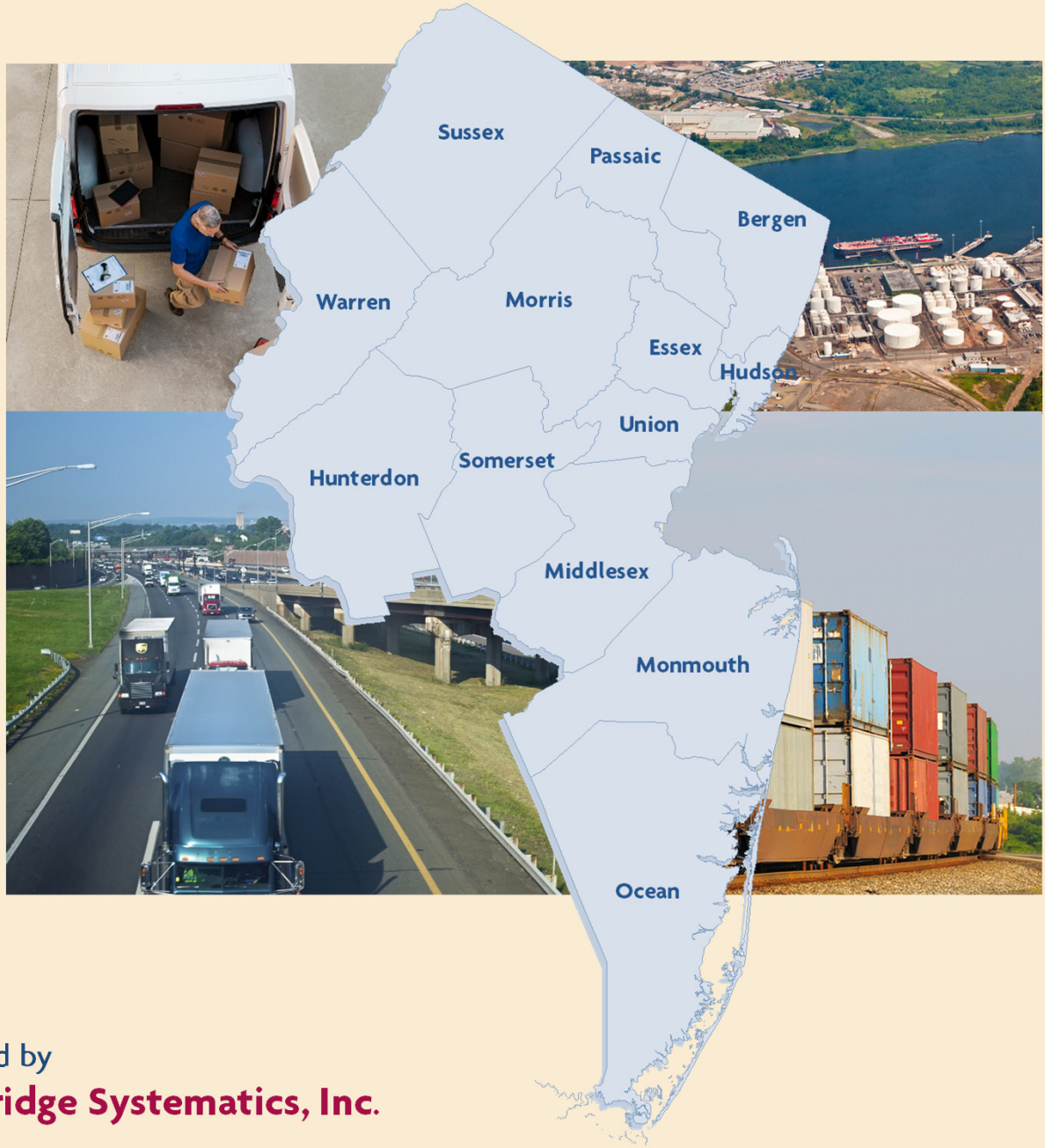
NJTPA NORTH JERSEY TRANSPORTATION PLANNING AUTHORITY
Defining the Vision. Shaping the Future.

2050 Freight Industry Level Forecasts Study
Final Report



prepared by
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with
WSP
Cheng Solutions LLC

June 2020

Final Report

2050 Freight Industry Level Forecasts Study

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prepared for

North Jersey Transportation Planning Authority

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June 30, 2020

Disclaimer

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About the NJTPA

The North Jersey Transportation Planning Authority (NJTPA) is the federally authorized Metropolitan Planning Organization for 6.7 million people in the 13-county northern New Jersey region. Each year, the NJTPA oversees the investment of more than $1 billion in federal funding for transportation projects and provides a forum for interagency cooperation and public input into funding decisions. It also sponsors and conducts studies, assists county planning agencies and monitors compliance with national air quality goals.

The NJTPA Board of Trustees includes 15 local elected officials, including one representative from each of the 13 northern New Jersey counties – Bergen, Essex, Hudson, Hunterdon, Middlesex, Monmouth, Morris, Ocean, Passaic, Somerset, Sussex, Union, and Warren – as well as from the cities of Newark and Jersey City. The Board also includes the Commissioner of the New Jersey Department of Transportation (NJDOT), the Executive Director of NJ TRANSIT, the Chairman of the Port Authority of New York and New Jersey, a Governor's Representative and a Citizens' Representative appointed by the Governor.

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Acronym Glossary

BTS	Bureau of Transportation Statistics
CAGR	Compound Annual Growth Rate
CPI	Consumer Price Index
CS	Cambridge Systematics
DC	Distribution Center
FAF	Freight Analysis Framework developed by FHWA and BTS
FFT	NJTPA's Freight Forecasting Tool
FHWA	Federal Highway Administration
FIC	NJTPA's Freight Initiatives Committee
FIPS	Federal Information Processing Standards, a coding system for geographic units
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GPS	Global Positioning Satellite; a technology that tracks the position of vehicles over time
GSP	Gross State Product (also used for Garden State Parkway)
FAST Act	Fixing America's Surface Transportation Act; This is the current federal transportation funding and policy law.
NAICS	North American Industry Classification System
NEC	Not Elsewhere Classified
NJDOT	New Jersey Department of Transportation
NJRTM-E	North Jersey Regional Transportation Model-Enhanced
O-D	Origin-Destination

PANYNJ	Port Authority of New York and New Jersey
RTAC	NJTPA's Regional Transportation Advisory Committee
SCTG	Standard Classification of Transported Goods
STCC	Standard Transportation Commodity Code
TAZ	Traffic Analysis Zone
USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation

Executive Summary

The 2050 Freight Industry Level Forecasts Study developed estimates of current and projected future freight demand out to 2050. Conditions in the goods movement industry have changed over the last several years. These updated forecasts will help ensure that the information the North Jersey Transportation Planning Authority (NJTPA) uses in its planning work and disseminates to its partner agencies is accurate. This effort built on two previous NJTPA Freight Planning studies, the 2040 Freight Industry Level Forecasts Study, completed in 2012, and the Regional Freight Commodity Profiles Study, completed in 2015.

The 2050 Freight Industry Level Forecasts Study helps the NJTPA and its member agencies to identify where concentrations of goods movement activity occur and will occur in the region, the types of commodities that are and will be moving, and where strategic investments should be considered to support economic opportunity and enhance resiliency. The results of this work help provide the context for the next NJTPA Long Range Transportation Plan as well as regional freight planning and subregional planning studies.

Figure 2.1 is a flow chart diagram that illustrates the progression and relationship of steps for completing this study and its deliverables.

a. **Step 1. Identify methodologies and data sources**. The first step in this process was to refine the approach and data needed in order to update and enhance NJTPA's Freight Forecasting Tool (FFT). In the 2050 Freight Industry Level Forecasts Study, add-on capabilities, such as processing U.S. Department of Transportation's (USDOT's) Freight Analysis Framework (FAF) commodity flow data, the addition of e-commerce activity in the NJTPA region resulting in a new commodity bundle, and a 2050 forecast horizon were incorporated into the tool. This first step also included a scan of all public and vendor-sourced data options available to fulfill the scope of the study and considered the value of the various options relative to cost in order to identify the best source(s) available for each need.

b. **Step 2. Acquire Data**. The second step was to acquire data from public and vendor sources. The data gathered included:

    a. The current version of FAF, which serves as the base commodity flow data;

b. Supplemental data needed to disaggregate FAF including the Surface Transportation Board's Carload Waybill Sample, and municipal solid waste flow data.

c. Market research data on e-commerce demand and carrier information from Rakuten was acquired to perform the e-commerce flow analysis.

d. Economic forecasts from Moody's were used to estimate future employment by industry sector by county, and assess alternative forecast scenarios;

e. Make-Use tables from the US Bureau of Economic Analysis were used to associate the industry-level economic forecasts with commodities produced and consumed by businesses in each industry sector; and

f. Business establishment data from Infogroup was used to enhance maps of businesses that ship, handle, and receive freight.

c. **Step 3. Disaggregate FAF to the county level.** While TRANSEARCH, the commodity flow database the FFT was initially developed to process, offers county-level geographic detail, the FAF data is grouped into 132 geographic regions across the country, corresponding to Census Metropolitan Area (CMA) boundaries located within each state. The State of New Jersey consists of 2 FAF regions. In order to create a county-level commodity flow database to support this study, the FAF data had to be disaggregated using a combination of industry sector employment data, Carload Waybill Sample, and approximate shares of port tons by county.

d. **Step 4. Estimate E-Commerce flows.** The project team developed an e-commerce delivery trip table for the base year using e-commerce market data provided by data vendor Rakuten Intelligence, along with research into the logistics chains of the major e-commerce delivery carriers and their respective facility locations serving the region. This table estimates the number of delivery vehicle trips from fulfillment centers, and other places where e-commerce deliveries are dispatched, to consumers' specified delivery locations. Population and household forecasts and an accounting for the expected growth of e-commerce as a share of retail sales were used to develop forecasted demand and trips through 2050.

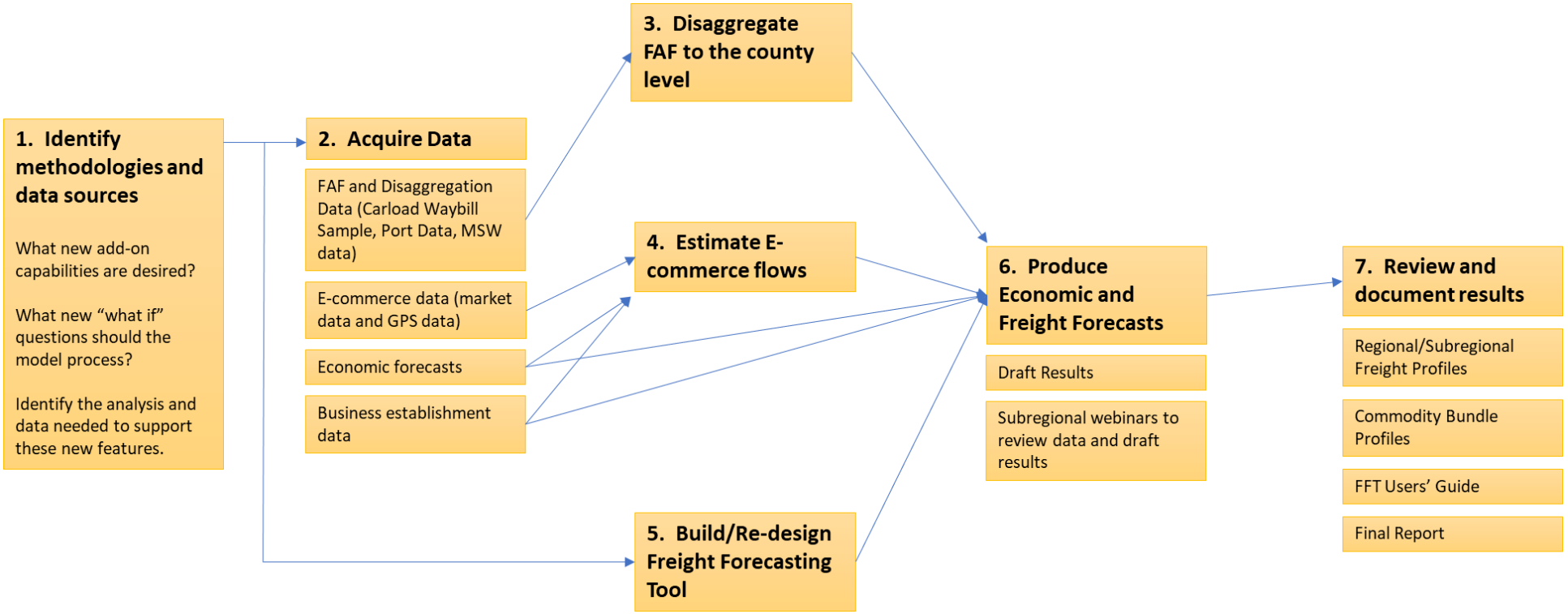
e. **Step 5. Build/Re-design Freight Forecasting Tool.** The FFT itself was updated and enhanced, to improve its operating efficiency, user interface, and output reporting. The basic logic was the same as previous versions of the tool: start with a base table of commodity tonnage by mode and origin-destination; determine changes in employment and productivity by industry sector, and translate those

changes into corresponding scalar factors for changes in tonnage; apply sensitivity adjustments reflecting variations in growth or logistics assumptions; produce a forecast table of tonnage by mode and origin-destination; and translate the forecast into an NJRTM-E compatible truck trip table. With respect to logic, the main differences in this updated FFT were: the use of disaggregated FAF rather than TRANSEARCH as the base table; the use of Moody's forecasts and their included alternative scenarios to capture employment changes; detailed investigation and projection of changes in labor productivity, which affects the amount of tonnage associated with each future employee; substantially expanded testing of 'disruptor' scenarios and alternative assumptions; incorporation of e-commerce as a net trip type; and a built-in "FAF Disaggregator" to create a comparably-formatted base table from an expected future release of FAF. With respect to structure, this updated FFT is quite different from previous versions. Earlier versions ran in MS Excel and were controlled by sequences of macro commands; this version consists of a series of spreadsheets containing input data and output calculations; the calculations are managed in a separate open-source programming application called "R;" the user interface is graphical, menu-driven, and intuitive; and results can now be immediately viewed from the user interface in attractive maps, charts, and tables.

f. **Step 6. Produce Economic and Freight Forecasts.** The new FFT produced a series of base-case forecasts to 2050 using the data and analysis produced in previous steps. As noted above, the new FFT provides a wealth of options for customized forecasting and sensitivity testing such as the impacts of lower oil price.

g. **Step 7. Review and document results.** Several key documents were produced upon the conclusion of the study, including a regional freight profile, profiles for each of NJTPA's 15 subregions, and a series of commodity bundle profiles for each of the 12 commodity bundles. In addition, a FFT Users' Guide, provided as Appendix D to this document, describes how the FFT is to be operated and updated going forward. When future updates to the FFT are performed, these documents will need to be updated or replaced with new versions.

Figure ES1.1 2050 Freight Industry Level Forecasts Study "Road Map"



1.0 Introduction

Freight transportation and supply chain logistics are dynamic, ever-changing industry sectors, and public data on freight movements and the factors that shape supply chains are often difficult to acquire and interpret. Further, commercially-available data and forecasts can be costly, assumptions used to develop such forecasts are often unclear to the buyer, and the ability to adjust the assumptions and develop forecasts that respond to recent or potential trends and issues is usually not available without procurement of an expensive subscription or support contract.

For these reasons, the North Jersey Transportation Planning Authority (NJTPA) developed its first-generation Freight Forecasting Tool (FFT), and a series of freight industry-level forecasts through 2040 in 2012. The FFT produces 2-digit Standard Transportation Commodity Code (STCC) level commodity flow forecasts that are further disaggregated from county-level geographic detail to North Jersey Regional Transportation Model-Enhanced (NJRTM-E) traffic analysis zones using traffic analysis zone (TAZ) employment and population data. Those commodity flows can then be assigned over the NJRTM-E network. A key product of the first-generation FFT was a series of regional and subregional freight profiles, summarizing freight flows using graphics and maps aimed at a public audience.

In 2015, the FFT was enhanced, allowing it to generate commodity-group-specific forecasts and truck trip tables. This capability allows NJTPA to analyze the effect of scenarios on bundles of freight commodities and assign flows of trucks carrying goods in each commodity bundle over the NJRTM-E network. This work, performed under the Regional Freight Commodity Profiles Study, also generated a suite of regional freight commodity profile documents, which used graphs, tables, maps, and narrative to explain and illustrate the supply chain and flows of goods in each commodity bundle in the NJTPA region.

The 2010 commodity flow and econometric data and forecasts to 2040, that are the primary FFT inputs have aged, however. Policies and relationships that shape international trade could change import-export balances and the supply chains that move a wide variety of materials and products. In addition, the industrial real estate market in the NJTPA and surrounding regions has burgeoned, fulfillment centers have been opened to serve growing e-commerce demand, and a number of major traditional brick-and-mortar retailers have closed. Further, the next update of the Long Range Transportation Plan will establish a 2050 planning horizon. There was clear need to update the FFT's underlying data and forecasts to reflect recent trends and potential future scenarios through 2050.

The 2050 Freight Industry Level Forecasts Study, therefore, aimed to update and enhance NJTPA's FFT, analyze and identify gaps in existing freight and industry data, collect data and information to fill those gaps, and prepare summary data products, including a set of regional and subregional freight profiles and regional freight commodity profiles, that will serve as stakeholder outreach and education materials. Key features of the updates and enhancements performed in this study include:

- An updated FFT, which uses the latest available commodity flow and econometric data and forecasts to 2050;
- Enhancements to the FFT to process USDOT Freight Analysis Framework (FAF) data, instead of the proprietary and expensive TRANSEARCH commodity flow data, and enhancements to improve the tool's operability and user interface;
- A simple, repeatable, yet accurate process for disaggregating FAF data and forecasts from regional to county-level detail;
- Refreshed analysis of business establishment data, including building inventory and tenant attributes, and up-to-date interviews with key industry representatives to understand the effects of recent trends and potential future scenarios on supply chains and freight flows;
- A truck trip table representing ecommerce deliveries in the NJTPA region, developed using a combination of vendor-sourced market research data, primary research, socioeconomic data analysis, and modeling. This truck trip table would be an output of the FFT, and responsive to user-selected scenarios and adjustments in the FFT's interface. The trip table would be assignable to NJRTM-E;
- Updated outreach and public information tools, in the form of a set of regional and subregional freight profiles, which present the highlights of economic and freight commodity flow data analysis; and regional freight commodity profile documents, which present summary information for each of the 11 commodity bundles described and analyzed in the Regional Freight Commodity Profiles Study, and a new commodity bundle profile describing e-commerce deliveries.

1.1 Goal and Organization of this Project

The 2050 Freight Industry Level Forecasts Study developed updated, accurate information on freight demand, both current and projected, out to 2050. Conditions in the goods movement industry have changed over the last several years. To ensure the information that NJTPA uses in its planning work and disseminates to its partner agencies is accurate,

this study developed updated freight forecasts for the region, building upon two previous NJTPA Freight Planning studies, the 2040 Freight Industry Level Forecasts Study, completed in 2012, and the Regional Freight Commodity Profiles Study, completed in 2015.

Key completed work tasks include:

- Modifying the Freight Forecasting Tool to process USDOT's FAF data and forecasts through 2050, and disaggregate the FAF to county-level geographic detail in New Jersey and in the surrounding areas;
- Estimating e-commerce delivery trips and incorporating them into the FFT;
- Gathering freight, economic, business establishment, and demographic data and conducting webinar meetings with subregional planning and economic development staff to review and validate the data and gather additional information; and
- Producing a regional profile and subregional freight profiles covering each of the NJTPA region's 13 counties and two major cities through 2050, and a set of 12 regional commodity profiles.

1.2 Organization of this Report

The most significant findings from each of the major steps in the work process have been documented and compiled into this report, which is organized as follows:

- Section 2: Methodological Overview, a high-level walkthrough of the approach to the study;
- Section 3: FAF Disaggregation Summary, a summary of the process for disaggregating FAF from the regional level to county level;
- Section 4: E-Commerce Analysis and Trip Table Development, a summary of the process for estimating e-commerce delivery demand and developing a delivery trip table for inclusion in the FFT;
- Section 5: FFT Enhancements, a summary of the enhancements made to NJTPA's FFT to improve operability;
- Section 6: Economic and Freight Forecasts, describes the process of using economic forecast scenarios, make-use tables, and commodity flow data to generate economic and freight demand forecasts through 2050;

- Section 7 summarizes the development of updates to NJTPA's regional, subregional, and commodity profile documents;
- Appendix A: Commodity Bundle Definitions, lists the commodity bundles by standard classification of transported goods (SCTG) commodity code;
- Appendix B: FAF Disaggregation Process, provides more detail on the process of disaggregating FAF to county-level;
- Appendix C: E-Commerce Forecast and Trip Table Development, provides more detail about the process of estimating and forecasting e-commerce delivery trips;
- Appendix D: FFT Users' Guide, an updated version of the Users' Guide, explaining how to operate and update the current version of the FFT.

In addition to this report, other deliverables have been provided to NJTPA under this contract, including:

- The updated and enhanced FFT;
- Data tables and script files required to assign FFT outputs to the NJRTM-E;
- One updated regional freight profile;
- 15 updated subregional freight profiles; and
- 12 updated regional commodity bundle profiles.

2.0 Methodological Overview

This section presents the methodological framework for the study. It reviews available approaches and data sources for completing the principal tasks of this study, and presents recommendations based upon the resources available for the study, value proposition, and confidence in results. The following activities were performed in the development of the methodological framework:

- Reviewed approaches to disaggregate USDOT's FAF to the county level, including previous consultant team experience, approaches described in USDOT and Transportation Research Board publications, to identify viable approach(es) that can be implemented within the available resources of the study, and with data available to the consultant team and NJTPA. The recommended approach can be repeated when USDOT releases new FAF databases;

- Conducted research on available data and methods for estimating e-commerce delivery trips, including procuring and analyzing probe data, market research, and requested information from key e-commerce industry representatives. The team determined a combination of approaches was necessary in order to estimate e-commerce demand and truck trip patterns. The team evaluated available sources of market and truck GPS data, and compared the cost, sample sizes, attributes, and available examples of applications of the data to public sector research efforts;

- Explored options and selected a preferred approach for creating a regional delivery truck origin-destination trip table for inclusion in the FFT;

- Described the available econometric forecasts and make-use tables, including R/ECON, Moody's and other vendors, and recommended sources to provide a forecast for the NJTPA region, matching the industry and commodity groups in the FFT, that was within the available budget. The team also considered alternative sources that could be used for validation purposes;

- Reviewed and recommended software applications and alternative design and user interfaces for the FFT;

- Engaged stakeholders, including private industry and subregions; and

- Developed a comprehensive list of data required to complete the study, by category. The list was categorized by intended use or value to the study and included the following attributes: data specifications, vendor(s), approximate cost (if any), and any non-disclosure or terms of use agreements that were required.

Figure 2.1 is a flow chart diagram that illustrates the study's progression and relationship of steps. The steps in the diagram are listed by number, in order of sequence. These steps can be repeated to perform future updates and enhancements to the FFT.

- **Step 1. Identify Methodologies and Data Sources**. The first step in this process was to identify the approach and data needed in order to update and enhance the FFT. In the 2050 Freight Industry Level Forecasts Study, add-on capabilities, such as processing FAF commodity flow data instead of TRANSEARCH, a new commodity bundle on e-commerce activity in the NJTPA region, and a 2050 forecast horizon were incorporated into the tool. In future updates, this step could be revisited to consider other capabilities that may be desired. Consideration should also be given to "what-if" questions that could be built into the FFT, and what data sources or research may be needed in order to develop adjustment factors that represent the "what-if" scenarios. This first step should include a scan of all public and vendor-sourced data options and consider the value of the various options relative to cost in order to identify the best source(s) available for each need.

- **Step 2. Acquire Data**. The second step was to acquire data from the various public and vendor sources. The data gathered includes the current version of FAF, which serves as the base commodity flow data, supplemental data needed to disaggregate FAF including the Surface Transportation Board's Carload Waybill Sample. To perform the e-commerce flow analysis, market research data on e-commerce demand was acquired from Rakuten Intelligence. Economic forecasts from Moody's were used to estimate future freight flows and validate or enhance other economic forecasts. Business establishment data from Infogroup were used to identify major businesses and clusters of businesses representing each commodity bundle, which supplemented the analysis and were used to generate maps for the freight profile documents.

- **Step 3. Disaggregate FAF to the County Level.** FAF reports commodity flows at the Census Metropolitan Area (CMA) and state levels. FAF data was disaggregated to the county level using several key pieces of transportation and economic data, as described in Section 3 and in Appendix B.

- **Step 4. Estimate E-Commerce Flows.** Employing the approach detailed in Section 4 and Appendix C, e-commerce market research data was used to identify demand and delivery carriers. Additional research was performed to estimate delivery trip origins, vehicle volumes, and to develop truck trip tables for assignment to the NJRTM-E regional travel demand model.

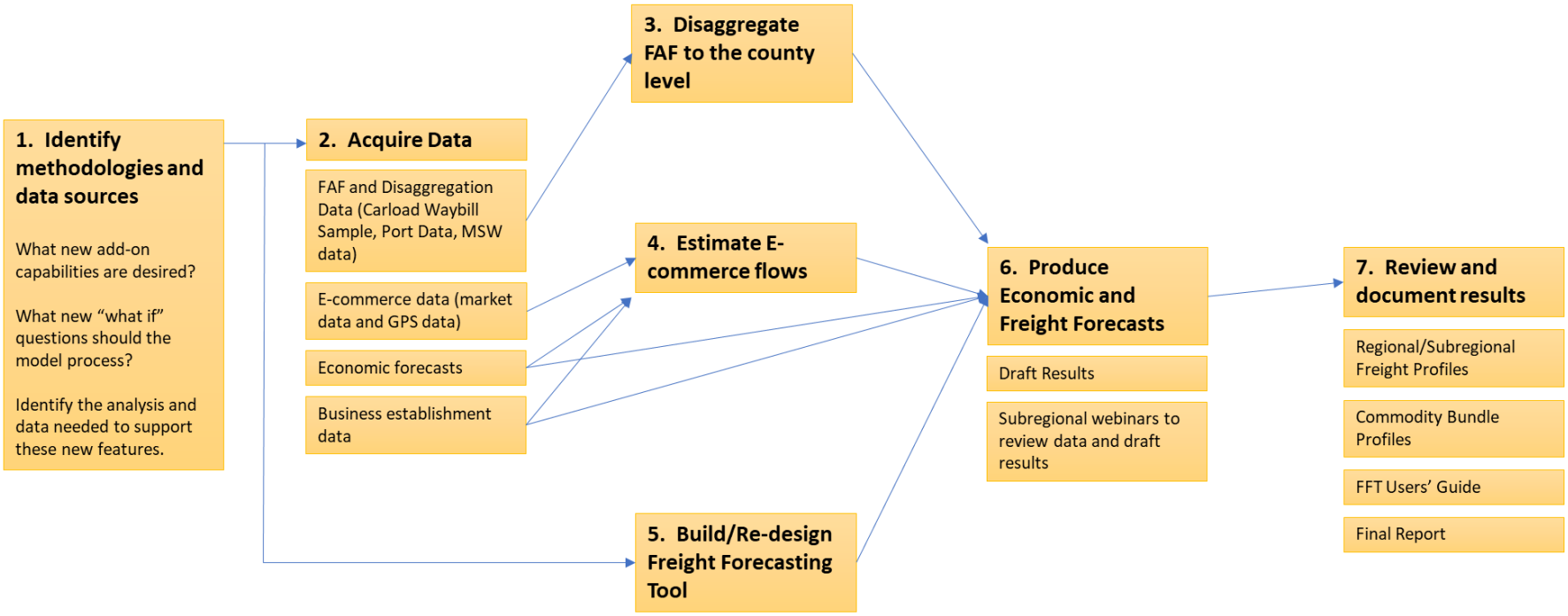
- **Step 5. Build/Re-design Freight Forecasting Tool.** Using the approach detailed in Section 5, the FFT itself was updated and enhanced, including developing a new user

interface application. Future updates to the FFT could take advantage of new software applications or data management tools, as available and desired.

- **Step 6. Produce Economic and Freight Forecasts.** The FFT now produces new forecasts using the data and analysis described in previous steps. Draft forecasts and business establishment data were reviewed with representatives from the subregions to validate the base and forecast data. In future FFT updates, any changes to the base or forecast data and/or adjustment factors can be made in this step.

- **Step 7. Review and Document Results.** This study produced a number of documents, including regional and subregional freight profiles, commodity bundle profiles, an FFT Users' Guide that describes how to operate and update the tool, and this Final Report describing all of the analysis, findings, and products of the study. These documents will need to be updated or replaced with new versions whenever the FFT is updated.

Figure 2.1 Methodological Framework "Road Map"



3.0 FAF Disaggregation Summary

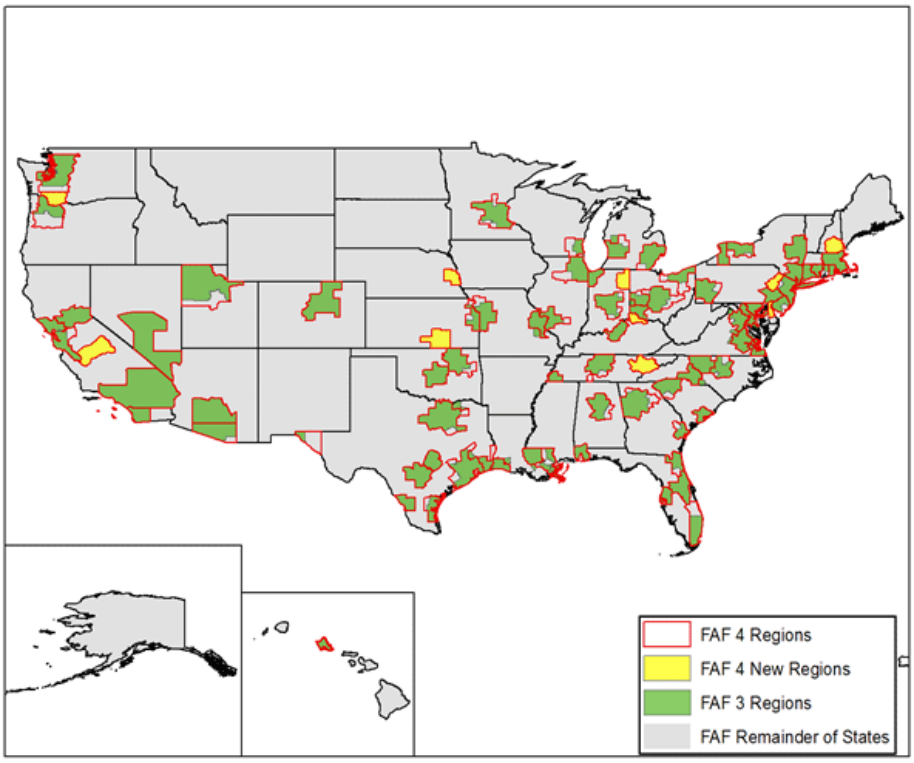
The objective of this task was to replace the commercial TRANSERCH freight database, used as an input in the previous version of the FFT, with the FAF database, which is produced through a partnership between the US Bureau of Transportation Statistics (BTS) and the Federal Highway Administration (FHWA), both of which are part of the USDOT. The FAF serves as a comprehensive national compendium and forecast of freight flows that are used in policy analysis. By using the FAF as an input, the NJTPA freight demand data is consistent with the official national forecasts and is available without additional cost for the underlying commodity flow data.

The FAF is released publicly every five years. The most recent version, FAF4, was released in 2015 with a base year of 2012 and forecast years from 2020 to 2045 in increments of 5 years. Between complete updates, occasionally versions are released with additional information or corrections of errors. The most recent update, at the time of this project, was FAF4.4.1, which was released in June 2018.

The FAF provides commodity flow data and forecasts by mode, commodity, and trade type (import, export, domestic). The unit of geography in FAF is a group of 132 regions across the country, corresponding to CMA boundaries located within each state as shown in Figure 3.1. The State of New Jersey consists of 2 FAF regions. This level of geographic detail was insufficient for the purpose of this study, as county-level detail in New Jersey and the FAF regions surrounding New Jersey was desired.

Disaggregating tons from regional geographies to smaller geographies within those regions requires knowledge of the number of tons produced in, or attracted to, those smaller geographies. The flow of tons of goods that are produced or attracted in those smaller geographies must be developed. Make-use tables from the Bureau of Economic Analysis were used to derive the tons produced (made) in and attracted (used) in each county.

Figure 3.1 FAF4 Regions

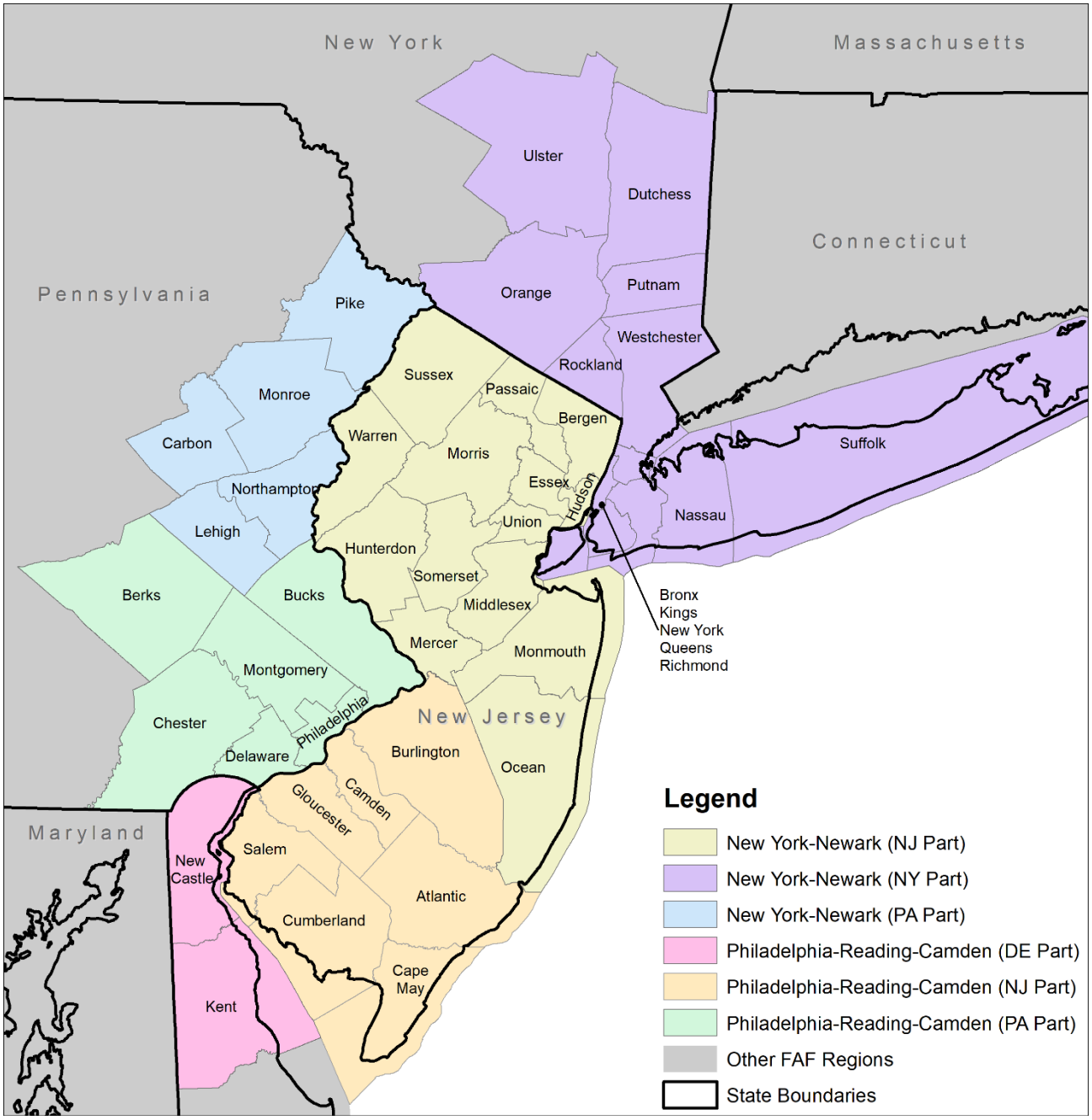


Source: https://www.bts.gov/archive/subject_areas/freight_transportation/faf/faf4/effects

For import and export flows, which the FAF identifies by U.S. Port of Entry/Exit region, it is necessary to also know the tons by entry or exit (e.g., border crossing for flows whose foreign mode is truck or rail, seaports whose foreign mode is water, etc.). The Bureau of Transportation Statistics provides entry and exit flows by border crossing for rail and truck, without distinguishing commodity. The U.S. Army Corps of Engineers (USACE) offers flows by Performance Management System (PMS) commodity to and from seaports. These additional data sources make it possible to disaggregate the FAF flows from its regions to domestic counties and international seaports in the New Jersey study area.

The study area includes 47 counties that compose the FAF regions in New Jersey and adjacent regions of New York, Pennsylvania, and Delaware, shown in Figure 3.2. Cambridge Systematics developed equations that use the estimated tons in the smaller geographies, and the current version of the FAF, to estimate the flow in tons to, or from, a study area. These equations also include disaggregation factors for FAF flows through ports. The USACE only reports the consolidated flows for the entire Port of New York and New Jersey. The distribution of import/export flows through each terminal was estimated based upon the area of each terminal within each county that hosts a terminal.

Figure 3.2 FAF Disaggregation Study Area



The FAF flows are reports of supply chains. These supply chains may include intermediate stops between the reported origin and the destination, but do not report intermediate locations. TRANSEARCH reports these intermediate locations. For import and export flows by air or sea in the FAF, intermediate points are explicitly identifiable. For domestic multimodal flows, those intermediate stops (e.g., the destination of the first leg of a supply chain, which is also the origin of the second leg of that same supply chain) are most likely a rail terminal. The Carload Waybill Sample was used to determine origins and destinations by commodity at rail terminals. This information, along with an association of

rail terminals to customer counties within the NJTPA model area, were used to insert the appropriate intermediate stops into the multimodal supply chains.

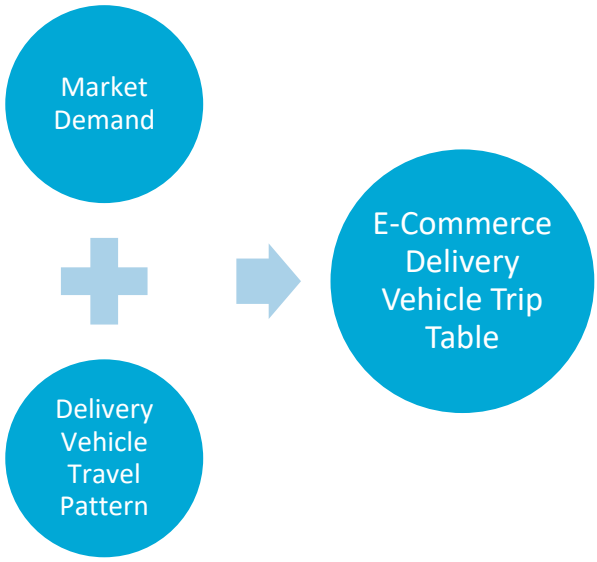
This process can be applied in the future to any revisions, or new versions, of the FAF. Further explanation of the FAF disaggregation process is provided in Appendix B.

4.0 E-Commerce Analysis and Trip Table Development

E-commerce delivery trips are notably absent from commodity flow databases, and little data is available to describe the volume and travel patterns of vehicles that deliver these orders to consumers. However, with the significant and continuing increase in e-commerce activity, incorporation of this information into traffic flows is important. Accordingly, this task developed a truck trip table representing e-commerce delivery vehicles that was incorporated into the FFT. The e-commerce delivery trip is the last-mile trip from a fulfillment center, a post office, or a parcel carrier's last-mile distribution facility to the consumer's desired delivery location. This trip table does not include trips between distribution nodes within a parcel carrier's logistics network.

To accomplish this objective, it was necessary to estimate the quantity of goods being delivered to consumers throughout the region, and to estimate the delivery vehicle travel patterns that connect fulfillment centers to the locations where shipments are delivered. These two needs are illustrated in Figure 4.1.

Figure 4.1 Two Analyses Needed to Develop E-Commerce Trip Table



The market analysis estimated and forecasted demand, measured as the number of shipments/packages and items, for e-commerce goods transported between origin and destination zones in the network. E-commerce market data from Rakuten Intelligence provided an estimated number of shipments at the county level and number of items at the zip code level, for every county and zip code in the NJTPA region. The Rakuten Intelligence data also estimated the proportional share of shipments delivered by carriers (e.g., UPS, Amazon, USPS, FedEx, and others). The team used this information,

combined with information on carrier facility locations in and around the NJTPA region, to identify origins and destinations for e-commerce delivery trips throughout the region.

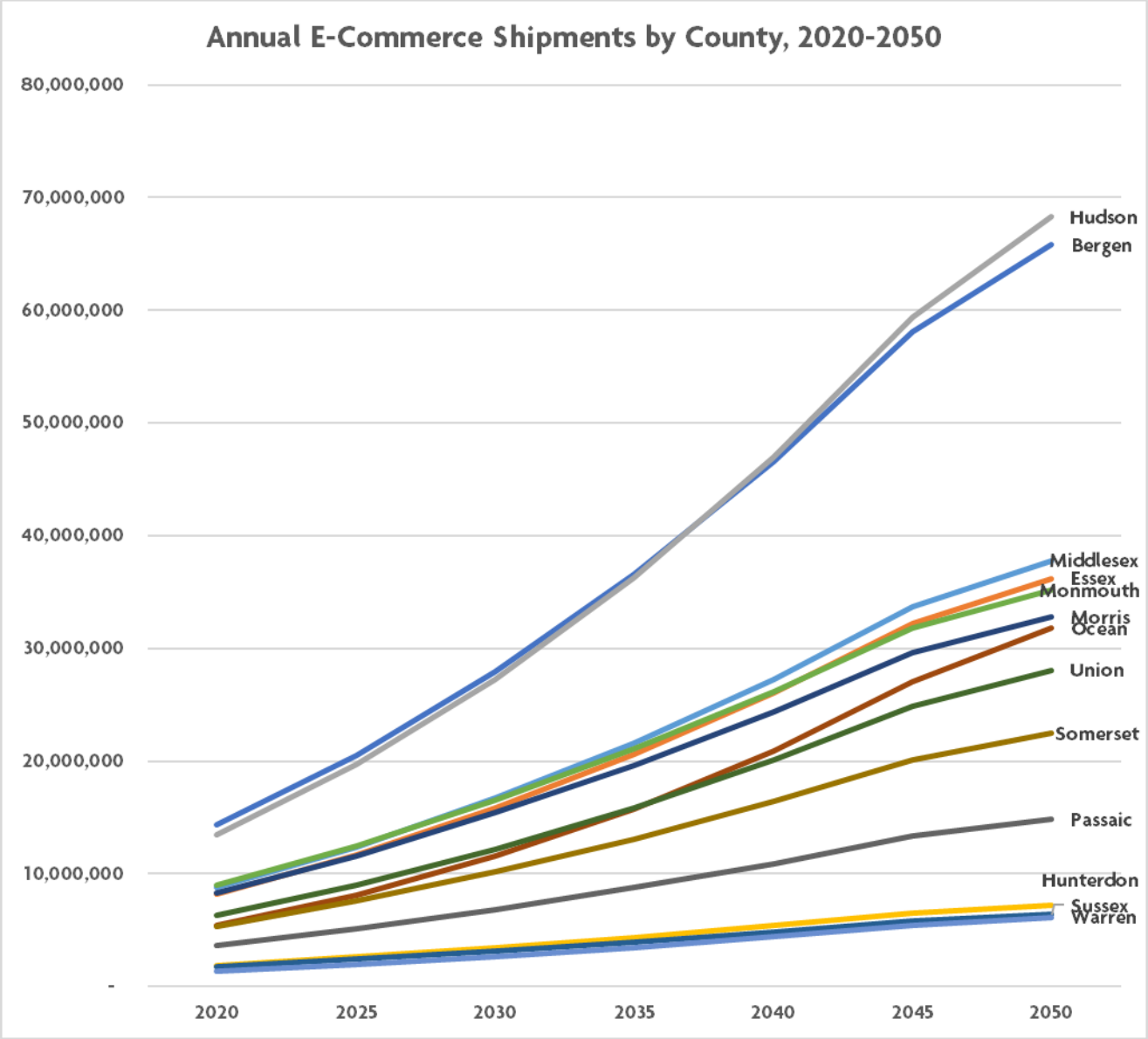
The following steps were performed:

1. Used e-commerce market research data from Rakuten Intelligence to quantify the number of e-commerce packages delivered in the NJTPA region, at the county and zip code levels;

2. Performed a multiple regression analysis to identify the socioeconomic predictors for e-commerce demand. This analysis found that population, households, median household income, and median age were the key variables that can best predict the demand for e-commerce packages in a given zip code.

3. Using the regression equation, e-commerce demand for future years was developed using future population and household forecasts by zip code. Future e-commerce demand was adjusted upward to account for further penetration of e-commerce into the retail landscape. Whereas e-commerce sales composed 11 percent of all retail sales in 2019, it was assumed based on research and trends that e-commerce would represent up to 47 percent of retail sales by 2050. Estimated base year and forecast year demands were disaggregated to the NJRTM-E traffic analysis zone (TAZ) level. Figure 4.2 shows the projected number of e-commerce packages by county, 2020-2050.

Figure 4.2 Estimated and Forecasted E-Commerce Package Demand by County, 2020-2050



4. Using the proportion of packages delivered by each of the top carriers at the county level, the base and forecasted number of packages by geographic area was distributed by carrier.

5. Using carrier information in the Rakuten Intelligence data, the logistics chains for the top four carriers (which together deliver 98 percent of e-commerce packages in the region) were analyzed. The steps in the logistics chains, types of facilities used and locations of those facilities, were identified and mapped.

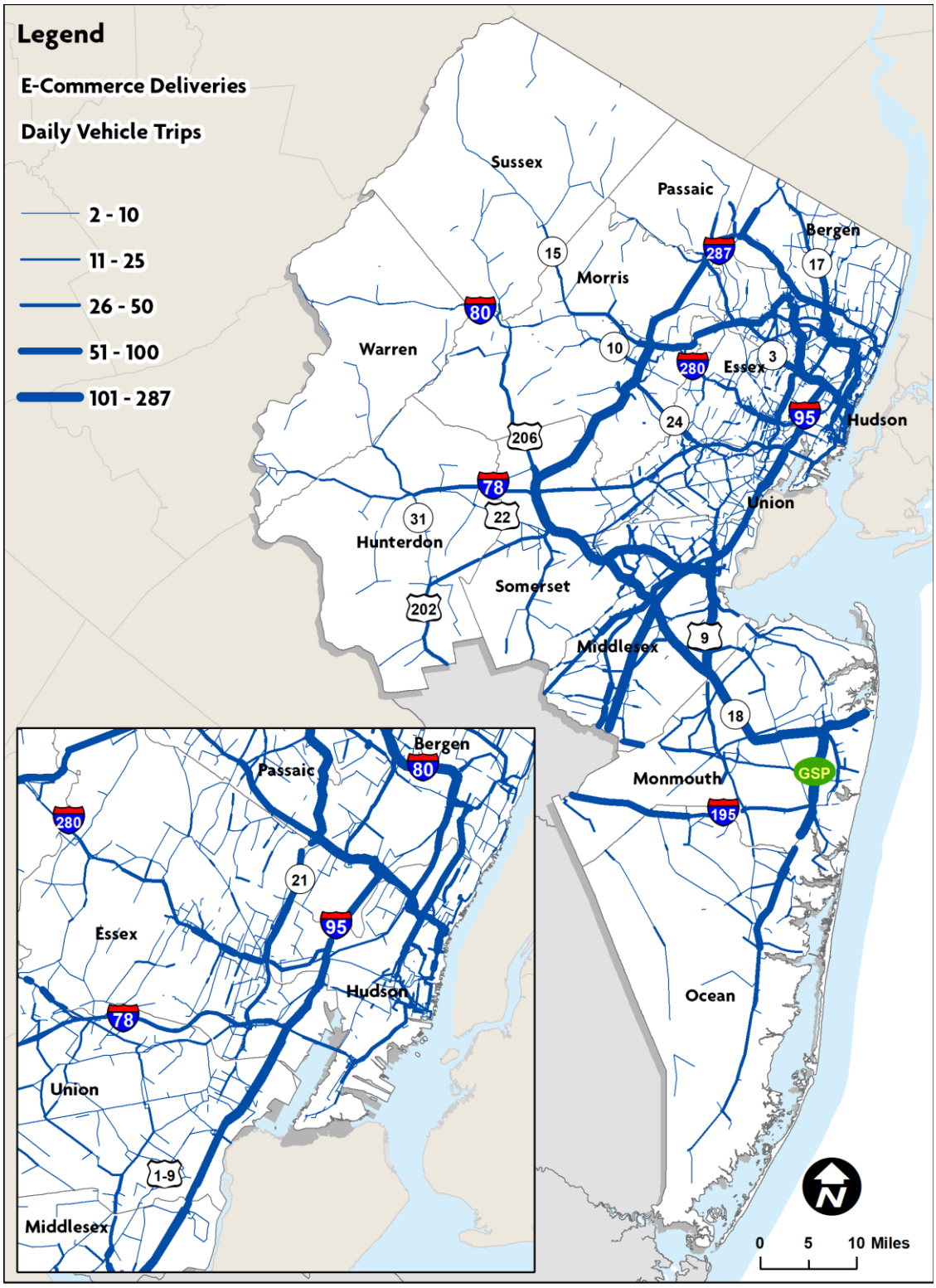
6. The types of vehicles each carrier uses to perform deliveries in the region were also identified. The capacity of these vehicles (by number of packages) was also estimated. This provided a load factor to convert the number of packages delivered by each carrier in each TAZ to the number of vehicle trips required to deliver those packages.

7. For some carriers, identifying the origin point for the last-mile delivery trip was straightforward. For example, the U.S. Postal Service delivers packages from the local post office. E-commerce trips to any TAZ in the region would be dispatched from the location of the local post office. But in the case of Amazon, for example, a package could be dispatched from the nearest fulfillment center, or from a different fulfillment center, depending upon the specific product ordered and the stocking and staging strategy Amazon uses at a given time. To account for the different potential origin points, a logit equation was developed to dispatch most Amazon trips from the nearest distribution center, but to allow a certain proportion of trips (varying by TAZ, depending upon the relative differences in distance from various facilities in Amazon's system) to be assigned from alternative facilities in Amazon's system.

8. The steps above resulted in a matrix of e-commerce delivery trips between origin (carrier facility) TAZs and consumer TAZs. This table was assigned to the NJRTM-E network to produce maps of the movement of e-commerce delivery trips on the region's highway network. Figure 4.3 is the assignment of estimated 2020 e-commerce trips on the highway network.

Further explanation of the e-commerce trip table development process is provided in Appendix C.

Figure 4.3 Daily Volume of E-Commerce Delivery Trips on the North Jersey Highway Network, 2020



Source: NJTPA Freight Forecasting Tool, 2020; NJRTM-E, 2019; NJOIT, 2008; Esri, 2014.

5.0 FFT Enhancements

This task focused on updating and enhancing the FFT, incorporating the results of the previous tasks. This included producing 2050 forecast outputs and developing clearly documented procedures for using the FFT and making future updates to the tool.

Key work product deliverables included:

- Updated and enhanced FFT, including all required software (open source) and code, along with all required data files;
- Base year and 2050 commodity flows by commodity and county for the NJTPA region, with the capability to test a variety of disruptor scenarios;
- NJRTM-E compatible truck trip tables, total and commodity bundle specific;
- Integrated map creation and viewing capability within the FFT itself, along with output of data in Excel form and charts and maps in .png form; and
- FFT documentation addressing the development process including the specific data and assumptions used, changes from the previous FFT, updated and detailed user's manual, and tutorial information.

5.1 Input Data

The core logic of the legacy FFT was sound, however, it had many limitations. The MS Excel platform required user-entered sequences of macro commands and hard coding of calculations. It lacked visual feedback and output and it was not easy to update information over time. The updated FFT is designed for improved accessibility and use and is also modular in the sense that required inputs can be easily updated, simply by replacing old files in the model directory with new ones of the same name and structure. This is critical because the FFT integrates multiple components that can change over time.

The key data inputs for the FFT include:

- FAF Business Economic Area (BEA)-level data, in the format provided by USDOT and then disaggregated to the county level (replacing TRANSEARCH in previous versions of the tool);
- A Disaggregation Matrix, which can be applied to convert future BEA-level releases of FAF to the county-level required by the FFT;

- An E-Commerce Truck Delivery Trip Table;
- Moody's Forecasts of employment and output by North American Industry Classification System (NAICS), including alternative forecast scenarios;
- Make-use tables relating NAICS industry activity to FAF commodity groups;
- Labor productivity tables relating growth in employment to corresponding growth in tonnage (e.g., changes in tons generated per employee, by industry sector);
- Basic math processing (econometric forecast × make-use tables = commodity growth factors; commodity growth factors × disaggregated/appended FAF = forecast);
- Enhanced math processing code, with definition and application of what-if and disruptor scenarios that modify the forecast in different specific user-directed ways; and
- Data tables relating county-level tonnage and truck trips to NJRTM-E TAZs, allowing for the direct creation of NJRTM-E compatible trip tables corresponding to each forecast created.

5.2 Data Processing/Handling and Output Generation

After researching and testing several possible applications, the selected platform was an open-source software package called "R." R essentially functions as the master controller and processor of a set of input and output files. It reads the inputs listed above, performs and directs the associated mathematical functions, and creates output tables (Excel and .png files). It also offers an intuitive graphical interface, allowing users to easily manage the functions and assumptions for each FFT forecast, to immediately view the results from the interface (as maps, charts, and tables), and to create output files for further processing outside the application. This open-ended structure, combined with the integrated FAF disaggregator, will allow NJTPA to easily substitute changes and updates to any data inputs as they become available, and to easily update processing functions, without major structural changes to the tool itself.

5.3 Detailed Description of FFT Functions

Please refer to Appendix D for a detailed and extended description of the FFT functions and outputs, along with installation and run instructions.

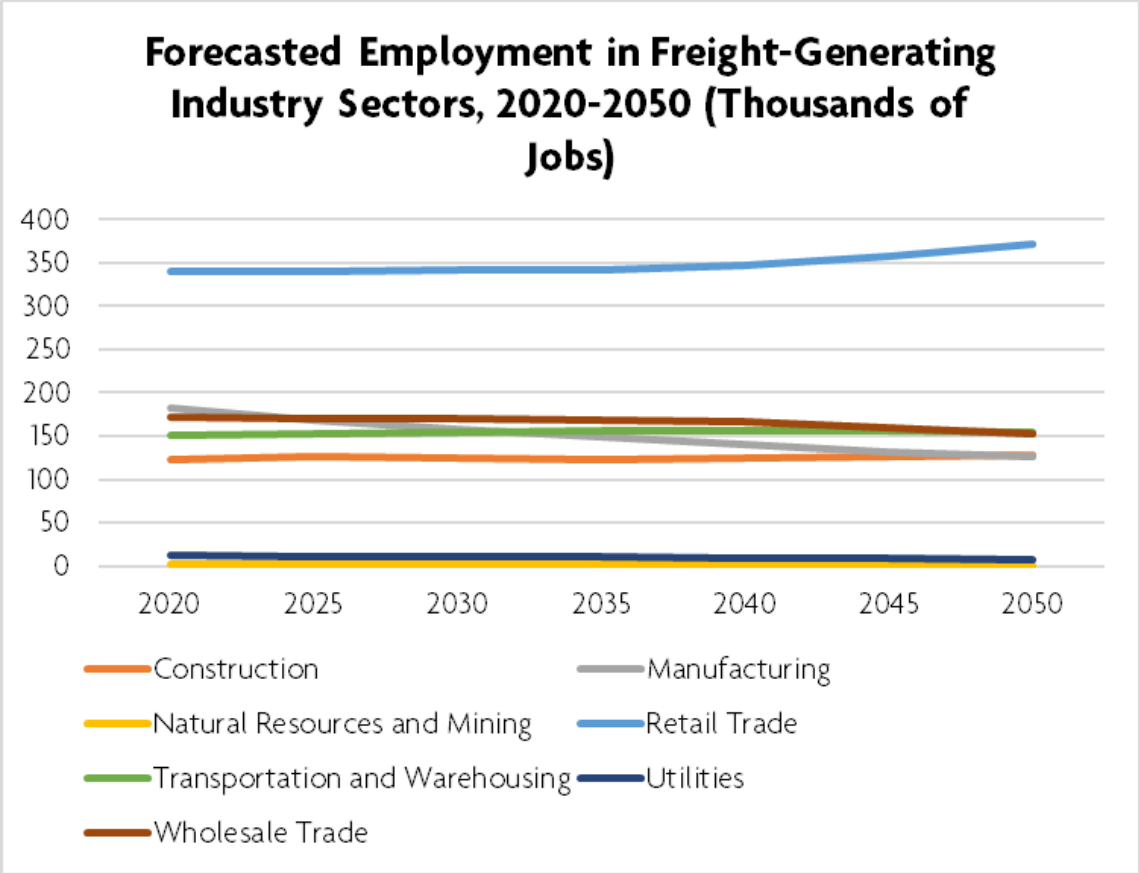
6.0 Economic and Freight Forecasts

6.1 Economic Forecast Source

The original FFT was developed using TRANSEARCH commodity flow data and economic forecasts from R/ECON, a product of the Rutgers Economic Advisory Service. The R/ECON model produced industry-level forecasts for subareas consisting of groupings of two-to-three counties.

The consultant team reviewed several potential sources of respected and documented economic forecasts to update the FFT and recommended Moody's because it offered county-level employment forecasts at an industry sector level, and the option to select desired industry sectors for detailed forecasts. This allowed some cost savings, as forecasts were not needed for all sectors. The forecasts were available through the fourth quarter of 2050, which meets the study's forecast horizon. Figure 6.1 illustrates the forecasted employment by industry sector for selected key freight-generating industry sectors in the NJTPA region from 2020-2050. Employment growth between 2020 and 2050 is expected to range from -31 percent in the manufacturing sector to +10 percent in the retail trade sector.

Figure 6.1 Baseline Forecasted Employment in Freight-Generating Industry Sectors, 2020-2050, in the NJTPA Region



In addition, Moody's offered several alternative scenarios at the state level, simulating alternative future scenarios linked to geopolitical, macroeconomic, environmental, logistics, and other trends. These alternative scenarios added considerable value to the Moody's forecast package. Each of the alternative scenarios comes with different assumptions about the range of effects, timing and duration of those effects.

Figure 6.2 shows the forecasted population for New Jersey for each alternative scenario from 2020 to 2050. Figure 6.3 shows the forecasted employment in key freight-generating industry sectors through 2050. Despite a projected increase in population in each scenario, employment in manufacturing, utilities, natural resources and mining, and wholesale trade are expected to decline in most scenarios. Projected growth in retail trade and construction (in most scenarios) does not overcome the projected losses in the other sectors analyzed.

Figure 6.2 Forecasted New Jersey Population, 2020-2050 by Forecast Scenario

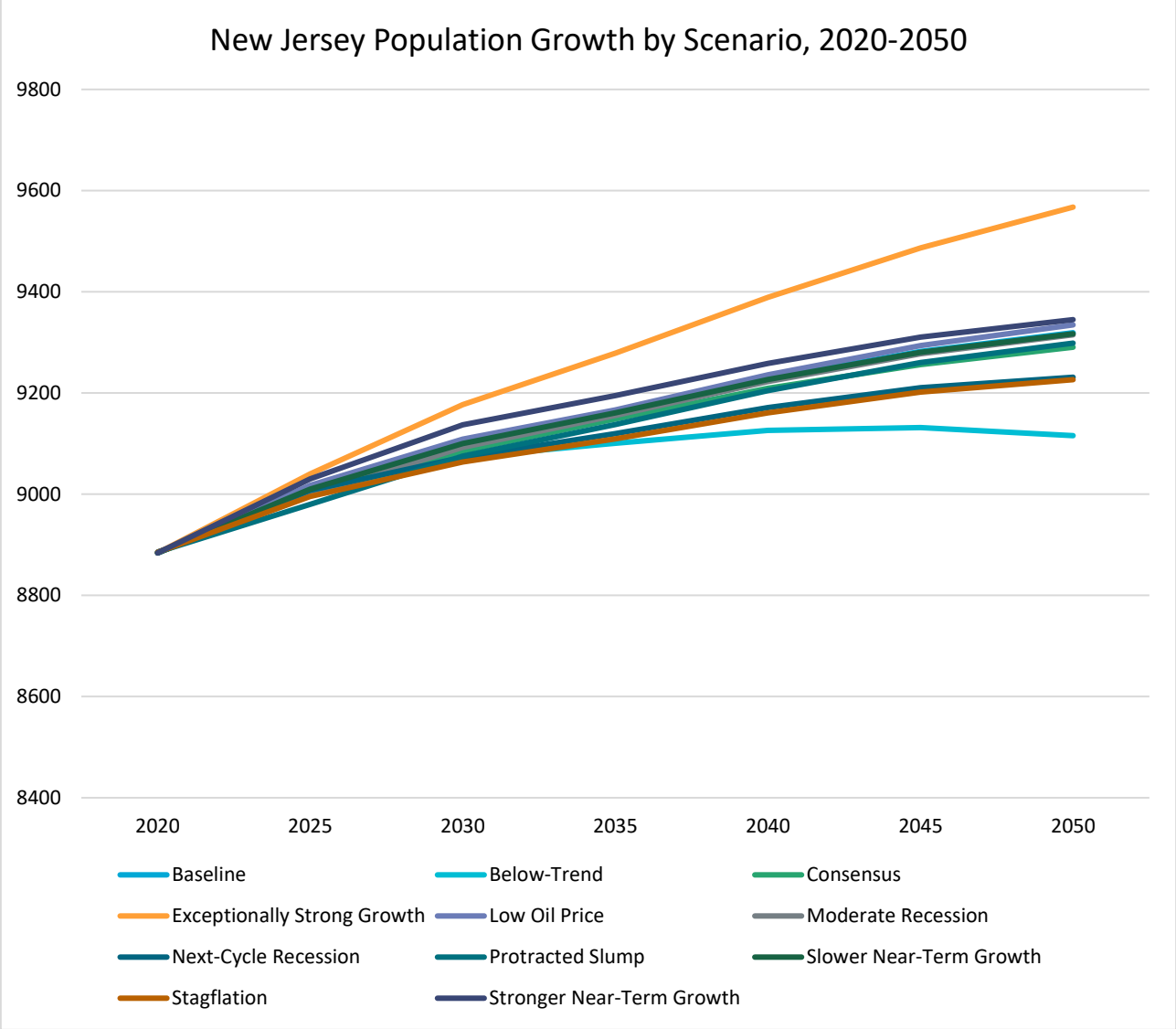
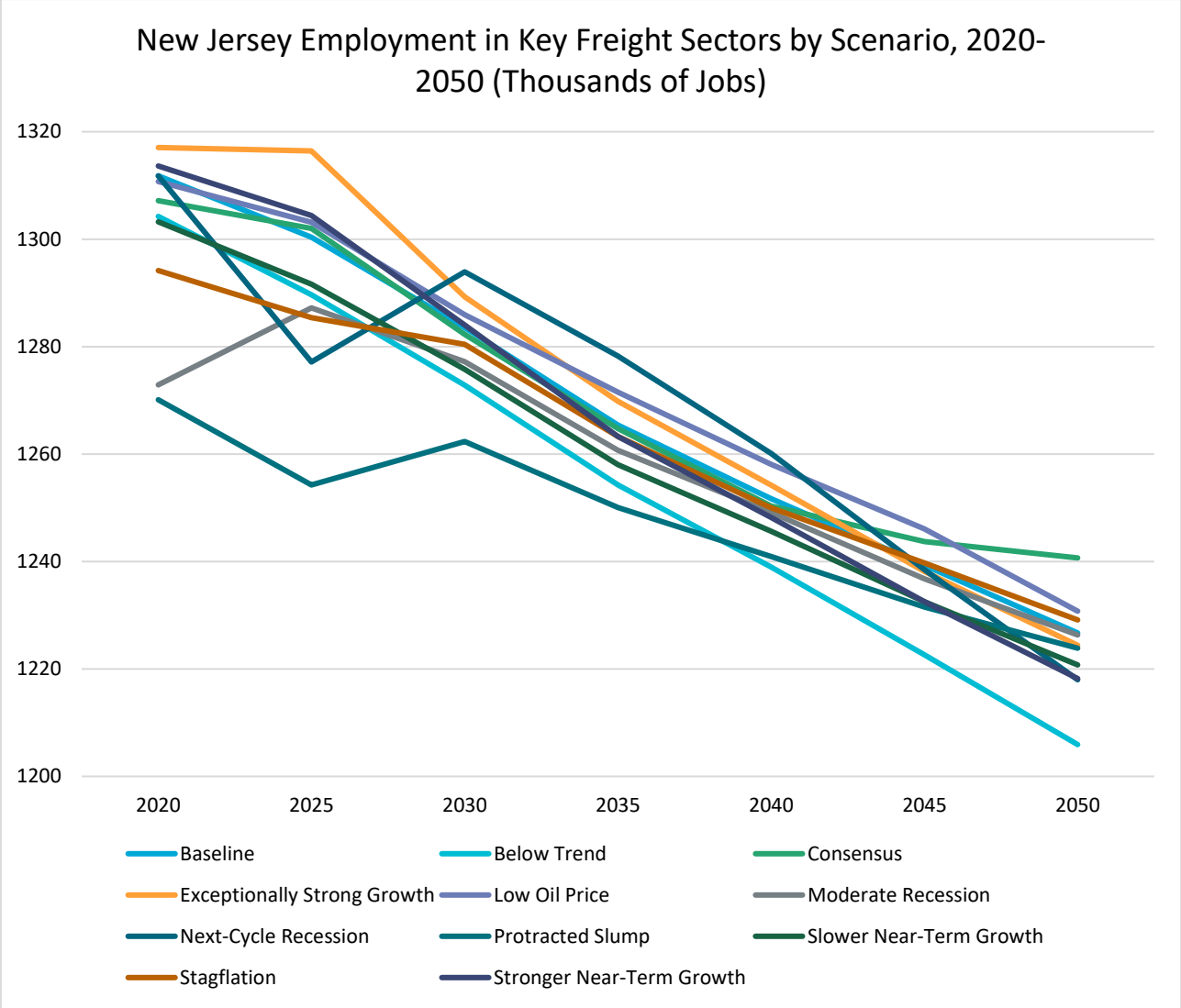


Figure 6.3 Forecasted New Jersey Employment in Freight-Generating Industry Sectors, 2020-2050 by Forecast Scenario



6.2 Make-Use Tables to Associate Employment Growth with Freight Demand

For purposes of freight forecasting, the most important output is Moody's employment forecasts. However, further analysis was needed to understand the relationship between employment and freight movement. Certain industries require commodities as inputs to their activity – for example, construction industries need lumber, cement, copper, etc. – and these are known as "use" commodities. Conversely, other industries create outputs from their activity – for example, manufacturers of pharmaceuticals or energy products – and these are known as "make" commodities. For any given industry, use commodities are inbound moves to a facility, and make commodities are outbound moves.

For this project, Make-Use tables from the U.S. Bureau of Economic Analysis, which relate major industry groups to the major types of commodities they make or use, were used to associate economic growth or decline by industry sector to growth or decline in demand for certain freight commodities. For example, the Make-Use table might show that a 10 percent increase in employment in a certain industry generates a 5 percent increase in the use of one commodity and a 3 percent increase in the use of another. These figures can be used to calculate freight tonnages, by commodity and direction, based on employment forecasts.

6.3 Freight Forecast

Using the baseline Moody's employment forecast, a baseline freight forecast was developed for 2050 and interim years using the updated and enhanced FFT. Analysis of this baseline 2050 freight forecast served as a validation exercise for the FFT. Table 6.1 shows the forecasted growth in freight by commodity bundle between 2020 and 2050. A full summary of freight forecast data is provided at the regional level in the Regional Freight Profile, at the subregional level in the subregional profiles prepared for each NJTPA subregion, and for all of the commodity bundles except for e-commerce. The e-commerce delivery forecast is explained in Section 4 and Appendix C.

Table 6.1 Forecasted Freight (Tons and Value) with Origin and/or Destination in the NJTPA Region, by Commodity Bundle, 2020-2050

Commodity Bundle	2020 Tons (thousands)	2050 Tons (thousands)	2020 Value (millions $)	2050 Value (millions $)	Change in Tons, 2020-2050	Change in Value, 2020-2050
Chemicals	25,684	29,214	98,379	111,844	14%	14%
Construction Materials	117,447	128,991	49,968	54,528	10%	9%
Durable Goods	4,661	5,137	40,022	44,250	10%	11%
Energy	119,791	147,187	75,104	89,590	23%	19%
Food and Beverages	46,609	54,153	87,772	100,087	16%	14%
Machinery, Electronics, Transp Equip	11,620	13,066	145,541	164,245	12%	13%
Paper and Printed Materials	6,984	8,436	15,769	20,746	21%	32%
Pharmaceuticals	1,681	1,892	49,477	55,050	13%	11%
Textiles and Leather	4,935	5,695	40,483	46,975	15%	16%
Warehouse and Terminal Moves	16,777	19,240	96,442	114,413	15%	19%
Waste	16,055	17,988	5,772	6,522	12%	13%
Grand Total	**372,244**	**430,999**	**704,729**	**808,250**	**16%**	**15%**

7.0 Freight Profiles

The updated suite of regional, subregional, and freight commodity profiles was a key product of this project. The 2040 Freight Industry Level Forecasts Study produced a Regional Freight Profile document, a 12-page booklet featuring highlights of the economic and commodity flow data for the region. Similar documents were prepared for each of NJTPA's 15 subregions. The Regional Freight Commodity Profiles Study produced a set of regional freight commodity profile documents, featuring highlights of the commodity flow, logistics chain, and economic data related to each of the 11 commodity bundles identified in that study.

The 2050 Freight Industry Level Forecast Study used the updated economic and freight forecasts to produce new profiles for the NJTPA region, each of NJTPA's 15 subregions, the 11 commodity bundles from the previous study, and e-commerce as described in Section 4 and Appendix C of this report. The profiles also feature maps and tables extracted from an updated business establishment location database. Data acquired from Infogroup, internet research, and feedback received from subregional planning and economic development officials engaged through a series of subregional webinars was used to develop this database. The subregional webinars were an opportunity to share draft versions of the study's data outputs and gather additional insight, updates, or corrections from each subregion.

The 2050 freight profiles are available on the NJTPA website, www.njtpa.org.

Appendix A. Commodity Bundle Definitions

The Freight Forecasting Tool (FFT) commodity bundles were defined previously using standard transportation commodity codes (STCC), which is the commodity classification system used in TRANSEARCH. With the conversion of the FFT's commodity flow base data to the Freight Analysis Framework (FAF), the commodity bundles had to be redefined using the standard classification of transported goods (SCTG) commodity classification system used in FAF. This appendix is a table that lists two-digit SCTG codes with their associated FFT commodity bundles.

Table A.1 SCTG-to-Commodity Bundle Table

FFT Commodity Bundle	SCTG Codes
Food and Beverages	01 – Live animals/fish 02 – Cereal grains 03 – Other agricultural products 04 – Animal feed 05 – Meat/seafood 06 – Milled grain products 07 – Other foodstuffs 08 – Alcoholic beverages 09 – Tobacco products
Textiles and Leather	30 – Textiles/leather
Paper and Printed Materials	27 – Newsprint/paper 28 – Paper articles 29 – Printed products
Waste	41 – Waste/scrap
Construction Materials	10 – Building stone

FFT Commodity Bundle	SCTG Codes
	11 – Natural sands 12 – Gravel 13 – Nonmetallic minerals 14 – Metallic ores 25 – Logs 32 – Base metals 33 – Articles – base metal
Machinery, Electronics, Transportation Equipment	34 – Machinery 35 – Electronics 36 – Motorized vehicles 37 – Transportation equipment
Durable Goods	26 – Wood products 38 – Precision instruments 39 – Furniture
Energy	15 – Coal 16 – Crude petroleum 17 – Gasoline 18 – Fuel oils 19 – Coal not elsewhere classified
Pharmaceuticals	21 – Pharmaceuticals
Chemicals	20 – Basic chemicals 22 – Fertilizers

FFT Commodity Bundle	SCTG Codes
	23 – Chemical products 24 – Plastics/rubber
Warehouse and Terminal Moves	40 – Miscellaneous manufactured products 43 – Mixed freight
E-Commerce Deliveries	N/A. E-Commerce delivery trips are not classified as a commodity in commodity flow databases

Appendix B. FAF Disaggregation Process

This technical appendix documents the results of Task 3 Disaggregation of Freight Analysis Framework (FAF) Data.

B.1 Methodology

B.1.1 Background

The legacy NJTPA Freight Forecasting Tool (FFT) uses the New Jersey TRANSEARCH freight database as an input. That database is commercially available through IHS Markit. It is available at the county level and supports the detailed development of county profiles and can be disaggregated to NJRTM-E TAZs in the FFT. The Freight Analysis Framework (FAF) is a publicly available database produced through a partnership between BTS and FHWA. More information on FAF can be found at https://faf.ornl.gov/fafweb/. The FAF has a different orientation than TRANSEARCH, which is developed from freight carriers' records. It is available at various levels of geography, including the county in New Jersey, and larger regions as necessary for the remainder of North America. It is available for a price that depends on the details of the data to be provided and is updated annually. The FAF is publicly available at no cost. It has a shipper-receiver orientation and a basic source of the data is the Commodity Flow Survey (CFS) for shippers. The geography in the FAF is the largest metropolitan regions in the United States and the remainder of states not included in these metropolitan regions. The metropolitan regions are those defined by the CFS. The FAF is developed every five years, from the CFS and freight flows that are Out of Scope (OOS) with respect to the CFS. The CFS itself is collected from a survey of shippers collected every five years as part of the U.S. Economic Census.

B.1.2 TRANSEARCH

As noted above, TRANSEARCH is developed from carrier records of freight shipments and has a primarily carrier centric focus. The freight flows in TRANSEARCH are shipments carried by modal vehicles, and consequently some of the "origins" and "destinations in TRANSEARCH are actually transfers between modal vehicles. Freight flows are available for all North America. Flows are reported by trade type (i.e., domestic, import, export), but with the exception of Canada and Mexico, no information is provided for the foreign portion of imports and exports, neither the modal vehicle of that import or export, nor the region from which its imported from, or exported to.

B.1.3 Freight Analysis Framework

The FAF is developed from the CFS and Out Of Scope shipments with respect to the CFS. It has a shipper centric focus. The “modes” listed in the FAF are more properly considered as supply chains, (one of the ”modes” is Multiple Modes), where the primary line haul mode is used to define the supply chain. The geography reported in the FAF consists of 132 domestic regions and 8 international regions. It reports both the foreign supply chain/mode and the foreign region for imports and exports as well as the domestic gateway through which it enters, or exits, the United States.

B.2 Disaggregation of FAF Domestic Origins and/or Destinations

The FAF can easily be restated as an origin destination table by supply chain/mode for individual SCTG2 commodities. Any trip table/matrix can be expanded into smaller cells based on the share that the smaller cell origin is to the total flows in the larger origin region and flow in the destination is to total flows in the destination region (larger cell). This process is known as disaggregation but has long been utilized in transportation planning as matrix/table expansion. There is no need to expand/disaggregate origins or destinations that are not in New Jersey. Disaggregation should only consider flows with at least one trip end in New Jersey. The FAF regions are not compatible with the TRANSEARCH zones currently used in the NJTPA FFT. In order to replicate the county flows in TRANSEARCH the regions that were disaggregated were the three FAF regions for Philadelphia (PA, NJ and DE parts) and three of the FAF regions for New York City (NY, PA and NJ part). Note that flows to the Connecticut portion of New York need not pass through New Jersey and need not be disaggregated. This disaggregation was of domestic flows, except Multiple Modes, which is assumed to be intermodal truck-rail flows described in Section B.4, and the imports and exports by air and water as described in Section B.3.

The disaggregation of through traffic, also known as external-external or overhead traffic, which has neither an origin or destination in New Jersey, is a separate process and is described in Section B.5.

In order to disaggregate FAF flows to smaller geographies (e.g., counties) it is necessary to estimate the freight activity in those smaller geographies as a share of the FAF region in which they are located. Freight activity is presumed to be a function of the employment in the NAICS industry that produces freight at an origin and the NAICS industry(s) that consumes/attracts freight at a destination. This activity can be estimated by trip rates as described in the next section, or through economic modeling as described in Section B.2.2. The economic modeling approach was used in this study.

B.2.1 Trip Rates

Trip rates define the number of trips in a zone based on some other activity in that zone which is correlated with those trips. There are no existing multimodal freight trip rates by commodity that can be used. Trip rates were estimated from 2012 three-digit NAICS (NAICS3) employment as estimated from the 2012 County Business Patterns (CBP) available from the U.S. Census, and the existing FAF. Since the FAF is only reported at the regional level, in order to develop trip rates, the NAICS county employment was aggregated to those regions before a regression was made with the FAF. A linear regression was performed with the 2012 base year flows in the FAF and the 2012 CBP employment. While the regression was developed from reported base year tonnages and base year employment at the regional level, it is assumed that the same rates are appropriate for smaller geographies based on the forecast variable in that smaller geography.

There are several issues with assuming that the regional trip rates reflect the freight activity in the counties.

1. The estimation data, the FAF is itself synthetically generated and should strictly not be used as the dependent data in a regression.

2. The regression of reported employment versus FAF reported tonnages is adjusted to account for outliers, an activity that is not well correlated with the explanatory variable(s). These outliers can be due to an industry that is more, or less, productive per employee that the national average (e.g., the production of chemical products in New Jersey), can be associated with facilities that should properly be at transfer facilities, not freight destinations (e.g., Mixed freight) or can be introduced by the synthetic generation of the FAF. Of the 42 two-digit SCTG commodity codes (SCTG2) in the FAF data, there are 22 production outliers for 12 commodities, and 20 attraction outliers for 17 commodities among the records in the 6 FAF regions to be disaggregated for New York City and Philadelphia.

3. The regression method allows negative rates which are not realistic as trip rates. Not allowing negative rates biases the rates in favor of one explanatory variable/industry. While this should not be an issue with the production of freight by commodity, which is associated primarily with one industry, it is an issue for the attraction of freight, which can be expected to be associated with several economic sectors/industries.

The use of trips rates, therefore, was not recommended to disaggregate the FAF regional freight data for New Jersey to counties.

B.2.2 BEA Make-Use Tables

Economic Models use ***Make*** Tables to associate the production of commodities with specific industries and ***Use*** Tables to associate the attraction of commodities with specific industries. This allows for an increase in forecast employment in one industry, and its resulting outputs, to impact the employment in other industries that use that commodity produced by that industry. While there are economic models associated with New Jersey, the Make-Use tables are either not readily or publicly available or the economic model is calibrated for areas that are different than the regions to be disaggregated. The Bureau of Economic Analysis does provide Make-Use tables for the entire Nation. If it is assumed that the value of freight (the output of the Make-Use tables) is well correlated with the tonnage of freight, then these Make-Use tables can be used to disaggregate O-D tables of tons. While the BEA Make-Use tables report economic sectors[1] and commodities that use labels that are specific to the BEA Make-Use tables, crosswalks were developed to NAICS3 industry and SCTG2 commodity codes. The resulting freight tonnages by county were then used to develop shares of county freight compared to the FAF region in which the county is located. The NJTPA region's economy is sufficiently large and diverse so that it can be assumed that the national Make-Use table relationships also represent the region.

The disaggregation of internal-to-external (IE) flows from production counties flows required only the shares for the production counties. The disaggregation of external-to-internal (EI) flows to attraction counties required only the shares for the attraction counties. The disaggregation of internal-to-internal (II) flows (with respect to the six FAF regions being disaggregated) required the cross product of both the production share and the attraction share.

B.3 Disaggregation of Gateways

While the disaggregation of the domestic county origin of exports, and the domestic county destination of imports, will use the same BEA Make-Use factors described in Section 0, the disaggregation of the foreign destination (for exports) or the foreign origin (for imports) is neither possible nor necessary for the FFT. However, the FAF also reports the domestic gateway region through which exports exit the U.S. and imports enter the U.S. This means that for imports and exports of freight with a foreign mode of water, the disaggregation factor by commodity can be based on the reported tonnages through a water port, summed over all water ports in that region. There are no international land border

[1] While most economic sectors can be associated with a specific NAICS3 industry, the business consumption sector was associated with total employment and the personal consumption sector was associated with total population. While there are additional economic sectors for imports and exports, the disaggregation of these flows will use other methods and zero percent was associated with these sectors for purpose of computing shares.

crossings for the regions to be disaggregated. There are also air imports and exports, but there is primarily one freight airport in each FAF region. Thus, it is possible to disaggregate imports by water and air to the counties in which a water, or air, port gateways are located.

B.3.1 USACE NDC Ports

The U.S. Army Corps of Engineers (USACE) Navigational Data Center (NDC) reports import and export tonnages by commodity through ports for most of the ports in the United States. These flows are reported as tons by Public Group Commodity. A crosswalk was developed by the Cambridge Systematics team to associate a Public Group Commodity with its SCTG2 equivalent. These flows are reported for the waterways that serve these ports by imports and exports. Flows are reported for two consolidated ports, one of which is the Port of New York and New Jersey which will be discussed in Section B.3.2.

The USACE reports the latitude and longitude for these ports which can be used to determine the FAF region in which a water port is located. The FAF reports the foreign mode and the foreign import (or export) region and the FAF gateway through which it must pass. The domestic region producing exports (or attracting imports) can be disaggregated using the same factors as described in Section B.2.

The USACE Ports in the FAF regions to be disaggregated are shown in Table B.1. The shares for import and exports tonnages will vary by SCTG2.

Table B.2 USACE NDC Ports To Be Disaggregated.

PORT_NAME	County Name	County FIPS	USACE Port Number	FAF4 Region
New Castle, DE	New Castle	10003	299	101
Wilmington, DE	New Castle	10003	554	101
Paulsboro, NJ	Gloucester	34015	5252	342
Camden-Gloucester, NJ	Camden	34007	551	342
Marcus Hook, PA	Delaware	42045	5251	421
Chester, PA	Delaware	42045	297	421
Philadelphia, PA	Philadelphia	42101	552	421
Penn Manor, PA	Bucks	42017	298	421

B.3.2 Consolidated Port of New York and New Jersey

Commodity specific tonnages for individual ports are not available from USACE NDC for the Consolidated Ports of New York and New Jersey. A single tonnage is reported for the Port and cannot differentiate among the multiple Ports that serve as gateways in each FAF region. The allocation of import and export tonnages through a FAF region are assigned to

those ports based on percentages developed in consultation with the Port Authority of New York and New Jersey and the NJTPA and are shown in Table B.3. While specific percentages are reported for the New Jersey ports, all New York port disaggregated tonnage is reported as using Richmond County's Port of Howland Hook. While tonnage is expected through other New York City NY Part ports (e.g., Brooklyn Marine or Red Hook), these ports are expected to use the same entry into New Jersey as Howland Hook and assigning all of the disaggregated FAF 363 port tonnage to Richmond County will not change the results in the NJTPA FFT.

Table B.3 Consolidated Ports of New York and New Jersey To Be Disaggregated

Principal Port	County Name	County FIPS	FAF Region	Share
Port Newark	Essex County	34013	341	21%
Port Jersey	Hudson County	34017	341	19%
Port Elizabeth	Union County	34039	341	60%
Howland Hook	Richmond County	36085	363	100%

B.3.3 Airports

The disaggregation of freight to the counties in which airports are located is simply a relabeling exercise if all the freight imported or exported through a FAF Gateway region is at single airport. All the freight imported or exported through the FAF Philadelphia PA part region (FAF 421) is through the Philadelphia International Airport in Philadelphia County. All the freight imported or exported through the FAF New York City NJ Part region (FAF 341) is through the Newark Liberty Airport in Essex County. While there are three freight Airports in the New York City NY Part region (FAF 363), over 99 percent of that freight is through JFK airport in Queens County. All the FAF tonnage imported or exported by air through the FAF 363 Gateway will be assumed to be through JFK.

B.4 Disaggregating Domestic Multiple Modes

The FAF reports tonnages by supply chain, which is different than the individual modal vehicle orientation in TRANSEARCH as used in the current NJTPA FFT. While it is not possible to disaggregate freight using a single modal supply chain (e.g., trucks transferring freight at truck distribution centers), it is assumed that the only Multiple Mode in the FFT should be freight transferring between truck and rail at an intermodal rail terminal in New Jersey. While Multiple Modes in FAF could be water-rail or water-truck, it is assumed that for New Jersey, all Multiple Mode traffic is truck-rail-truck. It is also assumed that the share from these intermodal rail terminals is tonnage of freight shipped to or from the New Jersey FAF region in which it is located.

B.4.1 Intermodal Terminals

The consultant team also obtained the NJ Carload Waybill Survey. Intermodal (IMX) Terminals are identified by the Originating County for traffic with a New Jersey Origin and the Terminating County for freight with a New Jersey Destination. All the intermodal terminal counties identified in New Jersey are in the New Jersey portion of the New York City metropolitan FAF region (FAF Region 341). It had been hoped that the usage of these terminals could be developed by specific SCTG2 commodity. However, over 80% of the freight tonnage was reported as nonspecific commodities (e.g., Freight All Kind in the Standard C Transportation Commodity Classification and not a specific commodity that could be converted to a SCTG2 commodity). Consequently, a single percentage was developed for inbound and outbound freight from the confidential Carload Waybill for New Jersey, as shown in Table B.4. A single Multiple Mode record in FAF would generate 4 rail modal records (between the intermodal terminals and the non-New Jersey trip end) and 4 truck records (between the intermodal terminal and a Northern New Jersey county).

Table B.4 IMX Rail Terminal Counties in Northern New Jersey To Be Disaggregated

County	FIPS	Outbound IMX Tons	Outbound IMX %	Inbound IMX Tons	Inbound IMX %
Union County	34039	2,770,880	41.24%	2,026,280	31.23%
Hudson County	34017	2,429,960	36.16%	2,976,560	45.87%
Essex Country	34013	1,048,800	15.61%	1,187,000	18.29%
Bergen County	34003	469,880	6.99%	298,840	4.61%

No disaggregation of domestic Multiple Modes was attempted for imports and exports. Those tonnages may be transferred at on-dock rail terminals at the port or by truck from those intermodal terminals shown in the Waybill Survey. There is no reported information to allocate between on-dock and off-dock intermodal rail terminals, and no disaggregation of imports or exports reported with a domestic mode of Multiple Modes was attempted.

B.5 Disaggregating Freight Through New Jersey

Commodities which pass through New Jersey cannot be identified solely by the origin and destination information in the FAF. It requires the assignment of the FAF O-D table to a national network. The FAF provides a national highway network, but it provides only loaded daily freight truck volumes and annual tons on that network. It does not provide the assignment scripts that can be used with a selected link analysis.

The national FAF highway network is available as a TransCAD network but it includes no loading centroids. To use as an assignable network, the assignment script also needs to be available. Centroid connectors were added to counites in the FAF highway network, and an O-D table of disaggregation to all U.S. counties was developed by the Cambridge Systematics team. Scripts assigning this O-D table to highway links were developed by the Cambridge Systematics team based on the FAF documentations. The Cambridge Systematics team developed scripts that made use of the outputs of the Selected Link assignment in TransCAD of the FAF highway network to identify the O-D pairs of the disaggregated FAF and the non-disaggregated FAF that seem to pass through New Jersey.

B.5.1 Disaggregated Counties That Should Not Pass Through New Jersey.

The disaggregation method described in Section 0 will also include commodity specific tonnages that need not pass through New Jersey. The disaggregation is to counties in the FAF regions described for the New York City and Philadelphia Metropolitan regions. This could result in disaggregation to counties that need not pass through New Jersey. This includes counties with a non-New Jersey County trip end and a non-disaggregated FAF Region (e.g., EI or IE traffic between Queens County, NY and FAF Region 251, Boston MA Part) as well as disaggregation of both trip ends, (e.g., II traffic between Queens and Suffolk Counties in NY). While the FAF highway network does not report the assignment methods used to develop its volumes, those assignment methods can be inferred. The FAF national network is publicly available and supports the selected link feature in TransCAD. By conducting a selected link analysis at each of the national links on the New Jersey border and using the origin and destination table resulting from that selected assignment, it is possible to identify O-D pairs by region and disaggregated county that have a reasonable path through New Jersey.

While the selected link analysis does allocate flows among multiple paths, this is not recommended for use in allocating flows among paths that pass-through New Jersey. The assignment method is only approximate and may not reflect congestion on non-New Jersey links. Additionally, the portion of the national network in New Jersey may not reflect the usage and performance of the transportation network in Northern or Southern New Jersey. The selected link process must rely on average weekday assignment while the MPO networks assign traffic based on Time of Day periods. Because of these differences it is only recommended that if a reasonable path is identified for an O-D pair that its usage be assumed for all of the freight tonnages between those O-D pairs.

B.5.2 Non-Disaggregated FAF Flows That Pass-Through New Jersey

The non-disaggregated FAF also includes freight flows that might pass through New Jersey based on the characteristics of the origin, destination and the New Jersey transportation network. As discussed above the association could allocate traffic by the selected tonnage, but this share is not recommended. The FAF highway network does not account for congestion in other states that might affect flows through New Jersey, and the assignment methodology of the FAF is undergoing changes such that allocations are forecast using the current network, e.g. the disaggregation to Freight Activity Centers (analogous to counties) is changing. A path between part of a FAF region as an Origin and another part of a different FAF region as Destination might not reflect the updated assignment. It will be assumed that if a reasonable path is found through New Jersey that all the reported non-disaggregated tonnage could use that path.

B.6 Conclusion

The FAF 4.5 was disaggregated using the recommended methods for a base year of 2012 and for 2020 and through 2050 in 5 year increments. The disaggregation was undertaken for both tonnage and value as reported in the FAF. Imports and exports in the FAF are reported by foreign mode and domestic gateway. This information has been retained even though it can be aggregated for use in the NJTPA FFT. It is retained because it is reported in the FAF and could be useful in other general transportation activities.

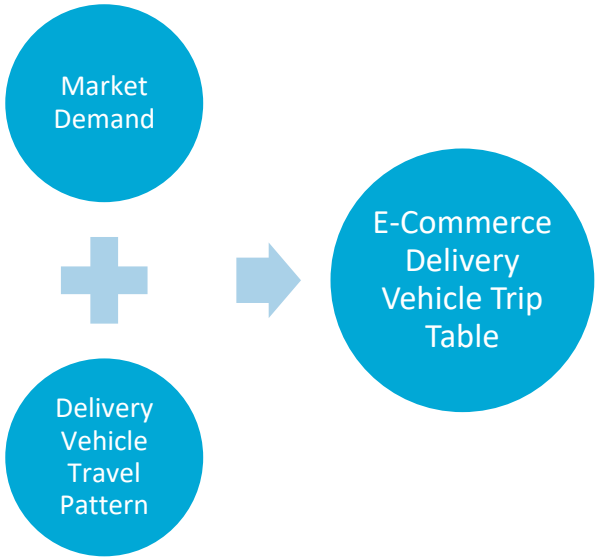
The FAF is generally similar to the freight flows reported in TRANSEARCH. The FAF does report flows by pipeline that are not reported in TRANSEARCH, but pipeline flows are not a focus of the NJTPA FFT. The commodity and modal perspective between the FAF and TRANSEARCH are different but the methods described provide a reasonable disaggregation of the FAF to counties by commodity. Additionally, while the SCTG commodities and the STCC commodities in TRANSEARCH may not match exactly at a detailed level, when aggregated by the commodity bundles in the NJTPA FFT, these differences are inconsequential.

Appendix C. E-Commerce Forecast and Trip Table Development

E-Commerce delivery trips are notably absent from commodity flow databases, and little data is used in transportation planning applications to describe the volume and travel patterns of vehicles that deliver e-commerce orders to consumers. To develop an e-commerce truck trip table that could be incorporated into the FFT, the CS Team employed an approach that relied upon market research data to learn about consumers' e-commerce purchasing habits in the NJTPA Region, about the carriers making e-commerce deliveries and their respective logistics chains, and travel demand modeling techniques to distribute trips between NJRTM-E TAZs.

To accomplish this objective, it was necessary to estimate quantity of goods being delivered to consumers throughout the region, and to estimate the delivery vehicle travel patterns that connect fulfillment centers to the locations where shipments are delivered. These two needs are illustrated in Figure C.1.

Figure C.1 Two Analyses Needed to Develop E-Commerce Trip Table



The market analysis estimated and forecasted demand, measured as the number of shipments/packages and items, for e-commerce goods transported between origin and destination zones in the network. Several types of data could be used in order to estimate household e-commerce demand. Market research data estimates household e-commerce spending either by a vendor-administrated survey or a proprietary data model. Next, we considered the possibility of administering a market research survey to NJTPA households to ask questions pertaining to e-commerce orders. We also reviewed several sources of shipment data, which tracks how many packages are delivered to and from locations within

the NJTPA region. Ultimately, market data from Rakuten Intelligence was selected because it offered a very robust sample size and projection to zip code and county levels based upon the sample. Rakuten Intelligence also offered information about the proportion of packages delivered by each carrier. The data on packages delivered offered information about the destinations of the delivery trips, while the carrier information was useful in identifying the origins of the delivery trips.

E-Commerce market data from Rakuten Intelligence provided an estimated number of shipments at the county level and number of items at the zip code level, for every county and zip code in the NJTPA Region. The Rakuten data also estimated the proportional share of shipments delivered by carriers (e.g., UPS, Amazon, USPS, FedEx, and others). Using this information, combined with information on carrier facility locations in and around the NJTPA Region, the team was able to identify origins and destinations for e-commerce delivery trips throughout the region.

C.1 Base Year E-Commerce Package Demand

The Rakuten Intelligence data was acquired for the 13 NJTPA counties and represented a period of one year from the second quarter of 2018 through the first quarter of 2019. The data deliverable included the projected number of packages by county, the projected number of items by product category at the county level, the projected number of items by zip code, and the number of packages delivered by each carrier.

Figure C.2 illustrates the number of projected items by zip code throughout the NJTPA region. The top two zip codes in the NJTPA region, by number of items delivered, were 07030 in Hoboken, Hudson County, and 07302 in Jersey City, Hudson County.

Figure C.3 illustrates the share of packages delivered by each carrier across the NJTPA region. The U.S. Postal Service (USPS) and UPS each deliver approximately 34 percent of e-commerce packages in the NJTPA region. Each carrier's share varies by county. USPS delivers between 28 percent (Middlesex County) and 58 percent (Sussex County) of e-commerce packages. UPS shares range from 28 percent (Warren and Middlesex counties) to 37 percent (Hunterdon County). Amazon shares range from less than 1 percent (Sussex County) to 25 percent (Somerset County). FedEx shares range from 8 percent (Sussex County) to 14 percent (Hudson County).

Figure C.2 E-Commerce Demand, Items by Zip Code, 2nd Quarter 2018 through 1st Quarter 2019

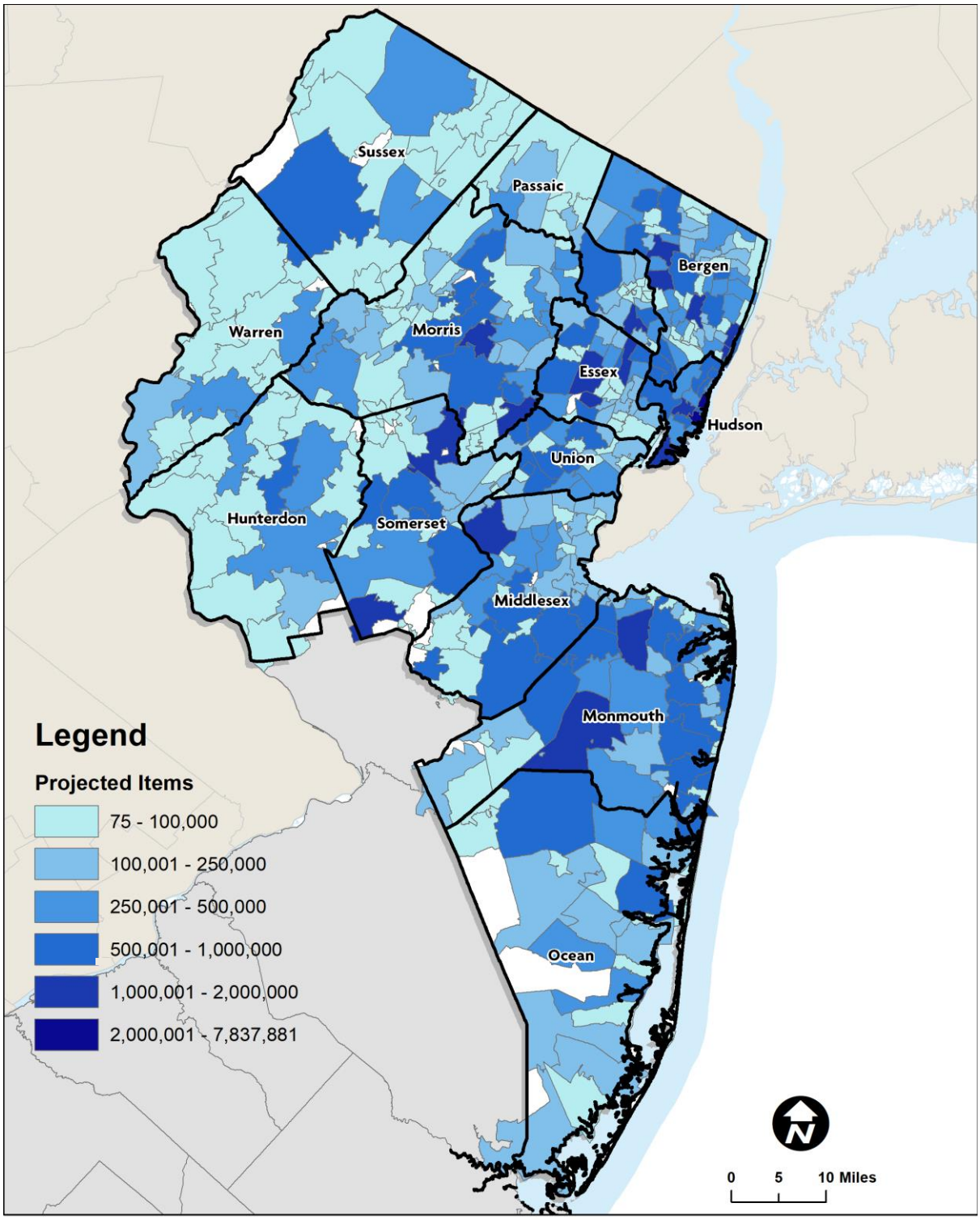
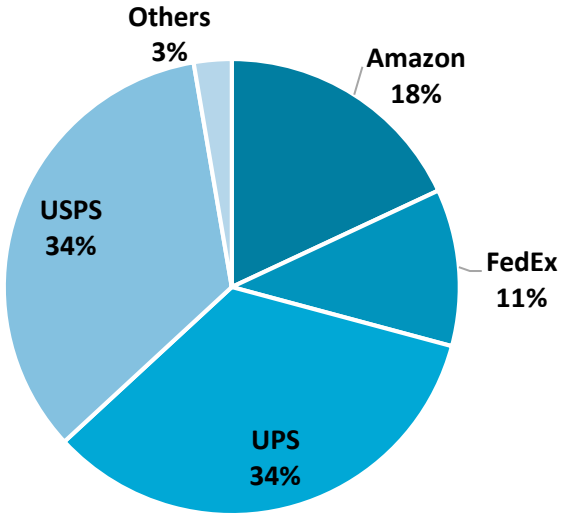


Figure C.3 Packages by Delivery Carrier, 2nd Quarter 2018 through 1st Quarter 2019



C.2 Estimate E-Commerce Package Demand in Future Years

The 2018-2019 data provided by Rakuten Intelligence served as a useful baseline from which a forecast of future year demand could be developed. By linking e-commerce demand to socioeconomic variables, future demand could be projected, given forecasted socioeconomic data for the region and its component counties, zip codes and TAZs. CS performed a multiple regression analysis to identify the socioeconomic predictors for e-commerce demand at the zip code level. Because Rakuten Intelligence provided the number of items by zip code, items were the unit of measurement used for this analysis. The number of packages was only available at the county level. The number of items estimated by this analysis was them multiplied by the average number of items per package in each county in order to project future packages.

The multiple regression analysis of items and socioeconomic variables found that population, households, median household income, and median age were the key variables that can best predict the demand for e-commerce packages in a given zip code. The combination of these variables produced a regression with an R squared of 81.50. Despite some high residuals in some zip codes, the regression equation developed from this analysis produced acceptable predicted values for the number of e-commerce items at the zip code level.

To predict future demand, the regression equation was applied to future year values for the four key socioeconomic variables. Because forecasts were only available for population, and only at five-year intervals, only that variable was adjusted. Population for interim years between the five-year intervals were estimated by calculating a compound annual growth rate (CAGR) between each interval and calculating the population for each interim year by

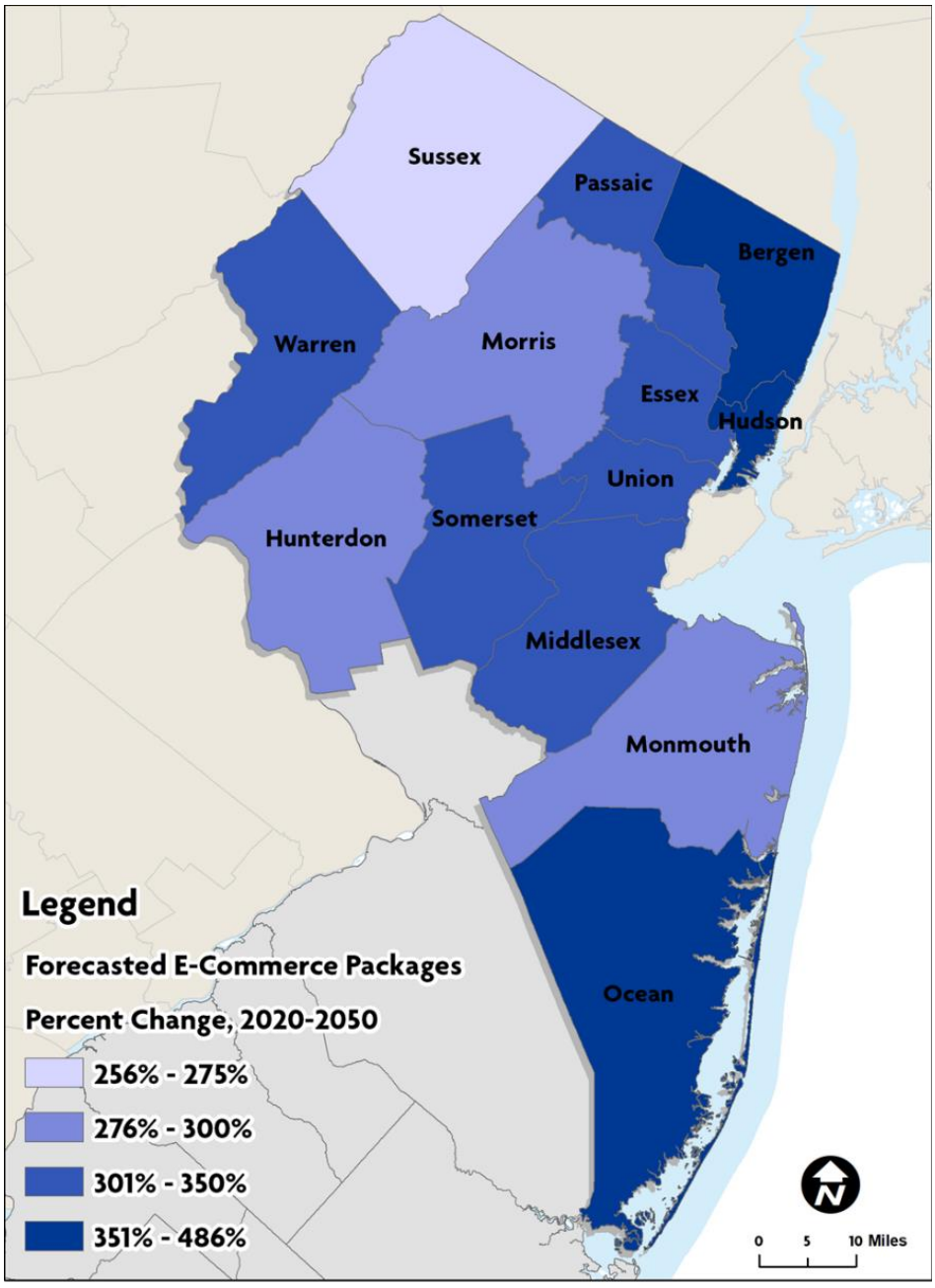
applying the CAGR to the previous year's estimated population. The other socioeconomic variables were held constant. There are placeholders in the calculation spreadsheet to insert alternative forecasted values for households, household income, and/or median age and adjust the forecast accordingly.

In addition to socioeconomic changes, e-commerce, as a share of all retail sales, is changing over time, and likely to continue changing in the future. In 1999, e-commerce represented 1 percent of retail sales in the United States. In 2019, e-commerce represented about 11 percent of retail sales in the U.S.[2] Continuing this rate of growth trend forward, e-commerce could represent 47 percent of retail sales by 2050. Certainly, in the near-term, e-commerce appears to be exceeding this rate of growth in light of the response to COVID-19. Whether e-commerce continues to gain market share at a more rapid rate during a longer duration, or a return to pre-COVID-19 growth rate remains to be determined. However, the rate of growth can be adjusted in the e-commerce demand calculation spreadsheet.

Figure C.4 shows the projected number of e-commerce packages, summed up to the county level, 2020-2050. The forecast anticipates that the number of e-commerce packages in the NJTPA region would increase from 88 million in 2020 to nearly 393 million by 2050. That represents approximately 447 percent growth in the number of packages over the forecast period.

[2] "Quarterly Retail E-Commerce Sales 1st Quarter 2020," U.S. Department of Commerce, available from: https://www.census.gov/retail/mrts/www/data/pdf/ec_current.pdf (accessed June 24, 2020).

Figure C.4 Forecasted Growth in E-Commerce Package Demand by County, 2020-2050



C.3 Last-Mile Delivery Trip Table

The rapid growth of e-commerce has made package delivery trucks an increasingly substantial share of local traffic. For the NJTPA region, we quantified this activity using zip code-based package data and locations of the facilities of USPS, UPS, FedEx, and Amazon. These four carriers delivered 98 percent of the e-commerce packages in the

NJTPA region, according to the Rakuten Intelligence data. The estimation of truck trips and tours is based on averages of capacity and distances from origin facilities.

C.3.1 Facility Locations

The systems of facilities used by the four operators vary greatly and were identified separately. Post Office locations are clearly available in exhaustive data sets, while the other 3 provide little information publicly. FedEx and UPS have more clearly established distribution centers than does Amazon which is dynamic and less formal. We considered many sources of information and criteria for designating sites as last mile origins for each carrier.

USPS

For USPS, the local post office is the final stop of packages being delivered and lists of all post offices (as well as other types of facilities) are readily available. This made USPS the most straightforward of the four. Each one was assigned to its zip code. In the case that a zip code had none, it was assigned to the nearest post office.

UPS

UPS had the fewest origin locations. While there are many places to send packages through UPS – drop boxes, “The UPS Store” and other retail stores – the incoming packages come from four “Customer Centers”, including the airport location.

FedEx

For FedEx, we started with all the FedEx locations and filtered from there. First, we dropped retail stores and drop off points, then small FedEx/Kinkos stores. We kept the “Shipping Centers” which could accommodate both large trucks and delivery vans. Each location was visually inspected using satellite images and Google Streetview. This resulted in 8 locations used in the model, including one in Bethlehem, PA.

Amazon

Amazon’s last mile facilities were the least clear. Some Amazon locations were labeled “Fulfillment Centers”, “Sortation Centers”, or “Amazon Flex”. While the Flex locations were specifically for distribution to vans, the other types were included to better capture the spread of possible origins of Amazon shipped packages. To find as many as possible, we searched Google, Google Maps, news reports, press releases, and job classifieds. Care was taken to only include locations at which operations were happening during the time of the package data.

C.3.2 Truck Capacity and "Items" Per Package

The capacity of trucks – i.e. number of packages in a single trip – was estimated using the survey data and relative sizes of trucks used. The Commodity Flow Survey (CFS) is a survey of approximately 100,000 establishments regarding domestic freight shipments conducted every five years by the Bureau of Transportation Statistics (BTS) and the US Census Bureau. We considered the weight of commodity shipments on "Parcel, USPS, or courier (mode code 14)" within New Jersey in the most recent CFS microdata (2012). Since the last mile delivery of e-commerce shipments are typically delivered by USPS or couriers, we estimated the average shipment size on "Parcel, USPS, or courier (mode code 14)" reported in CFS data. In addition, we considered shipping only with both origin and destination within New Jersey. Broader research indicated most of the carriers are using a truck with under 10,000 pounds gross vehicle weight rating (GVWR), so we assumed a typical payload of 4,000 pounds. We also considered a typical truck is 70% full when it is carrying the shipments. This led to an estimate of approximately 250 packages per delivery truck. The result agreed with anecdotal information from postal/delivery forums. This was set to different values for each shipper based on vehicle size: 220 for USPS, 300 for FedEx/UPS, and 140 for Amazon.

Because the number of packages to each zip code is not given in the data, the county level average items per package were assumed to be the same in all zip codes in the county. The number of items going to each zip code was divided by this ratio which ranged from 1.29 to 1.53.

C.3.3 Distribution to Zip Codes

The distribution of origin facilities to destinations (by zip code) was performed separately for each carrier. The methodology for USPS was different from the other carriers. Once the number of packages to each zip code by each carrier was calculated a process of selection of origin for each carrier was performed.

UPS, FedEx, and Amazon

Each zip code could be served by 1 or more facilities of each of the non-USPS shippers. A logit equation was used to calculate the probability of choosing facilities based on their relative travel time.

$$TT_{relative}(fac_i, zip_j) = {TT_{fac_i,zip_j}}\Big/{minTT_{facs,zip_j}}$$

Facilities which were relatively far (for example 45 minutes vs. 15 minutes or relative time of 3) would have much lower probability. The asserted parameters varied based on the

idea that Amazon, with varying stock at its warehouses may not always deliver from the nearest one. The closest was still the most likely.

Because logit equations produce probabilities for each option, packages or a small fraction of a package was designated to originate at each facility. Generally, however, after those with very small percentages were dropped only 1-3 remained.

USPS

As noted above, each zip code had an assigned post office. All packages to a zip code came from a single USPS location.

C.3.4 Truck Trips

With the given packages per truck for each carrier a fractional number of trucks was calculated for each facility-zip code pair. The fractional values were rounded up if they were above .1 for USPS and .3 for others – meaning that if 3.4 trucks were required to take packages from FedEx Moonachie to a nearby zip code, this would be rounded up to 4 trucks – i.e. 4 round trips between them. A post office would have 3 round trips if the required trucks was 2.2, but only 2 for 2.05. In the case that all of a carrier's facilities were dropped for a zip code, but the total required fractional trucks added up to more than the .3 threshold, all the packages would be assigned to one facility and one truck required. In this way, each zip code had a set number of trucks from 1 or more facilities of each carrier, and facilities with very low probability were dropped.

Because the data is provided at a zip code level, the number of trucks required was produced at this same geography. However, to sync with the NJRTM-E, a zip code to TAZ conversion was performed. Using an overlay in GIS the percentage of area of TAZs in each zip was found and the TAZ households were distributed. The trucks to each zip code were then distributed to the TAZs by the share of zip code households in each TAZ. This again produced fractional required trucks which were handled as follows:

1. If a TAZ has 1 or more whole number required trucks from a single facility create that number of round trips to that TAZ. Example: 2 facility-TAZ round trips from 2.6 required trucks

2. For any TAZ that has fractional values require one stop in that TAZ.

    a. Sum the fractional values (after whole numbers are removed) and round up to get the number of trucks (or truck tours).

    b. Randomly split all the TAZs within the zip code into groups to match the number of trucks.

c. Create facility-to-TAZ, TAZ-to-facility, and TAZ-to-TAZ trips.

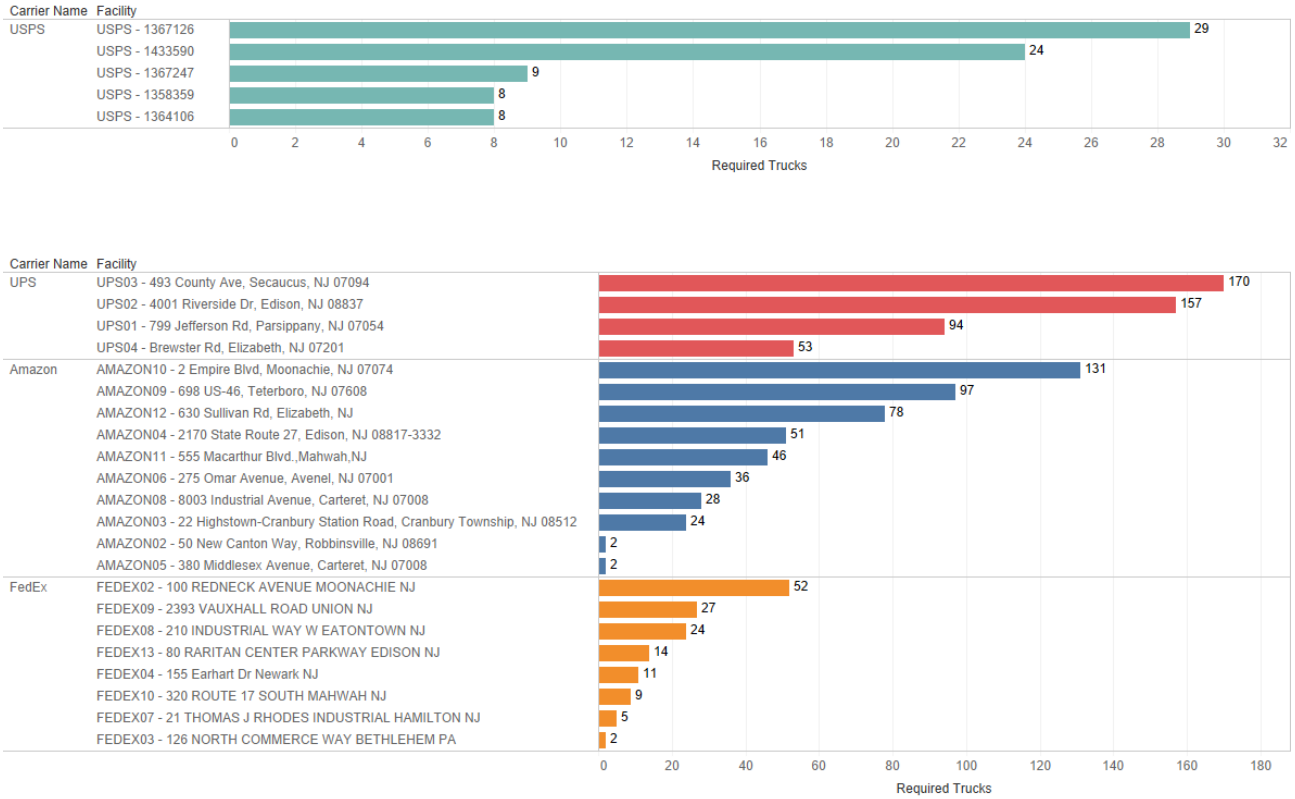
d. Identify the TAZ location of the carrier facilities to get the trip ODs.

The result is that the number of single and multi-stop tours are equal to the number of trucks required for the zip code and the trips are aggregated into a trip table.

C.3.5 Results Summary

The procedure allocated a certain amount of trip origins to each facility. Those which were further from other facilities and closer to more households had higher volumes. Figure C.5 shows the daily trucks required for top 5 USPS facilities and up to 10 top facilities of UPS, Amazon and FedEx.

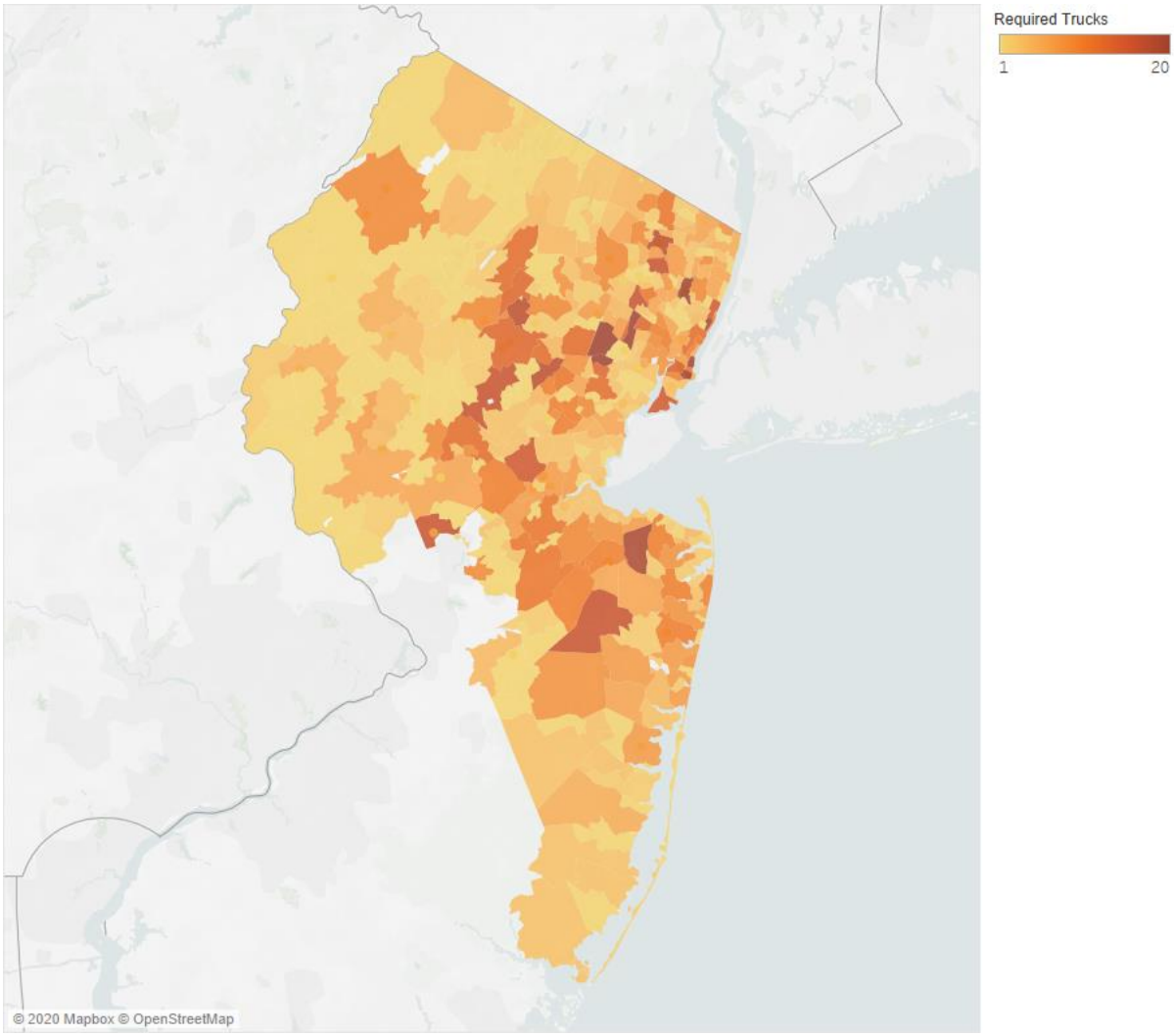
Figure C.5 Daily Required Trucks by Top Facilities for Each Carrier



For UPS, the Secaucus facility requires the maximum number of trucks to deliver their daily packages. For Amazon and FedEx, their corresponding facilities in Moonachie requires the highest number of trucks for daily package delivery to destination zip codes.

Figure C.6 shows the distribution of daily required trucks by delivery location zip codes for all carriers. This is very similar to the map of packages by zip code in Figure C.2.

Figure C.6 Map of Daily Required Trucks by Delivery Location Zip Codes



For USPS, a total of 4,513 trips were created from the delivery tours for all facilities, where 67% of them are intermediate trips (from one delivery location TAZ to the next). In terms of trip share, USPS generates 38% of the total trips followed by Amazon (29%), UPS (25%) and FedEx (8%). The detailed trip summaries for UPS, Amazon and FedEx are given in Figure C.7.

Figure C.7 Daily Truck Trips by Serving Facilities (UPS, Amazon and FedEx)

			Trip Type		
Carrier Name	Serving Facility	Grand Total	Facility to TAZ	TAZ to TAZ	TAZ to Facility
UPS	UPS02 - 4001 Riverside Dr, Edison, NJ 08837	1,039	157	725	157
	UPS03 - 493 County Ave, Secaucus, NJ 07094	1,009	167	675	167
	UPS01 - 799 Jefferson Rd, Parsippany, NJ 07054	541	94	353	94
	UPS04 - Brewster Rd, Elizabeth, NJ 07201	393	53	287	53
	Total	2,982	471	2,040	471
Amazon	AMAZON10 - 2 Empire Blvd, Moonachie, NJ 07074	841	128	585	128
	AMAZON09 - 698 US-46, Teterboro, NJ 07608	644	97	450	97
	AMAZON12 - 630 Sullivan Rd, Elizabeth, NJ	599	78	443	78
	AMAZON04 - 2170 State Route 27, Edison, NJ 08817-3332	371	51	269	51
	AMAZON06 - 275 Omar Avenue, Avenel, NJ 07001	238	36	166	36
	AMAZON11 - 555 Macarthur Blvd.,Mahwah,NJ	234	46	142	46
	AMAZON03 - 22 Highstown-Cranbury Station Road, Cranbur..	218	24	170	24
	AMAZON08 - 8003 Industrial Avenue, Carteret, NJ 07008	192	28	136	28
	AMAZON05 - 380 Middlesex Avenue, Carteret, NJ 07008	27	2	23	2
	AMAZON02 - 50 New Canton Way, Robbinsville, NJ 08691	13	2	9	2
	AMAZON14 - 2251 Cabot Blvd W, Langhorne, PA 19047	3	1	1	1
	Total	3,380	493	2,394	493
FedEx	FEDEX02 - 100 REDNECK AVENUE MOONACHIE NJ	362	52	258	52
	FEDEX09 - 2393 VAUXHALL ROAD UNION NJ	195	27	141	27
	FEDEX08 - 210 INDUSTRIAL WAY W EATONTOWN NJ	135	24	87	24
	FEDEX04 - 155 Earhart Dr Newark NJ	104	11	82	11
	FEDEX13 - 80 RARITAN CENTER PARKWAY EDISON NJ	90	14	62	14
	FEDEX10 - 320 ROUTE 17 SOUTH MAHWAH NJ	40	9	22	9
	FEDEX07 - 21 THOMAS J RHODES INDUSTRIAL HAMILT..	39	5	29	5
	FEDEX03 - 126 NORTH COMMERCE WAY BETHLEHEM P..	12	2	8	2
	Total	977	144	689	144
Grand Total		7,339	1,108	5,123	1,108

Appendix D. Updated FFT Users' Guide

D.1 Introduction

This User Guide is intended to guide and support NJTPA and its partners with installing, using, and maintaining the FFT in regular use over time. This User Guide is organized into the following sections:

- Section D.2 – Installation and FFT Files
- Section D.3 – Running the FFT
- Section D.4 – FFT Input and Output Folders
- Section D.5 – Updating the FFT
- Section D.6 – Test Runs

D.2 Installation and Model Files

D.2.1 Step One: R and RStudio

The user must install two open-source software applications – R and RStudio. R is the basic application and RStudio is a suite of interface tools. The model User Interface is written in RShiny, which is one of the interface tools. As open-source software, the applications are cost-free and general use licensed.

R and RStudio should be installed on the User's hard drive, rather than on a network server, to minimize issues associated with network permissions or conflicts. The files can be downloaded from the links below.

https://cran.r-project.org/mirrors.html

https://rstudio.com/products/rstudio/download/

Figure D.1. Directory of R Files Following Installation

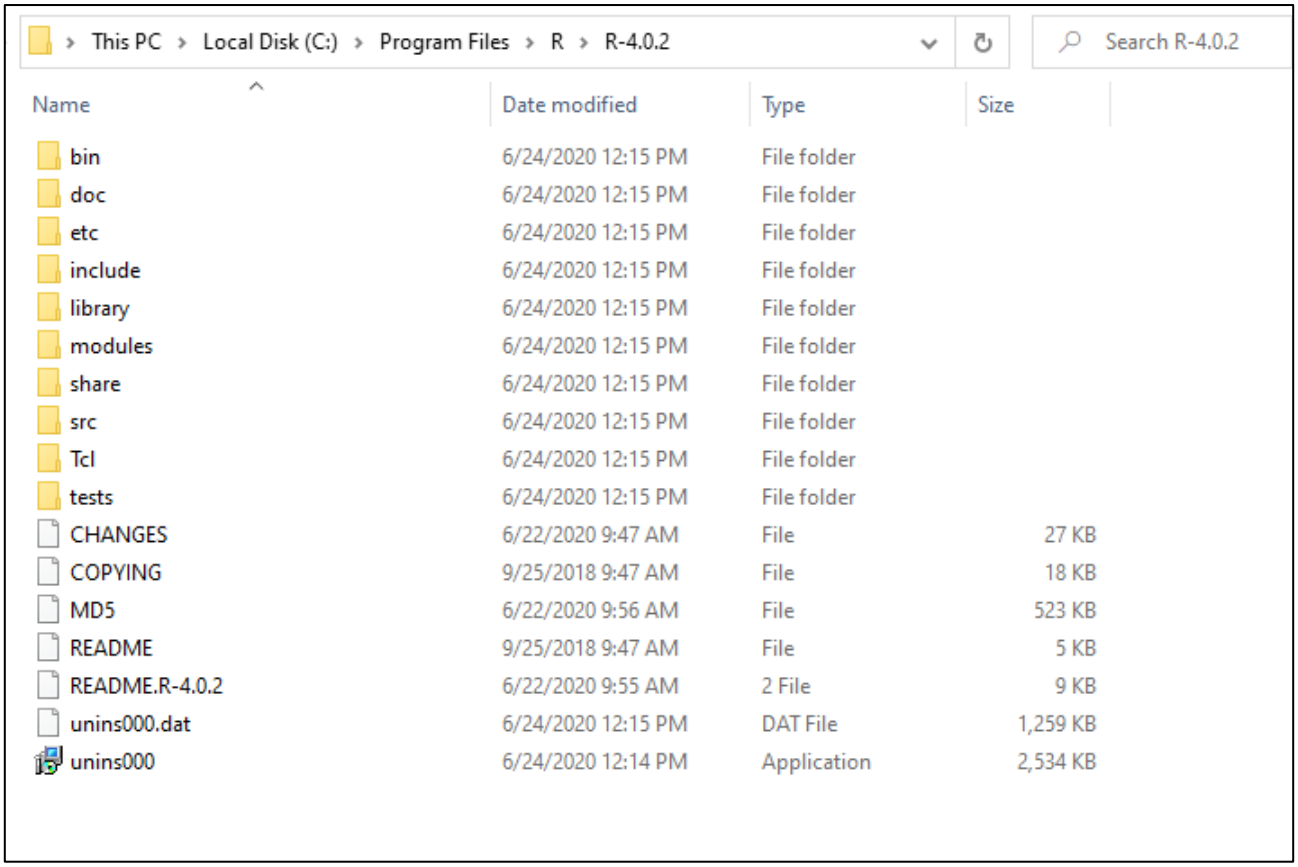
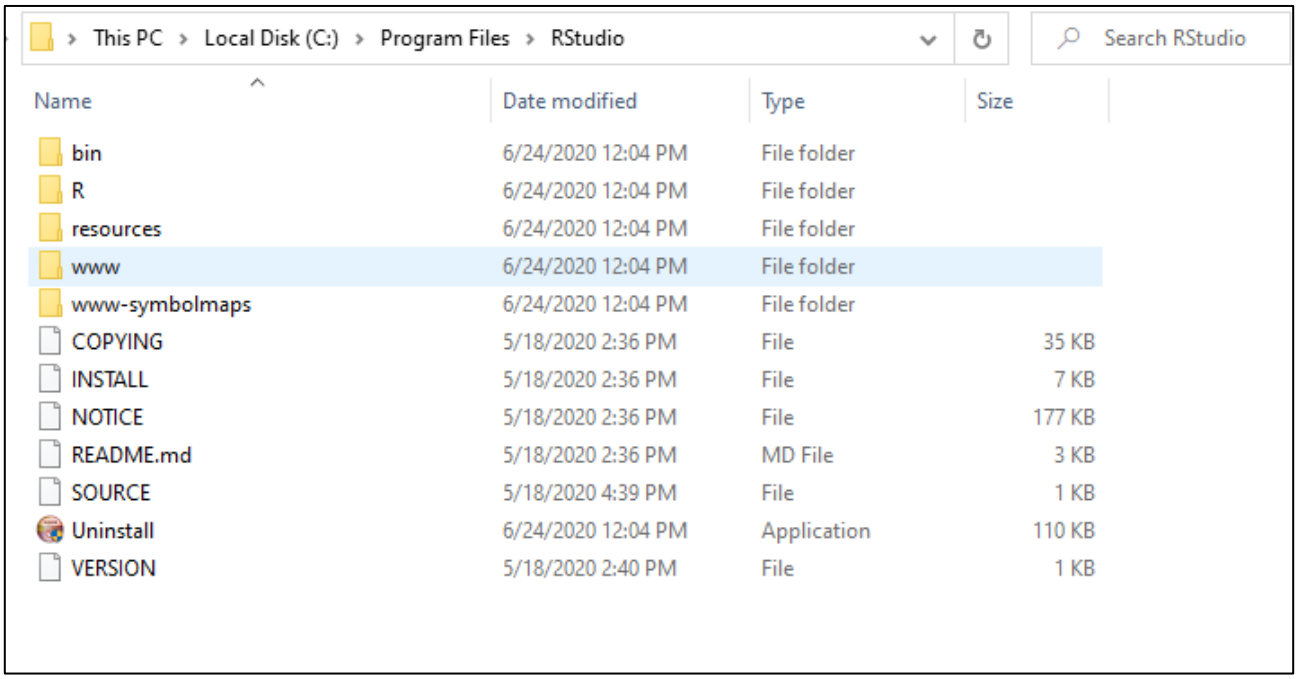


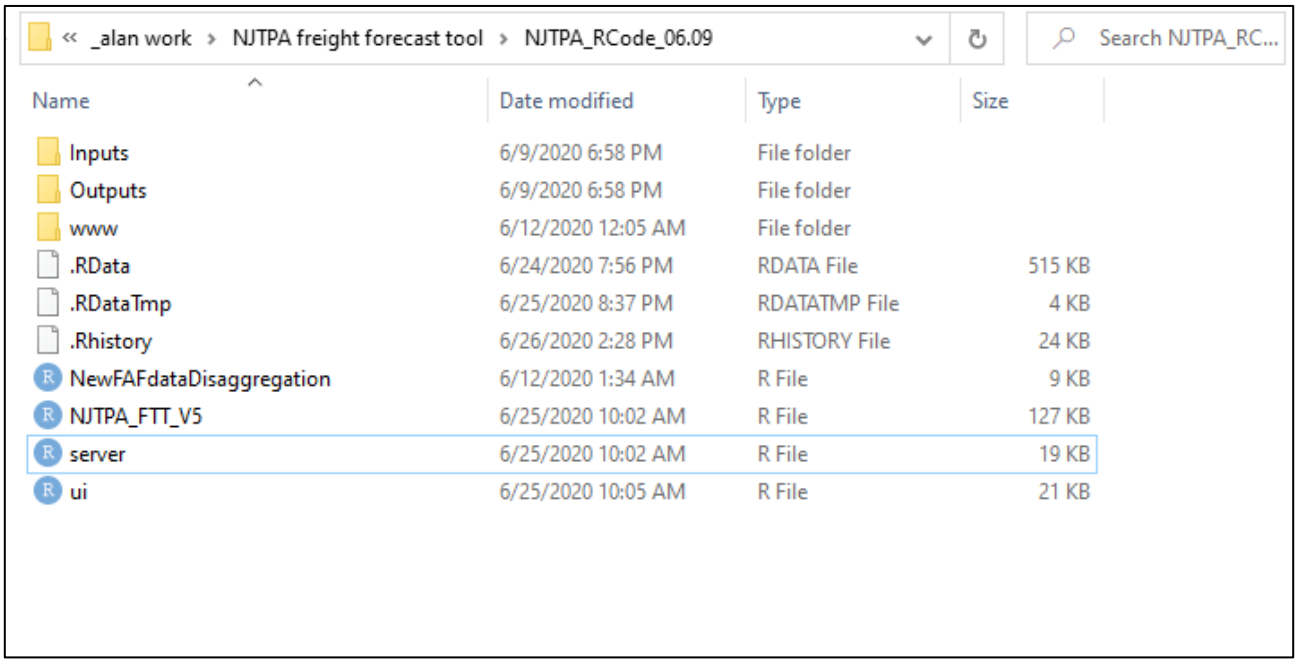
Figure D.2. Directory of RStudio Files Following Installation



D.2.2 Step 2: Freight Forecasting Tool Files

Next, the user must install the set of Freight Forecasting Tool (FFT) files provided. The FFT files should be saved to the User's hard drive. They can be in any directory location. When running the model for the first time, the User will tell the FFT the target directory so it can find the input and output file locations.

Figure D.3. Directory of FFT Files Following Installation



D.2.3 Step 3: Installing RStudio Packages

To complete the initial installation, the User will click and launch the “server” file. This initiates the process to download the various RStudio packaged applications required by the FFT.

At this point the installation process is complete and the FFT is ready for use.

D.3 Running the FFT

D.3.1 Launching the Application

To launch the FFT, the User will click and launch the “ui” (user interface) file. RStudio will then load. In the upper left of the visible window is a button marked “Run App”. The User will click this button to bring up the User Interface, which will appear as a separate window on top of RStudio. (Hint: if part of the User Interface is cut off due to the configuration of your desktop, try reducing the zoom percentage of your browser.)

Figure D.4. RStudio and “Run App” Button

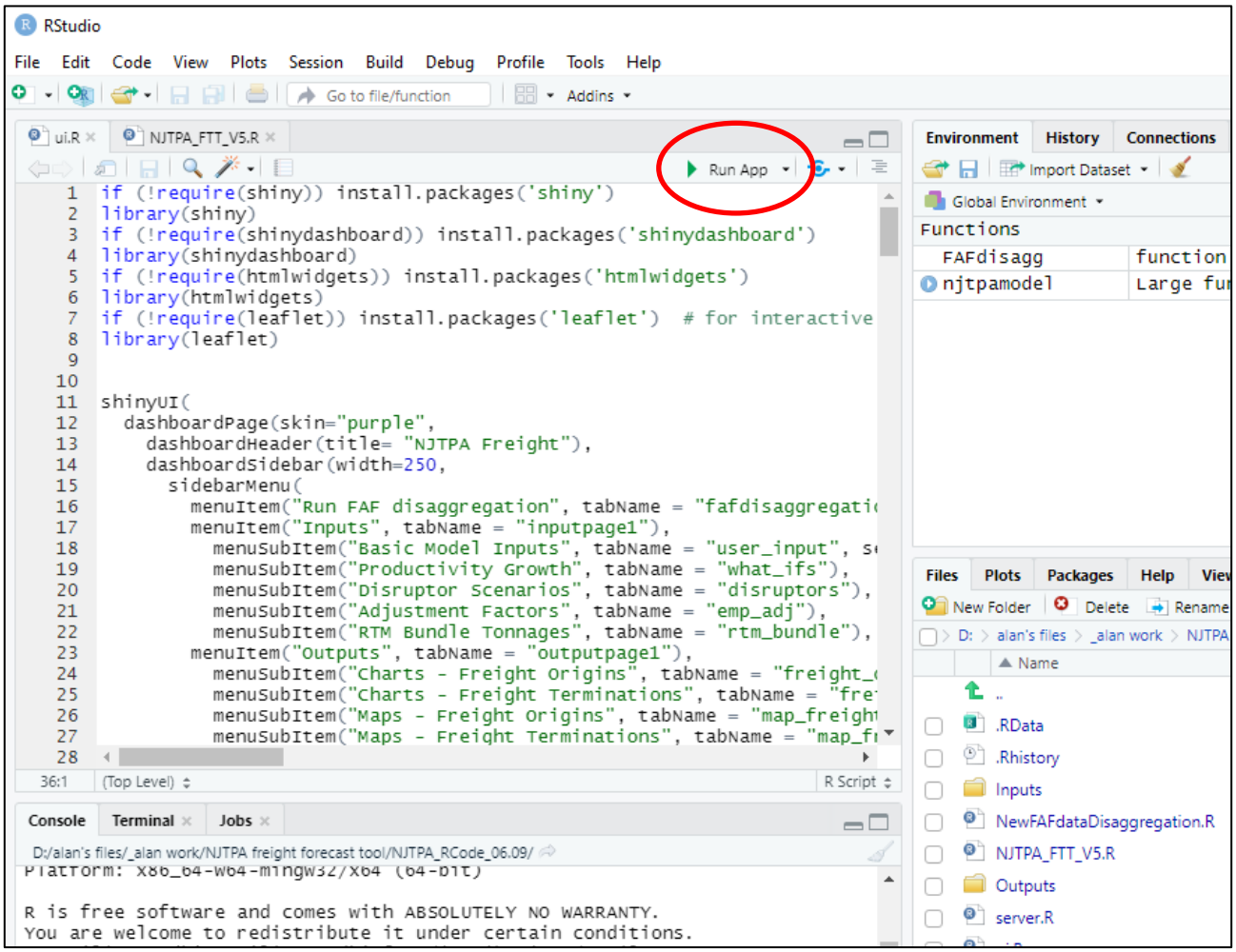
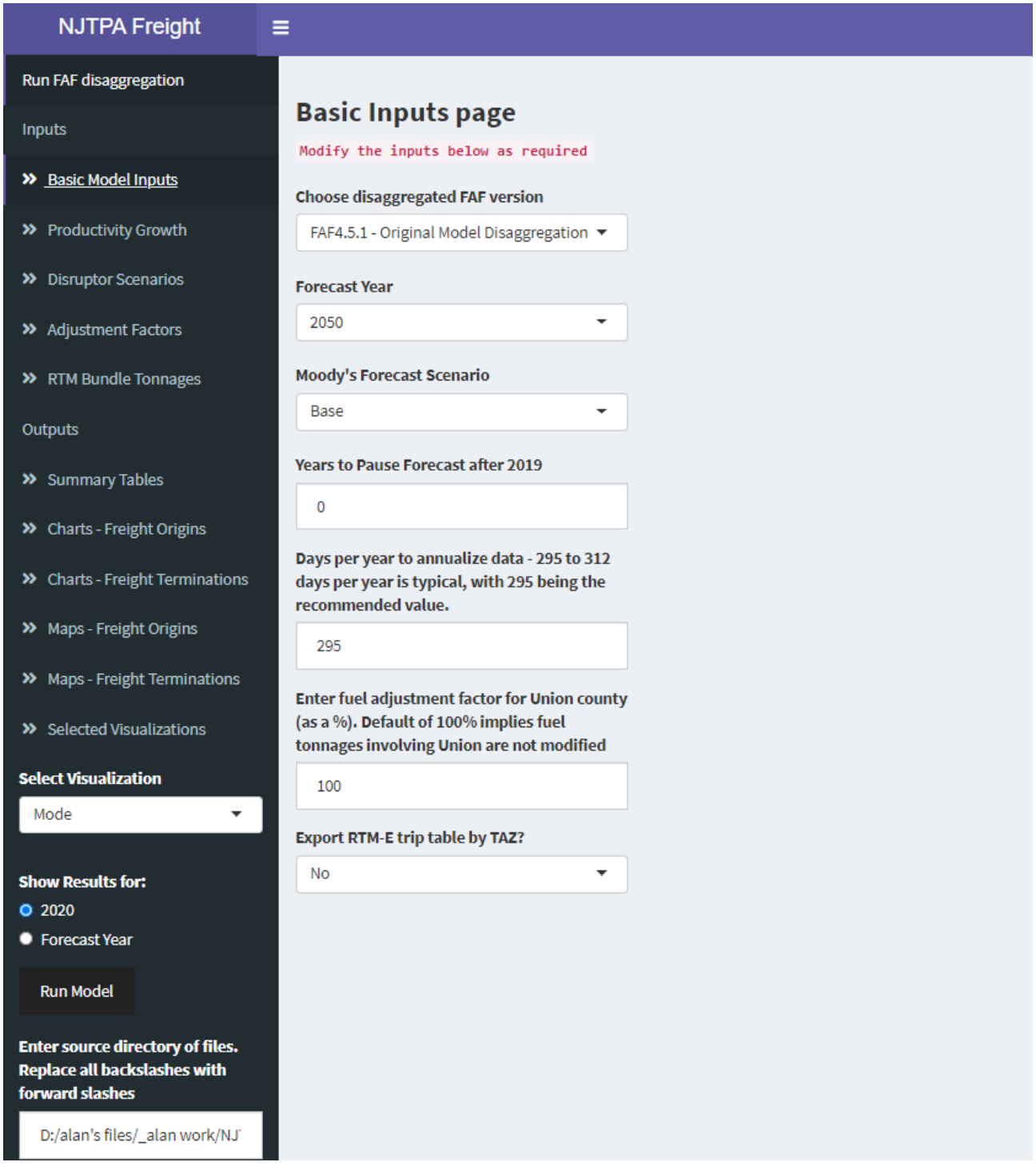


Figure D.5. The FFT User Interface



D.3.2 First-Time Use – Launching, Exiting, and Setting the User Directory

When the User launches the FFT for the first time, the User must specify the target directory where the FFT files (“ui” et al) are located. The User should delete the ‘default’ text in box at the bottom left of the User Interface (see Figure D.6) and paste in the text

address of the directory location on the User's hard drive. IMPORTANT – R cannot read back-slashes in the address, so the User MUST replace them with forward-slashes wherever they appear.

Figure D.6. FFT User Interface Source Directory Entry Box

At this point, it's a good idea to run the FFT to validate the installation. Click the Run Model button on the User Interface. A progress bar should appear on the lower right portion of the UI, and a successful run will be acknowledged with a pop-up window, which can be clicked to dismiss. The model generally takes less than five minutes to run on tested computers, although run times may vary depending on the User-defined specifications for each run.

Figure D.7. FFT User Interface Run Model Button and Progress Bar

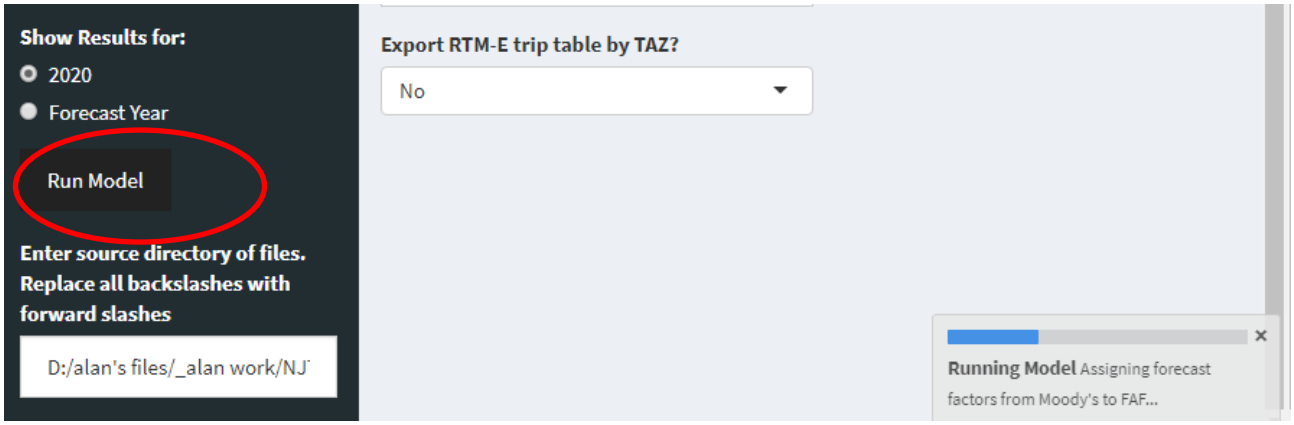


Figure D.8. FFT User Interface Acknowledgement Window

Following validation of the install, the User may continue to explore and experiment (as described in Section D.3) or elect to close the session. To close, click the X in the top right corner of the UI window; then close RStudio by clicking the X in the top right corner of its window and clicking “Save” on the pop-up menu if it appears. (Changes to RStudio, if needed, can also be saved by selecting “File” from the menu bar, then “Save As” the UI file.)

Figure D.9. Closing the FFT User Interface

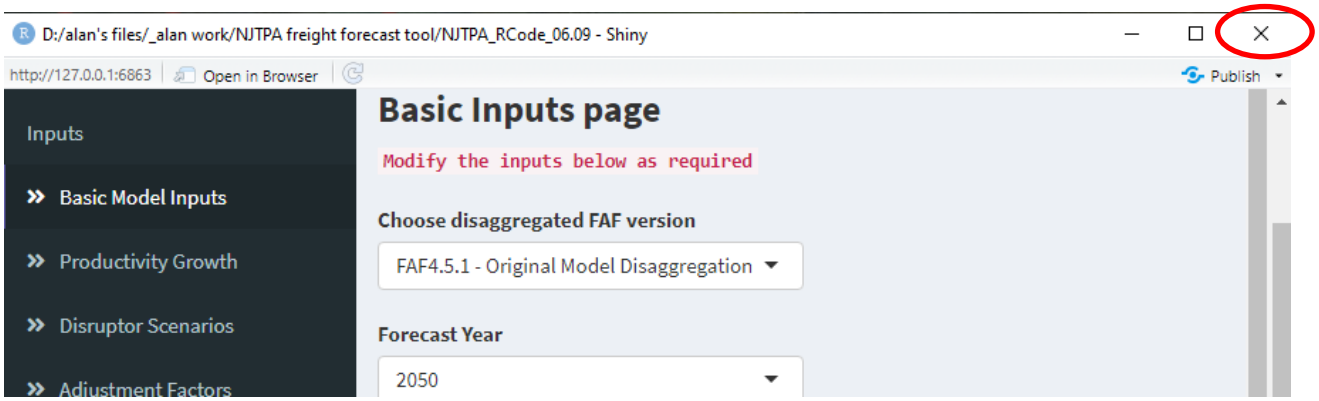
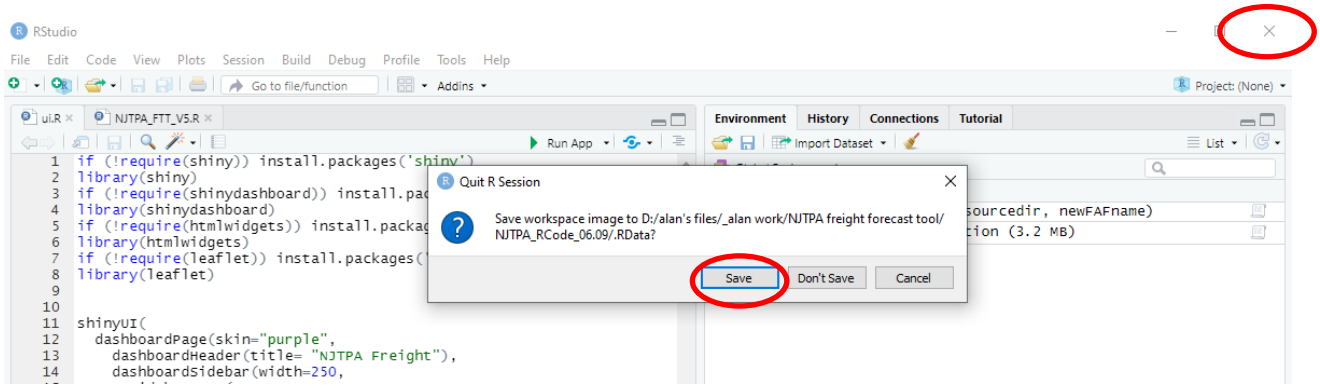


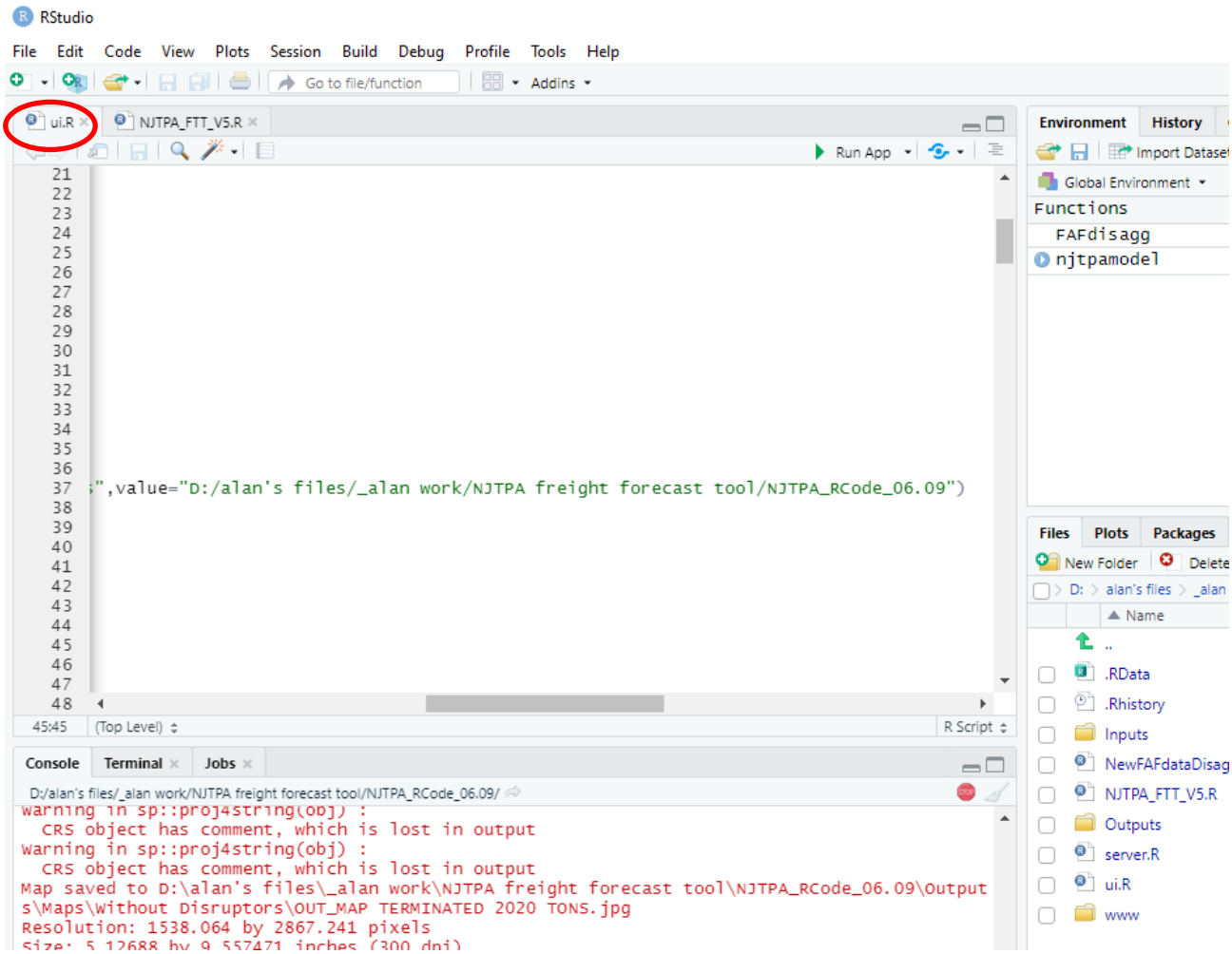
Figure D.10. Closing RStudio



The FFT is now validated and ready for use. However, the directory change entered by the User will not be “sticky” – it will revert to the original address which is hard coded the next time FFT is launched. This can be remedied by a simple change to one line of R code, which is strongly recommended. The steps are:

1. Open the UI file.
2. Make sure the ui.R window is active.
3. In the window on the top left, go to line 37.
4. Replace the text within the quotation marks with your preferred directory address. Make sure to leave the quotation marks, and to use forward slashes rather than backward slashes.
5. Use File/Save As then select the UI file to overwrite the previous UI file.
6. Close RStudio and relaunch FFT to ensure the User directory appears in the box at the lower left.

Figure D.11. Making the User Directory "Sticky"



D.3.3 Tour of FFT User Interface Inputs

"Basic Model Inputs"

After re-launching the FFT, the user can run the model with all default settings or manipulate a wide variety of input variables and scenario options. Different screens within the UI can be launched by clicking on different items in the menu bar on the left-hand side of the UI. The UI launches with the "Basic Model Inputs" screen loaded by default, as shown in Figure D.5. From the Basic Inputs Page, the User has the following choices. Note that all user inputs are reset to the default values each time the FFT is launched.

- **Choose disaggregated FAF version**. The default selection is "FAF4.5.1 – Original Model Disaggregation." This is the disaggregation file developed by Cambridge Systematics for the study. The FFT also has the capability to perform a future FAF disaggregation and append it to the FFT, as discussed in Section E.5. Choosing "New FAF Disaggregation" points the FFT to a new disaggregation if one exists.

- **Forecast Year**. The default year is 2050, but alternative years (2025, 2030, 2035, 2040, 2045 and 2055) can be selected. (Note that the 2055 option is based on an extension of the Moody's 2050 forecast, not an actual 2055 Moody's forecast.)

- **Moody's Forecast Scenario**. Moody's provided a "Base" forecast scenario which is used as the FFT default, along with ten alternative scenarios (documented in the Moody's delivery information). Many of these scenarios have similar long-term effects by 2050, with more pronounced effects in the interim years. In addition to Base, the User may select from:

  - Below Trend Long-Term Growth
  - Consensus Scenario
  - Exceptionally Strong Growth
  - Low Oil Price
  - Moderate Recession
  - Next Cycle Recession
  - Protracted Slump
  - Slower Near-Term Growth
  - Stagflation
  - Stronger Near-Term Growth

- **Years to Pause Forecast after 2019.** Disruptive events like the "Great Recession" and the COVID-19 Pandemic create substantial but (hopefully) relatively short-term disruptions of economic growth. Growth trends are interrupted and reversed, recovery to pre-disruption activity levels occurs, and growth resumes on a "normal" trajectory. To model the potential effects of disruption, the FFT allows the User to specify a number of years to delay the forecast after 2019. For example, entering "5" means that normally projected year 2021 growth would not be realized until year 2026. The default value is 0.

- **Days per Year to Annualized Data.** The FFT converts annual truck tonnage into daily truck trips. The default (and recommended) conversion factor is 295 days per year, but the User may specify other values.

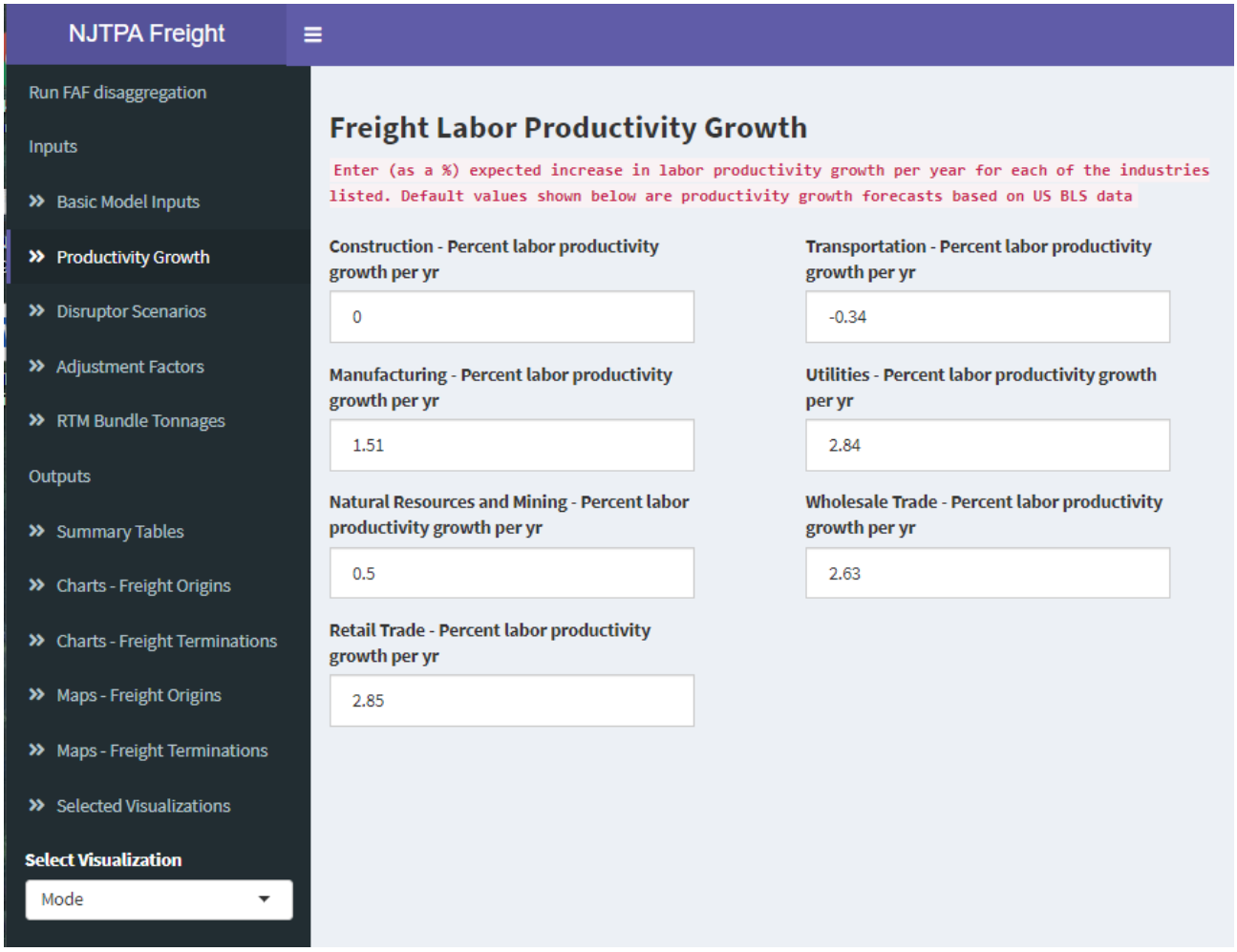
- **Fuel Adjustment Factor for Union County**. Cambridge Systematics and WSP believe that the underlying Freight Analysis Framework data may be overstating the amount of tonnage in the "Fuels" commodity group related to Union County. The User can specify the percentage of FAF tonnage to be assumed; the default value is 100 percent.

- **Export RTM-E Trip Table by TAZ.** The FFT creates truck trip tables in 12 defined "bundles", eleven based on commodity classification groups and one reflecting e-commerce delivery movements (based on original research by Cambridge Systematics) of those underlying commodities. These trip tables are developed at the TAZ level and formatted to be input directly and assigned over the NJRTM-E network. FFT will produce the TAZ-level trip tables when needed, but the calculation process takes more than a day. For everyday use, FFT is set by default to produce county-level trip tables, which can be produced quickly.

"Productivity Growth"

Under Inputs, the second menu selection is called "Productivity Growth." Currently, every employee is assumed to generate a particular amount of output and freight tonnage. As equipment and labor practices become more efficient, these factors are expected to change; each employee added in the future may generate more or less tons than an employee today. Extensive research was performed by Cheng Solutions to estimate likely changes in productivity by commodity group, but the User may override the default values.

Figure D.12. FFT User Interface, Productivity Growth Screen



"Disruptor Scenarios"

A diverse range of "Disruptor Scenarios" representing reasonably foreseeable trends or events were developed by the consultant team in collaboration with NJTPA and its study partners. These scenarios are treated by FFT as "what-if" modifiers to the forecast results. Some scenarios involve a high degree of generalized adjustment; others are limited to certain modes, geographies, or modes; but each can be toggled on or off by clicking the appropriate button, and the User can adjust the suggested default value for each factor within defined ranges. The User can activate any number of disruptors, as the calculations are sequential. The Disruptor Scenarios screen provides the following options.

- **Increased In-Migration/Urbanization.** This adjustment accelerates the growth of NJTPA originating and terminating freight tonnage.
- **Increase Out-Migration**. This adjustment slows the growth of NJTPA originating and terminating freight tonnage.

- **Increased NJ Self-Sufficiency**. This adjustment increases the share of NJ consumption that is served by NJ production, compared to non-NJ production.
- **Higher Utilization of E-Commerce**. The default forecast is for 5% per year growth in e-commerce trips. This applies to all Moody's forecast scenarios, unless changed by the User.
- **Limits to Pace of Globalization**. This adjustment decreases the rate of growth for imports and exports.
- **Shifting International Trade Geography/China Trade War**. This adjustment decreases the rate of growth for Asian imports and exports and transfers the difference to domestic production.
- **Trans-Atlantic Free Trade Area**. This adjustment increases the rate of growth for EU imports and exports and transfers the difference from domestic production.
- **Manufacturing Near-Shoring to Mexico.** This adjustment decreases the rate of growth for Asian imports and shifts the difference to Mexico.
- **Manufacturing Technology**. This adjustment decreases the rate of growth for all imports and shifts the difference to domestic production, reflecting the potential effects of 3D printing/distributed manufacturing and other domestic manufacturing technology advances.
- **Transportation Technology**. This adjustment reduces the forecast percentage of truck trips with origins and destinations in the same county, reflecting improved transportation or logistics efficiencies that eliminate "double moves". This is a shift applied on top of other growth effects.
- **Mode Share, Truck/Rail**. This adjustment reduces the forecast percentage of trips to/from the NJTPA region by truck and increases the percentage by rail, without impacting total tons or other modes. This is a shift applied on top of other growth effects.
- **Mode Share, Truck/Water**. This adjustment reduces the forecast percentage of trips to/from NAFTA trade partners by truck and increases the percentage by water, without impacting total tons or other modes. This is a shift applied on top of other growth effects.

Figure D.13. FFT User Interface, Disruptor Scenarios Screen (1 of 2)

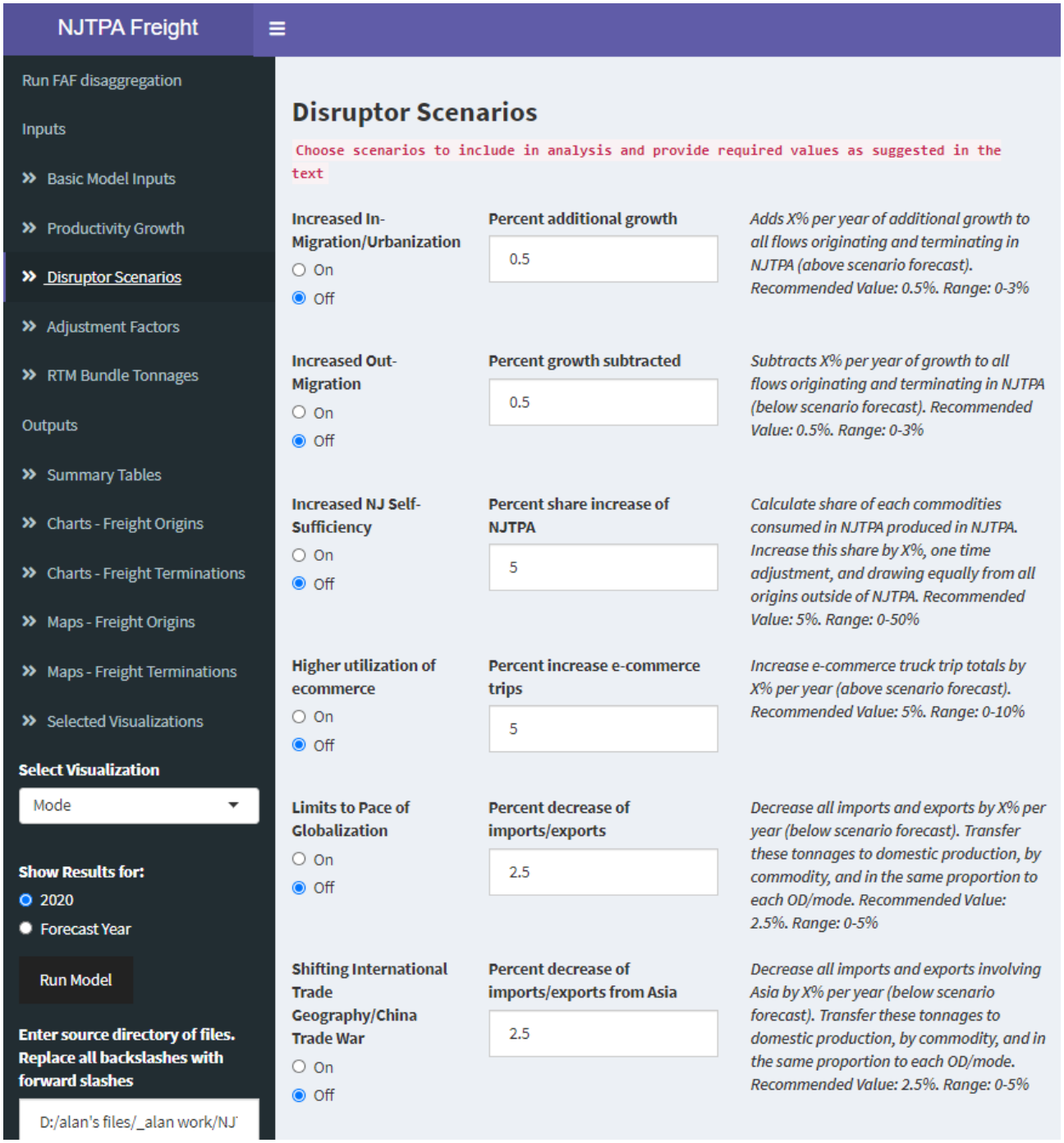
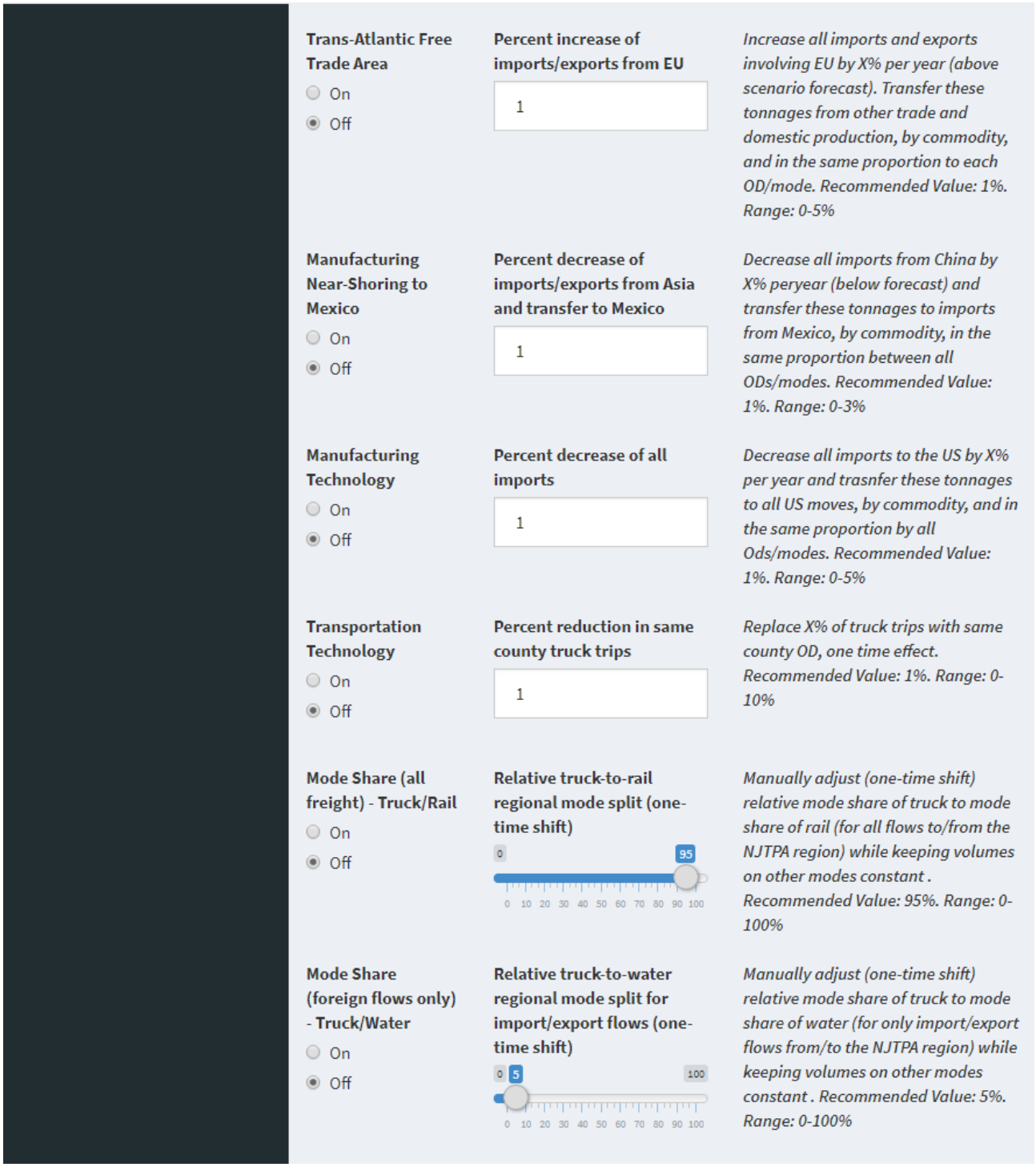


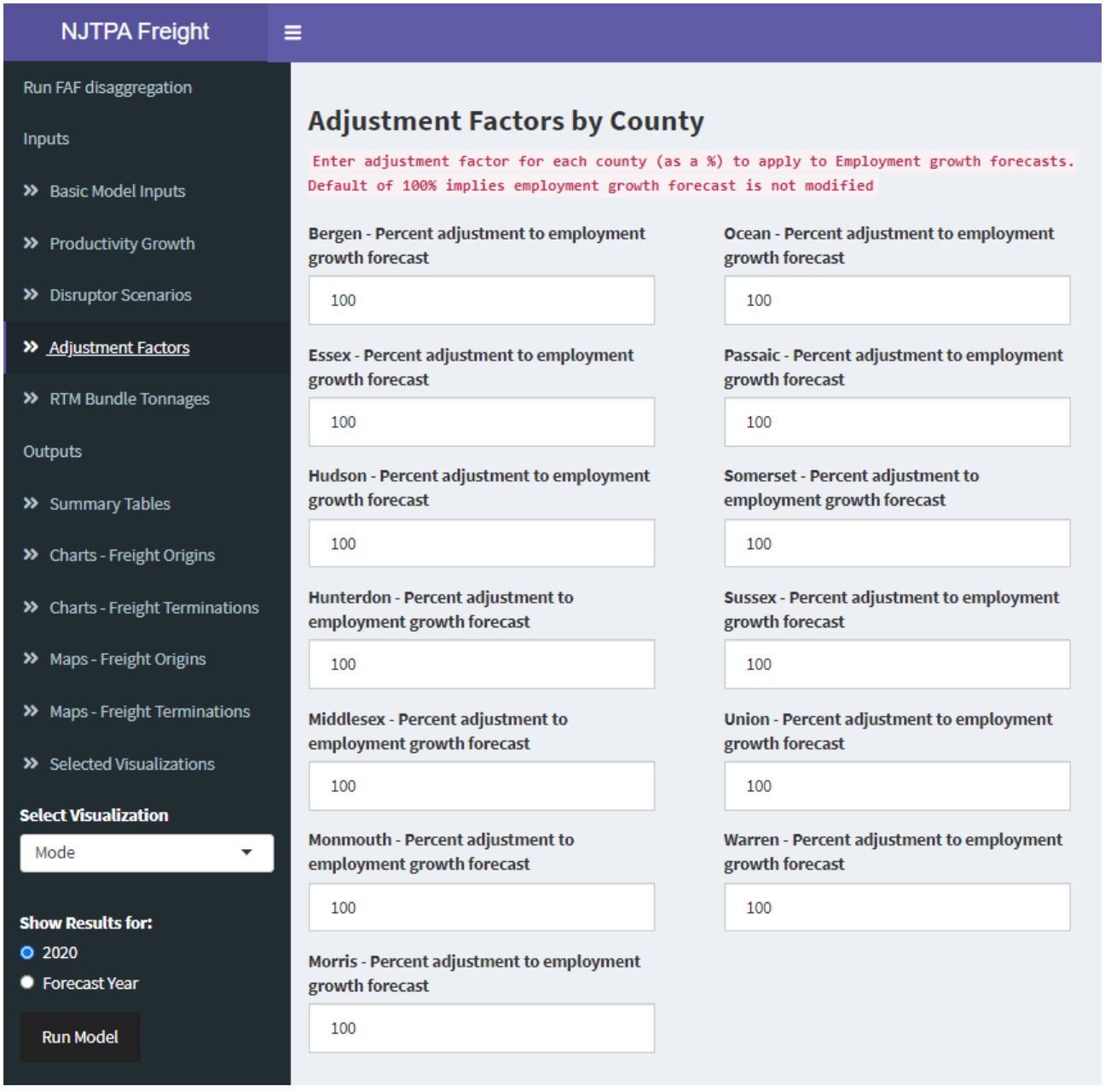
Figure D.14. FFT User Interface, Disruptor Scenarios Screen (2 of 2)



"Adjustment Factors by County"

This screen allows the User to modify the Moody's employment growth forecast for each NJTPA county upward or downward. The default value is 100; the effects of faster or slower growth in one or more selected counties can be tested by entering higher or lower percentages.

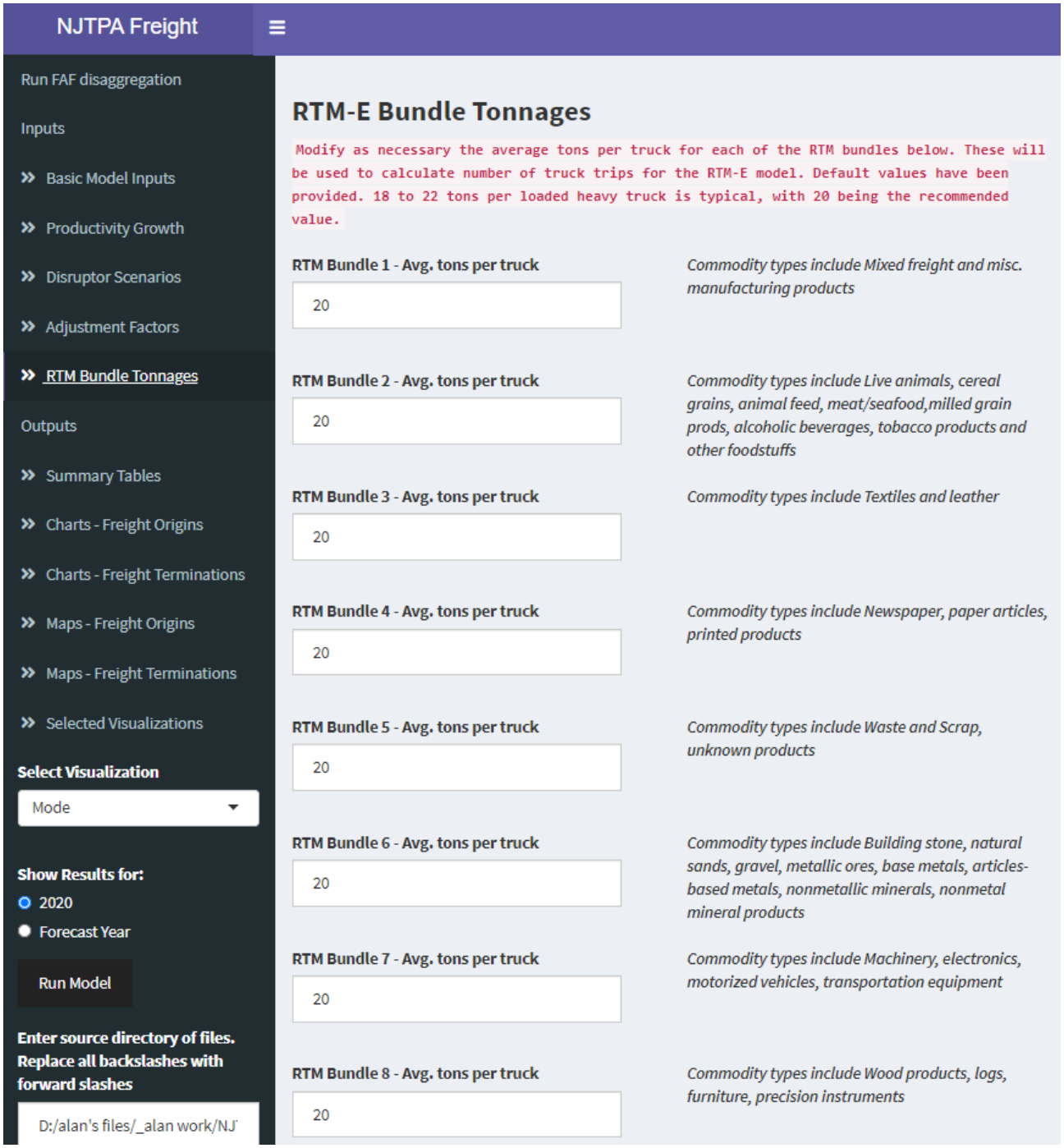
Figure D.15. FFT User Interface, Adjustment Factors by County



“RTM-E Bundle Tonnages”

This screen allows the User to modify the payload factors (tons per truck) used to convert the FFT tonnage forecast into RTM-E loaded truck trips. The default value is 20, with most commodity groups falling between 18 and 22, although certain commodities may be up to 25 tons and others significantly lower. Note there is no adjustment for Bundle 12 (E-Commerce), since those truck trips are estimated directly rather than being driven by the tonnage forecast.

Figure D.16. FFT User Interface, RTM-E Bundle Tonnages (partial view)



D.3.4 Tour of FFT User Interface Outputs

The FFT creates charts, maps, and visualizations upon completion of each model run. These are saved to the "Output Folder" (as discussed in Section D.4) and are also directly accessible by the user through the "Outputs" menu selection on the User Interface. This allows the User to immediately see the results of a model run in tabular, graphical, and map form, without having to exit the application. Images and data can be copied directly from the User Interface and pasted to Word documents, PowerPoint slides, Excel spreadsheets, etc. by right-clicking. Each time the FFT is launched, it clears any prior visualizations, so a model run must be completed before these viewing options are available. The menu items are as follows.

- **Summary Tables**. This view displays summary metrics for the selected scenario in table form. The user can view the data by: **Trade Type** (domestic, international, and linked trips); **Flow Type** (inbound, outbound, within NJTPA county, and within NJTPA region); **Domestic Mode**; **Foreign Mode**; and **Foreign Partner**. Metrics include 2020 tons and value, forecast year tons and value, change in tons and CAGR, and change in value and CAGR. The totals for all five views are identical. The number of data lines can be adjusted from 10 to 100, columns can be sorted by right-clicking on the arrows next to the column name, and the User can search for specific terms by entering them in the Search box.

- **Charts – Freight Origins**. This view displays a "Freight Origins Report" with bar charts showing tonnage and value originated by NJTPA County, under current and future forecast conditions.

- **Charts – Freight Terminations**. This view displays a "Freight Terminations Report" with bar charts showing tonnage and value terminated by NJTPA County, under current and future forecast conditions. Note that freight origins plus freight terminations will sum to more than the totals in the summary tables, because measuring at Origins and Terminations will capture volume at both ends of the trip, even if both ends are within an NJTPA county or the NJTPA region; the summary tables avoid this double-counting.

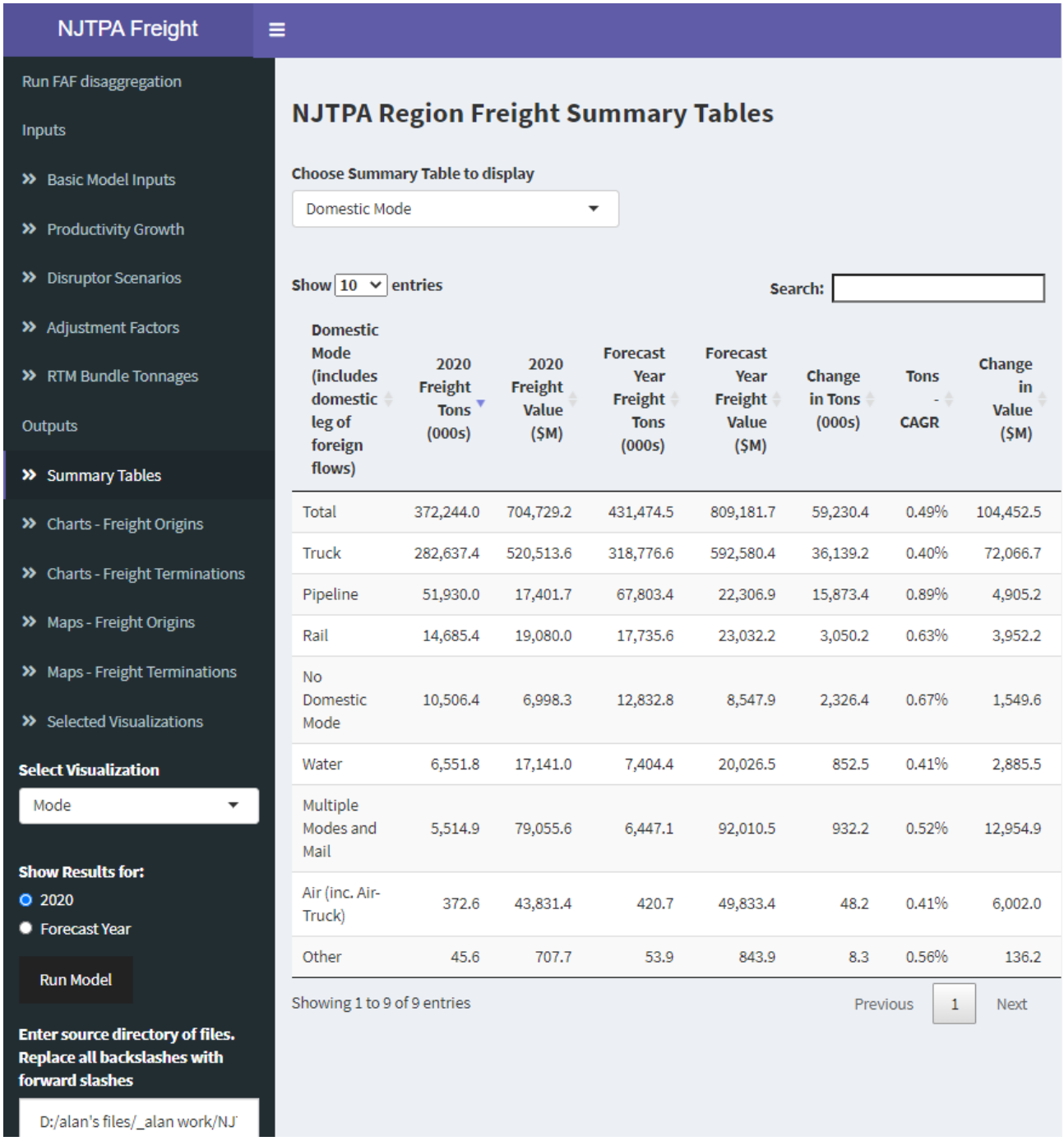
- **Maps – Freight Origins.** This view displays a "Freight Origins Report" where the User can choose to map 2020 tons, 2020 value, forecast year tons, or forecast year value from the pull-down menu. The User can zoom in or out using the "+" and "-" buttons or the mouse wheel, and can change the background visualization using the button below the "-" button.

- **Maps – Freight Terminations**. This view displays a "Freight Terminations Report" where the User can choose to map 2020 tons, 2020 value, forecast year tons, or

forecast year value. The User can zoom in or out using the "+" and "-" buttons or the mouse wheel and can change the background visualization using the button below the "-" button.

Selected Visualizations. In the list of Outputs, clicking on "Selected Visualizations" activates two additional functions: the "Select Visualization" pull-down menu, and the "Show Results for" selector buttons. These visualizations offer more in-depth reporting of the results. The pull-down menu options create bar chart displays for: Mode (by NJTPA county); Flow Direction (by NJTPA county); Commodity (regional level); and Foreign Trade (regional level). The buttons select whether the bar chart shows year 2020 results or forecast year results. Below the bar chart, the FFT displays a corresponding data table with: 2020 tons and value, forecast year tons and value, and (for reference) the associated 2040 tonnage and value projections taken directly from FAF, without any FFT processing. The number of data lines can be adjusted from 10 to 100, columns can be sorted by right-clicking on the arrows next to the column name, and the User can search for specific terms by entering them in the Search box.

Figure D.17. FFT User Interface, Outputs / Summary Tables



Domestic Mode (includes domestic leg of foreign flows)	2020 Freight Tons (000s)	2020 Freight Value ($M)	Forecast Year Freight Tons (000s)	Forecast Year Freight Value ($M)	Change in Tons (000s)	Tons - CAGR	Change in Value ($M)
Total	372,244.0	704,729.2	431,474.5	809,181.7	59,230.4	0.49%	104,452.5
Truck	282,637.4	520,513.6	318,776.6	592,580.4	36,139.2	0.40%	72,066.7
Pipeline	51,930.0	17,401.7	67,803.4	22,306.9	15,873.4	0.89%	4,905.2
Rail	14,685.4	19,080.0	17,735.6	23,032.2	3,050.2	0.63%	3,952.2
No Domestic Mode	10,506.4	6,998.3	12,832.8	8,547.9	2,326.4	0.67%	1,549.6
Water	6,551.8	17,141.0	7,404.4	20,026.5	852.5	0.41%	2,885.5
Multiple Modes and Mail	5,514.9	79,055.6	6,447.1	92,010.5	932.2	0.52%	12,954.9
Air (inc. Air-Truck)	372.6	43,831.4	420.7	49,833.4	48.2	0.41%	6,002.0
Other	45.6	707.7	53.9	843.9	8.3	0.56%	136.2

Figure D.18. FFT User Interface, Outputs / Charts / Freight Origins

Figure D.19. FFT User Interface, Outputs / Charts / Freight Terminations

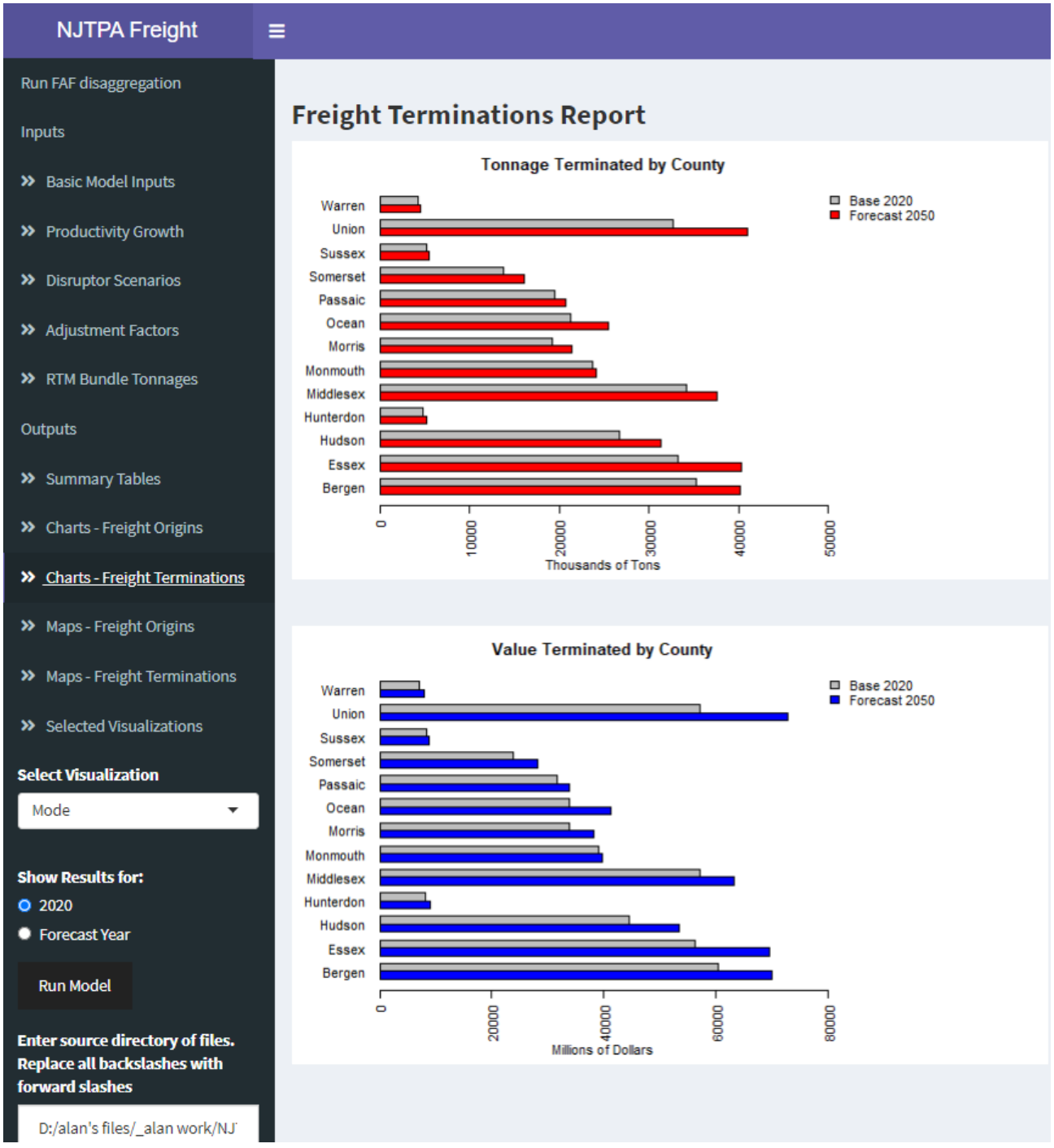


Figure D.20. FFT User Interface, Outputs / Maps / Freight Origins

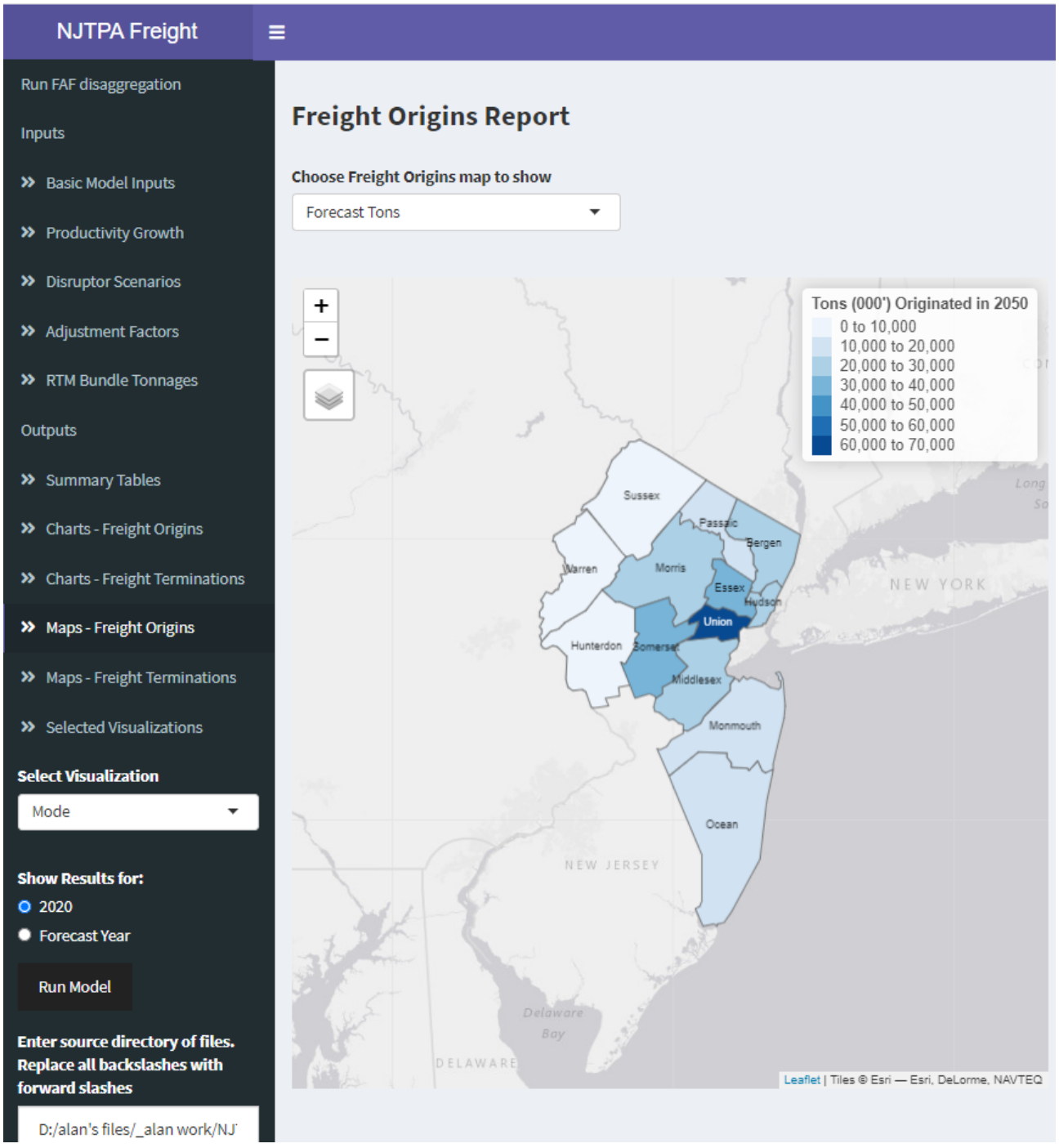


Figure D.21. FFT User Interface, Outputs / Maps / Freight Terminations

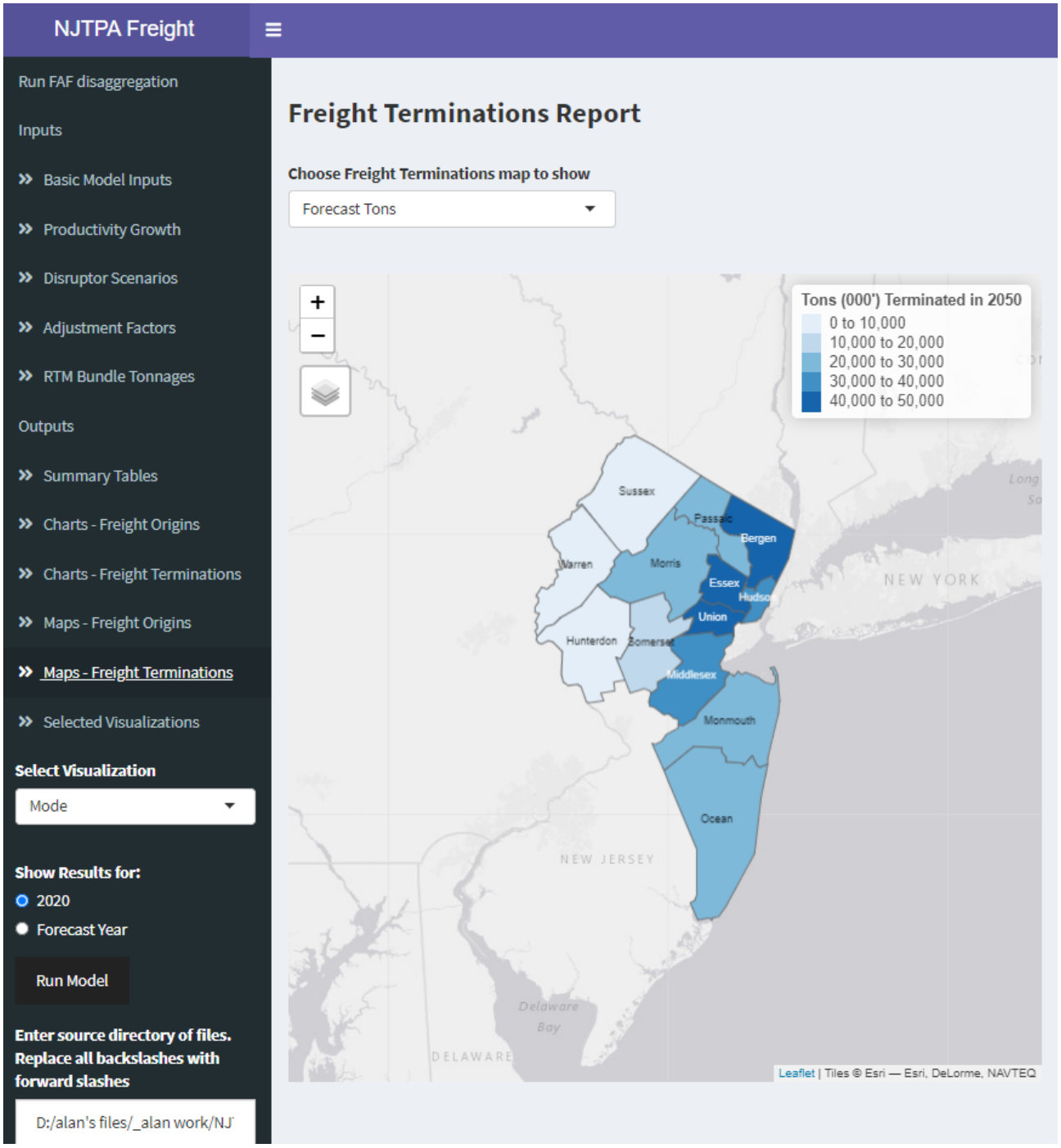
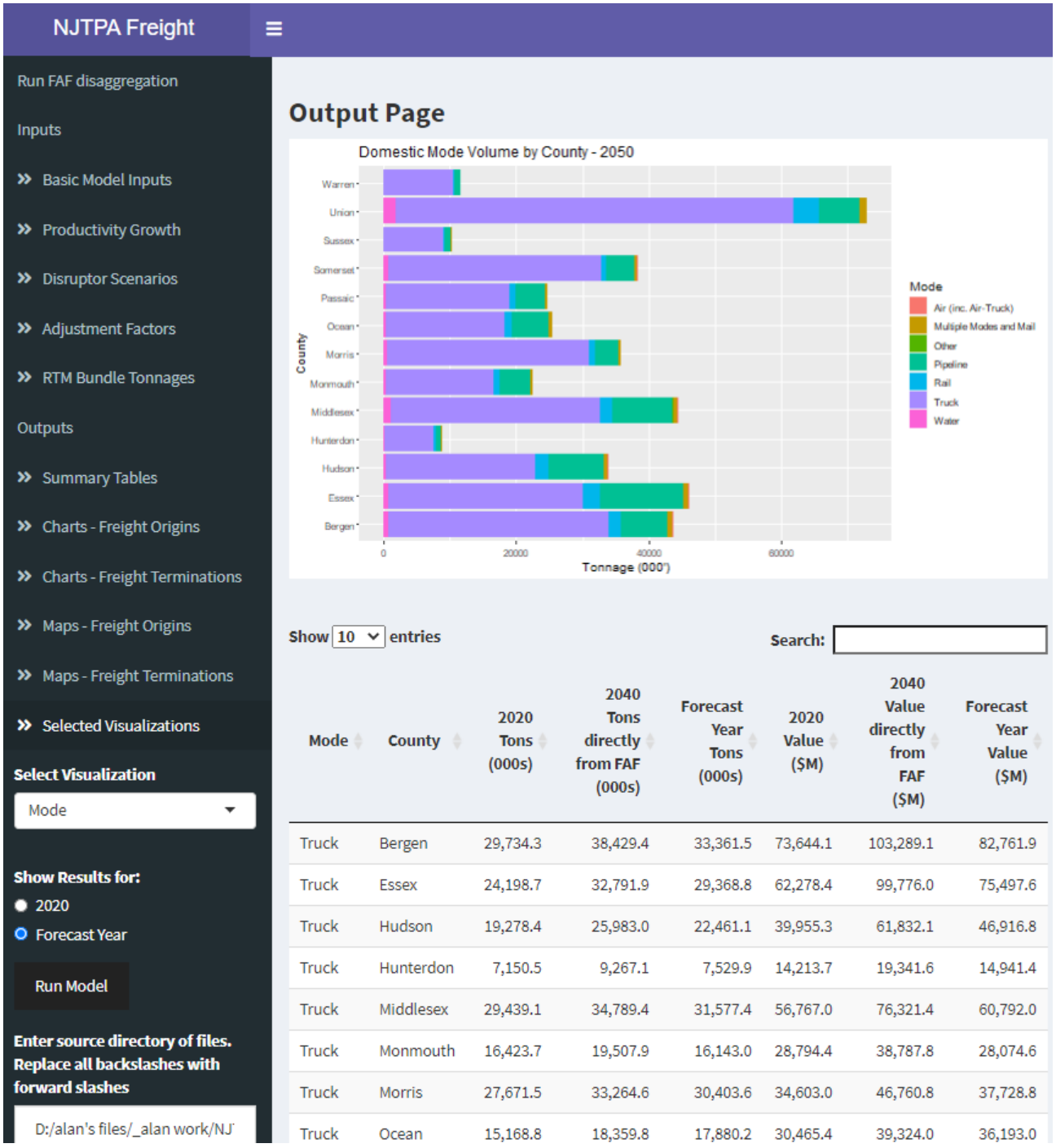


Figure D.22. FFT User Interface, Selected Visualizations / Mode



Mode	County	2020 Tons (000s)	2040 Tons directly from FAF (000s)	Forecast Year Tons (000s)	2020 Value ($M)	2040 Value directly from FAF ($M)	Forecast Year Value ($M)
Truck	Bergen	29,734.3	38,429.4	33,361.5	73,644.1	103,289.1	82,761.9
Truck	Essex	24,198.7	32,791.9	29,368.8	62,278.4	99,776.0	75,497.6
Truck	Hudson	19,278.4	25,983.0	22,461.1	39,955.3	61,832.1	46,916.8
Truck	Hunterdon	7,150.5	9,267.1	7,529.9	14,213.7	19,341.6	14,941.4
Truck	Middlesex	29,439.1	34,789.4	31,577.4	56,767.0	76,321.4	60,792.0
Truck	Monmouth	16,423.7	19,507.9	16,143.0	28,794.4	38,787.8	28,074.6
Truck	Morris	27,671.5	33,264.6	30,403.6	34,603.0	46,760.8	37,728.8
Truck	Ocean	15,168.8	18,359.8	17,880.2	30,465.4	39,324.0	36,193.0

Figure D.23. FFT User Interface, Selected Visualizations / Flow Direction

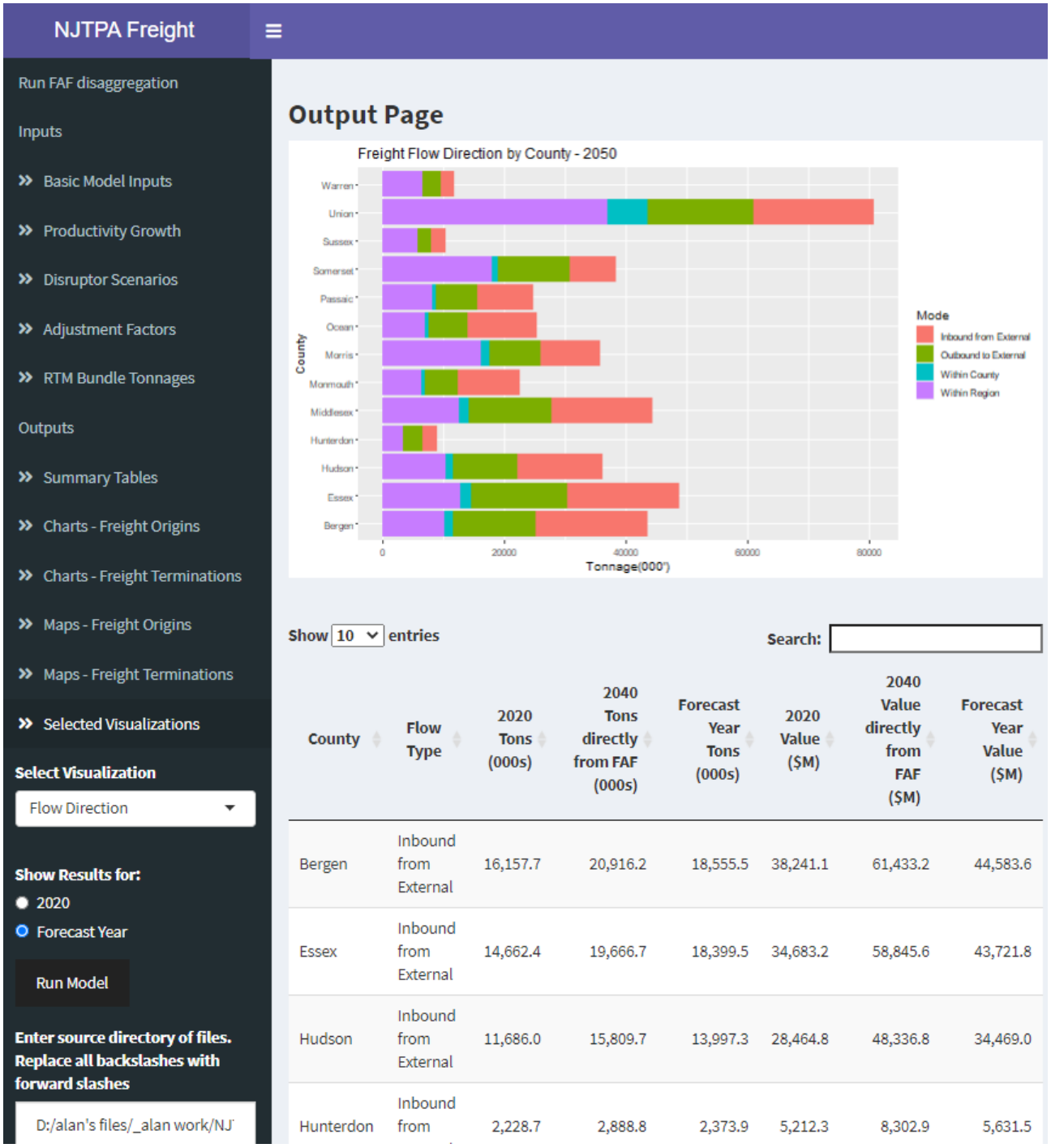
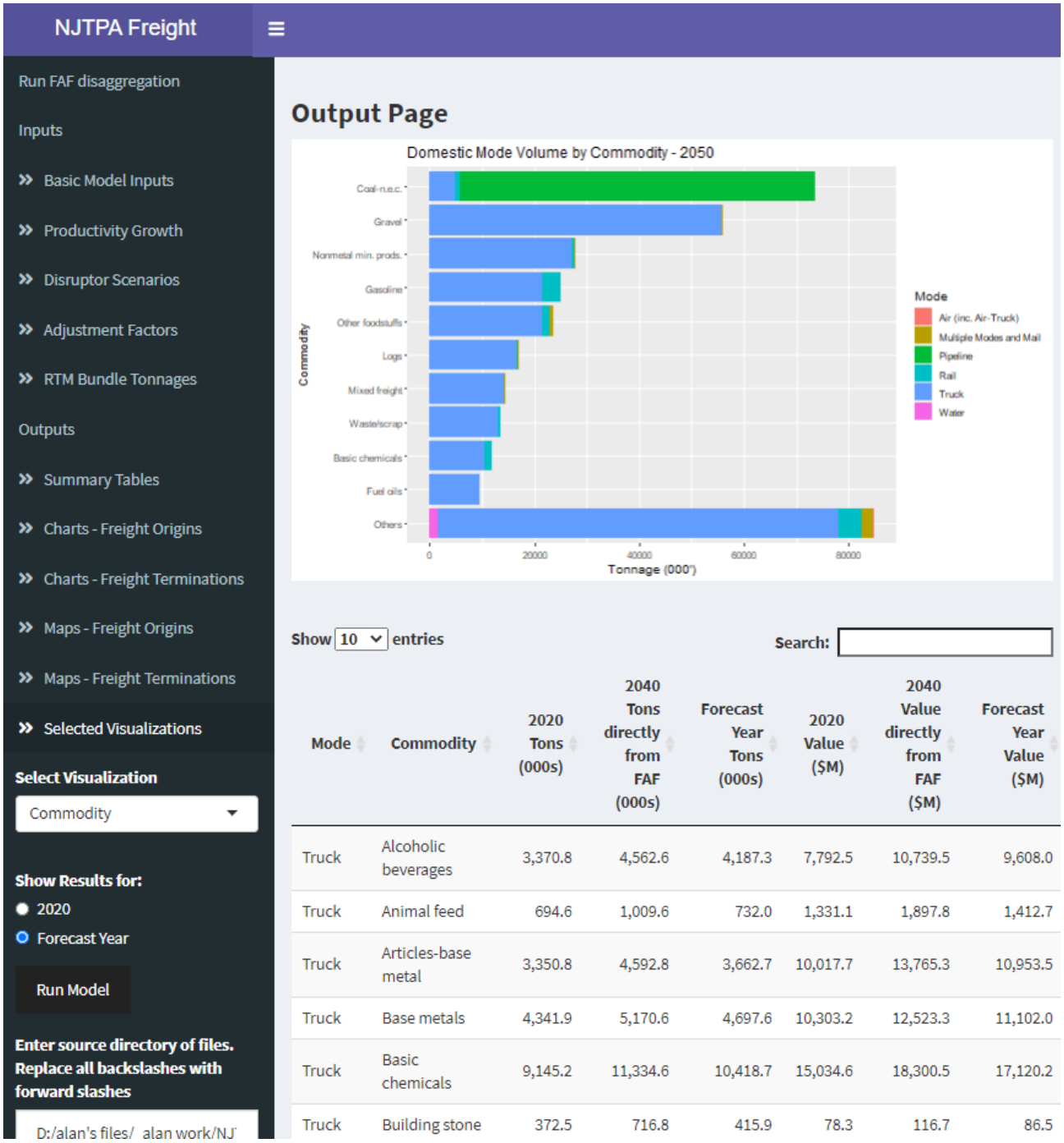
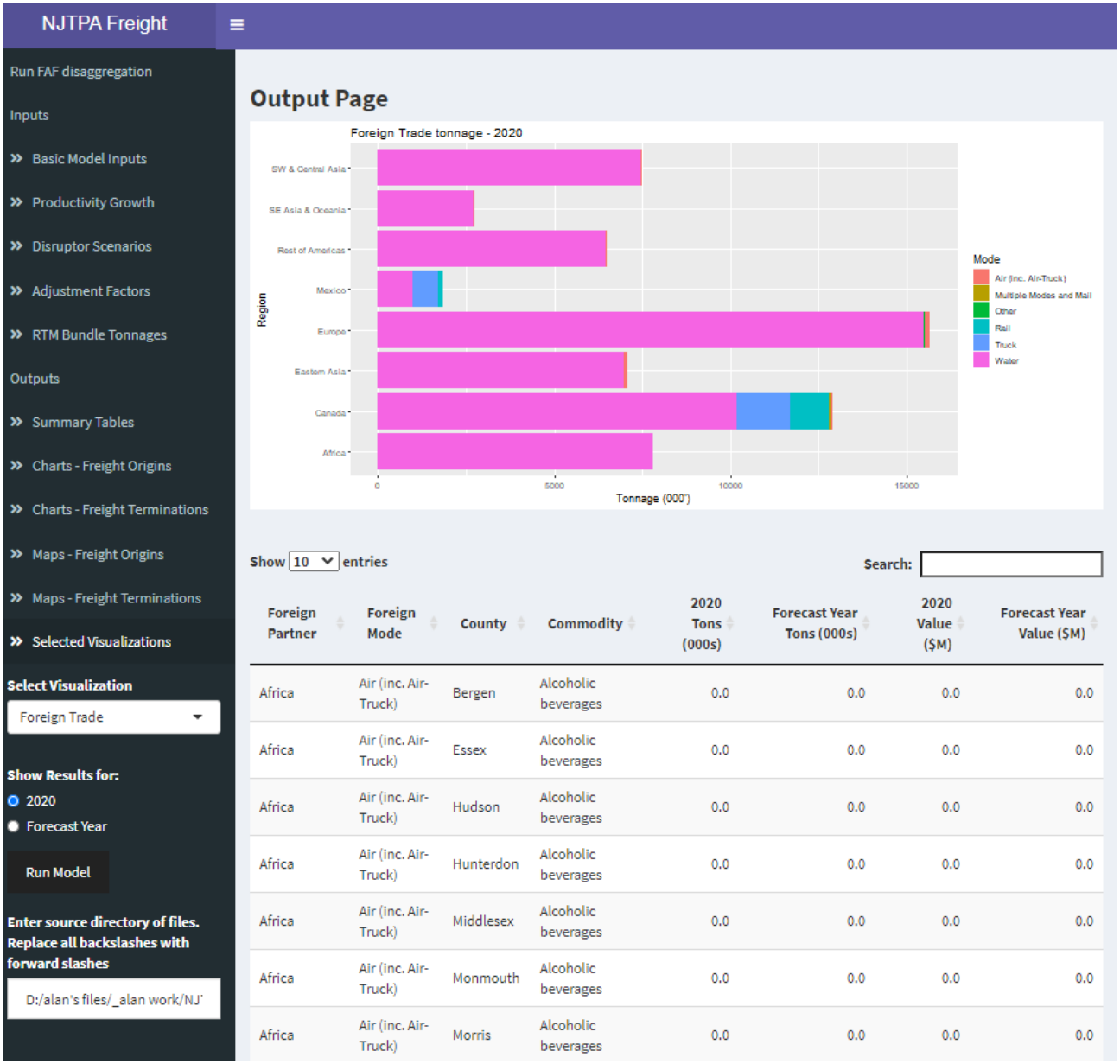


Figure D.24. FFT User Interface, Selected Visualizations / Commodity



Mode	Commodity	2020 Tons (000s)	2040 Tons directly from FAF (000s)	Forecast Year Tons (000s)	2020 Value ($M)	2040 Value directly from FAF ($M)	Forecast Year Value ($M)
Truck	Alcoholic beverages	3,370.8	4,562.6	4,187.3	7,792.5	10,739.5	9,608.0
Truck	Animal feed	694.6	1,009.6	732.0	1,331.1	1,897.8	1,412.7
Truck	Articles-base metal	3,350.8	4,592.8	3,662.7	10,017.7	13,765.3	10,953.5
Truck	Base metals	4,341.9	5,170.6	4,697.6	10,303.2	12,523.3	11,102.0
Truck	Basic chemicals	9,145.2	11,334.6	10,418.7	15,034.6	18,300.5	17,120.2
Truck	Building stone	372.5	716.8	415.9	78.3	116.7	86.5

Figure D.25. FFT User Interface, Selected Visualizations / Foreign Trade



Foreign Partner	Foreign Mode	County	Commodity	2020 Tons (000s)	Forecast Year Tons (000s)	2020 Value ($M)	Forecast Year Value ($M)
Africa	Air (inc. Air-Truck)	Bergen	Alcoholic beverages	0.0	0.0	0.0	0.0
Africa	Air (inc. Air-Truck)	Essex	Alcoholic beverages	0.0	0.0	0.0	0.0
Africa	Air (inc. Air-Truck)	Hudson	Alcoholic beverages	0.0	0.0	0.0	0.0
Africa	Air (inc. Air-Truck)	Hunterdon	Alcoholic beverages	0.0	0.0	0.0	0.0
Africa	Air (inc. Air-Truck)	Middlesex	Alcoholic beverages	0.0	0.0	0.0	0.0
Africa	Air (inc. Air-Truck)	Monmouth	Alcoholic beverages	0.0	0.0	0.0	0.0
Africa	Air (inc. Air-Truck)	Morris	Alcoholic beverages	0.0	0.0	0.0	0.0

D.4 FFT Output and Input Folders

As shown previously in Figure D.3, the directory of FFT files includes one directory called “Inputs” and one directory called “Outputs.” The inputs folder contains key data resources for the FFT, while the outputs folder is where the FFT places model results.

D.4.1 Output Folder

When the FFT completes a model run based on the User specifications, it saves copies of all the charts, maps, and visualizations to the “Outputs” folder. If the User is analyzing multiple scenarios, the User can copy/paste these files to a separate folder so they are not overwritten by the next FFT model run. The outputs are organized into separate folders for bar charts, excel summaries, and maps; and each folder provides two sets of results, one with the application of disruptors and one without the application of disruptors, allowing the user to evaluate the effect of the disruptors. Note that if no disruptors are activated, the With Disruptors folders will be empty.

Figure D.26. FFT Outputs Folder Structure

First Level	Second Level	Third Level	Contents
Outputs	Bar Charts	With Disruptors	PNG files; same visualizations as the FFT UI, plus: • Incremental commodity tonnage • Mode shares by county, 2020 • Mode shares by county, forecast
		Without Disruptors	
	Excel Summaries	With Disruptors	CSV files; same tables as the FFT UI, plus: • Tabular summary of data for the Bar Chart and Map visualizations • Complete Freight Forecast results with record-level detail, including 2020 and forecast year, allowing further analysis in Excel, Access, or other software • RTM-E daily E-commerce trips • RTM-E daily truck trips
		Without Disruptors	
		Out_Employment (file with employment by county/industry by year)	
	Maps	With Disruptors	PNG files; same visualizations as the FFT UI
		Without Disruptors	

D.4.2 Input Folder

The FFT draws on several different kinds of inputs to perform processing:

Figure D.27. FFT Inputs Folder Structure

First Level	Second Level	File Content
Inputs	Employment and Make-Use	*Data_MakeUse:* Make-Use table linking industries and commodities Data_Moody_Cambridge_NJ_Jan20: the Moody's forecast data *Industry_and_bundle_names*: NJTPA specifications for converting commodity tons to bundles
	FAF and Join Data	*FAF 451:* original FAF text file *NJ II IE EI II:* disaggregated FAF text file *Ecommerce_table*: current year e-commerce volume *2020_Daily Truck, 2050_Daily Truck,* and *NJTPA_TAZ_FIPS*: County-to-TAZ disaggregation specs to produce RTM-E trip tables Commodity, Counties in FAF 341, Zone, Xwalk files (9): used in FAF disaggregation
	Map Metadata	Shapefiles for county-level maps
	User Input (file with values for user-defined factors)	

D.5 Updating the FFT

D.5.1 Integrating an Updated Version of FAF

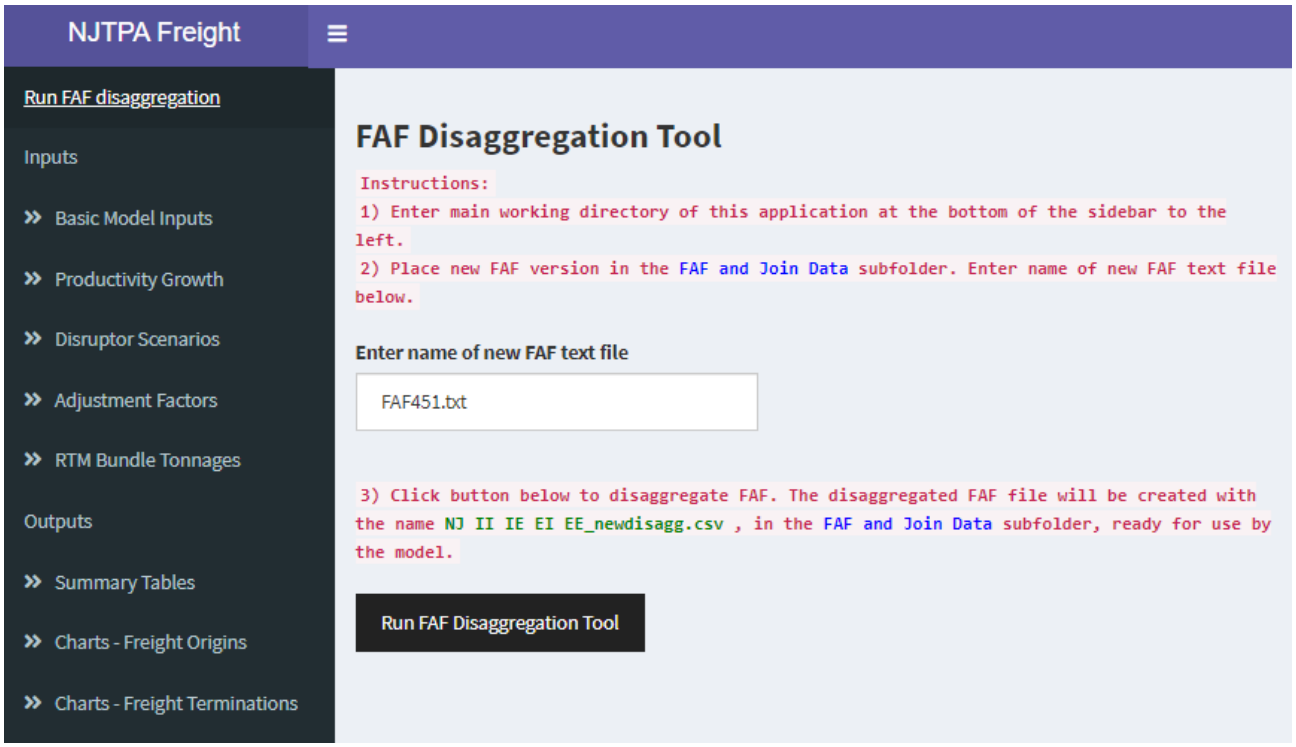
It is anticipated that sometime during the functional lifespan of the FFT, a new version of FAF will be released by USDOT with an updated base year. The FFT includes an application that will take the new version of FAF, apply disaggregation factors to take FAF from BEA level geography to county level geography, and make the new FAF accessible to the User within the FFT. Processing steps and requirements are as follows:

1. Ensure the new FAF has the same structure and column / field naming as the existing FAF. If it does not, it must be modified to conform to the existing FAF structure for FFT processing to be implemented

2. Open the FFT and click on the top-left menu option, “Run FAF Disaggregation.” Ensure your working directory is set correctly, as described in Section E.3.2. Place the new FAF tata as a text file in the working directory, in the “Inputs/FAF and Join Data” subfolder, Enter the name of the of the new FAF text file in the input box.

3. After completing these steps, click the “Run FAF Disaggregation Tool” button. This will create the new disaggregation in the FAF and Join Data subfolder. It will then be accessible as a User option under Basic Model Inputs.

Figure D.28. FAF Disaggregation Tool



Every reasonable effort has been made to provide FFT with the ability to adapt its functions and processes to work seamlessly with an updated forecast. However, it is possible that some of the R code may need to be revised. Updating code in R is a straightforward and transparent process – the User has already done this, as discussed in Section D.3.2 – and the required changes could be identified and provided to NJTPA.

D.5.2 Updating Other Inputs

Other required FFT inputs are even simpler to update. Simply replace an existing spreadsheet input file with an identically formatted update file. This applies to the:

- Employment and Make-Use folder
    - Moody's forecast
    - Make-Use tables
    - Definition of bundles
- FAF and Join Data folder
    - E-commerce forecast
    - TAZ disaggregation specifications
- Map Metadata
    - County shapefiles

Again, while substantive changes to the FFT will not be required for any of these updates, it is possible that some of the R code may need to be revised. For example, the commodities associated with the bundles as currently defined are listed on the "RTM-E Bundle Tonnages" input screen for the convenience of the User and changing the bundle definitions would call for this text to be updated. Required changes, if any, should be minor and could be identified and provided to NJTPA.

D.5.3 Adding New Functions

The open-ended design of the FFT allows for the addition of new functions -- different disruptor scenarios, different output displays, etc. – should NJTPA wish to explore them.

D.6 FFT Test Runs

To illustrate the results of the FFT in use, five test runs were performed. The scenarios were selected to illustrate different analytical capabilities of the FFT. For purposes of comparison, different types of summaries are presented to show how the scenarios vary. The Scenarios, all for forecast year 2050, are:

- #1: Base Forecast
- #2: Low Oil Price Forecast
    - Compared to #1, growth in tonnage and value is higher, reflecting the stimulus effect of lower fuel prices.
- #3: Low Oil Price with 2-Year Delay
    - The 2-year delay produces slightly lower forecast tonnage and value than #2, but the delay does not fully offset the positive effect of low oil prices, so growth is higher than #1.
- #4: Low Oil Price with 2-Year Delay, Trade War, Higher Self-Sufficiency
    - Forecast tonnage and value are the same as #3, but more tonnage and value is moving within the NJTPA region and less is moving inbound from external regions.
- #5: Low Oil Price with 2-Year Delay, Trade War, Higher Self-Sufficiency, Mode Shift to Rail
    - Forecast tonnage and value are the same as #3 and #4; rail volume is increased while truck volume is reduced, and other modes remain constant; and the flow direction is slightly changed from #4 (because rail flows are primarily inbound from external, increasing rail also increases that segment of volume).

The differences between scenarios are subtle but evident. More aggressive adjustments will produce more pronounced changes from the Base Forecast. Overall, the test runs demonstrate the FFT produces consistent output that reflects User-defined input assumptions.

Figure D.29. Scenario 1 Results (Trade Type)

Flow Type	2020 Freight Tons (000s)	2020 Freight Value ($M)	Forecast Year Freight Tons (000s)	Forecast Year Freight Value ($M)	Change in Tons (000s)	Tons - CAGR	Change in Value ($M)	Value - CAGR
Total	372,244.0	704,729.2	431,474.5	809,181.7	59,230.4	0.49%	104,452.5	0.46%
Within Region	135,873.8	151,890.8	153,729.9	174,438.3	17,856.1	0.41%	22,547.5	0.46%
Inbound from External	123,508.7	290,652.8	142,522.9	339,115.3	19,014.2	0.48%	48,462.4	0.52%
Outbound to External	98,317.9	243,878.0	118,204.8	273,838.7	19,887.0	0.62%	29,960.6	0.39%
Within County	14,543.7	18,307.6	17,016.8	21,789.5	2,473.1	0.52%	3,481.9	0.58%

Figure D.30. Scenario 2 Results (Flow Type)

Flow Type	2020 Freight Tons (000s)	2020 Freight Value ($M)	Forecast Year Freight Tons (000s)	Forecast Year Freight Value ($M)	Change in Tons (000s)	Tons - CAGR	Change in Value ($M)	Value - CAGR
Total	372,244.0	704,729.2	434,579.2	814,517.2	62,335.2	0.52%	109,787.9	0.48%
Within Region	135,873.8	151,890.8	154,942.5	175,667.8	19,068.8	0.44%	23,777.1	0.49%
Inbound from External	123,508.7	290,652.8	143,524.2	341,287.7	20,015.4	0.50%	50,634.9	0.54%
Outbound to External	98,317.9	243,878.0	118,954.5	275,615.2	20,636.6	0.64%	31,737.2	0.41%
Within County	14,543.7	18,307.6	17,158.0	21,946.5	2,614.4	0.55%	3,638.8	0.61%

Figure D.31. Scenario 3 Results (Flow Type)

Flow Type	2020 Freight Tons (000s)	2020 Freight Value ($M)	Forecast Year Freight Tons (000s)	Forecast Year Freight Value ($M)	Change in Tons (000s)	Tons - CAGR	Change in Value ($M)	Value - CAGR
Total	372,244.0	704,729.2	433,789.6	812,000.8	61,545.6	0.51%	107,271.6	0.47%
Within Region	135,873.8	151,890.8	153,771.4	174,693.2	17,897.7	0.41%	22,802.4	0.47%
Inbound from External	123,508.7	290,652.8	142,984.5	340,421.3	19,475.8	0.49%	49,768.5	0.53%
Outbound to External	98,317.9	243,878.0	120,052.6	275,099.8	21,734.7	0.67%	31,221.7	0.40%
Within County	14,543.7	18,307.6	16,981.1	21,786.6	2,437.4	0.52%	3,479.0	0.58%

Figure D.32. Scenario 4 Results (Flow Type and Domestic Mode)

Flow Type	2020 Freight Tons (000s)	2020 Freight Value ($M)	Forecast Year Freight Tons (000s)	Forecast Year Freight Value ($M)	Change in Tons (000s)	Tons - CAGR	Change in Value ($M)	Value - CAGR
Total	372,244.0	704,729.2	433,789.6	812,000.8	61,545.6	0.51%	107,271.6	0.47%
Within Region	135,873.8	151,890.8	166,766.2	182,084.6	30,892.4	0.69%	30,193.8	0.61%
Inbound from External	123,508.7	290,652.8	128,104.6	330,581.0	4,595.9	0.12%	39,928.1	0.43%
Outbound to External	98,317.9	243,878.0	120,451.0	276,627.3	22,133.1	0.68%	32,749.3	0.42%
Within County	14,543.7	18,307.6	18,467.9	22,707.9	3,924.2	0.80%	4,400.3	0.72%

Domestic Mode (includes domestic leg of foreign flows)	2020 Freight Tons (000s)	2020 Freight Value ($M)	Forecast Year Freight Tons (000s)	Forecast Year Freight Value ($M)	Change in Tons (000s)	Tons - CAGR	Change in Value ($M)	Value - CAGR
Total	372,244.0	704,729.2	433,789.6	812,000.8	61,545.6	0.51%	107,271.6	0.47%
Truck	282,637.4	520,513.6	324,585.7	597,873.2	41,948.3	0.46%	77,359.6	0.46%
Pipeline	51,930.0	17,401.7	67,489.6	22,653.8	15,559.6	0.88%	5,252.1	0.88%
Rail	14,685.4	19,080.0	15,569.8	21,704.0	884.4	0.20%	2,624.0	0.43%
No Domestic Mode	10,506.4	6,998.3	13,124.4	8,690.0	2,618.1	0.74%	1,691.7	0.72%
Water	6,551.8	17,141.0	6,720.4	19,390.9	168.6	0.08%	2,250.0	0.41%
Multiple Modes and Mail	5,514.9	79,055.6	5,849.9	91,686.6	335.0	0.20%	12,631.1	0.50%
Air (inc. Air-Truck)	372.6	43,831.4	399.3	49,164.9	26.8	0.23%	5,333.5	0.38%
Other	45.6	707.7	50.5	837.4	4.8	0.34%	129.7	0.56%

Figure D.33. Scenario 5 Results (Flow Type and Domestic Mode)

Flow Type	2020 Freight Tons (000s)	2020 Freight Value ($M)	Forecast Year Freight Tons (000s)	Forecast Year Freight Value ($M)	Change in Tons (000s)	Tons - CAGR	Change in Value ($M)	Value - CAGR
Total	372,244.0	704,729.2	433,789.6	812,000.8	61,545.6	0.51%	107,271.6	0.47%
Within Region	135,873.8	151,890.8	166,132.4	179,820.6	30,258.6	0.67%	27,929.8	0.56%
Inbound from External	123,508.7	290,652.8	128,995.6	334,396.8	5,486.8	0.14%	43,744.0	0.47%
Outbound to External	98,317.9	243,878.0	120,258.5	275,356.3	21,940.7	0.67%	31,478.3	0.41%
Within County	14,543.7	18,307.6	18,403.1	22,427.2	3,859.5	0.79%	4,119.6	0.68%

Domestic Mode (includes domestic leg of foreign flows)	2020 Freight Tons (000s)	2020 Freight Value ($M)	Forecast Year Freight Tons (000s)	Forecast Year Freight Value ($M)	Change in Tons (000s)	Tons - CAGR	Change in Value ($M)	Value - CAGR
Total	372,244.0	704,729.2	433,789.6	812,000.8	61,545.6	0.51%	107,271.6	0.47%
Truck	282,637.4	520,513.6	323,147.7	588,598.3	40,510.3	0.45%	68,084.7	0.41%
Pipeline	51,930.0	17,401.7	67,489.6	22,653.8	15,559.6	0.88%	5,252.1	0.88%
Rail	14,685.4	19,080.0	17,007.8	30,978.9	2,322.4	0.49%	11,898.9	1.63%
No Domestic Mode	10,506.4	6,998.3	13,124.4	8,690.0	2,618.1	0.74%	1,691.7	0.72%
Water	6,551.8	17,141.0	6,720.4	19,390.9	168.6	0.08%	2,250.0	0.41%
Multiple Modes and Mail	5,514.9	79,055.6	5,849.9	91,686.6	335.0	0.20%	12,631.1	0.50%
Air (inc. Air-Truck)	372.6	43,831.4	399.3	49,164.9	26.8	0.23%	5,333.5	0.38%
Other	45.6	707.7	50.5	837.4	4.8	0.34%	129.7	0.56%

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