MACROECONOMIC ANALYSIS of Florida's TRANSPORTATION INVESTMENTS

FISCAL YEAR 2019-2023 WORK PROGRAM

Florida Department of Transportation

August 2020

FDOT

Executive Summary

Purpose

The Florida Legislature requires that the Florida Department of Transportation (FDOT) assess the economic benefits of its five-year Work Program. FDOT conducts this analysis approximately twice per decade. This macroeconomic analysis estimates the effect of transportation investments on the state's economic competitiveness and compares the overall benefits and costs of FDOT's transportation investments.

The FDOT Work Program plans and budgets for five years of transportation projects and is developed collaboratively with metropolitan planning organizations and local governments in Florida. The Work Program includes transportation investments in highway, transit, rail, seaports and waterways, airports, spaceports, and related infrastructure.

Methodology

This macroeconomic analysis began with the investments in the FDOT Work Program that covers Fiscal Years 2018-19 through 2022-23. Approximately 90 percent of the total Work Program investments were considered in this analysis, with aviation, rail, and intermodal access investments excluded due to limitations in data and modeling. The Work Program contains investments in support functions - product development, operations and maintenance, and administrative costs. Ninety percent of these costs were included, consistent with the share of product-specific investments.

Virtually all Work Program expenditures produce two streams of benefits – short-term and long-term. The analysis does not consider short-term effects of construction spending. Instead, it focuses on long-term benefits to overall economic efficiency.

Industry-accepted models were used to estimate direct benefits of highway, safety, seaport, and transit investments. The outputs of these modeling processes where then applied to a nationally recognized economic model to estimate overall economic benefits to the state. These include indirect benefits, such as business expansion due to lower costs, and induced benefits to the economy, such as additional consumer spending related to greater job growth.

Together, the direct, indirect, and induced benefits for both users of the transportation system and the economy at large reflect one measure of economic impact of these investments. FDOT calculated a benefit-cost ratio by dividing the present value of the benefits by the present value of the investment. In addition to the benefit-cost ratio, FDOT also estimated other measures of economic impact: change in gross state product, economic output (productivity), and employment.

Findings

Over the years 2019 to 2048, Florida is projected to realize four dollars of cumulative personal and business economic benefit for each dollar spent on the FDOT Work Program between 2019 and 2023.

With adjustments for the present value of future benefits, total monetized benefits are projected to be approximately $164 billion in 2018 dollars.[1] Additional benefits are summarized below:

Present value of user benefits from personal travel	$86 billion
Present value of economic benefits from business travel	$78 billion
Total present value of benefits	$164 billion
Present value of Work Program budget (costs)	$41 billion
Estimated benefit-cost ratio	4.0
Present value increase in personal income	$72 billion
Present value increase in gross state product	$61 billion
Present value increase in output	$99 billion
Average increase in annual employment	31,000

Note: Values are presented in 2018 dollars, discounted at four percent to a present value in 2020

This analysis is based on economic trends prior to COVID-19. To test the sensitivity of this analysis to changes in investment level, the analysis was re-evaluated for both a 10 percent reduction and a 10 percent increase in the total Five-Year Work Program. In these scenarios, the estimated benefit-cost ratio varied from 3.9 to 4.2, and the other economic impacts generally varied within 10 percent of the baseline analysis.

[1] Calculation of a benefit-cost ratio requires discounting all benefits and costs to the present day. Separately, costs and benefits must also be converted to a consistent dollar-year using inflation factors. This study uses 2018 constant dollars, a discount rate of four percent, and a present value year of 2020.

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1.0 Background

This study analyzes the long-term economic benefits of the Florida Department of Transportation (FDOT) Work Program for fiscal years 2018/2019 to 2022/2023. This chapter describes the Florida legislative mandate that this study fulfills; reviews FDOT's Work Program; summarizes study results from prior cycles; and discusses the study methodology.

1.1 Introduction

The *Florida Transportation Plan (FTP) Vision Element,* updated in May 2020, establishes a vision for Florida's transportation future that focuses on seven goals:

- Safety and security for residents, visitors, and businesses.
- Agile, resilient, and quality transportation infrastructure.
- Connected, efficient, and reliable mobility for people and freight.
- Transportation choices that improve accessibility and equity.
- Transportation solutions that strengthen Florida's economy.
- Transportation systems that enhance Florida's communities.
- Transportation solutions that enhance Florida's environment.

With respect to the economy, the FTP Vision Element includes the following text:

"Our transportation system will be designed to connect workers to jobs, visitors to attractions, and businesses to suppliers, customers, and partners. We will provide connectivity for workforce, visitors, and commerce at all levels, global to local, to support an increasingly divers economy. Florida's supply chain needs world-class air, sea, and space gateways with service to global markets; it also needs e-commerce centers and delivery networks able to bring highly precise shipments to individual customers daily. Our workers and visitors also need safe, affordable, and reliable ways to travel to, from, and through Florida.

This analysis seeks to quantify the impact of Florida's transportation investments – through the FDOT Work Program – on the state's economy.

FDOT's Work Program for fiscal years (FY) 2018/2019 through 2022/2023, accounts for $52 billion in transportation investments.[2] This macroeconomic analysis establishes the link between Work Program investments in highways (specifically in bridge, pavement, and capacity), safety, seaports, and transit over the next five years and economic growth due to these investments in Florida over the following 25 years.

Economic impacts include increases in employment, business output, value-added (as measured by gross state product), and personal income. This study uses a benefit-cost analysis to compare the magnitude of benefits and costs over time. Direct user benefits experienced by travelers and freight carriers were determined first, and then served as inputs to a regional economic model that estimates long-run indirect and induced benefits to Florida's business community.

1.2 Response to Legislative Mandate

Since 2000, Florida's Legislature has required FDOT to study the macroeconomic implications of transportation investments and their impact on 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. See **Appendix A – Statute**, for broad definitions of several of these mandates.

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. This analysis quantifies direct benefits (in transportation cost savings) of Work Program investments on a mode-by-mode basis and then translates some of 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 impacts are increased output (sales), hiring additional workers, and, ultimately, increasing the personal income of Florida's residents. These impacts spread from the direct users of the transportation infrastructure to the broader Florida economy.

2. **Making the case for Florida as an attractive place to do business.** The 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. By providing efficiencies in the transportation system, the state reduces business costs and becomes more attractive to employers of all sizes.

[2] This is a total in year-of-expenditure dollars, not discounted. The present value of the investments in 2018 dollars in 2020, using a 4% discount rate, is $41 billion.

REMI estimates economic expansions, as well as an influx of workers that 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 the past few decades. Recent related work has been performed by the Florida Chamber Foundation and the Florida Department of Economic Opportunity.[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 impacts from construction spending. 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 4 of this report.

1.3 Florida Department of Transportation Work Program

Investments in the FY 2018/2019-2022/2023 Work Program include highway resurfacing/reconstruction; bridges (repair, reconstruction and replacement); upgrades to existing highways (widening and interchange improvements, among others); new highway or interchange construction; right-of-way purchases; safety improvements (improved curves among others); transit improvements (vehicle replacement and maintenance facilities among others); and seaport improvements (access roads, facilities improvements, dredging, among others). These and other 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, FDOT'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 were included in proportion to the included Product investments.

1.3.1 Product Investments in the Work Program

This analysis was computed using approximately 90 percent of the overall Work Program, as illustrated in Figure 1.

[3] Please see https://www.flchamber.com/florida-2030/; and http://www.floridajobs.org/office-directory/division-of-strategic-business-development/florida-strategic-plan-for-economic-development

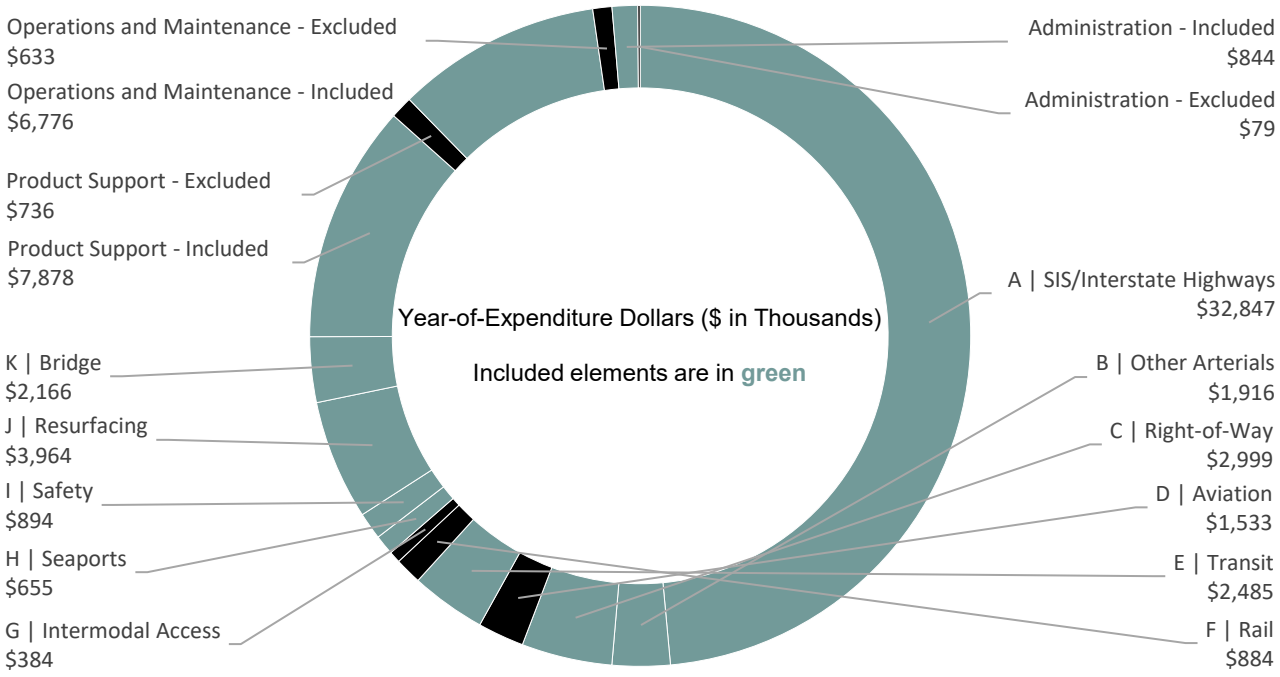

FIGURE 1 | INCLUDED ELEMENTS OF THE 2019-2023 WORK PROGRAM

Categories D (Aviation); F (Rail); and G (Intermodal Access) do not have associated benefit methodologies or current data, and were therefore excluded from the costs used in the benefit-cost ratio. Product support, operations and maintenance, and administration totals were scaled to account for the exclusion of these product categories.

Table 1 presents the proposed expenditures by Product and other investment categories contained in the 2018/2019 to 2022/2023 Work Program in year-of-expenditure dollars. For consistency with the prior macroeconomic analyses in 2003, 2006, 2009, and 2014, these amounts do not include "roll forward"[4] amounts from prior years. As the table shows, over 75 percent of the Work Program Product investments are focused on categories that 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 $2.5 billion, and seaport investments comprise $655 million.

[4] "Roll-forward" is an FDOT process by which funds for unopened project phases and the uncommitted portion of open project phases can be moved forward from one Work Program to the next. For details, see http://wbt.dot.state.fl.us/ois/WorkProgram101CBT/360030005.pdf

Program Areas	2019	2020	2021	2022	2023	Total
Product	$5,511	$7,984	$6,494	$6,479	$6,378	$32,847
A | SIS/Interstate Highways	$2,792	$2,788	$2,638	$3,315	$3,435	$14,968
B | Other Arterials	$410	$606	$311	$282	$308	$1,916
C | Right-of-Way	$477	$976	$824	$392	$330	$2,999
D | Aviation	$363	$277	$319	$266	$308	$1,533
E | Transit	$335	$794	$539	$406	$411	$2,485
F | Rail	$167	$269	$210	$119	$119	$884
G | Intermodal Access	$45	$87	$72	$83	$98	$384
H | Seaports	$149	$164	$118	$107	$117	$655
I | Safety	$149	$256	$213	$134	$142	$894
J | Resurfacing	$484	$641	$866	$1,008	$966	$3,964
K | Bridge	$142	$1,126	$385	$368	$145	$2,166
Product Support	$1,855	$2,392	$1,440	$1,460	$1,467	$8,614
Operations and Maintenance	$1,319	$1,585	$1,487	$1,504	$1,515	$7,409
Administration	$154	$177	$191	$197	$204	$923
Totals	$8,839	$12,138	$9,612	$9,641	$9,564	$49,793

TABLE 1 | FY 2019-2023 FDOT WORK PROGRAM (IN $ MILLIONS)

Source: https://www.fdot.gov/workprogram/programresourceplan.shtm

A variety of analytical tools were used to assess the related macroeconomic effects. Similar to past studies, three of the principal tools were the Highway Economic Requirements System (HERS), the National Bridge Investment Analysis System (NBIAS), and the REMI economic impact forecasting model. The effects of transit and seaport investments and investments under the Highway Safety Improvement Program (HSIP) were analyzed using spreadsheet models and appropriately integrated into the HERS, NBIAS, and REMI analyses. All these methodologies and tools are discussed in Chapters 2 and 3.

1.3.2 Understanding Work Program Expenditures

Work Program expenditures are presented in three ways in this report: year of expenditure dollars, constant dollars, and discounted constant dollar costs.

- **Year of Expenditure Dollars |** Year of expenditure dollars (sometimes called nominal dollars) reflect the actual Work Program investments expected to occur in future years. Because some degree of inflation is expected to continue, year of expenditure amounts will be greater than constant amounts to build/improve 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.

- **Constant Dollars |** Constant dollars are adjusted for inflation to reflect the extent of expenditures in each future year. They have been used as inputs into several economic models, including HERS and REMI. For the purposes of this study, the final results also are reported in 2018 constant dollars.[5]

- **Discounted Costs |** 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 in the year 2020. 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 used in the benefit-cost analysis section of this report.

See **Appendix B – Glossary** for broad definitions of these terms.

1.4 History of Macroeconomic Analysis

1.4.1 Results of Previous Macroeconomic Analyses

Previous evaluations of the Work Program showed significant economic benefits, as summarized in Table 2.

	2003	2006	2009	2015
Total Discounted Benefits	$155.5	$168.7	$150.5	$151.6
Present value of user benefits from personal travel	$58.0	$62.0	$64.4	$70.3
Present value of economic benefits from business travel	$97.5	$106.8	$86.2	$81.3
Total Discounted Costs	$28.2	$30.1	$30.6	$34.3
Net Present Value (benefits minus costs)	$127.3	$138.7	$119.9	$117.3
Benefit-Cost Ratio (benefits over costs)	5.5	5.6	4.9	4.4

TABLE 2 | RESULTS OF PREVIOUS MACROECONOMIC ANALYSES

Source: 2015 Macroeconomic Analysis, restated for comparative purposes.

Note: All dollar values shown are in billions of 2018 dollars. The benefit-cost ratio is unitless.

Scope and methodology changes over these studies included:

- **2003 |** The 2003 study included highway investment benefits (through the then-current versions of HERS and NBIAS), as well as benefits for transit and freight rail.

[5] The HERS and NBIAS models currently are calibrated for 2016 dollars, so their results were converted to 2018 dollars for consistency.

- **2006 |** The 2006 study updated the methodology for estimating benefits from freight rail and incorporated seaports for the first time. The study results were influenced by expected increases in transit ridership, additional freight rail investments, and increases in construction costs during the 2004 to 2007 period.

- **2009 |** The 2009 study enhanced the transit analysis by including user benefits and applied sensitivity analysis to estimate the range of potential effects given different policy assumptions.

- **2015 |** The 2015 study included an analysis of highway safety projects funded through the Highway Safety Improvement Program (HSIP). In addition, it changed the discount rate to four percent from seven percent used in the prior analyses to be consistent with the rate in FDOT economic analysis of major projects.

A discussion of the benefit-cost findings of this study relative to past analyses is provided in Section 5.1.

1.4.2 Methodological Changes for the 2020 Analysis

For this 2020 analysis, improvements and methodological changes include:

- **Evolved Highway Benefits Analysis |** This study uses the current national standard version of HERS to calculate the benefits of highway roadway investments. The 2015 analysis used a different, related software package (called "HERS-ST") that is no longer supported and further modified the parameters of that model to account for Florida's rapid recovery from the 2007-2009 recession. The national HERS is consistent with reports that FHWA makes to Congress.

- **Improved Safety Benefits Analysis |** The benefits estimation methodology for HSIP-funded projects first introduced in 2015 has been refined based on a review of the results from that initial analysis. More detail on this method and its results can be found in Section 2.1.3.

- **Exclusion of Freight Rail Benefits |** Freight rail has been excluded from the 2020 analysis. The methodology, data, and assumptions first developed in 2006 and carried through 2009 and 2014 have become outdated. New data collected over the coming years will allow freight rail to be considered in the next version of this analysis.

1.4.3 Modes Not Included

This analysis aims to analyze as much of the Work Program as possible, especially all capacity enhancing programs. However, the variety and complexity of modes, categories, and projects has prevented the quantitative analysis from being comprehensive to this point. In addition to freight rail as discussed above, several additional modes and programs also have not been included in this or prior analyses:

- **Aviation |** The Aviation Office first prepared the Florida Airport Benefit Cost Analysis (BCA) Tool in 2013. By focusing on airside capacity of seven illustrative airports throughout the state,[6] this tool lays the groundwork for a comprehensive assessment of the benefits and costs of much of the FDOT Aviation Work Program. Over the coming years, it is anticipated that continued development of the BCA tool will allow the inclusion of much of the Aviation Work Program in future macroeconomic analyses.

- **Space |** Florida Statute and FDOT policy provide 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. 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 demand and economic impacts.

- **Bicycle and Pedestrian |** The Shared-Use Nonmotorized (SUN) Trail program identifies and funds strategic paved multi-use paths throughout the state. There is no dedicated program for on-road bicycle and pedestrian projects, which are funded through highway, safety, intermodal development, or the federal passthrough for transportation alternatives. As such, some benefits of active transportation improvements are accounted in the highway and safety methodologies.

- **Intercity Passenger |** FDOT's direct investment in intercity passenger rail and bus service is limited. Commuter rail (TriRail and SunRail) are accounted for in the transit analysis, and investment in many intercity bus services and in Brightline is private.

- **Intermodal Access |** FDOT's Intermodal Access Program is not included because its size varies widely and unpredictably year-to-year.

Work on improving the analysis of benefits for all these modes is ongoing, and FDOT has the goal of including them in future versions of this analysis.

1.5 Methodology for the Macroeconomic Analysis

This analysis calculated three types of benefit: direct, indirect, and induced. These terms also are commonly referred to as initial, secondary, and tertiary impacts that ripple throughout the economy when an investment is made:

- The **direct benefits** (or initial impacts) are changes in the economy in response to the Work Program investment. In this study, they are typically cost savings for individuals and businesses from reduced crashes, reduced travel time, and reduced vehicle operating costs.

[6] The seven 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).

- The **indirect benefits** (or secondary impacts) are a response to the initial impact. For instance, reduced transportation costs lead businesses to hire more employees or to raise wages.

- The **induced benefits** (or tertiary impacts) are a response to the secondary impact. For instance, workers with more money buy more goods.

In this study, direct benefits were computed through different methodologies by mode and type of investment. These methodologies are described in Chapter 2. The direct benefits accrued due to both personal and business travel. The direct benefit due to business travel was then scaled up with indirect and induced benefits using the REMI economic modeling software. The methodology for doing this is described in Chapter 3.

The conceptual methodology is illustrated in Figure 2. A more detailed discussion of the specific methodologies for each modal analysis is provided in the coming chapters.

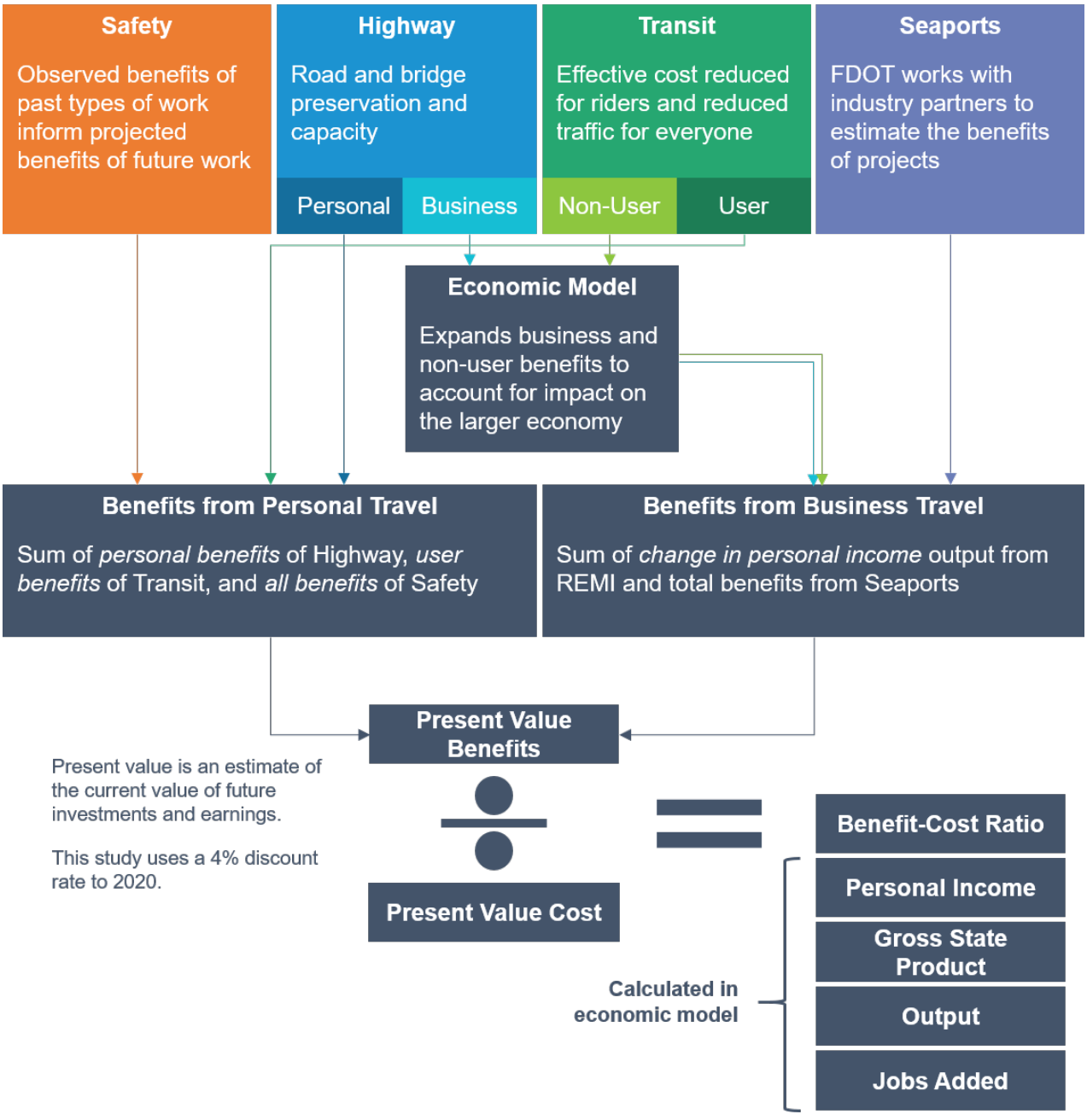

FIGURE 2 | OVERALL FRAMEWORK OF THE 2020 MACROECONOMIC ANALYSIS

2.0 Methodology for Direct Benefits

This chapter describes the methods used to compute direct benefits to transportation system users stemming from Work Program investments in highway pavement and bridges; highway safety; transit; and seaports.

2.1 Highway and Bridge Preservation and Capacity (Work Program Categories A, B, C, J, K)

Direct investments in highways have a direct impact on auto and truck travel time, vehicle operating costs, and crash costs. These cost savings represent direct economic benefits to both personal travel and business-related travel including freight.

2.1.1 Assumptions and Tools

HERS

Computation of direct benefits for highway pavement investments centers on the HERS software tool developed by the Federal Highway Administration (FHWA). HERS is used in several states, and at the national level, to estimate the direct economic benefits of highway investments. FHWA uses HERS to prepare its biennial report on the conditions and performance of U.S. highways and bridges. 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 levels.

HERS estimates three types of direct benefits:

- **Travel Time Savings |** Travel time savings result from reduced congestion due to increased highway capacity or reduced vehicle-miles of travel (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 also are captured.

- **Vehicle Operating Cost Savings |** Vehicle operating costs include fuel, tires, lubricants, depreciation, and maintenance. These costs are affected by both travel time and the general wear and tear on vehicles from substandard pavement conditions.

- **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.

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, the model has been used to project bridge investment needs in several states, and FHWA uses the system for its bridge investment modeling and reports to Congress.

Traffic Volume Forecasts

Forecasted future year traffic volume – typically expressed as vehicle-miles traveled (VMT) – is a key input for both HERS and NBIAS. FDOT and FHWA use different traffic volume forecasting methodologies. This analysis used two different VMT forecasts – one as an input to HERS and NBIAS and one in post-processing to project benefits from HERS:

- **HERS and NBIAS Input |** FDOT considered historic VMT reports, Florida statewide transportation demand model forecasts, and FHWA econometric models before selecting a VMT growth assumption of 1.9 percent per year for 2019-2023, considered to be representative of all these sources.

- **HERS Post-Processing |** Direct benefits from HERS – computed for 2019-2023 – were projected to 2048 using car and truck VMT growth assumptions developed for FDOT by the University of South Florida Center for Urban Transportation Research (CUTR).[7][8] CUTR's VMT forecasts were produced by adjusting national projections from FHWA[9] using weighted indices of key macroeconomic factors that are expected to have significant effect on VMT generation: population growth (15 percent); real GDP growth (25 percent); growth in disposable income per-capital (35 percent); and growth in gasoline prices (25 percent). The CUTR methodology provided growth rates by vehicle type as well as projected shares of total VMT by vehicle type.[10] The growth rates are shown in Table 3.

Vehicle Type	2023-2038	2039-2048
Automobile (light duty)	1.53%	0.84%
Truck (weighted average from single-unit and combination)	2.18%	2.15%

TABLE 3 | VMT GROWTH RATES FROM CUTR (COMPOUNDED ANNUALLY)

Source: Concas et al, 2019

[7] Sisinnio Concas, Alexander Kolpakov, Austin M. Sipiora, and Braden R. Sneath, "Autonomous Vehicle (AV) and Alternative Fuel Vehicle (AFV) Florida Market Penetration Rate and VMT Assessment Study." Center for Urban Transportation Research, University of South Florida, Tampa, FL, October 2019.

[8] The FDOT forecast was not used for this step because it was not designed for a thirty-year horizon.

[9] US Department of Transportation, "Special Tabulations: FHWA Forecasts of Vehicle Miles Traveled (VMT): Spring 2018". Federal Highway Administration, Washington, DC, 2018.

[10] CUTR Task 4 Final Report, p.63. Full methodological explanation on p.62-65.

Post-Processing Assumptions

Both HERS and NBIAS used a set of post-processing assumptions identical to those in prior macroeconomic analyses. These included:

- Percentage of benefits accruing to automobiles and to trucks.
- Percentage of automobile VMT occurring for business and non-business purposes.
- Percentage of VMT on internal (within Florida) and external (beginning or ending in another state) trips.
- Percentage of the safety benefits that are attributable to Work Program investments and are anticipated to have an impact on economic activity (not all crashes have a significant economic impact).

2.1.2 Methodology

Direct benefits from HERS were computed using the following steps:

1. The most recent available Highway Performance Monitoring System (HPMS) data were obtained, which represent road condition (pavement condition and traffic volume) as of 2017.
2. Costs and model parameters as of 2018 were obtained from FHWA. These include construction costs, as well as value-of-time estimates, per-mile operating costs, fuel costs, and vehicle usage efficiency assumptions, all by vehicle type.
3. The HERS model used these assumptions to prioritize the capacity and resurfacing investments in the Work Program based on predicted benefits. It is important to note that this list is not identical to FDOT's Work Program priorities (or to the order in which investments actually will be implemented). Rather, HERS sets priorities primarily based on economic efficiency. For the purposes of this analysis, the HERS priority list is a reasonable approximation of the Work Program.
4. Based on this prioritized investment list and an input assumption of 1.9 percent annual VMT growth, HERS projected per-VMT travel time costs, operating costs, and crash costs for autos and trucks for scenarios with and without the Work Program investments (in the latter case, performance was allowed to deteriorate over time).
5. The predicted benefits were reduced to those attributable to the Work Program and disaggregated into business and non-business benefits and into internal and external trips.

Direct benefits from NBIAS were computed using the following steps:

1. The most recent available National Bridge Inventory (NBI) data was obtained, which represent bridge condition as of 2017.
2. Costs and model parameters as of 2018 were obtained from FHWA, including Florida-specific treatment cost adjustments.

3. The NBIAS model read the NBI dataset and the Work Program budget and estimated the condition of structural elements for each bridge in the inventory. The analysis included bridges in Florida that are eligible for federal funding.

4. NBIAS determined the cost-minimizing approach to keep each element in a state of good repair.

5. NBIAS determined work that should be performed in each year to maximize return on the budget. This work included preservation (following Step 4) as well as functional improvements (widening lanes and shoulders and raising, strengthening, or replacing structures, for example). As with HERS, this list is not identical to FDOT's planned or actual project prioritization but is a reasonable approximation.

6. NBIAS predicted future physical and functional condition of bridges under the modeled Work Program, including costs and benefits in each year (2019-2048). NBIAS computed the following types of direct benefits (relative to deferring the investments):

   - Reduced travel time costs from raising or strengthening bridges.
   - Reduced crash costs from widening existing lanes and shoulders.
   - Reduced operating costs from improving bridge decks.

   Replacing a bridge yields all these benefits.

7. The predicted benefits were reduced to those attributable to the Work Program and disaggregated into business and non-business benefits and into internal and external trips.

2.2 Highway Safety (Work Program Category I)

Benefits for projects receiving HSIP funding were derived from the Work Program and from the Safety Office's Crash Data System (referred to as "CRASH"). For most HSIP projects completed since 2010, FDOT has observed five years of crash counts and compared them to historic rates, producing a database of observed crash reduction benefits for HSIP projects. From these data, the benefit was computed using the following steps:

1. CRASH and the Work Program classify projects differently. To apply the benefit-cost ratio observed in CRASH to Work Program investments, the two categorizations were associated with each other through a crosswalk.

2. A benefit-cost ratio was calculated for each of the historic projects in CRASH using their year of completion; averaged crashes reduced per year; life span value-of-reduced-crash; and total cost of the project (in present value (2020, four percent discount rate) 2018 dollars).

3. For the HSIP projects in the Work Program, a category of work was assigned through the crosswalk (using the "Work Mix" code in the Work Program) and a life span and CRASH-derived benefit-cost ratio were assigned from the category.

4. The benefit of each project was the BCR for the assigned category of work multiplied by the total cost of the project (present value in 2020 at four percent real discount rate).

2.3 Transit (Work Program Category E)

This analysis includes two direct benefits for transit:

- **User benefits** accrue to transit riders and are computed as the consumer surplus due to increased ridership.
- **Non-user benefits** accrue to drivers and are derived from estimated VMT reduction due to mode shift, which is monetized by HERS into value-of-time (reduced congestion); operating cost for non-business auto; and crash reduction benefits. The direct benefits derived from VMT reduction are used as inputs in the indirect and induced benefits analysis described in Chapter 3, alongside direct benefits from highway investments.

Both of these benefits are derived from regression models that relate vehicle revenue miles and transit ridership to cumulative investment in Florida's transit system. The historical dataset for all these variables is taken from the National Transit Database (NTD).[11]

The two direct benefits for transit were computed using the following steps:

1. Historical data for vehicle revenue-miles (VRM) on all transit and commuter rail systems in Florida was regressed (logarithmically and linearly) against spending on transit in Florida by all parties. The benefits were ultimately scaled down based on the Work Program's share of overall transit capital spending. [12]
2. Ridership (also called "unlinked passenger trips") was regressed linearly against VRM. The product of the first two steps was a system of mathematical equations that related ridership to spending.
3. Ridership growth was projected using the system of equations above and the Work Program investments.
4. User benefits were computed from the ridership increase as consumer surplus using assumptions for fares,[13] value-of-time,[14] elasticity,[15] and projected ridership increase. Consumer surplus typically represents the benefit of lowering a price (transit fares, for example) and seeing demand (ridership, for example) increase as a result. In this case the logic runs in reverse – ridership was assumed to increase, so the effective cost of riding (in terms of convenience and comfort) was assumed to decrease.

[11] https://www.transit.dot.gov/ntd/

[12] Derived from an analysis of the Transit Work Program by the Transit Office

[13] NTD annual "Fare Revenue" table for 2017 - https://www.transit.dot.gov/ntd/data-product/2017-annual-database-fare-revenue

[14] HERS-ST value for personal travel, converted to 2018 dollars – accessed for 2014 Assessment

[15] USF Center for Urban Transportation Research – accessed for 2009 Assessment

5. Non-user benefits were computed by converting the ridership increase to a VMT decrease (mode shift) using assumptions for trip distance[16] and vehicle occupancy.[17] This VMT reduction was applied to the HERS results in the postprocessor sheet and compared to the unaltered benefits to calculate the direct benefit. The REMI analysis calculated the indirect and induced benefit alongside that for highway.

2.4 Seaports (Work Program Cateogory H)

FDOT's Seaport Project Investment Tool (SPET) has been used for over a decade to assess the benefits of projects requesting state funds and to guide investment decisions for several state funding programs including the Florida Seaport Transportation and Economic Development Council (FSTED), Strategic Intermodal System (SIS), and past bond programs.

The SPET was designed to develop project level estimates of benefit cost ratio to the state of Florida based on:

- **Direct benefits of a project |** Economic benefits of increased cargo and cruise passenger throughput, determined based upon mode type, regional location, and passenger vacation trends (pre- and post-cruise hotel stays, for example) among other factors.
- **Indirect and induced benefits of a project |** Gross state product generated from increased cargo and/or cruise throughput, monetized benefits of improved transportation efficiencies, and related safety and operational benefits.
- **Total anticipated costs |** Total capital costs and maintenance costs over the life of the project, including any linked projects that are necessary to support the increased throughput.

The annual FSTED project application process provides a pool of project benefit-cost ratio – one for direct benefits and one for total direct, indirect, and induced benefits – that have been used to develop an estimate of economic benefits of the Seaport Office's 2019-2023 Work Program.

Some, but not all, funded projects included in the 2019-2023 Work Program had benefit-cost ratios available from the application records. If a project did not have an available benefit-cost ratio, one was matched from a similar project using engineering judgment. The average benefit-cost ratio across all projects (including matched values) was then applied to the full value of the Work Program for each of the five years to calculate the economic benefits of the state's seaport investments.

[16] From the 2018 Florida Transit Information and Performance Handbook, page 5.

[17] 2017 National Household Travel Survey - https://nhts.ornl.gov/ - Row Variable = HHSTATE

3.0 Methodology for Indirect and Induced Benefits

Indirect and induced benefits in this analysis were calculated in two ways. Indirect and induced benefits for seaports were estimated using FDOT's Seaport Office benefit-cost analysis tool, which includes the MARAD Port Kit Economic Impact model. The MARAD model estimates the same types of economic benefits projected by REMI. More detail on this methodology is provided in Section 2.4.

The Regional Economic Models, Inc. (REMI) TranSight model was used to estimate the indirect economic effects of the highway and transit mode investments. This is a statewide model, with 66 industry-sector detail, that is used for economic analysis by the Florida Legislature Office of Economic and Demographic Research and by Florida's 10 regional planning councils. 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:[18]

- **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 cost, market share, 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.

Direct benefits for businesses (business auto and truck) generated by the HERS and NBIAS models were input into REMI as reductions in production cost to estimate macroeconomic effects. The direct user benefits in terms of travel time and operating cost were input into REMI as:

- **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.

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

- **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.

At a high level, the method for running REMI consists of three steps:

- **Distributing business auto and transit non-user benefits** among 66 industries according to the industries' share of statewide employment in 2024, as projected by REMI in a control scenario.
- **Distributing truck benefits** for a single scenario among 66 industries according to the industries' **share of total use of for-hire and in-house truck transportation in Florida**, as reported by the U.S. Bureau of Transportation Statistics (BTS) in Transportation Satellite Accounts (TSA).
- **Uploading the production cost input tables** (the sum of auto and truck benefits for each scenario, multiplied by negative one) to the REMI software and running a statewide analysis.

This section provides more detail on each of these steps.

3.1 Distributing Business Auto Benefits

Business auto benefits were distributed among industries using industry-wise employment data for 2020 from REMI's control run. Once the employment table was exported to Microsoft Excel, each industry's share of business auto benefits is its percentage of projected overall statewide employment in 2024.

3.2 Distributing Truck Benefits

Truck benefits were distributed among industries using industry shares of trucking usage derived from BTS TSA data and the REMI control scenario. These shares were derived using the following steps:

1. The TSA table for direct requirements was downloaded.[19] This table shows the dollar value of commodities required to produce one dollar of industry output in 2016 (the most recent year available). This list of industries is similar, but not identical to, the one used by REMI.
2. The TSA table for use was downloaded.[20] This table shows the dollar value of commodities consumed by each industry total in 2016.

[19] https://explore.dot.gov/t/BTS/views/TSA_All/TSA_Main?:isGuestRedirectFromVizportal=y&:embed=y. Select "2016" for the year, "Industry" for the level of detail, and "Direct Requirements" for the table name.

[20] https://explore.dot.gov/t/BTS/views/TSA_All/TSA_Main?:isGuestRedirectFromVizportal=y&:embed=y. Select "2016" for the year, "Industry" for the level of detail, and "Use" for the table name. Note that Direct Requirements are computed by dividing the Use by the total Use across the industry, but TSA provides them raw.

3. The REMI table for use was downloaded.[21] This table shows the output in Florida for the 66 REMI industries from 2018 to 2060.

4. A crosswalk was developed (new for this analysis) between the TSA and REMI industry lists. Some REMI industries combine more than one TSA industry, but no REMI industries are split among multiple TSA industries.

5. The use of in-house and for-hire trucking in Florida was computed for each industry. This is the product of the requirement (in-house and for-hire) from the TSA table and the industry output from the REMI table. For REMI industries comprising multiple TSA industries, an average was computed and weighted by TSA use.

6. The percentage of total use of trucking was computed for each industry. For all industries except for-hire trucking (which is both an industry and a commodity) this was equal to the in-house use divided by the total of in-house and for-hire use across all industries. For the for-hire trucking industry, this was the total of all for-hire trucking uses and that specific industry's in-house use divided by the overall total.

3.3 Computing Indirect and Induced Benefits with REMI

Total direct benefits for business auto and truck (single scenario) were distributed according to the shares calculated as described in the prior sections. **The direct benefits used included the VMT reduction for transit described in Section 2.3 ("Yes Transit")**, converted to 2017 dollars. This created a table of modifications to the cost-of-doing-business for each industry and year. For REMI, this represents a "Production Cost," the lone input variable for this analysis.[22]

As a technical note: the REMI control scenario assumes that FDOT makes investments in transportation. For this reason, the modeling was done in inverse – the production costs were all multiplied by negative one. Technically, the benefits of the Work Program were modeled as the negative impacts to the Florida economy in a scenario where the Work Program is cancelled.

[21] The REMI output table can be accessed (in v4.3.4) by clicking "Regional Forecast" on the home screen, then "Detailed Economic" on the lower-left, then "Production and Trade" on the upper left and "Output" in the first column.

[22] The input tables were entered into the Production Cost variable using copy/paste (REMI no longer has an input function from .csv or .xlsx files). Beginning from the forecast screen, select "Select Inputs" from the top ribbon, then "Production Cost" from the pane on the left, then "Immediate Market Share Response", all the industries (using SHIFT-click), and "Fixed National" 2017 Millions in the wizard. Ensure that all the pre-entered values in the table are correct before saving the input sheet, and remember to begin the copy in 2019, not 2018 (the first column).

4.0 Results and Findings

The overall economic efficiency of transportation investments can be assessed by comparing the related economic benefits against the related costs. This chapter presents the summary of these benefits and costs, and the benefit-cost ratio, of investment in the FY 2018/2019-2022/2023 Work Program. Consistent with previous macroeconomic analyses, this approach includes economic impacts related to competitiveness and economic growth in addition to direct user benefits. The cost analysis follows a traditional benefit-cost approach by including all Work Program expenditures such as the costs to build, operate, and maintain infrastructure, as well as associated administrative and support costs.

The benefits attributable to the FY 2018/2019-2022/2023 period include both those that accrue to personal users of the transportation system (for example: a commuter, a tourist traveling to a destination, or a parent picking up a child from school), as well as to business users of the system (for example: a trucker or a traveling salesperson):

- **User benefits from personal travel** are computed for highway (roadway, bridge), highway safety, transit, and seaports using the methodologies described in Chapter 2. They include travel time savings, vehicle operating cost reductions, the value of prevented vehicle crashes, and consumer surplus to transit riders.

- **Economic benefits from business travel** build on the methodologies in Chapter 2 using the REMI macroeconomic model. They are presented as the change in personal income across all of Florida's economic sectors. They reflect the reduced cost of doing business in Florida and its impacts on business productivity and expansion.

Figure 3 summarizes benefits and costs used in the analysis in this chapter.

Benefits	Costs
User benefits from personal travel • Direct, personal benefits of highway investments • Benefits of safety projects receiving HSIP funding • User benefits of transit investments (consumer surplus) **Economic benefits from business travel** • Change in personal income due to highway investments • Change in personal income due to transit benefits • Business benefits of seaport investments	• Capacity spending • Costs for operations and maintenance • Costs for administrative support

FIGURE 3 | COMPONENTS OF THE BENEFIT-COST ANALYSIS

This approach avoids double counting because the direct benefits to business users are used as inputs to the REMI analysis.

Excluded from the benefits estimation are short-term construction impacts (including construction jobs) and environmental and community impacts (unless explicitly included).

Costs considered in the analysis include the Work Program itself with investments in highways, highway safety, transit, and seaports between the fiscal years 2018/2019 and 2022/2023. Also added to the total cost for the analysis are expenditures for investment support, operations and maintenance, and administration. Excluded from the analysis are investments in aviation, spaceports, intermodal access investments, and freight rail.

4.1 Analytical Assumptions

The analysis examined a period of 30 years, including five 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 2048.

The costs and benefits are expressed in constant 2018 dollars and discounted to a present value in 2020 using a four percent real discount rate, the rate selected by FDOT for benefit-cost analysis of capital projects. Use of discounted present value of future costs and benefits provides a consistent basis for comparing costs and benefits that occur in different future years.

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 related to the investment. Some similar studies may use the metric of “net present value” (NPV) to express effectiveness – defined by the difference between the discounted stream of future benefits and the discounted stream of future costs. The same information used to calculate the benefit-cost ratio could be used to calculate net present value.

4.2 Methodology

This section briefly explains benefits and costs that are included in the benefit-cost ratio calculation. For the details of how these benefits were initially computed, see Chapter 2 and Chapter 3.

4.2.1 User Benefits from Personal Travel

In brief, user benefits from personal travel were calculated as follows:

- Personal benefits for **highway and bridge preservation and capacity** were calculated using HERS and NBIAS respectively. The output of both models was post-processed to estimate statewide benefits for personal auto, business auto, and truck travel.
- Personal benefits for **highway safety** were calculated by associating Work Program projects funded by HSIP with categories of historic projects for which real-world benefits have been measured.

- User benefits for **transit** were calculated as the consumer surplus implied by projected increase to ridership.

4.2.2 Economic Benefits from Business Travel

In brief, economic benefits from business travel were calculated as follows:

- Business benefits for **highway and bridge preservation and capacity** and **transit** were calculated in the REMI TranSight software as the change in personal income. The highway post-processor isolated the HERS and NBIAS direct benefits that accrued to business auto and truck, respective of estimated VMT reduction due to investment in transit. These direct benefits took the form of annual increases[23] in the REMI input production cost.

- Business benefits for **seaports** were calculated from the project-specific benefit-cost ratios provided in the annual Florida Seaport Transportation and Economic Development Council (FSTED) application process.

4.2.3 Estimating Costs

The costs in this analysis are the direct planned expenditures in the Work Program on the modes with computed benefits. These include highway, transit, and seaports, but exclude aviation, rail, and intermodal access. The included costs represent 91 percent of the Work Program, including assigned shares of spending for product support, operations and maintenance, and administration.

Expenses related to Work Program projects in years after 2023 were not included. Similarly, salvage or residual values at the end of the period of analysis were assumed to be negligible.

4.3 Results of the Macroeconomic Analysis

Table 4 summarizes the benefit-cost analysis.

[23] It may seem counterintuitive to represent benefits as cost increases. To operationalize the modeling process, it was assumed that the REMI control scenario incorporates FDOT investment in transportation. The model was run as though that investment did not occur and its benefits were not felt. In general, the outputs reported in this section are the inverse of the raw REMI outputs.

Category	Model	Subcategory	Amount
Personal benefits	HERS	Personal auto	$74 billion
Personal benefits	NBIAS	Personal auto	$5.4 billion
Personal benefits	Transit	User	$0.90 billion
Personal benefits	Safety	Total	$5.4 billion
Personal benefits	Total	Total	$86 billion
Business benefits	REMI	Personal income	$72 billion
Business benefits	Seaport	Total	$6.2 billion
Business benefits	Total	Total	$78 billion
Total benefits	2019-2023 Work Program	Total	$164 billion
Total costs	2019-2023 Work Program	Total	$41 billion
Benefit-cost ratio	2019-2023 Work Program		4.0

TABLE 4 | RESULTS OF THE BENEFIT-COST ANALYSIS

Note: All costs and benefits are in 2018 constant dollars, present value in 2020 at four percent.

Table 5 lists four categories of annual impacts computed in REMI, sampled for three years during the analysis period:

- Personal income effects represent impacts 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.
- Output represents all sales (goods and services) by Florida businesses.
- Employment impact is a net job effect that includes both new jobs supported by greater economic competitiveness as well as jobs retained that otherwise would be lost without transportation investments.

Benefit Type	2022	2032	2042
Personal income	$3.1 billion	$4.2 billion	$5.1 billion
Gross state product	$3.0 billion	$3.5 billion	$4.0 billion
Output	$4.8 billion	$5.6 billion	$6.7 billion
Employment	32,600	33,000	33,100

TABLE 5 | ANNUAL COMPONENTS OF THE BENEFIT-COST ANALYSIS

Note: Monetary values are in 2018 constant dollars

In addition to these selected years, Figures 4 and 5 illustrate the total impact stream by variable. The benefit are anticipated to peak in the year 2043, after which the value will begin to decline as some assets reach their estimated 25-year lifespan and expire.

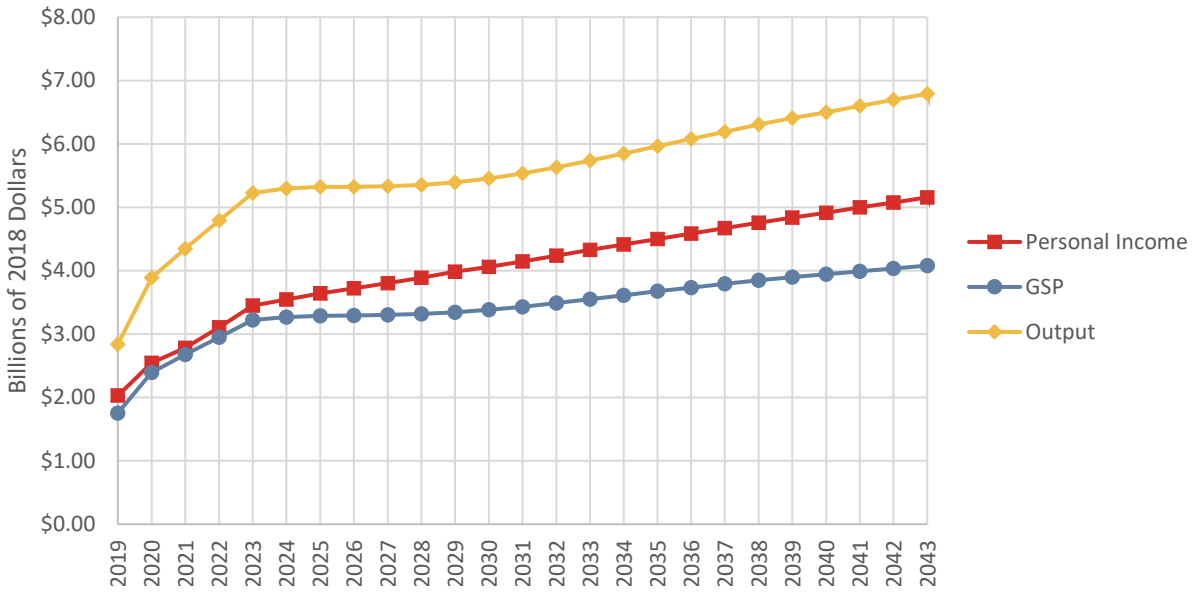

FIGURE 4 | PERSONAL INCOME, GROSS STATE PRODUCT, AND OUTPUT IMPACTS BY YEAR (REMI ANALYSIS)

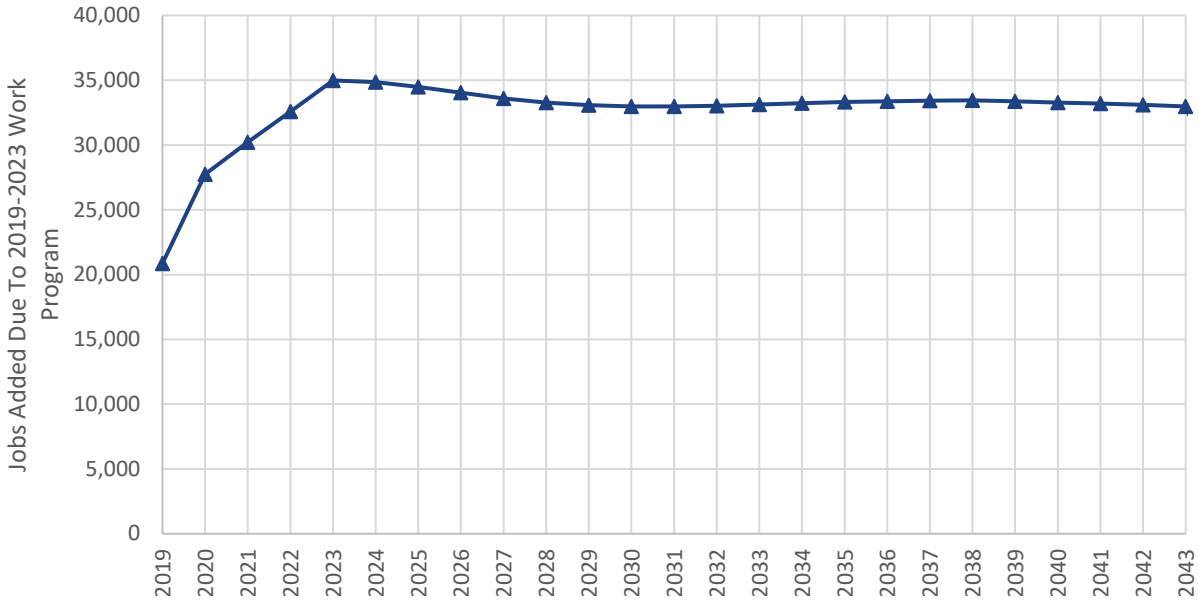

FIGURE 5 | EMPLOYMENT IMPACTS BY YEAR (REMI ANALYSIS)

Table 6 provides industry-level employment impacts in 2022, 2032, and 2042. Some of the industries showing large employment gains are significant overall in Florida (professional, scientific, and technical services, among others). Others show significant gains because they are uniquely dependent on for-hire (such as manufacturing) or in-house (such as waste management) truck transportation.

Industry	Projected Gains		
	2022	2032	2042
Forestry, fishing, and hunting	87	94	94
Mining	255	263	250
Utilities	55	67	66
Construction	5,233	2,122	1,683
Manufacturing	1,339	1,346	1,236
Wholesale trade	1,330	1,272	1,172
Retail trade	4,817	5,031	4,877
Transportation and warehousing	2,493	2,488	2,347
Information	249	285	316
Finance and insurance	1,066	1,107	1,164
Real estate and rental and leasing	1,735	1,798	1,820
Professional, scientific, and technical services	1,582	1,963	2,233
Management of companies and enterprises	89	96	96
Administrative, support, waste management, and remediation	2,105	2,351	2,488
Educational services; private	354	451	486
Health care and social assistance	2,342	3,101	3,558
Arts, entertainment, and recreation	593	678	691
Accommodation and food services	2,500	3,384	3,477
Other services (except public administration)	2,467	2,633	2,645
Total	32,582	33,037	33,096

TABLE 6 | IMPACTS TO PRIVATE NON-FARM EMPLOYMENT BY INDUSTRY (REMI ANALYSIS)

4.4 Summary of Results

As shown in Table 7, the benefit-cost ratio of FDOT's 2019-2023 Work Program is estimated to be 4.0 with an NPV of $123 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 four dollars. The results of this analysis demonstrate the value of FDOT's Work Program and its impacts on Florida's transportation system compared with making no investments and allowing the system to deteriorate.

Present value of user benefits from personal travel	$86 billion
Present value of economic benefits from business travel	$78 billion
Total present value of economic benefits	$164 billion
Present value of Work Program budget (costs)	$41 billion
NPV	$123 billion
Estimated benefit-cost ratio	4.0

TABLE 7 | SUMMARY OF THE BENEFIT-COST ANALYSIS

Note: Values are presented in 2018 dollars, discounted at four percent to a present value in 2020

In parallel with increasing personal income and GSP for Florida, the Work Program is projected to support over 30,000 jobs. Most of these are long-term jobs, with the vast majority generated by 2023. Although the analysis period ends in 2048, job growth should continue for decades beyond as a product of future FDOT investments.

5.0 Discussion

5.1 Benefit-Cost Ratio

This report, reflecting analysis performed in 2019 and 2020, is the fifth Macroeconomic Analysis following the 2000 legislative mandate. All the analyses have shown the State of Florida receives a strong positive benefit cost ratio. The methodology has evolved, broadened, and deepened over these two decades. FDOT believes that the 2020 Macroeconomic Analysis represents the most thorough and defensible accounting to date.

This study shows a lower overall benefit-cost ratio than the 2014 Macroeconomic Analysis. Indeed, the benefit-cost ratio has fallen with each iteration of the analysis since 2002. This trend reflects increasing construction costs and the advancing maturity of the system. Major highway expansion and construction that would reduce congestion on local roads has been accomplished over the past decades in many regions of Florida, and highway investments increasingly serve to meet FDOT's statutory commitment to maintaining pavement and bridges in good condition.

5.2 Economic Uncertainty

The analysis presented here was conducted in late 2019 and early 2020 and is based on data collected prior to the emergence of COVID-19. As a result, these projections should not be taken as a forecast for Florida's economic recovery from the current crisis. The analysis was not amended or modified to reflect COVID-19 impacts or recovery due to the significant uncertainty surrounding both travel and economic impacts from the pandemic in 2020 and 2021. Furthermore, this analysis is of the FY 2019-2023 Work Program, two years of which are already implemented. Finally, while this analysis should not be read as a forecast for COVID recovery, that does not make it invalid. The study covers a 30-year period in which both economic booms and recessions are assumed to occur; a similar study ending today would have been conducted in 1990 and the study period would include recognized recessions in 1990-1991, 2001, 2007-2009, and the current crisis, alongside all the growth that occurred in the intervening years.

FDOT conducts approximately two Macroeconomic Analyses per decade, in part to ensure that forecasts are regularly updated to reflect changing conditions. The next Macroeconomic Analysis will likely refine the predictions in this study in an environment where COVID-19 has stabilized and the long-term impacts are known. These impacts may touch every part of this analysis, including:

- Reduction in the size of the Work Program due to reduced transportation revenue.
- Increase in the size of the Work Program due to federal stimulus.
- Reduction in personal, business, or truck traffic volume.
- Reduction in sharing of vehicles (vehicle occupancy).

- Change in construction costs.
- Reduction in value-of-time for transportation users to reflect a reduced wage rate.
- Reduction in transit ridership.
- Reduction in seaport benefits to reflect reduced volume or value of global trade.
- Reduction in seaport benefits to reflect reduced cruise volume and/or revenue.

5.2.1 Sensitivity Analysis Relative to Work Program Size

FDOT conducted a sensitivity analysis for the benefits in this study based on one potential COVID-19 or economic impact: Work Program size. This approach mirrors the one taken for the 2009 Macroeconomic Analysis, similarly conducted during a time of economic uncertainty. The findings of this analysis, which compared the base scenario of the 2019-2023 Work Program with two alternative scenarios – a 10 percent reduction across the Work Program and a 10 percent increase across the Work Program – are shown in Table 8.

	Minus 10%	Base	Plus 10%
Present value of benefits from personal travel	$81 billion	$86 billion	$91 billion
Present value of benefits from business travel	$73 billion	$78 billion	$81 billion
Total present value benefits	$154 billion	$164 billion	$172 billion
Present value of Work Program budget (costs)	$37 billion	$41 billion	$45 billion
Estimated benefit-cost ratio	4.2	4.0	3.9
Present value increase in personal income	$67 billion	$72 billion	$74 billion
Present value increase in gross state product	$57 billion	$61 billion	$62 billion
Present value increase in output	$93 billion	$99 billion	$102 billion
Average increase in annual employment	29,000	31,000	32,000

TABLE 8 | RESULTS OF THE WORK PROGRAM SIZE SENSISTIVITY ANALYSIS

As a general observation, a greater investment by Florida in transportation will yield greater benefits, while a lesser one will yield less benefit. A slight diminishing returns effect applies, with the BCR decreasing slightly as spending increases; generally, it can be assumed that the next project funded with more spending has a slightly lower benefit-cost ratio than the ones chosen before that project. All three scenarios, however, have a BCR of approximately four, which is high for transportation investments.

Appendix A Statute

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 Glossary

Benefit-Cost Analysis | A systematic quantitative method of attempting to assess the desirability of government projects or policies.[24] 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, $2.2 million/$1.1 million = 2.0).[25]

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.[26]

Constant or Real Dollar Values | Economic units measured in terms of constant purchasing power. A real value is not affected by general price inflation.[27] 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, 2018 is usually chosen as the fixed time, so constant dollar values are expressed as "2018 dollars".

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.[28] Also known as Year of Expenditure Dollars.

Discount Rate | The interest rate used in calculating the present value of expected yearly benefits and costs.[29] The discount rate is used to reflect the time value of money in economic calculations. The discount rate is applied to Constant Dollars to estimate discounted benefits and costs.

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[24] 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.

[25] Based on U.S. Department of Transportation Federal Highway Administration (FHWA) Office of Asset Management, *Economic Analysis Primer*, August 2003.

[26] Florida Department of Transportation (FDOT) Office of Policy Planning (OPP), *Transportation Glossary of Terms and Acronyms*, August 2005.

[27] OMB, Circular No. A-94 Revised (Transmittal Memo No. 64), "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 1992.

[28] Ibid.

[29] Ibid.

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).[30]

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.

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).[31]

Inflation, Transportation Construction | Proportionate rate of change in the cost of constructing transportation facilities. 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.[32]

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 needs.[33]

Net Present Value (NPV) **|** The difference between the discounted present value of benefits and the discounted present value of costs.[34]

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[30] Adapted from Baumol, William J. and Alan S. Blinder, *Economics: Principles and Policy*, Ninth Edition, 2003.

[31] 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.

[32] For more information on this topic please refer to the following URL: http://www.fhwa.dot.gov/programadmin/contracts/price.cfm.

[33] Cambridge Systematics, *National Bridge Investment Analysis Version 3.3 User Manual*, technical report prepared for the FHWA, May 2007.

[34] OMB, Circular No. A-94 Revised (Transmittal Memo No. 64), "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 1992.

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.[35] 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. Discounting is the application of a discount rate to a future benefit stream, allowing apples-to-apples comparisons of the value of benefits or costs accruing over different time periods.[36]

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

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.

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.[37] 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.[38] 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).[39]

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[35] Bureau of Economic Analysis, *Glossary*, http://bea.gov/glossary/glossary.cfm?letter=P accessed January 2009.

[36] Adapted from FHWA Office of Asset Management, *Economic Analysis Primer*, August 2003.

[37] *Merriam-Webster's Ninth New Collegiate Dictionary*.

[38] http://economics.about.com/od/economicsglossary/g/productivity.htm

[39] FDOT OPP, *Transportation Glossary of Terms and Acronyms*, August 2005.

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.

Roll-Forward | The FDOT process by which budget for unopened project phases and the uncommitted portion of open project phases in the adopted Work Program is requested and by which the funds are moved forward into the new fiscal year in the Work Program Administration.

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.[40]

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). 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 (for instance, 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 | Costs of owning and operating vehicles, including fuel, oil, maintenance, tires and other costs. Vehicle operating costs 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.[41]

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.[42]

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[40] FDOT OPP, *Transportation Glossary of Terms and Acronyms*, August 2005. http://www.dot.state.fl.us/planning/glossary/glossary.pdf

[41] Adapted from FHWA Office of Asset Management, *Economic Analysis Primer*, August 2003.

[42] FDOT OPP, *Transportation Glossary of Terms and Acronyms*, August 2005.

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