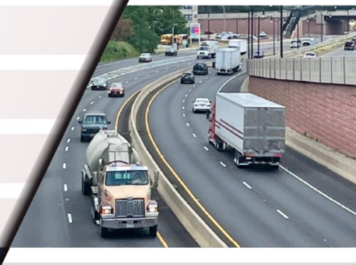
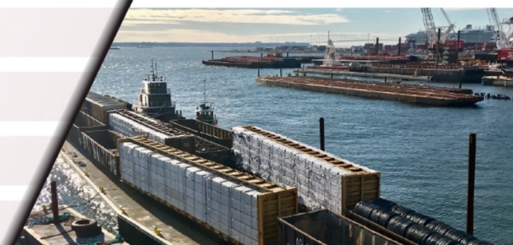


2050

FREIGHT INDUSTRY LEVEL FORECASTS UPDATE



prepared for

North Jersey Transportation Planning Authority

prepared by

Cambridge Systematics, Inc.

with

BJH Advisors, LLC

NJTPA NORTH JERSEY TRANSPORTATION PLANNING AUTHORITY

2050 Freight Industry Level Forecasts Update

Final Report

prepared for

The North Jersey Transportation Planning Authority

prepared by

Cambridge Systematics, Inc.
38 East 32nd Street, 7th Floor
New York, NY 10016

with

BJH Advisors, LLC

date

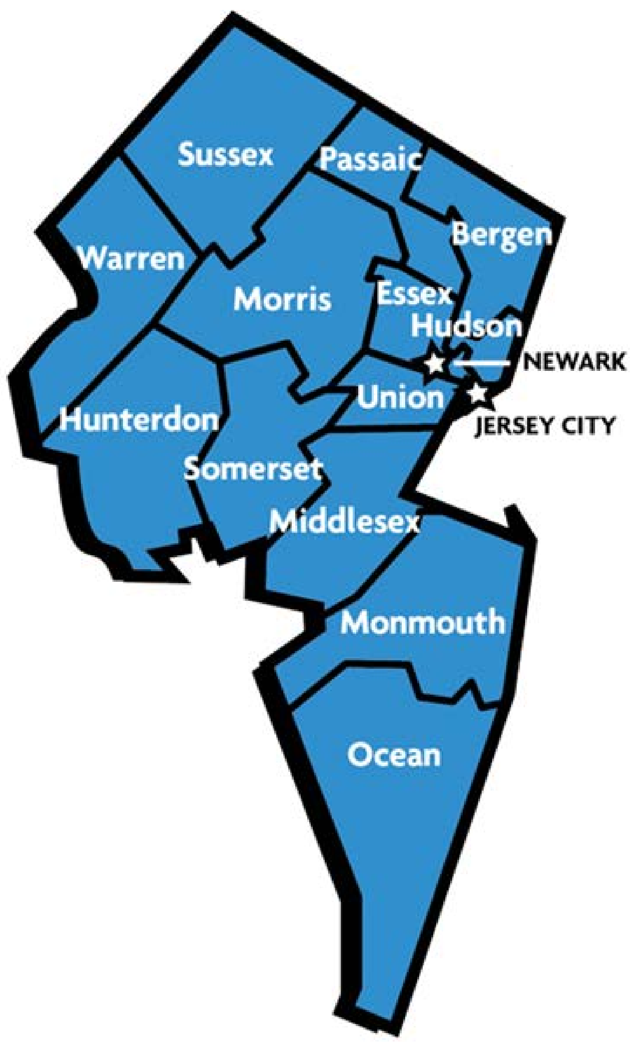
June 30, 2025

Disclaimer

About the NJTPA

The North Jersey Transportation Planning Authority (NJTPA) is the federally authorized Metropolitan Planning Organization (MPO) for the 13-county northern New Jersey region, home to 7 million people. It evaluates and approves transportation improvement projects, provides a forum for cooperative transportation planning, sponsors and conducts studies, assists county and city planning agencies, and monitors compliance with air quality goal.

The NJTPA Board includes 15 local elected officials representing 13 counties—Bergen, Essex, Hudson, Hunterdon, Middlesex, Monmouth, Morris, Ocean, Passaic, Somerset, Sussex, Union and Warren—and the cities of Newark and Jersey City. The Board also includes a Governor's Representative, the Commissioner of the New Jersey Department of Transportation (NJDOT), the President and CEO of NJ TRANSIT, the Chairman of the Port Authority of New York & New Jersey and a Citizens' Representative appointed by the Governor.



List of Acronyms

ACS	American Community Survey, a Census product
BJH	BJH Advisors, LLC
BTS	Bureau of Transportation Statistics
CAGR	Compound Annual Growth Rate
CFS	Commodity Flow Survey
CMA	Census Metropolitan Area
CPI	Consumer Price Index
CS	Cambridge Systematics, Inc.
CSS	Cascading Style Sheets
DC	Distribution Center
DTC	Direct-to-Consumer, the delivery of orders to a consumer's specified location
E-E	External-to-External, or through flows
E-I	External-to-Internal, or inbound flows
FAF	Freight Analysis Framework, a freight database developed by FHWA and BTS
FC	Fulfillment Center
FFT	Freight Forecasting Tool
FHWA	Federal Highway Administration
FIPS	Federal Information Processing Standards, a coding system for geographic units
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Global Positioning Satellite, a technology that tracks the position of vehicles over time
GSP	Gross State Product
HTML	HyperText Markup Language
I-E	Internal-to-External, or outbound flows
I-I	Internal-to-Internal, or flows that move within the region
IMX	Intermodal
LBS	Location-Based Services
NAICS	North American Industry Classification System
NDC	Navigational Data Center
NJDOT	New Jersey Department of Transportation
NJRTM-E	North Jersey Regional Travel Model-Enhanced
NJTPA	North Jersey Transportation Planning Authority
NN	Nearest Neighbor, an algorithm that uses stop proximity to build tours

NNN	Triple Net, a lease agreement where the tenant agrees to pay costs such as real estate taxes, building insurance, and utilities.
O-D	Origin-Destination
PANYNJ	Port Authority of New York and New Jersey
R	A coding language used to develop the FFT
SCTG	Standard Classification of Transported Goods
STB	Surface Transportation Board
TAC	Technical Advisory Committee
TAZ	Traffic Analysis Zone
UPS	United Parcel Service, Inc.
USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation
USPS	United States Postal Service
ZBP	Zip code Business Patterns
ZCTA	Zip Code Tabulation Area

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Executive Summary

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. For more than a decade, the North Jersey Transportation Authority (NJTPA) has developed, and periodically enhanced, its freight forecasting capabilities to make use of new and improved data and analysis methods.

These forecasts also informed the development of *Connecting Communities*: *The NJTPA Long Range Transportation Plan* (LRTP), which the Board of Trustees is expected to adopt in September 2025. The LRTP sets a vision for the future of transportation in the region over the next 25 years. Key highlights of freight movement in the NJTPA region include the following:

- **502 million tons of freight** are projected to move in, out, and within the region in 2050. This is **a 26 percent increase from the 399 million tons in 2025**.
- **Approximately 70 percent of freight tonnage will move by truck**, 23 percent by pipelines, 5 percent by rail, and 2 percent by domestic maritime.
- **E-commerce package deliveries increased by 237 percent from 2018 to 2023** in the NJTPA region, slightly outpacing the 217 percent growth at the national level. **Package deliveries are expected to increase an additional 152 percent by 2050**.

The latest forecasts are a bit different from past efforts. Prior to the initiation of this study, the 2050 Freight Industry Level Forecasts Study was completed in Spring 2020 as the COVID-19 pandemic was unfolding and its effects on supply chains and goods movement were not yet apparent. Since the completion of that study, consumers' demand for ordering products delivered to their doorsteps increased substantially. In response to supply chain disruptions and volatile transportation costs, many producers and retailers altered their inventory and logistics networks to build more resiliency into their supply chains.

These observations suggest that "business as usual" freight forecasting scenarios developed prior to the onset of this pivotal pandemic event are out-of-sync with realistic assumptions about current observations and near term (i.e., five to 10 year) forecasting horizons. In addition, longer-term forecast horizons ought to be reexamined as well considering how the movement of goods and consumer demands appear to have been changed for the long-term. Developing an updated baseline freight commodity flow database and updating the forecast scenarios to account for current outlooks helps the NJTPA to maintain confidence in and credibility of its Freight Forecasting Tool (FFT).

The 2050 Freight Industry Level Forecasts Update, therefore, has tapped updated data on commodity flows in the region, updated economic forecasts, e-commerce parcels, and business location data, and new sources of information regarding e-commerce parcel logistics, delivery vehicle movements, and facility-level truck trip generation estimates to update and enhance the FFT. In addition, improvements to the user interface and operability of the FFT itself and a public-facing dashboard summarizing forecast results in different economic growth scenarios was developed.

The 2050 Freight Industry Level Forecasts Update 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/will be moving and where strategic investments should be considered to support economic growth and enhance regional resiliency. The results of this work will serve as background for the next NJTPA Long Range Transportation Plan as well as freight planning and subregional planning studies.

Highlights of the methodological approach and outcomes to the study include:

- An updated disaggregation of the latest version of the U.S. DOT's Freight Analysis Framework (FAF) database to the subregional level (all 13 counties and the cities of Newark and Jersey City). Whereas previous NJTPA freight forecasting studies disaggregated FAF to the county level, this study included disaggregation to the two major cities as well.
- An enhanced approach to estimating e-commerce delivery trips. Whereas the 2050 Freight Industry Level Forecasts Study relied on consumer market research data and secondary research on carrier logistics systems, new data and analysis tools, including package scan history and truck GPS data, have been applied to improve the estimation of delivery vehicle origin-destination pairings.
- Updates and enhancements to the database of freight-generating business locations, applying a variety of industrial real estate and business information databases, along with estimates of daily truck trips generated.
- Improvements to the FFT's user interface, processing capabilities, and the development of revised and new "What-If" forecast adjustments.
- An online dashboard that displays forecast results for three forecast scenarios, with results displayed at the regional, subregional, and commodity bundle level.

Figure 1 is a flow chart diagram that illustrates the progression and relationship of steps for completing this study and its deliverables. It includes a step-by-step approach divided into three categories: preparation activities; key technical analyses; and presenting the results.

The steps in the diagram are listed by number, in order of sequence, and the numbers do not correspond to task numbers in the contract for the current study. This framework is explained below:

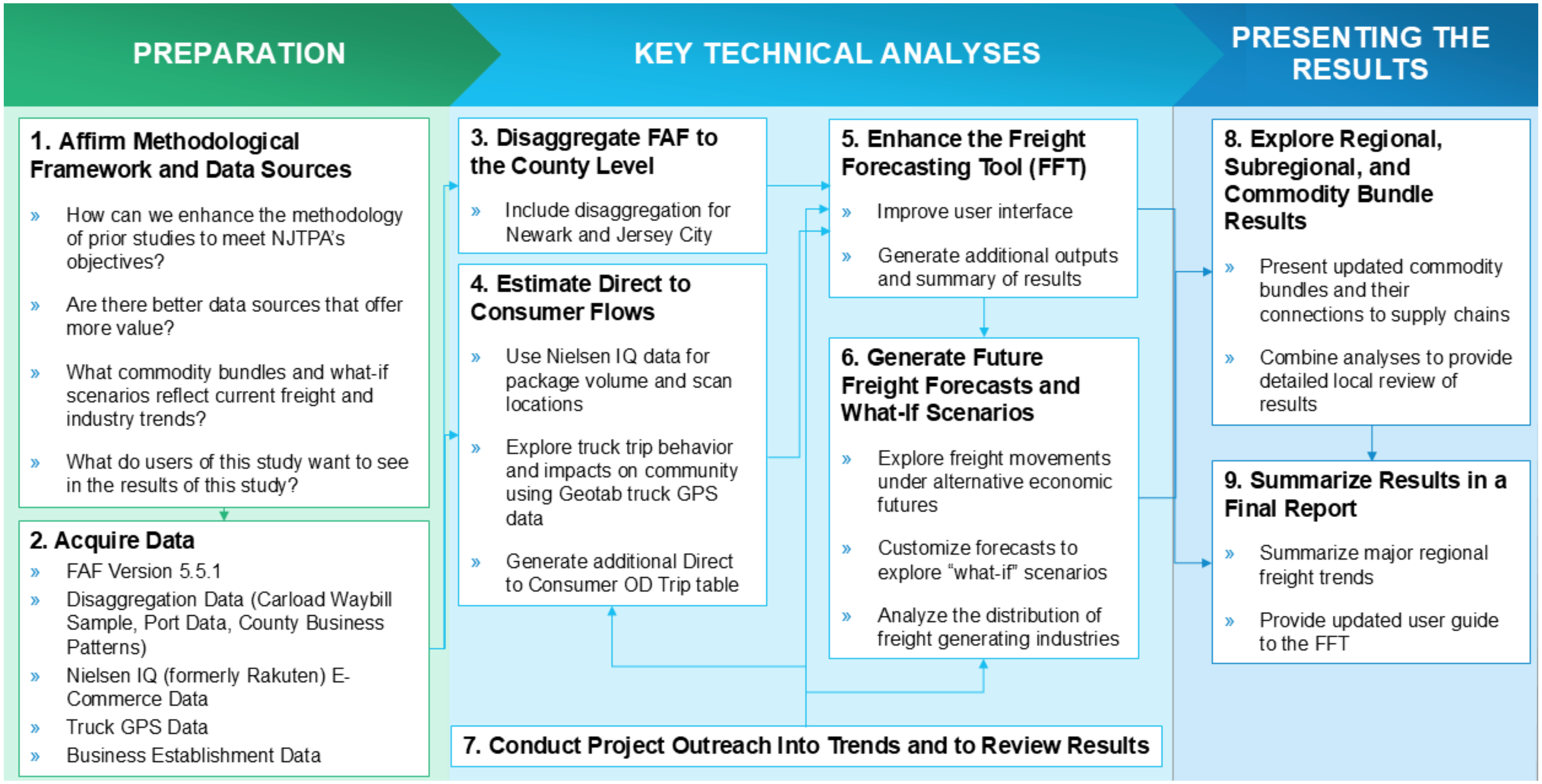
- **Preparation** – These are the steps to affirm the goals, objectives, and approach to the study as well as a plan for obtaining the data sources needed for the technical analyses.
  - **Step One: Affirm Methodological Framework and Data Sources** – This step was critical to laying out the goals and objectives of the study and exploring a variety of approaches and data sources to accomplish them. Key to the development of the methodological framework for this study update was to affirm the FAF disaggregation approach, commodity bundle makeup, approach to Direct to Consumer (DTC) trip table development, updates to the FFT, and the format of the planned results.
  - **Step Two: Acquire Data** – This step sought to acquire the data needed to complete the study. This includes the data sources needed to disaggregate the FAF database, the data sources used to build the DTC trip table and analyze the behavior of delivery trucks in the region, and the data sources needed to build up an inventory of commercial real estate and business establishments within the region.
- **Key Technical Analyses** – These are the core steps of the study where the data are used to carry out the approaches for the technical analyses scoped in the study.
  - **Step Three: Disaggregate FAF to the Subregional Level** – This step used the most recent version of FAF, Version 5.6, and disaggregated it to the county level for all 13 counties in the NJTPA region to have a clear picture of freight moving into, out of, and within the region. Additionally, this study also disaggregated Essex and Hudson counties into two zones — Newark and the rest of Essex County and Jersey City and the rest of Hudson County.
  - **Step Four: Estimate DTC Flows** – This step created a trip table of DTC flows to capture the impact that e-commerce is having on the NJTPA region. It started by using a Nielsen IQ consumer research data for e-commerce package volume and scan locations and then supplemented this data with e-commerce carrier facility locations, truck GPS, and regional travel demand model data to estimate the number and distribution of last-mile delivery trips on the region’s highway network.
  - **Step Five: Enhance the Freight Forecasting Tool** – This step updated the existing FFT with the new data sources acquired in Step Two and produced in

Steps Three and Four. Additional improvements were made to the tool, such as enhancing the user interface, incorporating the FAF disaggregation capability into the tool, better integrating the DTC data with other commodity flow data, and improving the outputs that are created after running a scenario.

- **Step Six: Generate Future Freight Forecasts and What-If Scenarios** – This step created a new freight forecast for the NJTPA region by combining the commodity flow database produced in Steps Three and Four with the acquired econometric forecast. Additionally, adjustments to existing What-If scenarios were made, and new What-If scenarios were added to the tool. Finally, as part of this step, the distribution of freight generating industries and commercial real estate in the NJTPA region were mapped, with facility-level truck trip estimates added.
- **Step Seven: Conduct Project Outreach into Trends and to Review Results** – Occurring concurrently with Steps Three through Six, the project team engaged the study's Technical Advisory Committee (TAC) in two working meetings to review proposed approaches, interim results, and build consensus on next steps. The team also met with the NJTPA subregions to review preliminary results of the study and receive comments on the outputs.

- **Presenting the Results** – These tasks were implemented to present the findings of the key technical analyses from a variety of perspectives in formats that are broadly useful for understanding freight from the regional level down to the local level and from the point of view of key supply chains.
  - **Step Eight: Explore Regional, Subregional, and Commodity Bundle Results** – This step presented the current and future freight flows within the region to show the major freight and supply chain trends and how these trends affect the region as a whole and the subregions within the NJTPA area.
  - **Step Nine: Summarize Results in a Final Report** – This step summarized the major regional freight trends and key analysis results and provided an updated user guide for the FFT.

Figure 1 Methodological Framework Diagram

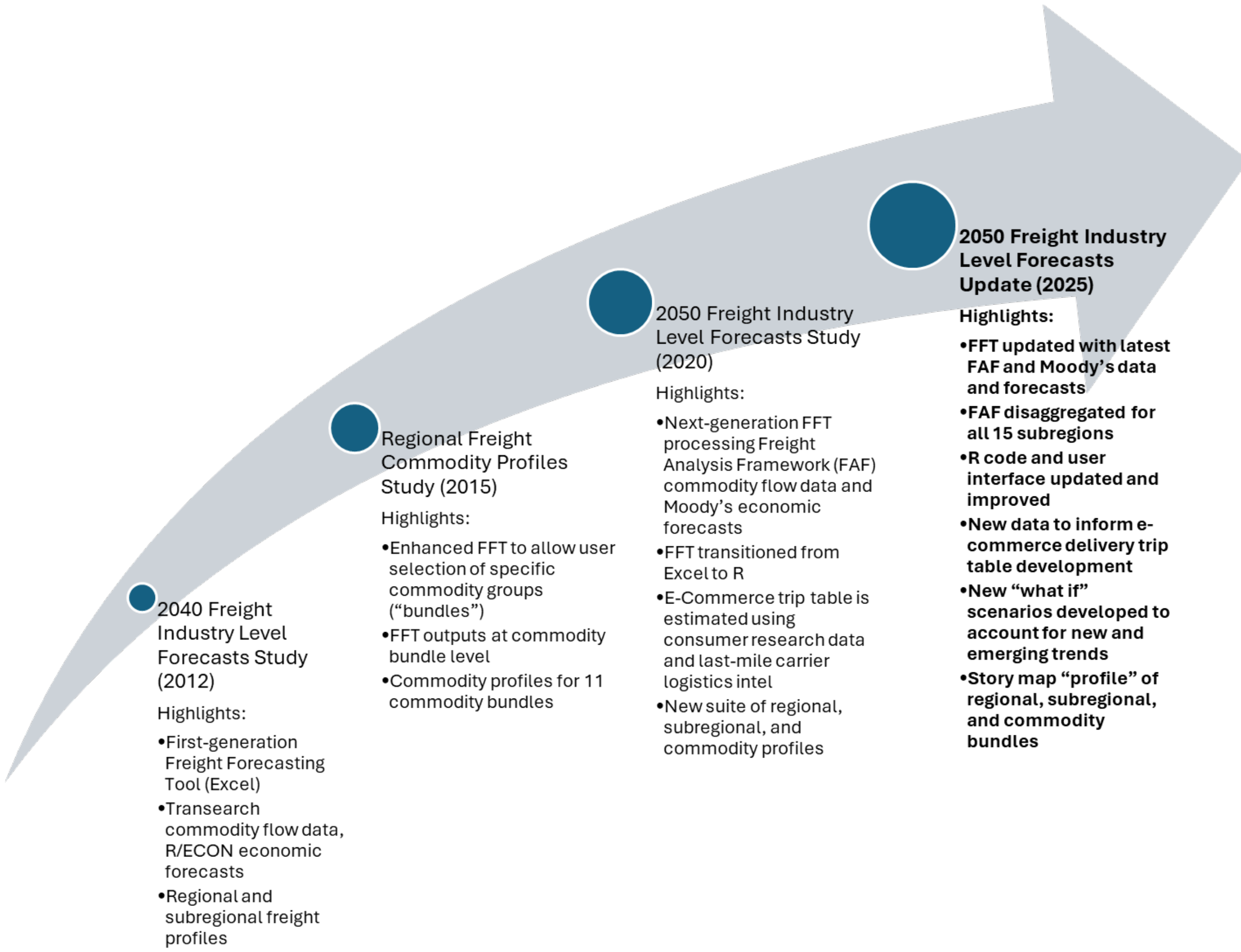


1.0 Introduction

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. More than a decade ago, the NJTPA recognized that commercially available freight 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 NJTPA initiated the 2040 Freight Industry Level Forecasts study in 2010.

That effort was the first of three studies that developed and enhanced the range of capabilities, processing and user interface, data and inputs, and the outputs of the FFT. Each subsequent study built upon work completed in the study before it. Figure 2 shows the progression of studies the NJTPA has performed over the past 13 years to develop and enhance its FFT.

Figure 2 Progression of NJTPA Freight Forecasting Studies, 2010–Present



Through its work on the three previous freight forecasting studies, the NJTPA has earned a reputation of being at the forefront of metropolitan regional freight forecasting and data tools development, and the alternative forecasts in the FFT are often cited as a leading example of freight scenario planning among metropolitan planning organizations (MPOs) in the United States.

The 2050 Freight Industry Level Forecasts study was nearing completion when the COVID-19 pandemic was beginning to disrupt the movement of people and goods throughout the world. At that time, it was difficult to ascertain the scale and duration of the effects that disruptive event would have on the global economy and freight transportation. Now, more than five years later, it is clear that there are lingering effects of the pandemic. The economy remains volatile, supply chains remain rattled, and transportation costs are coming down from 2021 peaks but remain higher than they were in the pre-pandemic era.

West Coast ports, beleaguered by a multitude of labor and access challenges, began losing market share to East Coast ports, helping the Port of New York and New Jersey become the Nation's busiest container port for a period in 2022.[1]

The lives of consumers in the NJTPA region and elsewhere around the country remain altered. Expectations regarding work locations (i.e., in an office or remote from home or elsewhere) seem to have permanently changed for many, especially higher-income office workers. Consumer spending on durable goods such as transportation equipment, home furnishings, and exercise equipment, which spiked in 2020-2021, have returned to something more closely resembling "normal." The dollar value of e-commerce sales nationally shot upward by 32 percent in the second quarter of 2020 and have continued to increase at a much lower growth rate since, though with brick-and-mortar stores reopening in late 2020 and into 2021, the percent share of retail sales made via e-commerce began to diminish slightly.

These observations suggest that "business as usual" freight forecasting scenarios developed prior to the onset of this pivotal pandemic event are out-of-sync with realistic assumptions about current observations and near term (i.e., five to 10 year) forecasting horizons. In addition, longer-term forecast horizons ought to be reexamined as well considering how the movement of goods and consumer demands appear to have been changed for the long-term. Developing an updated baseline freight commodity flow database and updating the forecast scenarios to account for current outlooks helps the NJTPA to maintain confidence in and credibility of its Freight Forecasting Tool (FFT).

1.1 Objectives of the Study

The 2050 Freight Industry Level Forecasts Update analyzed and identified gaps in existing freight and industry data, collected data and information to fill those gaps, enhanced the approach to estimating e-commerce delivery trips, and prepared summary data products. This information is valuable to NJTPA staff and member agencies, helping planning practitioners in the region identify where concentrations of goods movement activity could occur in the region, the types of commodities that could be moving and where strategic investments should be considered to support economic growth and enhance regional resiliency. The results of this work will serve as background for the next NJTPA Long Range Transportation Plan as well as Freight Planning and subregional planning studies.

[1] 1 Port Authority of New York and New Jersey, "Port of New York and New Jersey Regains Top Spot as Busiest Port in Nation," press release number 32-2023, April 3, 2023, https://www.panynj.gov/port-authority/en/press-room/press-release-archives/2022-press-releases1/port-of-new-york-and-new-jersey-regains-top-spot-as-busiest-port.html#:~:text=The%20Port%20of%20New%20York%20and%20New%20Jersey%20was%20previously,of%20cargo%20in%20its%20history.

The 2050 Freight Industry Level Forecasts Update was developed to accomplish the following objectives:

- Update the underlying data and forecasts to meet an adjusted 2050 planning horizon, and to extend the outer forecast horizon to 2055.
- Expand upon the methodology pioneered in the 2050 Freight Industry Level Forecasts Study to develop an e-commerce delivery trip table using new intelligence regarding vehicle travel patterns and purposes.
- Enhance the FFT to process the latest available version of the U.S. DOT Freight Analysis Framework (FAF) commodity flow data and forecasts, and to enhance user interface and ease-of-use.
- Augment historic business establishment inventory data that the NJTPA possesses with publicly available data, market reports, and/or other publications to account for recent trends and near-term future outlooks regarding development of industrial buildings that handle and/or generate freight shipments.
- Develop a new interactive suite of regional, subregional, and freight commodity profiles using outputs of the updated FFT.

1.2 Study Approach

Completing this study required investigations into key trends that should be captured in the forecasting tool, advancements in e-commerce estimation methods, approaches to disaggregating the FAF data, and new or updated sources of data to support all of the technical tasks in the study. A Methodological Framework was developed as the study’s first task, which established a detailed approach and recommended data and information sources. The Methodological Framework was reviewed by NJTPA staff and the Technical Advisory Committee (TAC) and then adopted as the Work Plan for the tasks that followed. The Methodological Framework Technical Memorandum is provided as Appendix A to this report.

To prepare this Methodological Framework, the project team completed the following activities:

- Affirmed the approach to disaggregate U.S. DOT’s Freight Analysis Framework (FAF) to the county level, as well as confirmed an approach to further disaggregate Essex County into Newark and the rest of Essex County and Hudson County into Jersey City and the rest of Hudson County.

- Reviewed the commodity bundles used in the last study and re-arranged those bundles based on emerging freight trends as well as community and business continuity.
- Updated prior research on available data and methods for estimating DTC delivery trips. The team then updated its approach to estimating DTC demand and truck trip patterns, which will again be based on a combination of approaches, as explained below.
- Evaluated the robustness and availability of data sources of location-based and GPS truck data and outlined how this data would be used to enhance DTC trip table development and truck trip patterns as well as validating the results of the North Jersey Regional Transportation Model-Enhanced (NJRTM-E) regional travel demand model results.
- Reviewed the available sources of econometric forecasts and make/use tables and recommended a source that provides a forecast that aligns with the NJTPA geography, matches the industry and commodity groups in the FFT, and fits within the available budget.
- Explored possible enhancements and changes to the user settings, platform access, and scenario outputs generated by the FFT.
- Review and recommend software applications and alternative design and user interfaces for the FFT.
- Affirmed its approach to engaging stakeholders, including the Technical Advisory Committee (TAC), and subregions.
- Developed a comprehensive list of data required to complete the study, by category.

Figure 3 shows a diagram of the methodological framework to complete the objectives of this study. It includes a step-by-step approach divided into three categories: preparation activities; key technical analyses; and presenting the results. The steps in the diagram are listed by number, in order of sequence, and the numbers do not correspond to task numbers in the contract for the current study. This framework is explained below:

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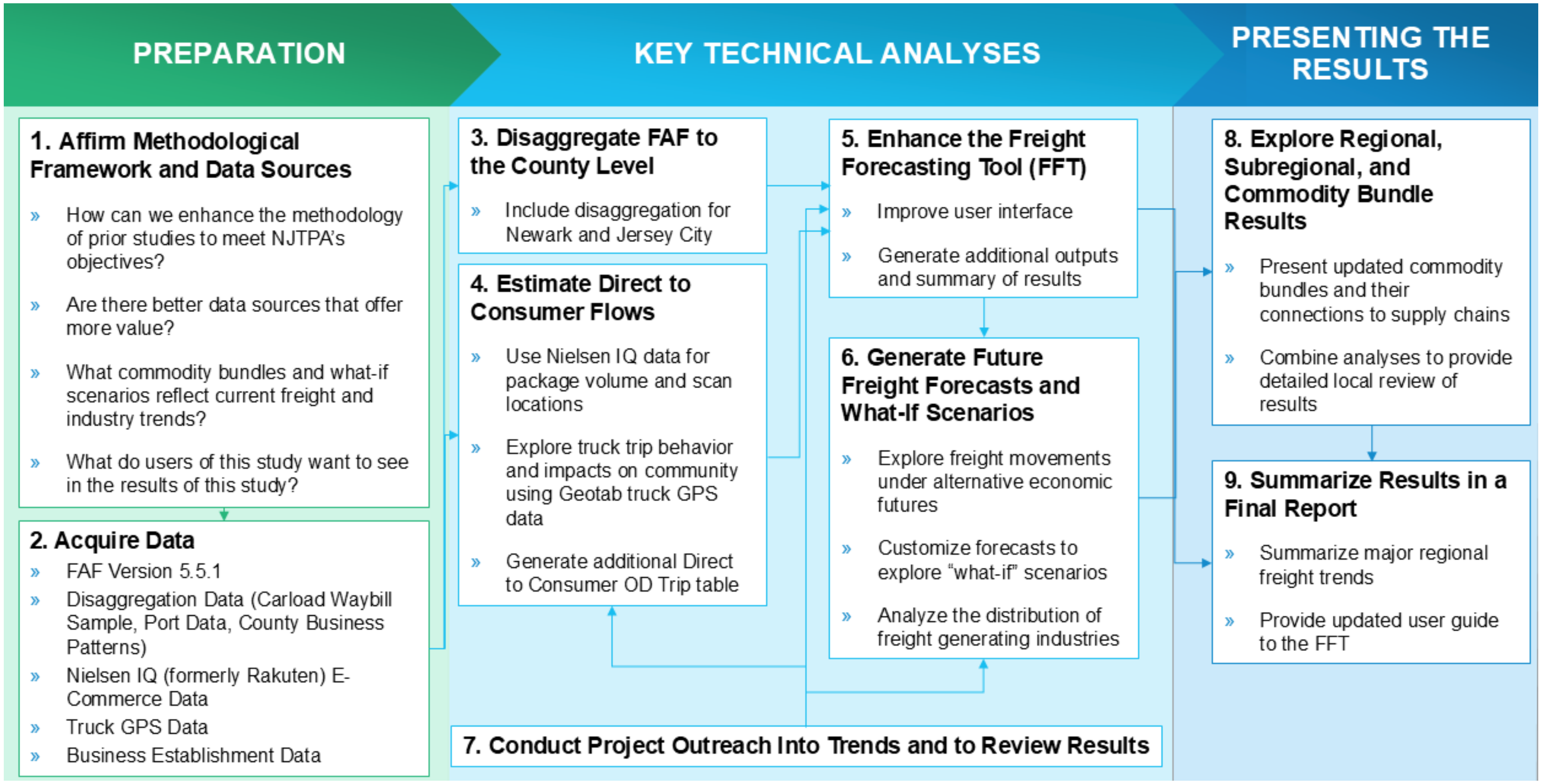
   - **Step Eight: Explore Regional, Subregional, and Commodity Bundle Results** – This step presented the current and future freight flows within the region to show the major freight and supply chain trends and how these trends affect the region as a whole and the subregions within the NJTPA area.

   - **Step Nine: Summarize Results in a Final Report** – This step summarized the major regional freight trends and key analysis results and provided an updated user guide for the FFT.

Figure 3 Methodological Framework Diagram



2.0 FAF Disaggregation

The FFT produces county-level base-year and forecast-year commodity flows based upon enhanced versions of the U.S. DOT's FAF commodity flow database. 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 census metropolitan area (CMA) boundaries located within each state. The State of New Jersey consists of two FAF regions. To support the analysis required for this study, the underlying commodity flow data must be at the county level for each of the NJTPA region's 13 counties. County-level FAF disaggregation was first performed for the 2050 Freight Industry Level Forecasts Study. This step will be performed again with an updated version of FAF that has been released since the completion of the previous study.

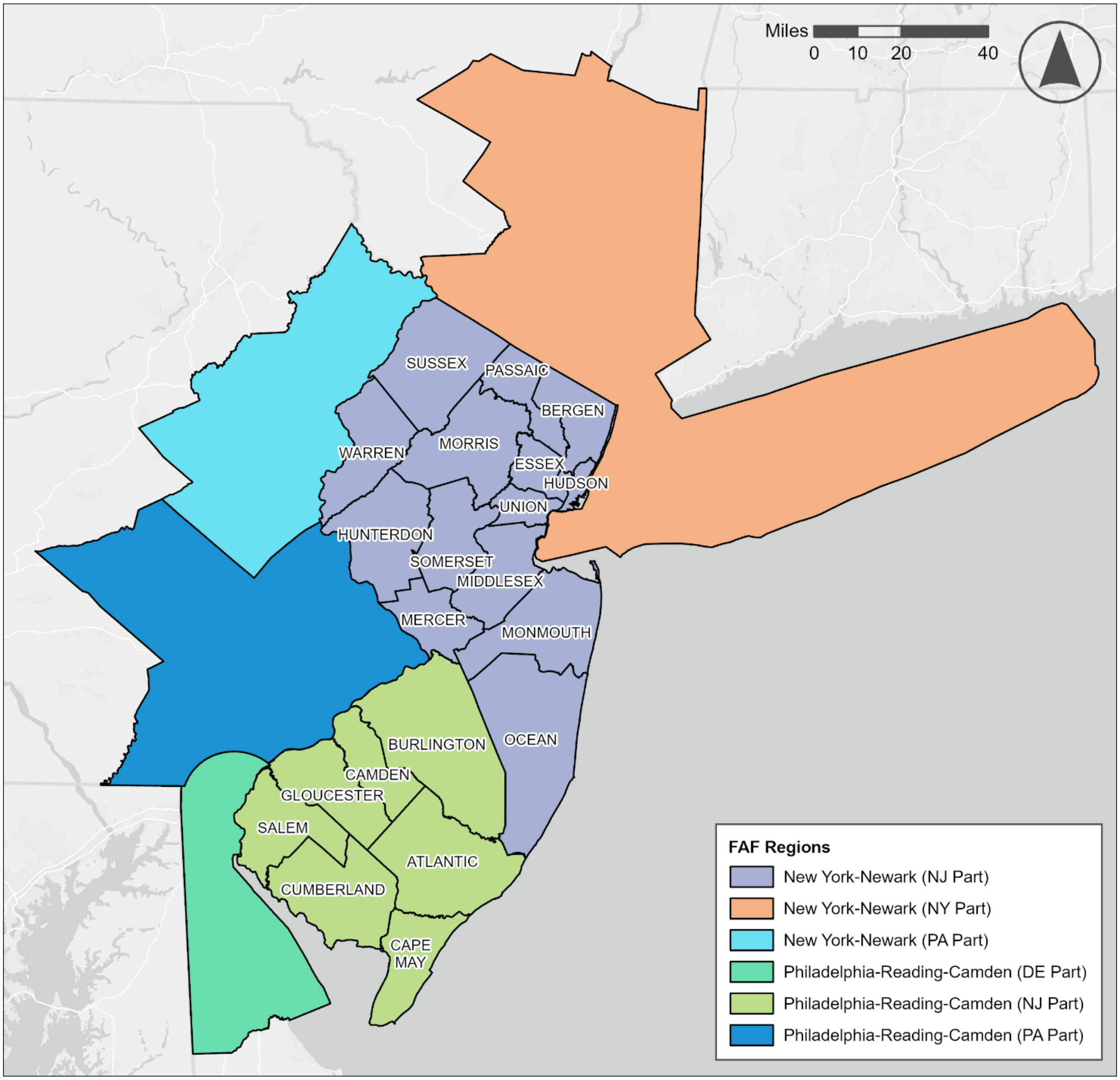
The disaggregation of FAF data into smaller geographies, such as counties and cities, involves determining factors that accurately reflect the freight activity at both the origin and destination points. In this study, disaggregation factors were updated and applied to FAF 5.6 to estimate the freight activity within smaller geographies as a proportion of the FAF regions in which they are situated. This process relies on the assumption that freight activity correlates with employment in NAICS (North American Industry Classification System) industries that produce freight at the origin and those that consume or attract freight at the destination. By applying these factors, the FAF flows between broad FAF regions were broken down into more granular county-level flows.

While FAF 5.6 has 132 FAF zones, this study focuses on disaggregating freight flows from a selection of FAF zones, including a total of 47 counties (see Figure 4). The FAF regions included are:

- 341 (New York NY-NJ-CT-PA - NJ Part)
- 363 (New York NY-NJ-CT-PA - NY Part)
- 423 (New York NY-NJ-CT-PA - PA Part)
- 101 (Philadelphia PA-NJ-DE-MD - DE Part)
- 342 (Philadelphia PA-NJ-DE-MD - NJ Part)
- 421 (Philadelphia PA-NJ-DE-MD - PA Part).

Additionally, the disaggregation of through traffic, also referred to as external-external or overhead traffic, which neither originates nor terminates in New Jersey, will be added to the disaggregated database as part of Task Five, updating the Freight Forecasting Tool.

Figure 4 Disaggregated FAF Regions and Counties

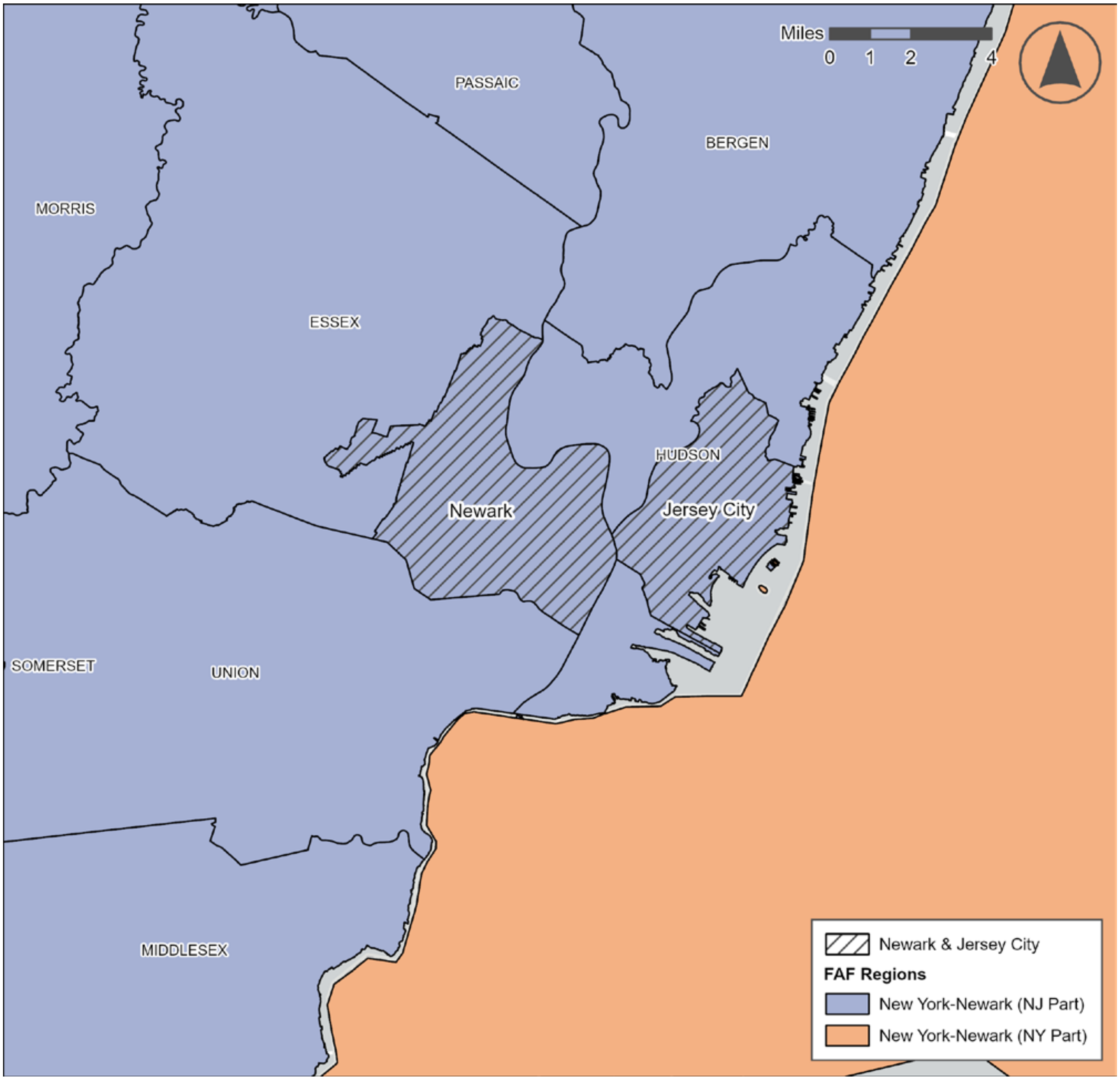


Source: Freight Analysis Framework, version 5.6.

2.1 Sub-County Disaggregation

In this study, Newark and Jersey City within the NJTPA region are further disaggregated by dividing Essex County into Newark and the rest of the Essex County, and Hudson County into Jersey City and the rest of Hudson County (Figure 5). Disaggregation factors of these four regions were needed and then developed based on the same disaggregation development process as described above. Presently, this disaggregation process has resulted in two databases: one where Essex and Hudson Counties are kept whole, and a second database where Essex County is divided into Newark (region “3401301”) and the rest of the Essex County (region “3401302”), and Hudson County is divided into Jersey City (region “3401701”) and the rest of Hudson County (region “3401702”).

Figure 5 Locations of Newark and Jersey City Within their Respective Counties



Source: County and Municipal Boundaries from the New Jersey Department of Transportation’s NJGIN Open Data portal.

2.2 Ports

The U.S. Army Corps of Engineers reports import and export tonnages by commodity for most U.S. ports, categorized by Public Group Commodity. The Cambridge Systematics team previously developed a crosswalk to match these with SCTG equivalents.

These flows include consolidated ports like the Port of New York and New Jersey. However, the terminals in the Port are located in different counties. The team allocated Port flows to their respective counties based on percentages of terminal land area obtained in consultation with the Port Authority of New York and New Jersey and the NJTPA (Appendix B). Additionally, more detail was applied for specific commodities in the disaggregation factors, including:

- All SCTG 36 Motorized Vehicle port flow commodities were assigned to Essex County because of the vehicle processing centers located in Port Newark
- Energy commodities SCTG 16-18 were allocated 80 percent to Middlesex County and 20 percent to Union County. This is to account for the team's estimate of the distribution of private port oil and gas facilities, especially those located near Perth Amboy in Middlesex County

Further disaggregation of the port flows has not been completed under this task so that this disaggregation step can potentially be a customizable user input in the Freight Forecasting Tool if additional information becomes available.

Table 1 Consolidated Ports of New York and New Jersey Disaggregation Factors Based on Land Area Share

Principal Port	County Name	County FIPS	FAF Region	Land Area Share
Port Newark	Essex County	34013	341	21 percent
Port Jersey	Hudson County	34017	341	19 percent
Port Elizabeth	Union County	34039	341	60 percent

Source: Provided by the Port Authority of New York and New Jersey

2.3 Rail and Domestic Multiple Modes

This project uses the same process as developed in the previous study for the disaggregation of the domestic multiple modes, using an earlier vintage of the Surface Transportation Board's Carload Waybill Sample to identify Intermodal terminals by the originating or terminating county in the study area.

2.4 Projection of Flows to 2055

FAF 5.6 provides forecasts of freight tonnage and value up to the year 2050. To extend these forecasts to the year 2055, this project uses a log-linear regression approach. This method involves using historical and forecasted data from previous years to predict future tonnage and value. Using linear regression with log-transformed freight measures stabilizes variance, handles exponential growth, reduces skew, and makes the results more reliable for forecasting.

2.5 FAF Disaggregation Conclusion

The FAF 5.6 was disaggregated at county and city level for the base year 2017 and for every five-year increment from 2025 to 2050. The year 2055 was not available in FAF 5.6 and was forecasted based on a log-linear regression approach. This disaggregation was performed for both tonnage and value as reported in the FAF. Imports and exports in the FAF are detailed by foreign mode and domestic gateway.

The disaggregated FAF database produced from this task was critical for future tasks of this study. In Task Four, the team developed and added estimates of flows from Direct-to-Consumer (DTC) last-mile movements of e-commerce shipments to the commodity flow database. In Task Five, estimates of through (external-to-external) flows were added, and this disaggregation process was incorporated as a customizable user input in the FFT. Also, the disaggregated FAF is the basis for the custom commodity flow forecasts, developed using industry output data provided by Moody's Analytics in the FFT.

A more detailed description of the FAF disaggregation inputs and methodology is provided in Appendix B.

3.0 Direct-to-Consumer Trip Table Development

With each year that passes, more American consumers buy products online, often for delivery to their homes, and sometimes for pick-up at a retail store. Between 2015 and 2024, e-commerce sales have represented progressively larger shares of total retail sales in the United States. In 2015, e-commerce represented about seven percent of total U.S. retail sales, and by the end of 2024, e-commerce represented about 18 percent of total U.S. retail sales.[2] The growth in online orders has facilitated the development and rapid expansion of logistics systems that support the staging of products, fulfillment of individual customer orders, and the distribution of parcels directly to the consumer's preferred delivery location (at home, in-store, or other location).

These direct-to-consumer deliveries generate trips by box trucks, cargo vans, and other vehicles, and thus contribute to traffic volumes and congestion, curbside parking demand, emissions, safety risks, and other impacts. 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 e-commerce orders to consumers. The ability to estimate the volume and distribution of these delivery trips on the region's highway network can illustrate the transportation system effects of consumers' demand for online shopping and home deliveries.

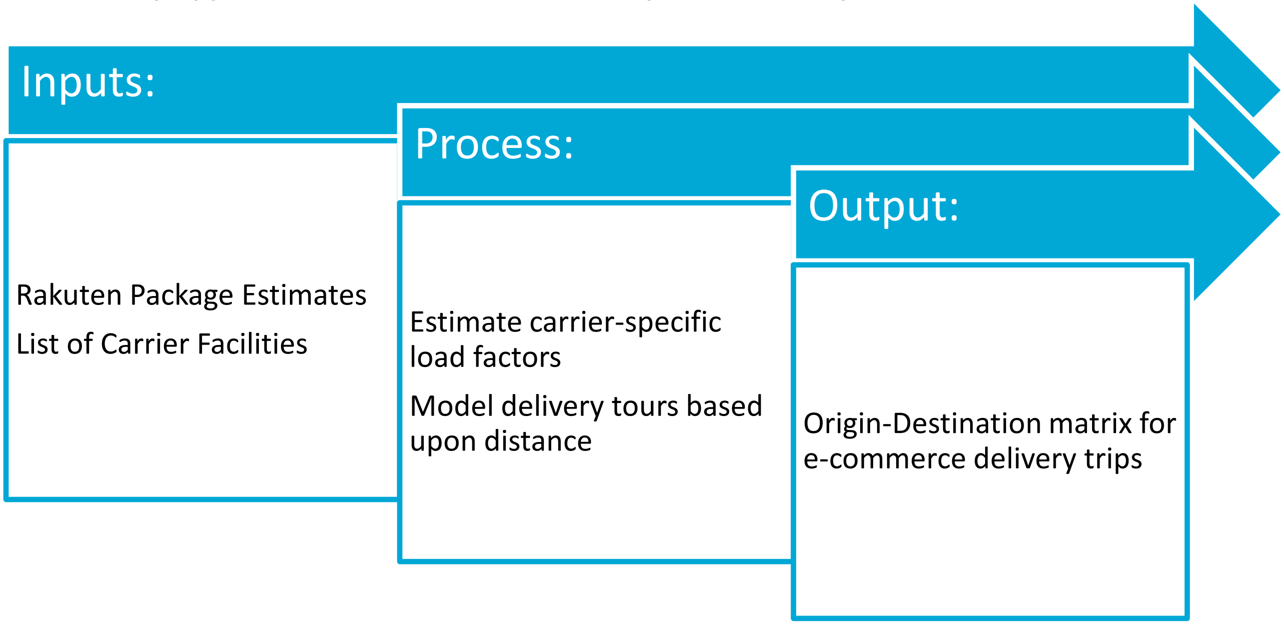
The 2050 Freight Industry Level Forecasts Study, completed in 2020, was the NJTPA's first attempt at estimating the volume and distribution of these trips on the region's highway network. Using estimates of e-commerce packages delivered at the zip code level, and a list of distribution facilities used by each of the major parcel carriers in the region, a model was developed to assign origin-destination pairs between the delivery zip codes and the nearest carrier facilities.

Since the completion of the previous study, new data sources and improved analysis approaches have emerged. The objective of this task is to apply a combination of package delivery estimates, carrier facilities, truck travel patterns acquired through GPS data samples, and package scan history data in order to improve the origin-destination model and develop an improved estimate of the origin-destination pairs that represent delivery trips in the region. Figure 6 compares the inputs, processes, and outputs used in the original 2050 Freight Industry Level Forecasts Study (2020) and in this 2050 Freight Industry Level Forecasts Update (2025).

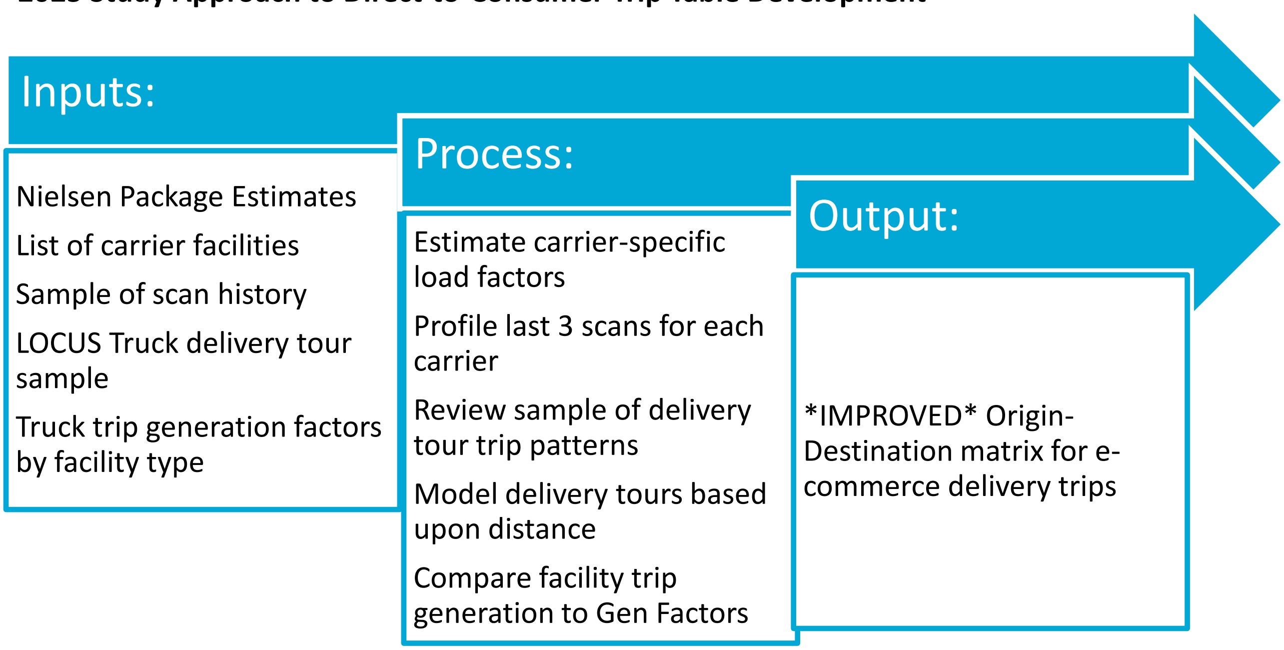
[2] U.S. Census Bureau News (2025, February 19), "Quarterly Retail E-Commerce Sales, 4th Quarter 2024," https://www.census.gov/retail/mrts/www/data/pdf/ec_current.pdf.

Figure 6 Disaggregated Comparison of Data and Methods Used in the 2020 and 2025 Freight Forecast Studies

2020 Study Approach to Direct-to-Consumer Trip Table Development



2025 Study Approach to Direct-to-Consumer Trip Table Development



The objective of this task, therefore, was to develop a trip table representing e-commerce delivery vehicles that can be 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.

3.1 Approach and Inputs

The DTC delivery trip table's purpose is to capture the behavior of all e-commerce trucks in the region and understand its contribution to truck traffic, including VMT. In a process further detailed in Appendix C, the model from the previous 2050 Freight Industry Level Forecasts Study was updated and improved with additional data which was not available in the prior project. These data sources include enhanced e-commerce market data from Nielsen IQ (explained in more detail below and in Appendix C) as well as location based data from LOCUS Truck to explore truck trip behavior (explained in more detail below and in Appendix C).

The Nielsen IQ data provided overall targets for the number of packages going to each zip code by carrier (e.g., UPS, U.S. Postal Service, Amazon, FedEx, etc.), as well as origin facility data for a large sample of packages, for which total scan history data were made available.

Table 2 lists the projected annual package counts provided by Nielsen IQ, summed up to the subregional level.

Table 2 E-Commerce Package Count by NJTPA Subregion, 2023

Subregion	2023 Annual E-Commerce Packages Delivered
Bergen County	40.5 million
Essex County (including Newark)	26.3 million
Newark	6.2 million
Hudson County (including Jersey City)	21.8 million
Jersey City	10.1 million
Hunterdon County	4.2 million
Middlesex County	26.7 million
Monmouth County	20.0 million
Morris County	15.8 million
Ocean County	20.3 million
Passaic County	11.2 million
Somerset County	10.5 million
Sussex County	3.6 million
Union County	16.4 million
Warren County	2.5 million
NJTPA Region Total	219.8 million

Source: Cambridge Systematics analysis of data from Nielsen IQ.

The LOCUS Truck data provides truck trip and stop data segmented by truck patterns, processed and expanded using Geotab data as its primary source. Its data include major delivery fleets which carry e-commerce parcels to their final destinations. In this study the relevant pattern segment is referred to as "door-to-door" and identifies those trucks which make many short stops. These data were used to develop and calibrate the model which describes how packages get from the distribution centers to their destinations. Several pieces of information were used for this purpose. Linked trips which count the short stops along the way can show a distribution of number of stops made as well as overall distance traveled in a delivery shift/run. Unlinked trips show the catchment areas of facilities by examining the interzonal trips. Stop and intrazonal trip data were used for relative comparisons to package volumes and linked trips to further understand the relationship between tours, packages, and local stops.

The basic steps to produce the O-D matrix, detailed in Appendix C, included:

1. Process Nielsen IQ data into packages per TAZ by each carrier;
2. Research and map distribution center locations used by each carrier to dispatch packages for delivery in the NJTPA region;

3. Estimate the number of packages moved from each carrier facility to each zip code in the NJTPA region;

3. Estimate delivery clusters and vehicle tours;

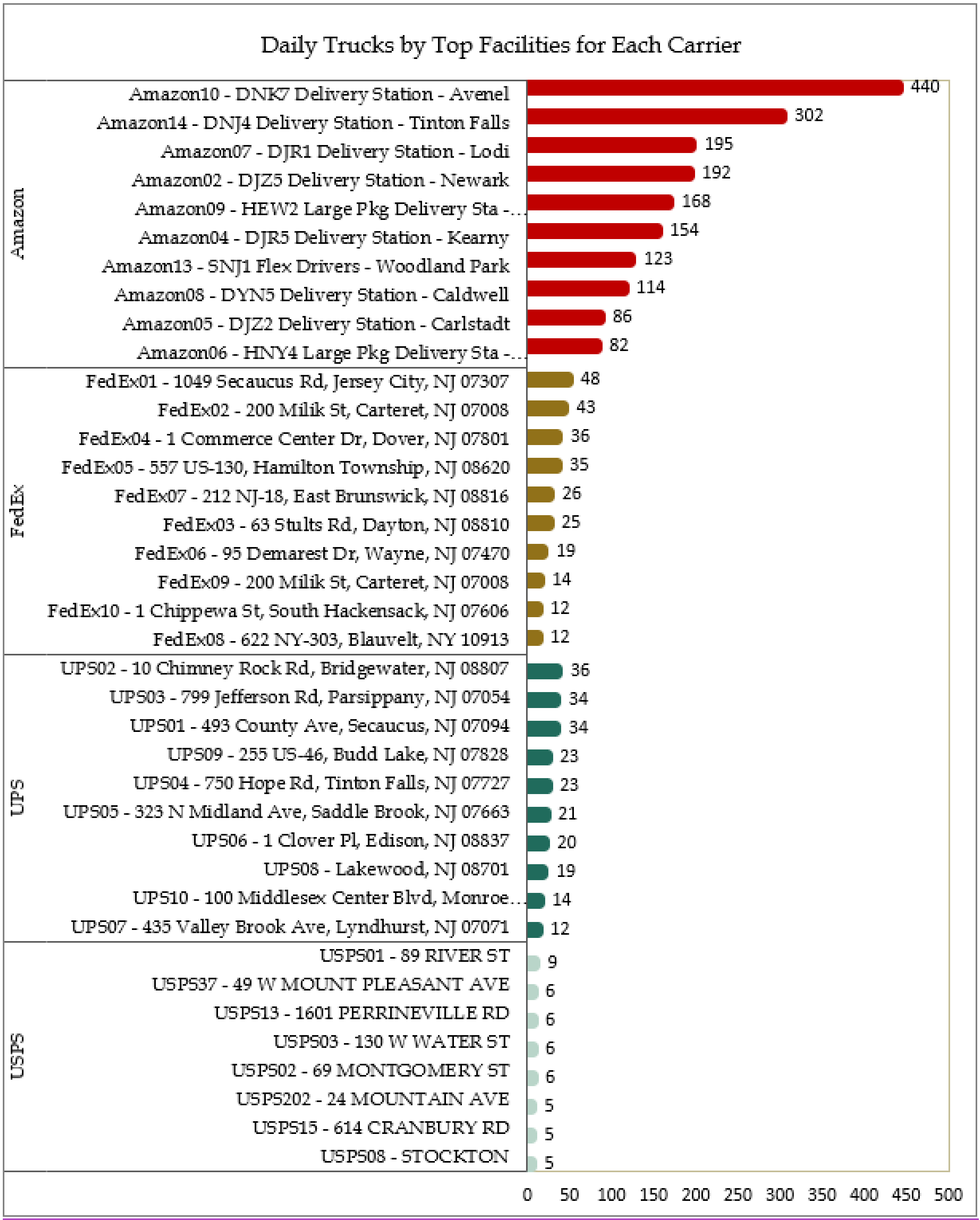
4. Calibrate and validate the tour model based upon real-world observations using LOCUS Truck; and

5. Develop a forecast of e-commerce packages and tours through 2055, using e-commerce and retail market trends and demographic forecasts.

3.2 Results

Figure 7 shows the estimated number of daily delivery truck trips generated from each carrier's top ten facilities serving customers in the NJTPA region. The Amazon delivery station in Avenel, for example, generates 440 daily delivery tours, on average, according to the estimates derived from this study.

Figure 7 Average Number of Daily Trucks by Top Facilities for Each Carrier

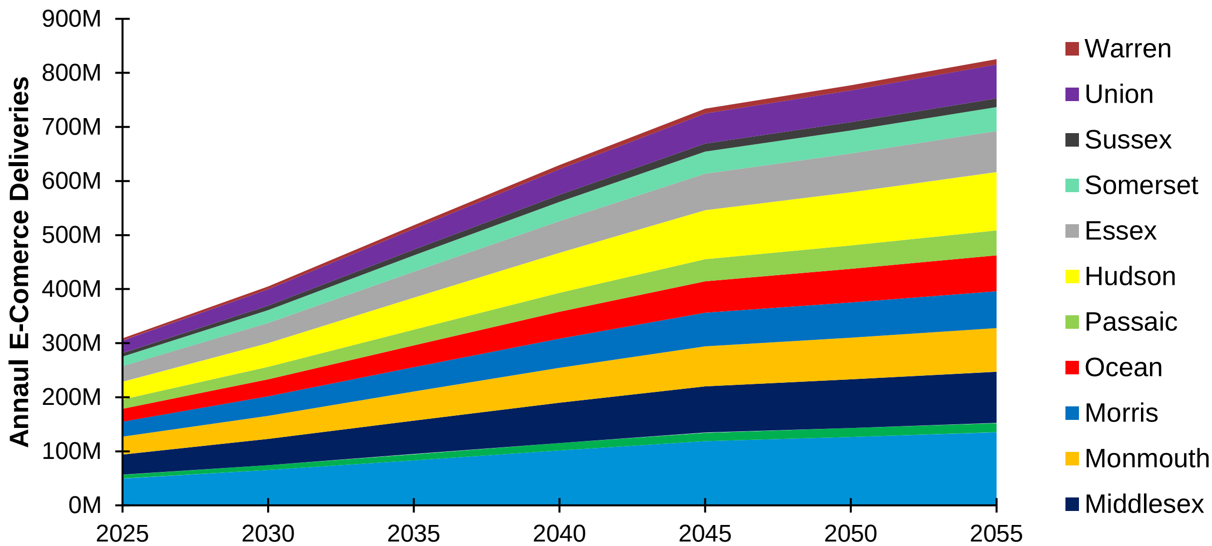


Source: NJTPA Direct-to-Consumer Forecast Model

As described in Appendix C, forecasts of the e-commerce packages and tours were developed through 2055. The forecasts assumed that e-commerce would continue to increase its share of retail sales in the U.S. According to the U.S. Census Bureau, e-commerce represented about seven percent of retail sales in 2015, 12 percent of retail sales in 2019, and 18 percent of retail sales in 2024. This trend suggests that 47 percent of retail sales would be made using e-commerce channels by 2050[3]. Using the regression equation, e-commerce demand for future years was developed using future population and household forecasts by zip code. While household income is also an important variable and predictor for e-commerce demand, forecasts for that variable are not available, and therefore its influence was not factored into the forecast.

Figure 8 shows the forecasted number of packages delivered in each county in the NJTPA region through 2055. From 2025 to 2050, the total number of packages will increase from 309M to over 770M, an increase of approximately 150 percent compared to the estimated 2023 package count.

Figure 8 Forecasted Annual E-Commerce Packages Delivered by County, 2023-2055

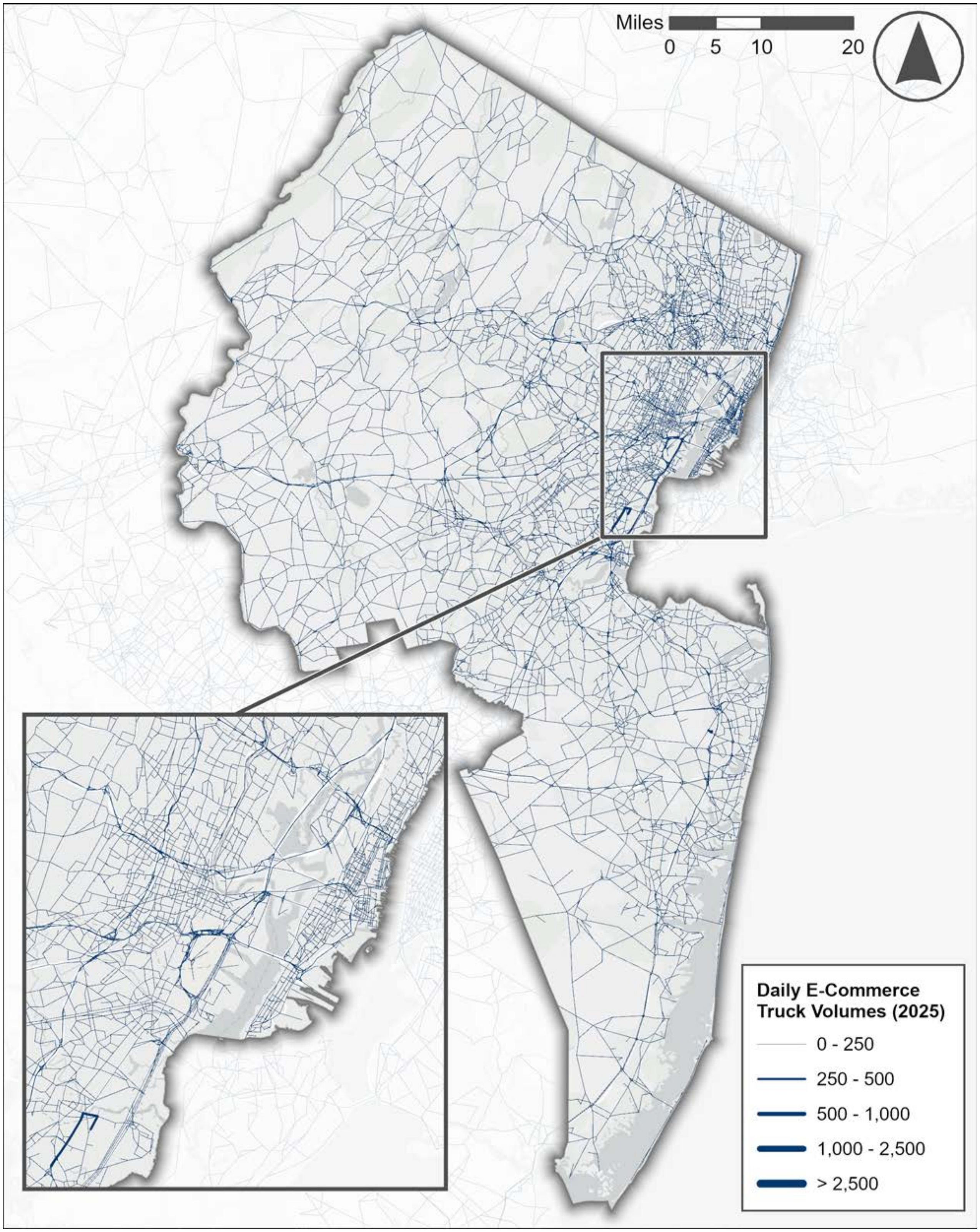


Source: NJTPA Direct-to-Consumer Forecast Model

The result of the analysis performed in this task is an origin-destination matrix of e-commerce delivery trips between carrier facilities (e.g., Amazon delivery stations, UPS, FedEx, and USPS facilities) and the TAZs where packages are delivered to consumers. The table was assigned to the NJRTM-E network to produce maps of the volume of delivery vehicles on the region’s highway network for base and future years, shown in Figure 9 and Figure 10, respectively.

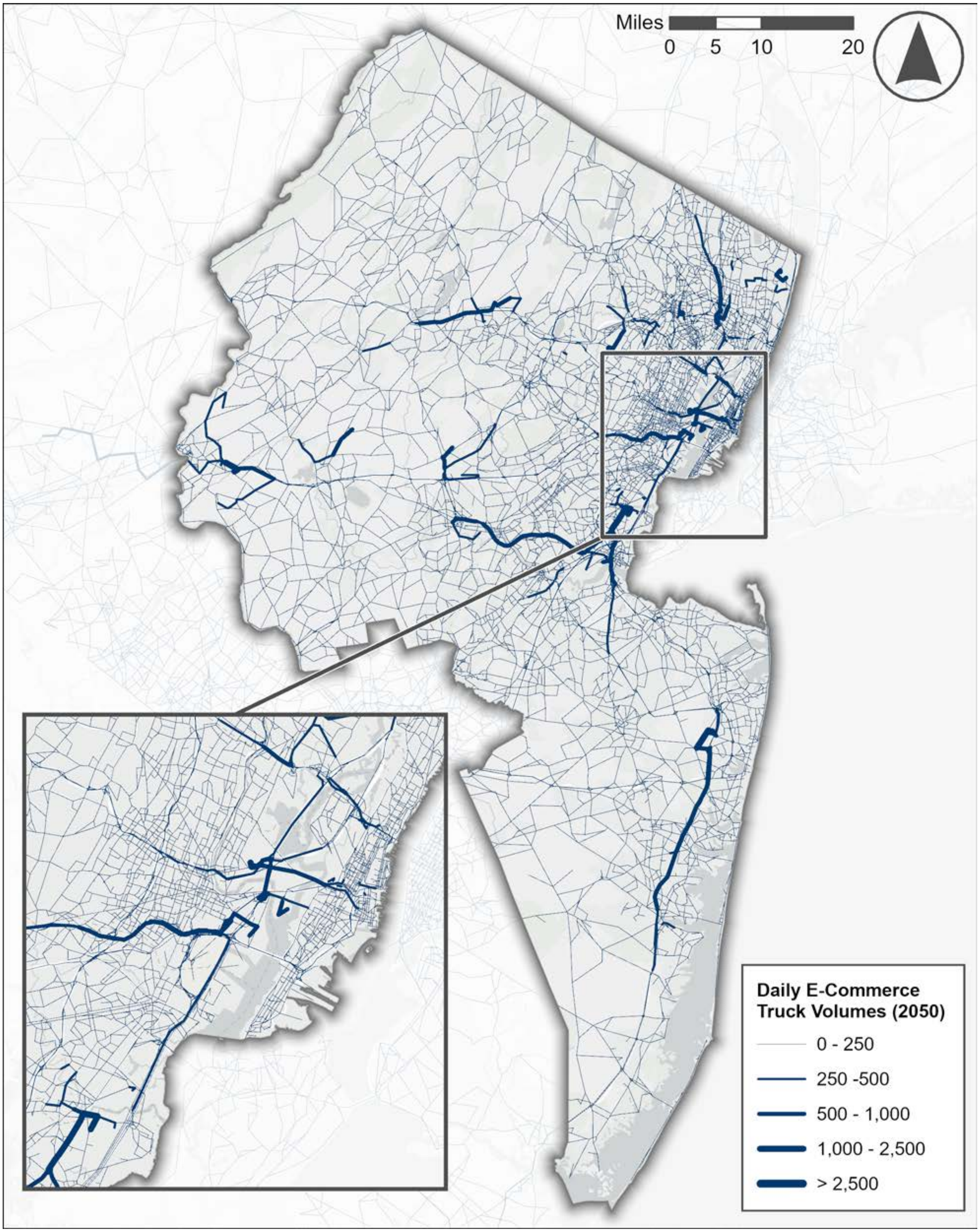
[3] This trend may level off at some point as market penetration reaches a critical point, but this assumption has not been included in this iteration of the Freight Industry Level Forecasts study. For the list of all assumptions to this process, see Appendix C.2.

Figure 9 Daily Volume of E-Commerce Delivery Vehicles on the North Jersey Highway Network, 2025



Source: NJTPA Freight Forecasting Tool, 2025; NJRTM-E

Figure 10 Daily Volume of E-Commerce Delivery Vehicles on the North Jersey Highway Network, 2025



Source: NJTPA Freight Forecasting Tool, 2025; NJRTM-E

4.0 Freight Forecasting Tool (FFT) Enhancements

Since the completion of the original study in 2012, the NJTPA has had a Freight Forecasting Tool (FFT) that processes freight commodity flow data and economic forecasts to produce freight forecasts that have transparent derivations and estimation methodologies. The FFT was initially a spreadsheet modeling tool built in Excel, which processed Transearch commodity flow data using make-use tables and economic forecast scenarios from the Rutgers Economic Advisory Service (R/ECON) . Over the course of several updates to the FFT, the source data shifted from Transearch to FAF and the economic forecasts were sourced from Moody's. Other enhancements, such as developing commodity bundle-specific forecasts and developing new "What-If" scenarios have also been incorporated over the years. The tool itself was re-built using R coding and run in R Studio. These changes have improved the operability of the tool and given it new capabilities and output options.

In this study, the FFT has been updated once again, including the incorporation of new FAF and economic forecast data, improved user interface and processing using streamlined coding, fuller incorporation of the direct-to-consumer data and forecasts into the tool, and revision and additions of new What-If scenarios.

The objectives of the FFT enhancements included:

- Assembling the data deliverables from the prior tasks, including the disaggregated FAF database and the direct-to-consumer truck O-D table.
- Incorporating economic forecast data to provide an updated forecast of freight flows from the disaggregated FAF database out to 2055.
- Developing a forecast of the e-commerce O-D table out through 2055, taking into account the growth in market share for e-commerce relative to brick-and-mortar retail sales, consumer spending, population growth, and another relevant demographic and economic factors (a process detailed in Section C.2).
- Updating the Freight Forecasting Tool used to generate these forecasts with the updated data sources and tool enhancements to the user selection process and outputs generated.
- Developing updated "What-If" scenarios generated by the forecasts that provide custom freight forecasts that reflect changes in trends that may affect freight movements in the region.

4.1 Tool Updates

When the FFT was last updated in 2020, it was written in the R programming language and uses the R Shiny set of packages to create a graphical user interface (GUI) where users can interact with the tool. This tool allows users to select basic model inputs, such as the forecast year and economic scenario, as well as a suite of customization parameters including What-If scenario parameters as well as adjustment factors for productivity and county-level growth.

This update maintained the basic structure of the FFT by keeping the tool in R and including a similar set of user inputs. The project team enhanced the FFT in several ways:

- **Improved the User Interface** – Since the creation of the last FFT, there have been a large expansion in the options for building out user interfaces in the R Shiny set of packages. The project team rebuilt the user interface in the bslib library, which uses a modern version of Bootstrap (a Cascading Style Sheets (CSS) framework that is popular for making responsive and flexible web applications). This facilitated a greater selection of user inputs as well as outputs once a scenario has been run.

- **Generating additional outputs**–Enhanced and interactive figures and tables were created as outputs to a scenario run that summarize the results of that scenario. This also offers the ability to filter the figures and tables to better explore the results of a scenario run. Examples are shown in the FFT Users' Guide, provided as Appendix E.

- **Generating a summary document** – In addition to the visualizations and tables created within the tool, it also currently saves data outputs in the output folder after each run. These outputs were enhanced by combining the summary outputs into an R Markdown HTML document that can be saved onto the user's computer. This document will preserve the interactive outputs created in the dashboard itself and summarize the major takeaways from the output run.

- **Comparing forecast results** – A function has been added to allow comparisons of the differences between two forecasts and provide a snapshot of differences by major categories, such as changes by mode, by commodity bundle, by direction, among trading partners, and at the county level. This allows the user to quickly see how differences in the forecast input parameters change the flow of freight in the NJTPA region.

- **FAF Disaggregation Module** – A new module has been developed that allows the user to disaggregate new FAF data tables within the tool.

4.2 What-If Scenario Development

One of the key features of the FFT is the ability to customize future forecast scenarios through What-If scenarios that allow the user to adjust specific freight trends within the forecast. By targeting specific commodity movements, the user can explore possible variations in future economic conditions such as, for example, increasing or decreasing the amount of import and export trade or by shifting commodity movements between different modes (i.e., truck to rail or truck to water).

To determine the What-If scenarios used in the next version of the FFT, the CS team reviewed What-If scenarios in the previous version of the tool and determined their continued relevance. The team also researched regional industry trends and consulted with NJTPA staff and the study's TAC. The goal of this work was to ensure that the FFT captures recent developments in freight issues that affect the NJTPA region and can incorporate the impact of those trends in the future freight forecasts.

The What-If scenarios included in the tool are listed below. Several were transferred from the previous version of the tool into the updated version developed in this study. These include:

- **Changes to In-Migration/Urbanization.** This adjustment accelerates the growth of freight tonnage originating and terminating in the NJTPA region.
- **Increase Out-Migration**. This adjustment slows the growth of freight tonnage originating and terminating in the NJTPA region.
- **Increased NJ Self-Sufficiency**. This adjustment increases the share of NJ consumption that is served by NJ production, compared to non-NJ production.
- **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.

- **Mode Share (all freight), 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 (foreign flows only), 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.

In addition, several new What-If scenarios were developed as part of this update. New What-If scenario adjustors in the FFT include:

- **Fluctuation in Fossil Fuel Commodities.** This adjustment has two options. The first option allows the user to select a year when fossil fuel commodities will zero e.g. a net-zero goal year. Option Two adjusts the fossil fuel commodities by a set percent negative or positive each year between the base year (2025) and the selected forecast year.

- **Increase in Advanced Domestic Manufacturing**. This adjustment increases the shipment tonnage and value of advanced manufacturing materials like microchips, batteries, and electric vehicle inputs by a specified percentage per year for all flows originating and terminating in the NJTPA region relative to base forecast.

- **Change in Natural Gas Production.** This adjustment increases or decreases the amount of natural gas moving through the NJTPA region by that percentage per year relative to base forecast.

- **Northeast New Jersey Growth.** This adjustment increase the tonnage and value of flows originating and terminating in Hudson, Bergen, Union, Middlesex, Essex County and Newark and Jersey City is increased by the chosen percentage each year, relative to base forecast.

- **Investment in Marine Highways.** This adjustment shifts the mode for NJTPA truck and rail shipments originating or terminating in coastal states from Virginia to Massachusetts into the water mode.

- **Port Growth.** This adjustment increases the existing hinterland flows and shifts landbridge Los Angeles/Long Beach port flows directly to NY/NJ port.
- **Manual Increase in Agriculture.** This adjustment increases the amount of agricultural commodities moving through the NJTPA region.

4.3 NJRTM-E Assignment

The truck trip table generated by the FFT can be assigned to the North Jersey Regional Transportation Model-Enhanced (NJRTM-E) regional travel demand model network in order to review the distribution of truck traffic on the highway network associated with the model scenario and What-If options selected by the user. The FFT processes county-level commodity flow data from the disaggregated FAF. A separate process can be initiated by the FFT user to convert the FFT outputs into a trip table consistent with traffic analysis zones (TAZs) in the NJRTM-E network. The process also assigns flows to or from locations outside the NJRTM-E model region to the appropriate external station. It generates a CUBE truck table in origin-destination format, where origins are NJRTM-E TAZs or external stations, and destinations are NJRTM-E TAZs or external stations. The flow unit is truck trips by commodity bundle and a final bundle that includes all other commodity trucks for each time period in the NJRTM-E (morning [AM], midday [MD], evening [PM], and nighttime [NT]).

Another process was developed to assign the adjusted truck trip tables to the NJRTM-E loaded networks for each time-of-day period, accounting for all of the NJTPA's assignment routine protocols (e.g., avoiding assignment of trucks to the Garden State Parkway north of Exit 105, etc.).

The result of these procedures is a series of network files that contain link volumes for each of the commodity bundles and non-commodity trucks during each time-of-day. The network file can be analyzed within the CUBE software application or exported as a shapefile for analysis in a variety of GIS applications.

4.4 FAF Disaggregation Module

The newly-updated FFT includes a new feature that disaggregates FAF data within the tool. If and when future versions of FAF are made available from USDOT, this module can be used to disaggregate the data to the subregional level and to estimate through flows. The Disaggregation Module assumes that FAF data structures, coding schemes for commodities, modes, and geographic zones will remain unchanged. If changes to those aspects of the data are different in future versions, some pre-processing of the FAF data (or re-coding of the module) would be necessary in order to use the FAF Disaggregation Module in the FFT.

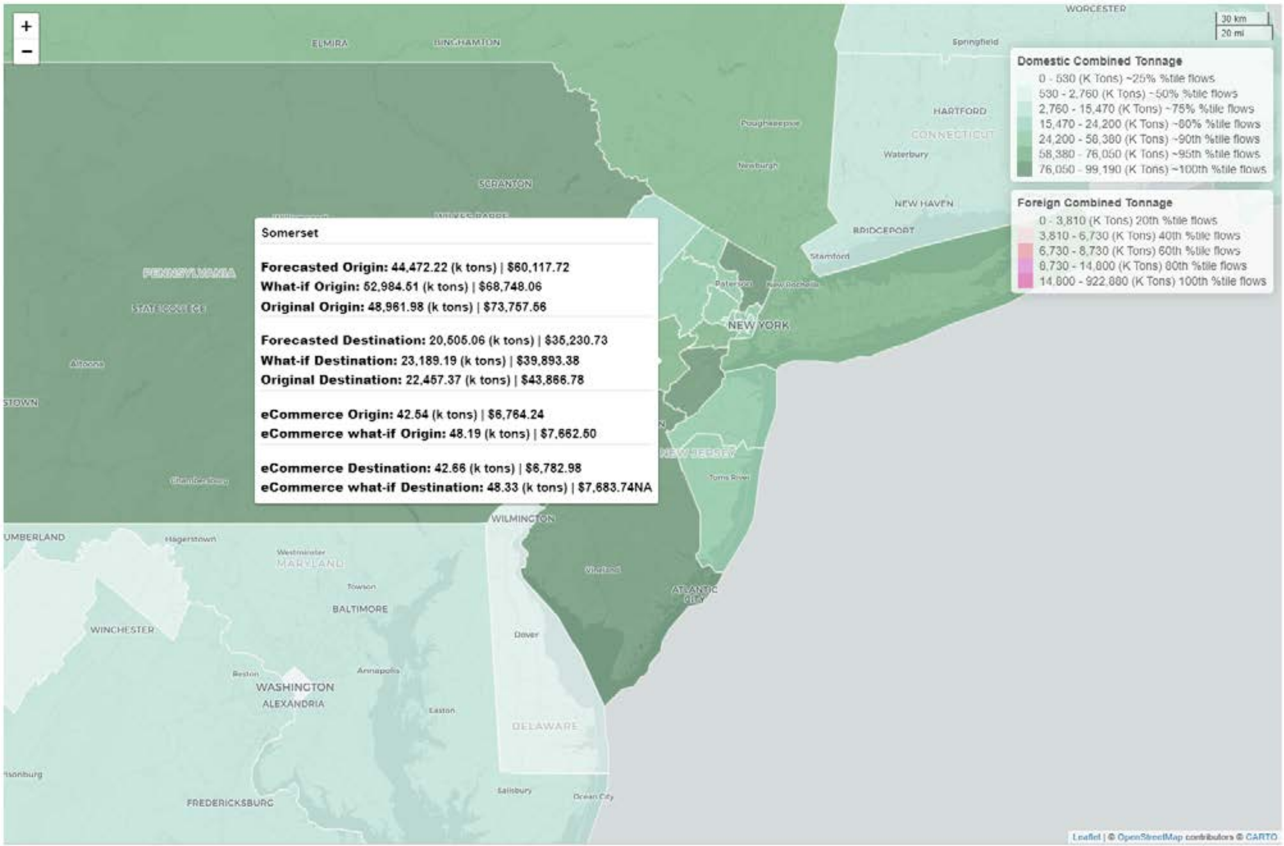
4.5 Expanded and Enhanced FFT Outputs

The updated FFT includes improved and expanded outputs that allow the user to explore the results of the forecast scenario selections. Key outputs include a map tab, which produces a mapped visualization of the forecast outputs. Clicking on a polygon in the map reveals a summary of the forecast results. Figure 11 shows an example of the mapped output, with summary results shown after clicking on Somerset County.

In addition, tabs that include graphs and tabular summaries of the forecast outputs are generated in the FFT. These graphs and tables allow for the analysis of the forecast results and comparisons of alternative scenarios and What-If selections to the baseline scenario.

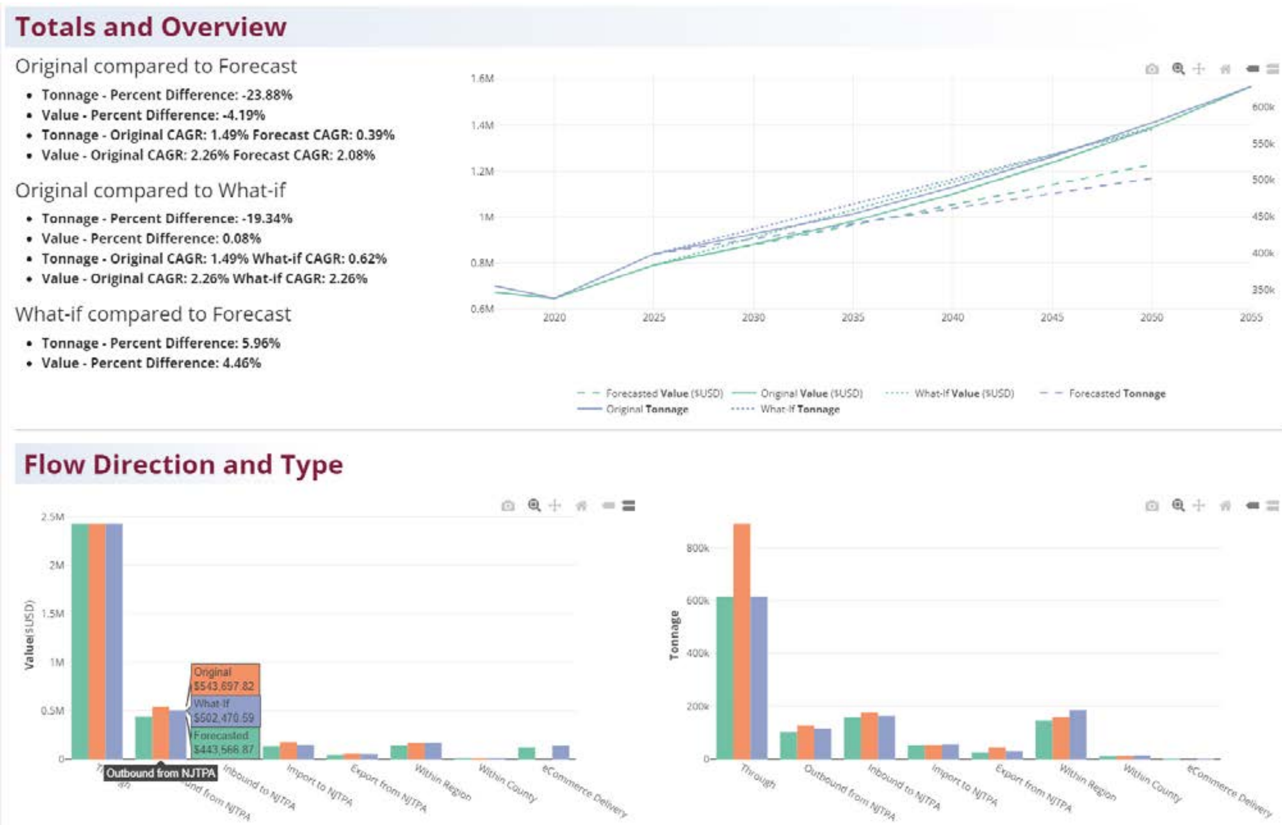
Figure 12 shows the overview summary of forecast results as displayed in the FFT. Users can scroll and click through to reveal more information in charts and tables that show the results measured in tons of goods and value of goods by direction of travel (inbound, outbound, etc.), transportation mode, commodity, and originating or terminating subregion.

Figure 11 Example of Mapped Forecast Results in the FFT



Source: NJTPA Freight Forecasting Tool, 2025

Figure 12 Example of an Overview of Forecast Results Presented in FFT



Source: NJTPA Freight Forecasting Tool, 2025

More examples of the FFT's user interface and outputs are shown in the FFT Users' Guide in Appendix E.

5.0 Economic and Freight Forecast Summary

The FFT uses economic forecasts at an industry sector level provided by Moody's and Bureau of Economic Analysis (BEA) Make-Use tables to associate freight commodities made or used by various industry sectors in order to generate estimates of commodities moving into, out of, or within the NJTPA region. This section describes the economic forecast scenarios, the process of associating freight commodities to economic sectors using make-use tables, and a high-level summary of the resulting freight forecast. More results can be found in the Freight Profiles Dashboard on the NJTPA's Freight Activity Locator website.

5.1 Economic Forecasts

Economic forecasts were purchased and acquired from Moody's. The forecasts included employment by industry sector at the county level for the baseline scenario, and state-level gross state product (GSP) by industry sector for all scenarios. The scenario forecasts also included forecasted personal consumption expenditures. The scenarios include:

- **Baseline Scenario:** This scenario is the baseline forecast of Moody's Analytics. Since it is a baseline, by definition the probability that the economy will perform better than this projection is equal to 50 percent, the same as the probability that it will perform worse. Employment projections by industry sector at the county level were provided, along with state-level GSP by industry sector forecast.

- **4th Percentile Scenario:** This above-baseline scenario is designed so that there is a four percent probability that the economy will perform better, broadly speaking, and a 96 percent probability that it will perform worse. A state-level GSP by industry sector forecast was provided.

- **10th Percentile Scenario:** This above-baseline scenario is designed so that there is a 10 percent probability that the economy will perform better, broadly speaking, and a 90 percent probability that it will perform worse. A state-level GSP by industry sector forecast was provided.

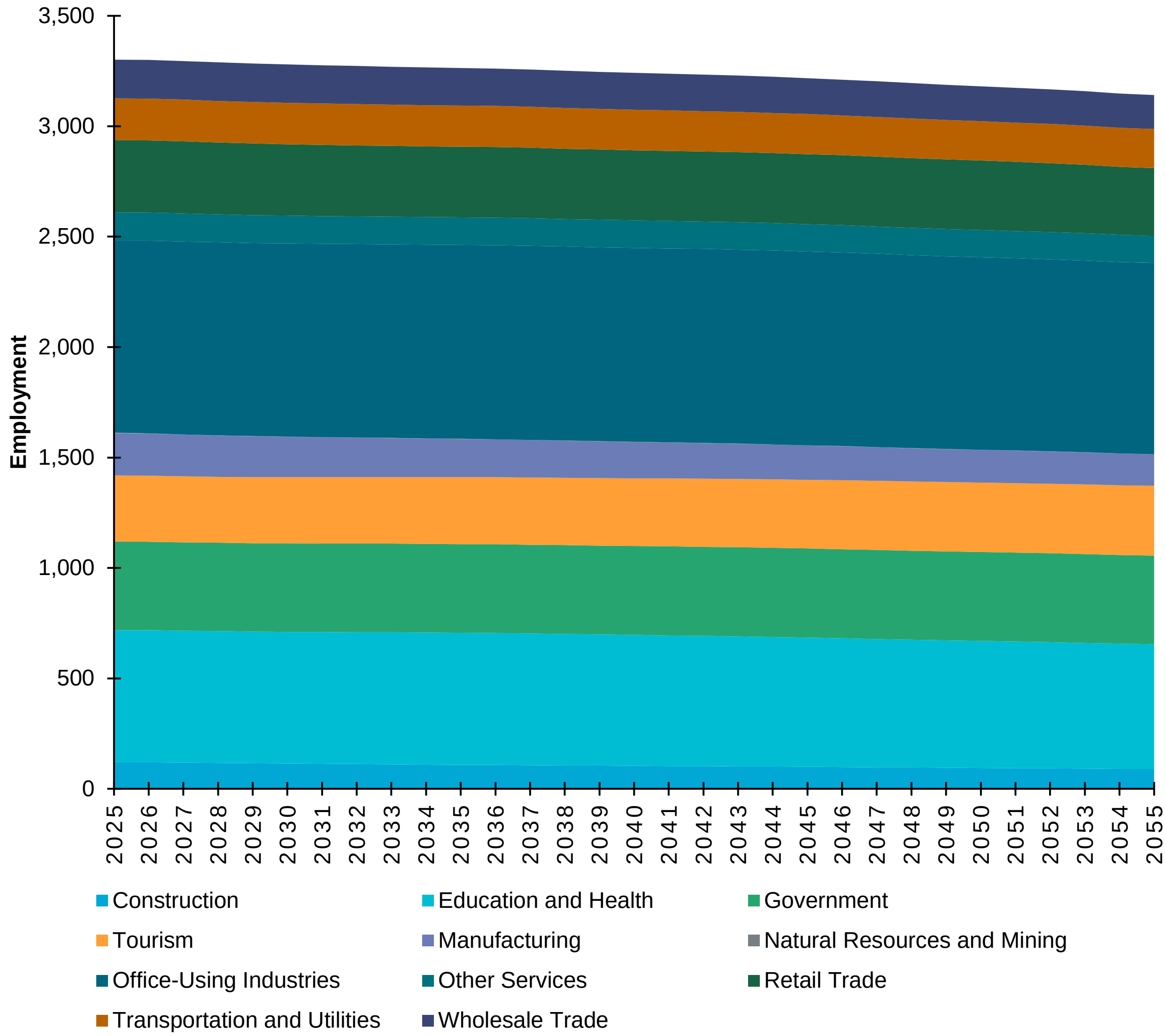
- **75th Percentile Scenario:** In this scenario, there is a 75 percent probability that the economy will perform better, broadly speaking, and a 25 percent probability that it will perform worse. A state-level GSP by industry sector forecast was provided.

- **90th Percentile Scenario:** In this scenario, there is a 90 percent probability that the economy will perform better, broadly speaking, and a 10 percent probability that it will perform worse. A state-level GSP by industry sector forecast was provided.

- **96th Percentile Scenario:** In this scenario, there is a 96 percent probability that the economy will perform better, broadly speaking, and a four percent probability that it will perform worse. A state-level GSP by industry sector forecast was provided.

Figure 13 shows the forecasted employment by industry sector for all major industries in the NJTPA region in the baseline scenario through 2055. The forecast anticipates a 3.5 percent decrease in total employment in the region during the forecast period. Sector projections range from six percent increase in tourism employment to a 29 percent decrease in natural resources and mining employment.

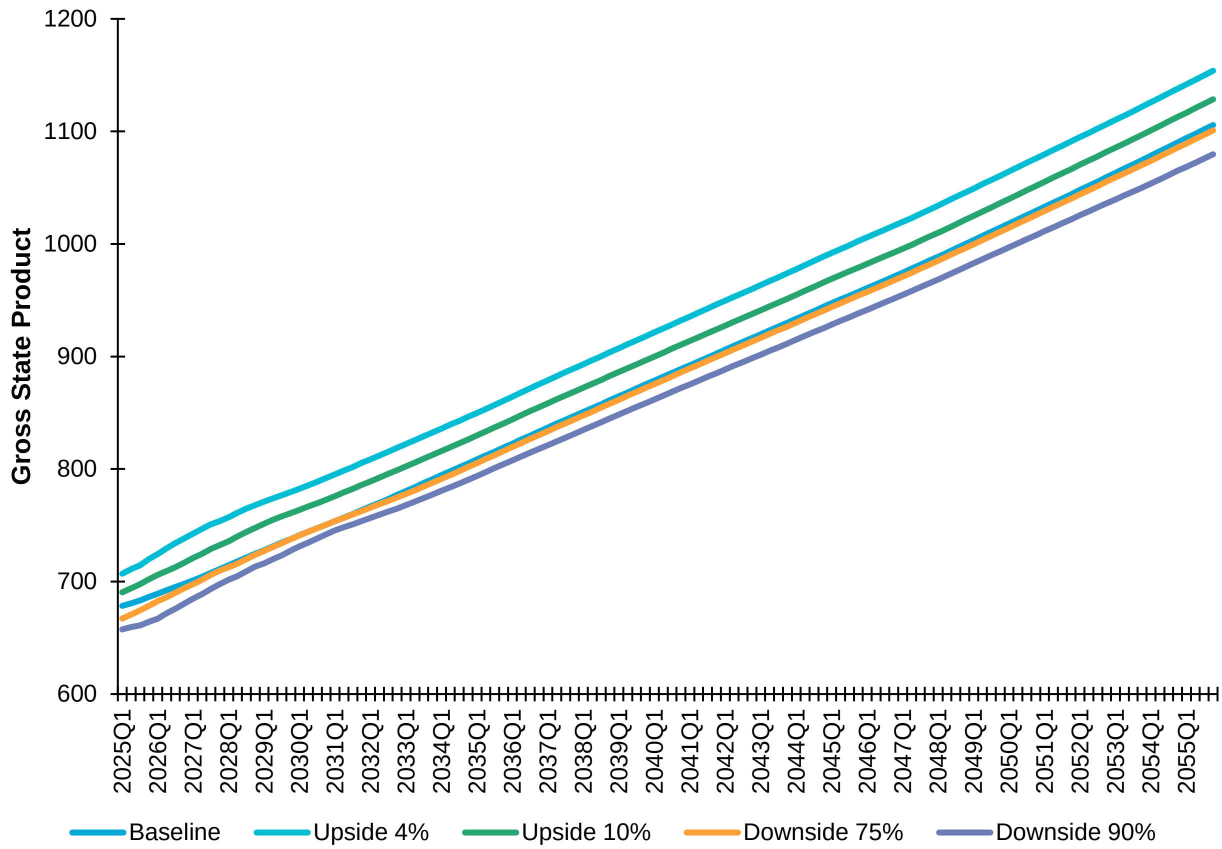
Figure 13 Employment by Industry Sector Forecast, Baseline Scenario, NJTPA Region, 2025-2055



Source: Cambridge Systematics analysis of data provided by Moody's.

Figure 14 shows the relative differences in gross state product forecasts by alternative economic scenario at the state level. The forecasts show that in all scenarios, gross state product is expected to increase between 2025-2055 by anywhere from 63 percent in the baseline scenario to 65 percent in the downside 75th percentile scenario. The expected growth in economic output despite stagnant employment growth suggests that substantial increases in labor productivity are expected in all scenarios.

Figure 14 Gross State Product by Economic Forecast Scenario for New Jersey, 2025-2055



Source: Cambridge Systematics analysis of data provided by Moody's.

5.2 Make-Use Tables

For purposes of freight forecasting, the most important output is the suite of Moody's economic forecasts. However, further analysis was needed to understand the relationship between economic output 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 output in a certain industry generates a five percent increase in the use of one commodity and a three percent increase in the use of another. These figures can be used to calculate freight tonnages, by commodity and direction, based on employment forecasts.

5.3 Freight Forecast

Using the baseline Moody’s economic forecast, a baseline freight forecast was developed for 2055 and interim years using the updated and enhanced FFT. Analysis of this baseline freight forecast for year 2050 served as a validation exercise for the FFT. Table 3 through Table 5 show the forecasted growth in freight by commodity bundle between 2025 and 2050 of freight that moves in, out, or within the NJTPA region. A full summary of freight forecast data is provided at the regional level in the regional, sub-regional, and commodity data summaries on the Freight Profiles Dashboard on the NJTPA’s Freight Activity Locator website. An explanation of the dashboard and samples of its contents are provided in Section 6.0.

While all scenarios are incorporated into the FFT, the Dashboard allows viewers to select one of three scenarios:

- **Baseline:** This is a freight forecast based upon the Moody’s Baseline Scenario;
- **Low:** This is a freight forecast based upon the Moody’s 4th Percentile Scenario; and
- **High:** This is a freight forecast based upon the Moody’s 96th Percentile Scenario.

Table 3 Forecast Results for the Baseline Growth Scenario

Commodity Bundle	Tonnage (2025)	Tonnage (2050)	Change in Tonnage (2025-2050)	Value (2025)	Value (2050)	Change in Value (2025-2050)
Aggregates	84.8M	110.8M	26.0M	$38.9B	$53.7B	$14.8B
Agriculture, Meat, & Fish	18.3M	16.1M	-2.2M	$32.8B	$29.6B	-$3.2B
Chemicals	27.8M	43.8M	15.9M	$102.5B	$162.2B	$59.7B
Durable Consumer Products & Direct-to-Consumer	20.4M	26.7M	6.3M	$167.4B	$277.4B	$110.0B
Food and Non-Durable Consumer Products	43.8M	46.4M	2.6M	$128.6B	$140.1B	$11.5B
Machinery, Electronics, & Transportation Equipment	12.8M	18.4M	5.6M	$204.7B	$326.2B	$121.5B
Natural Gas	100.1M	117.8M	17.7M	$21.5B	$25.5B	$4.0B
Other Energy Products	43.8M	59.8M	16.0M	$20.7B	$28.4B	$7.7B
Pharmaceutical Drugs	1.9M	3.1M	1.2M	$95.0B	$148.9B	$53.8B
Waste	27.4M	37.5M	10.1M	$3.7B	$5.1B	$1.4B
Wood & Paper Goods	18.2M	22.1M	3.9M	$25.2B	$30.9B	$5.6B
*E-Commerce**	*0.3M*	*0.8M*	*0.5M*	*$49.2B*	*$123.7B*	*$74.5B*
Total	**399.4M**	**502.4M**	**103.0M**	**$841.1B**	**$1,227.9B**	**$386.8B**

Source: NJTPA Freight Forecasting Tool, 2025.

*Note: *E-Commerce* is a part of the *Durable Consumer Products & Direct-to-Consumer* Bundle as well.

Table 4 Forecast Results for the Low Growth Scenario

Commodity Bundle	Tonnage (2025)	Tonnage (2050)	Change in Tonnage (2025-2050)	Value (2025)	Value (2050)	Change in Value (2025-2050)
Aggregates	84.8M	109.5M	24.7M	$38.9B	$52.5B	$13.5B
Agriculture, Meat, & Fish	18.3M	16.1M	-2.2M	$32.8B	$29.7B	-$3.1B
Chemicals	27.8M	43.2M	15.4M	$102.5B	$160.1B	$57.5B
Durable Consumer Products & Direct-to-Consumer	20.4M	26.4M	6.1M	$167.4B	$274.2B	$106.8B
Food and Non-Durable Consumer Products	43.8M	46.3M	2.5M	$128.6B	$139.0B	$10.4B
Machinery, Electronics, & Transportation Equipment	12.8M	17.8M	5.0M	$204.7B	$318.7B	$114.0B
Natural Gas	100.1M	117.3M	17.2M	$21.5B	$25.4B	$3.9B
Other Energy Products	43.8M	59.2M	15.3M	$20.7B	$28.1B	$7.3B
Pharmaceutical Drugs	1.9M	3.0M	1.1M	$95.0B	$147.1B	$52.1B
Waste	27.4M	36.5M	9.1M	$3.7B	$4.9B	$1.2B
Wood & Paper Goods	18.2M	22.0M	3.7M	$25.2B	$30.6B	$5.4B
*E-Commerce**	*0.3M*	*0.8M*	*0.5M*	*$49.2B*	*$121.9B*	*$72.7B*
Total	**399.4M**	**497.2M**	**97.8M**	**$841.1B**	**$1,210.2B**	**$369.1B**

Source: NJTPA Freight Forecasting Tool, 2025.

*Note: *E-Commerce* is a part of the *Durable Consumer Products & Direct-to-Consumer* Bundle as well.

Table 5 Forecast Results for the High Growth Scenario

Commodity Bundle	Tonnage (2025)	Tonnage (2050)	Change in Tonnage (2025-2050)	Value (2025)	Value (2050)	Change in Value (2025-2050)
Aggregates	84.8M	120.0M	35.2M	$38.9B	$59.1B	$20.2B
Agriculture, Meat, & Fish	18.3M	16.6M	-1.7M	$32.8B	$30.4B	-$2.4B
Chemicals	27.8M	47.6M	19.8M	$102.5B	$176.6B	$74.1B
Durable Consumer Products & Direct-to-Consumer	20.4M	28.7M	8.3M	$167.4B	$297.7B	$130.3B
Food and Non-Durable Consumer Products	43.8M	46.9M	3.1M	$128.6B	$143.3B	$14.8B
Machinery, Electronics, & Transportation Equipment	12.8M	21.6M	8.8M	$204.7B	$376.0B	$171.3B
Natural Gas	100.1M	120.0M	19.9M	$21.5B	$26.0B	$4.5B
Other Energy Products	43.8M	63.1M	19.3M	$20.7B	$30.0B	$9.3B
Pharmaceutical Drugs	1.9M	3.3M	1.4M	$95.0B	$160.4B	$65.4B
Waste	27.4M	40.2M	12.9M	$3.7B	$5.4B	$1.7B
Wood & Paper Goods	18.2M	23.0M	4.8M	$25.2B	$31.8B	$6.6B
*E-Commerce**	*0.3M*	*0.8M*	*0.5M*	*$49.2B*	*$133.8B*	*$84.6B*
Total	**399.4M**	**531.1M**	**131.7M**	**$841.1B**	**$1336.8B**	**$495.7B**

Source: NJTPA Freight Forecasting Tool, 2025.

*Note: *E-Commerce* is a part of the *Durable Consumer Products & Direct-to-Consumer* Bundle as well.

6.0 Online Dashboards

To present the final product of the forecasting tool in a publicly-accessible and easy-to-understand way, two online dashboards were created, the *Regional Profiles* dashboard and the *Commodity Profiles* dashboard. These are intended to be the evolution of the stand-alone PDF profiles produced for the previous iteration of the tool. The intent of the dashboards is to integrate outputs from the forecasting tool (both the FAF outputs and the e-commerce), the business establishment database, Moody's economic outputs, results from the NJRTM-E, and more into one package and have that package be interactive and informative to the public and other stakeholders.

Broadly, the two dashboards present the following information:

- Forecasts of freight data out to 2050
- Breakdowns of freight data by direction, commodity bundle, trading partner, and mode
- Highlights of e-commerce work including the e-commerce forecasts and the distribution of deliveries
- Link-level flows of all commodity bundles across the NJRTM-E network
- A summary of freight-related demographic information from the U.S. Census
- Aggregated historical and forecasted employment summaries from Moody's
- Maps showing the distribution and intensity of freight-related businesses and establishments
- Diagrams of key supply chain linkages for each commodity bundle (in the *Commodity Profiles* only)

In the *Regional Profiles*, this information is filterable to each of the 15 NJTPA subregions and in the *Commodity Profiles*, this information is filterable to each of the 11 commodity bundles in addition to e-commerce. In both dashboards, the information is available for three forecast growth scenarios: the baseline-growth scenario, the low-growth scenario, and the high-growth scenario, as defined in Section 5.3. These dashboards were developed within the NJTPA's ArcGIS Online environment and will be integrated into the larger ArcGIS Hub application known as the "Freight Activity Locator" when finalized. The dashboards were built primarily in ArcGIS Experience Builder, which is a browser-based tool that allows users to make web-based interactive applications that feature maps, charts, and more. All data and maps that the tool references are stored within the NJTPA's infrastructure as well.

Before being incorporated into the online dashboards, the data was prepared in specific ways to ensure smooth and efficient functionality within the online environment. Without this preparation, the tool would be slow and prone to hangs or crashes as it tried to process large amounts of data. The scripts used to clean and prepare this data have been provided to the NJTPA. These scripts will be necessary to maintain the tool and ensure consistent inputs to the online environment.

Screenshots of different parts of the tool are seen below in Figure 15, Figure 16, and Figure 17.

- **Figure 15:** The *Highway Utilization* module in the *Commodity Profiles* dashboard is used to show future forecasted e-commerce truck volumes. Some of the roads in Jersey City are projected to see between 2,500 and 5,000 e-commerce delivery vehicles per day in 2050.
- **Figure 16:** The *Demographics* module in the *Regional Profiles* dashboard is used to show the distribution and trend of population change from 2017 to 2022 is shown in Bergen County. Population in the County has grown only 1.6 percent from 2017 to 2022, one of the lowest amounts in the NJTPA region.
- **Figure 17:** The *Tonnage by Bundle* module in the *Regional Profiles* dashboard is used to show the top commodity bundles in 2025 and 2050, as well as if they're traveling out of the region, into the region, or within the region. Natural gas remains the top commodity bundle by tonnage in 2025 and 2050.

The Regional Profiles and Commodity Profiles dashboards are available for public viewing on NJTPA's Freight Activity Locator website.

Figure 15 Network Volumes of Trucks Carrying Durable Consumer Products and Direct to Consumer Deliveries, 2025

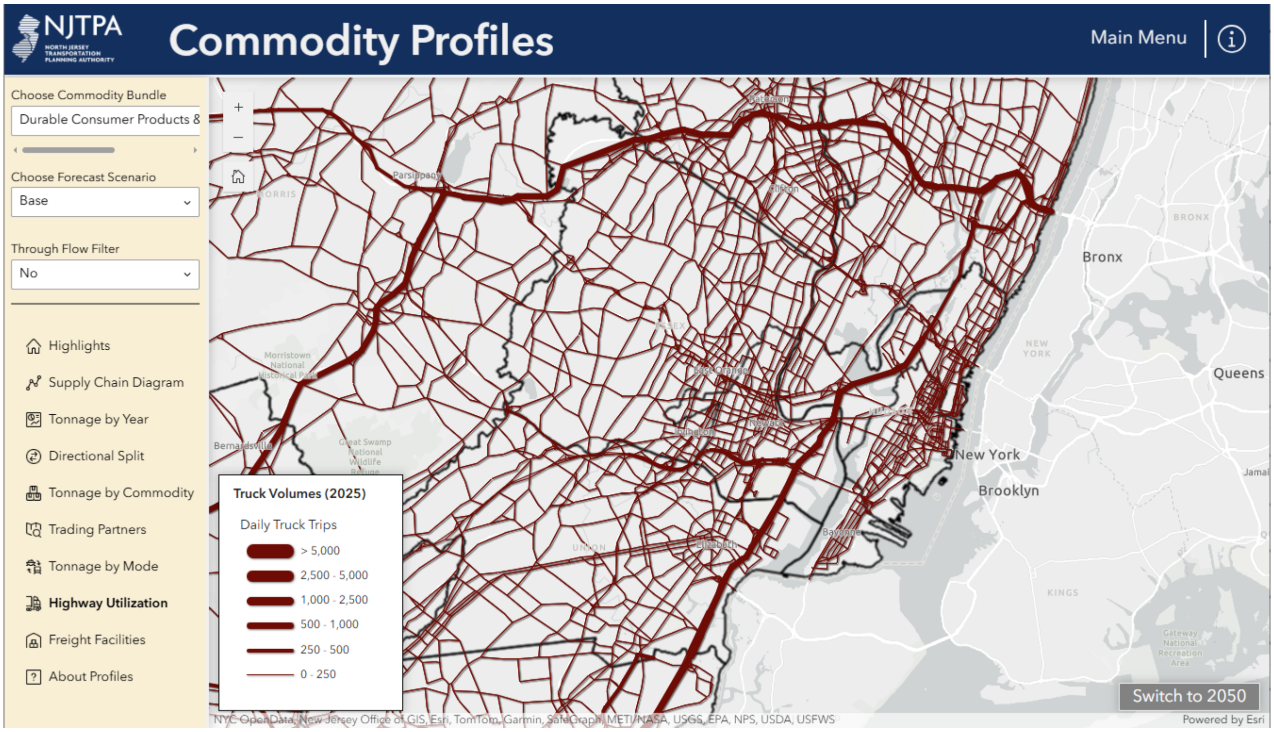


Figure 16 Population Change in Bergen County

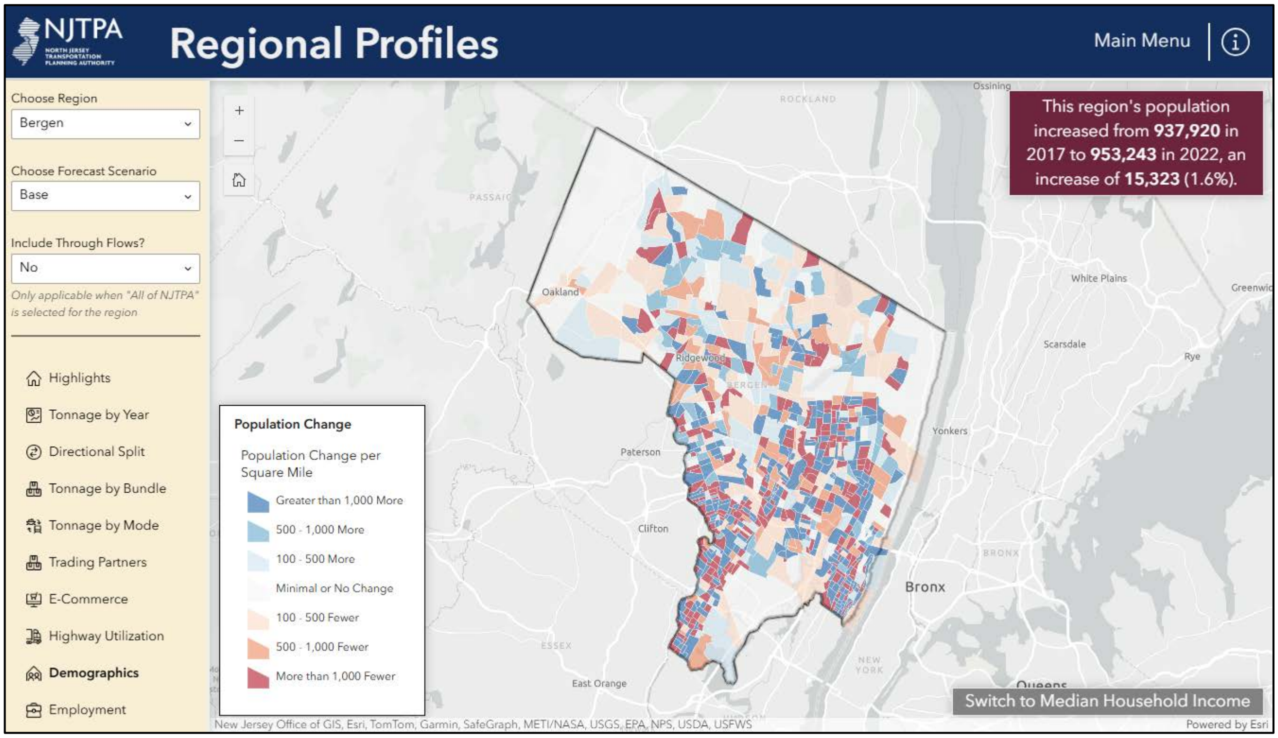
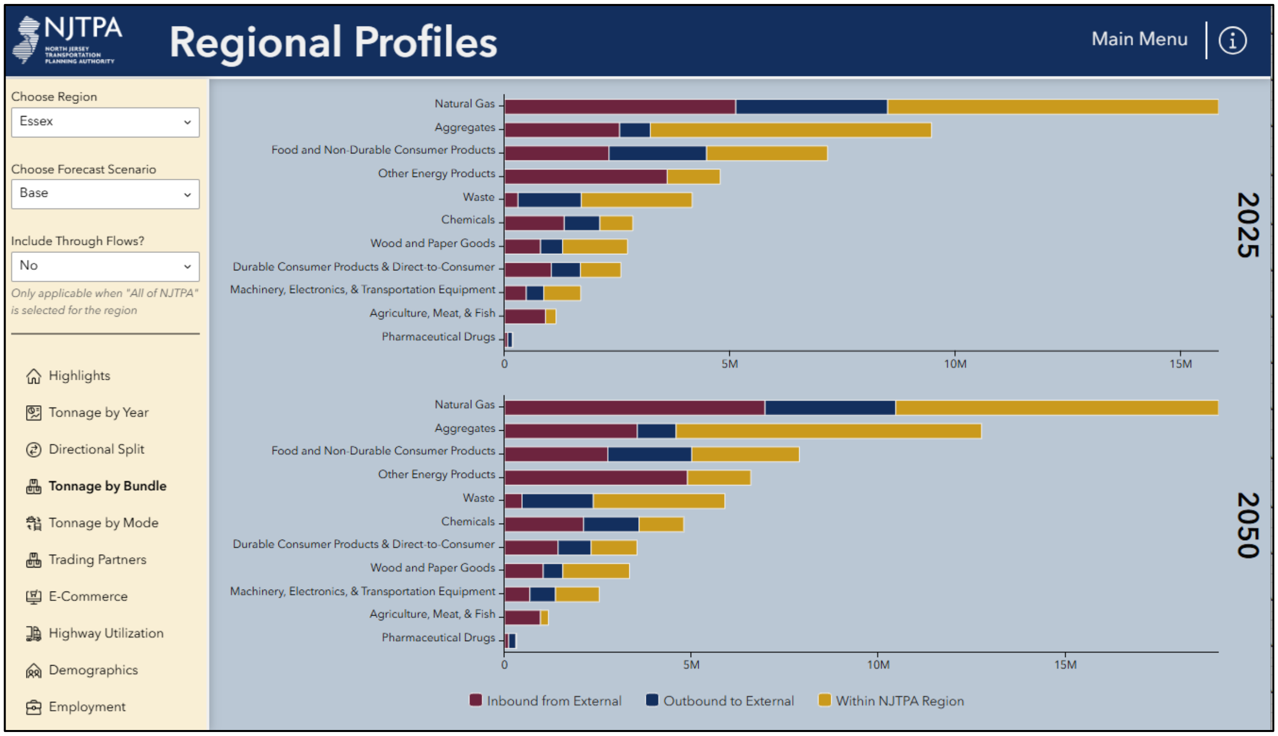


Figure 17 Tonnage in Essex by Commodity Bundle and Direction



Appendices

Appendix A. Methodological Framework

To keep up with emerging freight and industry trends, the North Jersey Transportation Planning Authority (NJTPA) has started an update of its Freight Industry Level Forecast study. The NJTPA has established themselves as a leader in freight forecasting among its peer MPOs and has previously conducted three freight forecasting studies since 2010. This memorandum provides an overview of the upcoming study's goals, objectives, and the methodological approach to implementing the scope of the study. This will help ensure that the consultant team, NJTPA staff, and the NJTPA's planning partners have a mutual understanding of the approach to the study and the study outputs that will be accomplished by the conclusion of the study.

To build on the prior work that the NJTPA has completed, the 2050 Freight Industry Level Forecasts Update will accomplish the following objectives:

- Update the underlying data and forecasts to meet an adjusted 2050 planning horizon, and to extend the outer forecast horizon to 2055.
- Expand upon the methodology pioneered in the 2050 Freight Industry Level Forecasts Study to develop a "Direct to Consumer" (DTC)4 delivery trip table using new intelligence regarding vehicle travel patterns and purposes.
- Enhance the FFT to process the latest available version of the U.S. DOT Freight Analysis Framework commodity flow data and forecasts, and to enhance the user interface and ease-of-use.
- Augment historic business establishment inventory data that the NJTPA possesses with publicly available data, market reports, and/or other publications to account for current trends and near-term future outlooks regarding development of industrial buildings that handle and/or generate freight shipments.
- Develop a new interactive suite of regional, subregional, and freight commodity profiles using outputs of the updated FFT.

To prepare this methodological framework to accomplish the above objectives, the project team completed the following activities:

- Affirmed the approach to disaggregate U.S. DOT's Freight Analysis Framework (FAF) to the county level, as well as confirmed an approach to further disaggregate Essex

[4] Note that "Direct to Consumer" flows were previously called "E-Commerce" flows in the prior NJTPA freight forecasting study.

County into Newark and the rest of Essex County and Hudson County into Jersey City and the rest of Hudson County.

- Reviewed the commodity bundles used in the last study and re-arrange those bundles based on emerging freight trends as well as community and business continuity.
- Updated prior research on available data and methods for estimating DTC delivery trips. The team then updated its approach to estimating DTC demand and truck trip patterns, which will again be based on a combination of approaches, as explained below.
- Evaluated the robustness and availability of data sources of location-based and GPS truck data, and outlined how this data would be used to enhance DTC trip table development and truck trip patterns as well as validating the results of the North Jersey Regional Transportation Model-Enhanced (NJRTM-E) regional travel demand model results.
- Reviewed the available sources of econometric forecasts and make/use tables and recommended a source that provides a forecast that aligns with the NJTPA geography, matches the industry and commodity groups in the FFT, and fits within the available budget.
- Explored possible enhancements and changes to the user settings, platform access, and scenario outputs generated by the NJTPA Freight Forecasting Tool (FFT).
- Review and recommend software applications and alternative design and user interfaces for the FFT.
- Affirmed its approach to engaging stakeholders, including the Technical Advisory Council (TAC), private industry and subregions.
- Develop a comprehensive list of data required to complete the study, by category.

Figure 18 shows a diagram of the methodological framework to complete the objectives of this study. It includes a step-by-step approach divided into three categories: preparation activities; key technical analyses; and presenting the results. The steps in the diagram are listed by number, in order of sequence, and the numbers do not correspond to task numbers in the contract for the current study. This framework is explained below:

- **Preparation** – These are the steps to affirm the goals, objectives, and approach to the study as well as a plan for obtaining the data sources needed for the technical analyses.

- **Step One: Affirm Methodological Framework and Data Sources** – This step was critical to laying out the goals and objectives of the study and exploring a variety of approaches and data sources to accomplish them. Key to the development of the methodological framework for this study update was to affirm the FAF disaggregation approach, commodity bundle makeup, approach to Direct to Consumer (DTC) trip table development, updates to the FFT, and the format of the planned results.

- **Step Two: Acquire Data** – This step sought to acquire the data needed to complete the study. This includes the data sources needed to disaggregate the FAF database, the data sources used to build the DTC trip table and analyze the behavior of delivery trucks in the region, and the data sources needed to build up an inventory of commercial real estate and business establishments within the region.

- **Key Technical Analyses** – These are the core steps of the study where the data are used to carry out the approaches for the technical analyses scoped in the study.

  - **Step Three: Disaggregate FAF to the Subregional Level** – This step used the most recent version of FAF, Version 5.6, and disaggregated it to the county level for all 13 counties in the NJTPA region to have a clear picture of freight moving into, out of, and within the region. Additionally, this study also disaggregated Essex and Hudson counties into two zones — Newark and the rest of Essex County and Jersey City and the rest of Hudson County.

  - **Step Four: Estimate DTC Flows** – This step created a trip table of DTC flows to capture the impact that e-commerce is having on the NJTPA region. It started by using a Nielsen IQ consumer research data for e-commerce package volume and scan locations and then supplemented this data with e-commerce carrier facility locations, truck GPS, and regional travel demand model data to estimate the number and distribution of last-mile delivery trips on the region’s highway network.

  - **Step Five: Enhance the Freight Forecasting Tool** – This step updated the existing FFT with the new data sources acquired in Step Two and produced in Steps Three and Four. Additional improvements were made to the tool, such as enhancing the user interface, incorporating the FAF disaggregation capability into the tool, better integrating the DTC data with other commodity flow data, and improving the outputs that are created after running a scenario.

  - **Step Six: Generate Future Freight Forecasts and What-If Scenarios** – This step created a new freight forecast for the NJTPA region by combining the commodity flow database produced in Steps Three and Four with the acquired econometric forecast. Additionally, adjustments to existing What-If scenarios were made, and new What-If scenarios were added to the tool. Finally, as part of this step, the distribution of freight generating industries and commercial real estate in the NJTPA region were mapped, with facility-level truck trip estimates added.

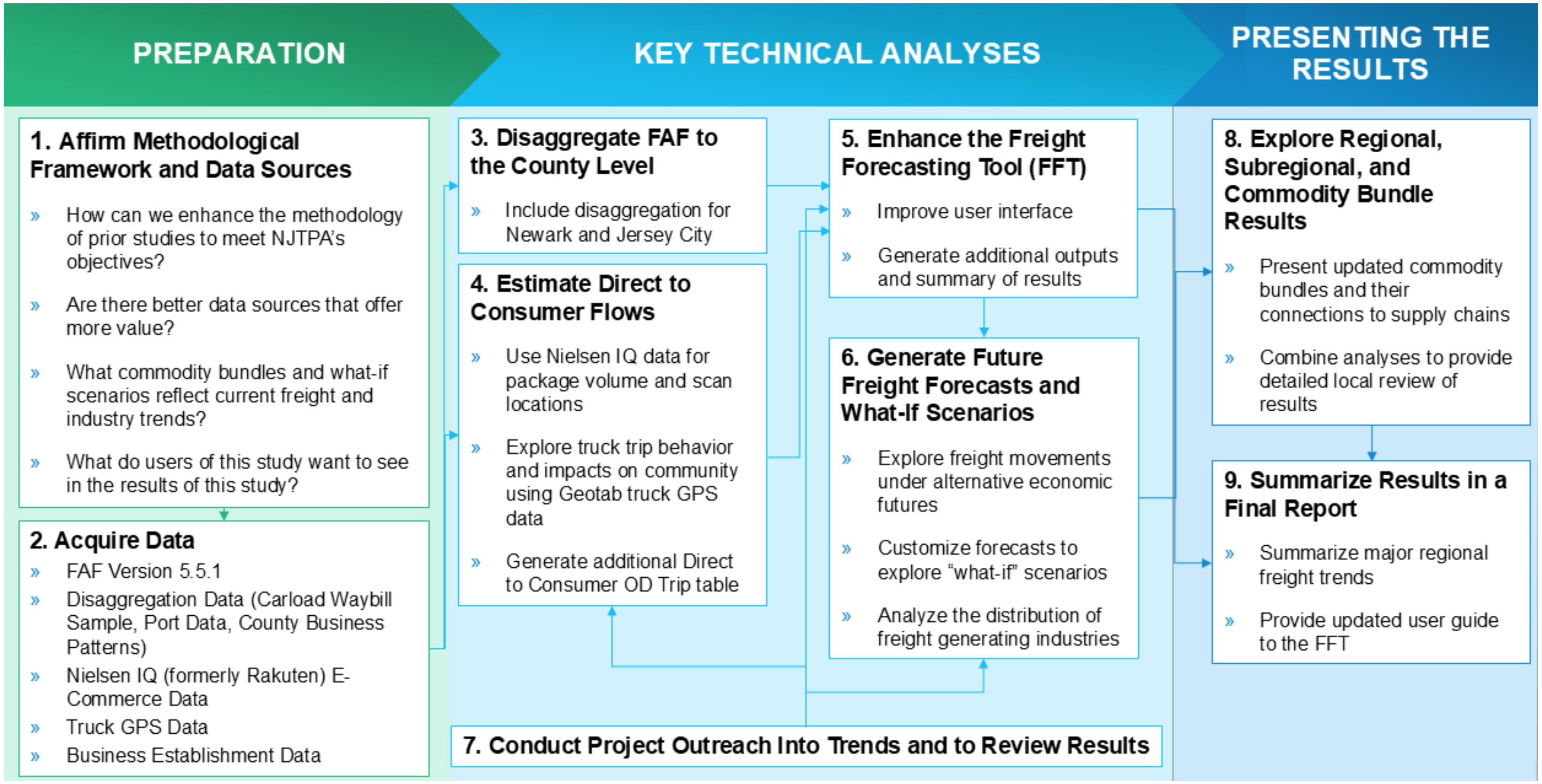
  - **Step Seven: Conduct Project Outreach into Trends and to Review Results** – Occurring concurrently with Steps Three through Six, the project team engaged the study's Technical Advisory Committee (TAC) in two working meetings to review proposed approaches, interim results, and build consensus on next steps. The team also met with the NJTPA subregions to review preliminary results of the study and receive comments on the outputs.

- **Presenting the Results** – These tasks were implemented to present the findings of the key technical analyses from a variety of perspectives in formats that are broadly useful for understanding freight from the regional level down to the local level and from the point of view of key supply chains.

  - **Step Eight: Explore Regional, Subregional, and Commodity Bundle Results** – This step presented the current and future freight flows within the region to show the major freight and supply chain trends and how these trends affect the region as a whole and the subregions within the NJTPA area.

  - **Step Nine: Summarize Results in a Final Report** – This step summarized the major regional freight trends and key analysis results and provided an updated user guide for the FFT.

Figure 18 Methodological Framework Diagram



A.1 Approach by Task

A.1.1 Task Three – Disaggregate FHWA's Freight Analysis Framework Database

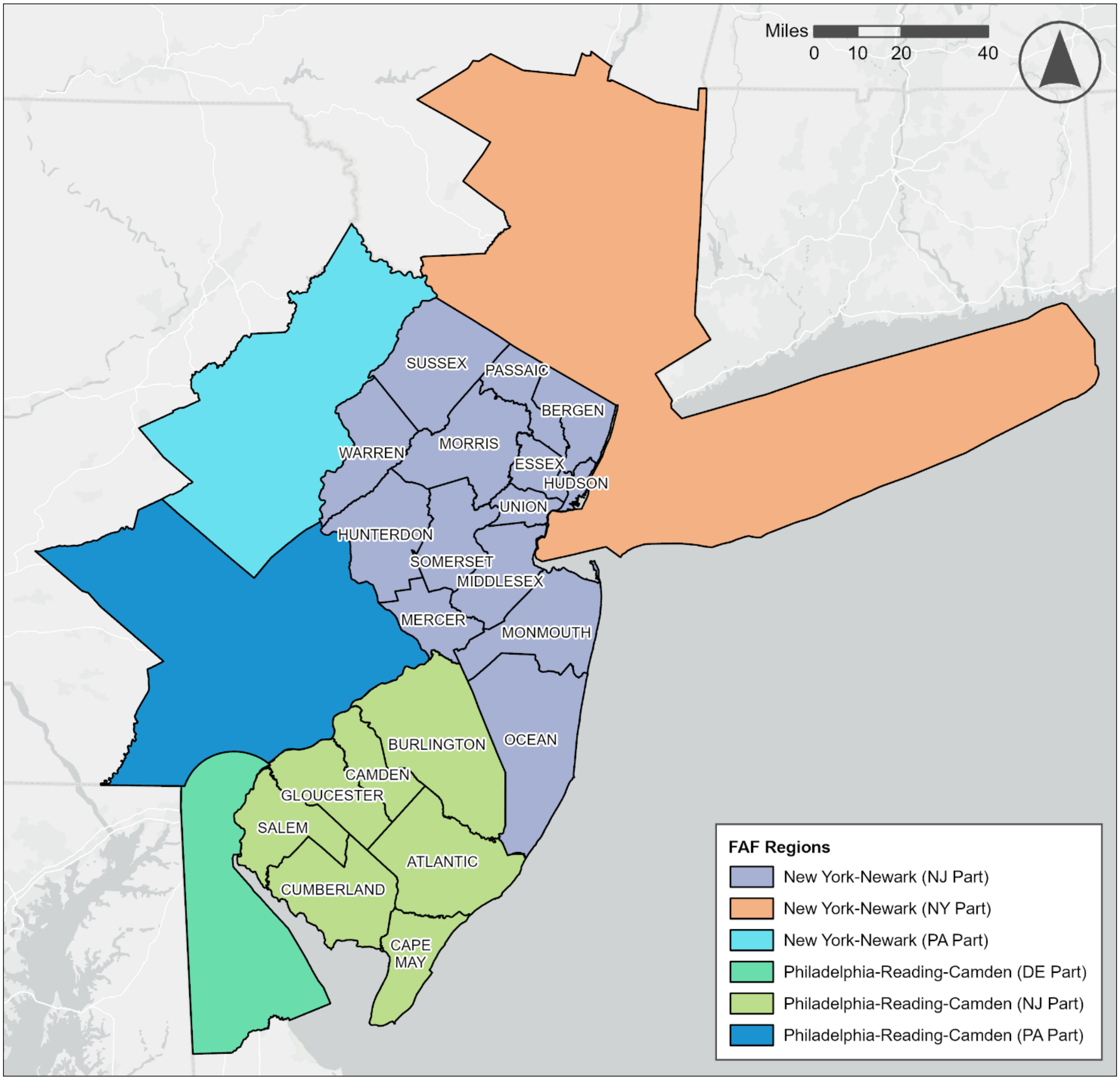
The FFT produces county-level base-year and forecast-year commodity flows based upon enhanced versions of the U.S. DOT's FAF commodity flow database. The FAF provides commodity flow data and forecasts by mode, commodity, and trade type (import, export, domestic). The unit of geography in FAF is a group of 132 regions across the country, corresponding to census metropolitan area (CMA) boundaries located within each state. The State of New Jersey consists of two FAF regions. To support the analysis required for this study, the underlying commodity flow data must be at the county level. County-level FAF disaggregation was performed for the 2050 Freight Industry Level Forecasts Study. This step will be performed again with an updated version of FAF that has been released since the completion of the previous study.

Update to Methodological Approach

The objective of this task is to use the Federal Highway Administration's (FHWA) FAF database for the disaggregation of regional freight flows to smaller geographies. The FAF data provides information on freight flows among states and metropolitan areas by all modes of transportation and has been extensively used for various freight planning and policy analysis. In addition, this task will require the use of other modes data including the Surface Transportation Board (STB) Waybill Sample data and port terminal data to determine commodity flows for rail and ports. Section A.2.3 provides more detailed information on the data required for this task.

The FAF data provides information on freight movements among states and metropolitan areas by all modes of transportation. The FAF database has a group of 132 domestic FAF regions across the country, corresponding to the state portion of Commodity Flow Survey metropolitan areas and the remainder of each state. The study area has 47 counties that compose multiple FAF regions in New Jersey (two FAF regions) and adjacent states (New York, Pennsylvania, and Delaware), as shown in Figure 19.

Figure 19 Freight Analysis Framework Regions in and Around New Jersey



Source: Federal Highway Administration's Freight Analysis Framework Version 5

The disaggregation of FAF data for the study area will be a two-step process. The first step is to disaggregate the FAF region data to the Federal Information Processing System (FIPS) county equivalent for New Jersey, New York, Pennsylvania, and Delaware. This process will require knowledge of the number of tons produced or attracted for each county within the study area. The first step will leverage the disaggregation factor methodology that the NJTPA and Cambridge Systematics have developed and used in prior studies and for other regional partners. The methodology established relationships between the tons produced or attracted from FAF and a selection of explanatory variables (e.g., employment and population). The relationships will be updated with the latest data.

The second step is to aggregate the FAF flows to two study cities – dividing Essex County into Newark and the rest of Essex County and Hudson County into Jersey City and the rest of Hudson County. The County Business Pattern data will be used at the ZIP code level (ZBP) to accomplish this. The ZBP database contains establishment information at the ZIP code geography. A spatial relationship will be developed to match ZIP code boundaries with city boundary, which will be used to apportion freight flows associated with the two host counties for Newark and Jersey City.

For disaggregation of FAF flows through the region's ports, the project team will seek data from Port Authority of New York and New Jersey (PANYNJ). The methodology that the NJTPA and Cambridge Systematics has developed includes disaggregation factors for FAF flows through ports. In addition, individual port details will used to produce port factors based on tonnages or percent split by commodity. For domestic multimodal flows, rail terminals are likely to serve as the intermediate stops within a supply chain. The STB Waybill sample will be used, along with an association of rail terminals with customer counties within the NJTPA model area, to produce origins and destinations by commodity and establish intermediate stops into the multimodal supply chains for rail.

It should be noted that FAF commodity flow data is based on Standard Classification of Transported Goods (SCTG) two-digit commodities. During the disaggregation process, the commodity flows will be converted based on the North American Industry Classification System (NAICS) three-digit industries.

Review of Commodity Bundles

In addition to updating the methodology used to disaggregate the FAF database for the NJTPA region, we have also reviewed the commodity bundles that were used in prior studies to consider different bundles in the upcoming study. The objective of this review is to examine commodity trends in the latest version of the FAF and the economic development priorities of the state to develop a new set of commodity bundles that reflect key supply chain groups for the region. We have reviewed these groups based on several factors:

- Total volume and value of commodities in FAF5.
- Business continuity potential – are there commodities that we can single out that are necessary for the key industries and businesses in the NJTPA region to sustain operations after a disruptive event has occurred?

- Community continuity potential – are there commodity movements that are essential for sustaining the residences of the region after a disruptive event has occurred?
- Industry trends and indicators in the present and future.

To determine key industries and anticipated trending commodities, we first reviewed the state economic development strategy. The NJ Economic Development Authority (NJEDA) finalized this economic development plan in 2018 that focused on five key goals and four strategic priorities[5]. These four strategic priorities call for investments in people, communities, innovation, and government. The four strategic priorities also emphasize industries in the innovation economy (e.g., life sciences, pharmaceuticals, and information technology), financial sector (e.g., finance and insurance), advanced manufacturing and logistics (including aviation), clean energy (e.g., wind), food and beverage, and film and digital media. The plans focus on biotechnology and pharmaceuticals, clean energy, and advanced manufacturing and logistics.

Next, we reviewed the trends available for the NJTPA region in the non-disaggregated FAF 5.5.1 database[6]. The forecasted changes in total flows for FAF Region 341 (New York NY-NJ-CT-PA (NJ Part)) from 2017 to 2050 for each SCTG code broken down by direction of travel are shown in Table 6.

Table 6 Forecasted Changes in SCTG Commodities in FAF5 for the NJTPA Region

SCTG2 Commodity Group	Change in Value - Inbound Everywhere (Except Northern NJ) to Northern NJ *(million 2017 $)*	Change in Value - Outbound Northern NJ to Everywhere *(million 2017 $)*	Change in Tons - Inbound Everywhere (Except Northern NJ) to NJ *(thousands of tons)*	Change in Tons – Outbound Northern NJ to Everywhere *(thousands of tons)*
01-Live animals/fish	285	359	89	80
02-Cereal grains	199	1,564	842	9,827
03-Other ag prods.	1,656	6,407	942	1,957
04-Animal feed	1,131	670	974	443
05-Meat/seafood	5,470	6,039	1,189	754
06-Milled grain prods.	4,737	14,395	2,977	4,678
07-Other foodstuffs	7,365	52,239	5,517	12,933
08-Alcoholic beverages	1,937	20,331	993	3,963

[5] New Jersey Economic Development Authority (NJEDA), The State of Innovation: Building a Stronger and Fairer Economy in New Jersey, October 2018 https://www.njeda.gov/wp-content/uploads/2021/02/StrongerAndFairerNewJerseyEconomyReport.pdf

[6] Bureau of Transportation Statistics, Freight Analysis Framework https://www.bts.gov/faf

SCTG2 Commodity Group	Change in Value - Inbound Everywhere (Except Northern NJ) to Northern NJ *(million 2017 $)*	Change in Value - Outbound Northern NJ to Everywhere *(million 2017 $)*	Change in Tons - Inbound Everywhere (Except Northern NJ) to NJ *(thousands of tons)*	Change in Tons – Outbound Northern NJ to Everywhere *(thousands of tons)*
09-Tobacco prods.	49	2,385	2	(25)
10-Building stone	66	582	116	631
11-Natural sands	17	156	323	4,088
12-Gravel	50	303	1,863	17,201
13-Nonmetallic minerals	272	1,266	1,336	6,235
14-Metallic ores	37	127	144	179
15-Coal	(7)	(5)	(38)	(128)
16-Crude petroleum	36	1,794	112	(4,273)
17-Gasoline	1,303	3,861	2,791	(6,126)
18-Fuel oils	243	3,146	568	(2,584)
19-Natural gas and other fossil products	2,684	11,216	11,713	43,937
20-Basic chemicals	10,495	22,390	8,631	6,786
21-Pharmaceuticals	76,768	88,925	935	2,249
22-Fertilizers	192	220	402	366
23-Chemical prods.	14,779	80,997	3,507	8,033
24-Plastics/rubber	14,781	46,874	3,983	8,928
25-Logs	12	1,641	46	997
26-Wood prods.	2,336	3,615	1,848	4,489
27-Newsprint/paper	1,520	1,571	1,646	589
28-Paper articles	1,842	5,896	850	1,453
29-Printed prods.	121	625	2	119
30-Textiles/leather	24,291	67,418	1,898	4,385
31-Nonmetal min. prods.	2,063	6,929	5,200	5,579
32-Base metals	1,989	6,813	1,001	1,607
33-Articles-base metal	2,134	10,262	559	1,223
34-Machinery	9,993	45,874	889	4,377
35-Electronics	16,254	101,702	676	3,386
36-Motorized vehicles	10,360	92,846	885	4,999
37-Transport equip.	1,305	4,918	6	192
38-Precision instruments	17,791	27,111	276	524
39-Furniture	3,600	22,565	531	3,089

SCTG2 Commodity Group	Change in Value - Inbound Everywhere (Except Northern NJ) to Northern NJ (million 2017 $)	Change in Value - Outbound Northern NJ to Everywhere (million 2017 $)	Change in Tons - Inbound Everywhere (Except Northern NJ) to NJ (thousands of tons)	Change in Tons – Outbound Northern NJ to Everywhere (thousands of tons)
40-Misc. mfg. prods.	26,136	63,874	1,298	5,938
41-Waste/scrap	687	5,413	1,669	12,007
43-Mixed freight	17,801	34,869	5,059	7,552
Total	**284,778**	**870,182**	**$74,250**	**$182,635**

Source: Freight Analysis Framework Version 5.5.1

The highest increase in the value of the commodities between 2017 to 2050 within any single SCTG code is the $101.7 billion increase for the value of electronics that will originate in Northern New Jersey and be outbound elsewhere and within the region. $92.8 billion in motorized vehicles is also anticipated to be sent outbound from Northern New Jersey to the region and elsewhere. Pharmaceuticals and chemical products outbound from the region are also estimated to increase greatly over this timeframe (values of $88.9 billion and $81.0 billion respectively). In terms of goods inbound into the region from elsewhere, pharmaceuticals are expected to have the greatest increase in value of $76.8 billion. The second highest increase is anticipated in miscellaneous manufacturing products at $26.1 billion.

In terms of tonnage, natural gas is expected to have the greatest increase from 2017 to 2050 for both goods inbound into the region (11.7 million tons) and outbound from the region (43.9 million tons). Other high tonnage commodities with increases in goods outbound from the region include other foodstuffs (5.5 million tons), nonmetal mineral products (5.2 million tons), and mixed freight (5.1 million tons). High tonnage commodities with the greatest increases outbound from the region include gravel (17.2 million tons), other foodstuffs (12.9 million tons), and waste/scrap (12.0 million tons).

Besides the forecasted changes in tonnages and value for each commodity classification and the highlighted industries and commodities in NJEDA’s economic development plan, commodity bundles that would distinctly support community and business continuity were also considered. These items would include things like energy (especially natural gas), durable consumer goods, and non-durable consumer goods. Another factor that supported the bundling is the grouping of the SCTG commodity code list. For example, codes 01-05 are normally grouped together as agriculture products and fish. Therefore, all these codes are grouped together for the “Agriculture, Meat, and Fish” bundle.

The list of commodity bundles is shown in Table 7. The chemicals, machinery, pharmaceuticals, and waste bundles are defined as they were in the 2050 Freight Industry Level Forecasts Study. The other changes are explained below.

Table 7 Proposed Commodity Bundles by SCTG Code

Commodity Bundle	SCTG Commodity Groups
01 – Durable Consumer Products and Direct-to-Consumer	• 39-Furniture • 40-Misc. mfg. prods. • 43-Mixed freight • Direct to Consumer (DTC) Flows (From Task Four)
02 – Food and Non-Durable Consumer Products	• 06-Milled grain prods. • 07-Other foodstuffs • 08-Alcoholic beverages • 09-Tobacco prods. • 30-Textiles/leather
03 – Agriculture, Meat, and Fish	• 01-Live animals/fish • 02-Cereal grains • 03-Other ag prods. • 04-Animal feed • 05-Meat/seafood
04 – Wood and paper goods	• 25-Logs • 26-Wood prods. • 27-Newsprint/paper • 28-Paper articles • 29-Printed prods.
05 – Waste/scrap	• 41-Waste/scrap
06 – Aggregates	• 10-Building stone • 11-Natural sands • 12-Gravel • 13-Nonmetallic minerals • 14-Metallic ores • 31-Nonmetal min. prods. • 32-Base metals • 33-Articles-base metal
07 – Machinery, Electronics, & Transportation Equipment	• 34-Machinery • 35-Electronics • 36-Motorized vehicles • 37-Transport equip. • 38-Precision instruments
08 – Natural Gas	• 19-Natural gas and other fossil products

Commodity Bundle	SCTG Commodity Groups
09 – Other Energy Products	• 15-Coal • 16-Crude petroleum • 17-Gasoline • 18-Fuel oils
10 – Pharmaceuticals	• 21-Pharmaceuticals
11 – Chemicals	• 20-Basic chemicals • 22-Fertilizers • 23-Chemical prods. • 24-Plastics/rubber

Natural gas is expected to increase greatly in tonnage between 2017 to 2050 unlike other energy commodities like coal that are expected to decrease. Therefore, natural gas was pulled out separately from the other energy commodities. Similarly, pharmaceuticals are expected to have large increases in the value of this commodity that moves through Northern New Jersey between 2017 to 2050 unlike other chemical products like fertilizers. So, it makes sense to continue including pharmaceuticals as separate bundle, as in the prior studies.

Aggregates contain many materials that would be important for construction. These materials are separate from wood and paper products, which we placed in its own distinct category. Food and non-durable consumer products were separated into two bundles, one of which is agriculture, meat, and fish, and the other is food and non-durable consumer products, which includes grain, alcohol, tobacco products, and textiles. Machinery and electronics is its own category and includes motorized vehicles and transportation equipment. Finally, there is a durable consumer products bundle, which includes products like furniture, sporting equipment, jewelry, and other products. Because the e-commerce economy is made of up of predominantly durable consumer products, we recommend including the DTC flows generated in Task Four (see Section A.1.2) within this commodity bundle to reflect the role it plays in the larger consumer, warehousing, and distribution economy. This is a change from prior studies when DTC flows were included in their own bundle.

The forecasted changes for each of these bundles from 2017 to 2050 is shown in Table 8 in terms of changes in tonnage and value.

Table 8 Commodity Bundle Forecasted Changes from 2017 to 2050

SCTG2 Commodity Group	Change in Value - Inbound Everywhere (Except Northern NJ) to Northern NJ (million 2017 $)	Change in Value - Outbound Northern NJ to Everywhere (million 2017 $)	Change in Tons - Inbound Everywhere (Except Northern NJ) to NJ (thousands of tons)	Change in Tons – Outbound Northern NJ to Everywhere (thousands of tons)
01 - Durable Consumer Products and Direct-to-Consumer	47,537	121,308	6,888	16,579
02 - Food and Non-Durable Consumer Products	38,380	156,769	11,388	25,933
03 - Agriculture, Meat, and Fish	8,741	15,038	4,036	13,062
04 - Wood and paper goods	5,830	13,348	4,391	7,646
05 - Waste/scrap	687	5,413	1,669	12,007
06 - Aggregates	6,627	26,438	10,542	36,742
07 - Machinery, Electronics, & Transportation Equipment	55,703	272,450	2,733	13,478
08 - Natural Gas	2,684	11,216	11,713	43,937
09 - Other Energy Products	1,574	8,795	3,433	(13,111)
10 - Pharmaceuticals	76,768	88,925	935	2,249
11 - Chemicals	40,247	150,481	16,523	24,113
Total	**284,778**	**870,182**	**74,250**	**182,635**

Source: Freight Analysis Framework Version 5.5.1

With this bundling, the greatest increase from 2017 to 2050 for the value of goods is an anticipated $272.5 million increase in the value of machinery, electronics, and transportation equipment being transported outbound from northern New Jersey to elsewhere. The other bundles that are expected to have large increases in the value of goods moving outbound from the region to elsewhere are food and non-durable consumer products ($156.8 billion), chemicals ($150.5 billion), durable consumer products and DTC goods ($121.3 billion), and pharmaceuticals ($88.9 billion). These five bundles are also the most significant in terms of change in value from 2017 to 2050 in goods inbound into the region as well.

In terms of tonnage, natural gas, aggregates, chemicals, food and non-durable consumer products, and durable consumer products and direct-to-consumer products are expected to increase the most from 2017 to 2050 both for goods inbound into the region and outbound from the region. The only bundle expected to decrease is the tonnage of other energy products besides natural gas (like coal and petroleum). The amount of this commodity bundle outbound from northern New Jersey is expected to decrease by 13.1 million tons from 2017 to 2050.

The new commodity bundle definitions were shared with the study's TAC for review and comment before being accepted and applied in the study.

A.1.2 Task Four – Create a Regional Direct to Consumer Delivery Truck Origin-Destination Matrix

The DTC delivery trip table's purpose is to capture the behavior of all e-commerce trucks in the region and understand its contribution to truck traffic, including VMT. The model from prior studies will be updated and improved with additional data which was not available in the prior project. These data sources include enhanced e-commerce market data from Nielsen IQ (explained in more detail in Section A.2.2, below) as well as Geotab location based data to explore truck trip behavior (explained in more detail in Section A.2.1, below).

The Neilson IQ data provides overall targets for the number of packages going to each zip code by carrier, as well as origin facility data for some packages. When the current model was developed, this data, then owned by Rakuten, included only number of packages by destination.

The Geotab data provides truck trip and stop data segmented by truck patterns. Its data include major delivery fleets which carry e-commerce parcels to their final destinations. In this study the relevant pattern segment is referred to as "door-to-door" and identifies those trucks which make many short stops. These data can be used to develop and calibrate the model which describes how packages get from the distribution centers to their destinations. Several pieces of information can be used for this purpose. Linked trips which count the short stops along the way can show a distribution of number of stops made as well as overall distance traveled in a delivery shift/run. Unlinked trips can show the catchment areas of facilities by examine the interzonal trips. Stop and intrazonal trip data can be used for relative comparisons to package volumes and linked trips to further understand the relationship between tours, packages, and local stops.

Research will be needed to update the assumptions about distribution locations and packages per truck. New trucks, such as EVs, have been incorporated into fleets.

The basic steps to produce the OD matrix will be:

1. Process Neilson IQ data into packages per TAZ by each carrier.

2. Research distribution center locations, including but not limited to through the CoStar dataset explained in Section A.2.5, below.

3. Query Geotab trip and stop data.

4. Analyze Geotab data to get travel metrics.

5. Incorporate new data into the model structure and inputs.

6. Calibrate based on travel metrics.

Additionally, several engineering firms, municipal and regional governments, and academics have conducted research to estimate the trip generation associated with the warehouses and distribution centers that have been developed to facilitate direct-to-consumer logistics. Daniel Disario of Langan Engineering has conducted such research based upon facilities located in New Jersey. Based upon documents shared with the project team, Disario has estimated daily truck, van, and automobile generation rates for several types of DTC retail distribution centers. Disario's factors appear to be heavily influenced by the logistics system used by Amazon, the largest e-commerce retailer. Rates are available for the following types of facilities:

- Receiving centers
- Sortable and non-sortable fulfillment centers
- Sortation centers
- Delivery stations

The delivery stations, in particular, are of interest to the project team when developing the DTC trip table in this task. As the team gathers parcel and truck trip/tour data from other data sources, warehouse trip generation estimates will be useful in validating some of those data and/or developing estimates where there may be gaps in the other data sources.

A.1.3 Task Five – Update the NJTPA Freight Forecasting Tool and Develop 2050 and 2055 Forecasts

The objectives of this task are to:

- Assemble the data deliverables from the prior tasks, including the disaggregated FAF database from Task Three and the e-commerce Delivery truck OD table from Task Four.

- Incorporate economic forecast data to provide an updated forecast of freight flows from the disaggregated FAF database out to 2055.
- Develop a forecast of the e-commerce OD Table out through 2055, taking into account the growth in market share for e-commerce relative to brick-and-mortar retail sales, consumer spending, population growth, and another relevant demographic and economic factors.
- Updated the Freight Forecasting tool used to generate these forecasts with the updated data sources and tool enhancements to the user selection process and outputs generated.
- Analyze the location of freight-generating businesses, with emphasis on industrial and retail commercial properties.
- Develop updated “What-If” scenarios generated by the forecasts that provide custom freight forecasts that reflect changes in trends that may affect freight movements in the region.

Forecast Updates

In the last study, the forecast was generated by a Freight Forecast Tool (FFT) that incorporated many data sources, including:

- A disaggregated FAF 4 database providing freight flows at the county level.
- An E-Commerce Truck Delivery Table that was appended to the FAF database.
- Moody’s Forecasts of employment and output by NAICS.
- Make-Use tables from the Bureau of Economic Analysis relating NAICS industry activities to FAF commodity groups.

The forecast was generated by relating the Moody’s industry forecasts with the FAF commodities using a make-use table from the Bureau of Economic Analysis (BEA) as an intermediary. This calculation resulted in commodity growth factors that were then applied to the base year commodity levels to generate a forecast of future freight flows. These forecasts could be customized by “What-If” scenarios applied to specific industries, commodities, or modes, which alter the commodity growth factors generated by the industry forecast to explore possible changes to the future forecast. Additionally, the future freight flows matrix could be disaggregated from the county-level data to the NJRTM-E zone structure, so that it could be applied to the region’s travel demand model. The prior

FFT was created using a set of modular tables with a user interface created in R Shiny, a set of packages in the R programming language that create interactive dashboards. Through this tool, users could set the forecast parameters, generate a custom forecast, and preview the forecast results.

We recommend maintaining the same basic structure of the FFT and propose updating the R Shiny application with new datasets that can be used to generate new forecasts. As described in prior sections, this will include a new base year commodity flow database developed by disaggregating FAF5 to the county level and supplementing this database with DTC flows to estimate package delivery in the region. Additionally, we propose using the same national table from the BEA for the make-use table and updating it to the most recent year available.

To produce an updated forecast requires acquiring new economic forecast data to estimate future freight demand. The CS team reviewed many different possible sources for this data, which are reviewed in Section A.2.4. As described in that section, we recommend proceeding with Moody's US Regional Forecasts to update this data source from what was used in the last study.

Tool Updates

The current version of the FFT is written in the R programming language and uses the R Shiny set of packages to create a graphical user interface (GUI) where users can interact with the tool. This tool allows users select basic model inputs, such as the forecast year and economic scenario, as well as a suite of customization parameters including What-If scenario parameters as well as adjustment factors for productivity and county-level growth.

We plan to keep the basic structure of the existing FFT by maintaining the tool in R and including a similar set of user inputs as to what is currently in the FFT. The project team will seek to enhance the FFT in several ways:

- **Improve the User Interface** – Since the creation of the last FFT, there have been a large expansion in the options for building out user interfaces in the R Shiny set of packages. The project team proposes rebuilding the user interface in the bslib library, which uses a modern version of Bootstrap (a CSS framework that is popular for making responsive and flexible web applications). This will facilitate a greater selection of user inputs as well as outputs once a scenario has been run.
- **Generating additional outputs**– We propose creating enhanced and interactive figures and tables to be created as outputs to a scenario run that summarize the results

of that scenario. This will include the ability to filter the figures and tables to better explore the results of a scenario run.

- **Generating a summary document** – In addition to the visualizations and tables created within the tool, it also currently saves data outputs in the output folder after each run. We propose enhancing these outputs by combining the summary outputs into an R Markdown HTML document that will be saved onto the user's computer. This document will preserve the interactive outputs created in the dashboard itself and summarize the major takeaways from the output run.

- **Comparing forecast results** – We propose adding a function to compare the differences between two forecasts and provide a snapshot of differences by major categories, such as changes by mode, by commodity bundle, by direction, among trading partners, and at the county level. This will allow the user to quickly see how differences in the forecast input parameters change the flow of freight in the NJTPA region. Additionally, this feature will be pre-loaded with a "baseline" forecast (that uses the consensus forecast with no changes to any of the What-If scenarios) that will provide a default point of comparison when generating new forecasts.

What-If Scenario Development

One of the key features of the FFT is the ability to customize future forecast scenarios through "What-If" scenarios that allow the user to adjust specific freight trends within the forecast. By targeting specific commodity movements, the user can explore possible variations in future economic conditions such as, for example, increasing or decreasing the amount of import and export trade or by shifting commodity movements between different modes (i.e., truck to rail or truck to water). The full list of What-If scenarios included in the last version of the FFT is included in Table 9.

Table 9 What-If Scenarios from the Prior 2020 Freight Forecasting Tool

Scenario Title	Description
Increased In-Migration/Urbanization	Adds X percent per year of additional growth to all flows originating and terminating in the NJTPA region (above scenario forecast).
Increased Out-Migration	Subtracts X percent per year of growth to all flows originating and terminating in the NJTPA region (below scenario forecast).
Increased NJ Self-Sufficiency	Calculate share of each commodity consumed in NJTPA produced in NJTPA. Increase this share by X percent, one time adjustment, and drawing equally from all origins outside of the NJTPA region.
Higher Utilization of E-Commerce	Increase e-commerce truck trip totals by X percent per year (above scenario forecast).
Limits to Pace of Globalization	Decrease all imports and exports by X percent per year (below scenario forecast). Transfer these tonnages to domestic production, by commodity, and in the same proportion to each OD/mode.
Shifting International Trade Geography/China Trade War	Decrease all imports and exports involving Asia by X percent per year (below scenario forecast). Transfer these tonnages to domestic production, by commodity, and in the same proportion to each OD/mode.
Trans-Atlantic Free Trade Area	Increase all imports and exports involving EU by X percent per year (above scenario forecast). Transfer these tonnages from other trade and domestic production, by commodity, and in the same proportion to each OD/mode.
Manufacturing Near-Shoring to Mexico	Decrease all imports from China by X percent per year (below forecast) and transfer these tonnages to imports from Mexico, by commodity, in the same proportion between all ODs/modes.
Manufacturing Technology	Decrease all imports to the US by X percent per year and transfer these tonnages to all US moves, by commodity, and in the same proportion by all ODs/modes.
Transportation Technology	Replace X percent of truck trips with same county OD, one time effect.
Mode Share (all freight) - Truck/Rail	Manually adjust (one-time shift) relative mode share of truck to mode share of rail (for all flows to/from the NJTPA region) while keeping volumes on other modes constant.
Mode Share (foreign flows only) - Truck/Water	Manually adjust (one-time shift) relative mode share of truck to mode share of water (for only import/export flows from/to the NJTPA region) while keeping volumes on other modes constant.

Source: NJTPA 2020 Freight Forecasting Update

To determine the What-If scenarios used in the next version the FFT, the CS team will review regional industry trends and consult with the TAC as well as the private outreach conducted in Task Six (see Section A.1.4, below). The goal of this work is to be able to ensure that the FFT captures recent developments in freight issues that affect the NJTPA region and can incorporate the impact of those trends in the future freight forecasts. An example of some of these trends includes:

- Shifts in energy policies in favor of renewable energy and alternative fuels and away from traditional petroleum and coal products.
- Changes in the amount of freight moving by rail or water modes.
- Changes in the location of manufacturing facilities and the industries that make up the manufacturing base of the NJTPA region.
- Changes in regional immigration and emigration that result in changes in the overall population.
- A revitalization of manufacturing industries related to clean energy and electric vehicle production.

At the first TAC meeting, we polled the TAC to identify what it sees as the most important freight trends that have developed since the completion of the last study. Next, the CS team presented the previous “What-If” scenarios used in the last tool and inquire about what has changed since that study was completed and whether those scenarios accurately reflect evolving freight trends in the region. Finally, the CS team presented additional “What-If” scenario options (shown in Table 10) and described the assumptions within those scenarios.

Table 10 Possible What-If Scenarios for the Freight Forecasting Tool Update

Scenario Title	Description
Reduction in Fossil Fuels Use	The user will have two options: • Decreases the use of petroleum and fuel products by X percent per year for all flows originating and terminating in the NJTPA region (above scenario forecast). • User selects a year when all fossil fuel surface transportation movements will be removed from the network, and the FFT gradually removes these flows from the forecast to hit that target.
Increase in Advanced Domestic Manufacturing	Increases the use of advanced manufacturing materials, such as microchips, batteries, and electric vehicle inputs, by X percent per year for all flows originating and terminating in the NJTPA region (above scenario forecast).
Change in Natural Gas Production	Increase or decrease the production of natural gas and that moving through the NJTPA region by X percent per year (above or below scenario forecast).
Northeast New Jersey Growth	Adds X percent per year of additional growth to all flows originating and terminating in Hudson, Bergen, Union, Middlesex, Essex County and Newark and Jersey City.
Investment in Marine Highways	Manually adjust (one-time shift) relative mode share of water to mode share of truck and rail for outbound and inbound flows from/to the NJTPA region with coastal and inland waterway trading partners while keeping volumes on other modes constant.

In the first TAC meeting, members suggested additional trends to consider exploring in the FFT. Those include:

- Additional variability in international trade patterns, such as shifts in manufacturing from Asia to the European Union being possible along with other shifts already captured in the FFT.
- Changes to global food prices resulting from climate change that may to different food trading patterns.
- Changes to regulation and technological development, such those affecting operations of unmanned aircrafts, which lead to the next evolution of delivery business models (i.e., the next “just-in-time”).

Of the existing scenarios, TAC members noted that high utilization of e-commerce, shifting international geography, and a mode shift from truck to rail remain highly relevant to the NJTPA region. Of the new proposed scenarios, TAC members noted that reduction in fossil fuel use and investment in marine highway scenarios rank the highest as the most important scenarios to try to incorporate into the FFT.

Following the first TAC meeting and as the other technical analyses unfold as part of this study, we will continue to gather information on freight trends impacting the region and considering how those trends could be incorporated into the FFT. The CS team will finalize its list of What-if scenarios to include in the FFT update and present it to the TAC at the second meeting to affirm these choices.

NJRTM-E Assignment and Validation

The truck trip table generated by the FFT will be assigned to the North Jersey Regional Transportation Model-Enhanced (NJRTM-E) regional travel demand model network. As discussed in Section A.1.3, this table from FFT will be at FAF5 county level. We will generate a process that will convert this table into a trip table consistent with traffic analysis zones (TAZs) in the NJRTM-E network. The process will also assign flows to or from locations outside the NJRTM-E model region to the appropriate external station. It will generate a CUBE truck table in origin-destination format, where origins are NJRTM-E TAZs or external stations, and destinations are NJRTM-E TAZs or external stations. The flow unit will be truck trips by several commodity bundles and a final bundle that includes all other commodity trucks for each time period in the NJRTM-E (morning [AM], midday [MD], evening [PM], and nighttime [NT]).

Another process will be developed to assign the adjusted truck trip tables to the NJRTM-E loaded networks for each time-of-day period, accounting for all of the NJTPA’s assignment routine protocols (e.g., avoiding assignment of trucks to the Garden State Parkway north of Exit 105, etc.).

The result of these procedures will be a series of network files that will contain link volumes for each of the commodity bundles and non-commodity trucks during each time-of-day. The network file can be analyzed within the CUBE software application or exported as a shapefile for analysis in a variety of GIS applications.

Real Estate Analysis

The project team will prepare a database of industrial real estate listings. We will consider the distribution of industrial assets and corresponding relationship to commodity flows when developing freight forecasts. For example, areas with a high and/or growing inventory of food processing facilities are likely to see a high and/or increasing flow of agriculture and fish commodities.

Real estate data will also inform the “What-If Scenarios.” For example, counties with a high concentration of distribution centers might see an increase in DTC commodity flows for an “increase in e-commerce” scenario.

A.1.4 Task Six – Project Outreach

The objective of the outreach task is to obtain additional input and feedback on the approach, methodology, data, forecasts, and findings throughout the project. This includes soliciting additional insight on key components of the study, including existing and future commodity flows, the e-commerce trip table, and overarching trends. The plan for project outreach is grouped according to the four categories of stakeholders which will be engaged with throughout the project.

NJTPA Subregion Input Strategy

The project team is proposing to utilize the same strategies which guided the 2040 and 2050 Freight Industry Level Forecasts Studies to directly engage the NJTPA’s subregions. The project team and NJTPA staff will invite planning, economic development, and transportation staff from each subregion to participate in a webinar, with the goal of holding one webinar for each subregion. At these webinars, the project team will share FAF data in order to validate or hear concerns about the draft results of the FAF disaggregation process, review and validate the business establishment data analysis performed in Task Five and discuss any economic development initiatives that may necessitate changes to the economic forecasts. These webinars will also be used to solicit suggestions on contents and formatting of the subregional profiles, as the subregion staff will likely use and help to distribute links to the subregional profiles once they are completed. Prior to each webinar, the project team will prepare materials and presentations. The project team will also collaborate with NJTPA to identify dates and times for each webinar.

Technical Advisory Committee (TAC)

A project TAC, consisting of participants identified and assembled by the NJTPA, will provide feedback and guidance throughout the entirety of the project. This TAC is expected to consist of representatives from NJTPA's subregions, as well as regional and state agency representatives who are regularly engaged in NJTPA's freight planning activities. Outreach and collaboration with the TAC is expected to occur through the hosting of two virtual TAC meetings described as follows:

- **TAC Meeting #1:** To be held around the conclusion of Task One, this first meeting will be used to review the methodology framework, data sets, and overall scope of work for the study. The meeting will also be used to gather input on what the TAC believes to be the most useful products and outcomes of the study, to discuss potential scenarios for inclusion in the FFT, and to suggest format, layout, and contents for the regional, subregional, and commodity profiles.

- **TAC Meeting #2:** To be held around the conclusion of Task Five, this second meeting will be used to review data analysis, enhancements to the FFT, and draft outputs of the Tool. This meeting will also be an opportunity to collect TAC comments on in-progress drafts of sample subregional and regional freight commodity profiles.

Prior to each TAC meeting, the project team will prepare materials and presentations. The project team will also collaborate with the NJTPA to identify dates and times for each meeting.

Freight Initiatives Committee (FIC) and Regional Transportation Advisory Committee (RTAC)

The FIC and RTAC are two of the NJTPA's five Committees of the Board of Trustees, made up of representatives from member agencies. Both committees host regularly scheduled meetings to include presentations and discussions on a wide array of topics affecting freight and other transportation topics in Northern New Jersey and beyond. Outreach to the FIC and RTAC is anticipated to consist of the preparation of materials and presentations at up to two meetings per committee. The first of these meetings, to be held in the early stages of the project, will introduce the study and solicit suggestions on approach, data, and/or industry contacts. The second of these meetings, to be held in the latter stages of the project, will disseminate the results of the study, including a demonstration of the updated FFT. Prior to each TAC meeting, the project team will prepare materials and presentations.

A.1.5 Task Seven – Regional, Subregional, and Commodity Profiles

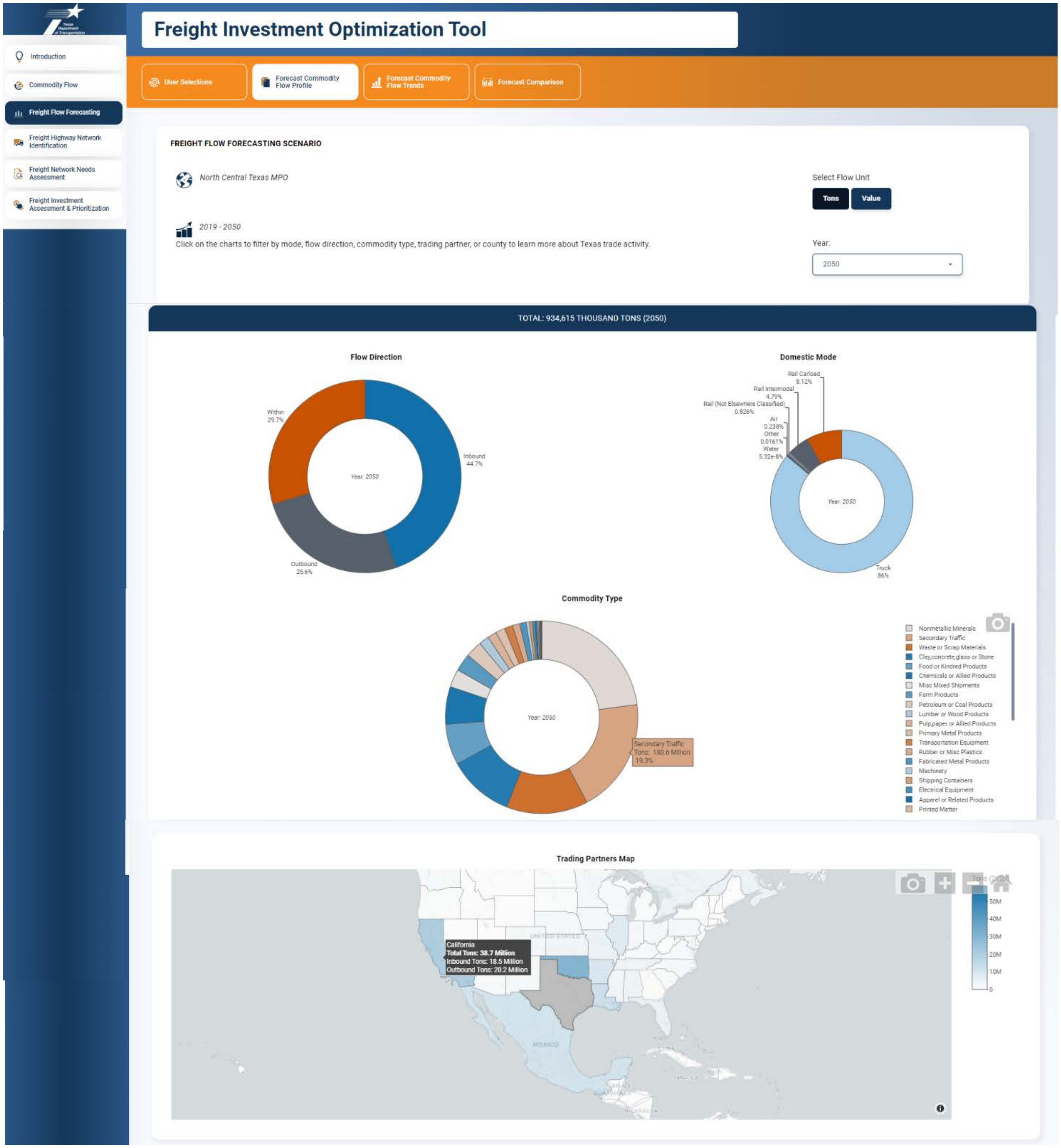
The purpose of Task Seven is to summarize and analyze the outputs produced in the prior tasks in a format that reflects the most important regional- and commodity-specific freight trends. To accomplish this objective, prior studies have created a regional profile for the entire NJTPA region along with a series of profiles for each of the counties in the NJTPA region plus Jersey City and Newark and a profile for each of the commodity bundles. These profiles have assembled the major findings of this study, including major land use and employment findings, how freight is impacting the transportation system, and what freight trends are expected in the future. They also connect the commodity bundles to major supply chains that are essential to the economy of the NJTPA region.

As part of this study update, we are exploring the possibility of creating interactive web pages or applications to provide a way to better explore the information produced in this study. As part of this process, we will first start with discussing the current set of profiles with the TAC at the first TAC meeting. We will ask the TAC what information they find useful within the profiles, what is the critical information they have used from past studies, and their level of desire to have this information available in a more interactive format.

As part of this effort, we are also exploring the possibility of creating an interactive dashboard that would be loaded with several forecasts generated by the FFT. This dashboard would allow the user to select these different forecasts and explore their freight flow results and supply chain trends. We have shown prior work with the Texas Department of Transportation (Figure 20) as a starting point for what this dashboard may look like.

Additionally, as discussed in Section A.2.5, the project team will prepare a database of industrial real estate listings and evaluate industrial real estate trends at the subregional and commodity level. This data will be used to create real estate asset maps as well as real estate trend reports for each subregional and commodity profile.

Figure 20 Texas Department of Transportation Freight Flow Forecasting Tool Commodity Profile Page



Source: Texas Department of Transportation

A.2 Data Needs, Options, and Recommendations

As discussed in the prior selection, accomplishing the key technical analyses to fulfill the study objectives requires obtaining a significant amount of data from a variety of sources.

As part of the development of this methodological framework, the project team has reviewed data sources across several different topics, including the following:

- Location-based or GPS data for truck travel patterns
- E-commerce market data
- Primary commodity flow database
- Economic forecast
- Real estate analysis

This section documents our review of all available data in the sections that follow. Additionally, Table 11 summarizes the data we recommend obtaining as part of this study, including which task the data is tied to and the associated cost of obtaining that data.

Table 11 Summary of Recommended Data Sources

Task	Data Category	Source	Notes	Cost
Task 3	FAF Disaggregation	FAF 5.5.1		$0
		County Business Patterns		$0
		Waybill	Processing Fee	$500
		Port		$0
		BEA Make-Use Table		$0
Task 4	Package Delivery Data	Nielsen IQ	Package shipment totals and trucks with scan information	$35,000
	Truck Location Data	Geotab	Processed by LOCUS, Inc. Also used for model validation	$55,000
Task 5	Econometric Data Forecast	Moody's		$14,500
Task 4, Task 5, and Task 7	Business Establishment Data	CoStar	BJH Advisors has a subscription	$0
			TOTAL	**$105,000**

A.2.1 Location Data for Truck Travel Patterns

Location-based big data such as Global Positioning System (GPS) or Location-Based Services (LBS) data has been widely used by transportation professionals for various transportation planning and operation purposes. For this task, GPS and LBS data will be evaluated and used to understand regional direct to consumer delivery truck origin-destination (OD) patterns.

LBS data is typically collected by smartphone devices, utilizing technologies such as GPS, cell phone towers, and Wi-Fi to determine users' precise locations. The data is usually collected through mobile device software and can be used for numerous location-based services such as navigation, marketing, etc. LBS data contains geographic coordinates recorded over time and by locations through devices. The data could then be transformed into trip-level data at different geographic granularities, capturing useful travel behavior information such as trip purposes, origin and destination information, etc. LBS data has many advantages. For example, the wide use of smartphone applications often leads to larger sample sizes, which in turn provides more accurate representations of travel behaviors. LBS's adequate time and location information are fairly accurate and allow for a higher level of granularity of analysis.

GPS data tracks the movements of trucks during their active service and is collected periodically by location and time. The data is usually collected through vehicle navigation systems, mobile phones, or other GPS-enabled devices. GPS data provides useful information to understand travel patterns. For example, the information can be aggregated and leveraged to construct truck O-D travel patterns or optimize truck delivery routes.

Two modeling approaches will be explored with the integration of GPS/LBS data. One approach is to leverage the existing method that CS developed previously with the NJTPA and create e-commerce delivery travel patterns. LBS and GPS data will be used to identify volumes and travel-shed of trucks from/to distribution and delivery centers. A second approach would be using GPS or LBS data as the basis for the model to infer truck patterns with socio-economic data. Package data and other data will be used for validation purposes. A trip table for e-commerce delivery will be produced to understand its regional traffic impacts.

In terms of the availability of this data, it is important to distinguish between the providers of the raw data, which track and maintain the LBS or GPS data of freight vehicles, from the processors of that data, who acquire that data and analyze it in regard to truck travel behavior. There are currently three providers of the raw data for truck GPS or LBS data:

- **Geotab:** Geotab collects freight movement data from devices within its commercial fleet which has detailed truck information such as industry, vehicle class, and vocation. Geotab estimates that its devices are used within 8-10 percent of the commercial fleet and it provides broad coverage of heavy, medium, and light duty vehicles. This information can be used to answer a variety of freight planning and operation topics. The typical unit of Geotab data is at Census Tract level and can also be aggregated based on customized zone boundaries.

- **INRIX**: INRIX collects data from a mix of sources including cars, trucks as well as GPS-enabled smartphones and applications. INRIX provides commercial vehicle movement information through its connected vehicle sources. It includes commercial heavy-, medium-, and light vehicle information, but lacks personal light-duty vehicle information.

- **American Trucking Research Institute (ATRI**): ATRI offers freight truck GPS database sourced from its commercial fleets. This data has played a role in supporting numerous freight studies at regional, state, and federal levels. However, ATRI has relatively small sample sizes of last-mile delivery trucks as it tends to feature heavy trucks with long-distance travel.

Based on the review of these sources, we recommend using Geotab as the provider of the raw data of truck movements. Compared to INRIX, StreetLight, and ATRI data, Geotab has better commercial vehicle/trip representation for last-mile delivery patterns, and inclusion of light-duty vehicles that are performing last-mile deliveries. The next question is then who to use to process that data and convert it into a source that can be used within this study. For this, there are two potential providers of the processed Geotab data:

The following GPS/LBS data sources have been evaluated (A detailed comparison of the data sources is in Table 12):

- **LOCUS:** LOCUS is a big transportation data analytics platform that partners with Geotab. They are a subsidiary of Cambridge Systematics, Inc, who is their sole owner. The platform can visualize and analyze truck movements and commodity flows at various geographic granularities. Additionally, through the partnership between Geotab and LOCUS which has less restriction in the data sharing agreement, the raw truck movement data could be acquired under certain conditions and can be post-processed for broader uses. In addition, LOCUS platform offers the option for customized raw sample expansion for O-D analysis. This option will allow the project team and the NJTPA to have direct access to the sample expansion process and conduct any necessary supporting analyses such as quality assurance/quality control (QA/QC), validation, etc.

- **StreetLight**: LBS is one of StreetLight's data sources, which comes from smartphone apps with location services. In the past, StreetLight has used INRIX data to provide commercial vehicle movement information. More recently, StreetLight has started using Geotab data. StreetLight's outcomes are usually index-based or developed by its proprietary models. Compared to LOCUS, StreetLight offers less insight into its proprietary sample expansion methods, and the data procurement would be specific and rigid in scope, offering less flexibility for an iterative process of data review, QA/QC, and potential recalculations.

Based on the review of available options, we recommend proceeding with LOCUS as the data process of Geotab data to understand the e-commerce movement pattern for this task due to the flexibility this vendor would provide. Additionally, this arraignment will allow us to apply the Geotab data toward model validation of the NJRTM-E results of the O-D trip table produced by the FFT. This analysis would require an iterative review of the Geotab data to ensure that the data included matches with the assignment parameters of NJRTM-E. This type of iterative analysis would not be possible with StreetLight due to the proprietary models it uses to process the Geotab data.

Table 12 Comparison of Location-Based Big Data Sources

LBS or GPS Data	Vendor	Description	Geography/ Penetration	Temporal coverage
Geotab	LOCUS, Inc.*	LOCUS truck utilizes Geotab truck fleet data classified by industry, vocation, and vehicle class. The data provides truck flows, trip length, trip time, and other related information.	Tract or customizable zone level; 8-10 percent	Longitudinal data over 3 years.
Geotab or INRIX	StreetLight	StreetLight recently started using Geotab data but has used INRIX truck fleet data in the past. The data provides weighted truck flows, and other related truck information.	Tract or customizable zone level	Varies
INRIX	INRIX	Raw unweighted truck GPS data or processed trips. It includes heavy- and medium- vehicle information, but lacks light-duty vehicle information	Point	A few weeks in a year
ATRI	ATRI	Assumed to be long distance heavy truck data. Test of ATRI data in previous NJTPA freight model project showed no useable last mile data.	Point	A few weeks in a year

Source: Research by Cambridge Systematics, Inc.

A.2.2 E-Commerce Market Data

Granular e-commerce market data is needed in this study to provide insights into the current and future demand for the movement of DTC goods in the region. While there are many data sources that provide e-commerce data about the market for online purchases for particular geographic areas, there are limited sources that provide data about the exact volume of e-commerce purchases made in certain zip codes. Stackline, Acxiom, Profitero, Amazon Web Services, and Nielsen IQ (formerly Rakuten) were contacted by the consultant team to determine the kinds of e-commerce consumer datasets that are available for purchase. Acxiom, Profitero, and Nielsen IQ responded and only Nielsen IQ provides e-commerce consumption data by zip code as well as the last scan location of all major package carriers except Amazon. The scan data can allow us to estimate the specific distribution centers where delivery trucks originate and can provide vital information for developing the DTC trip table described in Section A.1.2. Nielsen indicated that the cost to obtain one year of data, including weights and order totals as well as activity scan information, would total $35,000.

A.2.3 Primary Commodity Flow Database

In this study, the U.S. Department of Transportation's (U.S. DOT) Freight Analysis Framework (FAF) will be used as the primary commodity flow data source. FAF data provide information on freight movements among states and metropolitan areas by all modes of transportation. The data is built upon the Commodity Flow Survey (CFS), foreign trade data, and other freight data sources. It provides freight flows (weight, value, and activity) and forecasts by freight mode, commodity type, and trade type (import, export, domestic). FAF data consists of 132 FAF regions which correspond to census metropolitan area (CMA) boundaries. The FAF is published every five years. The most recent version is FAF 5, which was released in 2021 with a base year of 2017 and forecast years up to 2050. Between complete updates, occasional versions are released with additional information or corrections of errors. The most recent update is FAF 5.5.1, which was released in July 2023. In this study, FAF regions that cover the 47 study counties in New Jersey and adjacent New York, Pennsylvania, and Delaware will be selected and disaggregated at the county level. In addition, FAF will be disaggregated at the city level – Newark and Jersey City, and such effort would allow for more detailed subregional freight profiles. The proposed disaggregation process of the FAF data is explained previously in Section A.1.1.

ZIP Codes Business Patterns (ZBP) data can be used to disaggregate freight flows at the city level (i.e., Newark and Jersey City), as it provides detailed economic data at smaller geographies. The ZBP is part of the County Business Pattern product from the U.S. Census Bureau. The data provides annual statistics for businesses with paid employees within the U.S. at the ZIP Code level. The dataset provides information on the number of establishments, employment, and payroll. The data are shown by the North American Industry Classification System (NAICS) code at the ZIP Code level. The disaggregation will require the ZIP Code geographies to be matched with city boundaries through the U.S. Census Bureau's ZIP Code Tabulation Areas (ZCTA). A post-processing of the spatial conversion between ZIP Code and ZCTA geographies will be developed and performed.

As part of the base commodity flow disaggregation effort, supplemental data will be acquired. The Carload Waybill Sample from the Surface Transportation Board (STB) and port terminal data (i.e., terminal-level volumes) from the Port Authority of New York and New Jersey (PANYNJ) will be obtained to produce commodity flow by rail and port, respectively. These data will be used to disaggregate FAF to/from flows by ports and rail to smaller geographies as defined in this study. Alternatively, the flows by Performance Management System (PMS) commodity the U.S. Army Corps of Engineers (USACE) could be obtained. However, only consolidated flows for the Port of New York and New Jersey are available through USACE's database. For more detailed disaggregation of port flows, PANYNJ will be preferred.

A.2.4 Economic Forecast

To forecast commodity flows out to 2050 and 2055 as part of the FFT, we need a source of economic forecast data that provides an estimate of expected industry growth over the long term for the NJTPA region. There are several economic indicators that could be used to predict future freight flows, including industry output and employment. The previous study used employment trends as an indicator of economic growth that was used to calculate the freight forecasts by the FFT.

To identify the best economic forecast data source for this study to produce an updated forecast, we explored a variety of data sources. We looked for sources that provided data for the following requirements:

- **Geographical Coverage:** We need economic forecasts at the county level for all thirteen counties in the NJTPA region.
- **Industry Detail:** We need economic forecasts that provides a certain level of detail of various industries in the NJTPA region, as classified by the North American Industry Classification System (NAICS). As manufacturing (NAICS 31-33), wholesale trade (NAICS 42), and retail trade (NAICS 44) play critical roles in freight movement, this analysis seeks for three-digit NACIS level forecast for these industries, and two-digit NACIS level data for all other industries.
- **Future year:** We need an economic forecast that extends to 2050 with a preference for forecasts that extend to 2055.

- **Scenarios:** We prefer to have several different economic scenarios to be able to compare freight forecasts under different economic futures.
- **Data Custody:** Can the data be shared with and by the NJTPA?

To find the best source for this data, we started by reviewing the sources used in the past and any related studies. We also looked to identify vendors that have provided reliable economic forecasts that have been used in various market analyses and economic forecasting circumstances. Through our search, we identified the following providers:

- **Moody's:** the US Regional Forecast by Moody's provides projections on multiple economic indicators at the county-level and four-digit NACIS level. Other than the baseline forecast, this source provides ten alternate scenarios at the state level.
- **R/ECON:** Rutgers Economic Advisory Service (R/ECON) of Rutgers University produces labor forecasts at different geographical levels.
- **S&P Global:** Their Business Market Insights (BMI) database provides six-digit NACIS industrial-level employment and output at the county, Metropolitan Statistical Area (MSA), and state levels.
- **Woods & Poole:** The Complete Economic and Demographic Data Source (CEDDS) provides labor and industrial earnings forecasts with annual projections extending to 2060 at county and Core Based Statistical Area (CBSA) levels.
- **Oxford Economics:** As a global economic forecasting data provider, Oxford Economics offers forecasts for various indicators at the county, MSA, or state levels. In addition to baseline estimations, the forecasts provide three alternative scenarios at the MSA and state levels.
- **IBISWorld:** The industry-level database provides revenue, establishments, employment, and wage forecasts for the next five years at different geographical levels.

Each source provides valuable insights into the future economic trends, further guiding the commodity flow projection. After comparing the six sources, four of them meet most of the criteria for this study. R/ECON does not provide forecasts at the county level and IBISWorld provides only five years' worth of forecast data. Table 13 summarizes each of the remaining potential data sources based on how their fared on our data requirements. Additionally, we have confirmed that each of these sources provides data that can be shared with the NJTPA.

Table 13 Econometric Forecast Data Vendor Summary by Requirements

Data Source	Baseline Geographic Level	Detailed Industry Level	Forecast Year	Alternative Scenarios	Related Indicators	Price
Moody's	County	3-Digit NAICS	2054	Yes	County-level Employment, Gross State Product	Ranges from $14,750 (for five scenarios) to $17,500 (for 10 scenarios)
S&P BMI	County	3-Digit NAICS	2055	Yes*	Employment, GDP, Sales	Range from $10,000 – $18,000
Woods& Poole	County	2-Digit NAICS	2060	No	Employment, Industry Earnings	$1,195
Oxford Economics	County	3-Digit NAICS**	2055**	Yes	Employment, GDP	Ranges from $10,000 – 42,500**

* S&P Global BMI does not provide scenarios. Scenarios are generated by the Macro-Scenario Model. Cost for baseline forecast without scenarios is $10,000 and adding the scenarios increases the cost to $18,000.

** Oxford Economics provides greater industry level detail, additional forecast years, and additional scenarios for a custom cost.

Based on our review, we recommend proceeding with Moody’s US Regional Forecasts and include five scenarios in the data acquisition for a total cost of $14,500. This source provides the level of detail required for this study, including data for each of the NJTPA counties, different scenarios of possible economic futures, and sufficient granularity of industries in each forecast. Using this source will maintain the forecast data source from the last study, providing a reference point to compare and validate the results of this study. Additionally, this would ensure that the forecast produced in this study would be consistent with other state and regional forecasts, such as R/ECON. Finally, the last FFT was designed with periodic updates in mind, and proceeding with and update of Moody’s data will facilitate the update of the tool.

A.2.5 Real Estate Analysis

Industrial real estate data will be gathered and evaluated to support the following tasks:

- **Task Four, Regional E-Commerce Delivery Truck Origin-Destination Matrix:** Industrial real estate listings, specifically distribution centers, will inform origins and destinations included the matrix.
- **Task Five, Update the NJTPA Freight Forecasting Tool and Develop 2050 and 2055 Forecasts:** The distribution of industrial real estate assets by typology (e.g., distribution center, warehouse, food processing, etc.) will inform commodity flow projections, including for the What-If Scenarios.

- **Task Seven, Regional, Subregional, and Commodity Profiles:** Industrial real estate listings will be used to create maps of freight facility locations for the sub-regional and commodity profiles. In addition, real estate trends (e.g., inventory SF, vacancy rate, rental rates, etc.) will be summarized for each regional and commodity profile.

The project team will primarily pull industrial real estate data from CoStar, a proprietary database with the most comprehensive set of real estate listings in the US. The project team will also cross-reference and complement CoStar data with other publicly available sources. The project team has access to the data sources listed below:

- Lightcast – Proprietary data source with business listings by NAICS code
- Broker Reports – Industrial real estate market reports published by brokerage firms such as JLL, Colliers, Cushman & Wakefield, and others.
- Port Authority of New York and New Jersey Warehouse Directory

Drawing from the above sources, the project team expects to share with NJTPA the physical address, type of asset, and associated commodity bundle for properties related to freight activity and commodity flows. Table 14 includes additional detail on industrial real estate classifications and their relationship to commodity bundles. Additionally, the team will provide a square footage range (e.g., between 2,500 – 5,000 square feet) and year-built range (e.g. between 1900-1920) for each asset. This data will be able to be shared by the NJTPA with their subregional partners.

Table 14 Association Between Real Estate Typologies and Commodity Bundles

Real Estate Typology	Commodity Bundle
Distribution*	01 - Durable Consumer Products and Direct-to-Consumer
Food Processing	03 - Agriculture and Fish
Light Industrial	*TBD – Commodity bundle to be identified depending on the tenant / NAICS classification for each listing*
Manufacturing	*TBD – Commodity bundle to be identified depending on the tenant / NAICS classification for each listing*
Refrigeration / Cold Storage	02 - Food and Non-Durable Consumer Products
Warehouse*	*TBD – Commodity bundle to be identified depending on the tenant / NAICS classification for each listing*
Truck Terminal	*TBD – Commodity bundle to be identified depending on the tenant / NAICS classification for each listing*

Source: Real Estate Typologies from CoStar, Inc.
Note: Starred typologies (*) will be used as part of step two of the DTC trip table development, explained above in Section A.1.2.

The project team will also summarize industrial real estate trends at the subregional and real estate typology level. Trends will be evaluated in terms of 10-year change, five-year change, and/or other time periods of interest. In addition, trend data for a given subregion or real estate typology may be benchmarked against the broader market. This summary and trend data will be published publicly, including a map of freight generating businesses similar to what has been published in prior subregional profiles in past studies.

The following metrics will be summarized:

- Total Inventory (No. Buildings and SF)
- Vacancy / Occupancy Rates
- Rental Rates
- Absorption
- Average Age

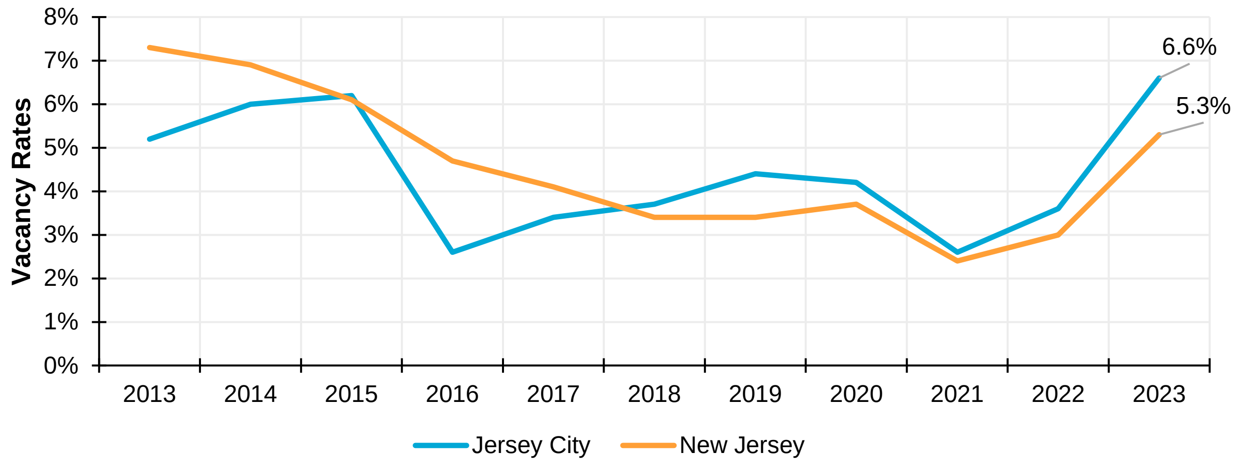
Example tables and charts for the Jersey City subregion are included in Table 15, Figure 21, and Figure 22.

Table 15 Example Industrial Real Estate Inventory Table

Area	Inventory (Buildings)			Inventory (Square Feet)			Net Absorption (Square Feet)	
	2013	2023	Percent Change	2013	2023	Percent Change	10-Year (2013-2023)	5-Year (2018-2023)
Jersey City	306	310	1.3%	19,235,764	21,153,525	10.0%	1,866,729	-595,439
New Jersey	14,593	15,067	3.2%	784,800,026	910,444,979	16.0%	146,089,634	71,517,540

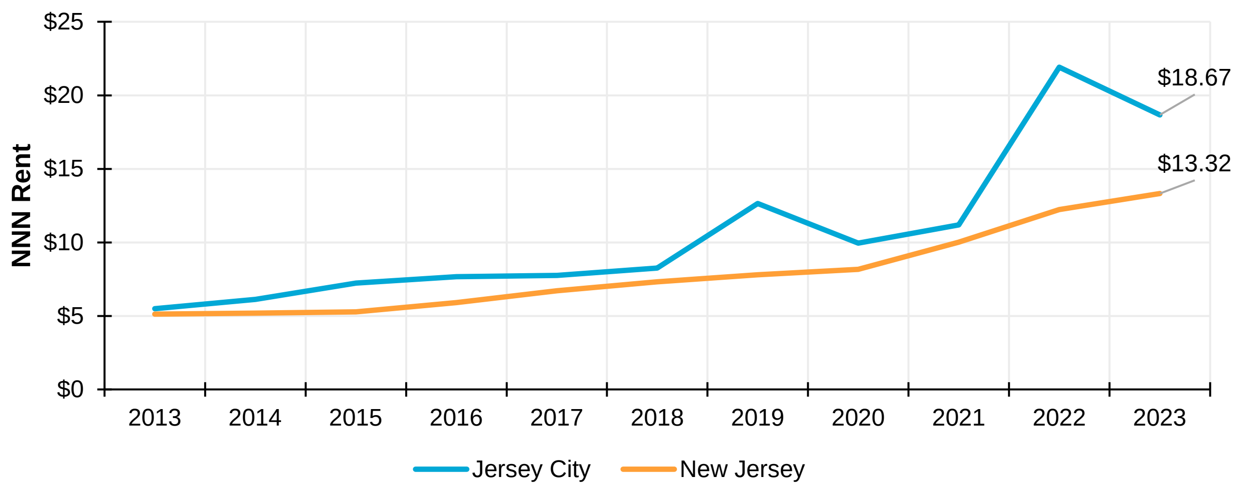
Source: CoStar, Inc.

Figure 21 Example Industrial Real Estate Vacancy Rates



Source: CoStar, Inc.

Figure 22 Example Triple Net Lease (NNN) Rent Chart



Source: CoStar, Inc.

Appendix B. FAF Disaggregation Technical Memorandum

B.1 Introduction

This memorandum documents the results of the third task of the 2050 Freight Industry Level Forecasts Update study. This task is focused on an updated disaggregation of the Freight Analysis Framework (FAF) database. The FAF is a publicly available database that is developed from the Commodity Flow Survey (CFS) by the Bureau of Transportation Statistics (BTS) and used by the Federal Highway Administration (FHWA) to support national transportation policy. It provides an estimate of shipper-receiver freight movements by mode at a geographic level of large metropolitan areas and the remainder of states not in these metropolitan areas.

For the purposes of this study, the FAF is not at a geographic level which is granular enough to be used by the NJTPA and its member organizations to understand freight movements in the region and make planning decisions. Therefore, this task disaggregates FAF from the FAF regions present in the raw database into county-equivalents by updating a methodology used in the prior NJTPA freight forecasting study, the 2050 Freight Industry Level Forecasts study. This memorandum will summarize the parts of that methodology that have been maintained and other parts that have been updated for the present study.

The disaggregated FAF database produced from this task formed the basis of later tasks of this study, including a detailed analysis of freight movements within the NJTPA region and among different commodity bundles. Future tasks will supplement this database by generating estimates of through flows, finalizing port flow disaggregation, incorporating estimates of flows from Direct-to-Consumer (DTC) last-mile movements of e-commerce shipments, and the generation of commodity flow forecasts based on the economic outlook for the region.

B.2 Data Sources Updated in this Study

The primary data source for this task is the raw **FAF version 5.6** database, accessed from the Bureau of Transportation Statistics (BTS). FAF is updated every five years and is built from the Commodity Flow Survey, foreign trade data, and other sources. Version 5.6, published in April 2024, was the latest-available version at the time the study was underway.[7] It offers detailed information on freight movements across states and metropolitan areas for all transportation modes and provides insights into freight flows in

[7] Version 5.6.1 was released on July 19, 2024 which is after the FAF disaggregation processing was completed. Based on a cursory review of FAF 5.6.1, it contains no information which contradicts the use of FAF5.6 in this project.

terms of weight, value, and activity by origins and destinations. Additionally, it includes forecasts by freight mode, commodity type, and trade type (import, export, and domestic). The unit of geography used in the FAF data is a group of 132 regions across the country, corresponding to census metropolitan area (CMA) boundaries located within each state.

In order to disaggregate FAF flows to smaller geographies (e.g., counties and two major cities) 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 was estimated through economic modeling.

The **Zip Code Business Patterns (ZBP)** dataset provided by the U.S. Census Bureau offers detailed annual information on the number of business establishments, employment, and payroll for Zip Codes across the United States. This dataset provides useful information for analyzing economic activity and business distribution at a granular geographic level. In this study, disaggregation factors were developed for cities with the information of ZBP data. It uses Zip Code Tabulation Areas (ZCTA) which are a US Census designation which is similar, but not identical, to the operational Zip Codes used by the US Postal Service (USPS). Unlike operational Zip Codes, ZCTAs are contiguous with Census geographies.

Bureau of Economic Analysis (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 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 FAF Disaggregation Updates

B.3.1 Update of Domestic Origin and Destination Disaggregation Factors

This task leveraged the disaggregation factor development methodology that the NJTPA and Cambridge Systematics have developed and used in prior studies and for other regional partners. The methodology established relationships between the tons produced or attracted from FAF based on a selection of explanatory variables (e.g., employment and population).[8]

The disaggregation of FAF data into smaller geographies, such as counties and cities, involves determining factors that accurately reflect the freight activity at both the origin and destination points. In this study, disaggregation factors were updated and applied to FAF 5.6 to estimate the freight activity within smaller geographies as a proportion of the FAF regions in which they are situated. This process relies on the assumption that freight activity correlates with employment in NAICS (North American Industry Classification System) industries that produce freight at the origin and those that consume or attract freight at the destination. By applying these factors, the FAF flows between broad FAF regions were broken down into more granular county-level flows.

While FAF 5.6 has 132 FAF zones, this study focuses on disaggregating freight flows from a selection of FAF zones, including a total of 47 counties (Figure 23). The FAF regions included are:

- 341 (New York NY-NJ-CT-PA - NJ Part)
- 363 (New York NY-NJ-CT-PA - NY Part)
- 423 (New York NY-NJ-CT-PA - PA Part)
- 101 (Philadelphia PA-NJ-DE-MD - DE Part)
- 342 (Philadelphia PA-NJ-DE-MD - NJ Part)

[8] For complete methodology details, refer to the prior memorandum.

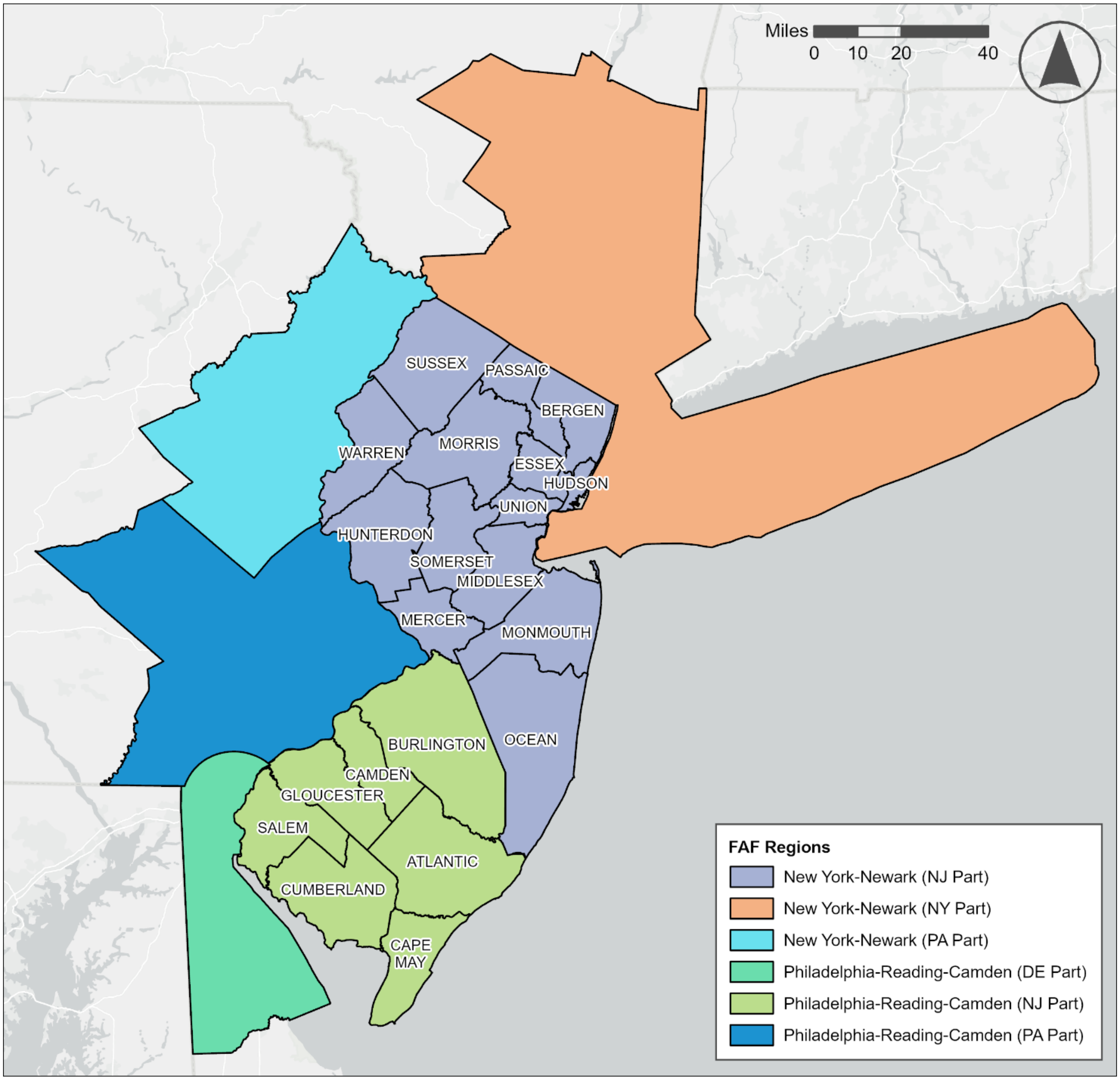
- 421 (Philadelphia PA-NJ-DE-MD - PA Part).

Additionally, the disaggregation of through traffic, also referred to as external-external or overhead traffic, which neither originates nor terminates in New Jersey, will be added to the disaggregated database as part of Task Five, updating the Freight Forecasting Tool.

B.3.2 Sub-County Disaggregation

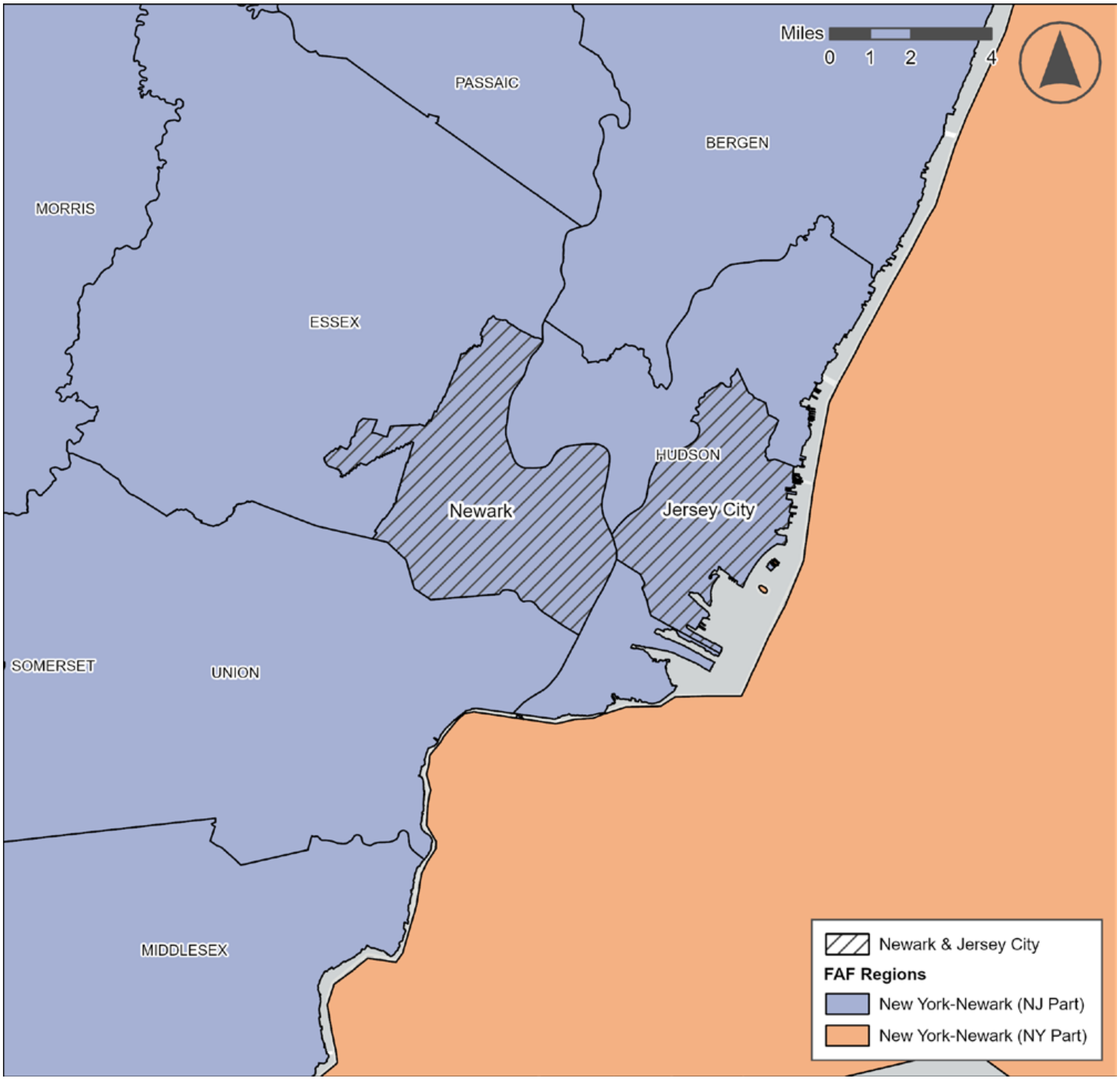
In this study, Newark and Jersey City within the NJTPA region are further disaggregated by dividing Essex County into Newark and the rest of the Essex County, and Hudson County into Jersey City and the rest of Hudson County (Figure 24). Disaggregation factors of these four regions were needed and then developed based on the same disaggregation development process as described above. Presently, this disaggregation process has resulted in two databases: one where Essex and Hudson Counties are kept whole, and a second database where Essex County is divided into Newark (region “3401301”) and the rest of the Essex County (region “3401302”), and Hudson County is divided into Jersey City (region “3401701”) and the rest of Hudson County (region “3401702”).

Figure 23 Disaggregated FAF Regions and Counties



Source: Freight Analysis Framework, version 5.6

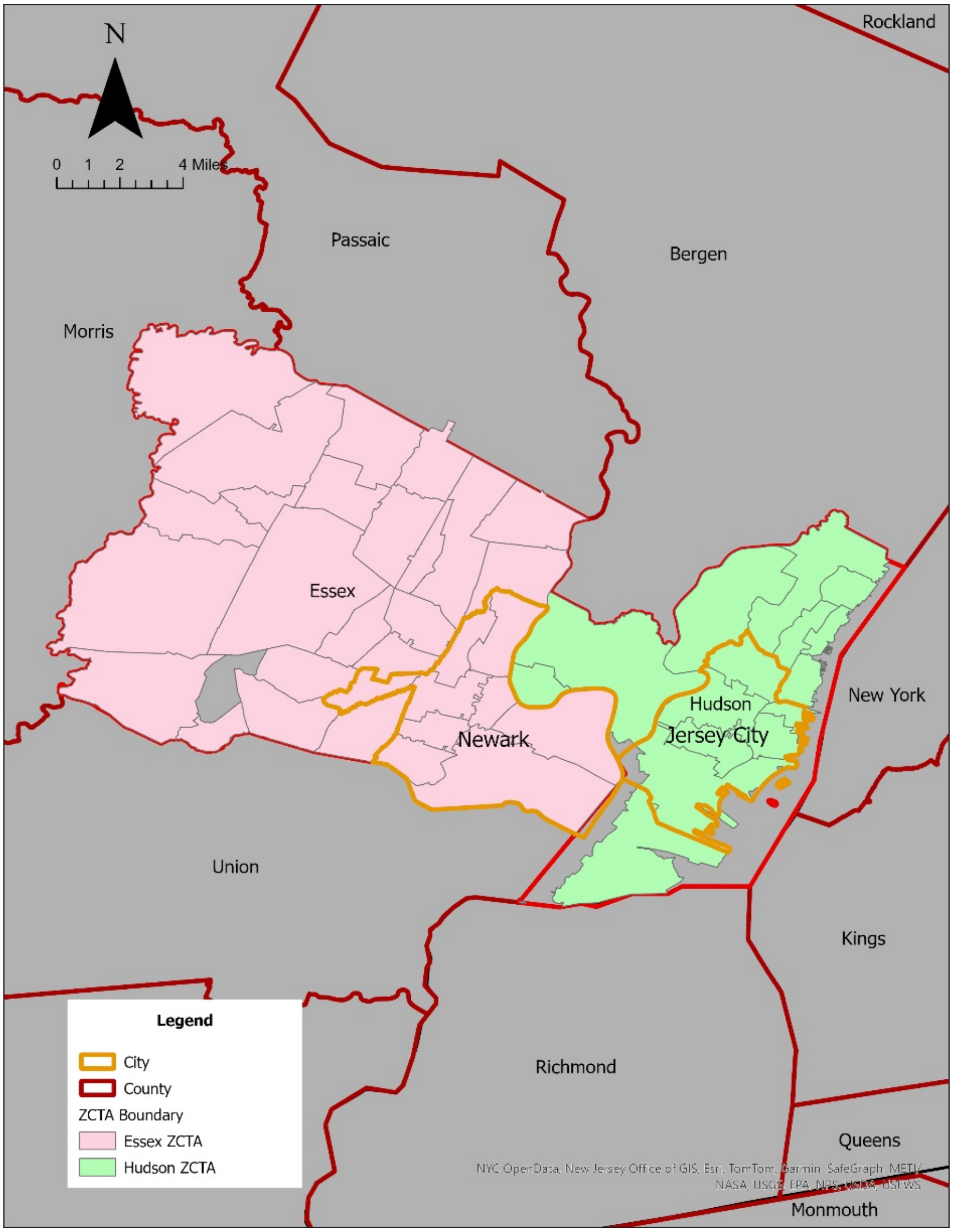
Figure 24 Locations of Jersey City and Newark



Source: County and Municipal Boundaries from the New Jersey Department of Transportation's NJGIN Open Data portal

Because the development of disaggregation factors of subregions requires employment information to reflect freight production and attractions, ZIP code level ZBP employment information was used to match city boundaries with ZIP code boundaries (See city and ZCTA relationship, Figure 25 and Table 16). The ZIP code data from 2021 County Business Pattern contains establishment information at ZIP Code Tabulation Areas (ZCTAs). However, due to various factors including privacy, aggregation granularity, etc., specific employment information was not available from ZBP data— it only provides information on the total number of establishments by size at individual ZCTA level. To address this limitation, the mid-point of each establishment's cohort size was multiplied by total number of establishments to estimate total employment at the individual ZCTA level.

Figure 25 ZCTA, City, and County Boundaries



Source: U.S. Census Bureau Zip Code Tabulation Areas

Table 16 ZCTA, City, and County Boundary Crosswalk for Essex and Hudson Counties

ZCTA	City	County	ZCTA	City	County
07003	Rest of County	Essex	07302	Jersey	Hudson
07004	Rest of County	Essex	07304	Jersey	Hudson
07006	Rest of County	Essex	07002	Rest of County	Hudson
07009	Rest of County	Essex	07305	Jersey	Hudson
07079	Rest of County	Essex	07306	Jersey	Hudson
07039	Rest of County	Essex	07307	Jersey	Hudson
07040	Rest of County	Essex	07086	Rest of County	Hudson
07041	Rest of County	Essex	07087	Rest of County	Hudson
07042	Rest of County	Essex	07093	Rest of County	Hudson
07043	Rest of County	Essex	07094	Rest of County	Hudson
07044	Rest of County	Essex	07047	Rest of County	Hudson
07102	Newark	Essex	07029	Rest of County	Hudson
07103	Newark	Essex	07030	Rest of County	Hudson
07050	Rest of County	Essex	07032	Rest of County	Hudson
07052	Rest of County	Essex	07310	Jersey	Hudson
07104	Newark	Essex			
07105	Newark	Essex			
07106	Newark	Essex			
07107	Newark	Essex			
07108	Newark	Essex			
07109	Rest of County	Essex			
07110	Rest of County	Essex			
07111	Rest of County	Essex			
07068	Rest of County	Essex			
07112	Newark	Essex			
07114	Newark	Essex			
07078	Rest of County	Essex			
07017	Rest of County	Essex			
07018	Rest of County	Essex			
07021	Rest of County	Essex			
07028	Rest of County	Essex			

Source: U.S. Census Bureau

B.3.3 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.

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.3.1 and B.3.2. The USACE Ports in the FAF regions to be disaggregated are shown in Table 17. The shares for import and exports tonnages will vary by SCTG2.

Table 17 USACE NDC Ports to Be Disaggregated

Port Name	County Name	County FIPS	USACE Port Number	FAF 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

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 marine terminals that serve as gateways in each FAF region where the Port's terminals are located. The team allocated port flows to their respective counties based on percentages of terminal land area obtained in consultation with the Port Authority of New York and New Jersey and the NJTPA (Table 18). Additionally, we will also apply additional specificity in the disaggregation factors for specific commodities, including:

- All SCTG 36 Motorized Vehicle port flow commodities were assigned to Essex County because of the vehicle processing centers located in Port Newark;
- Energy commodities SCTG 16-18 were allocated 80 percent to Middlesex County and 20 percent to Union County. This is to account for the team's estimate of the distribution of private port oil and gas facilities, especially those located near Perth Amboy in Middlesex County.

Table 18 Consolidated Ports of New York and New Jersey Disaggregation Factors Based on Land Area Share

Principal Port	County Name	County FIPS	FAF Region	Land Area Share
Port Newark	Essex County	34013	341	21%
Port Jersey	Hudson County	34017	341	19%
Port Elizabeth	Union County	34039	341	60%

Source: Provided by the Port Authority of New York and New Jersey

B.3.4 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 a 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 International 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.3.5 Domestic Multiple Modes

This project uses the same process as developed in the previous study for the disaggregation of the domestic multiple modes. The NJ Carload Waybill Sample was obtained by the Cambridge Systematics team during the prior study to identify Intermodal (IMX) Terminals by the originating county for New Jersey-origin traffic and the terminating county for New Jersey-destination freight. An updated Carload Waybill Sample was sought from the New Jersey Department of Transportation but was not made available for this study. Therefore, the results from the prior Carload Waybill Sample are applied to this study. The team believes that the distribution of rail terminals, and their relative volumes of traffic, have not changed substantially in recent years.

It should be noted that no disaggregation of domestic Multiple Modes was attempted for imports and exports. Tonnages might be transferred at on-dock rail terminals at the port or by truck from the intermodal terminals in the Waybill Survey, but there is no information to allocate between on-dock and off-dock terminals.

B.3.6 Intermodal Terminals

The consultant team turned to analysis performed for the 2050 Freight Industry Level Forecasts Study in 2020, which used the NJ Carload Waybill Sample. 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 percent 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 19. A single Multiple Mode record in FAF would generate four rail modal records (between the intermodal terminals and the non-New Jersey trip end) and four truck records (between the intermodal terminal and a Northern New Jersey county).

Table 19 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 County	34013	1,048,800	15.61%	1,187,000	18.29%
Bergen County	34003	469,880	6.99%	298,840	4.61%

B.3.7 Freight Flows 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.

Disaggregated Counties That Should Not Pass Through New Jersey

The disaggregation method 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.

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.3.8 Projection of Flows to 2055

FAF 5.6 provides forecasts of freight tonnage and value up to the year 2050. To extend these forecasts to the year 2055, this project uses a log-linear regression approach. This method involves using historical and forecasted data from previous years to predict future tonnage and value. Using linear regression with log-transformed freight measures stabilizes variance, handles exponential growth, reduces skew, and makes the results more reliable for forecasting.

The process begins with calculating the natural logarithms of the freight tons and values for the years 2025 to 2050 and creating weighted sums for these two measures. Then, a weighted sum and a simple sum are computed for the calculation of coefficients used in the linear regression. Finally, these coefficients are used to extrapolate the logarithm of freight tons and values for 2055, which were converted back to the original scale for the forecasted value. These forecast results will be reviewed and compared to FAF forecasts, and, in consultation with NJTPA staff, additional adjustments may be considered, if necessary. Alternatively, this forecast and the FAF forecasts could be considered as alternative scenarios.

B.4 Conclusion

The FAF 5.6 was disaggregated at county and city level for the base year 2017 and for every five-year increment from 2025 to 2050. The year 2055 was not available in FAF 5.6 and was forecasted based on a log-linear regression approach. This disaggregation was performed for both tonnage and value as reported in the FAF. Imports and exports in the FAF are detailed by foreign mode and domestic gateway.

The disaggregated FAF database produced from this task was critical for other tasks in the study. In Task Four, the team developed and added estimates of flows from Direct-to-Consumer (DTC) last-mile movements of e-commerce shipments to the commodity flow database. Also, the disaggregated FAF is the basis for the custom commodity flow forecasts, developed using industry output data provided by Moody's Analytics in the FFT.

Appendix C. Direct-to-Consumer Trip Table and Forecasting Methods and Results

This appendix describes the methodology and results of two analysis tasks related to e-commerce, or direct-to-consumer deliveries. The first is developing an origin-destination matrix, or trip table, representing the estimated number of vehicle trips traveling from e-commerce fulfillment and other distribution centers to the point-of-delivery, at the traffic analysis zone (TAZ) level. The second analysis develops future-year forecasts of e-commerce demand using a combination of e-commerce retail market trends and forecasted demographic trends.

C.1 Direct-to-Consumer Trip Model Method and Results

E-commerce continues to reshape freight movement across the United States, particularly at the urban and regional scale where last-mile delivery activity has surged. Because these deliveries to consumers are largely absent from commodity flow databases used to develop freight models, there is a significant gap in the data in the estimation of e-commerce truck trips used for regional freight forecasting efforts. To develop a trip table that could be incorporated into the NJTPA's Freight Forecasting Tool (FFT), the CS Team leveraged an approach that synthesized truck GPS data from LOCUS Truck and package data from NielsenIQ in the NJTPA region. The analysis was conducted as part of an update of the broader freight demand modeling and forecasting initiative in the NJTPA region. The primary objective was to improve the estimation and allocation of e-commerce last-mile delivery truck tours and trips—originating from carrier facilities and ending at consumer destinations— in North Jersey Regional Transportation Model-Enhanced (NJRTM-E) TAZs. The resulting trip table would be incorporated as an input into the FFT, which will be used to support long-range scenario analysis and investment planning.

Our methodology used expanded package totals by zip code and carrier from NielsenIQ as targets for the model. To determine the zip codes served by each facility a combination of LOCUS Truck data and a large sample of package scan data from NielsenIQ were analyzed. These data were processed to produce a volume of packages going from each facility to each zip code. The methodology employed a clustering-based multi-step process to assign package stops to individual trucks creating tours. The model calibration and validation included comparisons to truck movement data from LOCUS Truck to ensure resulting tours were accurate. This approach enabled the team to identify the origin and destination for e-commerce delivery trips throughout the NJTPA region.

C.1.1 Data Description

This analysis utilized multiple datasets, each contributing to the development of a freight trip table for e-commerce modeling. These datasets fall under three main categories: package-related data from NielsenIQ, truck movement data from LOCUS Truck, and geospatial reference data.

NielsenIQ Package Data

NielsenIQ provides two datasets which were used in this effort. The first is a weighted database of total e-commerce packages delivered in a calendar year. The second is a sample of package scans which record the progress of the package from origin (i.e. original scan location) to destination (e.g. consumer's home) from the carrier perspective.

The expanded package count dataset is composed of the following components:

- **Total Package Counts by ZIP Code:** This includes records of all destination ZIP codes in the region with two main attributes: the raw package count delivered to each ZIP code based on the sample, and the estimated total annual package volume for each ZIP code.

- **Carrier Share per ZIP Code:** This dataset contains the market share of each delivery carrier per destination ZIP code. It reports both raw carrier share computed from sample deliveries and projected carrier share, adjusted to reflect market-wide estimates. The four main carriers – Amazon, UPS, USPS, and FedEx – accounted for over 93 percent of packages. Other carriers were not included in the model and their packages reallocated.

The scan data is an event-level dataset recording every scanning event along the package journey for a large sample set of packages. The dataset contained a total of 588,710 unique packages with 5,586,298 individual scan records, indicating that on average each package was scanned more than nine times. Among these, USPS accounted for the highest share, accounting for 37 percent of all unique packages. FedEx and UPS followed, contributing 28 percent and 27 percent of the package volume, respectively, while other carriers made up the remaining eight percent. Note these shares do not represent the share of total packages carried by each. Each record includes:

- A unique Package ID (which links all the records for a single package)

- A Scan Sequence Number, indicating the order of each scan

- The Scan Location, comprising city name, state abbreviation, ZIP code, and country

- The Scan Notes or Activity Values, which describes the nature of the scan (e.g., "Order Processed", "Arrived at UPS facility", "In Transit to USPS", “Package Delivered”, etc.)

Each of the package-related datasets underwent reasonability checks and data cleaning to remove missing or duplicate values, ensure ZIP code validity, and maintain consistent formatting before integration into the model. Samples in the scan data which were not recorded as delivered to the final destination were not used.

LOCUS Truck Trip Data

Actual truck movement data were drawn from the LOCUS Truck data set which draws from GPS units on a large set of trucks through the Geotab Altitude platform. Trucks are assigned types based on their behavior over long periods of time. All analysis for this project was limited to trucks making frequent short stops, as delivery trucks do. Because delivery vehicles fall into the medium and light truck categories both were included, but not heavy trucks which serve long distance, facility to facility travel. A combination of trip- and domicile-based queries allowed for estimation of facility delivery area, trip making, and tour characteristics. Geofencing of facilities produced results which were more limited in number of records, but more specific to exactly the trips of interest. This information was gathered:

- Total tour distance and duration, queried by facility, zip code, and region
- Tour and trip departure times, regional
- Tour number of stops, queried by facility, zip code, and region
- Share of trips which are intrazonal, regional
- Destinations of trips originating at specific facilities

Geospatial and Reference Data

To support spatial modeling and allocation of deliveries, the following geographic datasets were used:

- **ZIP Code Boundary Data:** This shapefile contains polygon boundaries for ZIP Code Tabulation Areas (ZCTAs) across the region. These were used to geolocate delivery and facility ZIP codes and to support spatial joins. This dataset was downloaded from NJGIN Open Data[9].

- **Traffic Analysis Zone (TAZ) Data:** This shapefile contains polygon boundaries for the official TAZ definitions used in regional transportation planning. TAZs served as the spatial unit for the final trip table and tour assignment. The data was provided directly by the NJTPA.
- **Land Use Polygons with Density Classifications:** This dataset contains nearly 700,000 land use polygons in the region, each assigned an area in acres, a land use classification (e.g., residential, commercial, mixed use), a corresponding density label (e.g., rural, low-density, medium-density, high-density), among other variables. This dataset was downloaded from NJGIN Open Data[10].
- **Facility Locations:** facility locations from the previous implementation of the model were reviewed and modified to reflect changes. This data set included all of the last mile facilities serving zip codes within the model region. The NielsenIQ scan data was used to compare to the facility locations.

Each of these geospatial layers was projected into a common coordinate reference system and processed to align with the ZIP and TAZ identifiers extracted from the scan data.

C.1.2 Data Processing

The data were processed to create inputs to the model. This included identifying facility locations associated with each carrier and determining the assignment of package flows between these facilities and destination ZIP codes. The package totals by carrier and zip code were then applied to the origins (last mile facilities) and destinations (delivery zip codes).

Carrier Facility Mapping

The key element of the preparation for the model is identifying the catchment areas of each facility for each carrier. The result of this exercise was the assignment of one or more facilities of each carrier to each zip code.

From the NielsenIQ scan records, key features were extracted:

[9] https://njogis-newjersey.opendata.arcgis.com/datasets/acdc2b609da74297a25ff36626d1392a_16/explore?showTable=true

[10] https://njogis-newjersey.opendata.arcgis.com/datasets/2deaaa3cadd94166bdbff92a44ade284_5/explore?showTable=true

- The last scan information is assumed to be of final delivery (consumer location), unless otherwise indicated by the activity value.
- The second-to-last scan information is interpreted as information at the delivery facility or hub.
- Featuring carrier label (Amazon, FedEx, UPS, USPS, Others) from activity values or notes indicate carrier used to deliver package.
- The third-to-last scan are used in cases when activity values of second-to-last scan indicate final delivery.
- Package IDs without a final delivery were dropped from the data.

For FedEx and UPS, the scan prior to final delivery indicated the zip code or town of the last mile facility. These locations were matched to specific facilities. For zip codes with packages coming from more than one facility for a single carrier each facility was assigned a percentage based on the number of packages. Facilities with less than five percent of the zip code's packages were excluded and their percentage reallocated to the other facilities.

For Amazon, the scan prior to the final delivery did not indicate the location of the last mile facility. Rather it gave one of a few zip codes which were found to not have last mile facilities. Instead, LOCUS Truck data were used to identify the catchment area of the known facilities. Trips coming from those facilities by delivery type behavioral patterns were identified by their zip code destination. These facility to zip code trips were used in the same way as the last and 2nd to last scan locations. In this way zip codes were assigned shares (of packages) to the last mile facilities.

Destination zip codes without any scans or data were assigned the same facilities based on their nearest zip code neighbor.

USPS operations are unlike those of the private carriers. While the others operate more regionally, the Post Office package delivery is mostly done by zip code using the local post office. In zip codes without a Post Office, the nearest neighbor was assigned.

Package Allocation by Carrier

After establishing the facility-ZIP mapping, the number of packages delivered from each facility to a destination ZIP code was estimated by multiplying the projected total package volume at each destination ZIP was by the carrier share associated with that ZIP code and the facility share associated with that ZIP.

$$Packages_{i,j} = Packages_j \cdot FacilityShare_{i,j} \cdot CarrierShare_j$$

For facility *i* and destination zip *j*

For many ZIP destinations the facility shares were 100 percent for one facility and zero percent for all others. This procedure resulted in a facility-ZIP level package flow table for each carrier that represents the assignment of daily package deliveries from facility hubs to ZIP code destinations.

C.1.3 Clustering and Tour Formation

The clustering of delivery locations was a key step in approximating truck tours for each facility. K-Means clustering was applied iteratively for each carrier and facility combination. The rationale behind clustering is grounded in real-world delivery operations, where carriers consolidate delivery stops geographically to optimize costs, minimize travel distance, and meet service-level agreements. Each cluster represents a set of delivery stops likely served within a single tour by one truck.

Preprocessing Before Clustering

Before clustering, the projected annual package count at each ZIP code was first converted into daily package volume by dividing by 365. Since trucks stop at physical locations and not individual packages, the packages were then converted into estimated stop counts. This conversion relied on assumed package-per-stop ratios by carrier type.

To assign these stops to spatial locations, the regional land use dataset was used. Only residential polygons were used to distribute delivery stops geographically. A density weighting system was employed based on assumed dwelling units per acre and delivery demand intensity, as shown in Table 20 (see New Jersey Department of Environmental Protection website for more information on the number of dwellings per acre for each class):

Table 20 Residential Density Levels and Associated Weighting Factors

Residential Density Level	Dwellings per Acre	Weight Factor
Single Unit, Rural	<1	1
Single Unit, Low Density	1–2	2
Single Unit, Medium Density	2–5	4
Multiple dwelling or High Density	>5	7
Mixed Residential	Varies	3

Each polygon's weighted land area was calculated as:

$$Weighted\ Land\ Area = Polygon\ Acres * Density\ Weight$$

The total number of daily stops in each ZIP code was then distributed across polygons proportionally:

$$Stops\ (polygon) = \left(\frac{Weighted\ land\ area\ of\ polygon}{Total\ Weighted\ Land\ Area\ in\ ZIP}\right) * Daily\ Stops$$

Stop Rounding and Redistribution

Because most residential polygons were small and many received fewer than one stop (especially in suburban and rural areas), the resulting stop values were often fractional. Since stops must be integers in the clustering step, a reallocation procedure was applied. Polygons with at least 0.5 stops were rounded to the nearest whole number. The fractional remainder was calculated: the remaining stops were reallocated to polygons with the highest original fractional values, ensuring total stop counts matched the original ZIP-level totals. This redistribution prioritized polygons with higher fractional stops and preserved the spatial pattern of stop demand while enabling clean integer-based input for clustering.

Clustering Algorithm

After the stops were spatially distributed across residential polygons, clustering was performed per facility using the K-Means algorithm to define truck tours. Each cluster represents a set of delivery stops served by a single truck within a single day (from a single facility). Facility locations were not included in the clustering; the focus was solely on grouping delivery points (i.e., stops). The goal of this clustering was to simulate how carrier operations might group deliveries geographically while minimizing travel costs.

The clustering process began by extracting the geographic coordinates of each stop associated with a given facility. A pairwise distance matrix was computed (in miles) using Euclidean distance, and the convex hull of all stops for that facility was used to approximate the service area in square miles. This allowed for the calculation of the facility's delivery density, defined as the number of stops divided by the convex hull area.

A scaling factor was then computed based on this density. This factor ranging from 0.75 to 1.0 lowers the upper bounds for stops and packages per cluster in less dense areas, allowing trucks to make less stops in those areas. This adjustment reflects the operational efficiency in urban and suburban regions where delivery points are closer together, compared to rural areas where stops are further apart and fewer deliveries can be completed in a single route.

Using the adjusted constraints, an initial number of clusters was calculated by dividing the total number of stops by the adjusted maximum stop threshold. K-Means was then applied using this estimated number of clusters. After the initial clustering, each resulting cluster was tested for compliance with two operational constraints:

- **Stop Limit:** The total number of stops in a cluster must not exceed the adjusted threshold of 200 stops per tour. This stop limit is the same as a package limit of 300 packages per tour. Note that this number is multiplied by the density-based scaling factor, meaning that in rural areas, the maximum number of packages is 200 packages per tour.
- **Distance Limit:** The maximum Euclidean distance between any two stops in the cluster must not exceed 10 miles.

Clusters that violated one or more constraints were split further using a new K-Means run, increasing the number of sub-clusters based on the magnitude of the violation (i.e., degree of excess stops/packages or distance). K-Means was re-applied iteratively to these sub-clusters. This process continued until all resulting clusters met the defined constraints. The clustering algorithm is summarized in the pseudocode below:

F: Set of facilities.

$\mathrm{S_f}$: Set of stops associated with facility $\mathrm{f} \in \mathrm{F}$.

$\mathrm{x_i}$, $\mathrm{y_i}$: Coordinates of stop $\mathrm{i} \in \mathrm{S_f}$.

Set initial values for the clustering constraints:

$\mathrm{Base\ max\ stops} = 200$

$\mathrm{Base\ max\ pairwise\ distance} = 10$ (in miles)

For each $\mathrm{f} \in \mathrm{F}$

Compute pairwise Euclidean distances:

$$\mathrm{P(i,j)} = \mathrm{sqrt}\left(\left(\mathrm{x_i} - \mathrm{x_j}\right)^2 + \left(\mathrm{y_i} - \mathrm{y_j}\right)^2\right)$$

Compute convex hull area in square miles:

$A_f = \mathrm{Area}(\mathrm{ConvexHull}(S_f))\ /\ 5280^2$

Compute density of stops served by facility f:

$D_f = |S_f|/A_f$ if $A_f > 0$ else $D_f = |S_f|$

Compute scaling factor based on residential density:

$F_f = \min(1.0, \max(0.75, D_f/10))$

Compute adjusted maximum stops per cluster:

$M_f = \text{Base max stops} \cdot F_f$

Set initial number of clusters:

$K_f = \mathrm{ceil}(S_f/M_f)$

Apply K-Means clustering with K_f clusters

for each $C_i \in C_f$

Compute $|C_i|$ (Number of stops in cluster)

next C_i

while exists $C_i \in C_f$ where $|C_i| > M_f$ or $\max\big(P(i,j)\big) > \text{Base max pairwise distance}$

for each $C_i \in C_f$ violating constraints

Compute new sub-cluster count:

$K'_i = \max\ ($

$\mathrm{ceil}(|C_i|/M_f),$

$\mathrm{ceil}(\max\big(P(i,j)\big)\ /\text{Base max pairwise distance})$

$)$

Apply K-Means clustering to C_i with K'_i clusters

Update C_f by replacing C_i with new sub-clusters

next C_i

end while

next f

This iterative splitting method ensured that the final clusters reflected realistic and manageable delivery tours while preserving geographic compactness and operational feasibility. The procedure was implemented separately for each carrier. These clusters serve as the foundation for subsequent steps in the modeling workflow, including route sequencing and trip table construction.

Stop Sequencing and Optimization

Once stops were clustered as part of delivery tours, the sequence in which the truck would visit each stop within a cluster was determined. The sequencing of stops aimed to reflect realistic delivery behavior while respecting traffic analysis zone (TAZ) groupings and proximity to the facility. A customized Nearest Neighbor (NN) algorithm with TAZ-priority heuristic was implemented for this purpose. The stop sequencing algorithm can be summarized in the pseudocode as follows:

For each final cluster C_i

Let $B_i = \text{facility}_{\text{origin}} \cup C_i \cup \text{facility}_{\text{end}}$

Compute pairwise Euclidean distances between all stops in B_i

$$D(i,j) = \text{sqrt}((x_i - x_j)^2 + (y_i - y_j)^2)/5280$$

Initialize tour $R = [0]$ *start from facility

Let $V = \{1, 2, \ldots, n\}$ * indices of unvisited stops (excluding 0 and n)

Sort $\text{TAZ}s = \{t_1, t_2, \ldots, t_k\}$ by distance from facility

for each $t \in \text{TAZ}s$:

while exists $j \in V$ such that $\text{TAZ}_j = t$:

$i = \text{last}(R)$ *last stop in the tour

$j = \text{argmin}\{D(i,j) \mid j \in V \text{ and } \text{TAZ}_j = t\}$ *nearest unvisited stop

Append j to R

Remove j from V

Append return to facility:

R.append(n+1)

for each trip ($\mathrm{i} \rightarrow$ j) in tour R:

Assign category:

if $\mathrm{i} == 0 \rightarrow$ "Facility to TAZ"

else if $\mathrm{j} == \mathrm{n} + 1 \rightarrow$ "TAZ to Facility"

else if $\mathrm{TAZ_i} == \mathrm{TAZ_j} \rightarrow$ "Intrazonal"

else $\rightarrow$ "Interzonal"

Compute:

$\mathrm{Distance} = \mathrm{D(i, j)} * 1.4$

$\mathrm{Duration} = ((\mathrm{Distance/truck\ speed}) * 60) + \mathrm{stop\ time}$

In this procedure, each tour (cluster) begins at the assigned facility, proceeds through delivery stops grouped by TAZ and finally returns to the originating facility. Within each TAZ, the nearest unvisited stop is selected iteratively based on the shortest Euclidean distance to the last stop added to the tour. Also, the TAZs themselves are sequenced based on their centroid proximity to the facility. To approximate real-world travel conditions, Euclidean distances were multiplied by an adjustment factor of 1.4 to account for indirect road paths. Trip categories are assigned for each trip leg of the tour as follows:

- "Facility to TAZ" if the stop departs from the facility to a delivery zone.
- "TAZ to Facility" if returning from the last delivery stop to the facility.
- "Intrazonal" if both origin and destination stops belong to the same TAZ.

- "Interzonal" if origin and destination stops belong to different TAZs.

Truck Tour Assumptions

- **Truck Speed:** This is the assumed average speed to travel between stops. It is applied in place of skims, as skims have a single travel time for each OD pair and the multitude of trips in e-commerce delivery are very short. Trips from facility to destination areas are longer and could be accurately represented by skims. It is expected that truck speed would vary by residential density and by trip type. These assumptions were applied to inter- and intra-zonal trips between delivery stops:
  - **Rural (25 mph):** The effective speed during active delivery is expected to be higher in rural areas since there are fewer interruptions in rural areas. This assumption applies to all category of trips in rural areas.
  - **Suburban/Urban (15 mph):** These trips are often shorter and localized within neighborhoods and would have lower speeds due to frequent stops and/or lower speed enforcements in residential areas.
- **Stop Time:** While an average of two minutes per stop is expected, this value tends to vary by residential density:
  - **Rural (2.5 mins):** Rural deliveries involve longer driveways, larger lots, and more walking to doorsteps. Stop time per delivery in rural areas is assumed to be higher than suburban areas.
  - **Suburban (2.0 mins):** Suburban neighborhoods are denser and more uniform, with closer houses and easier access to front doors. There is also less walking and less searching, leading to lower stop time compared to rural areas.
  - **Urban (2.5 mins):** Although addresses are closer together in urban settings, parking difficulties, elevator access, and security protocols (buzzing, concierge, stairs) increase stop time compared to suburban areas.

Overall, differentiating between facility-to-first-delivery and delivery-to-delivery segments and residential density level in our assumptions is necessary to improve the accuracy of the model.

C.1.4 Model Calibration and Validation

Model calibration and validation involves adjusting model assumptions and parameters to align model outputs with observed real-world data from LOCUS Truck. It serves as a quality assurance process to confirm that the model's structure and logic are appropriate for broader application. In this project, calibration was necessary to refine assumptions such as truck speed, stop time, stop density, and trip distance, while validation ensured that the delivery behavior emerging from the synthesized tours reasonably matched observed freight operations in the region.

Truck Geofencing Analysis

To validate the modeled freight delivery patterns, geofencing was conducted around major facilities for FedEx, UPS, and Amazon. Each facility location was buffered using a one-mile radius. Using the truck GPS data queried by facility, we created distributions of tour behavior analogous to the model output.

Comparison between initial model outputs and truck data indicated several areas that required adjustments such as truck speeds and stop durations. Iterative changes were made and the final assumptions were the ones provided in the previous subsection. The geofencing analysis thus directly informed the final set of model parameters, ensuring the synthetic delivery tours resembled the operational profiles of trucks serving the facilities.

Skim Data Matrix

In addition to geofencing validation, model outputs were compared against skim matrices (obtained directly from the NJTPA) representing average interzonal travel times and distances in the regional travel demand model. Because skim matrices represent TAZ centroid-to-centroid travel, they do not capture intrazonal travel. Intrazonal and Interzonal trips within the model, which reflect finer-grained spatial proximity between delivery stops, were not directly calibrated against the skims to avoid introducing inconsistency. Therefore, calibration using skim matrices was restricted to Facility to TAZ and TAZ to facility trips.

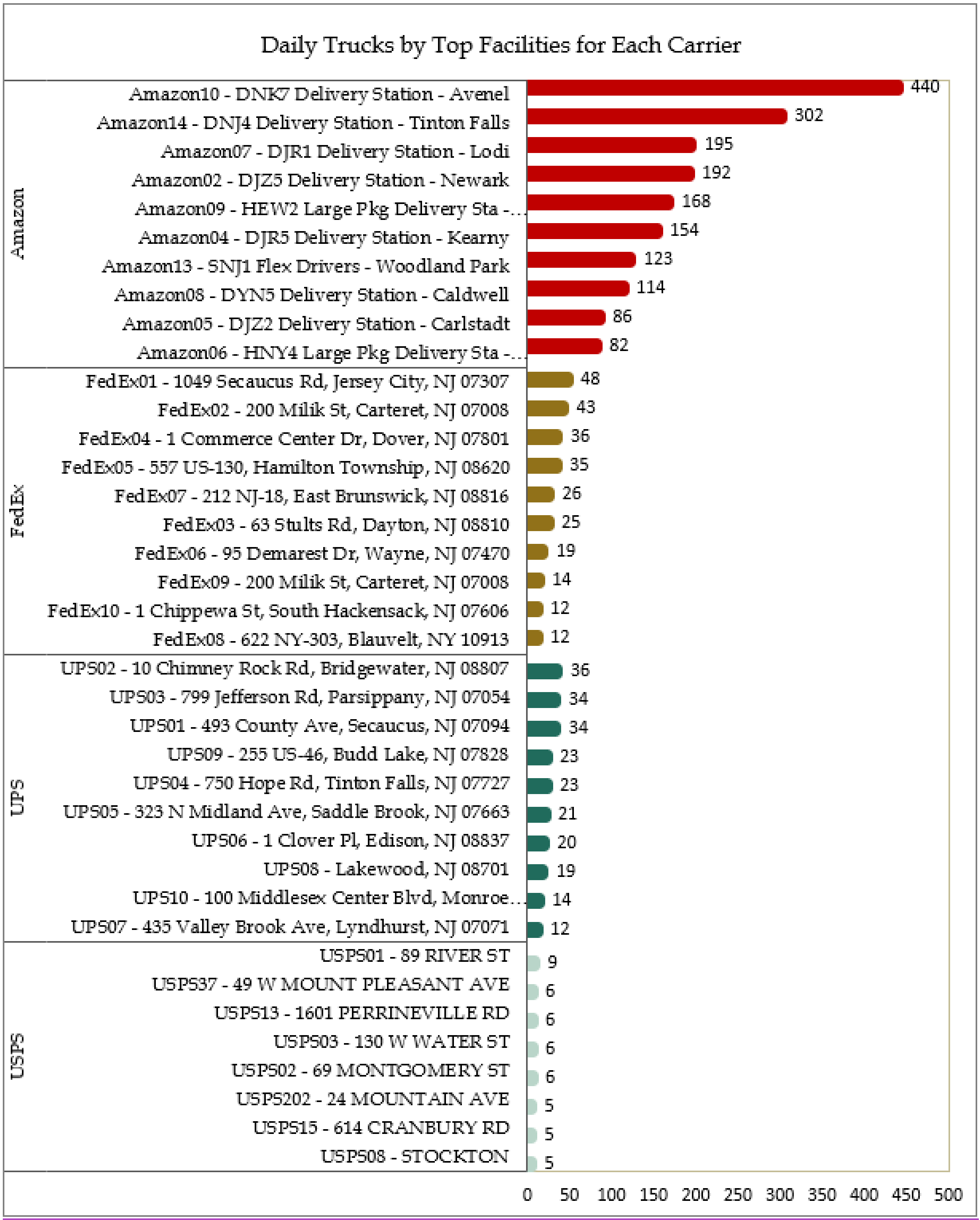
C.1.5 Results

The model produces two separate but related datasets. The table of trips includes a roster of all the trips made by each truck with tour ID. The table of tours summarizes the travel by tours, including the total stops, packages, distance, duration, and facility. Several key outputs were obtained from the clustering and stop sequencing procedures, including summaries of truck tours by facility, carrier, trip category, and operational characteristics such as distance, duration, and stop counts. Figure 26 shows the daily trucks needed for the 10 top facilities of each carrier.

The results show substantial variation in the number of truck tours across facilities and carriers. Amazon facilities exhibited the highest average number of daily trucks, driven by their high volume of package deliveries and regional operational density. The dominance of Amazon can be attributed to its growth in delivery, especially in dense regions, and the skew towards e-commerce. The data do not account for other types of delivery – parcel and letter – which are served by the other carriers.

Among all facilities, Amazon's DNK7 at the Avenel location was the most active, generating 440 delivery tours per day. Other Amazon sites such as DNJ4 at Tinton Falls and DJR1 at Lodi also contributed significantly to the overall delivery tours by Amazon in the region. FedEx facilities followed Amazon in number of tours, with their busiest location in Jersey City, which sees 48 tours per day. UPS facilities showed a lower number and more even distribution of delivery tours relative to Amazon and FedEx, perhaps reflecting a balance of package flows specifically for e-commerce. USPS facilities had the lowest number of tours per facility, consistent with their localized delivery model.

Figure 26 Average Number of Daily Trucks by Top Facilities for Each Carrier



Source: NJTPA Direct-to-Consumer Trip Model

Table 21 shows the number of trips generated by each carrier facility. As expected, intrazonal trips accounted for the vast majority of all modeled truck movements—approximately 95 percent. While it is unlikely that any of the carriers use the TAZ boundaries in their operations, the predominance of short trips makes it likely that most stay within the zones which are typically bound by large roadways or natural obstructions.

Table 21 Daily Truck Trips to the NJTPA Region by Serving Facilities

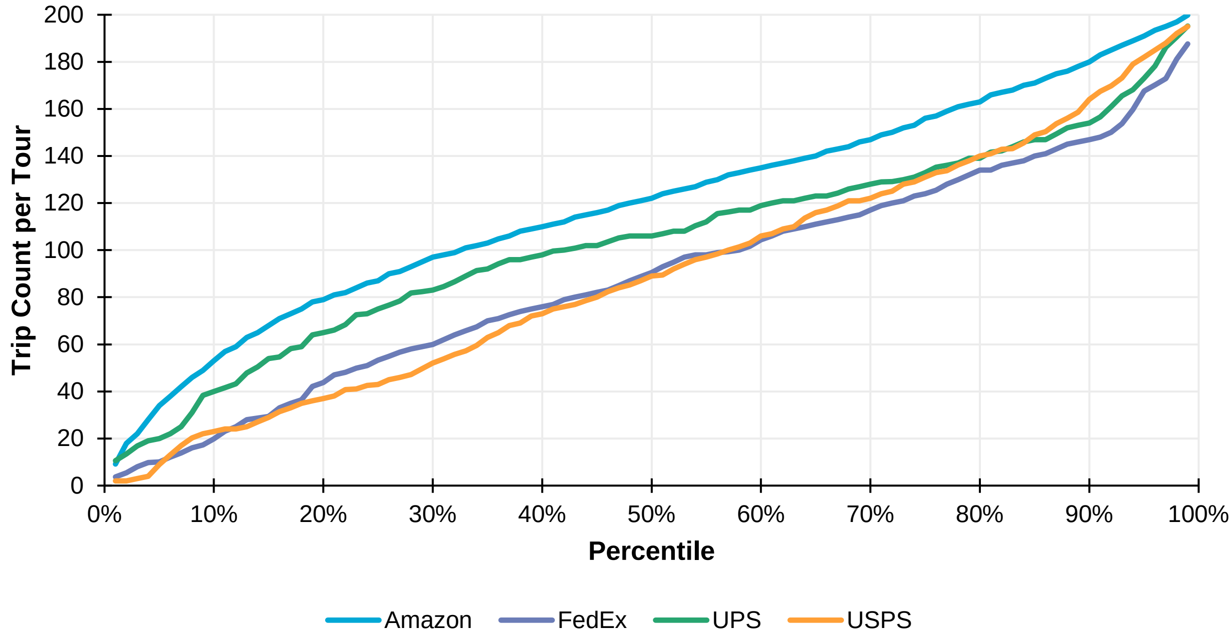
Facility	Trip Category				
	FIPS	Outbound IMX Tons	Outbound IMX %	Inbound IMX Tons	Inbound IMX %
Amazon01	63	224	7,710	63	8,060
Amazon02	192	529	21,377	192	22,290
Amazon03	79	217	8,892	79	9,267
Amazon04	154	366	16,807	154	17,481
Amazon05	86	311	9,467	86	9,950
Amazon06	82	275	9,474	82	9,913
Amazon07	195	382	22,640	195	23,412
Amazon08	114	220	13,161	114	13,609
Amazon09	168	364	19,739	168	20,439
Amazon10	440	952	50,963	440	52,795
Amazon11	42	145	3,538	42	3,767
Amazon12	16	30	2,080	16	2,142
Amazon13	123	246	14,188	123	14,680
Amazon14	302	527	35,969	302	37,100
Amazon15	33	82	4,125	33	4,273
Amazon16	26	47	3,132	26	3,231
FedEx01	48	392	5,407	48	5,895
FedEx02	43	316	3,860	43	4,262
FedEx03	25	209	2,464	25	2,723
FedEx04	36	203	2,479	36	2,754
FedEx05	35	170	2,552	35	2,792
FedEx06	19	155	2,056	19	2,249
FedEx07	26	158	2,195	26	2,405
FedEx08	12	69	1,347	12	1,440
FedEx09	14	108	1,633	14	1,769
FedEx10	12	121	1,335	12	1,480
FedEx11	7	149	830	7	993
FedEx12	6	243	336	6	591

Facility	Trip Category				
	FIPS	Outbound IMX Tons	Outbound IMX %	Inbound IMX Tons	Inbound IMX %
FedEx13	8	38	455	8	509
FedEx14	6	25	462	6	499
FedEx15	5	182	196	5	388
FedEx16	8	170	127	8	313
FedEx17	7	102	129	7	245
FedEx18	8	149	197	8	362
FedEx19	6	84	88	6	184
FedEx20	5	82	131	5	223
FedEx21	8	76	101	8	193
FedEx22	8	94	79	8	189
FedEx23	8	40	35	8	91
FedEx25	4	12	18	4	38
FedEx26	4	10	13	4	31
UPS01	34	284	3,750	34	4,102
UPS02	36	242	3,211	36	3,525
UPS03	34	194	3,058	34	3,320
UPS04	23	196	2,059	23	2,301
UPS05	21	159	2,518	21	2,719
UPS06	20	231	2,293	20	2,564
UPS07	12	158	1,402	12	1,584
UPS08	19	152	1,721	19	1,911
UPS09	23	128	989	23	1,163
UPS10	14	141	1,398	14	1,567
UPS11	7	142	797	7	953
UPS12	5	145	369	5	524
UPS13	7	15	264	7	293
UPS14	4	21	251	4	280
All USPS Facilities	539	2,322	45,090	539	48,490
Total Trips	**3,281**	**12,804**	**340,957**	**3,281**	**360,323**

Source: NJTPA Direct-to-Consumer Trip Model

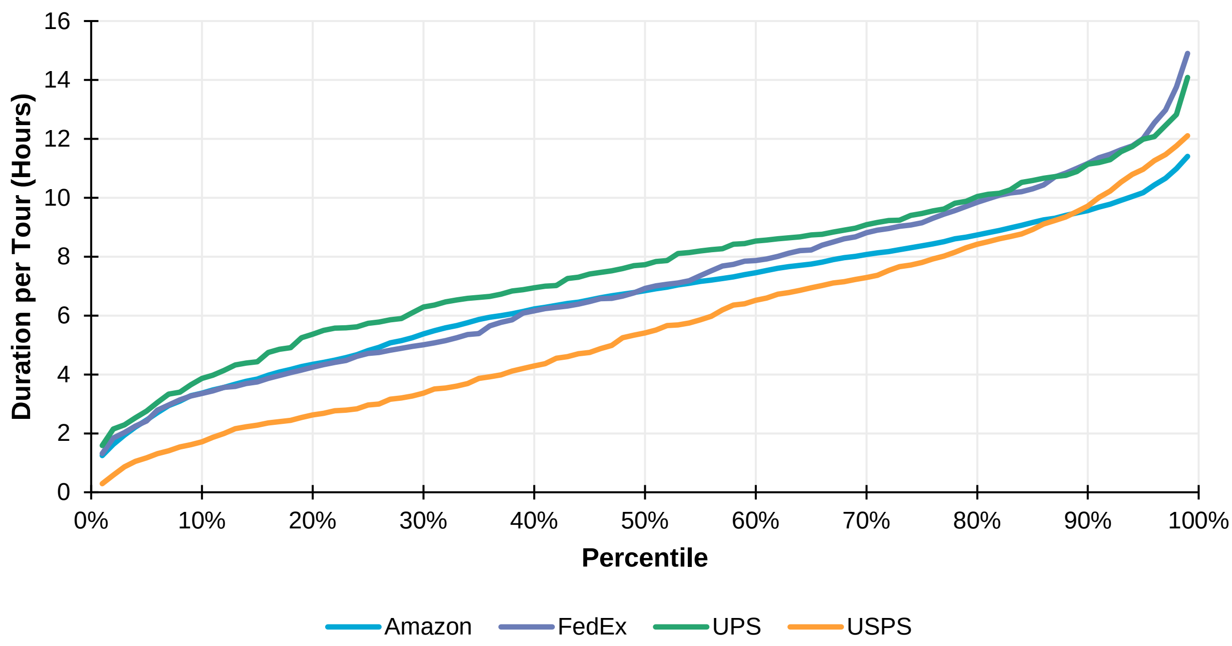
Figure 27, Figure 28, and Figure 29 show the distribution of trip count per tour, duration of tour, and distance traveled per tour, categorized by carrier. Across all carriers, the median number of stops per tour was 113, delivering an estimated 168 packages, covering 41 miles, and consuming 6.8 hours of delivery time. It is important to note that these durations reflect only travel and stop time. Additional break times (e.g., for lunch or refueling) were not modeled and could add one to 1.5 hours to the total duration per tour under real-world conditions.

Figure 27 Distribution of Trip Count per Tour



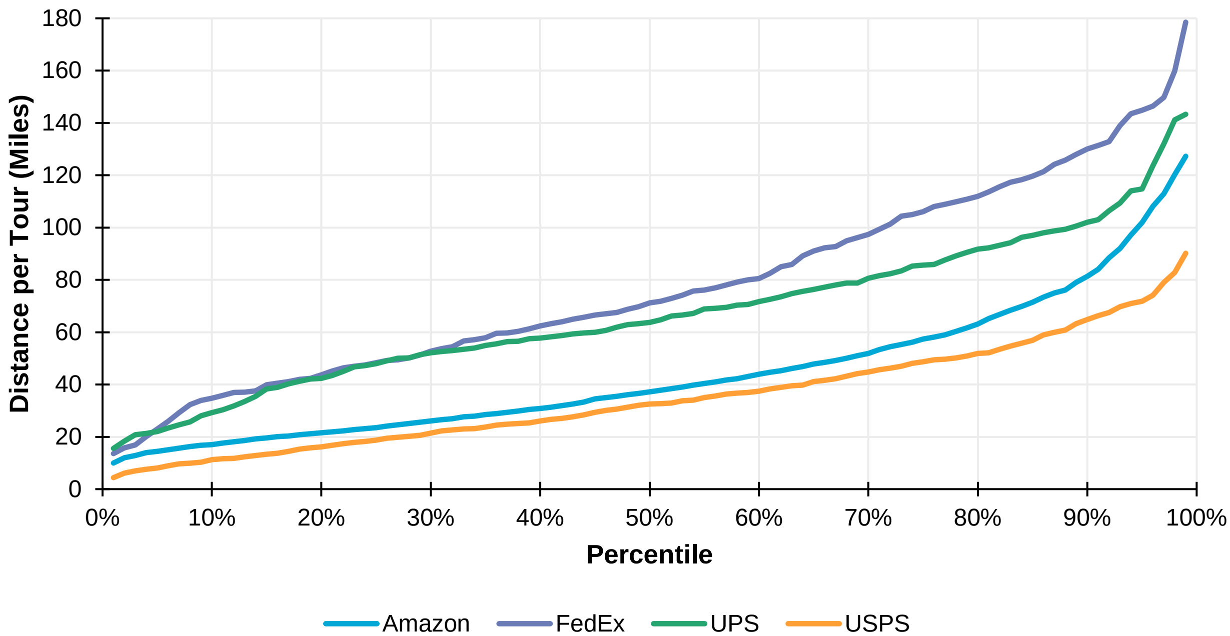
Source: NJTPA Direct-to-Consumer Trip Model

Figure 28 Distribution of Duration per Tour



Source: NJTPA Direct-to-Consumer Trip Model

Figure 29 Distribution of Distance per Tour



Source: NJTPA Direct-to-Consumer Trip Model

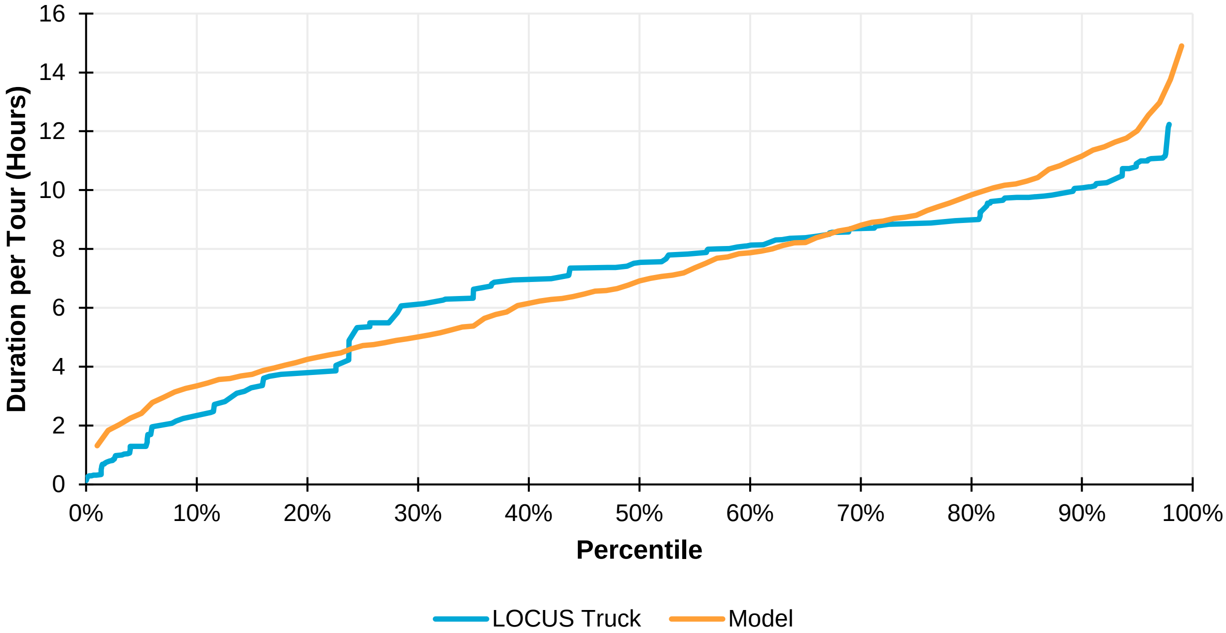
To assess the reliability of the modeled results, we compared them with a constructed distribution of tour statistics based on the LOCUS Truck dataset of GPS-based truck movements from geofenced facilities. The comparison focused on the distribution of tour durations and distances for FedEx and UPS drivers.

Figure 30 and Figure 31 present the percentile distributions of tour distance and duration for FedEx and UPS, respectively. For FedEx, both distributions align well, with median tour durations of approximately 7.6 hours in the LOCUS data and 6.9 hours in the model. The tour distance distributions also follow similar trends, though the model results exhibit a slightly more linear progression, while the LOCUS data displays a steeper curve between the 25th and 75th percentiles. While the time of the tours is shorter in the model, the distance is longer, suggesting that the time between or at stops is underestimated or the distance between overestimated.

A similar pattern is observed for UPS. The median tour duration for both datasets is approximately eight hours, showing close agreement. However, for tour distances, the model again slightly overestimates values up to the 85th percentile, after which the LOCUS data surpasses 100 miles, reflecting longer tail-end deliveries in the observed data.

Overall, these comparisons suggest that the model generally captures some distributional characteristics of real-world delivery tours, particularly in terms of duration, while slightly overestimating distances in some scenarios. The extreme ends of the distributions may be unrealistic the overall behavior, on average, provides an accurate estimate of travel.

Figure 30 Comparison of LOCUS Truck and Model Distributions for FedEx



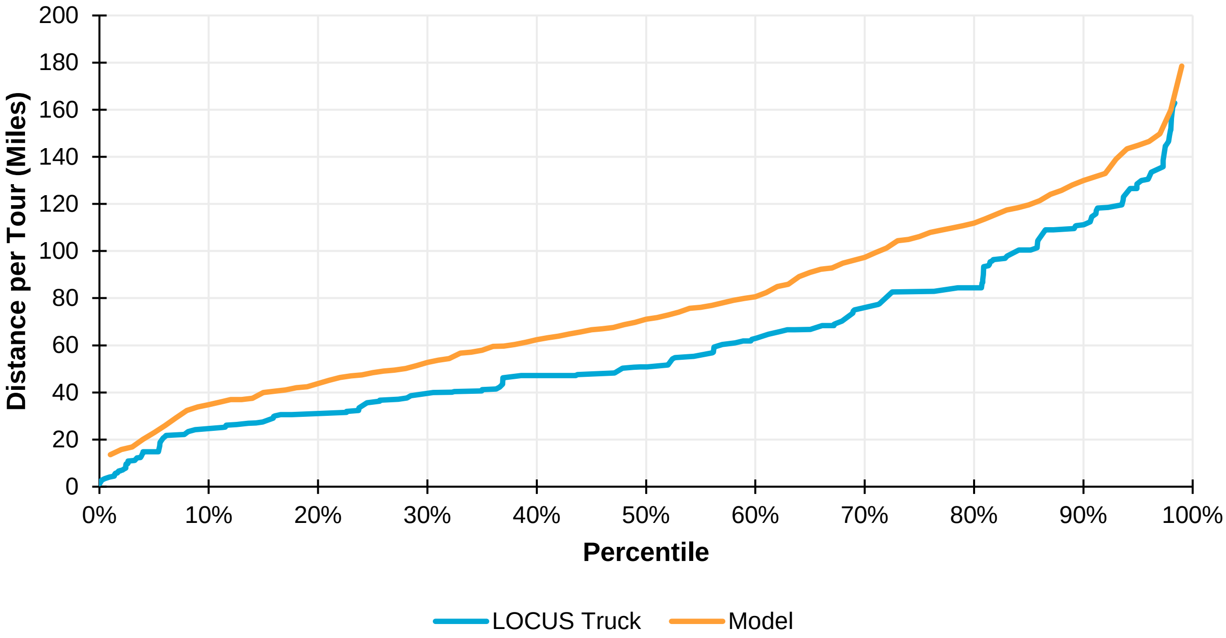
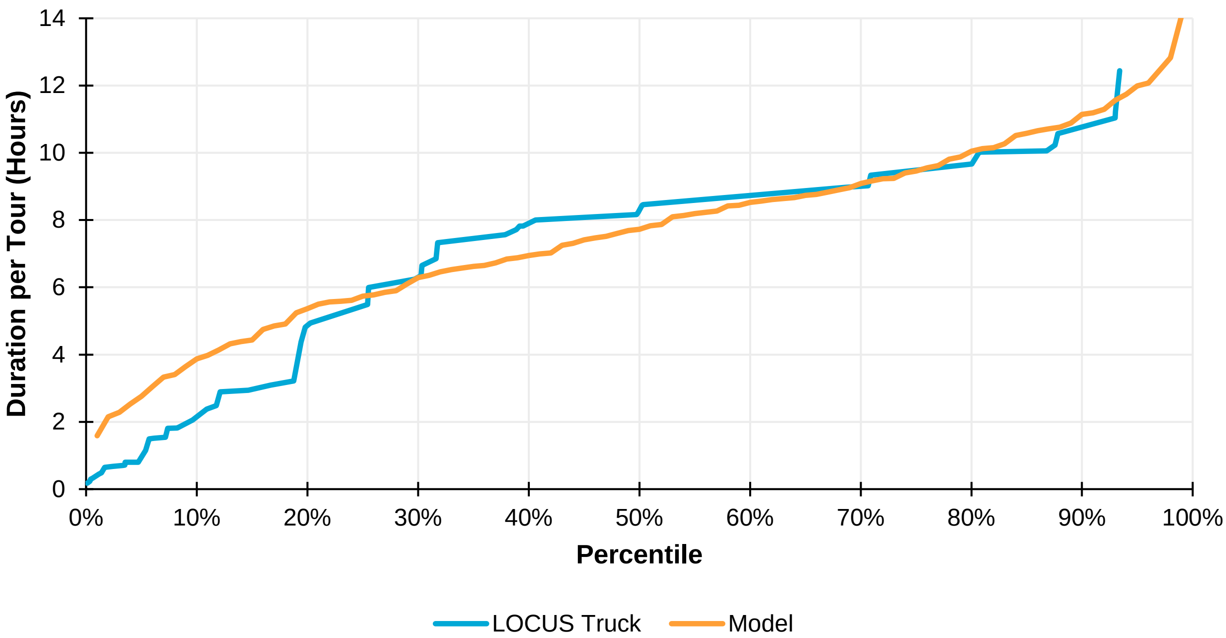
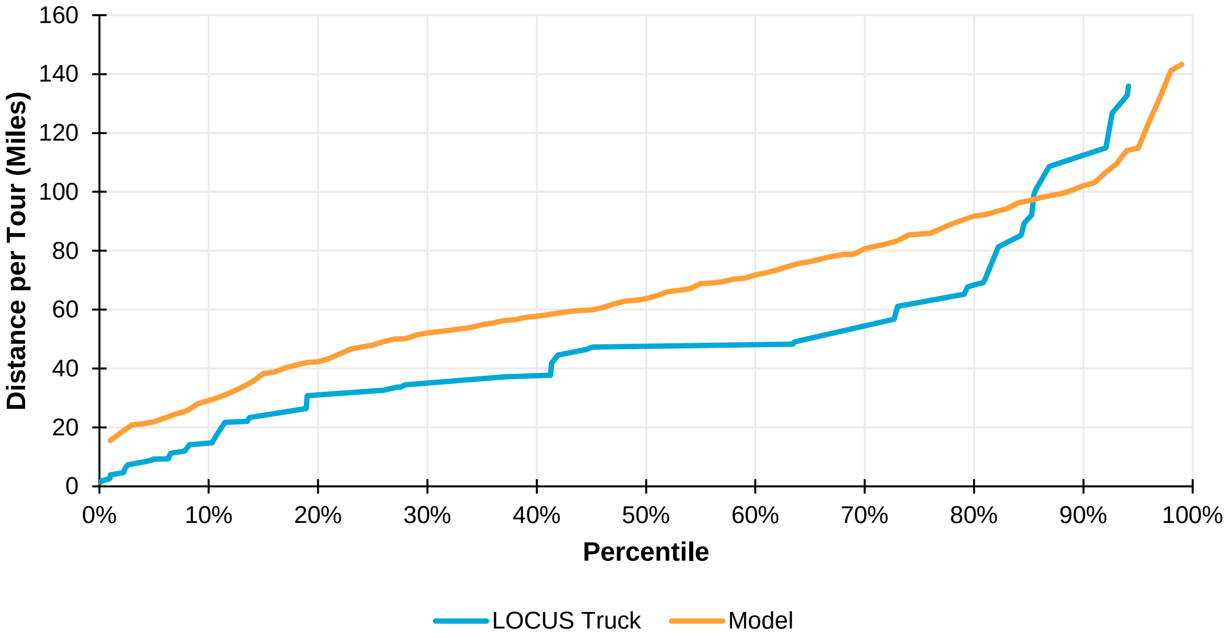


Figure 31 Comparison of LOCUS Truck and Model Distributions for UPS





C.2 Forecasting E-Commerce Demand

This section explains the technique and details the process of developing and implementing a methodology to forecast future e-commerce demand through 2055. The demand forecasts were used to generate forecasted e-commerce package counts for use in the data dashboard, and to develop future year delivery vehicle trip tables. After evaluating the methodology used for the 2050 Freight Industry Level Forecasts Study in 2020, and reviewing alternative approaches, we determined that the previous methodology remains the most suitable option for generating explainable, reliable, and scalable projections for e-commerce market penetration trends.

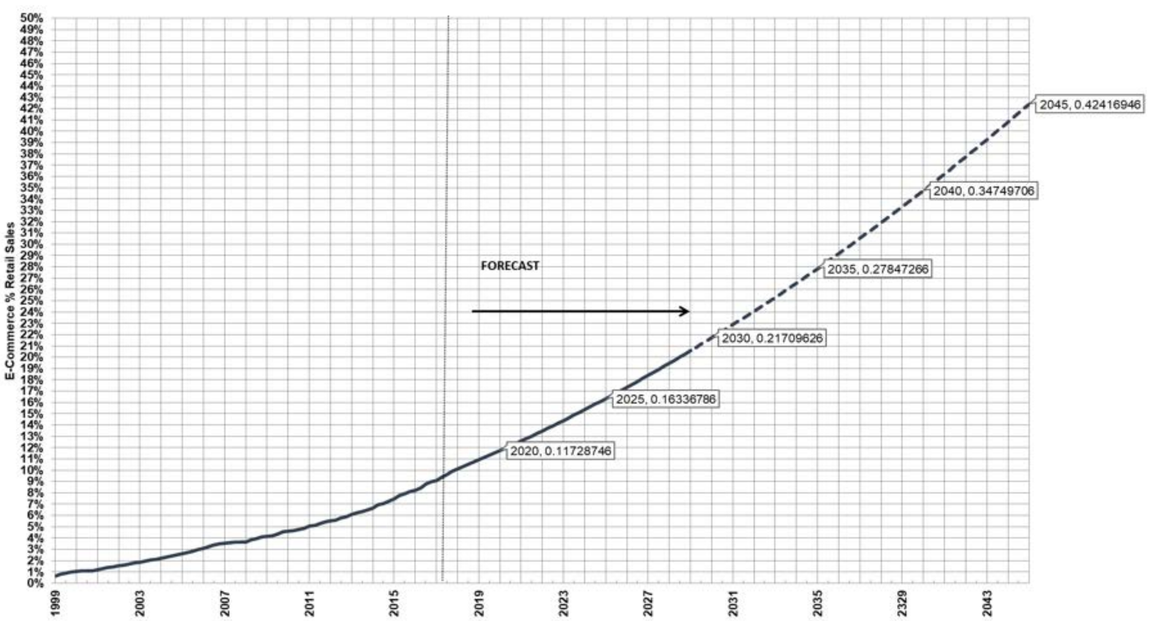
C.2.1 Overview of the Forecast Methodology in the 2050 Freight Industry Level Forecasts Study

The previous study used a regression-based framework to project future e-commerce demand at the county level in New Jersey, using population forecasts, income forecasts, and a predicted trend line for e-commerce market penetration.

The e-commerce market penetration trend line is a product of 2019 Cheng Solutions research, which informed the 2050 Freight Industry Level Forecasts Study in 2020. Figure 32 shows that forecast. From 1999 to 2019, e-commerce share of retail sales increased in a gentle near-linear fashion, rising from under one percent to around 11 percent in 2019, and Cheng Solutions' research established that the most appropriate predicted future trajectory entailed steady increases each year between one and 1.5 percentage points. As shown below, the predicted trend follows visual intuition.

This trend may level off at some point as market penetration reaches a critical point, but this assumption has not been included in this iteration of the Freight Industry Level Forecasts study.

Figure 32 E-Commerce Market Penetration Forecast, 2019-2045



Source: Cheng Solutions, 2019

Other sources for predictors in the 2019 model include population and household count forecasts provided by Moody's, as well as median household income and median age. E-commerce market data, including packages delivered by ZIP code, is provided by Rakuten Intelligence. These predictors and interaction terms were selected by evaluating coefficient significance. Least-squares regression was used to produce ZIP code-level e-commerce demand in five-year intervals between 2022 and 2050.

C.2.2 Evaluation of Alternative Methods and Enhancements

In evaluating alternative approaches, the following methods were considered:

- Reutilization of existing model with updated data; choose some technique to find a suitable e-commerce trend
- Enhancement of existing model: either creating multiple models to chart potential regulatory environments, e-commerce saturation scenarios, and economic outlooks; adding additional predictors based on market segments, carrier capacity, local freight facilities, etc.
- Advanced modeling: Bayesian/econometric/deep learning model: a less explainable, possibly more flexible model

There are not many widely publicized resources for producing long-term e-commerce forecasting. These approaches are all general in nature and would involve models built from the ground up.

After consideration, we concluded that the previous forecast method remains the best option for the following reasons:

1. **Data Compatibility:** Relevant data sources have already been procured; an update of old data is all that is necessary to construct a new model. This approach ensures a level of consistency and continuity that the other approaches do not provide.
2. **Transparency:** Regression-based models provide transparent and interpretable outputs, ensuring that the model can be easily evaluated.
3. **Alignment with Trends:** Despite turbulence surrounding the onset and progression of the Covid-19 pandemic, e-commerce penetration as a percentage of retail sales were in line with Cheng Solutions' prediction through 2024. Research to establish a new trend line would be expensive and time-consuming.
4. **Proven Reliability:** Past projections based on this framework have yielded sensible estimates as published in the previous study, demonstrating its validity.

5. **Relative Simplicity:** The other approaches we considered may not provide a non-negligible value add despite the increased resources which would be involved in their production. Bayesian models would be more difficult to interpret, deep learning models would essentially function as "black box" models, and adding additional predictors would require data that may be costly if even available.

Additionally, maintaining a regression-based framework allows for the validation of ongoing market penetration trends (e.g., 47 percent saturation by 2050) against observed data, ensuring robustness and adaptability. Therefore, a similar methodological approach was undertaken in this study, with the following enhancements:

1. Validating projections against post-pandemic e-commerce data to confirm the sustained trajectory.

2. Updating socioeconomic predictors with data from the most recent Census Bureau population forecasts.

3. Exploring sensitivity analyses to quantify uncertainties around key predictors and market saturation assumptions.

These refinements ensured that the forecast model remains accurate, explainable, and aligned with evolving market dynamics.

C.2.3 Data Preparation and Assumptions

To implement the selected modeling approach, data were sourced from the Census Bureau's 2023 American Community Survey (ACS) five-year estimates. The original selections of predictor variables for the 2019 iteration of this project were the first variables assessed for their value in model development. These variables: population, households, median household income, and median age were all found to be useful in predicting deliveries. Other measures were included in test models, but they did not improve prediction accuracy and were not included in the final model. For maximum granularity, the ACS estimates were found at the census tract level and aggregated to the ZIP code level, weighted by the number of tracts per ZIP code. To ensure statistical robustness, census tracts with fewer than 100 households were filtered out. In four ZIP codes originally specified as part of this project, none of the relevant census tracts had available data; these areas were removed from the model. The primary predictor variables mentioned above were centered to mitigate multicollinearity concerns.

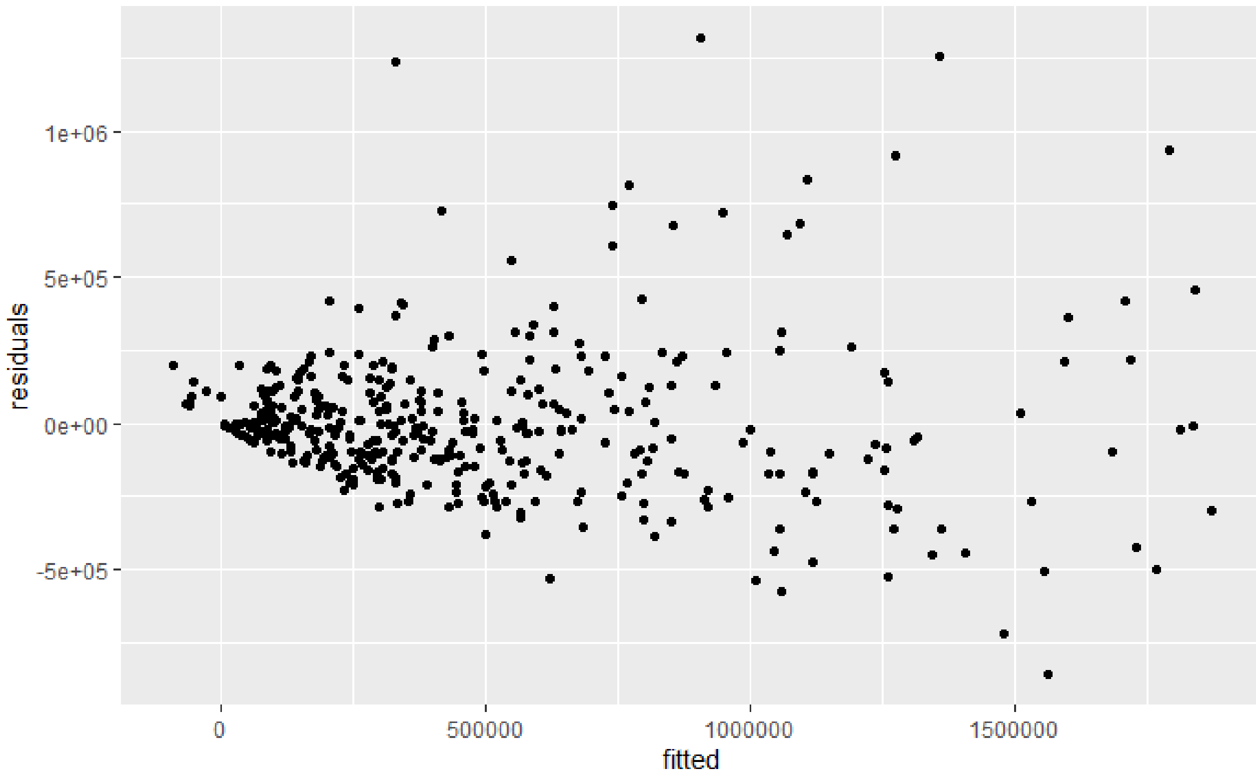
C.2.4 Model Specification and Selection

Using the 2019 methodology with updated data, we retained a multiple regression framework. Nonlinear and interaction terms (up to the second degree) were introduced and, as previously, improved predictive performance. Using the regsubsets() function from the leaps R package, the best subsets of predictors were identified; models with different numbers of predictors were compared using adjusted R squared and the Bayesian Information Criterion (BIC). Adding predictors always increases models' accuracy, but it is important to balance model parsimony to avoid overfitting and improve explainability—the final model we selected uses eight predictors. In all the models tested, residual analysis revealed a consistent overestimation pattern for ZIP codes with predicted package counts below 500,000. A review of the 2019 study confirmed that this trend was also present in the previous model, potentially highlighting a persistent limitation in applying linear regression to areas with lower e-commerce penetration. The final equation is:

- Projected packages = 580,200 + 4.919*(median HHI) + 34.33*(population) + .0201*(households^2) – 0.000014*(median HHI^2) + 0.0017*(population^2) + 0.000859*(households*median HHI) – 0.0123*(households*population) + 2.15*(median HHI*average household size). Or:
- Projected packages = 580,200 + 4.919*(median HHI) + 34.33*(population) + [*Nonlinear and interaction terms*]

The residuals plot is shown in Figure 33.

Figure 33 Residuals Plot



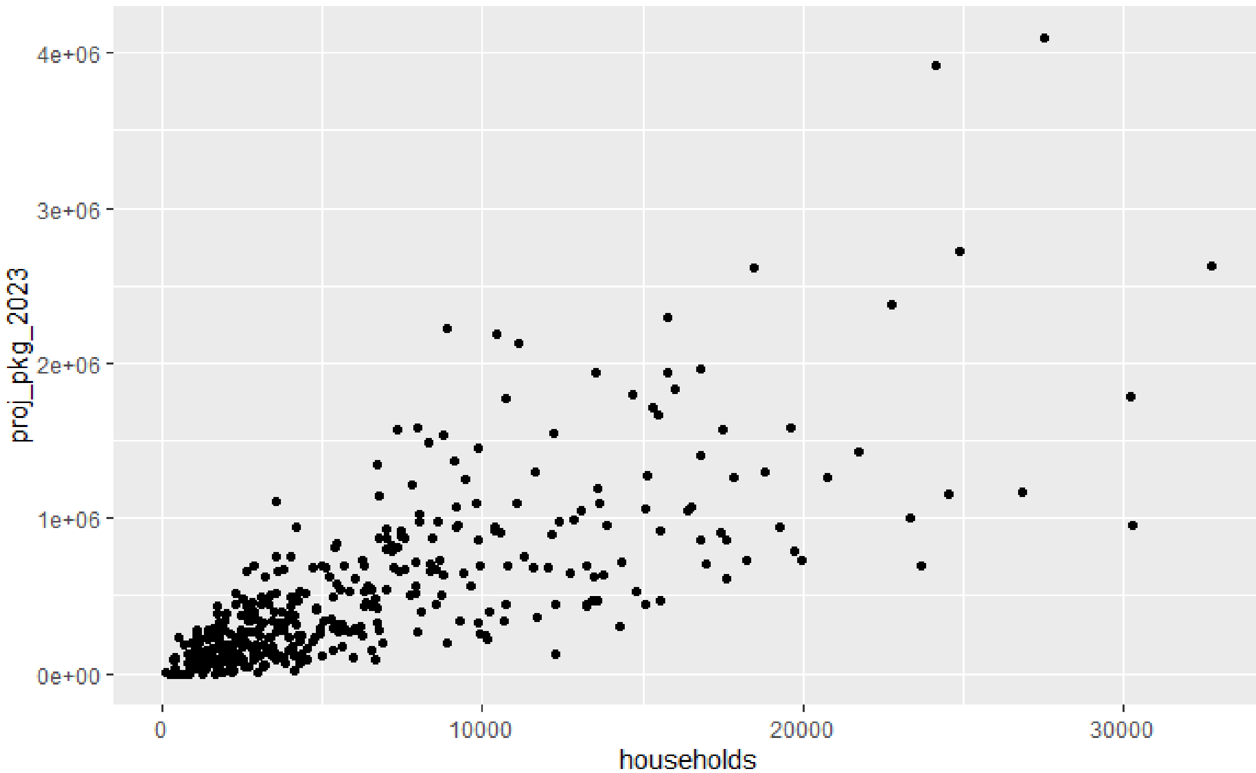
Source: NJTPA Direct-to-Consumer Forecast Model

Some conclusions follow from the model results:

- Increasing median HHI of a ZIP by $1000 is associated with an increase in projected packages of 4,919 (absent changes to nonlinear components and other coefficients)
- Adding one individual to the population of a ZIP is associated with an increase in projected packages of 34.3 (absent changes to nonlinear components and other coefficients)
- All coefficients are significant at the p=.05 level, good evidence that the coefficients are truly nonzero
- Model has a slightly lower R^2 than the model used in 2020 (0.80 vs. 0.82)

The model implies a complicated relationship in each Zip code between total households and projected packages. This can be seen in the presence of the nonlinear household^2 term plus interaction terms for households with both median household income and population. As Figure 34 shows, there is clearly some positive, noisy, potentially nonlinear relationship between the two.

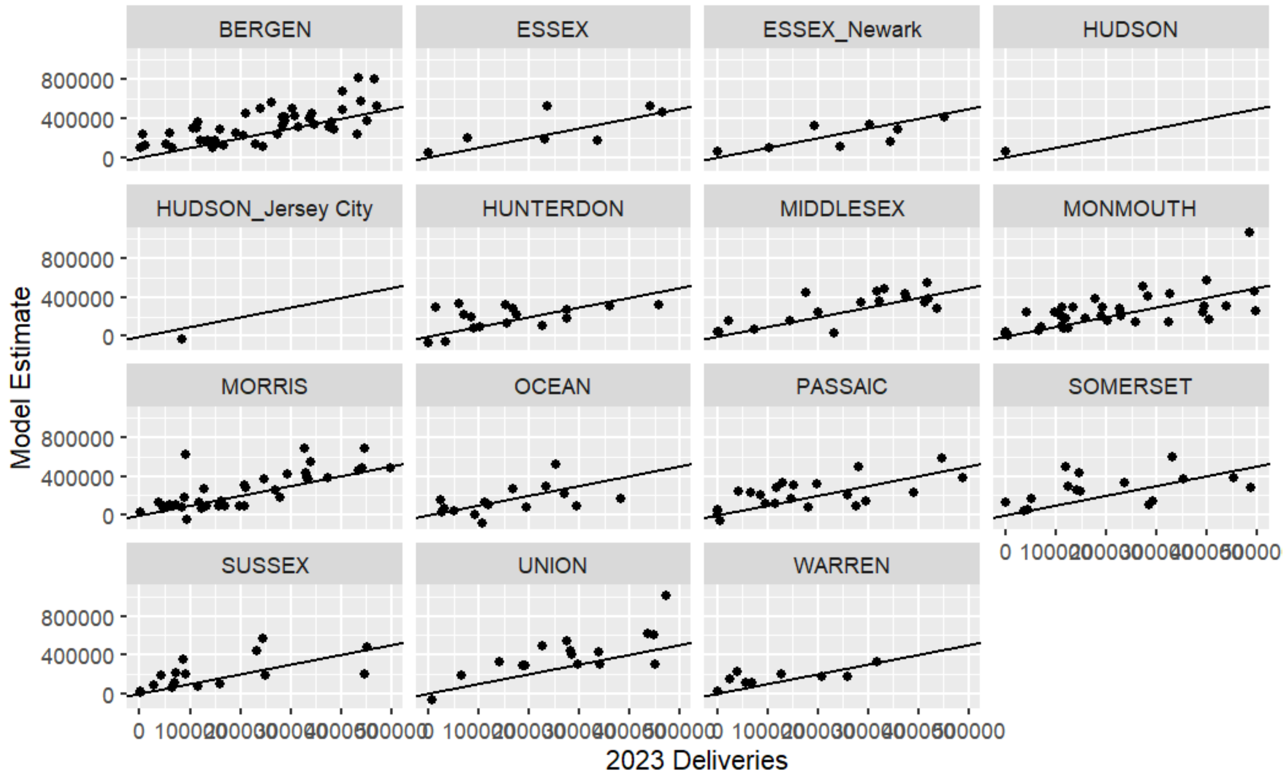
Figure 34 Relationship between Households and Projected Packages



Source: NJTPA Direct-to-Consumer Forecast Model

Figure 35 shows the model-estimated number of packages delivered in each subregion. As mentioned, the model tends to overestimate deliveries for ZIP codes with less than 500,000 deliveries.

Figure 35 Plot of Model-Estimated Deliveries by Subregion



Source: NJTPA Direct-to-Consumer Forecast Model

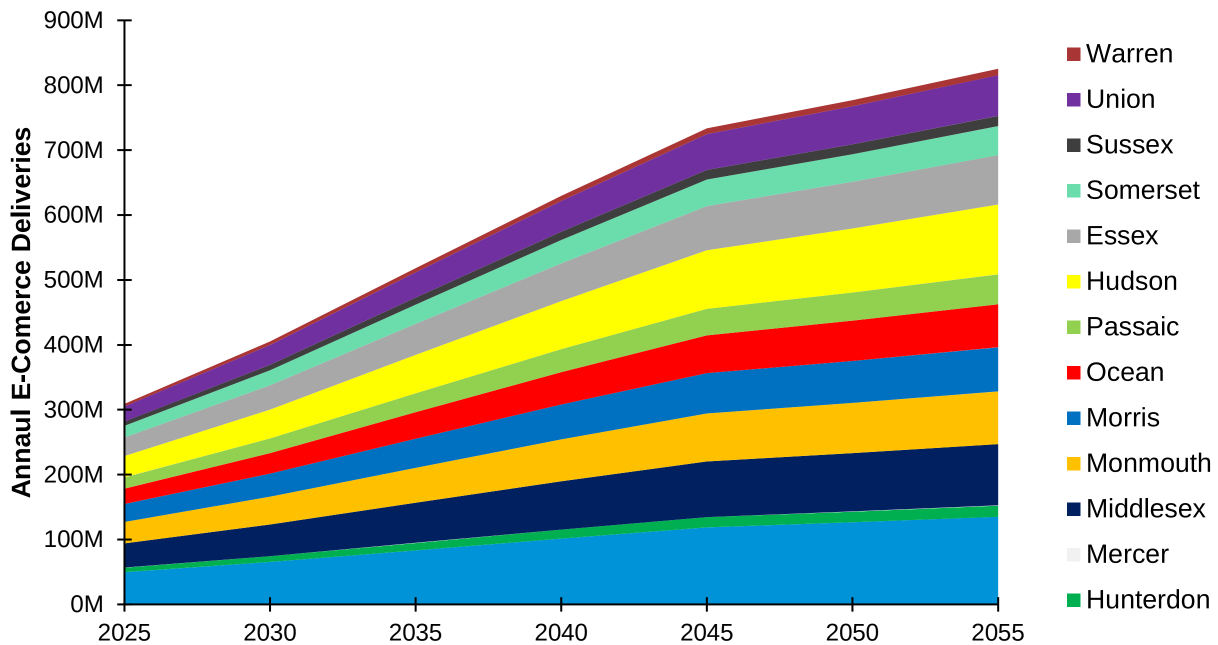
C.2.5 Forecasting Future E-Commerce Demand

Using the final regression model, package deliveries for the years 2023 through 2055 were predicted. The production of model inputs for future years was complex and designed to incorporate the NJTPA estimates of growth and demographic change. Population estimates for each year were produced by multiplying the NJTPA's county-level expected population growth figures times the ZIP code level estimates sourced from the ACS. Initial household figures were also sourced from the ACS; by dividing the ACS population estimate by the ACS households estimate in each ZIP code, the 2023 individuals per household was derived. The NJTPA publishes estimates of future individuals per household in all its counties, and the respective growth rates of these estimates were used to grow the individuals per household statistics derived from the 2023 ACS. Using these estimates of 2023-2055 population counts and individuals per household, 2023-2055 households were also found. Median household income was left constant across the interval and corresponds to the weighted average of the ACS figures in their respective census tracts. Also, e-commerce market penetration estimates (seen above) sourced from Cheng Solutions were used, scaled to the interpolated 2023 e-commerce saturation level.

Predictor variables were centered based on 2023 mean values to ensure consistency in application of the regression model. Using the regression model described previously, the centered populations, households, median household incomes, and median ages were used to produce estimated package counts. These estimated counts were then multiplied by the scaled market penetration estimates corresponding to year (i.e., for 13 percent expansion in 2025 over 2023 levels, multiplied by 1.13).

Forecasts were aggregated to county-level geographies, with specific segmentation for Newark and Jersey City within Essex and Hudson counties, respectively. Figure 36 shows the predicted number of e-commerce packages delivered in each NJTPA subregion through 2055.

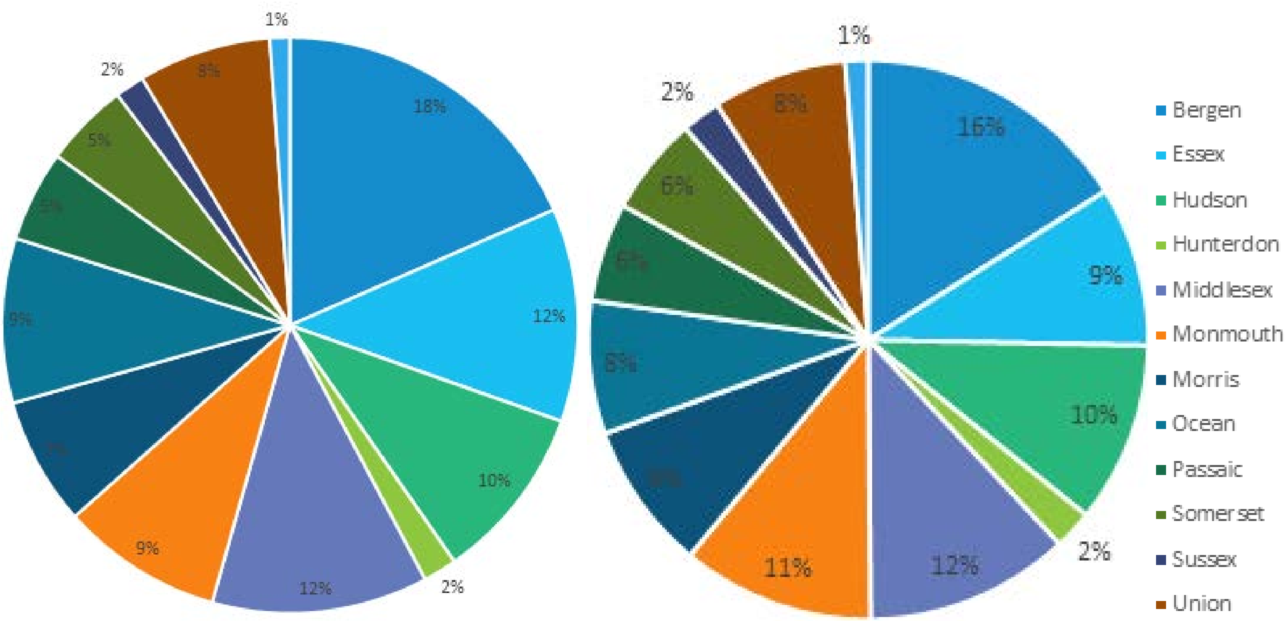
Figure 36 Forecasted Package Count by Subregion in the NJTPA Region



Source: NJTPA Direct-to-Consumer Forecast Model

Figure 37 shows a comparison of the projected package counts for 2023, as estimated in the Nielsen IQ data deliverable, with the model-derived estimate of packages for the same year. This demonstrates how closely the model aligns with observed data for the base year.

Figure 37 Nielsen IQ-Estimated Packages (Left) Compared to CS-Modeled Package Counts (Right) by County, 2023

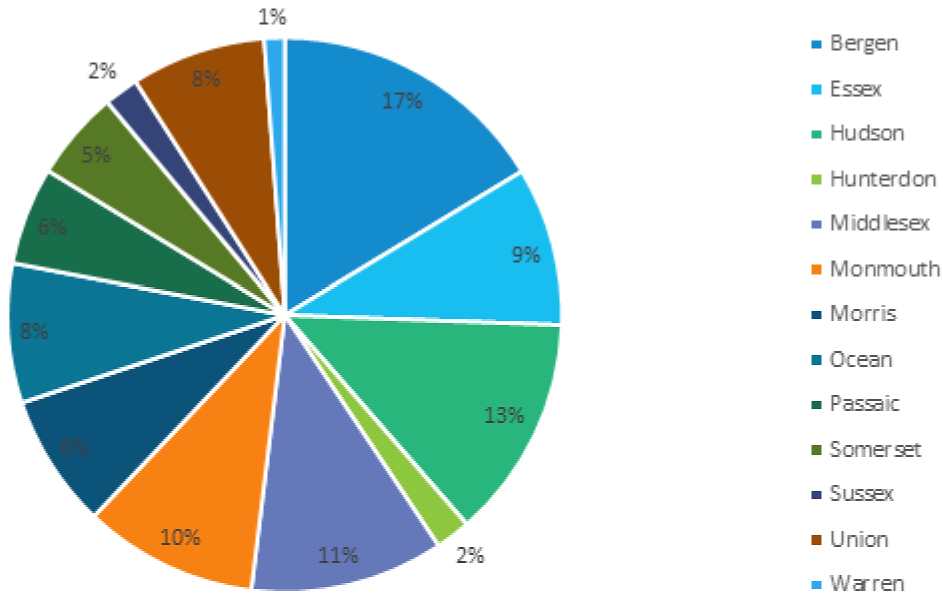


Source: NJTPA Direct-to-Consumer Forecast Model

For model validation, it is clear that the model's high R^2 results in accurate predictions of county share in delivery. The counties in which share of regional deliveries is predicted least accurately are Essex County, Bergen County, Monmouth County, and Morris County.

Figure 38 shows the model's forecast of package counts by county in 2055. Bergen County is expected to remain the leading county for deliveries and to grow in its regional share. Essex County is expected to shrink from 12 percent of the NJTPA region's deliveries to nine percent; however, since the model underestimates Essex County's deliveries in 2023, the model may be missing some information that explains why Essex County receives more packages than expected. Hudson County is expected to increase its share by 30 percent, the highest relative increase.

Figure 38 Forecasted Package Count by County in the NJTPA Region, 2055



Source: NJTPA Direct-to-Consumer Forecast Model

Appendix D. Business Establishment Data Technical Memorandum

D.1 Business Location and Attributes Data Sources and Analysis Methods

BJH Advisors (BJH) was tasked with pulling industrial real estate data from CoStar to inform the 2050 Freight Industry Level Forecast Update Study.[11] The CoStar properties database includes a comprehensive inventory of industrial buildings and their key features, including location, facility type, rentable building area in square feet (SF), and various other attributes. With the CoStar data, BJH engaged in a data classification task to identify the physical addresses, types of assets, and associated commodity bundles for properties related to freight activity and commodity flows.

This memorandum describes the progression of methods that BJH deployed to identify this information for industrial properties in New Jersey.

D.1.1 Method One: Secondary Type Assignment

After compiling CoStar data for industrial properties larger than 5,000 SF for 13 New Jersey counties, BJH began assigning commodity bundles to property listings based on the "secondary type" assigned by CoStar. Listings classified as the following "secondary types" were assigned to the corresponding commodity bundle:

- **Distribution**: Durable Consumer Products and Direct-to-Consumer
- **Refrigeration/Cold Storage:** Food and Non-Durable Consumer Products
- **Food Processing:** Agriculture, Meat, and Fish

BJH proceeded with the data classification as a process of elimination, such that in subsequent approaches, the listings that fell under one of these "secondary types" were not reconsidered under different methodologies.

D.1.2 Method Two: NAICS Commodity Assignment

Next, BJH assigned the remaining listings a North American Industry Classification System (NAICS) code by matching the addresses and ZIP codes of the remaining listings with

[11] CoStar is a proprietary database with the most comprehensive set of real estate listings in the US. CoStar also offers analytics services and data-driven real estate news.

those listed in the Lightcast Business Table.[12] In some cases, there were multiple Lightcast businesses with the same address, in which case BJH chose the NAICS code that was most closely aligned with a commodity bundle or skipped to Method Five: Google Search Assignment (searching the listing manually).

D.1.3 Method Three: Property Name Search Assignment

Next, BJH searched for key words in the Property Name column (column C – see Table 23) that were indicative of specific commodity bundles. These key words were directly informed by the Standard Classification of Transported Goods (SCTG) Commodity Groups list.[13]

D.1.4 Method Four: Mergent Intellect Assignment

Next, BJH assigned remaining listings to a commodity bundle based on the company description found on Mergent Intellect.[14] In many cases, Mergent Intellect produced a primary and secondary commodity assignment based on the presence of multiple businesses at the same address. BJH included both commodity assignments, matching them to the addresses of listings in the database. The final assignment prioritizes the primary Mergent Intellect assignment, then the Google assignment, and then the secondary Mergent Intellect assignment in cases where the first two assignments did not yield the same results.

D.1.5 Method Five: Google Search Assignment

For the final step, BJH manually searched property addresses on Google and in CoStar to determine the closest commodity bundle match. To identify commodity bundles for listings across a broad range of rentable built areas (RBAs), BJH was intentional about searching for properties of different sizes but ensured that all buildings over 100,000 square feet were classified with an assignment. Additionally, BJH noted the business name where possible to identify major distribution centers.

[12] Lightcast is a labor market analytics company that holds comprehensive information on jobs and businesses. Lightcast gathers data from publicly available information on the web, third-party resume databases and job boards, sales and marketing databases, and consumer/identity databases.

[13] SCTG Commodity Groups are used by the U.S. Census Bureau to classify commodities by shipment characteristics. SCTG Commodity Groups are designed to be comparable with NAICS codes, typically aligning at the two-digit level.

[14] Mergent Intellect is a web-based database with information on businesses, industries, and individuals. This includes data on both private and public companies, demographic reports, and industry news. Mergent Intellect primarily sources its business data from Dun & Bradstreet.

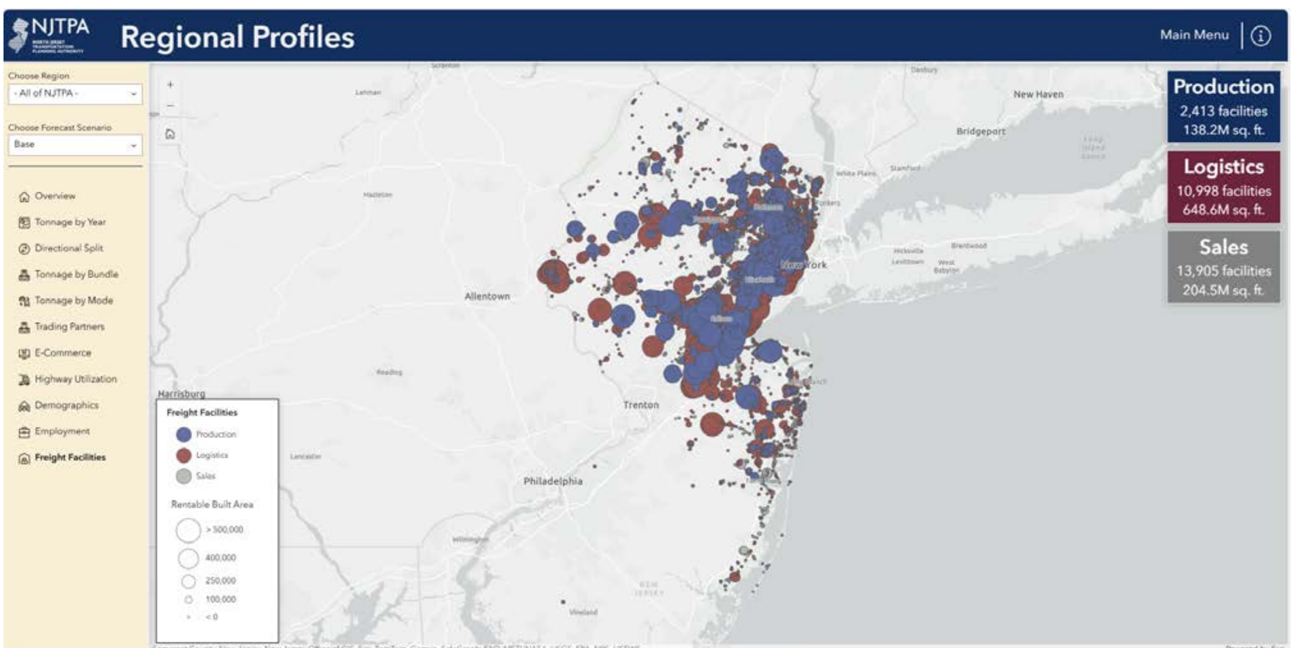
D.1.6 Result

Ultimately, a database of business establishments associated with each commodity bundle was developed. The establishments are categorized by the following three facility types:

- **Production**, including manufacturing, agricultural, mining, or other facilities where goods are produced. There are 2,413 production facilities with a combined total of 138.2 million square feet of floor space in the NJTPA region;
- **Logistics**, including warehouses, distribution centers, fulfillment centers, and other facilities where goods are handled at intermediate points along the supply chain. There are 10,998 logistics facilities with a combined total of 648.6 million square feet of floor space in the NJTPA region; and
- **Sales**, which includes retail stores, institutional buildings, and other locations where goods are delivered for use or sale to consumers. There are 13,905 sales facilities with a combined total of 204.5 million square feet of floor space in the NJTPA region.

The business establishments have been mapped and are included in the data dashboard described in Section 6.0 of this report. A screenshot of this module within the dashboard environment is below in Figure 39.

Figure 39 Business Establishments by Facility Type and Size (Square Feet) in the NJTPA Region



D.2 Truck Trip Estimation

In addition to the location and identification of these facilities, an estimated truck trip generation was given for each facility, where applicable. Truck trip generation factors were sourced primarily from the ITE Truck Trip Generation Manual with additional context for e-commerce facilities provided by Dan D. Disario, an expert in the field of warehousing. To acknowledge potential ranges in truck generation by facility type and size, low and high estimates were given to show a range of possible trip generation values. Even in the cases where low and high values do not differ, ***it is important to remember that these values are solely an estimate, and have not been validated using field research or other methods.***

Medium e-commerce facilities may generate more trucks than larger facilities as they have a greater number of smaller trucks compared to a smaller number of larger trucks at the biggest e-commerce facilities. The biggest e-commerce facilities break down bulk shipments and begin to deliver parcels to either individual houses/neighborhoods or even smaller facilities.

Truck trip generation rates were applied to the facilities using the following steps:

1. Identify e-commerce facilities associated with Amazon, FedEx, USPS, or UPS.

2. Using Google Maps satellite imagery, classify the e-commerce facilities as either a **small e-commerce facility** (less than 200,000 square feet), a **medium e-commerce facility** (less than 500,000 square feet), or a **large e-commerce facility** (greater than 500,000 square feet).

3. Identify all facilities in the *Agriculture, Meat, and Fish* commodity bundle and classify those facilities as **cold storage warehouses**.

4. Identify all facilities taller than 24 feet and with at least 500,000 square feet of floor area. Classify those as **high-cube facilities**. Assign truck trip generation based on square footage.

5. Classify the remaining facilities as **traditional warehouses**. Assign truck trip generation based on square footage.

6. For any traditional warehouses without floor area information, take an average floor area from the rest of the traditional warehouses in the NJTPA region.

Truck trip generation numbers associated with these facilities and floor areas are seen in Table 22.

Table 22 Truck Trip Estimates By Facility Type and Size

Facility Type	Square Footage (Thousands)	Low Truck Trip Estimate	High Truck Trip Estimate
Small E-Commerce Facility	0 – 50	0	15
	50 – 100	15	25
	100 – 150	25	35
	150 – 200	35	45
Medium E-Commerce Facility	200 – 250	150	200
	250 – 300	175	250
	300 – 350	200	300
	350 – 400	225	350
	400 – 450	250	400
	450 – 500	275	450
Large E-Commerce Facility	500 – 550	110	150
	550 – 600	125	175
	600 – 650	140	200
	650 – 700	145	225
	700 – 750	150	250
	> 750	155	275
High Cube Facility	500 – 550	88	110
	550 – 600	100	135
	600 – 650	112	150
	650 – 700	124	160
	700 – 750	136	170
	750 – 800	148	200
	800 – 850	160	225
	850 – 900	172	250
	900 – 950	184	275
	950 – 1,000	200	300
	1,000 – 1,100	210	325
	1,100 – 1,200	230	350
	> 1,200	250	375

Facility Type	Square Footage (Thousands)	Low Truck Trip Estimate	High Truck Trip Estimate
Cold-Storage Warehouse	0 - 50	0	37.5
	50 – 100	60	75
	100 - 150	90	112.5
	150 – 200	120	150
	200 – 250	150	187.5
	250 – 300	180	225
	300 – 350	210	262.5
	350 – 400	240	300
	400 – 450	270	337.5
	450 – 500	300	375
	500 – 550	330	412.5
	550 – 600	360	450
	600 – 650	390	487.5
	650 – 700	420	525
	700 – 750	450	562.5
	750 – 800	480	600
	800 – 850	510	637.5
	850 – 900	540	675
	900 – 950	570	712.5
	950 – 1,000	600	750
	1,000 – 1,100	660	825
	1,100 – 1,200	720	900
	1,200 – 1,300	780	975
	1,300 – 1,400	840	1,050
	> 1,400	900	1,125

Facility Type	Square Footage (Thousands)	Low Truck Trip Estimate	High Truck Trip Estimate
Traditional Warehouse	0 - 50	0	30
	50 – 100	30	60
	100 - 150	60	90
	150 – 200	90	120
	200 – 250	120	150
	250 – 300	150	180
	300 – 350	180	210
	350 – 400	210	240
	400 – 450	240	270
	450 – 500	270	300
	500 – 550	300	330
	550 – 600	330	360
	600 – 650	360	390
	650 – 700	390	420
	700 – 750	420	450
	750 – 800	450	480
	800 – 850	480	510
	850 – 900	510	540
	900 – 950	540	570
	950 – 1,000	570	600
	> 1,000	600	630

Source: ITE Trip Generation Manual with advice from Dan D. Disario.

D.3 Business Location Database Data Dictionary

Table 23 is a data dictionary for the final business location geodatabase. The file is in a .gdb folder, which is a geodatabase, a type of spatial file that is accessible through programs such as ArcGIS Pro, QGIS, R, or other GIS-enabled programs.

Table 23 Data Dictionary

Column	Field Name	Data Type	Description	Example
A	Property ID	Mix	Unique number that identifies a building in the CoStar database	Bergen-17
B	Property Address	Mix	Address for individual CoStar listings, may contain multiple businesses	20 Honeck St.
C	Property Name	Text	Building name generated by CoStar or by BJH manual search	Accurate Precision Fasteners

Column	Field Name	Data Type	Description	Example
D	Submarket Cluster	Text	Group of geographically close submarkets sharing characteristics (property types, tenant demographics, & market dynamics), designated by CoStar	Central Bergen
E	Submarket Name	Text	Smaller, more specific area within a larger real estate market, designated by CoStar	Englewood / Edgewater
F	City	Text	City in which the Costar listing is located	Englewood
G	State	Text	State in which the Costar listing is located	NJ
H	Zip	Mix	Zip+4 code (longer/more precise) in which the Costar listing is located	07631-4134
I	Zip (five-digit)	Integer	Zip code (shortened version) in which the Costar listing is located	07631
J	County Name	Text	County in which the Costar listing is located	Bergen
K	Secondary Type	Text	More specific categorization of CoStar commercial properties, additional detail about building use beyond the primary property type	Manufacturing
L	Tenancy	Text	Designation of property as having a single tenant or multiple tenants, designated by CoStar	Single/Multi
M	Percent Leased	Integer	Percentage of the property's RBA leased to tenants, as reported by CoStar	100
N	RBA	Integer	Rentable built area of the CoStar listing (square feet)	21000
O	Total Available Space	Integer	Entire area of the CoStar listing currently being marketed for lease (square feet)	8135
P	Year Built	Integer	Year the building was constructed, as reported by CoStar. Listed as "0" if unavailable	1965
Q	Year Renovated	Integer	Year the building was renovated, as reported by CoStar. Listed as "0" if N/A or unavailable	2013
R	Ceiling Ht	Mix	Ceiling height of the CoStar property. Listed as "0" if unavailable	14'0"
S	Number of Loading Docks	Integer	Number of loading docks present at the CoStar listing	1
T	Drive Ins	Mix	Dimensions or number of drive ins (grade-level entrances for trucks to drive in) present at the CoStar listing	1/8'0"w x 14'0"h Or 2
U	Power	Mix	Power capacity of CoStar listing	1600a/270-480v 3p
V	Rail Lines	Integer	Presence of rail lines on the CoStar listing	0
W	Sewer	Mix	Source or presence of sewer system for the CoStar listing	City/Yes/0
X	Final Commodity Assignment	Text	Assignment of the CoStar listing to a commodity bundle based on BJH data classification methods	Aggregates

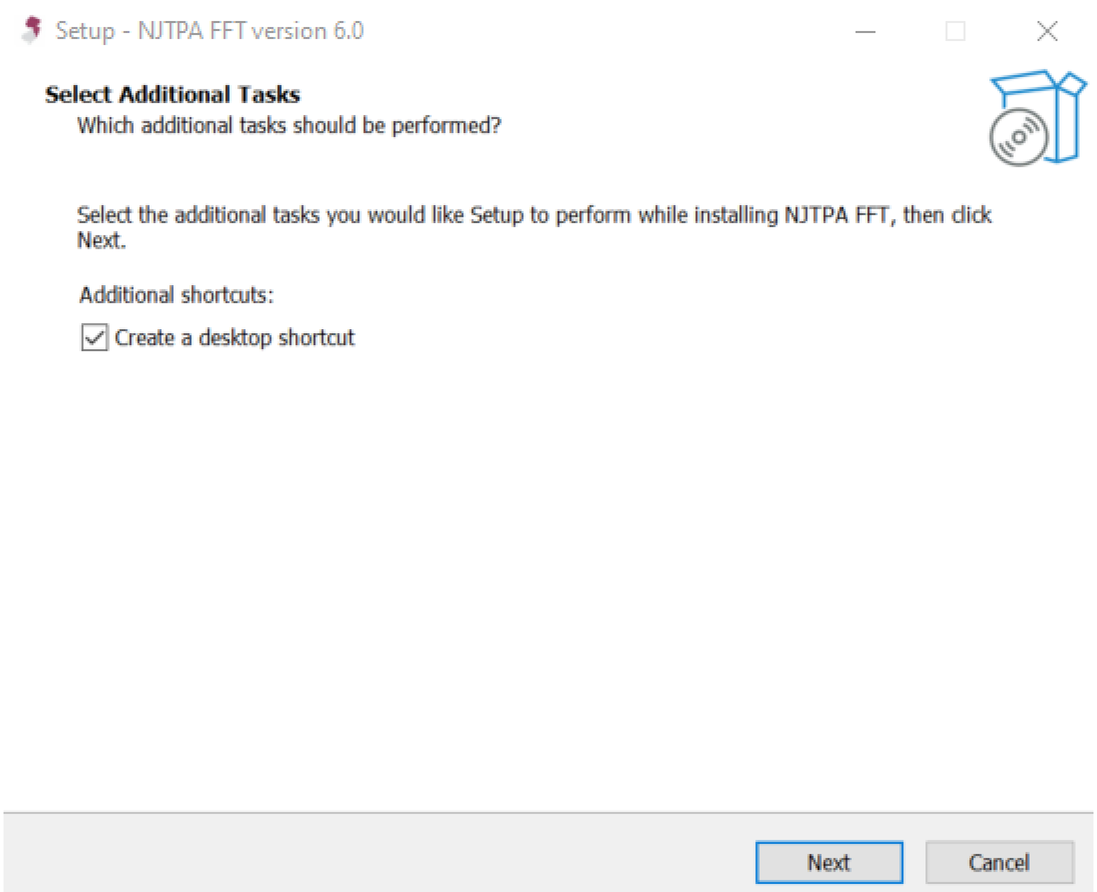
Column	Field Name	Data Type	Description	Example
Y	Non-Commodity Tenant	Text	Description of tenant for CoStar listings that are deemed a non-commodity property	Korean BBQ Restaurant

Appendix E. Updated FFT User Guide

This User Guide is intended to guide and support the 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:

E.1 Installing and Opening the Tool

Previous version of the tool required the user to install R and RStudio to be able to run the tool on their desktop. This process is outlined below in Sections E.1.1 - E.1.3 as it can still be helpful for non-windows users. Alternatively, the app can be installed as traditional desktop software using the “nj_fft_setup.exe” file. When opened a standard Window’s installation wizard will walk through the few steps required for installing the tool. The installation will create a start menu shortcut and desktop icon that can be used to launch the tool. All of the source code – including the default output folder are installed without any access restriction to the folder the User chooses from the Installation Wizard.



E.1.1 Step One: R and RStudio

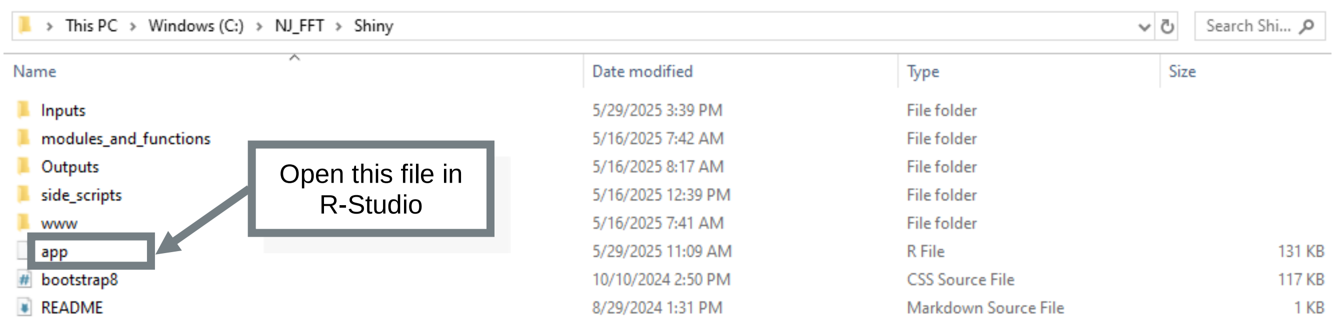
The user must install two open-source software applications – R and RStudio. R is the basic application and RStudio is a suite of interface tools. The model User Interface is written in RShiny, which is one of the interface tools. As open-source software, the applications are cost-free and general use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

E.1.2 Step Two: 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.



E.1.3 Step Three: Installing RStudio Packages

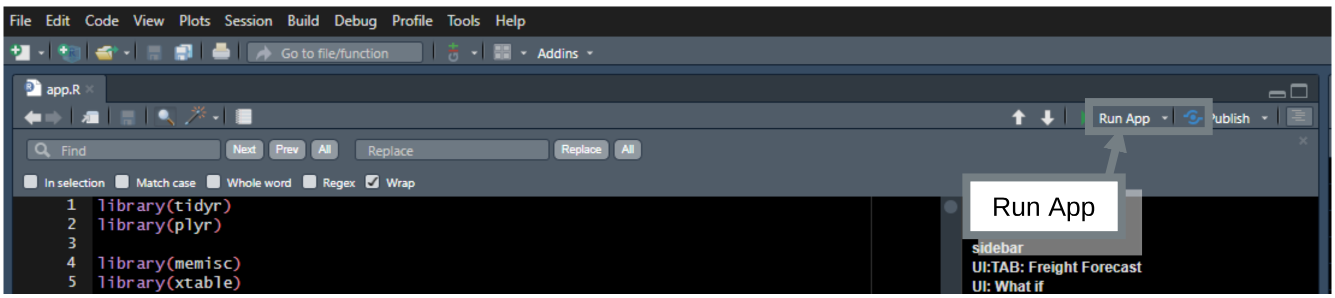
To complete the initial installation, the User will click and launch the "app" file. This initiates the process to download the various RStudio packaged applications required by the FFT.

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

E.2 Launching the FFT

To launch the FFT, the User simply navigates to the NJ FFT desktop icon or start menu item. Alternatively, the user can run the run.bat file that is installed in the software directory. Launching the app will open a Windows terminal and the app in a browser window. The window terminal will record the underlying outputs of the tool and can be helpful to troubleshoot errors with file uploads. In order to close the app simply close the browser window. The window terminal window will wait for a key press from the user to close.

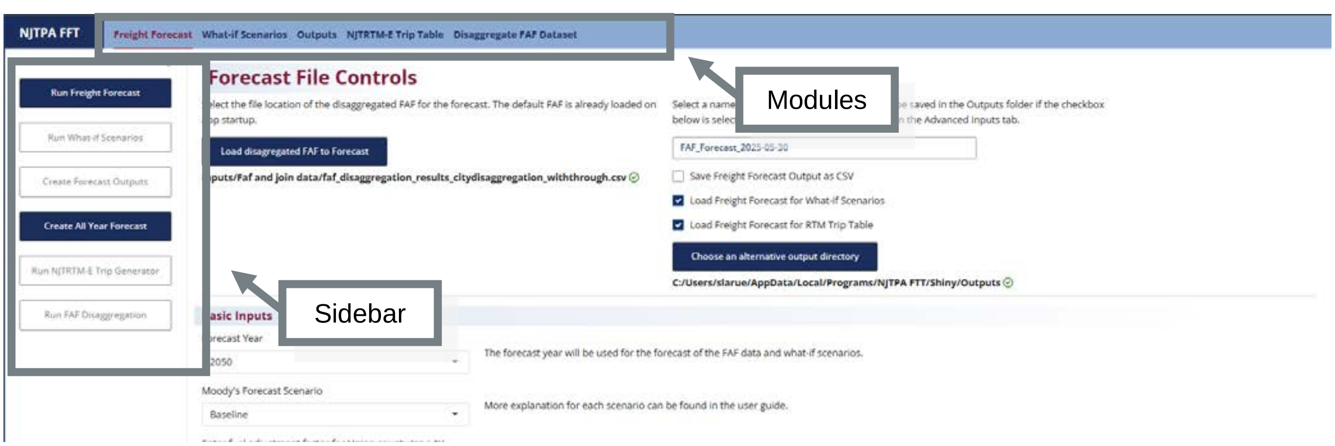
If the User has installed R and R Studio instead, they will need to launch R Studio and open the “app.R” file. In the upper right of the visible window is a button marked “Run App”. The User can click this button to launch the app, which will appear as a separate window on top of RStudio. If part of the User Interface is cut off due to the configuration of your desktop, try reducing the zoom percentage of your browser.



E.3 Tour of FFT User Interface

E.3.1 Home Page

By default the FFT opens on the Freight Forecast module. Each module is a tab across the top-bar of the page and can be navigated to simply by clicking. Along the left-hand side of the page is the sidebar which can be closed using the grey arrow in the top right corner.



E.3.2 Sidebar

The sidebar contains a series of buttons. Each button runs a particular module. If a button is deactivated or greyed out that means an input needs to be set for the module before it can be ran. This can often be resolved by navigating to the particular module and ensuring a file has been selected for the input, see below for more information. The tool loads in a default disaggregated FAF on start up, so the run forecast and run all years forecast modules are enabled by default.

E.3.3 Suggested Workflow

It is helpful as a new user to understand the general approach to the FFT in order to have a picture of how the different modules fit into one another. Compared to previous versions of the FFT this version aims to partition what was once a multi-step process into individual modules. The file inputs, options, and other settings for each module can be found in the appropriate tab in the navigation bar at the top of the tool page. The tool also allows users to feed outputs of one module into the next. For instance, it's possible to run each of the four modules in the figure below in order, starting with a new FAF file from FHWA in the proper format which can be disaggregated using the "Disaggregate FAF Dataset" module. The outputs of that module can be loaded into the "Freight Forecast" module to run the model that estimates future commodity flows using Moody's Data. After running the forecast the user could then use the "What-If Scenarios" module to apply specific freight scenarios to the forecast, and the result of that What-if analysis can be loaded into the "NJRTM-E Trip Table" module to estimate truck trips between TAZs based on the results.

Detailed descriptions of each module and how to use them are provided in Section E.4.

E.4 FFT Modules

The FFT has five key modules that perform different functions. The user may use one or a combination of several modules in order to develop and process a freight forecast. The modules include:

1. Freight Forecast Module;
2. What-If Scenarios Module;
3. Outputs Module;

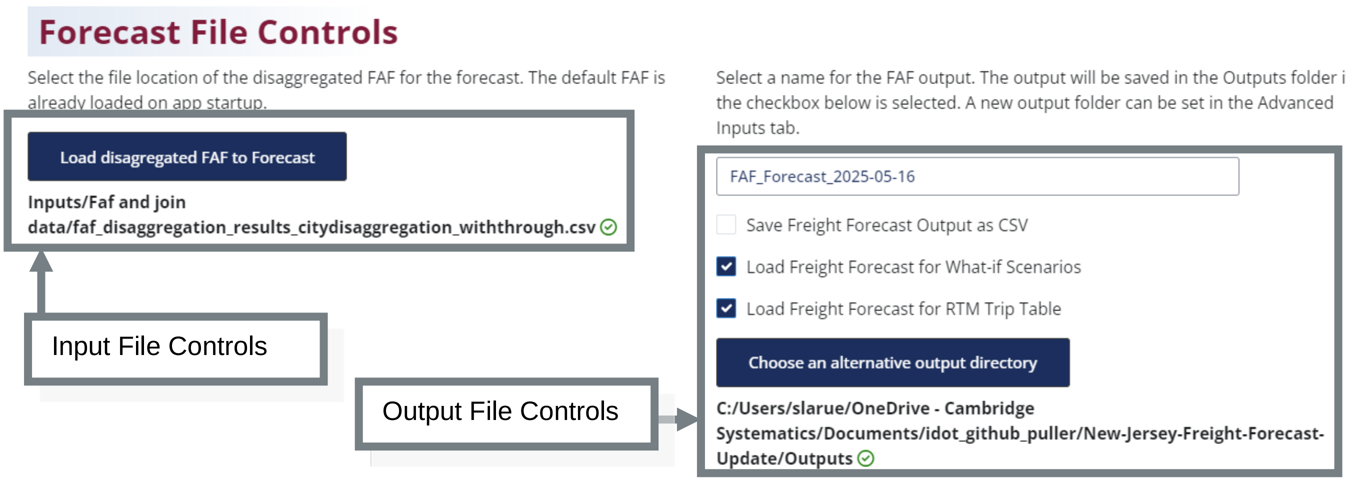
4. NJRTM-E Trip Table Module; and

5. FAF Disaggregation Module.

An overview of the contents and instructions on how to use each module are provided in the remainder of Section E.4.

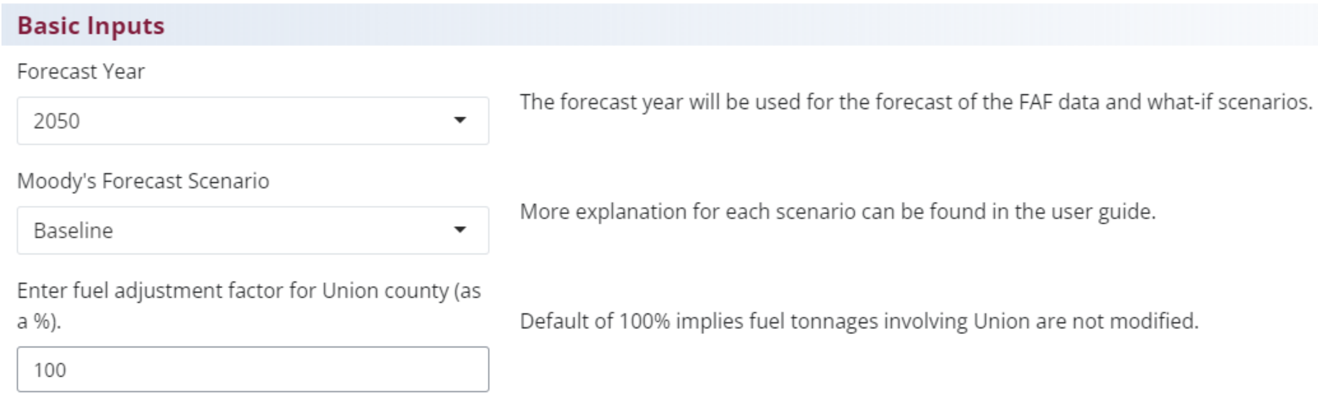
E.4.1 Freight Forecast Module

The Freight Forecast Module is the main purpose of the FFT. After launching the FFT, the user can run the forecast module immediately using the default disaggregated FAF 5.6. Note that all user inputs are reset to the default values each time the FFT is launched.

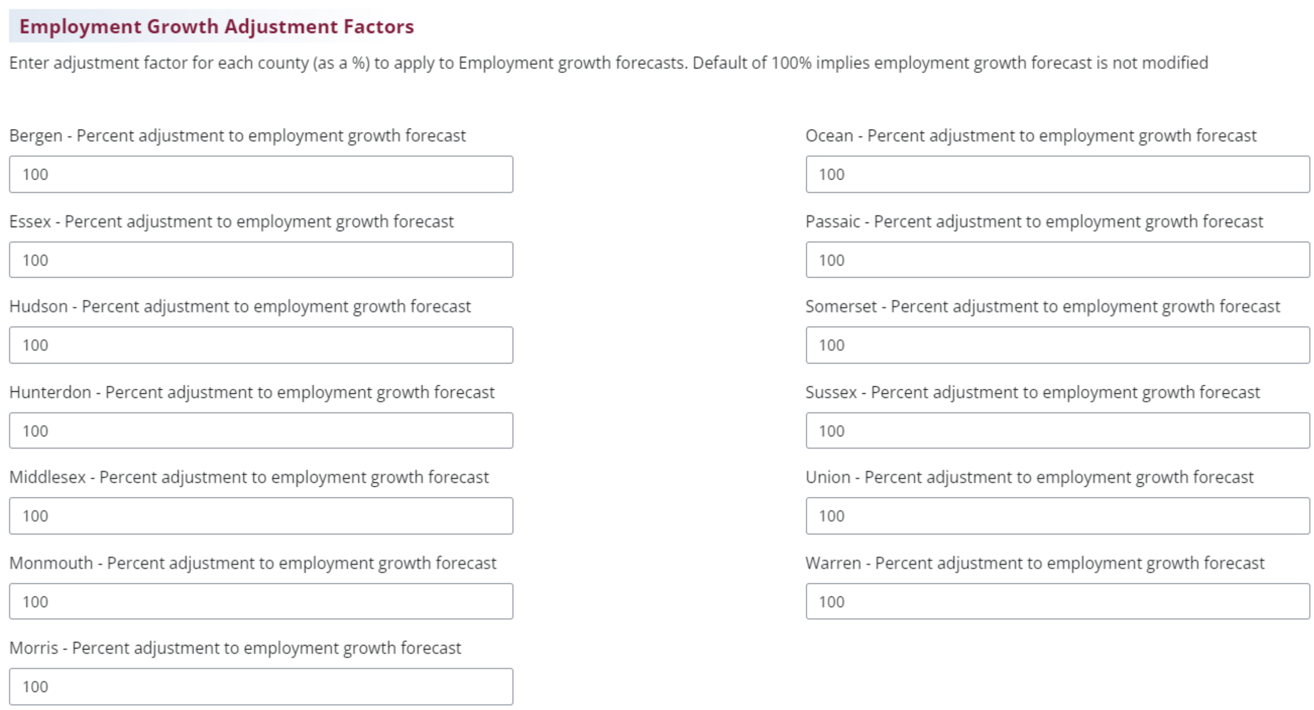


- **Forecast File Controls.** These features control how the inputs and outputs for the module are handled. On the left the user can press the “Load disaggregated FAF to Forecast” button to change which disaggregated FAF file the FFT will apply the forecast methodology on. The current selection’s file path is shown below. On the right the user can select a name for the output file in the text box and an output directory using the blue button. Additionally, three checkboxes control how the results of the module will be used:
  - **Save Freight Forecast Output as CSV** will save the output with the name and directory the user selects.
  - **Load Freight Forecasts for What-If Scenarios** will load the forecast results into the What-If module
  - **Load Freight Forecasts for RTM Trip Table Generator** will load the forecast results into the RTM Trip Table Generator module.

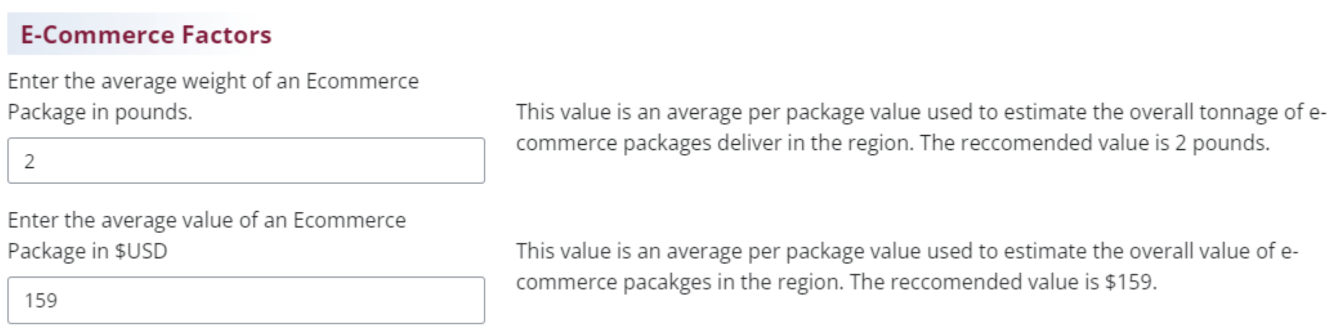
- Note that loading a file into a module in the tool does not save the results. The User must select "Save Freight Forecast Output as CSV" to save the results to a local directory of their choosing.



- **Basic Inputs.** These inputs are part of the module's inputs and alter the results.
  - **Forecast Year**. The default year is 2050, but alternative years (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.) The tool assumes a base year of 2025 for forecasting purposes.
  - **Moody's Forecast Scenario**. Moody's provided a "Baseline" forecast scenario which is used as the FFT default, along with five 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:
    - » 4^{th} percentile (Low Scenario)
    - » 10^{th} percentile
    - » 75^{th} percentile
    - » 90^{th} percentile
    - » 96^{th} percentile (High Scenario)
  - **Fuel Adjustment Factor for Union County**. Cambridge Systematics believes 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.

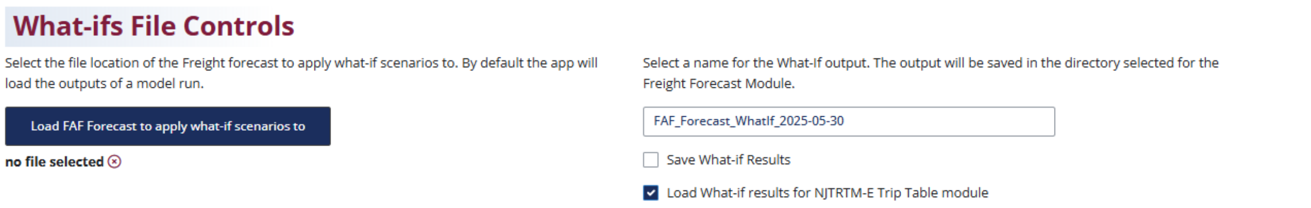


- **Employment Adjustment Factors by County.** These inputs allow the User to modify the Moody's employment growth forecast for each NJTPA county upward or downward. The default value is 100; the effects of faster or slower growth in one or more selected counties can be tested by entering higher or lower percentages.

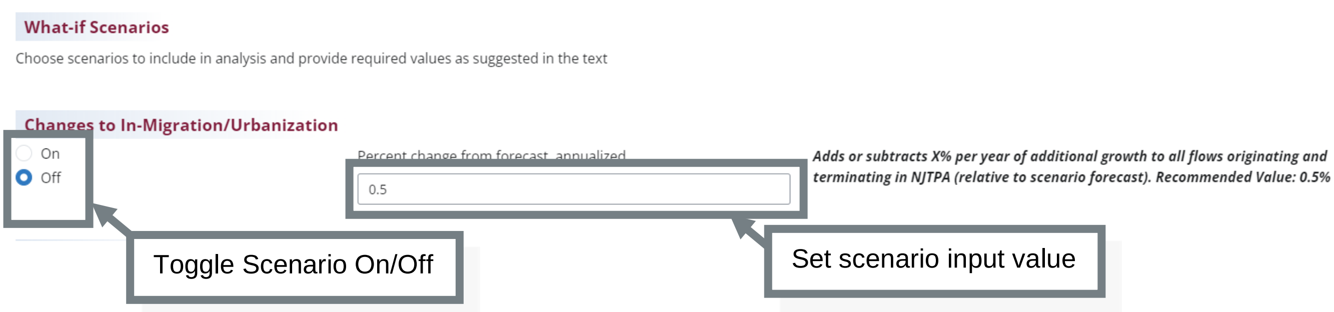


- **E-Commerce Factors.** These inputs adjust the average weight in pounds and value in USD that the tool assumes for each e-commerce parcel.

E.4.2 What-If Scenarios Module



The What-If module includes file controls similar to the Freight Forecast module with input controls on the left and output controls on the right. The What-If module uses the same output directory as the Freight Forecast module, but the name from the input textbox on the right. In the screen-capture above the User has selected to load the results of the Freight Forecast module which the file path indicate. The user can choose to upload a Forecast FAF file that was previously outputted from this tool. Similar to the previous module the results of the What-If module can be saved and/or loaded into the NJRTM-E Trip Table module.



A diverse range of "What-If" scenarios representing foreseeable trends or events were developed by the consultant team in collaboration with the NJTPA and its study partners. These scenarios are treated by FFT as modifiers to the forecast results. Some scenarios involve a high degree of generalized adjustment; others are limited to certain modes, commodities, 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 What-If scenarios, as the calculations are sequential. To activate a scenario select the On option and determine the value that should be used. A description of the scenario and how the value is applied are noted on the left.

The What-If Scenarios screen provides the following options:

- **Changes to In-Migration/Urbanization.** This adjustment accelerates the growth of NJTPA originating and terminating freight tonnage.

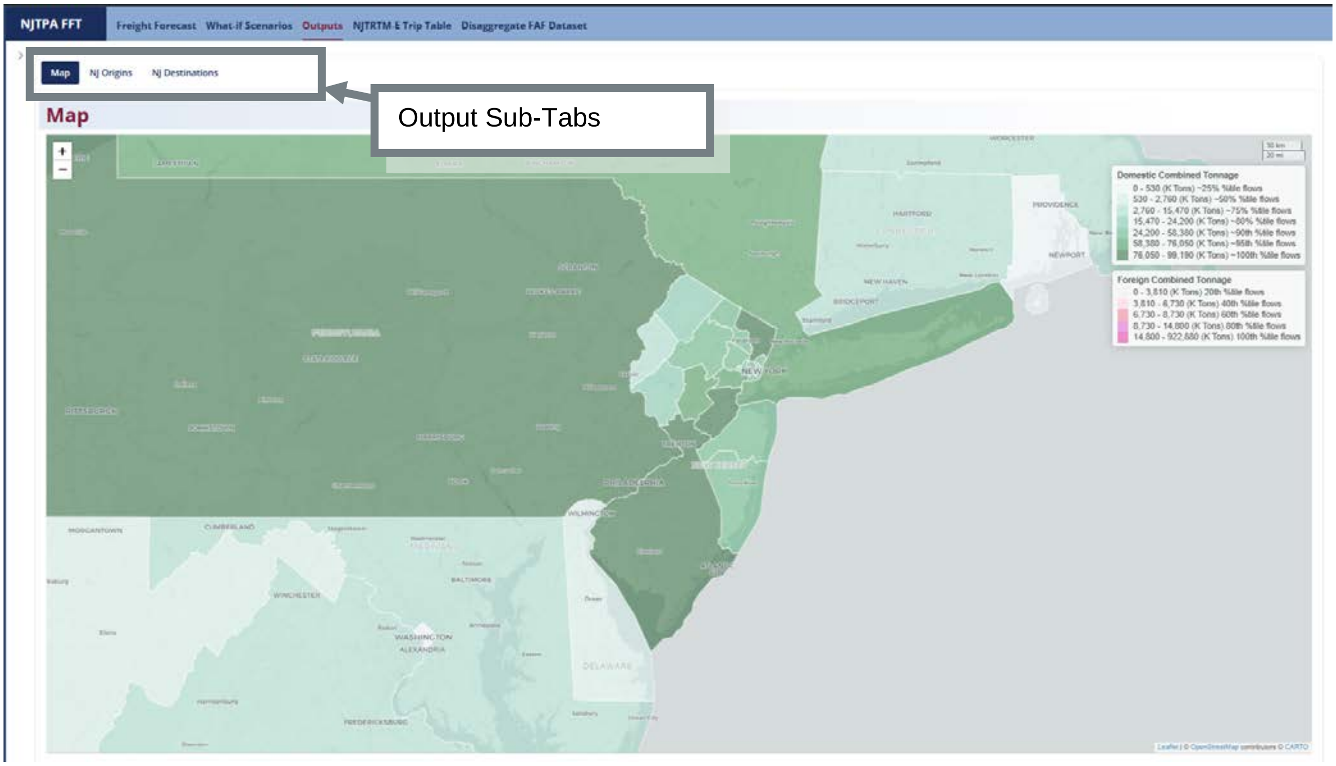
- **Increase Out-Migration**. This adjustment slows the growth of NJTPA originating and terminating freight tonnage.
- **Increased NJ Self-Sufficiency**. This adjustment increases the share of NJ consumption that is served by NJ production, compared to non-NJ production.
- **Limits to Pace of Globalization**. 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.
- **Mode Share (all freight), 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 (foreign flows only), 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.
- **Fluctuation in Fossil Fuel Commodities.** This adjustment has two options. The first option allows the user to select a year when fossil fuel commodities will zero e.g. a net-zero goal year. Option Two adjusts the fossil fuel commodities by a set percent negative or positive each year between the base year (2025) and the selected forecast year.
- **Increase in Advanced Domestic Manufacturing**. This adjustment increases the shipment tonnage and value of advanced manufacturing materials like microchips,

batteries, and electric vehicle inputs by a specified percentage per year for all flows originating and terminating in the NJTPA region relative to base forecast.

- **Change in Natural Gas Production.** This adjustment increases or decreases the amount of natural gas moving through the NJTPA region by that percentage per year relative to base forecast.
- **Northeast New Jersey Growth.** This adjustment increase the tonnage and value of flows originating and terminating in Hudson, Bergen, Union, Middlesex, Essex County and Newark and Jersey City is increased by the chosen percentage each year, relative to base forecast.
- **Investment in Marine Highways.** This adjustment shifts the mode for truck and rail shipments originating or terminating in coastal states from Virginia to Massachusetts into the water mode.
- **Port Growth.** This adjustment increases the existing hinterland flows and shifts land bridge Los Angeles/Long Beach port flows directly to NY/NJ port.
- **Manual Increase in Agriculture.** This adjustment increases the amount of agricultural commodities moving through the NJTPA region.

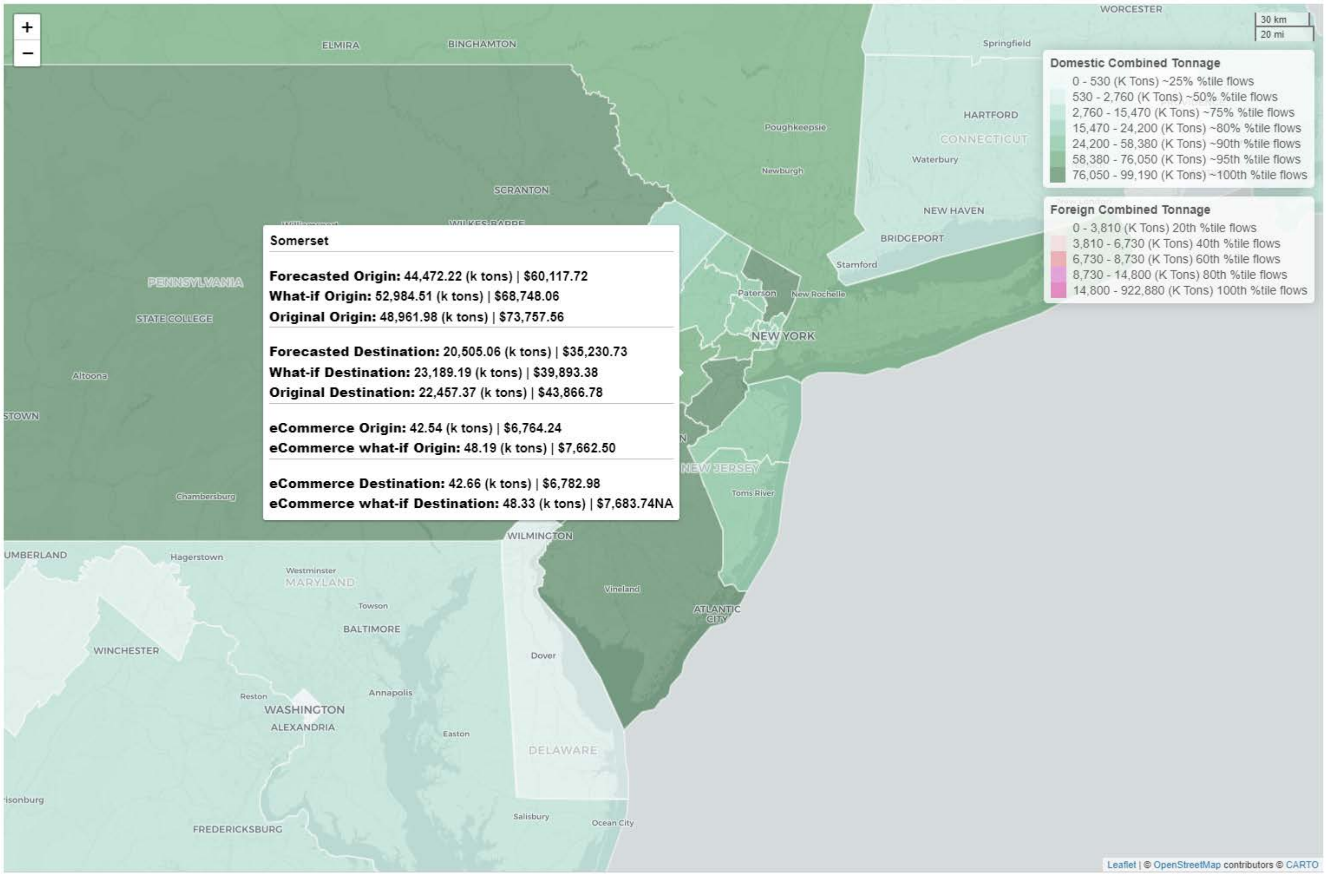
E.4.3 Outputs Module

The Outputs Module takes in no inputs and is disabled until the “Create Forecast Outputs” button is pushed. To enable “Create Forecast Outputs” in the sidebar either the “Freight Forecast” or “What-If Scenarios” module need to have finished – whichever module finished last will appear in the Outputs Module after pressing the button. Note that the outputs module loads on click and may not appear immediately when the tab is selected. If the small red loading bar along the top of the tool is visible then it is busy and still loading the results. Additionally, the Output module has three subtab selections for the User. The subtabs will also not necessarily load all content immediately on click and may need a moment to load. If the tabs are not loading or the load bar is not displaying trying toggling the tabs back and forth. The memory usage for this module can cause issues with loading depending on computer.

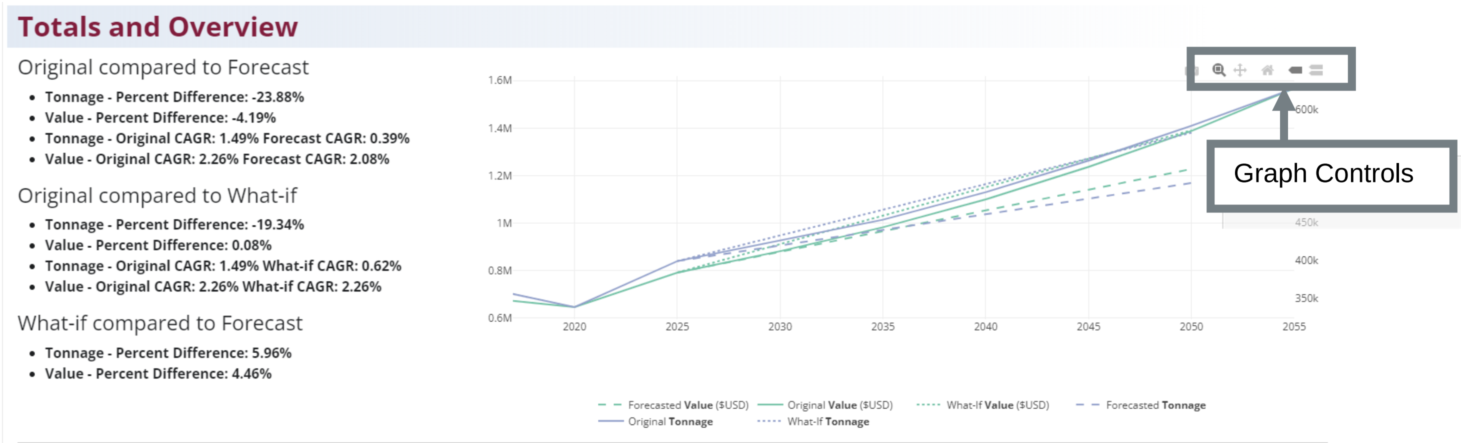


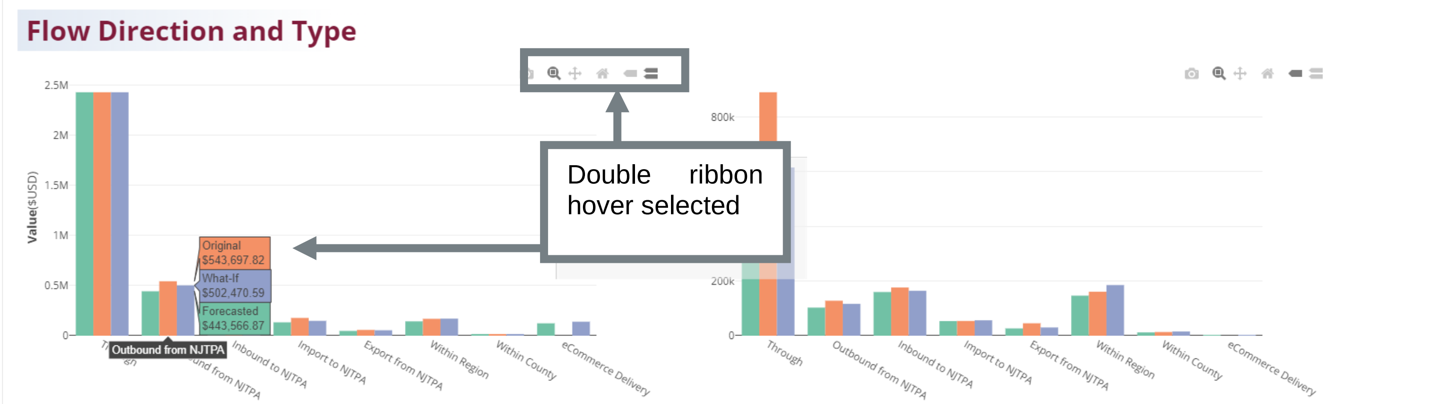
Map Tab

This tab includes an interactive map and several charts that give an overview of the results by overall tonnage, flow direction, commodities, and mode. The map legend displays all NJTPA subregions, US states, and international trade zones by combined tonnage (i.e., it is a combination of inbound and outbound flows for the region displayed). International and domestic flows have been separated by color. When hovering over a region on the map a more detailed description of the region's commodity flow composition is displayed.

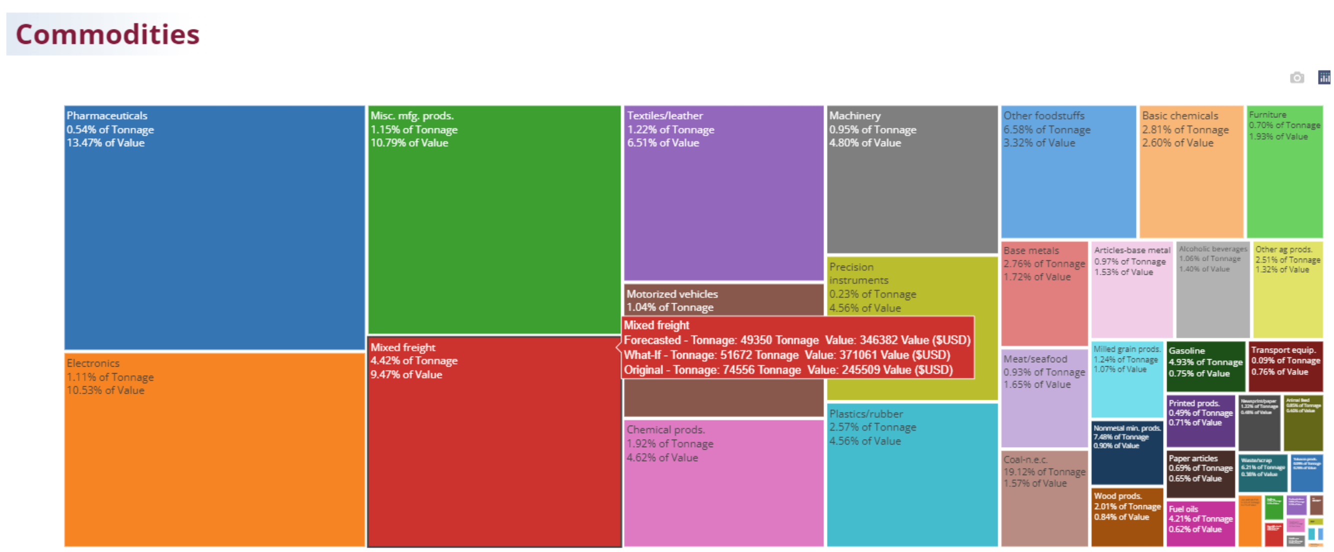


Every chart is interactive in the Outputs module. Axes can be moved around and hover information will provide exact numbers for the information displayed. Additionally the camera icon on the right corner of the graphs will download a PNG file of the graph's current extents. The home button in the same area over the graph will return the graph to its original extents. The single and double ribbon buttons will change how many hover labels are displayed at once allowing you to see multiple at once. Note that the Totals and Overview line graph includes original tonnage and values for all years including 2017 and 2020, otherwise forecast information starts in 2025 (base year) and ends on the forecast year the User selected.

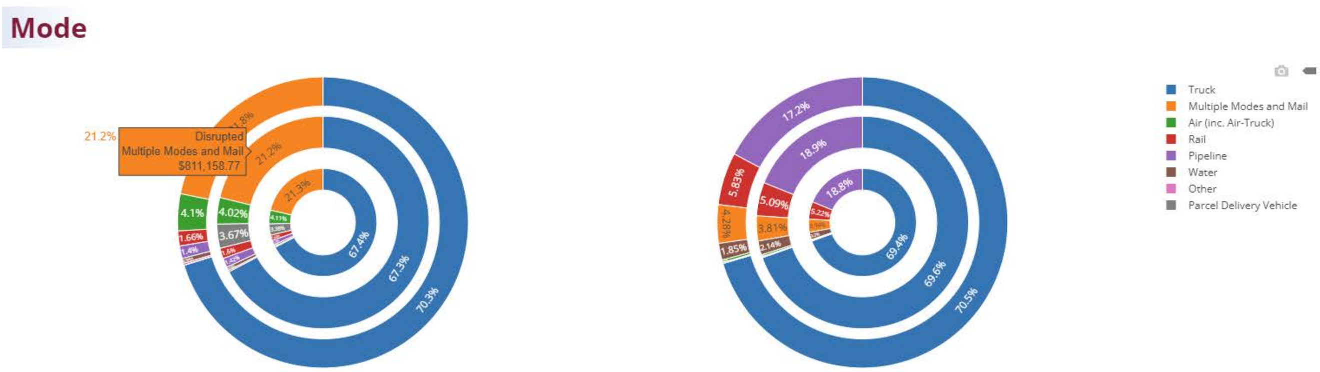




The commodities tile graph displays all commodities by the overall size of the forecast values relative to all other commodities. It can be difficult to read the smallest commodities but the hover text is the same size for each tile. A tile can also be zoomed in on by clicking.

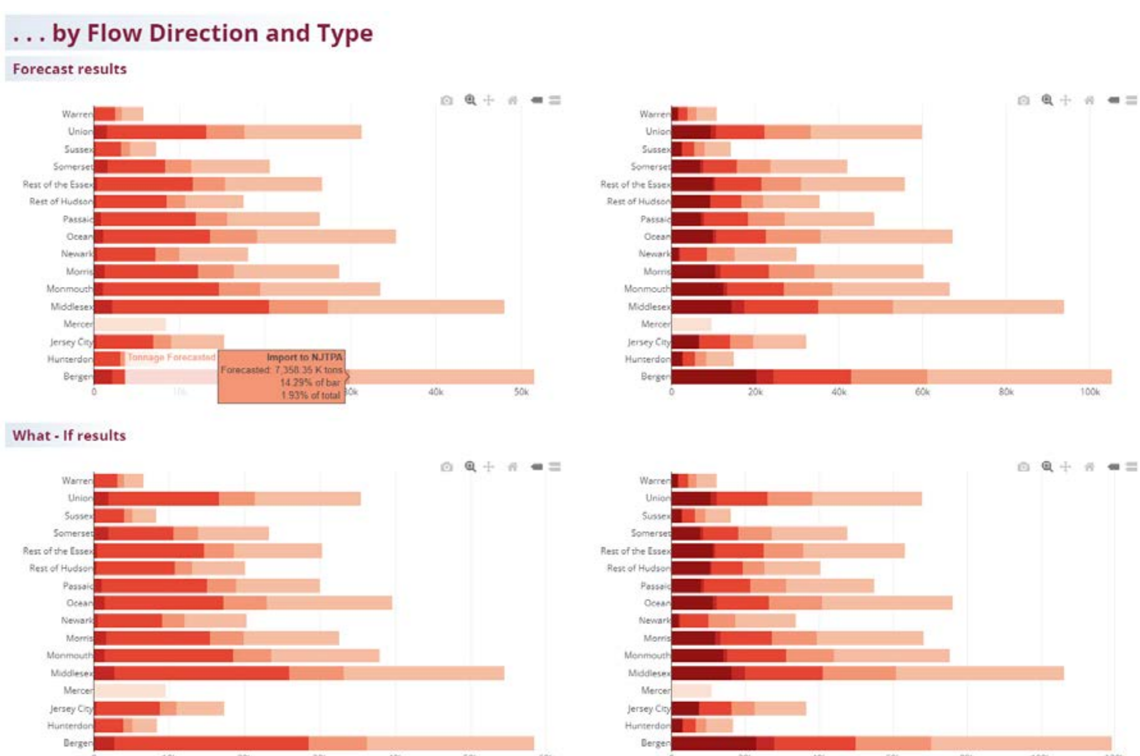


The mode donut graphs compare the percentage of commodity flows moved by each mode in the FAF by value and tonnage. The three concentric pie graphs show the original, What-If, and forecasted percentages allowing the user to compare differences across the predicted future tonnages. Note that if the user did not run a What-If analysis then the What-If and forecasted metrics will be identical.



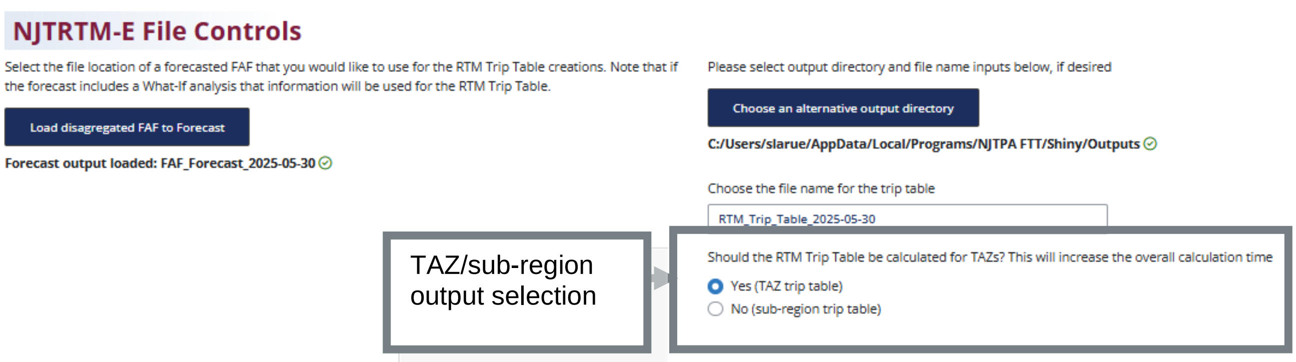
The NJ Origins and NJ Destinations tabs

These tabs use the same graphs for the same major information in the Maps tab but cross-walked with either NJTPA Origin flows (commodity flows that began in New Jersey) or NJTPA Destination Flows (commodity flows that ended in New Jersey) respectively. Each tab has three sections “Flow Direction and Type”, “Mode”, and “NJRTM-E Commodity Bundles”.

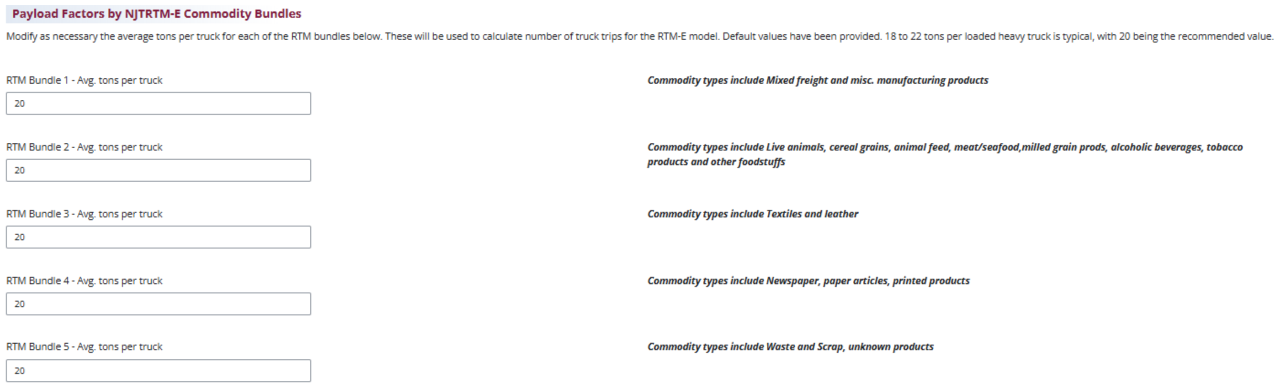


E.4.4 NJRTM-E Trip Table Module

Similar to the previous modules at the top of the module page are file controls that allow the user to control which file to use for the RTM-Trip Table generator. Note that by default the RTM-trip table are generated based on What-If Scenario module outputs. When saving What-If Scenario results the outputs include both Freight Forecast and What-If Scenario but only the latter will be used to calculate the truck trip tables. In order to see truck trip table results for a Freight Forecast the user simply needs to load the results of that module to the NJRTM-E Trip Table module directly either through a file they have saved or the tool options. The outputs side of the file control also includes an option to either create results at the TAZ or sub-region level. The sub-region level includes all NJTPA counties as well as Essex and Newark. The TAZ level takes significantly more time to complete – at least an hour if not more. The results of the NJRTM-E module are automatically saved to the output directory using the file name selected.

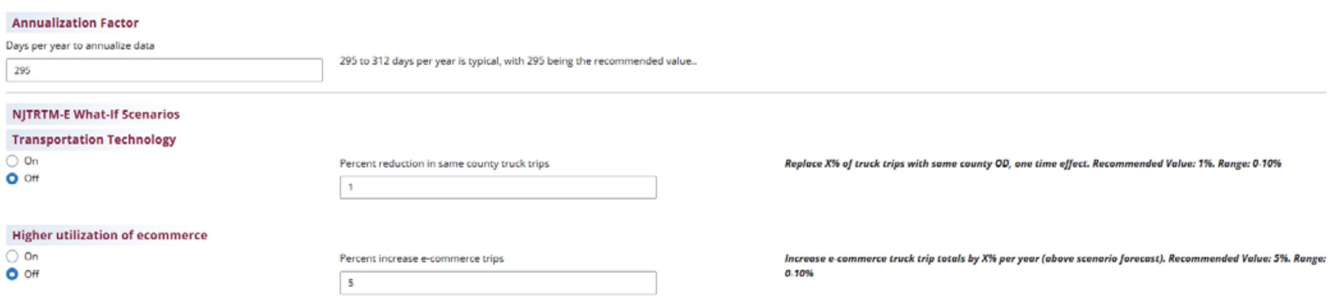


Below the file controls the User can modify the payload factors (tons per truck) used to convert the FFT tonnage forecast into RTM-E loaded truck trips. The default value is 20, with most commodity groups falling between 18 and 22, although certain commodities may be up to 25 tons and others significantly lower. Note that e-commerce truck trips are estimated directly rather than being driven by the tonnage forecast and will be coded with Bundle One with an additional flag to allow users to separate them from the rest of that bundle.



There is one additional input for the module: **the Annualization Factor.** 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. Finally, the NJRTM-E module includes two What-If scenarios that will adjust the values of the outputs. Due to the size of the truck trip tables the results of the scenarios are not reported separately. If the user turns on the What-If adjustments they are automatically applied. The two What-If scenarios included are:

- **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".
- **Higher Utilization of E-Commerce**. This adjustment increases the number of e-commerce truck trips by a specified percent per year.



E.4.5 FAF Disaggregation Module

The FAF disaggregation module contains very few inputs. On the left-hand side, the "Load FAF to Disaggregate" button allows the user to select the new FAF file to disaggregate. The FFT will confirm that the selection is appropriate and alert the user if something is mis formatted in the input. On the left, the user can control the name and file location of the resulting disaggregated FAF. The module will disaggregate the FAF for the NJTPA sub-regional zones as well as an estimation of through flows.

The Disaggregation Module assumes that FAF data structures, coding schemes for commodities, modes, and geographic zones will remain unchanged. If changes to those aspects of the data are different in future versions, some pre-processing of the FAF data (or re-coding of the module) would be necessary in order to use the FAF Disaggregation Module in the FFT.