travel time, which will benefit both existing transit passengers and new transit passengers. As transit investments are made, a portion of those who once relied on auto transportation will now shift to public transit. In addition public transit passengers will benefit, through reductions in their

travel time. Reduced travel time increases the net value, or consumer surplus, of each trip for transit riders.

Highway Safety Benefits: For the highway safety benefits included in the Highway Safety Improvement Program (HSIP, described in Chapter 2), the Safety Office generated estimates of numbers of reduced crashes per year. For each of 38 categories of improvement, the duration of the crash reduction effect depends on how long the improvement will remain effective. The crashes were broken down into five categories:

1) Property Damage Only (i.e. no injuries)
2) Possible or Minor Injury
3) Non-incapacitating Injury
4) Incapacitating Injury
5) Fatality

An average economic value for each crash avoided was estimated, based on the literature, for each category of crash. These ranged from $3,000 for Property Damage Only to $6,380,000 for Fatality crashes.[19] The number of crashes reduced by category was multiplied by their appropriate economic values, and a real discount rate of 4% was applied to these dollar values. An estimated total present value of benefits of $3.9 billion was generated. Because most of these benefits would not result in increased efficiency of business operations or other economic production

Benefits to Businesses

Benefits to businesses take the form of increases in Florida's real personal income. Real personal income is a major component of gross state product, which is projected to rise as well.

The main benefits for this analysis were the estimates for real personal income generated as a result of the Work Program investments. Real personal income is a true measure of a region's economic well-being and is adjusted for inflation to represent purchasing power. The real personal income estimates combine the REMI and MARAD results. The personal income estimates derived in the REMI analysis include the economic effects of highway, bridge, and freight infrastructure improvements. The results from a sample of Seaport projects deemed representative of the current Work Program were extrapolated to estimate economic benefits for this study.

Estimating Costs

The direct planned expenditures of the Work Program represent the costs used as denominator in the benefit-cost ratio. This analysis only includes costs of highway, bridge, rail, seaport, highway safety and transit improvements, which account for the overwhelming majority of the Work Program budget. Planned expenditures for aviation and most intermodal program

[19] The other values are $63,510 for possible or minor injury, $104,052 for non-incapacitating injury and $521,768 for incapacitating injury crashes. Some documentation of the FDOT Crash Reduction Analysis Safety Hub (CRASH) is available at http://www2.dot.state.fl.us/trafficsafetywebportal/CrashLogin.aspx. However, the data and analytic capabilities of the system are not currently available to the public.

investments are not included. Appropriate costs for Product Support, Operations and Maintenance, and Administration were included in the analysis. These three cost categories were adjusted to match the modal investments considered in the analysis.[20] Expenses from either major reconstruction projects or operations and maintenance work after Fiscal Year 2018 are excluded from the cost computations. Similarly, salvage values at the end of the period of analysis were assumed to be negligible. The cost analysis is narrowly focused on the evaluation of the next five years of transportation expenditures.

7.4 Economic Results

The economic effects below are based on the adopted Florida DOT Work Program as of July 2013. Table 7.2 shows economic estimates for selected years. Personal income effects range from $2.6 billion in 2016 to $4.8 billion in 2036 and represent benefits to Florida residents due to increased employment and wages. Gross State Product (GSP) is the most commonly used macroeconomic indicator of value-added economic activity, while business output represents all sales (goods and services) by Florida firms. In 2036, GSP annual effects are over $7.7 billion while total business output effects are $4.8 billion. The employment impact is a net job effect that would include both new jobs supported by greater economic competitiveness as well as jobs retained (that otherwise would be lost without transportation investments). Employment effects are over 26,300 in 2016 and increase to 38,107 jobs in 2036.

Table 7.2: Summary of Economic Results

	2016	2026	2036	2041
Personal Income*	$2.6	$4.0	$4.8	$4.1
Gross State Product*	$3.8	$6.7	$7.7	$6.3
Output*	$2.4	$4.3	$4.8	$4.0
Employment	26.3	38.3	38.1	29.0

** All monetary values reported in billions of 2014 dollars. Employment reported in thousands of jobs.*

Figure 7.1 displays the total employment impact from 2014 to 2043 due to Work Program investments. The employment impact grows rapidly over the five years of the Work Program (FY 2013/14 to 2017/18) and then expands gradually in line with projected growth in transportation volumes. The employment impact peaks in 2028 at 38,347 jobs. The substantial drop-off after 2036 is simply due to assumptions about the useful life of FDOT investments as investments are generally modeled to produce a 20 to 25 year stream of benefits.

Figure 7.2 shows the time series of effects for personal income, GSP, and business output from 2014 to 2043. Each series has a similar pattern as the job trend shown in Figure 7.1.

[20] On average for the five years, the share of aviation expenses is about 3.5 percent of total capacity investment in the Work Program. The share of intermodal access is only 0.7 percent.

Figure 7.1: Total Employment Effects

In Thousands of Jobs

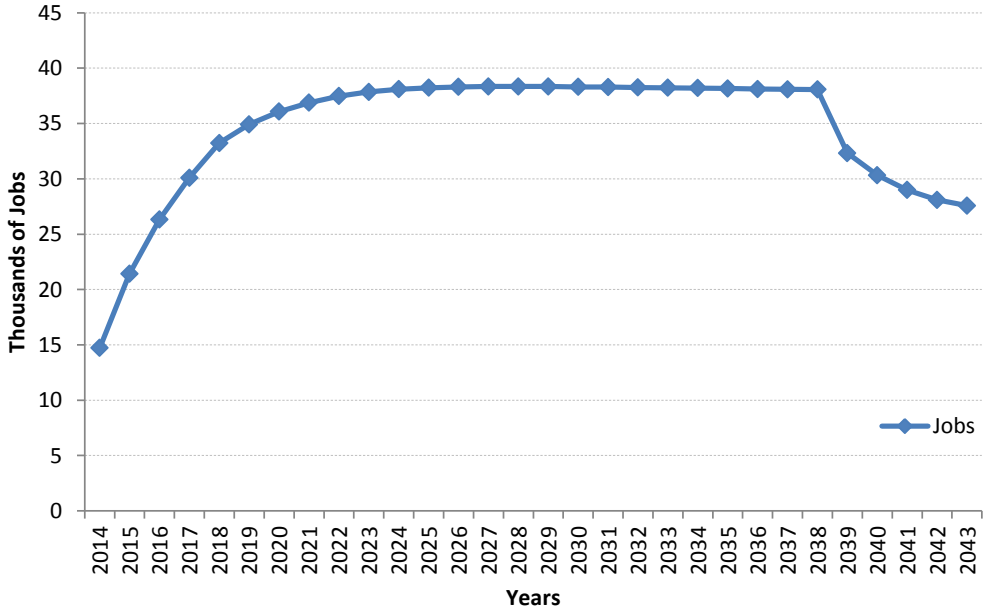

Figure 7.2: Personal Income, GSP, and Output Effects

In Millions of 2014$

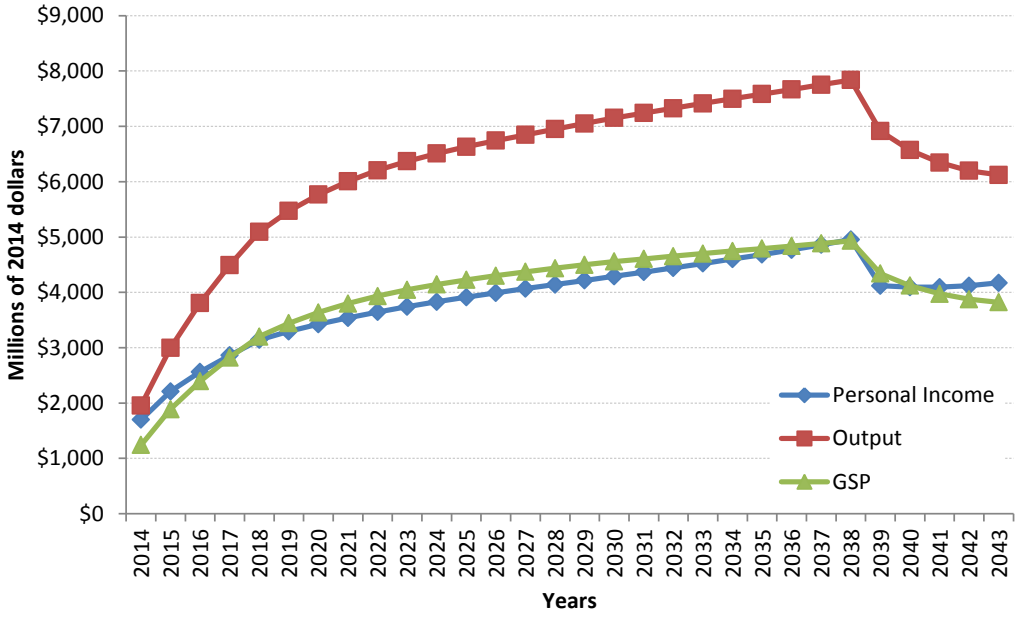

Table 7.3 provides industry-level employment impacts in 2016, 2026, 2036 and 2041. The industries that are projected to benefit the most from the FDOT Work Program include health care and social assistance, retail trade, accommodation and food services, other services, and administrative and waste management services. These industries tend to be well-represented in Florida, and also require transportation services. The employment impacts to transportation and warehousing (as a share of total job impacts) are estimated to exceed their current share of all jobs in Florida, reflecting the importance of transportation to these industries.

Table 7.3: Private Non-Farm Employment by Industry Impacts

Industry	2016	2026	2036	2041
Forestry, Fishing & Related Activities	127	226	189	135
Mining	28	40	36	28
Utilities	72	112	96	78
Construction	3,341	3,728	3,188	1,437
Manufacturing	534	771	695	519
Wholesale Trade	780	1,090	1,099	824
Retail Trade	3,498	4,576	4,276	3,128
Transportation & Warehousing	584	1,134	1,185	930
Information	257	344	292	211
Finance & Insurance	907	1,146	1,029	767
Real Estate, Rental & Leasing	1,802	2,326	1,896	1,186
Professional, Scientific & Technical Services	1,563	2,838	3,114	2,570
Management of Companies & Enterprises	116	165	158	122
Administrative & Waste Management Services	2,086	3,448	3,673	2,976
Educational Services	338	744	866	757
Health Care & Social Assistance	2,507	3,955	5,000	4,599
Arts, Entertainment & Recreation	434	637	668	526
Accommodation & Food Services	2,478	4,342	4,307	3,371
Other Services, except Public Administration	2,817	3,473	3,361	2,551
Total	**24,270**	**35,095**	**35,129**	**26,714**

7.5 Summary of Results

As shown in Table 7.4, the benefit-cost ratio of the FDOT five-year Work Program is estimated to be 4.4 with a net present value of $110 billion over 30 years. The analysis indicates that for every dollar invested into the Work Program, Florida's residents and businesses will receive a benefit of $4.4. The results of this analysis show the benefits of the FDOT Work Program and its effects on the Florida transportation system compared with making no investments and allowing the system to deteriorate.

Table 7.4: Benefit-Cost Summary of the FDOT Work Program

(All monetary values reported in billions of 2014 dollars)

BENEFITS	
Present Value of Personal Income Change	$65.7
Present Value of Non-Business User Benefits	$76.0
Total Discounted Benefits	$141.7
COSTS	
Present Value of Total Costs	$32.1
Net Present Value (Benefits Minus Costs)	$109.6
Benefit-Cost Ratio	4.4

In parallel with increasing personal income and gross state product for Florida, the Work Program is projected to support over 38,000 jobs. Most of these are long-term jobs; the vast majority is generated by 2020. Although the analysis period ends in 2043, job should continue for decades beyond. However, the jobs of the 2040s and 2050s are likely to stem from future FDOT work programs that are not considered in this analysis.

8.0 Discussion

8.1 Benefit-Cost Ratio

This report, reflecting the analysis performed in 2013 and 2014, is the fourth macroeconomic evaluation following the 2000 legislative mandate. All of the analyses continue to show that the State of Florida receives a good return on its investment in the FDOT Work Program. As we have performed the four studies, economic analysis has been applied to several additional transportation modes. And with this report, a better, but still incomplete, accounting of safety benefits from highway construction is provided.

However, this study shows a lower overall Benefit-Cost Ratio (BCR) than the previous analysis, performed in 2008, did. The drop from 4.9 to 4.4 mostly reflects changes in travel behavior and other effects of the housing crash of 2008 and the ensuing long and deep recession. In terms of its effects on the role of transportation in the Florida economy, the recession lasted from 2008 to 2012 (see the last page of Chapter 1 for a brief discussion).

Largely because of the recession, automobile ownership, auto vehicle miles travelled and truck vehicle miles traveled all declined from 2008 to 2012, with lingering effects still being felt in October 2014. In lay terms, the recession caused traffic congestion to go down, which provided a silver lining for millions of Florida residents and tourists. With traffic congestion already reduced, the value of the congestion-relieving benefits of the FDOT Work Program was substantially reduced, and this had a notable effect on the results of this study.

Additionally, the value of congestion relief is affected by the assigned value of time for people stuck in traffic. The value of time is estimated based on the median real prevailing wage, or estimates thereof.[21] Reflecting changing trends in the U.S. economy, estimates of the median wage used in the HERS and NBIAS models did not increase between 2000 and 2009. When median wage does not increase and overall construction costs do, that combination reduces the Benefit-Cost Ratio.

The effects of these economic trends were dominant for the estimation of overall BCR. These factors outweighed several factors that normally would have raised the estimated BCR. Most notably, the Real Discount Rate used for both future costs and benefits was decreased, compared to prior studies, from 7% to 4%. This would normally have the effect of substantially increasing the BCR.[22]

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[21] See US DOT, Revised Departmental Guidance on VTT in Economic Analysis, Sept. 2011. The median, which is the middle value in a collection of observations sorted from lowest to highest, is sometimes chosen as a measure of central tendency in preference to the arithmetic mean. One advantage of using the median is that it is not affected, or hardly affected, if one or a few values are dramatically in error.

[22] Decreasing the discount rate applied to a stream of future monetary values will always have the effect of increasing that stream's present value. Since the Work Program benefits extend far further into the future than do Work Program costs, lowering the discount rate will normally increase the present value of benefits far more than the increase in the present value of costs. Therefore, the Benefit-Cost Ratio will go up when such a change is made.

The new analysis of highway safety, specifically the Highway Safety Improvement Program (HSIP), estimated an additional $3.9 billion in safety benefits, which were not included in the prior studies. All other factors being equal, this would have an effect of increasing the overall BCR by about 0.1. But the effects of the change in real discount rate and the additional safety analysis were overshadowed by economic changes that were reflected in the HERS and NBIAS models.

FDOT is taking several major steps to increase and improve our contribution to Florida's economy. As the U.S. and Florida economies recover and flourish, traffic congestion can become much worse, constituting a further threat to the Florida economy and to the lifestyles of most Floridians. The FDOT statewide program of express lanes will increase the capacity of many major facilities and relieve congestion for both toll-paying express lane users and general purpose motorists. The express lane program is also fully funded, enabling the FDOT to proceed aggressively with building and operating the lanes.

Florida already is a leading state for tourism and among the leaders in freight transportation and business travel. However, with the expansion of the Panama Canal (expected to be complete in 2016) and continued globalization, opportunities for growth in all three areas are exceptional. As shown in Table 1.1, the FDOT Work Program provides for over $1 billion in expenditures on freight improvements, including those located at Seaports, Airports, Highways, Spaceports and Intermodal Logistics Centers. As goods movement patterns evolve and transform following the Panama Canal expansion, FDOT will be better able to analyze the effects of significant projects, such as seaport dredging. The Department expects to tailor the freight Work Program to generate greater benefits for Florida's economy.

Finally, the related technologies of autonomous and connected vehicles are expected to eventually transform everyday transportation for millions of Floridians.[23] As one of the largest and most densely populated states, Florida has established a leadership position in researching, developing and implementing these ground-breaking technologies.[24] While they may involve disruption of existing infrastructure, traffic patterns and insurance law, autonomous and connected vehicles have the potential to produce enormous benefits with respect to safety, mobility, freight transportation and urban form.

[23] IHS Automotive "Emerging Technologies: Autonomous Cars – Not If, But When" January 2014. This report projects that autonomous cars will account for 9% of worldwide automobile sales in 2035. All projections at this point must be based on conjecture, but this is one of the better-researched reports available. It can be accessed at http://orfe.princeton.edu/~alaink/SmartDrivingCars/PDFs/IHS%20_EmergingTechnologies_AutonomousCars.pdf

[24] See http://en.wikipedia.org/wiki/Autonomous_car, accessed Oct. 10, 2014. Also see http://www.automatedfl.com/.

8.2 Economic Forecasts and Contingencies

As already discussed, the long and deep economic recession of 2008 to 2012 had a significant effect on the results of this study. Therefore, there is strong interest in the likely future course of the national and Florida economies, and in the interaction of other factors influencing economic growth with transportation policy and future FDOT Work Programs.

According to the Florida Economic Estimating Conference (FEEC), Florida has achieved clear progress toward recovery, but our state has not yet achieved full recovery.[25] Areas of progress include growth of real Gross State Product (GSP) from a low of $721 billion in Calendar Year 2010 to $751 billion and steadily rising in Calendar Year 2013, and an increase in the number of out-of-state tourists from an estimated 85.9 million in 2011 to 94.7 million in 2013.[26]

According to the FEEC, overall economic recovery (or normalcy, in their parlance) is expected in FY 2016/17, or during the period including January 1, 2017. During this period, Florida Real Per Capita Income is forecast to reach almost $42,700 and Non-Farm Employment to reach about 8.3 million.[27] However, the construction industry is not forecast to reach prior peak expenditure levels until FY 2023/24.[28] These findings and forecasts suggest a distinct long-term change in the Florida economy, with rapid growth in tourism, along with other factors, making up for continued slow growth in the traditionally strong construction industry.

A lower growth rate in construction implies a lower volume of one category of freight transportation, and a slightly lower contribution to economic growth than was forecast prior to the housing crash of 2008 and the ensuing long and deep recession. However, observed increases in tourism, potential major increases in international freight and renewed growth in the number of person trips as the economy continues to recover indicate that transportation infrastructure needs will substantially increase in the coming years. As the economy grows and the models used for the macroeconomic analysis reflect increased transportation demand, the projected macroeconomic benefits of the Work Program are likely to increase noticeably.

Sensitivity analyses were performed to test the effects of a substantial increase (10% of the 5 Year total) or decrease (also 10% of the total) in available Work Program funding. Effects on the overall BCR were in the expected direction.[29] Compared to a baseline Benefit-Cost Ratio of 4.4, if Work Program funding were to increase, the projected BCR goes ***down*** to 4.2. Conversely, if Work Program funding were to decrease, the projected BCR goes ***up*** to 4.8. Please see Appendix B-5 and Table B-16 for detailed results.

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[25] http://edr.state.fl.us/content/conferences/fleconomic/floridaeconomicsummary.pdf, released September 3, 2014.
[26] See http://www.statista.com/statistics/187850/gdp-of-the-us-federal-state-of-florida-since-1997/, and http://www.bizjournals.com/jacksonville/news/2014/02/14/florida-posts-record-2013-tourism.html, both accessed October 14, 2014.
[27] See http://edr.state.fl.us/Content/conferences/fleconomic/floridaeconomicresultslongrun.pdf
[28] http://edr.state.fl.us/content/conferences/fleconomic/floridaeconomicsummary.pdf,
[29] The HERS model is programmed to initially select the projects with the greatest economic returns, As funding levels increase, the model will select good projects, but ones with lower estimated BCRs than the initial set. Therefore, it is to be expected that a higher funding level will be associated with a slightly lower overall BCR.

8.3 Relationship With FDOT's Return On Investment Analytic Program

Since the prior macroeconomic analysis was performed in 2008 and posted in 2009, the Department has greatly expanded its program of economic analysis focused on planned capacity projects across several transportation modes. The economic analysis consists primarily of Benefit-Cost Analysis (BCA), although the term Return On Investment (ROI) analysis is preferred. In many cases, the ROI analysis is coordinated with financial analysis, which is referred to as Internal Rate of Return (IRR) analysis within FDOT. With the Department's focus on the Strategic Intermodal System (SIS), projects within the Highway, Seaport, Aviation and Freight Rail modes have been the subject of intensive analysis. A few projects in transit and other modes have also been analyzed.

Economic analysis of capacity projects is similar to macroeconomic analysis of the Work Program in several respects, but the difference in scale between one project and the entire Work Program makes it challenging to fully integrate the analyses. Significant similarities include:

- The use of a Benefit-Cost Ratio to summarize the results of the analysis into a single metric,
- The combination of both construction and operations and maintenance (O&M) costs to generate the cost denominator;
- The use of a uniform discount rate to express all benefits and costs as present values. The two analyses now both use a 4 percent real discount rate to achieve this.

However, the analyses are difficult to compare or integrate, primarily for the following reasons:

- The difference of scale makes it possible for project-level analyses to go into much greater detail than can be done with the macroeconomic analysis;
- Because of the difference in scale, benefits which should be conceptually comparable are measured and valued using differing methods. Specifically, the macroeconomic analysis uses the HERS, NBIAS and REMI models, which are not available or applicable for analyses of individual projects;
- Certain categories of benefits, such as esthetic or recreational benefits or dis-benefits, may be important for a few individual projects, but not worthwhile to estimate for the entire Work Program.

The coming years may see coordination, reconciliation and ultimately integration of these two different sets of analyses. The macroeconomic methodology may be informed and modified because of findings from individual ROI analyses. However, for now the two will be kept separate.

9.0 Ideas for Further Analysis and Research

Statutory language does not specify how often this study is to be updated. However, over the past 15 years, our analysis program has gone well beyond what is required in statute. The analyses have helped Florida's decision-makers and a wider group of stakeholders understand the economic benefits generated by transportation investments and improved system performance. We anticipate that continuing economic and financial analysis of FDOT projects, programs and policies will break new ground and contribute to still better mobility, safety and quality of life for all Floridians. The goal is to produce serious and well-documented analysis which will yield a factual and objective assessment of FDOT's future contributions.

Several areas have been identified for potential further development. The following ideas for enhancement would continue the process of refining the analysis and providing full modal coverage.

1. Improving Highway Analysis Within the Current Framework – The highway analysis could incorporate detailed commodity flow data, which would create a more accurate picture of the freight benefits generated by the highway improvements, as well as by projects in other freight modes. The sources for such data need to be defined but it may be possible to use TRANSEARCH, the statewide freight travel demand model or another data resource as the basis for such analysis. The development of the Florida Freight Mobility and Trade Plan, and related work, is likely to be helpful in focusing and defining analytic goals for more specific analysis of benefits from truck and other freight shipments.

In addition to user benefits such as time savings, operating cost reductions and crash cost reductions, highway reliability benefits should be included in the analysis. Investments in transportation infrastructure and/or operational improvements expand capacity and allow for the peak congestion period to be flattened or shortened. As a result the buffer time, the time added to a trip in order to be on time, can be reduced as well. The decrease in this time can be picked up as a reliability benefit from the Work Program.

The HERS estimate of travel time savings accounts for anticipated reduction in non-recurring delay (e.g. reductions in the number of incidents) but does not include the full economic value to people or businesses of having more reliable travel times. This is also true for most transportation demand models. FDOT is working on measuring reliability on the Interstates and State Highways, and developing useful measures of the economic benefits of improved or preserved reliability will be a priority for future analysis.

Greater attention also could be given to the user and economic benefits of improved or new interchanges. Interchange projects are not directly modeled in HERS, but benefit data could be extracted from other models applied by the Districts and the FDOT Systems Management Section.

2. Developing a More Accurate and Integrated Modeling Process – The analysis of highway investments is currently accomplished by applying the HERS model, with annual Work

Program expenditures constituting the primary inputs to the model. User benefits are then annualized and used as inputs for the regional economic model (REMI). Overall, this analysis approach works well for the macroeconomic evaluation, but more accurate data and expanded software capabilities may provide more useful forecasts in the future.[30]

A travel demand model could be used in addition to HERS. This type of model is available either at the state, district or metropolitan level. The FDOT modeling section maintains the statewide model and coordinates District and metropolitan models. Highway improvements would be coded so the structure and detail of the Work Program would be more thoroughly analyzed in the future. The adoption of a travel demand model would entail significant effort to code the entire Work Program, but it would give the study greater accuracy and specificity on the facility level. Highway preservation investments and bridge improvements could still be evaluated using HERS and NBIAS or other options could be explored.

If we consider the entire FDOT macroeconomic modeling process, it includes a wide variety of analytic tools. HERS, NBIAS, MARAD, freight and transit analyses completed in Excel, and REMI all play a role. Adding a travel demand model would increase the complexity of the process. While most or all of these individual tools will be needed in the future, it would be desirable to integrate them into a coordinated interface. The exact information technology configuration would need to be researched, but there are a variety of tools available for data integration, including Geographic Information Systems (GIS).

3. Freight Methodology Improvements – The current analysis includes benefits and costs of seaport projects, and shipping costs savings and highway travel benefits associated with freight rail projects. Several factors will enhance these modal analyses and facilitate the incorporation of multi-modal factors in the macroeconomic study. With the development of the Florida Freight Mobility and Trade Plan, improved commodity flow data and new methodologies for analyzing and forecasting freight flows within and across modes, these analyses will be revised and extended.

For example, expanded capacity on a highway or rail line serving a seaport could eliminate delays near the gate. The reduction of this bottleneck could enable the entire seaport to process more cargo each day, effectively expanding the capacity of the seaport. The FDOT ROI analysis of the capital program at Port Everglades considers such factors affecting the operations of one facility. Performing a comprehensive analysis of interactions between facilities of different modes in the freight realm, including Intermodal Logistics Centers (ILCs), could enhance the next macroeconomic study.

4. Inclusion of the Aviation Work Program – Because of the importance of the aviation mode to the SIS, it is a high priority to include aviation in the analysis and results of the next macroeconomic study. As discussed in Chapter 6, the Aviation Office has developed the Florida Airport BCA Tool. This tool facilitates the analysis of airside capacity expansion at multiple

[30] In particular, the HERS and NBIAS models do not analyze the specific projects of our Work Program, but simulate the Work Program based on facility data and the internal criteria of those models. Improving the modeling process to incorporate more specific and accurate data about the Work Program might result in more specific and accurate projections and summary results.

commercial airports, but additional work is needed to generate an overall FDOT Aviation Work Program BCR. Analysis of airport projects needs to take into account other sources of funding, frequently from the Federal Aviation Administration (FAA) and from the airport itself. The specific steps include:

a) The BCRs identified for capacity expansion programs at specific airports will be further developed to generate sketch-plan BCRs for specific projects located at each of those airports. This method could be applied to all 19 commercial service airports, or to selected projects located at those airports.
   i. A method for evaluating the sketch-plan BCR of either landside projects or programs at the state's largest airports will be developed.
   ii. A set of specific airside and landside projects within the Aviation Work Program will be identified and analyzed.
   iii. The sketch-plan BCRs will be adjusted for the percentage of project funding provided by FDOT. Usually, this will be straightforward. The percentage of project benefits ascribed to FDOT will equal the percentage of funding the Department provided. In some cases, FDOT funding may be as low as 5 or 10 percent of the project total.

b) A method for aggregating from specific projects analyzed to all projects within a certain category will be developed. The most likely methods for doing this are,
   i. Analyzing all projects within a category and aggregating the results;
   ii. Analyzing a random sample of projects and using well-known statistical methods to determine the confidence interval of the BCR of all the projects[31];
   iii. Selecting a limited set of projects (possibly the largest projects in the category) and only generating a BCR for the benefits and costs of those specific projects, excluding the others; or
   iv. Finding and applying a model, analogous to the HERS model, which simulates all the Aviation Work Program projects within a category or multiple categories. As with HERS, modifications or additions to the model output may be needed for the greatest possible accuracy and usefulness.

c) If some categories of aviation projects, for example, projects at General Aviation facilities, cannot be analyzed as part of the next macroeconomic study, then it is important to only include benefits and costs for the categories that can be analyzed.

[31] Please note that the application of this method requires additional caution. In particular, it is important not to imply that all analyses of individual projects are completely accurate and unbiased.

Appendices

Appendix A - Florida Statutes

Title XXXVI, Public Transportation

Chapter 334, Transportation Administration

334.046 Department mission, goals, and objectives.--

(1) The prevailing principles to be considered in planning and developing an integrated, balanced statewide transportation system are: preserving the existing transportation infrastructure; enhancing Florida's economic competitiveness; and improving travel choices to ensure mobility.

(2) The mission of the Department of Transportation shall be to provide a safe statewide transportation system that ensures the mobility of people and goods, enhances economic prosperity, and preserves the quality of our environment and communities.

(3) The department shall document in the Florida Transportation Plan, in accordance with s. 339.155 and based upon the prevailing principles of preserving the existing transportation infrastructure, enhancing Florida's economic competitiveness, and improving travel choices to ensure mobility, the goals and objectives that provide statewide policy guidance for accomplishing the department's mission.

(4) At a minimum, the department's goals shall address the following prevailing principles.

(a) *Preservation*.--Protecting the state's transportation infrastructure investment. Preservation includes:

1. Ensuring that 80 percent of the pavement on the State Highway System meets department standards;

2. Ensuring that 90 percent of department-maintained bridges meet department standards; and

3. Ensuring that the department achieves 100 percent of the acceptable maintenance standard on the state highway system.

(b) *Economic competitiveness*.--Ensuring that the state has a clear understanding of the economic consequences of transportation investments, and how such investments affect the state's economic competitiveness. The department must develop a macroeconomic analysis of the linkages between transportation investment and economic performance, as well as a method to quantifiably measure the economic benefits of the district-work-program investments. Such an analysis must analyze:

1. The state's and district's economic performance relative to the competition.

2. The business environment as viewed from the perspective of companies evaluating the state as a place in which to do business.

3. The state's capacity to sustain long-term growth.

(c) *Mobility*.--Ensuring a cost-effective, statewide, interconnected transportation system.

Appendix B - Technical Appendices

This appendix provides quantitative description and examples of several of the analysis tools used to produce quantitative results. These will be of interest to persons who wish to know exactly how the results were achieved or who are interested in replicating this study or performing a similar study. Some of the terms used here are defined and explained in the Glossary at the end of this report.

Appendix B-1 – Highway Improvement Analysis Steps

The basics of HERS and NBIAS are described in Chapter 3. The analysis of the benefits of the Highway Safety Improvement Program (HSIP), performed for the first time for this edition of the study, is presented in Chapter 2.

HERS-ST

The following steps were followed in using the Highway Economic Requirements System – State Version (HERS-ST) for the analysis of at-grade highway improvements:

1) FDOT provided the most recent available Highway Performance Monitoring System data, which represents road conditions as of 2012, for input to HERS-ST. The road conditions contain data on the performance level of a road segment as well as the traffic volume. Adjustments were made to the expansion factors to ensure overall vehicle-miles traveled in the data set match actual counts and to the truck growth factors to match freight growth predicted by the Freight Office.
2) Current costs and model parameters for use with HERS-ST were obtained from the Federal Highway Administration and compared to those collected at FDOT. These model parameters were current as of 2013. These parameters include estimates of the values of time to be used in the analysis. HERS differentiates the value of time by type of vehicle and also incorporates occupancy factors when determining the combined value of time for a vehicle category. In addition to these values of time, the parameters also included construction cost estimates (i.e. construction unit costs and cost escalation factors) as well as assumptions of the current per mile operating costs for the different types of vehicles, fuel cost estimates and vehicle usage efficiency assumptions. The cost assumptions and value of time parameters were compared to real world data and Florida-specific cost figures, as well as value of time assumptions taken from the literature. It was concluded the HERS default value of time parameters were adequate for the analysis but that HERS default construction cost and "on-the-clock" percent should be revised to reflect Florida-specific values. Further adjustments were made to address default capacity calculations that overestimated the capacity of Florida roadways compared to FDOT's own calculations.
3) The budget for the analysis was determined as described in Chapter 1. Specifically, the highway capacity portions of the Work Program (i.e., Strategic Intermodal System highways, other arterials and right of way) were combined with the resurfacing components in order to develop the inputs into HERS. These budget numbers were changed from year of expenditure dollars to constant dollars and included as parameters in HERS. Conceptually, the model runs through the network of roads and

analyzes it. The model's product is a prioritized list of capacity improvements and resurfacing projects based on the expected transportation benefits. This list of projects is not identical to the final Work Program priorities, which also reflect additional factors, but it is a useful approximation.

4) An adjustment was made to HERS-ST in order to retain the same relationship between investments in resurfacing and reconstructing projects contained in the Work Program. HERS-ST does not allow for the separate specification of budgets by work type. By statute and policy, FDOT funds the pavement to meet specific condition targets. An adjustment was made to pavement preservation spending such that pavement condition remained consistent with statute. This adjustment is important because in HERS-ST pavement condition impacts mobility and user costs.
5) HERS-ST was run, simulating conditions for five one-year analysis periods under two scenarios: with the proposed highway program funding, and without funding. In the funding case, HERS-ST optimized the selection of projects based on the estimated benefits. In the no funding case, HERS-ST illustrated the decline of the performance of the infrastructure when no money is spent.
6) Unit user costs (dollars per vehicle mile traveled) were obtained for each year of the analysis for autos and trucks for travel time costs, operating costs and crash costs. The direct transportation benefits of investment were calculated as the difference between the unit costs with and without investment multiplied by predicted vehicle miles traveled. Vehicle miles traveled were assumed to be the same in both scenarios of highway capacity improvements, and the effects of elasticity were assumed to be minimal, consistent with previous macroeconomic analyses.[32]
7) The predicted benefits were disaggregated into business and non-business benefits, and into internal versus external trips. This involved applying a set of assumptions identical to those made in previous macroeconomic analyses concerning the fraction of auto and truck trips internal to the state (versus trips beginning or ending in another state), the fraction of auto trips related to business and the fraction of safety benefits associated with property damage.

HERS-ST was also used to analyze benefits to highway users realized from transit investment. For this analysis, HERS-ST was run as described above. However, the predicted future traffic was adjusted based on the transit analysis described in Chapter 4 and Appendix B-3. The reduction in traffic was compared to the unit user costs to update total benefits.

NBIAS

The HERS model and Highway Performance Monitoring System data do not include information regarding bridges. The National Bridge Investment Analysis System (NBIAS) is used to capture the benefits of bridge investments. This system contains Florida-specific bridge data and allocates investments from the Work Program to Florida bridges to generate program-level benefits. Similar to the highway analysis, NBIAS benefits are then used as inputs to REMI to generate macroeconomic effects. The following steps were followed in using NBIAS for the analysis:

[32] The transit and rail analyses estimated a change in highway vehicle miles traveled from these modal investments, as discussed in Appendix B-3.

1) FDOT provided the most recent available National Bridge Inventory data, which represents bridge conditions as of 2011, for input to NBIAS. The 2012 data were investigated but results were not inconsistent.
2) Current costs and model parameters for use with NBIAS were obtained from the Federal Highway Administration. These model parameters were current as of 2013. The NBIAS parameters include Florida-specific cost adjustments.
3) The budget was determined as described in Chapter 1. Specifically, the bridge component of the Work Program was used as the input parameter for NBIAS.
4) The system reads National Bridge Inventory data, uses these data to determine functional characteristics and estimates the conditions for the structural elements for each bridge in the inventory. The analysis included almost all bridges on the Florida road system eligible for federal funding.
5) NBIAS determines the cost minimizing approach to keep each type of structural element in a state of good repair. The best approach, termed the "optimal preservation policy," is determined for each element and climate zone.
6) NBIAS predicts future conditions for a specified budget or a range of budgets.
7) For each year of an analysis period, NBIAS determines what work should be performed based on the objective of maximizing user and agency benefits. The system considers preservation actions consistent with the optimal preservation policy. Also, the system considers performing certain types of functional improvements where a bridge fails to meet specified functional specifications. Improvements considered by the system include widening existing lanes and shoulders, raising bridges, strengthening bridges and bridge replacement.
8) The system predicts future conditions, including physical conditions, funds spent and benefits obtained from the planned work. User benefits modeled by NBIAS include reduced travel time costs from raising or strengthening bridges, reduced crash costs from widening existing lanes and shoulders and reduced operating costs from improving bridge decks. Replacing a bridge yields all of the benefits achieved by performing needed preservation and functional improvement work.
9) NBIAS was run, simulating conditions for five one-year analysis periods with the proposed funding. Similar to the HERS analysis, the NBIAS project list is not identical to the final Work Program priorities, which also reflect additional factors, but it is a close approximation.
10) Predicted benefits were obtained by year relative to the alternative of deferring investments. Direct transportation benefits obtained included travel time, operating and safety benefits obtained from preservation, functional improvement and replacement work.
11) The predicted benefits were disaggregated into business and non-business benefits, and into internal versus external trips as described above for the HERS-ST analysis.

HSIP

Safety impacts analyzed in HERS and NBIAS do not address the full range of safety benefits supported by the Work Program. Safety improvements are included routinely in pavement and bridge improvement projects but data specifically identifying safety improvements to support analysis do not yet exist. The Highway Safety Improvement Program (HSIP) and High Risk Rural Roads Program (HRRRP) funds and project tracking efforts do provide data for assessing economic benefits, which would involve:

Estimating the number of crashes avoided using specific projects identified in the HSIP and HRRRP. FDOT's Safety Office tracks predicted crash reductions for specific safety improvements in the Crash Reduction Analysis System Hub (CRASH) database;

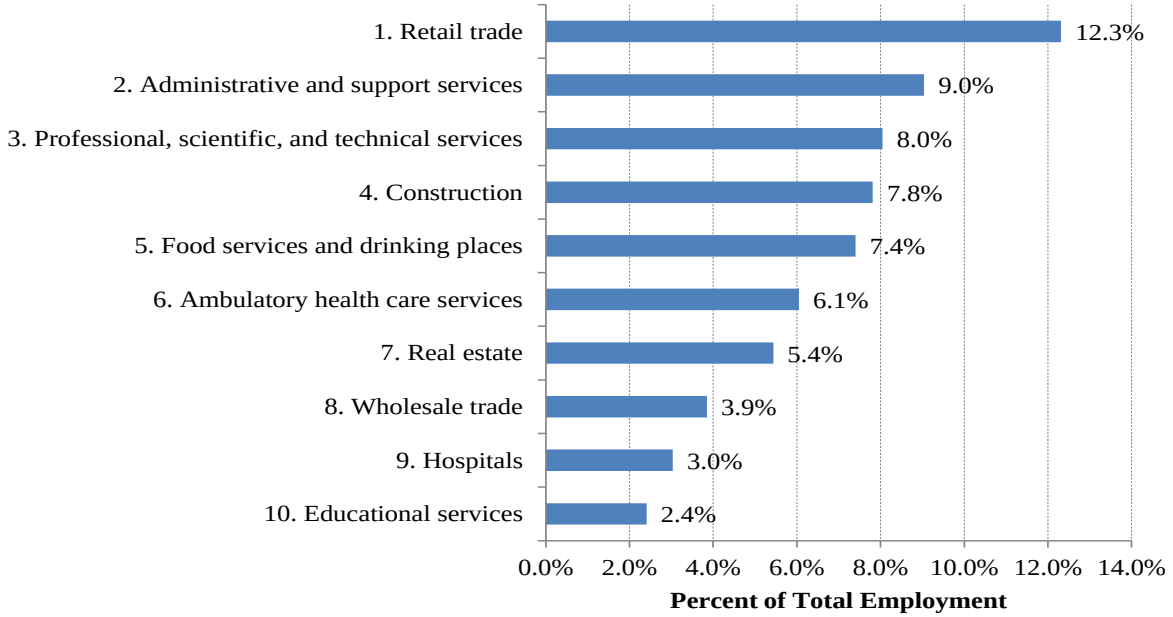
1) **Evaluating the monetary value of the crashes reduced.** The Safety Office develops cost per crash estimates in the Crash Analysis Reporting System (CARS) based on FHWA guidance. The office combined the crashes reduced with the cost per crash to develop a total monetary value saved for all crashes.
2) **Evaluating the useful life of each safety improvement.** The Safety Office determined, for each category of safety improvement, what the expected useful life is likely to be. For example, an infrastructure improvement (e.g., adding a left turn lane at an intersection) is expected to have a 20-year life span while modifying signal and phasing is expected to have a five-year life span.
3) **Aggregation.** The benefits of the Safety Work Program were aggregated from these project types. The benefits are considered personal and not applicable to industrial benefits. As such, the benefits were not modeled in REMI.

Appendix B-2 – REMI Projections

The use of REMI to model long-term economic growth benefits was presented in Chapter 5. One valuable function of the REMI model is to distribute the transportation benefits to each industry for the forecast years. The following information and methods were used to distribute business auto, trucking, and freight rail benefits:

Business Auto. Industry employment estimates from REMI's baseline forecast (in the year 2019, which is the first calendar year following the new Work Program) were used to determine employment shares by industry. Industries with the most employees received the largest portion of the business auto benefits, while industries with fewer employees received a smaller portion of the benefits. Figure B.1 shows projections for the year 2019. According to the REMI analysis, the top five industries in Florida in terms of employment will be Retail trade, Administrative and support services, Professional, scientific, and technical services, Construction, and Food services and drinking places. Table B.1 shows the full list of the industries and the REMI TranSight data (which were used to calculate the share of business auto benefits that each of the industries receives).

Figure B.1: Top Ten Industries in Florida by Percent of Total Employment, Estimate of 2019



Source: REMI TranSight baseline data, HDR calculations

Table B.1: Business Auto Share of Benefits Calculation

Industry	2019 Florida Employment (thousands) from REMI	Percent of Total Use
Forestry and logging; Fishing, hunting, and trapping	13.2	0.1%
Agriculture and forestry support activities	52.8	0.5%
Oil and gas extraction	18.2	0.2%
Mining (except oil and gas)	7.8	0.1%
Support activities for mining	1.9	0.0%
Utilities	23.0	0.2%
Construction	821.7	7.8%
Wood product manufacturing	14.4	0.1%
Nonmetallic mineral product manufacturing	25.2	0.2%
Primary metal manufacturing	5.0	0.0%
Fabricated metal product manufacturing	40.5	0.4%
Machinery manufacturing	24.9	0.2%
Computer and electronic product manufacturing	40.2	0.4%

Table B.1: Business Auto Share of Benefits Calculation

Industry	2019 Florida Employment (thousands) from REMI	Percent of Total Use
Electrical equipment and appliance manufacturing	9.6	0.1%
Motor vehicles, bodies and trailers, and parts manufacturing	6.7	0.1%
Other transportation equipment manufacturing	31.2	0.3%
Furniture and related product manufacturing	14.1	0.1%
Miscellaneous manufacturing	30.3	0.3%
Food manufacturing	32.3	0.3%
Beverage and tobacco product manufacturing	9.4	0.1%
Textile mills; Textile product mills	6.2	0.1%
Apparel manufacturing; Leather and allied product manufacturing	6.6	0.1%
Paper manufacturing	8.9	0.1%
Printing and related support activities	20.4	0.2%
Petroleum and coal products manufacturing	3.2	0.0%
Chemical manufacturing	18.3	0.2%
Plastics and rubber product manufacturing	14.6	0.1%
Wholesale trade	404.9	3.9%
Retail trade	1295.3	12.3%
Air transportation	32.0	0.3%
Rail transportation	6.0	0.1%
Water transportation	16.2	0.2%
Truck transportation	107.3	1.0%
Couriers and messengers	71.4	0.7%
Transit and ground passenger transportation	31.1	0.3%
Pipeline transportation	0.2	0.0%
Scenic and sightseeing transportation; Support activities for transportation	67.7	0.6%
Warehousing and storage	44.6	0.4%
Publishing industries, except Internet	40.0	0.4%
Motion picture and sound recording industries	15.9	0.2%
Internet publishing and broadcasting; ISPs, search portals, and data processing; Other information services	27.2	0.3%
Broadcasting, except Internet	20.8	0.2%
Telecommunications	72.7	0.7%
Monetary authorities - central bank; Credit intermediation and	215.1	2.0%

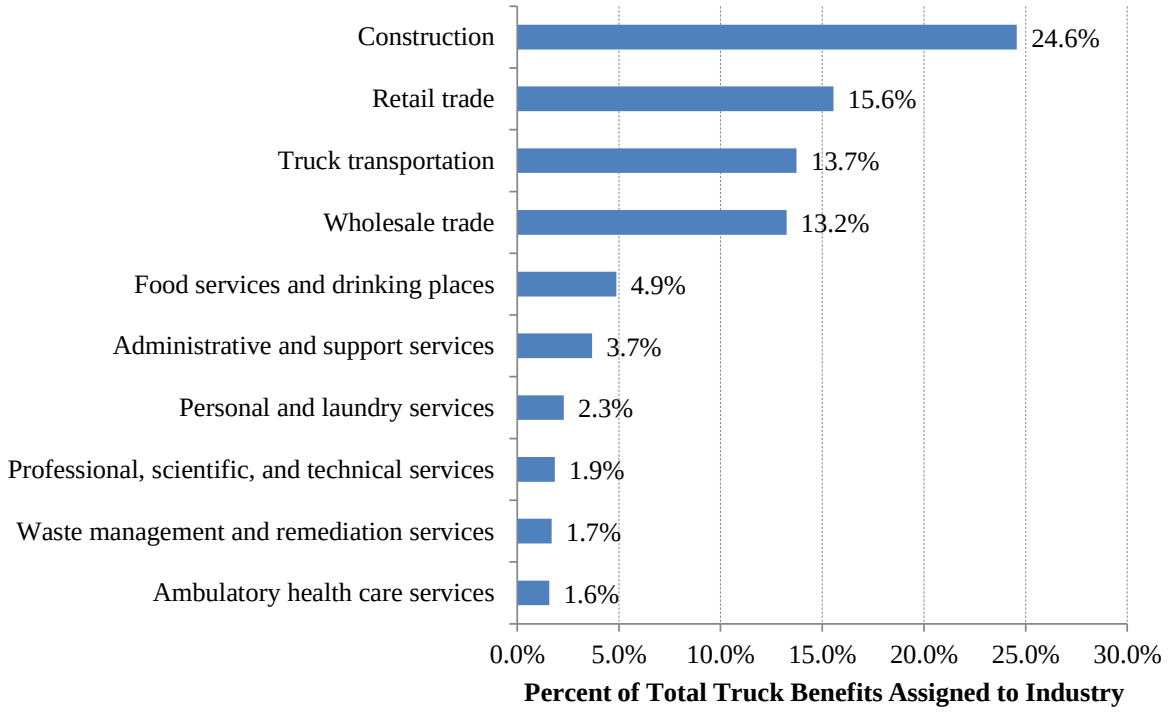
Table B.1: Business Auto Share of Benefits Calculation

Industry	2019 Florida Employment (thousands) from REMI	Percent of Total Use
related activities; Funds, trusts, & other financial vehicles		
Securities, commodity contracts, investments	250.8	2.4%
Insurance carriers and related activities	187.0	1.8%
Real estate	571.8	5.4%
Rental and leasing services; Lessors of nonfinancial intangible assets	55.2	0.5%
Professional, scientific, and technical services	846.6	8.0%
Management of companies and enterprises	106.6	1.0%
Administrative and support services	950.8	9.0%
Waste management and remediation services	22.5	0.2%
Educational services	253.4	2.4%
Ambulatory health care services	636.3	6.1%
Hospitals	319.3	3.0%
Nursing and residential care facilities	229.7	2.2%
Social assistance	194.7	1.9%
Performing arts and spectator sports	138.6	1.3%
Museums, historical sites, zoos, and parks	8.1	0.1%
Amusement, gambling, and recreation	198.0	1.9%
Accommodation	206.3	2.0%
Food services and drinking places	778.4	7.4%
Repair and maintenance	151.9	1.4%
Personal and laundry services	173.7	1.7%
Membership associations and organizations	219.2	2.1%
Private households	249.6	2.4%
Total	**10,518**	**100.0%**

Source: REMI TranSight baseline data, HDR calculations

Trucking and Freight Rail. For the year 2019 and other future years, the total trucking and rail benefits were distributed by industry using the U.S. Bureau of Transportation Statistics' Transportation Satellite Accounts. These accounts estimate the amount of transportation usage by mode by industry.[33] The truck and freight rail dependency factors are multiplied by the business output of each industry to determine the projected total transportation use and thus the share of benefits. Figure B.2 below shows the potential future (2019) top ten industries using truck services. Table B.2 shows how these industry shares are calculated and provides the full list of industries, in the same order as presented in REMI TranSight. Figure B.3 and Table B.3 provide the same information applicable to rail services. Transportation requirements for truck and in-house truck transportation (Table B.2) are calculated by dividing the use of commodities value (in millions of dollars at producers' prices) for items labeled 4840 (Truck transportation) and 484A (In-house truck transportation) by the total industry output. Similarly, for Rail (Table B.3), the sum of values for items 4820 (Rail transportation) and 4820A (In-house rail transportation) is divided by the total output in each industry. See Table B.5 for TSA industry classification.

Figure B.2: Top Ten Industries in Florida by their Use of Truck Transportation



Source: REMI TranSight baseline data, HDR calculations based on TSA data

[33] TSA data include in-house truck and in-house rail transportation, in addition to for-hire truck and rail transportation. According to the data, the total commodity output for in-house truck transportation is almost twice as large as for truck transportation (for rail, however, the in-house part is almost negligible). The latest available TSA numbers were published in 2011. They are based on data collected in 1997.

Table B.2: Truck Share of Benefits Calculation

Industry	2019 Florida Output (billions of 2005 dollars)	For-Hire Truck Transportation Requirements	In-House Truck Transportation Requirements	Use of For-Hire Truck Transportation	Use of In-House Truck Transportation	Percent of Total Use
Forestry and logging; Fishing, hunting, and trapping	1.4	0.001	0.137	0.00	0.19	0.5%
Agriculture and forestry support activities	1.1	0.011	0.074	0.01	0.08	0.2%
Oil and gas extraction	2.0	0.003	0.003	0.01	0.01	0.0%
Mining (except oil and gas)	0.9	0.017	0.077	0.01	0.07	0.2%
Support activities for mining	0.2	0.010	0.080	0.00	0.02	0.0%
Utilities	15.3	0.003	0.006	0.05	0.09	0.2%
Construction	78.7	0.014	0.124	1.08	9.74	24.6%
Wood product manufacturing	3.4	0.030	0.018	0.10	0.06	0.2%
Nonmetallic mineral product manufacturing	5.8	0.049	0.050	0.29	0.29	0.7%
Primary metal manufacturing	2.2	0.029	0.006	0.06	0.01	0.0%
Fabricated metal product manufacturing	8.2	0.012	0.008	0.10	0.06	0.2%
Machinery manufacturing	7.5	0.010	0.004	0.08	0.03	0.1%
Computer and electronic product manufacturing	29.5	0.003	0.001	0.08	0.02	0.1%
Electrical equipment and appliance manufacturing	2.8	0.011	0.003	0.03	0.01	0.0%
Motor vehicles, bodies and trailers, and parts manufacturing	3.5	0.013	0.004	0.05	0.01	0.0%
Other transportation equipment manufacturing	10.9	0.008	0.003	0.08	0.04	0.1%
Furniture and related product manufacturing	2.2	0.017	0.022	0.04	0.05	0.1%
Miscellaneous manufacturing	7.7	0.011	0.019	0.08	0.15	0.4%
Food manufacturing	12.1	0.018	0.016	0.22	0.20	0.5%

Table B.2: Truck Share of Benefits Calculation

Industry	2019 Florida Output (billions of 2005 dollars)	For-Hire Truck Transportation Requirements	In-House Truck Transportation Requirements	Use of For-Hire Truck Transportation	Use of In-House Truck Transportation	Percent of Total Use
Beverage and tobacco product manufacturing	7.4	0.012	0.019	0.09	0.14	0.4%
Textile mills; Textile product mills	1.0	0.020	0.007	0.02	0.01	0.0%
Apparel manufacturing; Leather and allied product manufacturing	0.5	0.010	0.004	0.01	0.00	0.0%
Paper manufacturing	3.8	0.027	0.007	0.10	0.03	0.1%
Printing and related support activities	3.9	0.023	0.012	0.09	0.05	0.1%
Petroleum and coal products manufacturing	8.2	0.006	0.002	0.05	0.02	0.0%
Chemical manufacturing	12.8	0.016	0.004	0.20	0.05	0.1%
Plastics and rubber product manufacturing	3.5	0.028	0.006	0.10	0.02	0.1%
Wholesale trade	89.2	0.001	0.059	0.10	5.25	13.2%
Retail trade	107.1	0.002	0.058	0.17	6.17	15.6%
Air transportation	9.5	0.002	0.000	0.02	0.00	0.0%
Rail transportation	2.7	0.004	0.000	0.01	0.00	0.0%
Water transportation	7.1	0.002	0.000	0.01	0.00	0.0%
Truck transportation	11.9	0.044	0.000	0.53	0.00	13.7%
Couriers and messengers	6.6	0.009	0.000	0.06	0.00	0.0%
Transit and ground passenger transportation	1.6	0.012	0.000	0.02	0.00	0.0%
Pipeline transportation	0.1	0.003	0.000	0.00	0.00	0.0%
Scenic and sightseeing transportation; Support activities for transportation	7.0	0.002	0.000	0.01	0.00	0.0%
Warehousing and storage	3.0	0.002	0.000	0.01	0.00	0.0%
Publishing industries, except	20.1	0.007	0.012	0.15	0.23	0.6%

Table B.2: Truck Share of Benefits Calculation

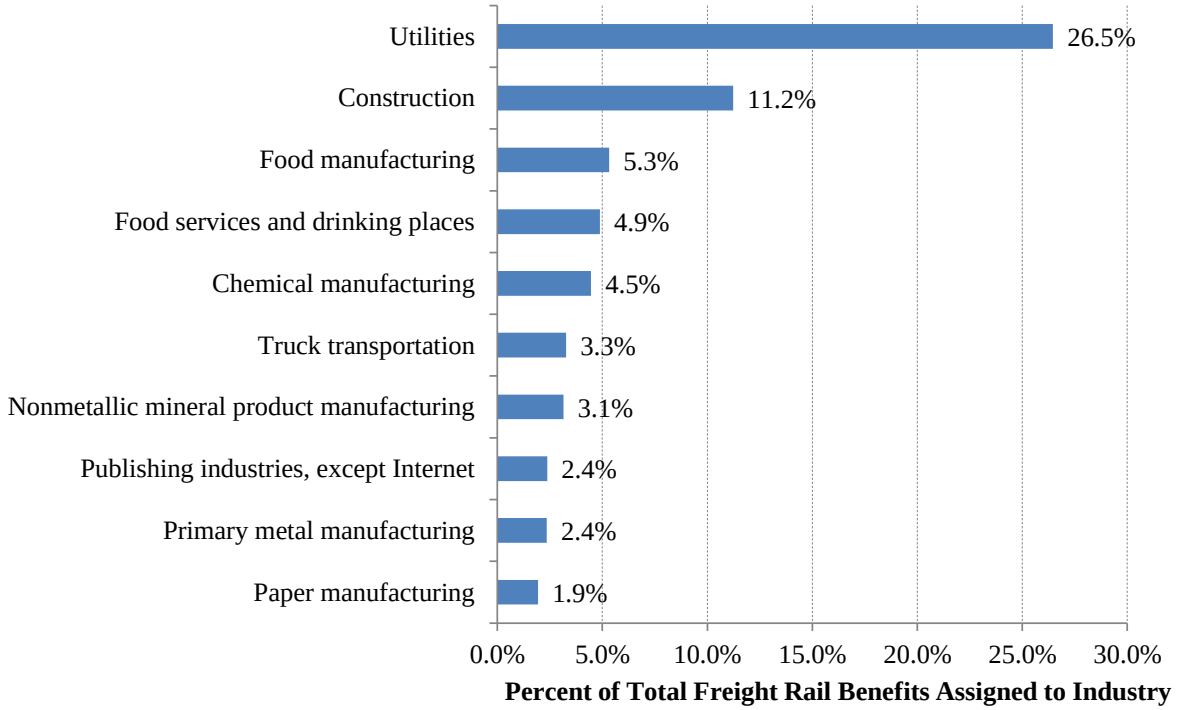
Industry	2019 Florida Output (billions of 2005 dollars)	For-Hire Truck Transportation Requirements	In-House Truck Transportation Requirements	Use of For-Hire Truck Transportation	Use of In-House Truck Transportation	Percent of Total Use
Internet						
Motion picture and sound recording industries	3.2	0.001	0.014	0.00	0.04	0.1%
Internet publishing and broadcasting; ISPs, search portals, and data processing; Other information services	12.5	0.000	0.027	0.01	0.34	0.8%
Broadcasting, except Internet	6.9	0.000	0.003	0.00	0.02	0.1%
Telecommunications	42.4	0.001	0.004	0.04	0.15	0.4%
Monetary authorities - central bank; Credit intermediation and related activities; Funds, trusts, & other financial vehicles	77.8	0.000	0.001	0.02	0.10	0.3%
Securities, commodity contracts, investments	27.6	0.000	0.001	0.01	0.03	0.1%
Insurance carriers and related activities	39.4	0.000	0.001	0.01	0.05	0.1%
Real estate	217.9	0.001	0.002	0.14	0.47	1.2%
Rental and leasing services; Lessors of nonfinancial intangible assets	28.5	0.001	0.004	0.02	0.13	0.3%
Professional, scientific, and technical services	104.5	0.001	0.007	0.10	0.74	1.9%
Management of companies and enterprises	21.2	0.001	0.007	0.01	0.14	0.4%
Administrative and support services	50.5	0.002	0.029	0.08	1.46	3.7%
Waste management and remediation services	4.2	0.011	0.160	0.05	0.67	1.7%

Table B.2: Truck Share of Benefits Calculation

Industry	2019 Florida Output (billions of 2005 dollars)	For-Hire Truck Transportation Requirements	In-House Truck Transportation Requirements	Use of For-Hire Truck Transportation	Use of In-House Truck Transportation	Percent of Total Use
Educational services	11.8	0.002	0.038	0.03	0.45	1.1%
Ambulatory health care services	60.0	0.001	0.010	0.08	0.63	1.6%
Hospitals	35.1	0.003	0.011	0.09	0.40	1.0%
Nursing and residential care facilities	12.4	0.003	0.014	0.03	0.18	0.5%
Social assistance	8.2	0.005	0.040	0.04	0.33	0.8%
Performing arts and spectator sports	10.2	0.001	0.015	0.01	0.15	0.4%
Museums, historical sites, zoos, and parks	1.0	0.001	0.015	0.00	0.01	0.0%
Amusement, gambling, and recreation	11.8	0.002	0.025	0.02	0.29	0.7%
Accommodation	26.2	0.002	0.023	0.04	0.60	1.5%
Food services and drinking places	44.0	0.008	0.044	0.36	1.93	4.9%
Repair and maintenance	13.1	0.005	0.041	0.06	0.54	1.4%
Personal and laundry services	9.4	0.004	0.097	0.03	0.91	2.3%
Membership associations and organizations	15.4	0.001	0.023	0.02	0.36	0.9%
Private households	1.8	0.000	0.000	0.00	0.00	0.0%
Total	**1,399**	**0.560**	**1.500**	**5.45**	**34.19**	**100.0%**

Source: REMI TranSight baseline data, HDR calculations based on TSA data

Figure B.3: Top Ten Industries in Florida by their Use of Rail Transportation



Source: REMI TranSight baseline data, HDR calculations based on TSA data

Table B.3: Freight Rail Share of Benefits Calculation

Industry	2019 Florida Output (billions of 2005 dollars)	For-Hire Rail Transportation Requirements	In-House Rail Transportation Requirements	Use of For-Hire Rail Transportation	Use of In-House Rail Transportation	Percent of Total Use
Forestry and logging; Fishing, hunting, and trapping	1.4	0.001	0.000	0.00	0.00	0.1%
Agriculture and forestry support activities	1.1	0.005	0.000	0.01	0.00	0.4%
Oil and gas extraction	2.0	0.001	0.000	0.00	0.00	0.1%
Mining (except oil and gas)	0.9	0.016	0.001	0.01	0.00	1.2%
Support activities for mining	0.2	0.002	0.000	0.00	0.00	0.0%
Utilities	15.3	0.021	0.000	0.33	0.01	26.5%
Construction	78.7	0.002	0.000	0.14	0.00	11.2%
Wood product manufacturing	3.4	0.006	0.000	0.02	0.00	1.5%
Nonmetallic mineral product manufacturing	5.8	0.007	0.000	0.04	0.00	3.1%
Primary metal manufacturing	2.2	0.013	0.000	0.03	0.00	2.4%
Fabricated metal product manufacturing	8.2	0.002	0.000	0.02	0.00	1.4%
Machinery manufacturing	7.5	0.001	0.000	0.01	0.00	0.7%
Computer and electronic product manufacturing	29.5	0.000	0.000	0.01	0.00	0.7%
Electrical equipment and appliance manufacturing	2.8	0.002	0.000	0.00	0.00	0.4%
Motor vehicles, bodies and trailers, and parts manufacturing	3.5	0.002	0.000	0.01	0.00	0.7%
Other transportation equipment manufacturing	10.9	0.001	0.001	0.01	0.01	1.6%
Furniture and related product manufacturing	2.2	0.002	0.000	0.00	0.00	0.4%
Miscellaneous manufacturing	7.7	0.002	0.001	0.01	0.00	1.3%
Food manufacturing	12.1	0.005	0.000	0.07	0.00	5.3%

Table B.3: Freight Rail Share of Benefits Calculation

Industry	2019 Florida Output (billions of 2005 dollars)	For-Hire Rail Transportation Requirements	In-House Rail Transportation Requirements	Use of For-Hire Rail Transportation	Use of In-House Rail Transportation	Percent of Total Use
Beverage and tobacco product manufacturing	7.4	0.002	0.000	0.01	0.00	1.1%
Textile mills; Textile product mills	1.0	0.003	0.000	0.00	0.00	0.2%
Apparel manufacturing; Leather and allied product manufacturing	0.5	0.000	0.000	0.00	0.00	0.0%
Paper manufacturing	3.8	0.006	0.000	0.02	0.00	1.9%
Printing and related support activities	3.9	0.005	0.000	0.02	0.00	1.5%
Petroleum and coal products manufacturing	8.2	0.002	0.000	0.02	0.00	1.8%
Chemical manufacturing	12.8	0.004	0.001	0.05	0.01	4.5%
Plastics and rubber product manufacturing	3.5	0.005	0.000	0.02	0.00	1.3%
Wholesale trade	89.2	0.000	0.000	0.02	0.00	1.7%
Retail trade	107.1	0.000	0.000	0.01	0.00	1.1%
Air transportation	9.5	0.001	0.000	0.01	0.00	0.9%
Rail transportation	2.7	0.003	0.000	0.01	0.00	0.6%
Water transportation	7.1	0.001	0.000	0.00	0.00	0.3%
Truck transportation	11.9	0.003	0.000	0.04	0.00	3.3%
Couriers and messengers	6.6	0.002	0.000	0.01	0.00	0.9%
Transit and ground passenger transportation	1.6	0.002	0.000	0.00	0.00	0.2%
Pipeline transportation	0.1	0.001	0.000	0.00	0.00	0.0%
Scenic and sightseeing transportation; Support activities for transportation	7.0	0.002	0.000	0.02	0.00	1.3%
Warehousing and storage	3.0	0.000	0.000	0.00	0.00	0.1%
Publishing industries, except	20.1	0.001	0.000	0.03	0.00	2.4%

Table B.3: Freight Rail Share of Benefits Calculation

Industry	2019 Florida Output (billions of 2005 dollars)	For-Hire Rail Transportation Requirements	In-House Rail Transportation Requirements	Use of For-Hire Rail Transportation	Use of In-House Rail Transportation	Percent of Total Use
Internet						
Motion picture and sound recording industries	3.2	0.000	0.000	0.00	0.00	0.0%
Internet publishing and broadcasting; ISPs, search portals, and data processing; Other information services	12.5	0.000	0.000	0.00	0.00	0.1%
Broadcasting, except Internet	6.9	0.000	0.000	0.00	0.00	0.0%
Telecommunications	42.4	0.000	0.000	0.00	0.00	0.3%
Monetary authorities - central bank; Credit intermediation and related activities; Funds, trusts, & other financial vehicles	77.8	0.000	0.000	0.01	0.00	0.6%
Securities, commodity contracts, investments	27.6	0.000	0.000	0.00	0.00	0.1%
Insurance carriers and related activities	39.4	0.000	0.000	0.00	0.00	0.1%
Real estate	217.9	0.000	0.000	0.02	0.00	1.7%
Rental and leasing services; Lessors of nonfinancial intangible assets	28.5	0.000	0.000	0.00	0.00	0.4%
Professional, scientific, and technical services	104.5	0.000	0.000	0.02	0.00	1.4%
Management of companies and enterprises	21.2	0.000	0.000	0.00	0.00	0.2%
Administrative and support services	50.5	0.000	0.000	0.01	0.00	0.9%
Waste management and remediation services	4.2	0.001	0.000	0.00	0.00	0.4%

Table B.3: Freight Rail Share of Benefits Calculation

Industry	2019 Florida Output (billions of 2005 dollars)	For-Hire Rail Transportation Requirements	In-House Rail Transportation Requirements	Use of For-Hire Rail Transportation	Use of In-House Rail Transportation	Percent of Total Use
Educational services	11.8	0.000	0.000	0.00	0.00	0.2%
Ambulatory health care services	60.0	0.000	0.000	0.01	0.00	0.9%
Hospitals	35.1	0.000	0.000	0.01	0.00	1.1%
Nursing and residential care facilities	12.4	0.000	0.000	0.00	0.00	0.3%
Social assistance	8.2	0.001	0.000	0.00	0.00	0.4%
Performing arts and spectator sports	10.2	0.000	0.000	0.00	0.00	0.1%
Museums, historical sites, zoos, and parks	1.0	0.000	0.000	0.00	0.00	0.0%
Amusement, gambling, and recreation	11.8	0.000	0.000	0.00	0.00	0.1%
Accommodation	26.2	0.000	0.000	0.00	0.00	0.2%
Food services and drinking places	44.0	0.001	0.000	0.06	0.00	4.9%
Repair and maintenance	13.1	0.001	0.000	0.01	0.00	1.0%
Personal and laundry services	9.4	0.000	0.000	0.00	0.00	0.1%
Membership associations and organizations	15.4	0.000	0.000	0.00	0.00	0.2%
Private households	1.8	0.000	0.000	0.00	0.00	0.0%
Total	**1,399**	**0.142**	**0.006**	**1.22**	**0.04**	**100.0%**

Source: REMI TranSight baseline data, HDR calculations based on TSA data

To distribute total benefits by industry, a manual mapping between REMI's 66 industries and TSA's 131-industry classification was performed. Table B.4 and Table B.5 present the list of industries in the two classifications.

Table B.4: REMI TranSight Industry Classification

REMI Industry ID	Industry Description	REMI Industry ID	Industry Description
7801	Forestry and logging; Fishing, hunting, and trapping	**7834**	Couriers and messengers
7802	Agriculture and forestry support activities	**7835**	Transit and ground passenger transportation
7803	Oil and gas extraction	**7836**	Pipeline transportation
7804	Mining (except oil and gas)	**7837**	Scenic and sightseeing transportation; Support activities for transportation
7805	Support activities for mining	**7838**	Warehousing and storage
7806	Utilities	**7839**	Publishing industries, except Internet
7807	Construction	**7840**	Motion picture and sound recording industries
7808	Wood product manufacturing	**7841**	Internet publishing and broadcasting; ISPs, search portals, and data processing; Other information services
7809	Nonmetallic mineral product manufacturing	**7842**	Broadcasting, except Internet
7810	Primary metal manufacturing	**7843**	Telecommunications
7811	Fabricated metal product manufacturing	**7844**	Monetary authorities - central bank; Credit intermediation and related activities; Funds, trusts, & other financial vehicles
7812	Machinery manufacturing	**7845**	Securities, commodity contracts, investments
7813	Computer and electronic product manufacturing	**7846**	Insurance carriers and related activities
7814	Electrical equipment and appliance manufacturing	**7847**	Real estate
7815	Motor vehicles, bodies and trailers, and parts manufacturing	**7848**	Rental and leasing services; Lessors of nonfinancial intangible assets
7816	Other transportation equipment manufacturing	**7849**	Professional, scientific, and technical services

Table B.4: REMI TranSight Industry Classification

REMI Industry ID	Industry Description	REMI Industry ID	Industry Description
7817	Furniture and related product manufacturing	**7850**	Management of companies and enterprises
7818	Miscellaneous manufacturing	**7851**	Administrative and support services
7819	Food manufacturing	**7852**	Waste management and remediation services
7820	Beverage and tobacco product manufacturing	**7853**	Educational services
7821	Textile mills; Textile product mills	**7854**	Ambulatory health care services
7822	Apparel manufacturing; Leather and allied product manufacturing	**7855**	Hospitals
7823	Paper manufacturing	**7856**	Nursing and residential care facilities
7824	Printing and related support activities	**7857**	Social assistance
7825	Petroleum and coal products manufacturing	**7858**	Performing arts and spectator sports
7826	Chemical manufacturing	**7859**	Museums, historical sites, zoos, and parks
7827	Plastics and rubber product manufacturing	**7860**	Amusement, gambling, and recreation
7828	Wholesale trade	**7861**	Accommodation
7829	Retail trade	**7862**	Food services and drinking places
7830	Air transportation	**7863**	Repair and maintenance
7831	Rail transportation	**7864**	Personal and laundry services
7832	Water transportation	**7865**	Membership associations and organizations
7833	Truck transportation	**7866**	Private households

Source: REMI TranSight Model

Table B.5: TSA Industry Classification

TSA Industry ID	Industry Description	TSA Industry ID	Industry Description
1110	Crop production	**3210**	Wood product manufacturing
1120	Animal production	**3221**	Pulp, paper, and paperboard mills
1130	Forestry and Logging	**3222**	Converted paper products manufacturing
1140	Fishing, hunting and trapping	**3230**	Printing and related support activities
1150	Agriculture and forestry support activities	**3240**	Petroleum and coal products manufacturing
2110	Oil and gas extraction	**3251**	Basic chemical manufacturing
2121	Coal mining	**3252**	Resin, rubber, and artificial fibers manufacturing
2122	Metal ores mining	**3253**	Agricultural chemical manufacturing
2123	Nonmetallic minerals mining and quarrying	**3254**	Pharmaceutical and medicine manufacturing
2130	Support activities for mining	**3255**	Paint, coating, and adhesive manufacturing
2211	Power generation and supply	**3256**	Soap, cleaning compound, and toiletry manufacturing
2212	Natural gas distribution	**3259**	Other chemical products and preparation manufacturing
2213	Water, sewage and other systems	**3260**	Plastics and rubber products manufacturing
2301	New residential construction	**3270**	Nonmetallic mineral product manufacturing
2302	New nonresidential construction	**331A**	Iron and steel mills and manufacturing from purchased steel
2303	Maintenance and repair construction	**331B**	Nonferrous metal production and manufacturing
3110	Food manufacturing	**3315**	Foundries
3121	Beverage manufacturing	**3321**	Forging and stamping
3122	Tobacco manufacturing	**3322**	Cutlery and hand tool manufacturing
3130	Textile mills	**3323**	Architectural and structural metals manufacturing
3140	Textile product mills	**3324**	Boiler, tank, and shipping container manufacturing
3150	Apparel manufacturing	**332A**	Ordnance and accessories manufacturing
3160	Leather and allied product manufacturing	**332B**	Other fabricated metal product manufacturing

Table B.5: TSA Industry Classification

TSA Industry ID	Industry Description	TSA Industry ID	Industry Description
3331	Agriculture, construction, and mining machinery	**3370**	Furniture and related products manufacturing
3332	Industrial machinery manufacturing	**3391**	Medical equipment and supplies manufacturing
3333	Commercial and service industry machinery	**3399**	Other miscellaneous manufacturing
3334	HVAC and commercial refrigeration equipment	**4200**	Wholesale trade
3335	Metalworking machinery manufacturing	**4A00**	Retail trade
3336	Turbine and power transmission equipment manufacturing	**4810**	Air transportation
3339	Other general purpose machinery manufacturing	**4820**	Rail transportation
3341	Computer and peripheral equipment manufacturing	**4830**	Water transportation
334A	Audio, video, and communications equipment manufacturing	**4840**	Truck transportation
3344	Semiconductor and electronic equipment manufacturing	**4850**	Transit and ground passenger transportation
3345	Electronic equipment manufacturing	**4860**	Pipeline transportation
3346	Magnetic media manufacturing and reproducing	**48A0**	Scenic and sightseeing transportation and support activities for transportation
3351	Electric lighting equipment manufacturing	**4920**	Couriers and messengers
3352	Household appliance manufacturing	**481A**	In-house air transportation
3353	Electrical equipment manufacturing	**482A**	In-house rail transportation
3359	Other electrical equipment and component manufacturing	**483A**	In-house water transportation
3361	Motor vehicle manufacturing	**484A**	In-house truck transportation
336A	Motor vehicle body, trailer, and parts manufacturing	**4930**	Warehousing and storage
3364	Aerospace product and parts manufacturing	**5111**	Newspaper, book, and directory publishers
336B	Other transportation equipment manufacturing	**5112**	Software publishers
5120	Motion picture and sound recording industries	**5417**	Scientific research and development services

Table B.5: TSA Industry Classification

TSA Industry ID	Industry Description	TSA Industry ID	Industry Description
5131	Radio and television broadcasting	**5418**	Advertising and related services
5132	Cable networks and program distribution	**5419**	Other professional and technical services
5133	Telecommunications	**5500**	Management of companies and enterprises
5141	Information services	**5613**	Employment services
5142	Data processing services	**5615**	Travel arrangement and reservation services
52A0	Monetary authorities, credit intermediation and related activities	**561A**	All other administrative and support services
5230	Securities, commodity contracts, investments	**5620**	Waste management and remediation services
5240	Insurance carriers and related activities	**6100**	Educational services
5250	Funds, trusts, and other financial vehicles	**6210**	Ambulatory health care services
5310	Real estate	**6220**	Hospitals
S008	Owner-occupied dwellings	**6230**	Nursing and residential care facilities
5321	Automotive equipment rental and leasing	**6240**	Social assistance
5324	Machinery and equipment rental and leasing	**71A0**	Performing arts, spectator sports, museums, zoos, and parks
532A	Consumer goods and general rental centers	**7130**	Amusements, gambling and recreation
5330	Lessors of nonfinancial intangible assets	**7210**	Accommodation
5411	Legal services	**7220**	Food services and drinking places
5412	Accounting and bookkeeping services	**8111**	Automotive repair and maintenance
5413	Architectural and engineering services	**811A**	Electronic, commercial, and household goods repair
5414	Specialized design services	**8120**	Personal and laundry services
5415	Computer systems design and related services	**813A**	Religious, grant making and giving, and social advocacy organizations
5416	Management and technical consulting services	**813B**	Civic, social, professional and similar organizations
		8140	Private households

Source: TSA 2011

Table B.6 shows the results of the manual mapping: the list of the REMI TranSight industries and their TSA's equivalent(s). As described above, Table B.2 and Table B.3 report transportation requirements calculated by dividing the use of commodities value by the total industry output. In cases where there was more than one TSA industry that matched a REMI industry, the sum of requirements was divided by the sum of total outputs.

Table B.6: Results of Manual Mapping of REMI and TSA Industry Classifications

REMI Industry ID	TSA Industries Equivalent	REMI Industry ID	TSA Industries Equivalent
7801	1130, 1140	**7834**	4920
7802	1110, 1120, 1150	**7835**	4850
7803	2110	**7836**	4860
7804	2121, 2122, 2123	**7837**	48A0
7805	2130	**7838**	4930
7806	2211, 2212, 2213	**7839**	5111
7807	2301, 2302, 2303	**7840**	5120
7808	3210	**7841**	5112, 5141, 5142
7809	3270	**7842**	5131, 5132
7810	331A, 331B	**7843**	5133
7811	3315, 3321, 3322, 3323, 3324, 332A, 332B	**7844**	52A0
7812	3331, 3332, 3333, 3334, 3335, 3336, 3339	**7845**	5230, 5250
7813	3341, 334A, 3344, 3345, 3346	**7846**	5240
7814	3351, 3352, 3353, 3359	**7847**	5310
7815	3361, 336A	**7848**	S008, 5321, 5324, 532A, 5330
7816	3364, 336B	**7849**	5412, 5413, 5414, 5415, 5416, 5417, 5418, 5419
7817	3370	**7850**	5500, 5613
7818	3391, 3399	**7851**	5411, 5615, 561A
7819	3110	**7852**	5620
7820	3121, 3122	**7853**	6100
7821	3130, 3140	**7854**	6210
7822	3150, 3160	**7855**	6220
7823	3221, 3222	**7856**	6230
7824	3230	**7857**	6240
7825	3240	**7858**	

Table B.6: Results of Manual Mapping of REMI and TSA Industry Classifications

REMI Industry ID	TSA Industries Equivalent	REMI Industry ID	TSA Industries Equivalent
7826	3251, 3252, 3253, 3254, 3255, 3256, 3259	**7859**	
7827	3260	**7860**	7130
7828	4200	**7861**	7210
7829	4A00	**7862**	7220
7830	4810, 481A	**7863**	8111, 811A
7831	4820, 482A	**7864**	8120
7832	4830, 483A	**7865**	813A, 813B
7833	4840, 484A	**7866**	8140

Source: HDR

After creating the three lists of industries (for business auto, trucks, and freight rail) with the corresponding shares of benefits that each of the industries receives, the changes in production costs were calculated and input into REMI. For each industry the change in costs was calculated as the sum of:

a) Total business auto benefits (calculated as the sum of HERS and NBIAS business auto benefits) multiplied by the share of the industry in Florida's total employment;
b) Total truck benefits (calculated as the sum of HERS and NBIAS truck benefits) multiplied by the share of the industry in total truck use (for-hire and in-house); and
c) Total freight rail benefits multiplied by the share of the industry in total freight rail transportation (for-hire and in-house).

These changes in costs were entered in the REMI TranSight model as positive numbers, so that REMI could simulate a scenario in which the Work Program does *not* exist. REMI output from this simulation was then compared to the baseline REMI run to calculate changes in employment, output, and other economic indicators.

Appendix B-3 – Transit Analyses

As discussed in Chapter 4, Section 1, two analyses were performed to estimate the two major economic effects of the Transit Work Program. The first estimated the relief of highway congestion as a result of transit improvements. The second estimated the change in consumer surplus.

Transit Travel Efficiency Benefits

While we anticipate increases in transit ridership as a result of the Work Program, our projections show that the majority of person-trips will continue to use the highway mode. Similarly, truck trips will continue to be crucial to freight transportation. The travel efficiency

benefits of the transit Work Program are best captured by assessing the extent to which increases in transit investment, service and ridership reduce highway congestion in the business travel and freight sectors. Travel times and operating costs for business travel (trucks and business auto) are reduced when the number of trips made on transit rather than automobiles increases.

Two regression analyses were conducted to estimate the vehicle miles traveled reductions as a result of the transit investments.

The first of the two regressions linked the number of transit revenue miles to the cumulative Work Program transit expenditures. The data on the year-of-expenditure nominal capital investment (independent variable) were collected from FDOT[34]. This series was converted to 2012 dollars using FDOT Present Day Cost Multipliers for the historical data[35] and FDOT Office of Work Program Construction Cost Inflation Factors[36] for projections. The assumption was made that prior to 1983-84 a total of $1,000 million of 2006 dollars ($1,1194 million when converted to 2012 dollars) had been invested into Florida's transit system by state and local government. The data for the transit revenue miles (dependent variable) were collected from the National Transit Database[37]. See Table B.7.

Table B.7: Data for Transit Analysis

Year*	Nominal Transit Investment (millions of YOE dollars)	Real Transit Investment (millions of 2012 dollars)	Real Cumulative Investment (millions of 2012 dollars)	Total Vehicle Revenue Miles (miles per year)	Transit Ridership (trips per year)
1984	$35.4	$74.7	$1,193.7	56,673,599	123,766,434
1985	$38.0	$79.4	$1,273.2	64,122,642	141,322,187
1986	$16.1	$33.4	$1,306.5	65,860,740	138,451,855
1987	$17.6	$36.1	$1,342.7	68,545,226	131,177,059
1988	$16.2	$33.0	$1,375.6	72,685,589	127,978,890
1989	$24.7	$49.1	$1,424.8	76,798,285	141,276,725
1990	$16.1	$31.0	$1,455.8	84,595,542	151,466,071
1991	$37.4	$69.7	$1,525.5	86,847,878	153,074,865
1992	$51.0	$95.1	$1,620.5	92,753,771	153,521,293
1993	$64.1	$120.1	$1,740.6	110,633,292	177,653,922

[34] Historical data (1983-84 to 2011-12) were collected from http://www.dot.state.fl.us/programdevelopmentoffice/pra/ProgramAndResourcePlanHistory.pdf and planned expenditures (2013-14 to 2019-20) were collected from the Adopted 2014 Work Program Budget.
[35] Source: http://www.dot.state.fl.us/planning/policy/costs/RetroCostInflation.pdf.
[36] Source: http://www.dot.state.fl.us/planning/policy/costs/inflation.pdf.
[37] Source: Vehicle Revenue Miles (Passenger Car Revenue Miles for Rail Modes), http://www.ntdprogram.gov/ntdprogram/pubs/HistoricalData/2012/TS2.2TimeSeriesSysWideOpexpSvc.xls

Table B.7: Data for Transit Analysis

Year*	Nominal Transit Investment (millions of YOE dollars)	Real Transit Investment (millions of 2012 dollars)	Real Cumulative Investment (millions of 2012 dollars)	Total Vehicle Revenue Miles (miles per year)	Transit Ridership (trips per year)
1994	$77.2	$142.5	$1,883.1	113,073,927	170,739,024
1995	$81.4	$146.6	$2,029.7	118,647,106	172,168,139
1996	$101.3	$176.9	$2,206.6	118,404,047	169,782,749
1997	$109.2	$184.8	$2,391.5	129,540,958	175,776,980
1998	$110.7	$183.3	$2,574.8	134,040,140	180,932,359
1999	$102.5	$171.7	$2,746.5	137,520,709	189,210,465
2000	$120.9	$197.0	$2,943.5	138,666,397	195,361,463
2001	$130.3	$198.7	$3,142.3	157,999,214	202,852,856
2002	$139.3	$211.2	$3,353.4	169,447,447	203,104,569
2003	$160.7	$249.8	$3,603.2	178,280,533	214,319,569
2004	$171.8	$262.3	$3,865.5	183,271,544	234,358,753
2005	$211.9	$299.6	$4,165.1	195,289,373	251,117,320
2006	$246.7	$313.3	$4,478.4	198,880,718	256,011,148
2007	$283.4	$327.9	$4,806.2	202,633,486	264,215,328
2008	$328.6	$362.0	$5,168.3	202,074,808	271,845,312
2009	$306.1	$300.4	$5,468.7	196,859,525	255,994,633
2010	$299.9	$319.9	$5,788.5	195,301,735	252,387,547
2011	$346.8	$353.5	$6,142.1	197,507,461	268,167,533
2012	$497.5	$497.5	$6,639.6	200,696,728	277,695,880

*Notes: * Fiscal year for transit investment data (columns 2, 3 & 4) and report year for NTD data (columns 5 & 6); YOE stands for Year-of-Expenditure*

The equation to predict revenue miles of service was estimated in the Log-Log form and specified as follows:

$$ln(Revenue\ Miles) = \beta_1 + \beta_2 ln(Cumulative\ Investment) + \varepsilon \qquad \textbf{(Equation 1)}$$

where $ln(Revenue\ Miles)$ is the natural logarithm of revenue miles
$ln(Cumulative\ Investment)$ is the natural logarithm of cumulative Work Program transit expenditures
β_1 is an intercept coefficient
β_2 is a slope coefficient
ε is an error term

Table B.8 presents the results of this regression. The resulting intercept and slope coefficients are 12.987 and 0.731. The slope coefficient suggests that if cumulative transit investment increases by 1 percent, transit revenue miles would increase by approximately 0.7 percent. The R-squared is over .92, meaning that the great majority of the variation in the dependent variable is accounted for by the explanatory variables. Applying these coefficients allows forecasting the Vehicle Revenue Miles based on Florida's planned investments in transit.

Table B.8: Regression Output – Total Vehicle Revenue Miles Model

Dependent Variable:	Natural Log of Total Vehicle Revenue Miles			
Method:	Least Squares			
Included observations:	29			
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	12.897	0.314	41.129	0.000
Natural Log of Cumulative Investment	0.731	0.040	18.387	0.000
Multiple R	0.962			
R Square	0.926			
Adjusted R Square	0.923			
Standard Error	0.116			

Source: HDR analysis

The second regression estimated the slope and intercept coefficients for the relationship between Vehicle Revenue Miles (independent variable) and Transit Ridership (dependent variable). The data for the independent variable came from the National Transit Database (as explained above). The data on transit ridership were collected from the National Transit Database[38] as well. Both the dependent and independent variables enter the equation in their linear form, as follows:

$$Transit\ Ridership = \beta_1 + \beta_2 Revenue\ Miles + \varepsilon \qquad \textbf{(Equation 2)}$$

where $Transit\ Ridership$ is the number of unlinked transit trips
$Revenue\ Miles$ is total transit vehicle revenue miles
β_1 is an intercept coefficient
β_2 is a slope coefficient
ε is an error term

[38] Source: National Transit Database Unlinked trips historical data for 1991-2012, http://www.ntdprogram.gov/ntdprogram/pubs/HistoricalData/2012/TS2.2TimeSeriesSysWideOpexpSvc.xls.

Table B.9 presents the regression output. In the resulting equation, the slope coefficient is 0.945, which suggests that a one-mile increase in the number of revenue miles increases the number of unlinked transit trips approximately by one. The R-Squared is over 0.95, once again showing that variability in the dependent variable is accounted for by the explanatory variables.

Table B.9: Regression Output – Transit Ridership Model

Dependent Variable:	Transit Ridership			
Method:	Least Squares			
Included observations:	29			
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	6.6×10^7	5.7×10^7	11.600	0.000
Total Vehicle Revenue Miles	0.945	0.039	24.117	0.000
Multiple R	0.978			
R Square	0.956			
Adjusted R Square	0.954			
Standard Error	1.1×10^7			

Source: HDR analysis

The projected decrease in the miles traveled by auto is calculated using the estimated increase in transit ridership. In converting transit trips to auto vehicle miles traveled, the following two assumptions are used: average trip distance for transit is 5.7 miles per trip[39] and occupancy rate for cars is 1.58 persons per car[40]. First, transit trips are multiplied by the average transit trip distance to calculate transit miles traveled. Then, this product is divided by the occupancy rate to calculate the increase in auto vehicle miles traveled.

[39] Source: 2013 Florida Transit Handbook
http://www.dot.state.fl.us/transit/Pages/2013FloridaTransitHandbook.pdf
[40] Source: A Report on Florida Transportation Trends and Conditions, Table 10
http://www.dot.state.fl.us/planning/trends/tc-report/behavior.pdf

Based on these regression results, transit ridership is expected to increase from 277.7 million trips in 2011/12 to 309.9 million trips in 2012/13 and to 348.2 million trips in 2017/18. This increase in transit ridership is expected to reduce vehicle miles traveled by approximately 56.2 million in 2013/14 and 24.1 million in 2017/18 (see Table B.10).

Table B.10: Transit Investment and Reduction in Vehicle Miles Traveled

Fiscal Year	Transit Investment (millions of 2012 dollars)	Revenue Miles of Service (millions)	Transit Ridership (millions)	Estimated Reduction in Highway Travel (mil vehicle-miles)
2012-13	$335.4	200.7	277.7	N/A
2013-14	$616.4	258.1	309.9	56.2
2014-15	$358.0	274.5	325.5	32.1
2015-16	$280.3	283.9	334.4	24.8
2016-17	$285.7	291.2	341.3	25.1
2017-18	$276.5	298.6	348.2	24.1

Source: HDR analysis

Reductions in vehicle miles traveled were allocated to Florida highway segments based on the current distribution of transit ridership in the state. The portion of these user benefits accruing to businesses are input to the REMI model as cost savings, similar to the highway analysis. The analysis was careful to isolate the effect due to the Work Program, which includes state and limited federal investments for capital and operations, but does not include other local, private or federal expenditures.[41]

The Work Program share of total transit expenditures in recent years (FY 2007 to 2011) has averaged 33.8 percent. Tables B.11 and B.12 summarize the calculation steps described below:

- Total transit capital investment for the new Work Program was estimated at $585 million (nominal).
- Total nominal transit investments in the Work Program were used to calculate the share of each year's expenditures in overall nominal transit expenditures.
- The shares were used to distribute the total of $585 million among the five years of the Work Program (FY 2014 to 2018) and to convert the estimates to 2013 dollars.
- Total transit capital investment in 2013 dollars was estimated at $541 million.

[41] Most federal funds for mass transit are distributed directly to local transit agencies rather than through the FDOT Work Program.

Table B.11: Estimation of Transit Capital Expenditures in the Work Program

Fiscal Year	Total Work Program Transit Investment (millions of YOE dollars)	Share of the FY in Work Program	Work Program Transit Capital Expenditures (millions of 2013 dollars)
2014	$642	32.4%	$184
2015	$384	19.4%	$107
2016	$309	15.6%	$83
2017	$324	16.4%	$85
2018	$323	16.3%	$82
Total	**$1,981**	**100.0%**	**$541**

Data from NTD[42] were used to calculate total transit capital funding for each report year between 2008 and 2012.
Report years were converted to fiscal years by calculating averages between two subsequent years.
The estimates were converted from YOE dollars to 2013 dollars.
Total transit capital funding over the 5-year period was estimated at $1,602 million.
The Work Program share of total transit expenditures in recent years (33.8 percent) was calculated by dividing Work Program Transit Capital Expenditures ($541 million) by Total Transit Capital Funding ($1,602 million).

Table B.12: Calculation of Total Transit Capital Funding (2007-2011)

Year	Total Transit Capital Funding (millions of YOE dollars), by Report Year	Total Transit Capital Funding (millions of 2013 dollars), by Report Year	Total Transit Capital Funding (millions of 2013 dollars), by Fiscal Year
2008	$329	$343	$412
2009	$298	$314	$357
2010	$313	$305	$305
2011	$237	$275	$297
2012	$211	$224	$231
Total	**$1,388**	**$1,461**	**$1,602**

Note: Total transit capital funding in report year 2007 was $357 million (YOE dollars)

42 http://www.ntdprogram.gov/ntdprogram/pubs/HistoricalData/2012/TS1.1TimeSeriesOpCapFundingSummary.xls

Transit Rider Benefits

The analysis of benefits to transit riders also uses the projected increase in ridership as a starting point. Most of the benefits are enjoyed by existing riders, who substantially outnumber new riders.[43] It was assumed that transit investments would not affect fare levels but rather lower the travel time by making transit function more efficient. In order to estimate the time savings from improved transit service, it was necessary to "work backwards" and estimate the degree of time savings attracting the estimated number of ***new*** riders. Then the benefits of the time savings were applied to existing riders as well as new riders.

The transit model differentiates among three different transit types: Bus, Heavy Rail (Miami Dade Transit), Street Car (Hillsborough Area Regional Transit), and Commuter rail (Tri-Rail). In the calculation of consumer surplus, assumptions were made about the generalized cost elasticity of demand, which is defined as the percentage increase in transit ridership in response to a one percent change in the generalized cost of travel. These elasticity assumptions are presented in Table B.13.

Table B.13: Elasticity Assumptions

Transit Type	Elasticity
Bus	-0.30
Heavy Rail	-0.15
Street Car	-0.15
Commuter Rail	-0.20

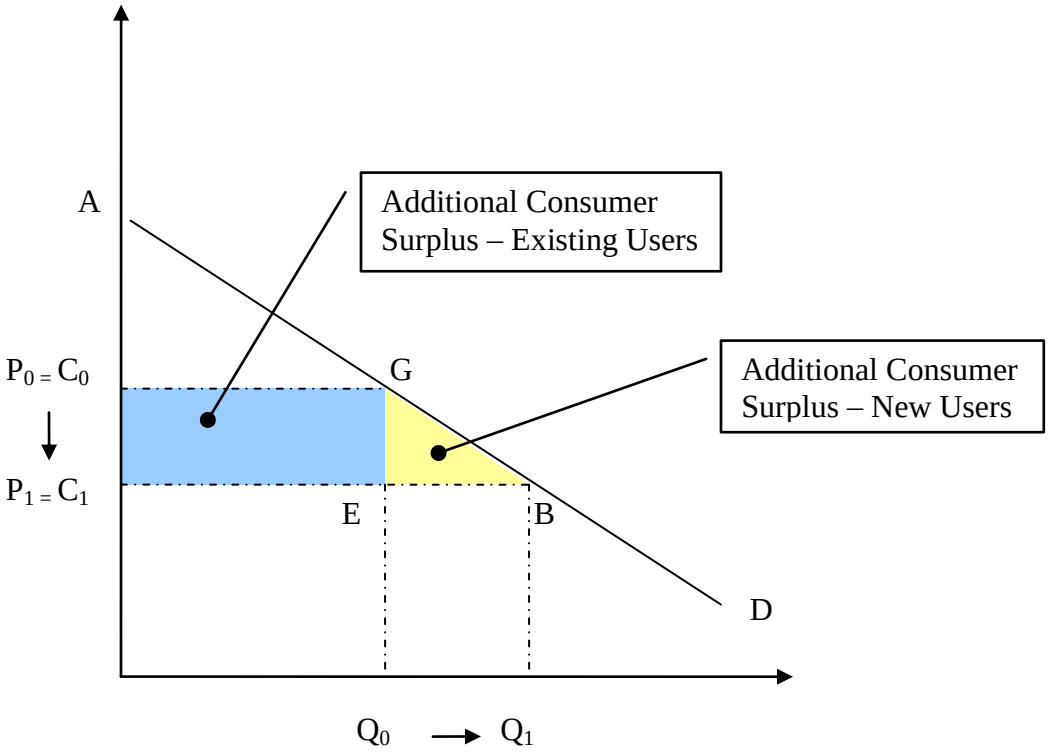
Source: HDR assumptions

As mentioned above, a set of regression models were used to estimate the impacts of the Transit Work Program on transit ridership. In economic terms, the benefits from reduced transit travel time represent a change in consumer surplus. The difference between the estimated consumer surpluses in each year is equal to the benefits generated by the annual investment. Figure B.4 provides a graphical representation of the increase in consumer surplus, where:

- P stands for generalized cost, which includes trip fare and travel time cost;
- Q stands for number of transit trips;
- Triangle (AC_0G) is total consumer surplus <u>before</u> the transit investment;
- Triangle (AC_1B) is total consumer surplus <u>after</u> the transit investment; and
- Quadrilateral (C_0C_1BG) is the change in consumer surplus as a result of the transit investment.

[43] Because of the bivariate nature of the econometric model used to estimate future transit ridership, the full ridership growth estimate was assumed to be caused by transit investments.

Figure B.4: Change in Transit Consumer Surplus



The final estimates of the change in consumer surplus also take into consideration the portions of total transit investments by federal and local governments not included in the FDOT Work Program. Benefits have been reduced by 66.2 percent[44] to account for this effect. The Transit Work Program covers a wide variety of projects and programs. In performing this analysis, emphasis was placed on capital expenditures, including the purchases of buses and train cars. These were assumed to provide additional consumer surplus for many years. On the other hand, subsidies to transit agencies' operating expenditures, including salaries for drivers and other personnel, were assumed to only provide consumer surplus during the year of expenditure. It was estimated that 29.5 percent of transit expenditures are capital investment.[45]

The estimated consumer surplus benefits are shown in Table B.14 below.

[44] This was estimated as 1 minus 33.8 percent, the share of the Work Program in total transit capital expenditures.

[45] This was calculated as $585 million (transit capital expenditures in the Work Program) divided by $1,981 million (total transit expenditures in the Work Program).

Table B.14: Transit Investments and Change in Consumer Surplus Estimates

Calendar Year	Investment Level (millions of YOE dollars)	Cumulative Change in Consumer Surplus (millions of 2014 dollars)
2014	$642	$103
2015	$384	$90
2016	$309	$94
2017	$324	$109
2018	$323	$122
2019-2038	$0	$89
2039	$0	$59
2040	$0	$41
2041	$0	$28
2042	$0	$14
2043	$0	$0

Appendix B-4 – Seaport Analysis

FDOT's Seaport Investment Tool was used for seven years to guide seaport investment decisions for FSTED/311, SIS, and the recent $150M Bond Program, was applied to develop an estimate of economic benefits of the Seaport Office's FY14/FY18 Work Program. During late 2014 and early 2015, the Department is undertaking a revision of the SeapInvestment Toolit is anticipated that revised tool willd in future iterations of the macroeconomic study.

The Tool was designed to develop project level estimates of return on investment (ROI). The ROIs are based on the economic benefits of a project (Gross Regional Product generated from increased cargo and/or cruise throughput, monetized benefits of improved transportation efficiencies and related safety and operational benefits) compared to total anticipated costs (total capital costs and maintenance costs of the life of the project, including any linked projects that are necessary to support the increased throughput).

ROI's have not been prepared for all of the projects listed in the Seaport Work Program. In order to develop a programmatic estimate, the "average" ROI based on those projects for which ROIs are available was applied to those with no established ROI. The "average" ROI was developed for the seaport's five year Work Program based on project evaluations completed over the last several years as part of the annual evaluation process. ROI was converted to a Benefit-Cost Ratio (BCR) and then applied to the official Seaport Work Program to estimate the benefits. The following describes the process:

Projects were grouped into those with and without an ROI.

For those projects with an ROI, benefits corresponding to the FDOT match were calculated by multiplying the costs (from the FDOT Work Program) by the ROI of the projects with an ROI.

For those projects without an ROI, an "average" ROI was needed. The "average" ROIs were calculated based on the summation of the total costs and total benefits for all projects with an

ROI. The overall/"average" ROIs based on the original analysis were 6.4, based on all projects with funding in 2014 thru 2018.

This ROI was then converted to BCRs to be consistent with the other modes.

The final step was to extrapolate the benefits of the official five year work program using the estimated BCRs as multipliers. Note the benefits were based on the full FDOT costs which included the bond debt payments.

Appendix B-5 – Sensitivity Analysis Scenarios

Funding Scenarios

For the sensitivity analysis, three funding scenarios were examined:

- Base scenario,
- Base scenario plus 10 percent of investment spending, and
- Base scenario minus 10 percent of investment.[46]

The results of this analysis are presented in Table B.16. The benefit-cost ratio increases to 4.8 under the "Minus 10 percent" scenario, and decreases to 4.2 under the "Plus 10 percent" scenario.

Table B.16: Benefit-Cost Summary for Investment Scenarios

(All monetary values reported in billions of 2014 dollars)

	Base Scenario	Plus 10 percent Scenario	Minus 10 percent Scenario
BENEFITS			
Present Value of Personal Income Change	$65.7	$67.3	$64.4
Present Value of Non-Business User Benefits	$76.0	$79.3	$73.2
Total Discounted Benefits	$141.7	$146.6	$137.6
COSTS			
Present Value of Total Costs	$32.1	$35.3	$28.9
Net Present Value (Benefits Minus Costs)	$109.6	$111.4	$108.7
Benefit-Cost Ratio	4.4	4.2	4.8

[46] For both scenarios ("plus 10 percent" and "minus 10 percent"), all cost categories were modified proportionally.

Benefits Buildup Scenarios

Another dimension of the sensitivity analysis allows investigating how the benefits build up and how the benefit-cost ratio changes when more benefit categories are considered. Table B.17 shows the results of this analysis for the following scenarios:

- Scenario 1: No auto VMT reduction due to transit improvements, no truck VMT reduction due to freight rail improvements, no freight rail cost savings;[47]
- Scenario 2: No truck VMT reduction due to freight rail improvements, no freight rail cost savings;
- Scenario 3: No freight rail cost savings; and
- Base scenario: includes all benefit categories.
- Buildup Scenario 1 shows that if the benefits exclude reductions in auto and truck VMT due to transit and freight rail improvements and the freight rail cost savings to the users, the benefit-cost ratio is 4.1. The present value of personal income change is $58.0 billion and the present value of non-business user benefits is $72.3 billion.
- Buildup Scenario 2 shows that if some of auto traffic is substituted by transit (as discussed in Chapter 4), both business and non-business auto costs decrease. As a result, change in personal income increases to $59.1 billion and non-business user benefits increase to $76.2 billion, which results in the benefit-cost ratio of 4.2.
- Scenario 3 results reflect how the benefit-cost ratio changes as congestion relief benefits of freight rail improvements are introduced into the analysis. Changes in personal income are estimated to increase to $60.1 billion, mainly because of decreased travel time costs, operating costs and reduced crashes for trucks. On the other hand, because it is assumed in the HERS analysis that the VMT reduction in trucks will be substituted by the equal number of auto VMT, there is an increase in auto travel time, operating, and crash costs, which is the reason why non-business user benefits drop to $76.0 billion. Scenario 3 shows an improvement of the benefit-cost ratio, even though it is still estimated at 4.2.
- Finally, the base scenario includes all benefit categories, including freight rail cost savings to the users (which is an input into REMI analysis), so the present value of the change in personal income increases to $65.7 billion. This results in the benefit-cost ratio of 4.4, as described in Chapter 7.

[47] All scenarios include changes in transit consumer surplus.

Table B.17: Benefit-Cost Summary for Buildup Scenarios

(All monetary values reported in billions of 2014 dollars)

	Buildup Scenario 1	**Buildup Scenario 2**	**Buildup Scenario 3**	**Base Scenario**
Changes in transit consumer surplus included?	**Yes**	**Yes**	**Yes**	**Yes**
Auto VMT reduction due to transit improvements benefits included?	**No**	**Yes**	**Yes**	**Yes**
Truck VMT reduction due to freight rail improvements benefit included?	**No**	**No**	**Yes**	**Yes**
Freight rail cost savings included?	**No**	**No**	**No**	**Yes**
BENEFITS				
Present Value of Personal Income Change	$58.0	$59.1	$60.1	$65.7
Present Value of Non-Business User Benefits	$72.3	$76.2	$76.0	$76.0
Total Discounted Benefits	$130.2	$135.3	$136.1	$141.7
COSTS				
Present Value of Total Costs*	$32.1	$32.1	$32.1	$32.1
Net Present Value (Benefits Minus Costs)	$98.2	$103.3	$104.0	$109.6
Benefit-Cost Ratio	4.1	4.2	4.2	4.4

** Present Value of Total Costs is assumed to the same, for demonstration purposes, to show how the benefits (rather than costs) build up.*

Appendix B-6 – Discount Rate

In examining the issue of appropriate real discount rate for Benefit-Cost Ratio calculations for major public programs, it was determined that there are two main rationales for setting a discount rate in the public sector: 1) the Social Opportunity Cost of capital (SOC); and, 2) the Social Rate of Time Preference (SRTP). The SOC is based on the idea that funds used in government projects – or as a result of government actions – have an "opportunity cost" in terms of foregone investment elsewhere in the economy. In this view, the discount rate should reflect the rate of return on the investments that might be foregone or crowded-out. The SRTP focuses on the idea that individuals, and society as a whole, value outcomes that occur in the present more highly than those occurring in the future. In this view, the discount rate should reflect the rate at which society is willing to trade current for future consumption.

These two approaches have been used by a number of public agencies around the world. Resulting estimates for developed economies range from 3 percent in Germany to 12 percent in Mexico. In the United States, the White House Office of Management and Budget (OMB) recommends the use of an SOC-based discount rate of 7 percent whenever the main effect of a project or action is to displace or alter the use of capital in the private sector. The rate of 7 percent is based on the pretax rate of return on an average investment in the private sector in the U.S. during the 1970s and 1980s.

Use of the 7 percent rate for discounting is equivalent to assuming that public financing of a project results in a "dollar-for-dollar" crowding-out of investment in the private sector. When it is not the case, OMB recommends the use of a lower discount rate, at 3 percent. This rate is based on the pre-tax return on long-term government debt (estimated between 1973 and 2003), which is generally considered a fair approximation of the SRTP. The debate between the SOC and SRTP views is not fully settled, but an emerging consensus among economists involves using an estimate of the SRTP to discount future benefits and costs, and to adjust the costs of the project upward to account for the opportunity cost of capital (including the administrative costs of tax collection and potential effects on private sector investment). This approach, while preferred by "purists", is difficult to implement in practice because the degree of crowding-out is generally unknown. Best practice in this case involves producing estimates of return (i.e., benefit-cost ratio) with both the SOC and SRTP-based discount rates. In Florida, a more practical approach was retained with the use of a single, blended rate of 4 percent, which also reflects the recent reduction in interest rates.

Appendix C - REMI TranSight Instructions

This appendix contains a set of instructions used internally by the study team to run REMI TranSight and produce the results needed for the macroeconomic analysis. The different models run in REMI are presented first.

Models Run in REMI

Table C.1 below shows the 12 models simulated with REMI. Model 10 is the baseline model that is at the center of this report. The inputs to this model include all benefits estimated in the HERS and NBIAS analyses, and with the Transit and Freight rail models.

Table C.1: Model Descriptions

Model Number	Model Description	Budget Scenario	HERS Transit VMT Reduction	HERS Freight VMT Reduction	Freight Rail Cost Savings
Model 01	Base NoTransit NoFreightVMTReduction NoFreightRail	Base			
Model 02	Base +10% NoTransit NoFreightVMTReduction NoFreightRail	Base +10%			
Model 03	Base -10% NoTransit NoFreightVMTReduction NoFreightRail	Base -10%			
Model 04	Base Transit NoFreightVMTReduction NoFreightRail	Base	✓		
Model 05	Base +10% Transit NoFreightVMTReduction NoFreightRail	Base +10%	✓		
Model 06	Base -10% Transit NoFreightVMTReduction NoFreightRail	Base -10%	✓		
Model 07	Base Transit FreightVMTReduction NoFreightRail	Base	✓	✓	
Model 08	Base +10% Transit FreightVMTReduction NoFreightRail	Base +10%	✓	✓	
Model 09	Base -10% Transit FreightVMTReduction NoFreightRail	Base -10%	✓	✓	
Model 10	**Base Transit FreightVMTReduction FreightRail**	**Base**	✓	✓	✓
Model 11	Base +10% Transit FreightVMTReduction FreightRail	Base +10%	✓	✓	✓
Model 12	Base -10% Transit FreightVMTReduction FreightRail	Base -10%	✓	✓	✓

Models 11 and 12 closely relate to Model 10 in that they also include all benefits, but with slightly modified budget assumptions. These models, together with Model 10, are used in the Funding (Investment) sensitivity analysis discussed in Appendix B-5. Model 10 corresponds to the *Base scenario*, while Models 11 and 12 correspond to the *Base scenario plus/minus 10 percent of investment spending*, as defined in Appendix B-5.

Models 01, 04, and 07 relate to Model 10 in that they all use the base budget assumptions, while the included benefits vary. This set of models was used in Appendix B-5 for the Benefits Buildup sensitivity analysis. In that analysis, models 01, 04, and 07 are *Buildup Scenarios 1*, *2*, and *3*, while Model 10 is defined as the *Base scenario*.[48]

Given the importance of Models 10, 11 and 12, the instructions contain additional steps for these three models. These additional steps include collecting more result tables from REMI (i.e., employment and value added by industry).

The legend of the styles used in the instructions is provided in Table C.2. The instructions start on the next page.

[48] Results from running all other models presented in Table C.1 (i.e., Models 02, 03, 05, 06, 08, and 09) were not used in this report.

Table C.2: Style Descriptions

Color / Style	Description
Model Differences	Instructions explaining the difference between the first 9 and the last 3 models. These include where to stop with the current model and how to go to the next model.
Models 10-12 Additional Instructions	Special formatting used as background for steps 13-19 (which only apply to the last 3 models).
File Naming Notes	Instructions reminding that it is important to be consistent in naming files within each model.

Instructions on how to run simulations in REMI TranSight

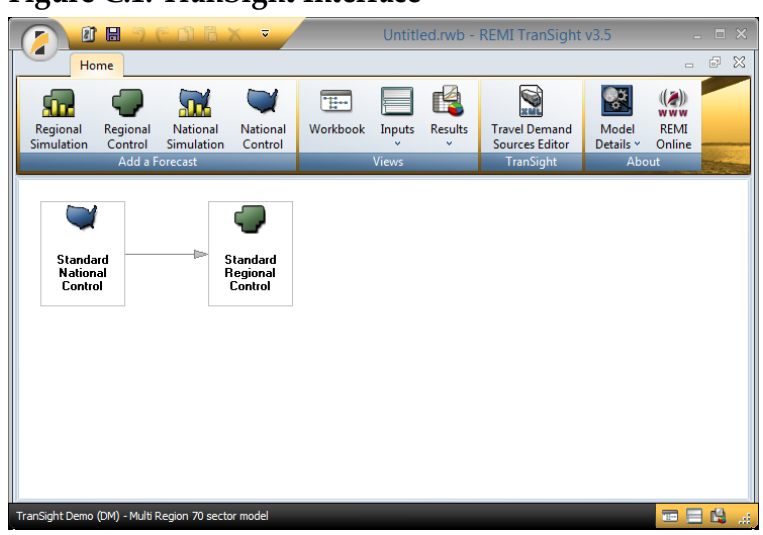
Each model run simulates the effects of transportation investments on the State economy. Depending on the model specifications (see Table C.1) each simulation has a different set of benefit categories included, or different budget assumptions.

Perform steps 1-12 for each of the 12 models.

For Models 10-12 perform additional steps 13-19.

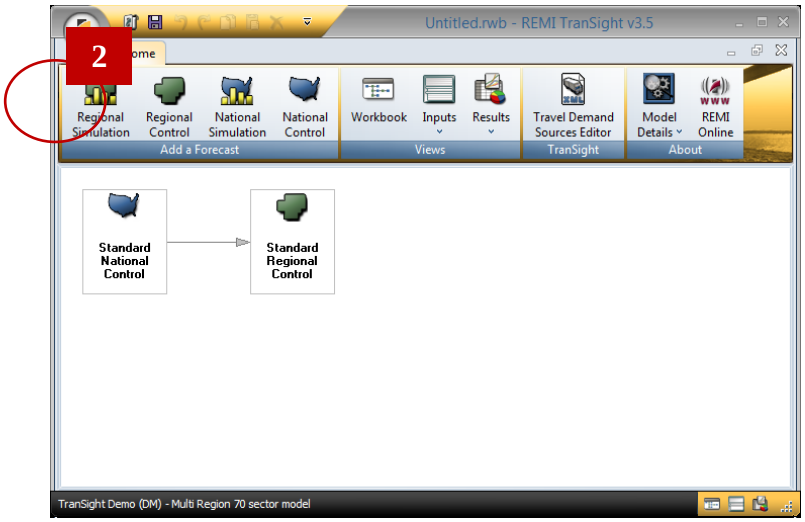
1. Open REMI TranSight v3.5 application.

Figure C.1: TranSight Interface



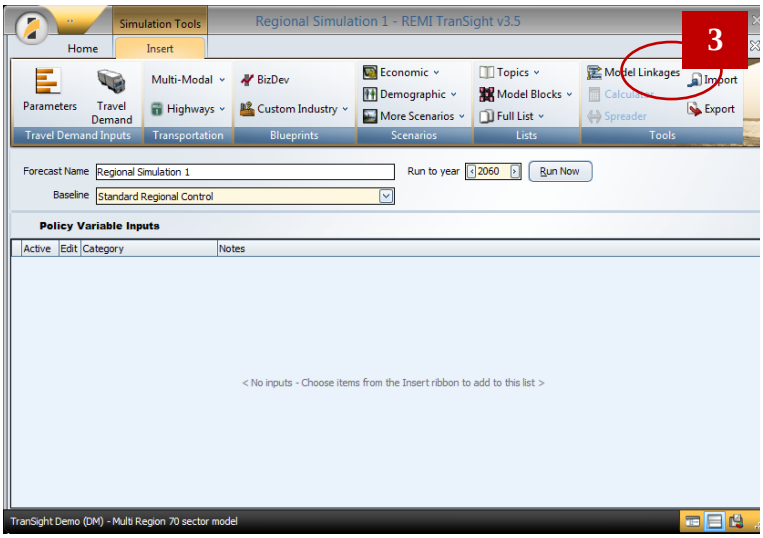
2. In the REMI TranSight window, select "Regional Simulati (see Figure C.2).

Figure C.2: REMI TranSight Interface: Home Tab



3. Insert Tab will open. Click "Import" button (see Figure C.3).

Figure C.3: Simulation Tools Window: Simulation Tools Tab: Screen 1.

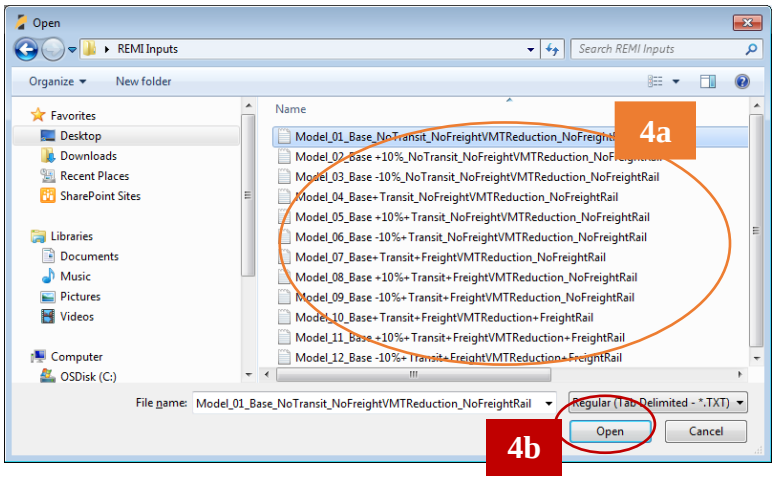


4. In the Open dialog window (see Figure C.4), navigate to the REMI Inputs file (e.g. "Model_01_Base_NoTransit_NoFreightVMTReduction_NoFreightRail"), select it (4a), and click the "Open" button (4b).

•

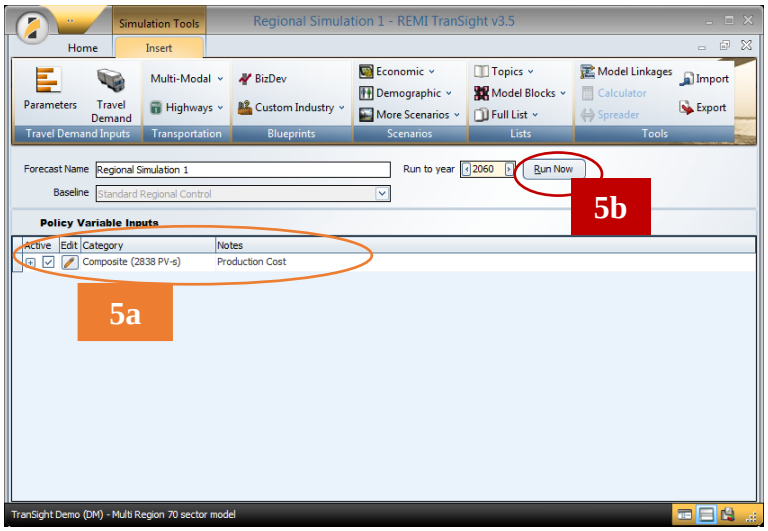
When this selection is being made, take note of what model (01 through 12) input file you are currently working with. This will be important when saving the outputs: the input file model number should match the output file's model number.

Figure C.4: Open Dialog Window



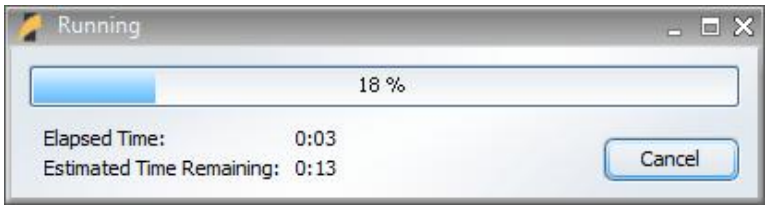
5. When input procedure is completed, a new line with the policy variable inputs (named "Composite (2838 PV-s)" should appear (5a). Click the "Run Now" button (5b) to run simulation.

Figure C.5: Simulation Tools Window: Simulation Tools Tab: Screen 2.



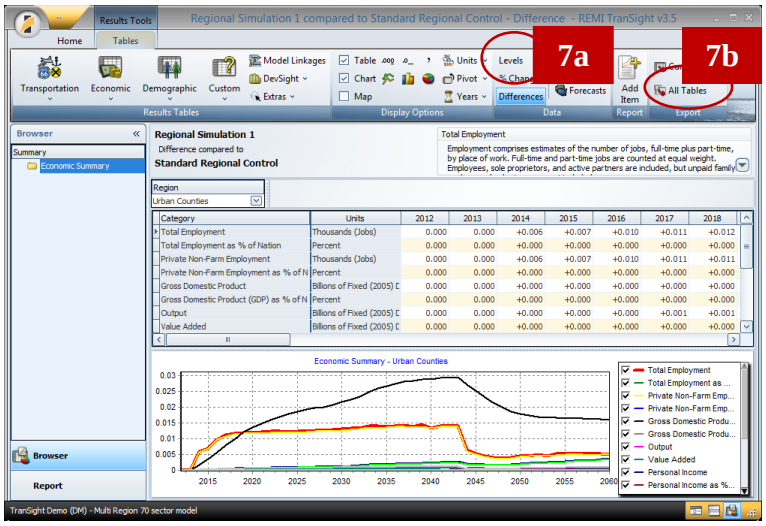
6. While the model is running, the progress bar (see Figure C.6) will show the progress of the model run.

Figure C.6: Progress Bar



7. After the TranSight model has finished running (see Figure C.7), to get the first output:
    a. Select "Levels" in "Data" frame (7a).
    b. Click "All Tables" in "Export" section (7b).

Figure C.7: Results: Screen 1



8. Save As window appears (see Figure C.8). First, navigate to a folder where you want to save the model output (in the Figure we created folder "REMI Outputs" on Desctop).

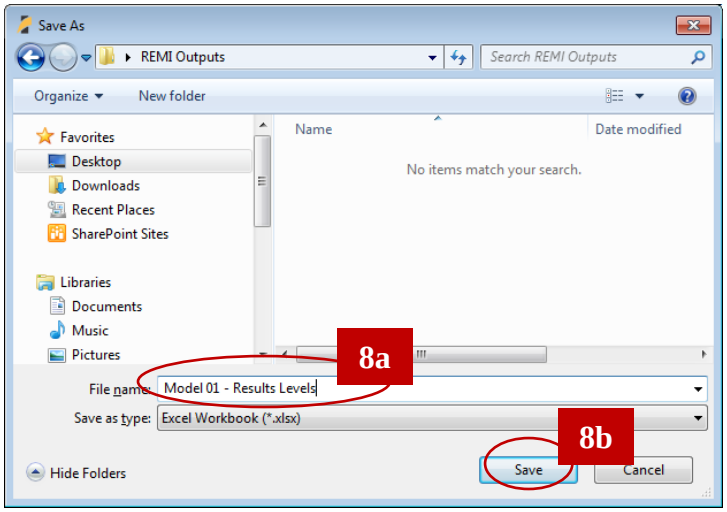
Then:

    a. type in file name ***"Model ## - Results Levels"*** into the "File name" field (8a) and
    b. click "Save" button (8b)

An example of the file name (for Model #01) is "Model 01 - Results Levels"

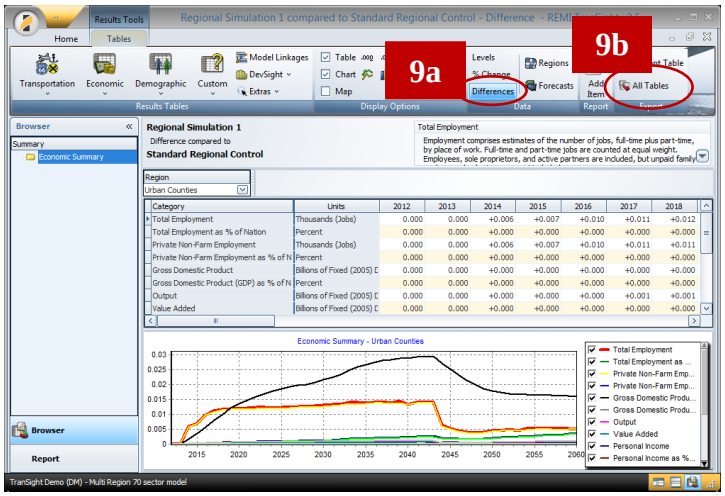
If the file already exists, confirm that you want to replace the file or choose a different file name.

Figure C.8: Save As Dialog Window: Screen 1



9. After saving the Levels results:
    a. Select "Differences" in "Data" frame (9a).
    b. Click "All Tables" in "Export" section (9b).

Figure C.9: Results: Screen 2

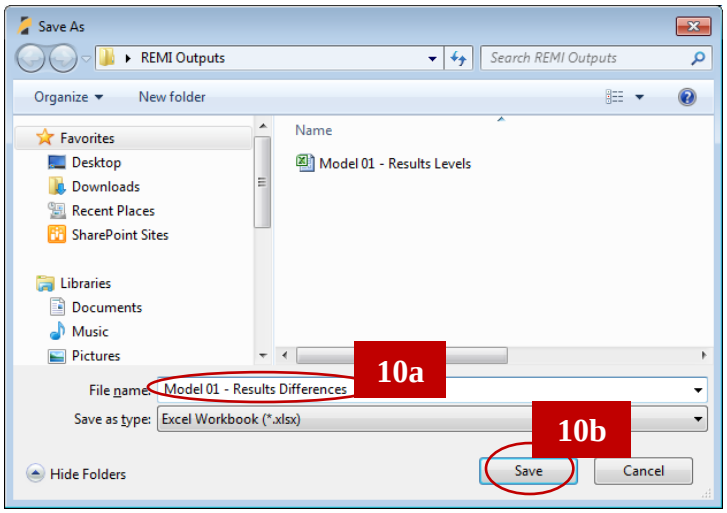


10. Save As window appears (see Figure C.10). Select a folder where you want to save the model output:
    a. type in file name ***"Model ## - Results Differences"*** into the "File name" field (10a) and
    b. click "Save" button (10b)

An example of the file name (for Model #01) is "Model 01 - Results Differences"

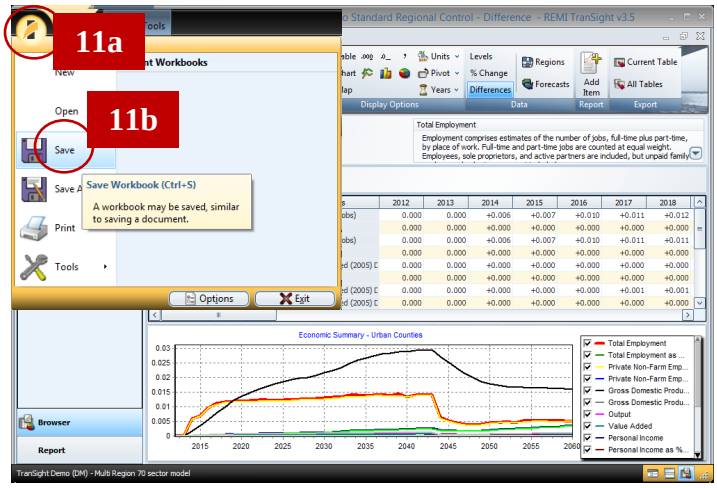
If the file already exists, confirm that you want to replace the file or choose a different file name.

Figure C.10: Save As Dialog Window: Screen 2



11. To save the model:
    a. Click TranSight Application Menu
    b. Click Save Menu Item in the Menu.

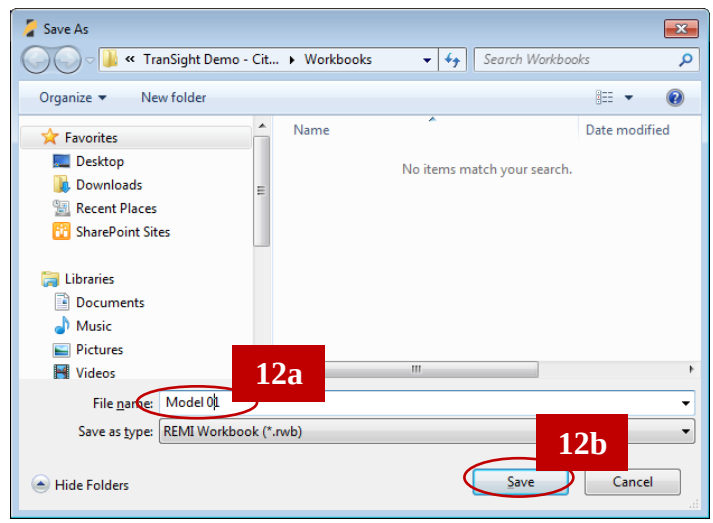
Figure C.11: Results: Screen 3



12. Save As window appears (see Figure C.12). Select a folder where you want to save the model (or use the default location):
    a. type in file name ***"Model ##"*** into the "File name" field (12a) and
    b. click "Save" button (12b)

An example of the file name (for Model #01) is "Model 01"

Figure C.12: Save As Dialog Window: Screen 3



If you are working on models 01 through 09, close TranSight Software and move on to the next model Input File and repeat steps starting from Step 1.

Otherwise, if you are working on models 10 through 12, then make sure you finish steps 13-19 and then close TranSight before you go to the next model Input file.

13. After saving the workbook, make sure that you are in Results section (see Figure C.13).
    a. Make sure that in "Data" frame, "Levels" is selected (13a).
    b. Click "Economic"

drop-down menu in "Results Tables" frame (13b).

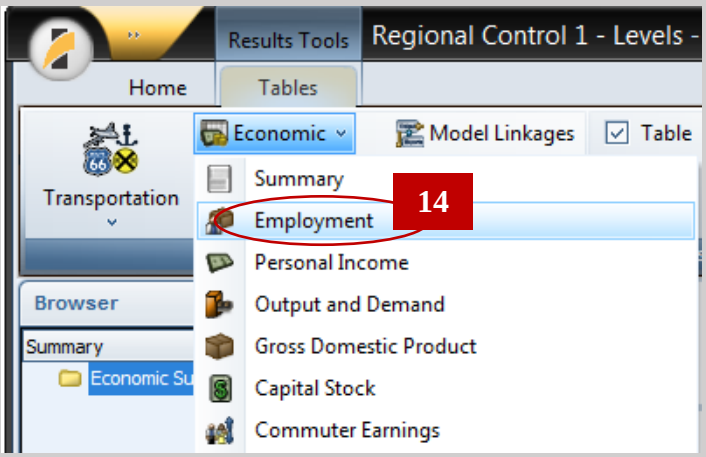
This step only applies to models 10-12

Figure C.13: Results: Screen 4

14. In the "Economic" drop-down menu (see Figure C.14), select "Employment" .

This step only applies to models 10-12

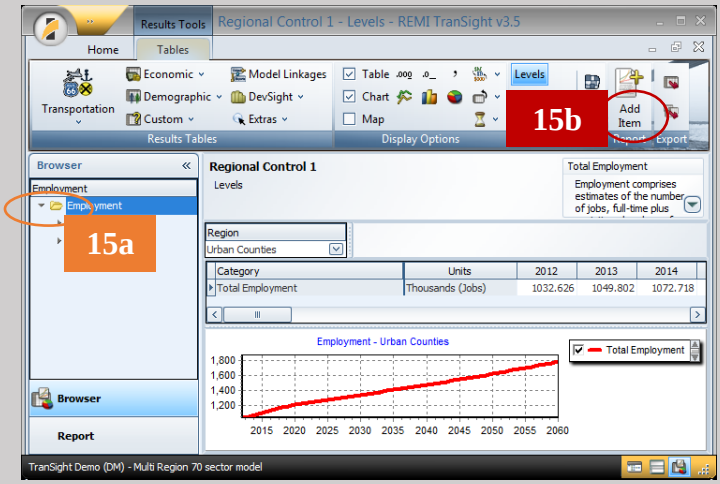
Figure C.14: Economic Drop-Down Menu: Screen 1



15. When "Employment" selection is made, the output table shown on the screen and the chart should change (see Figure C.15).
    a. Make sure that "Browser" section of the Window shows "Employment" (15a).
    b. Click "All Tables" in "Export" section (15b).

This step only applies to models 10-12

Figure C.15: Results: Screen 5

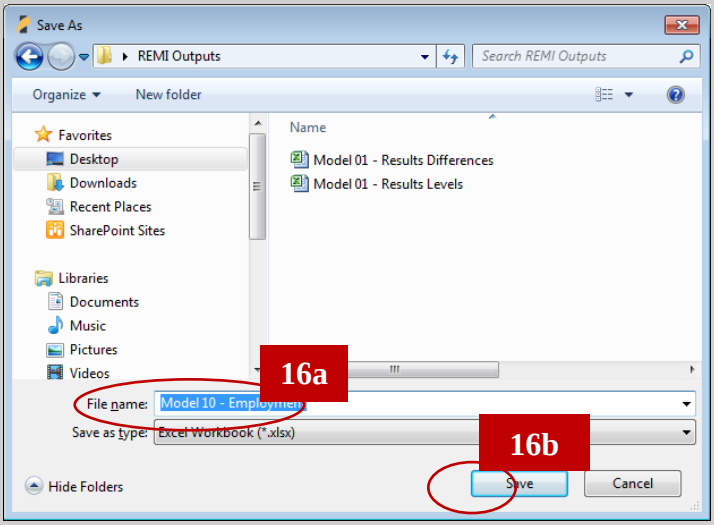


16. When REMI TranSight Save As window appears (see Figure C.16), select a folder (that can be easily found). Then
    a. type in file name ***"Model ## - Employment"*** into the "File name" field (16a) and
    b. click "Save" button (16b)

An example of the file name (for Model #10) is "Model 10 - Employment"

This step only applies to models 10-12

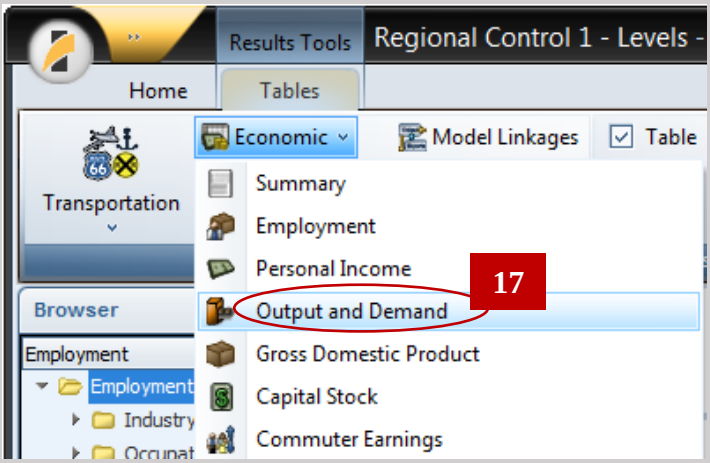
Figure C.16: Save As Dialog Window: Screen 5



17. In the "Economic" drop-down menu (see Figure C.17), select "Output and Demand" .

This step only applies to models 10-12

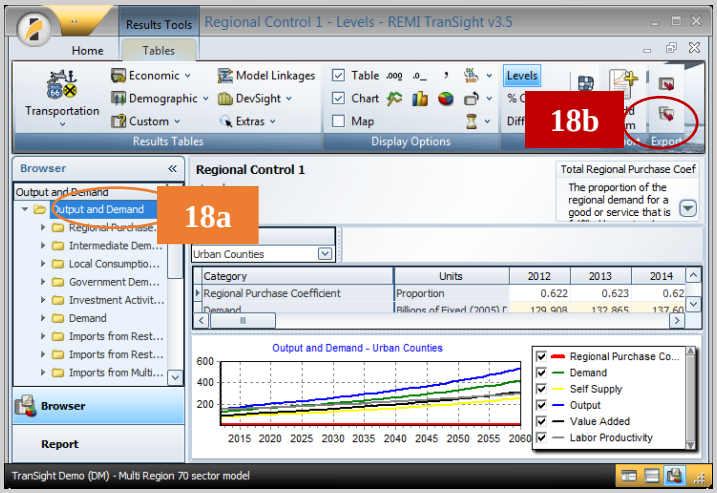
Figure C.17: Economic Drop-Down Menu: Screen 2



18. When "Output and Demand" selection is made, the output table shown on the screen and the chart should change again (see Figure C.18).
    a. Make sure that "Browser" section of the Window shows "Output and Demand" (18a).
    b. Click "All Tables" in "Export" section (18b).

This step only applies to models 10-12

Figure C.18: Baseline Results: Screen 6

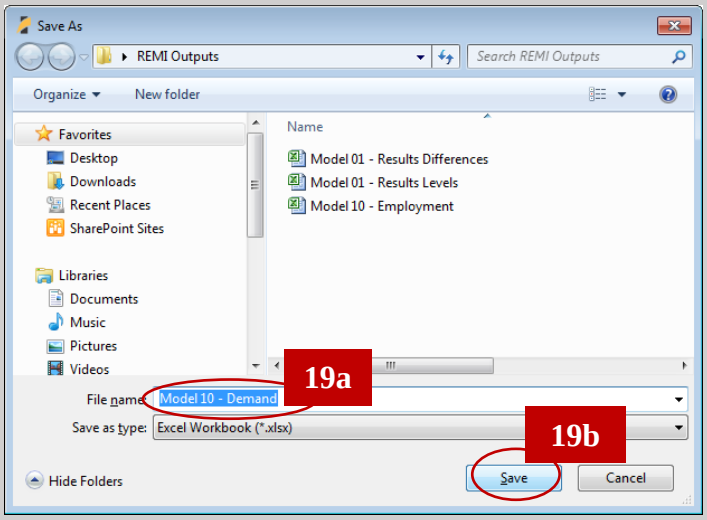


19. When REMI TranSight Save As window appears (see Figure C.19), select the output folder. Then
    a. type in file name ***"Model ## - Demand"*** into the "File name" field (19a) and
    b. click "Save" button (19b)

An example of the file name (for Model #10) is "Model 10 - Demand"

This step only applies to models 10-12

Figure C.19: Save As Dialog Window: Screen 6



After Model 12 results are saved, check if the results contain the following 30 files

All 12 models:
Model ## - Results Levels (12 files)
Model ## - Results Differences (12 files)

Models 10-12 only:
Model ## - Employment (3 files)
Model ## - Demand (3 files)

Appendix D - Glossary

Benefit-Cost Analysis – A systematic quantitative method of attempting to assess the desirability of government projects or policies.[49] It requires calculating or estimating all significant benefits and all significant costs.

Benefit-Cost Ratio (BCR) - The ratio of the benefits of a project or program to the cost of the project or program, with the present value of benefits (including negative benefits) placed in the numerator of the ratio and the present value of the initial agency investment cost in the denominator. The ratio is usually expressed as a quotient (also known as a pure number, e.g., $2.2 million/$1.1 million = 2.0).[50]

Congestion – Increased delay and inconvenience caused by traffic. Highway congestion results when traffic demand approaches or exceeds the available capacity of the transportation facility or facilities.[51]

Congestion Reduction – Any set of actions that will lower the degree of congestion, and hours of delay, on a highway network, in this case the Florida State Highway System (SHS). The congestion reduction programs analyzed by this study consist primarily of highway and transit improvements. Frequently, highway improvements reduce congestion by increasing capacity or making more efficient use of existing capacity. Transit improvements may reduce congestion by drawing trip takers from automotive vehicles to transit.

Constant or Real Dollar Values – Economic units measured in terms of constant purchasing power. A real value is not affected by general price inflation.[52] In expressing dollar amounts in constant dollars, it is necessary to choose a fixed time as the constant reference for valuing all dollar amounts. In this study, 2014 is usually chosen as the fixed time, so constant dollar values are expressed as "2014 dollars". Please see Chapter 1, Section 3 for an explanation of the use of Constant dollars in this study.

Current or Nominal Dollar Values – Economic units measured in terms of purchasing power of the date in question. A current or nominal value reflects the effects of general process inflation.[53] Also known as Year of Expenditure Dollars.

Discount Rate – The interest rate used in calculating the present value of expected yearly benefits and costs.[54] The discount rate is used to reflect the time value of money in economic

[49] Based on Office of Management and Budget (OMB), Circular No. A-94 Revised (Transmittal Memo No. 64), "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 1992.
[50] Based on U.S. Department of Transportation Federal Highway Administration (FHWA) Office of Asset Management, *Economic Analysis Primer*, August 2003.
[51] Florida Department of Transportation (FDOT) Office of Policy Planning (OPP), *Transportation Glossary of Terms and Acronyms*, August 2005.
[52] OMB, Circular No. A-94 Revised (Transmittal Memo No. 64), "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 1992.
[53] Ibid.

calculations. The discount rate is applied to Constant Dollars to estimate discounted benefits and costs. Please see Chapter 1, Section 3 for further explanation.

Gross State Product (GSP) – The sum of the money values of all final goods and services produced in the state economy and sold on organized markets during a year. It is the state equivalent of gross domestic product (GDP).[55]

Highway Economic Requirements System (HERS) – An engineering/economic analysis (EEA) tool developed for the U.S. Federal Highway Administration (FHWA) that uses engineering standards to identify highway deficiencies, and then applies economic criteria to select the most cost-effective mix of improvements for system-wide implementation. The State Version of HERS (HERS-ST) is used in this analysis.[56]

Inflation, General – The proportionate rate of change in the general price level, as opposed to the proportionate increase in a specific price. General inflation erodes consumer purchasing power. Inflation is usually estimated by a broad-based price index, such as the implicit deflator for the Gross Domestic Product or the Consumer Price Index (CPI).[57] If consumer prices are generally *decreasing*, then the appropriate term is *deflation*. Deflation was not seen in the U.S. during the second half of the twentieth century, but it is possible during recessions.

Inflation, Transportation Construction – Proportionate rate of change in the cost of constructing transportation facilities. Highway construction is a major component of transportation construction, and increases in highway construction costs have been closely tracked by a number of federal and state agencies. However, transportation construction includes rail lines, airports and seaports. Costs are highly influenced by a small number of commodities, particularly steel, concrete, asphalt and other petroleum products. At any given time, the level of transportation construction inflation may be quite different than the level of general inflation.[58]

Maritime Administration (MARAD) – A U.S. Department of Transportation agency dealing with waterborne transportation. It promotes the use of waterborne transportation, integration with other segments of the transportation system, and the viability of the U.S. merchant marine. MARAD has developed a model to estimate the economic effect of seaport investments, and an adapted version of this model is used in this study to evaluate the seaport work program.

National Bridge Investment Analysis System (NBIAS) – An engineering/economic analysis (EEA) tool developed for the FHWA to predict bridge maintenance, improvement and replacement

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[54] Ibid.
[55] Adapted from Baumol, William J. and Alan S. Blinder, *Economics: Principles and Policy*, Ninth Edition, 2003.
[56] FHWA, *HERS-ST 2.0: Highway Economics Requirements System-State Version Overview*, 2002.
[57] Derived from OMB, Circular No. A-94 Revised (Transmittal Memo No. 64), "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 1992, and www.forextips.com/forex-terms-ghijkl.htm.
[58] For more information on this topic please refer to the following URL: http://www.fhwa.dot.gov/programadmin/contracts/price.cfm.

needs.[59] NBIAS complements HERS and is used here to estimate and analyze the benefits of the bridge component of the Florida DOT Work Program.

Net Present Value (NPV) – The difference between the discounted present value of benefits and the discounted present value of costs.[60] Expressed as a formula,[61]

$$NPV = \sum \frac{R_t}{(1+i)^t}$$

Where, t – the time the benefit or cost is realized

i – the discount rate

R_t – net benefits (total benefits minus total costs) at time t

In the U.S., R_t is expressed in terms of dollars, and thus NPV is a dollar value. The choice of discount rate, i, will have a dramatic effect on the computed NPV of most projects, especially projects that entail benefits and costs over a decade or longer. Normally, in such cases a small increase in the discount rate will generate a large decrease in the NPV.[62]

Personal Income – Income received by persons from all sources. It includes income received from participation in production as well as from government and business transfer payments.[63] Note that the economic definition of personal income differs from that used for tax and accounting purposes. In this report, we use the economics definition with special focus on the total increases in personal income, over a period of many years, which result from the transportation investments of the Work Program.

Present Value (PV) – The value of a future benefit or cost, or stream of benefits or costs considering discounting. If an analyst knows the appropriate discount rate, he or she can calculate the PV of any sum of resources or money to be spent or received in the future. The application of the discount rate to future sums to calculate their present value is known as "discounting". Through discounting, different investment alternatives can be objectively compared based on their respective present values, even though each has a different stream of future benefits and costs.[64] PV can be calculated for any date, past, present or future, for example "present value as of 1975".

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[59] Cambridge Systematics, *National Bridge Investment Analysis Version 3.3 User Manual*, technical report prepared for the FHWA, May 2007.
[60] OMB, Circular No. A-94 Revised (Transmittal Memo No. 64), "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 1992.
[61] Adapted from FHWA Office of Asset Management, *Economic Analysis Primer*, August 2003.
[62] Adapted from http://en.wikipedia.org/wiki/Net_present_value
[63] Bureau of Economic Analysis, *Glossary*, http://bea.gov/glossary/glossary.cfm?letter=P accessed January 2009.
[64] Adapted from FHWA Office of Asset Management, *Economic Analysis Primer*, August 2003.

Product – This term is used in two different ways in this report:

1. In the economic terms Gross Domestic Product (GDP) and Gross State Product (GSP) and related uses, "product" includes all goods and services produced by the economy, valued in monetary terms.
2. A category of the Program and Resource Plan (PRP, see below). In this context, "product" refers to expenditures that directly build transportation infrastructure or provide transportation services. In the PRP, "products" include road and bridge construction, the cost of land purchased for rights of way for transportation facilities, transit vehicles and several categories of grants. "Product" is different from "product support," which includes preliminary engineering, operations and maintenance, and/or administration. See also "Productivity" immediately below.

Productivity –Quality or state of being productive.[65] Transportation investments generate long-term increases in GDP as a result of improved efficiency in the movement of people and goods, which increases productivity. This contrasts with the short-term effect of employing workers for construction, which stimulates the economy. This effect is referred to as "stimulus". Another definition of productivity refers to labor productivity which can be measured by output per unit of effort.[66] Although very important to the economy, labor productivity, per se, is not a focus of this study.

Program and Resource Plan (PRP) - A 10-year plan that establishes financial and production targets for the Florida Department of Transportation programs, thereby guiding program funding decisions to carry out the goals and objectives of the Florida Transportation Plan (FTP).[67]

Regional Economic Modeling, Inc. (REMI) – A software and consulting company best known for its economic modeling software packages, including TranSight and Policy Insight. Sometimes the term REMI is used to describe any of these packages. The economic modeling for this project, including future projection of GSP, was performed using REMI software.

Overall Rate of Return – This is the discount rate that sets the net present value of the stream of net benefits equal to zero. There may be multiple values for this rate when the stream of net benefits alternates from negative to positive more than once.[68] Usually expressed in terms of percent per year, as in "a return of 4% per year". Within FDOT, the Overall Rate of Return, or Socio-economic Rate of Return, is used for economic analyses, while the term Internal Rate of Return (IRR) is used for financial analyses.

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[65] *Merriam-Webster's Ninth New Collegiate Dictionary*.
[66] http://economics.about.com/od/economicsglossary/g/productivity.htm
[67] FDOT OPP, *Transportation Glossary of Terms and Acronyms*, August 2005.
[68] OMB, Circular No. A-94 Revised (Transmittal Memo No. 64), "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 1992.

Stimulus – Also referred to as economic stimulus or fiscal stimulus, this is government spending or reduction in tax collections for the purpose of stimulating an economy and increasing employment in the short-term.

Strategic Intermodal System (SIS) - A transportation system comprised of facilities and services of statewide and interregional significance, including appropriate components of all modes. The SIS was designated in Florida Statute in 2003.[69]

User Benefits – In this study, this term refers to benefits to individuals or businesses from improvements to transportation facilities and services. These include direct reductions in transportation costs (see Vehicle Operating Costs below). The most typical user benefit is reduced travel time. Very often, user benefits accrue to individuals in their roles as consumers, and the user benefits do not necessarily directly increase GSP. However, user benefits have real economic value because users would be willing to pay for them (i.e. a shopper stuck in traffic would be willing to pay some amount to eliminate it).

Value of Time – Measure of the economic value an individual places on their personal time. This may also be viewed as one's willingness to pay, on average, to reduce their travel time. The value of time is needed to assign aggregate economic value to reductions in congestion for automobile traffic or improvements in transit service. The values of time used in this study are based on the values used by FHWA when running HERS to develop its biannual Report to Congress: Conditions and Performance of the National's, Highways, Bridges and Transit.

Vehicle Operating Costs (VOC) – Costs of owning and operating vehicles, including fuel, oil, maintenance, tires and other costs. VOC can be affected by a project due to the changes that it causes in highway speeds, traffic congestion, pavement surface, and other conditions that affect vehicle fuel consumption and wear and tear.[70] The sum of these costs, aggregated over the entire state, was estimated using HERS software for this report.

Work Program - The five-year listing of all transportation projects planned for each fiscal year by the Florida Department of Transportation, as adjusted for the legislatively approved budget for the first year of the program.[71]

Year of Expenditure Dollars – see definition for "Current or Nominal Dollar Values". Also, see Chapter 1, Section 3 for an explanation of why and how Year of expenditure dollars are presented in this study.

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[69] FDOT OPP, *Transportation Glossary of Terms and Acronyms*, August 2005. http://www.dot.state.fl.us/planning/glossary/glossary.pdf
[70] Adapted from FHWA Office of Asset Management, *Economic Analysis Primer*, August 2003.
[71] FDOT OPP, *Transportation Glossary of Terms and Acronyms*, August 2005.