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Development of the Freight Analysis Framework Version 5 (FAF5) Annual Estimates

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Title

Development of the Freight Analysis Framework Version 5 (FAF5) Annual Estimates

Performing Organizations

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Abstract

This technical report describes the development of the U.S. Department of Transportation's Bureau of Transportation Statistics (BTS) Freight Analysis Framework version 5 (FAF5) annual estimates. FAF is a dataset of U.S. commodity flow estimates that provides a comprehensive national picture of freight movements among states and major metropolitan areas by all commodity types and freight transportation modes. Estimates include domestic and foreign flows. BTS releases a new FAF benchmark every 5 years. To provide more timely estimates, BTS develops annual estimates and preliminary annual estimates for intervening years. This report documents the data sources, methods, assumptions, and benchmarking used to develop these estimates.

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1. Introduction

This technical document describes the data sources and methodology used to develop the Freight Analysis Framework version 5 (FAF5) annual estimates. This section provides a brief background on the annual estimates' data products and describes the organization of the rest of this report.

1.1. BACKGROUND

The U.S. Department of Transportation's Bureau of Transportation Statistics (BTS) develops the Freight Analysis Framework (FAF), a dataset of U.S. commodity flow estimates. FAF meets the requirements of Title 49 U.S. Code § 6303(c)(1), which directs BTS to produce "information on the volumes and patterns of movement of goods, including local, interregional, and international movement, by all modes of transportation, intermodal combinations, and relevant classification."

FAF provides a comprehensive national picture of freight movements among states and major metropolitan areas by all freight transportation modes. The benchmark year (or base year) for FAF5 is 2017. The benchmark year for FAF6 will be 2022. FAF5 provides estimates of commodity flows by origin, destination, commodity type, and mode (ODCM) [BTS, FHWA 2017]. FAF describes commodity types using two-digit Standard Classification of Transported Goods (SCTG) codes [BTS, Census 2017], which are designed to characterize goods by their importance to demand for transportation. Each SCTG category is an aggregation of 6-digit Harmonized System codes used in trade data [Census 2024c].

In addition to the benchmark year releases, BTS develops annual estimates of commodity flows to provide the freight data community with more timely information. For FAF5, the annual estimates began with year 2018. Annual reports follow a consistent format, enabling relatively quick development compared to the effort required for the benchmark versions. Releases of preliminary annual estimates began in 2023. BTS releases preliminary annual estimates soon after the end of each calendar year but before all the data needed to produce the final annual estimates are available. BTS publishes details about each FAF5 release online [BTS 2024a and BTS 2024b].

Annual estimates cover both domestic and foreign flows. For the domestic portion, most estimates are based on activity indicators for each commodity, comparing growth in volume to the benchmark year. The methodology utilizes inputs from a wide range of sectors (e.g., agriculture, manufacturing, utility, construction, and energy). In addition, the U.S. Census Bureau provides data on U.S. foreign trade volumes.

The FAF5 forecast development also generated estimates of annual commodity flows for the near term [Bingham et al. 2022]. Annual estimates for each year have replaced these near-term forecasts as soon as the annual estimates are released.

Additional references for FAF5 include the *Freight Analysis Framework Version 5 (FAF5) Base Year 2017 Data Development Technical Report* [Hwang et al. 2021] and the FAF5 user's guide [ORNL 2021]. These references provide information on the development of the benchmark database. BTS [2024b] summarizes the version naming convention used to identify the various base year and annual products.

1.2. ORGANIZATION OF THE REPORT

Chapter 1 provides an overview of the FAF program and background on the FAF5 annual estimates. Chapters 2 and 3 discuss domestic trade flows, summarizing the data sources and how the data are used to prepare the annual estimates, respectively. Chapter 4 describes the data and methodology used to estimate the foreign trade flows.

Throughout this report, commodity type descriptions use two-digit SCTG codes [BTS, Census 2017]. Appendix A has a complete list of SCTG codes. Appendix B summarizes the countries in each FAF zone.

2. Domestic Flows: Data Sources

To maintain consistency and allow comparability across interations and to streamline production from year to year, BTS uses the same data sources for each annual update when possible. When this approach is not possible, BTS uses inputs that are similar to the unavailable inputs. From these data sources, BTS collects the information needed to estimate growth factors or the magnitude and direction of changes from the benchmark year.

2.1. DATA SELECTION CRITERIA

BTS considers many sources of information for use in the annual estimation process. Given that the emphasis of the dataset is transportation, the most preferred data contain *weight shipped*. If *weight shipped* is not available but *weight produced* is, then BTS uses *weight produced* to represent the growth trend for associated commodities. When no weight-based measures are available, monetary *value shipped* is preferred.

BTS also prefers sources of information with geographic granularity that provides state-level or lower data. Otherwise, BTS uses national-level data.

2.2. DATA SOURCES

The following list provides summaries of the data sources used to determine annual estimates:

1. **Agricultural statistics from the National Agricultural Statistics Service (NASS)**—The U.S. Department of Agriculture (USDA) NASS conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture [USDA n.d.]. NASS statistics on food production form the primary data source for estimating the growth in flows of agricultural commodities, including SCTGs 01–07 (Table 1).

Table 1. Agricultural Commodities in FAF

SCTG code	Commodity description
01	Animals and fish (live)
02	Cereal grains (includes seed)
03	Agricultural products (excludes animal feed, cereal grains, and forage products)
04	Animal feed, eggs, honey, and other products of animal origin
05	Meat, poultry, fish, seafood, and their preparations
06	Milled grain products and preparations, and bakery products
07	Other prepared foodstuffs, fats, and oils

2. **Fisheries data from the National Oceanic and Atmospheric Administration (NOAA)**—BTS uses NOAA data on fisheries' (live fish) shipment data as part of the estimation of growth in SCTG 01 goods [NOAA n.d.].
3. **Employment statistics from the Bureau of Labor Statistics (BLS)**—The BLS occupational employment statistics (OES) program produces state-level annual employment estimates for nearly 800 occupations [BLS 2023]. BTS uses these data as the primary source to estimate the growth trend for SCTGs 05 (meat, poultry, fish, seafood, and their preparations), 06 (milled grain products and preparations, and bakery products), 07 (other prepared foodstuffs, fats and oils), and 25 (logs and other wood in the rough) in each state. In addition, BTS adjusts the state employment-based estimation results to make them consistent with national production data.

4. **Commodity Flow Survey (CFS) by BTS and Census**—CFS is a quinquennial survey of shippers in manufacturers, wholesalers, and other industries [BTS 2024c]. BTS and Census provide the data in summary tables as well as in a shipment-level dataset called the Public-Use File (PUF) [BTS, Census 2020].
5. **Tax-related data collected by the Alcohol and Tobacco Tax and Trade Bureau (TTB)**—TTB collects taxes on alcohol, tobacco, firearms, and ammunition. BTS uses TTB as the primary data source for the estimation of SCTGs 08 (alcoholic beverages and denatured alcohol) [U.S. Department of the Treasury 2024a] and 09 (tobacco products) [U.S. Department of the Treasury 2024b]. BTS converts the tax data collected by TTB (e.g., tax revenues, taxable volumes) on products associated with these two commodities to tonnages, then uses this information to estimate overall growth from the base year at the national level.
6. **Mineral production published by the U.S. Geological Survey (USGS)**—USGS provides information on the worldwide supply, demand, and flow of minerals and materials. USGS provides production data for dimension stone, sand, gravel, and other minerals at the national and state levels [USGS 2023a]. BTS uses these data to measure trends for SCTGs 10 (monumental or building stone), 11 (natural sands), 12 (gravel and crushed stone except dolomite and slate), 13 (other non-metallic minerals), and 14 (metallic ores and concentrates). USGS provides additional information that the annual estimates' development uses [USGS 2023b].
7. **Energy data collected by the Energy Information Administration (EIA)**—EIA provides information on energy production, stocks, demand, imports, exports, and prices. EIA provides the primary data sources for coal and petroleum products including SCTGs 15 (coal), 16 (crude petroleum), 17 (gasoline, aviation turbine fuel, and ethanol, including kerosene, and fuel alcohols), 18 (fuel oils, including diesel, Bunker C, and biodiesel), and 19 (formerly other coal and petroleum products; currently natural gas [NG] and fossil products). BTS uses data on the production and movement of these goods from multiple EIA resources [EIA 2024a, EIA 2024b, and EIA 2024c].
8. **Forestry production published by the Food and Agriculture Organization (FAO)**—FAO provides annual production and trade statistics for forest products, primarily wood products such as roundwood, saw wood, wood panels, pulp, and paper [FAO 2024]. FAO provides the primary data source for commodity SCTGs 25 (logs and other wood in the rough), 26 (wood products), 27 (pulp, newsprint, paper, and paperboard), 28 (paper or paperboard articles pulp), and 29 (printed products).
9. **Population estimates from Census**—Census provides population estimates in years between the dicennial census [Census 2024e].
10. **Shipment values from the Annual Survey of Manufactures (ASM) (discontinued after 2021)**—Census conducted ASM annually through 2021 [Census 2024f]. The survey program provided sample estimates of employment, payroll, and the estimated value of shipments for all manufacturing establishments with one or more paid employees. The survey provided continuous measurements of change among manufacturing establishments over the years. BTS uses the estimated value of shipments by industry as the primary data source for estimating commodity growth (Table 2). Availability of similar data is expected for the 2022 Economic Census [Census 2024g], which is scheduled for full release in 2025, and in the forthcoming Annual Integrated Economic Survey [Census 2024a].

Table 2. Commodities Whose Growth Was Formerly Estimated Using ASM Data

SCTG code	Commodity description
20	Basic chemicals
21	Pharmaceutical products
22	Fertilizers
23	Other chemical products and preparations
33	Articles of base metal
34	Machinery
36	Motorized and other vehicles (includes parts)
37	Transportation equipment, not elsewhere classified
38	Precision instruments and apparatus
39	Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs
40	Miscellaneous manufactured products

11. **Shipment values from Manufactures' Shipments, Inventories, and Orders (M3)**—M3 provides monthly statistics on current economic conditions and indications of future production commitments in the manufacturing sector [Census n.d.]. Data include manufacturers' value of shipments, new orders (net of cancellations), and end-of-month order backlog (unfilled orders). The estimated value of shipments for different industries is the primary data source for the commodities listed in Table 3. Before Census discontinued ASM, growth from ASM and M3 data matched. The M3 data were available sooner than the ASM data for a given year, although ASM contains more detail. As a result, BTS used M3 to estimate growth prior to the ASM statistical release, and M3 use will continue now that ASM is discontinued. Previously, BTS supplanted estimates calculated from the M3 series once the ASM series became available.

Table 3. Commodities Whose Growth Is Estimated Using M3 Shipment Values

SCTG code	Commodity description
24	Plastics and rubber
30	Textiles, leather, and articles of textiles or leather
31	Non-metallic mineral products
32	Base metal in primary or semi-finished forms and finished basic shapes
35	Electronic and other electrical equipment and components, and office equipment
36	Motorized and other vehicles (includes parts)
37	Transportation equipment, not elsewhere classified
38	Precision instruments and apparatus
39	Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs

The primary data sources associated with each commodity are summarized in Table 4.

Table 4. Summary of Data Sources by Commodity

Commodity group	Data source
SCTGs 01–03	USDA
	NOAA
SCTG 04	USDA
SCTGs 05–07	BLS
	BLS
	USDA Economic Research Service
	USDA Economic Research Service
SCTGs 08 and 09	TTB Tax collection quarterly issues
	TTB distilled spirits/wine statistical report/tobacco statistical monthly issues
SCTG 10	USGS
SCTGs 11 and 12	USGS
SCTGs 13 and 14	USGS
SCTGs 15 and 16	EIA
SCTGs 16–18	EIA
SCTG 19	EIA non-NG related
	EIA NG related
SCTG 25	BLS
	FAO
SCTGs 26–29	FAO
SCTGs 20–24 and 30–40	ASM
	M3
SCTG 41	U.S. Census Bureau
SCTG 43 (mixed freight)	SCTG 43 is estimated based on other commodities (SCTGs 03–09, 23–24, 28–29, and 33–40). The source data of each of these commodities listed in this table are the source data for SCTG 43.

3. Domestic Flows: Estimation Methodology

This section describes the methods that generate the domestic flow estimates. It gives an overview of the approach and then provides more detail for various commodities.

3.1. OVERVIEW OF THE APPROACH

FAF categorizes freight flows using an ODCM system. In the context of freight transportation, “origin” is the starting point of a shipment, “destination” is where the shipment is going, “commodity type” describes the type of goods being transported, and “mode” is the method of transport used to move the goods.

While BTS prioritizes data sources that include ODCM, information on destination and mode is usually not available. Consequently, annual updates of FAF5 domestic flows are generally based on a combination of commodity type and origin (or the commodity-origin level). This section notes exceptions to this methodology.

For each commodity type, BTS estimates growth (whether positive, negative, or unchanged) between the base year and the annual estimate year, then uses the growth rates to estimate the domestic flows for the annual estimate year. The estimation process follows:

1. Gather source data (identified in Section 2.2) for each commodity type for the base year (2017) and target annual estimate year (e.g., 2018).
2. Compute the magnitude and direction of change by commodity and origin. BTS calculates these growth rates as the ratio of weights (tons) from the estimation year and base year for a commodity-origin pair. The growth by origin is estimated at the following geographic levels that depend on the input data resolution:
   A. National growth: A growth factor for the entire nation is estimated. In FAF5, BTS uses the national level to estimate growth for 27 commodities:
      SCTGs 04, 08, 09, 10, 13, 14, 20–24, 26–31, 32–40, and 43.
   B. State-level growth: A growth factor is estimated for each origin state. BTS computes growth at this level for 11 commodities:
      SCTGs 01, 02, 03, 05, 06, 07, 11, 12, 15, 16, and 25.
   C. FAF zone growth: A growth factor is estimated for each FAF zone. BTS computes growth at this level for four commodities:
      SCTGs 17, 18, 19, and 41.
3. Apply the resulting growth factors from list items 1 and 2 to the 2017 base year estimates, based on commodity type and geography, to obtain the total flow in each target year.

This approach leverages the usefulness of available information while balancing the need to generate the updated dataset in the same manner every year.

Table 5 categorizes commodities into eight groups. The annual estimates methodology and input data are similar (or the same) for the commodities in each group. The next subsections describe the processes for each group.

Table 5. Commodity Groups

Commodity group	SCTG codes
Agriculture Products, Fish, and Grains	SCTGs 01–07
Alcohol and Tobacco Products	SCTGs 08 and 09
Stones, Nonmetallic Minerals, and Metallic Ores	SCTGs 10–14
Coal and Petroleum Products	SCTGs 15–19
Logs and Wood Products	SCTGs 25–29
Waste and Scrap	SCTG 41
Mixed Freight	SCTG 43
Other Commodities	SCTGs 20–24 and 30–40

3.2. AGRICULTURE PRODUCTS, FISH, AND GRAINS (SCTGS 01–07)

BTS uses USDA production data as the primary source for estimating the growth in flows for commodity SCTGs 01–07. BTS also uses supplementary data sources, including fishery data from NOAA. Because these seven commodities have different characteristics and data sources, BTS divided them into three subgroups, each with a unique estimation approach: SCTGs 01–03 (agriculture products and fish), SCTG 04 (animal feeds and other products of animal origin), and SCTGs 05–07 (meat, poultry, fish, seafood, and grain products). The following subsections describe the three estimation methods. Each process generates a growth factor that BTS applies to all flows originating from the production location.

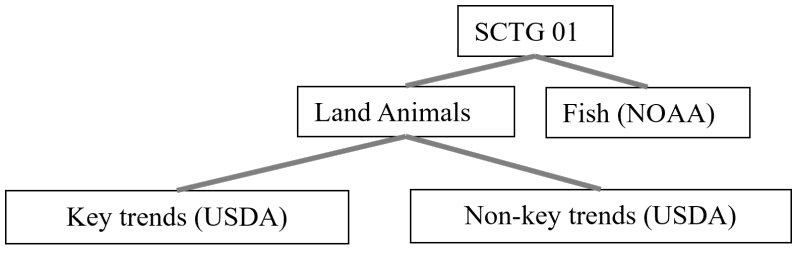
3.2.1. Agriculture Products and Fish (SCTGs 01–03)

Agriculture products and fish are represented by three 2-digit SCTG codes: 01, 02, and 03. The estimation process differs slightly for each. The following subsections outline each process.

3.2.1.1. Live Animals and Live Fish (SCTG 01)

For SCTG 01 goods, BTS uses NOAA data on fisheries' (live fish) shipment data and USDA data regarding land animals. Including data for all types of animals would be a lengthy process. Instead, BTS computes growth in farm-animal shipments using data for four major farm animals (cattle, hogs, young chickens, and young turkeys). USDA provides these data at the state level. BTS further splits land animal growth into key trends and non-key trends for each state. NOAA and USDA provide these data on an annual basis. Thus, the same estimation process can be applied each year. Figure 1 outlines the growth factor components for SCTG 01.

Figure 1. Growth Factor Components for SCTG 01



Source: BTS 2025.

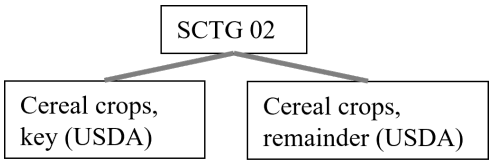
The following is a step-by-step discussion of the growth factor estimation process:

1. **Determine the land animals and fish shares in each state**—Using the base year FAF5 data for SCTG 01, BTS summarizes tonnages of live animals and live fish in each origin state. Using these tonnages, BTS then computes the shares of live animals and live fish by origin state. BTS assumes these shares are the same in the target year.
2. **Determine the key and non-key animals in each state**—If a given state produces substantial numbers of one (or more) of the four animals—cattle, hogs, young chickens, and young turkeys—then the animal is a key animal in that state. This assessment was made using the judgment of a subject-matter expert. Otherwise, the animal is a non-key animal in that state. The determination is based on 2017 production data. The following list summarizes the states where each animal is key:
   A. Cattle—Arizona, California, Colorado, Kansas, Michigan, Nebraska, Pennsylvania, Texas, Utah, Washington, and Wisconsin
   B. Hogs—California, Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, Ohio, Oklahoma, Pennsylvania, Tennessee, and Wisconsin
   C. Young chickens—Alabama, Arkansas, California, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, West Virginia, and Wisconsin
   D. Young turkeys—Arkansas, California, Indiana, Iowa, Minnesota, Missouri, North Carolina, Ohio, and Virginia
3. **Compute the growth factor for each origin state**—The growth of fish is calculated as the ratio of total fishery weight in the target year to the total weight in the base year. For land animals, the key trend is calculated as the production growth of all key animals in that state. The non-key trend equals the nationwide production growth of non-key animals. The growth of SCTG 01 is then computed as the weighted average growth using each series (fish, animal key trends, and animal non-key trends) relative to the base year of 2017.

3.2.1.2. Cereal Grains (SCTG 02)

SCTG 02 has two components that impact its growth: key cereal crops and non-key cereal crops (Figure 2). The non-key crop trend is used when there is otherwise missing information for a state in a year.

Figure 2**. Growth Factor Components for SCTG 02**



Source: BTS 2025.

BTS uses the following two steps to estimate growth of cereal grains:

1. **Determine the key and non-key products in each state**—BTS has selected seven products to represent cereal grains: barley, corn, oats, rice, rye, sorghum, and wheat. Similar to SCTG 01, if a state has large production volumes for one of these products, then BTS categorizes the product as key in that state. Otherwise, the products are classified as non-key products. For each state, BTS computes the key trend as the growth of key product volumes in that state. The non-key trend equals the nationwide growth of non-key product volumes.
2. **Obtain growth factor by state**—The share of key and non-key products in a state is determined based on combined weights of associated products in the base year. The shares are assumed to be the same in target years. The growth of SCTG 02 in a state will then equal the combined growth of the key and non-key series based on their corresponding shares.

3.2.1.3. Agricultural Products (SCTG 03)

BTS estimates flows of Agricultural products (SCTG 03) for the 2017 FAF benchmark using both CFS data and non-CFS sources. Likewise, BTS estimates the growth in SCTG 03 in two parts: CFS and non-CFS contributions. The non-CFS category is further split into key and non-key crop trends.

BTS uses the following process to estimate flows for SCTG 03:

1. **Compute CFS-based and non-CFS-based shares**—BTS subtracts the CFS-based tonnage from the base year estimates to determine the non-CFS tonnage. Using this result, BTS computes the shares of CFS-based flows and non-CFS-based flows. These shares are assumed to be the same in the target year.
2. **Compute CFS-based growth**—BTS estimates CFS-based growth with USDA data on national production of non-food crops, crops processed for food and non-food, and direct food crops. Production data from base year and target years for each of the three categories are used to compute the growth factor.
3. **Compute non-CFS-based growth**—BTS estimates non-CFS-based growth by combining key and non-key crop growth in that state based on their shares.The following products are non-CFS crops of SCTG 03: non-citrus, hazelnuts, flaxseed, mustard, rapeseed, hops, maple syrup, mint, spearmint, oil, tobacco, lentils, peas, mushrooms, citrus, vegetable, almonds, macadamias, pecans, pistachios, walnuts, canola, cotton, cottonseed, peanuts, safflower, sunflower, mint, soybeans, sugarbeets, sugarcane, taro, coffee, potatoes, sweet potatoes, beans, chickpeas, apples, onions, sweet corn, lettuce, avocados, bananas, papayas, apricots, blueberries, cherries, dates, figs, grapes, kiwifruit, mushrooms, nectarines, olives, peaches, pears, plums, prunes, raspberries, and strawberries.
   Like SCTG 01, the key and non-key distinction and shares of each are based on 2017 production volumes. Production growth is computed for key and non-key trends.
4. **Combine component growth to obtain total growth for SCTG 03**—BTS calculates total growth for SCTG 03 using growth in each series (non-CFS trend, and CFS trend) weighted by its relative share.

3.2.2. Animal Feed and Other Products of Animal Origin (SCTG 04)

BTS computes growth of SCTG 04 for a given year (*y*) as the change in the total weight of its individual components (indexed by *i*) relative to the base year as shown in Equation 1.

$$Growth_y = \frac{\sum Weight_{i,y}}{\sum Weight_{i,2017}} \quad (1)$$

Where:

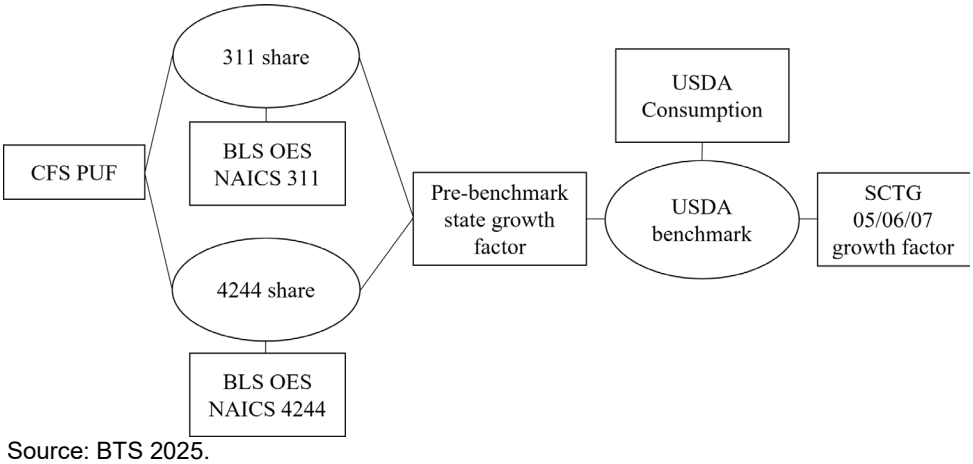
- $Growth_y$ = growth of an SCTG category for *y*
- $Weight_{i,y}$ = weight of *i* in *y*
- $Weight_{i,2017}$ = weight of *i* in 2017

Key components of SCTG 04 are alfalfa, cottonseed, flaxseed, fish meal, meat meal, wheat mill feeds, gluten feed and meal, canola meal, soybean, cake and meal, sunflower meal, eggs in the shell, mink pelts, wool, mohair, hone, and pet food. USDA NASS is the source of production data in the base and target years.

3.2.3. Meat, Poultry, Fish, Seafood, and Grains Products (SCTGs 05–07)

Employment in food shipping industries by state is the basis for estimating growth for SCTGs 05–07. BTS benchmarks these results to national production growth. The two industries associated with SCTGs 05, 06, 07 are North American Industry Classification System (NAICS) 311—Food Manufacturing and 4244—Grocery and Related Product Merchant Wholesalers. Figure 3 illustrates the growth factor estimation process.

Figure 3. SCTGs 05–07 Estimation Process



Source: BTS 2025.

The following is the estimation process for SCTGs 05–07:

1. **Determine relative proportion for industry NAICS 311 and 4244**—The shares for each industry (NAICS 311 and 4244) for each state are based on tons shipped for each state–industry combination in the 2017 CFS PUF [BTS, Census 2020]. Because of product similarity and overlap, BTS combines CFS PUF commodities 05, 06, and 07 in this process.
2. **Obtain pre-benchmarked growth factor by state**—BLS OES is the source of employment growth for the two industries. The shares from step 1 form the basis to combine the results to obtain total growth.
3. **Obtain national benchmark factor**—The national growth factor is obtained by combining growth of each component based on USDA production data. The components for each commodity are listed in Table 6. A single national benchmark factor is then calculated as the ratio of USDA-based production growth to the employment-based growth for the entire nation.

Table 6. Primary Source and Components That Represent the Overall Trend of the Selected Commodity

SCTG code	Components
05—Meat/seafood	Red meat, poultry, tallow, lard, fisheries and fishery products
06—Milled grain prods.	Wheat flour, rye flour, rice, milled basis, oats products, barley, corn
07—Other foodstuffs	Coffee, tea, cocoa, spices, all dairy products, total fats, canned fruit, frozen fruit, dried fruit, fruit juice, canned vegetables, frozen vegetables, dehydrated onions, dehydrated potatoes, potato chips, legumes, caloric sweeteners, peanuts, total tree nuts

4. **Obtain benchmarked growth factor by state**—The single national benchmark factor (from step 3) is applied to the pre-benchmarked growth factor by state (from step 2). The result is the benchmarked growth factor for each state.

3.3. ALCOHOL AND TOBACCO PRODUCTS (SCTGS 08 AND 09)

The growth of SCTGs 08 and 09 in a year is determined by the change in the total combined weight of the components (Table 7) from the total combined weight in the base year (Equation 1). The source data are tax revenues and taxable withdrawal volumes for selected components from the Alcohol and Tobacco TTB. Tax revenues and taxable withdrawal volumes are all are converted to tonnages to obtain weight-based growth factors.

Table 7. Selected Components Represent the Change in Associated Commodities

SCTG code	Components
08—Alcoholic beverages and denatured alcohol	Beer, wine, spirits, wine cooler, denatured alcohol
09—Tobacco products	Cigarettes, cigars, snuff, chewing tobacco, pipe tobacco, roll-your-own tobacco

3.4. STONES, NONMETALIC MINERALS, AND METALIC ORES (SCTGS 10–14)

The growth of stones, nonmetallic minerals, and metallic ores (SCTGs 10–14) is determined by the change in the total combined weight of the components in a year from the total combined weight in the base year. The production weight of each component is obtained from the *U.S. Geological Survey Mineral Commodity Summaries 2023 Data Release* [USGS 2023a] or *National Minerals Information Center* [USGS 2023b]. Based on the availability of data, the growth factors of SCTGs 10, 13, and 14 were estimated at the national level using Equation 1, while those for SCTGs 11 and 12 were estimated at the state level using Equation 2.

$$Growth_{state\ ,y} = \frac{\sum Weight_{i,state\ ,y}}{\sum Weight_{i,state\ ,2017}} \quad (2)$$

Where:

- $Growth_{state,y}$ = growth of an SCTG category for a given year for a given state
- $Weight_{i,state,y}$ = weight of *i* in a given year for a given state
- $Weight_{i,state,2017}$ = weight of *i* in 2017 for a given state

The components for SCTG 11 overlap with those of SCTG 12, as shown in Table 8. The contribution of the overlapping components (namely, sand and gravel) to each of the two commodities is determined based on type of use information provided in the source data.

Table 8. Selected Components That Represent the Overall Trend for Associated Commodities

SCTG code	Components
10—Monumental or building stone	Dimension stone
11—Natural sands	Tripoli, sand and gravel – industrial (silica), sand and gravel – construction
12—Gravel and crushed stone	Sand and gravel – industrial (silica), sand and gravel – construction, lime, crushed stone
13—Other non-metallic minerals, not elsewhere classified	Salt, bromine, phosphate rock, clays, pumice, gypsum, asbestos, arsenic, diatomite, industrial garnet, natural graphite mica, peat, perlite, talc
14—Metallic ores and concentrates	Iron, copper, lead, zinc, gold

3.5. COAL AND PETROLEUM PRODUCTS (SCTGS 15–19)

EIA provides information on the production, consumption, and shipment of coal and petroleum products and is the primary data source for the growth rate estimation of SCTGs 15–19 (coal and petroleum products).The estimation uses dampening of coal, crude petroleum, and gasoline and fuel oils because the production for these commodities is concentrated while their transport is widespread. The dampening process generally involves combining a state average and the national average for production states, as well as using the national average for states with little or no reported production.

3.5.1. Coal (SCTG 15)

The growth of coal movements originating from a state is associated with the coal production status of that state. For states that produce coal in *y*, the growth of SCTG 15 is determined by the weighted combination of two quantities: the change in total volume of coal produced in a state and the change in the national total (Equation 3). For states that do not produce coal in *y*, the state growth equals national growth.

$$Growth_{state,y} = \left(\left(0.5 \times \frac{EIAprod_{state,y}}{EIAprod_{state,2017}}\right) + \left(0.5 \times \frac{EIAprod_{y}}{EIAprod_{2017}}\right)\right) \quad (3)$$

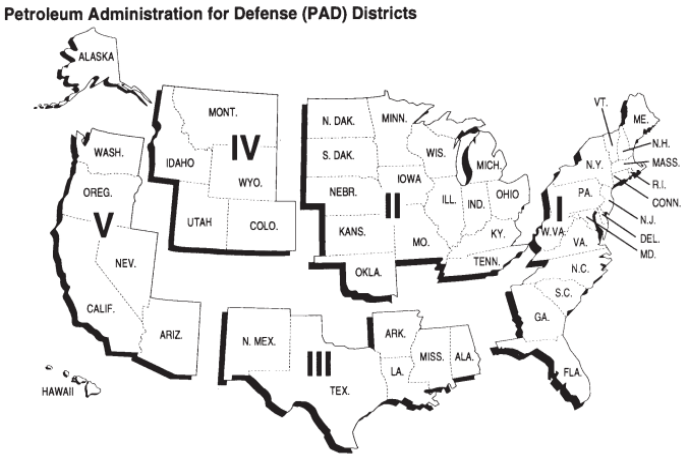
Where:

- $EIAprod_{state,y}$ = total volume of coal produced in *y* for a given state
- $EIAprod_{state,2017}$ = total volume of coal produced in 2017 for a given state
- $EIAprod_{y}$ = total volume of coal produced in *y*
- $EIAprod_{2017}$ = total volume of coal produced in 2017

3.5.2. Crude Petroleum (SCTG 16)

The growth of crude petroleum flows depends on the production status in the corresponding state. For states that produce crude petroleum in a given year, the growth of SCTG 16 is determined by the change in total volume of crude petroleum produced in a state, with a subnational average used as a dampening factor, with the weighting split evenly. The calculation of the dampening factor differs slightly based on the state's location. For states in Petroleum Administration for Defense Districts (PADDs) I – IV, as shown in Figure 4, the collective growth factor for those states is used for dampening (Equation 4). The collective growth factor for states in PADD V is used for dampening (Equation 5).

Figure 4. PADDs



Source: EIA 2024d.
Note: Alaska and Hawaii are part of PADD Ⅴ.

$$Growth_{state\ ,I-IV,y} = \left(\left(0.5 \times \frac{CrudeProd_{state\ ,I-IV,y}}{CrudeProd_{state\ ,I-IV,2017}}\right) + \left(0.5 \times \frac{CrudeProd_{I-IV,y}}{CrudeProd_{I-IV,2017}}\right)\right) \quad (4)$$

Where:

- $Growth_{state,\ I-IV,y}$ = growth of SCTG 16 for *y* for a state in PADDs Ⅰ–Ⅳ
- $CrudeProd_{state,\ I-IV,y}$ = total volume of crude petroleum in for a state in PADDs Ⅰ–Ⅳ
- $CrudeProd_{state,\ I-IV,2017}$ = total volume of crude petroleum in 2017 for a state in PADDs Ⅰ–Ⅳ
- $CrudeProd_{\ I-IV,y}$ = total volume of crude petroleum in *y* for PADDs Ⅰ–Ⅳ
- $CrudeProd_{\ I-IV,2017}$ = total volume of crude petroleum in 2017 for PADDs Ⅰ–Ⅳ

$$Growth_{state\ ,V,y} = \left(\left(0.5 \times \frac{CrudeProd_{state\ ,V,y}}{CrudeProd_{state\ ,V,2017}}\right) + \left(0.5 \times \frac{CrudeProd_{V,y}}{CrudeProd_{V,2017}}\right)\right) \quad (5)$$

Where:

- $Growth_{state,\ V,y}$ = growth of SCTG 16 in for *y* for a state in PADD Ⅴ
- $CrudeProd_{state,\ V,y}$ = total volume of crude petroleum in *y* for a state in PADD Ⅴ
- $CrudeProd_{state,\ V,2017}$ = total volume of crude petroleum in 2017 for a state in PADD Ⅴ
- $CrudeProd_{\ V,y}$ = total volume of crude petroleum in *y* for PADD Ⅴ
- $CrudeProd_{\ V,2017}$ = total volume of crude petroleum in 2017 for PADD Ⅴ

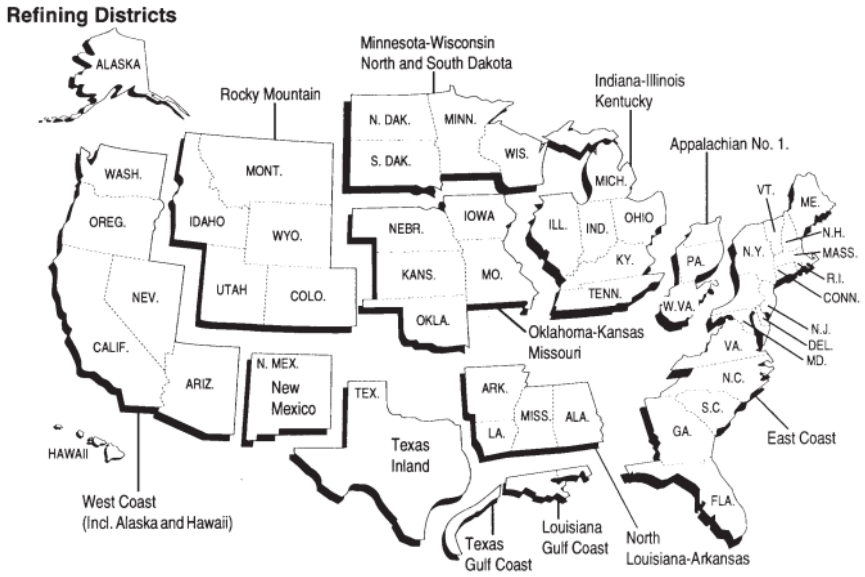
For states that do not produce crude petroleum in the given year, information from the state's PADD is used. In this case, the collective growth factor of that PADD is directly used as the factor for the state.

Offshore production in the Gulf of Mexico is split evenly between Louisiana and Texas. Offshore production in the Pacific is allocated entirely to California.

3.5.3. Gasoline and Fuel Oils (SCTGs 17 and 18)

The growth of SCTGs 17 and 18 is determined by the growth in production volumes of the petroleum products relevant to the two commodities. These petroleum products include outputs from refiners and blenders and ethanol and biodiesel. EIA publishes production data of these products at either the refining district (Figure 5) level or PADD level. The match between PADD areas and refining districts is summarized in Table 9.

Figure 5. Refining Districts



Source: EIA 2024d.

Table 9. PADDs and Their Refining Districts

PADD	Refining district
I	East Coast
	Appalachian
II	Indiana-Illinois-Kentucky
	Minnesota-Wisconsin-Dakotas
	Oklahoma-Kansas-Missouri
III	Texas Inland
	Texas Gulf Coast
	Louisiana Gulf Coast
	North Louisiana-Arkansas
	New Mexico
IV	Rocky Mountain
V	West Coast

The following are the steps to obtain growth factors for SCTGs 17 and 18:

1. **Distribute data from PADD regions to refining districts**—Data for ethanol and biodiesel production is available at the PADD levels (Table 10). The volume is apportioned to refining districts based on the relative volumes of refiners and blenders.

Table 10. SCTGs 17 and 18 Components Available at PADD Level

SCTG code	Component	Data source	Data availability
SCTG 17	Fuel ethanol	The EIA table entitled Oxygenate plant production of fuel ethanol [2024b]	PADD
SCTG 18	Biodiesel	The EIA table entitled U.S. biodiesel production, capacity, sales, and stocks [2024b]	PADD

2. **Obtain total petroleum productions**—For each SCTG commodity, the associated net outputs from refiners and blenders from Table 11 are combined with the disaggregated production data from step 1. This results in total petroleum production.

Table 11. SCTGs 17 and 18 Components Available at Refining District Level

SCTG code	Component	Data source	Data availability
SCTG 17	Motor gasoline	The EIA table entitled Refinery and blender net production [2024b]	Refining district
	Aviation gasoline		
	Kerosene-type jet fuel		
	Kerosene		
SCTG 18	Distillate fuel oil		
	Residual fuel oil		

3. **Obtain growth factor**—For FAF areas in PADDs I–IV, the average growth factor of the refining district and I–IV subtotal is taken, with equal weighting (Equation 6). PADD V is treated as independent and has no dampening. The growth factor of the FAF areas in PADD V equals the growth in the combined total petroleum productions (Equation 7).

$$Growth_{sctg,REFDIST,I-IV,y} = \left(\left(0.5 \times \frac{PETROproduction_{sctg,REFDIST,I-IV,y}}{PETROproduction_{sctg,REFDIST,I-IV,2017}}\right) + \left(0.5 \times \frac{PETROproduction_{sctg,I-IV,y}}{PETROproduction_{sctg,I-IV,2017}}\right)\right) \quad (6)$$

Where:

- $Growth_{sctg,REFDIST,\ I-IV,y}$ = growth of an SCTG for *y* for a refining district in PADDs I–IV
- $PETROproduction_{sctg,REFDIST,\ I-IV,y}$ = total weight of petroleum in *y* for a refining district in PADDs I–IV
- $PETROproduction_{sctg,REFDIST,\ I-IV,2017}$ = total weight of petroleum in 2017 for a refining district in PADDs I–IV
- $PETROproduction_{sctg,\ I-IV,y}$ = total weight of petroleum in *y* for PADDs I–IV
- $PETROproduction_{sctg,\ I-IV,2017}$ = total weight of petroleum in 2017 for PADDs I–IV

$$Growth_{sctg,V,y} = \frac{PETROproduction_{sctg,V,y}}{PETROproduction_{sctg,V,2017}} \quad (7)$$

Where:

- $Growth_{sctg,\ V,y}$ = growth of an SCTG for *y* for a refining district in PADD V
- $PETROproduction_{sctg,\ V,y}$ = total weight of petroleum in *y* for PADD V
- $PETROproduction_{sctg,\ V,2017}$ = total weight of petroleum in 2017 for PADD V

3.5.4. Natural Gas and Other Fossil Products (SCTG 19)

The growth of SCTG 19 is determined by the growth in intrastate and interstate shipments of NG plus relevant outputs from refineries and blenders (non-NG). The steps are as follows:

1. **Determine the shares for non-NG and NG**—Because the initial FAF process (2017 base year estimation) involves directly adding estimated NG movements based on EIA data, that data are subtracted out to determine the total weight from refineries and blenders (the non-NG portion) in the base year. From that value, the shares of non-NG and NG components are calculated. These shares are assumed to be the same in the target years.
2. **Determine the growth factor for non-NG**—EIA publishes data on refinery and blender outputs for each refining district. The outputs (non-NG components) that belong to SCTG 19 are listed in Table 12. The growth factor for non-NG within each refining district is obtained by combining the component growth. FAF zone level growth equals the growth in associated refining districts.

Table 12. SCTG 19 Components and Data Availability

Component	Data source	Data availability
Propane	The EIA table entitled Refinery and blender net production [2024b]	Refining district
Lubricants		
Waxes		
Petroleum coke		
Asphalt and road oil		

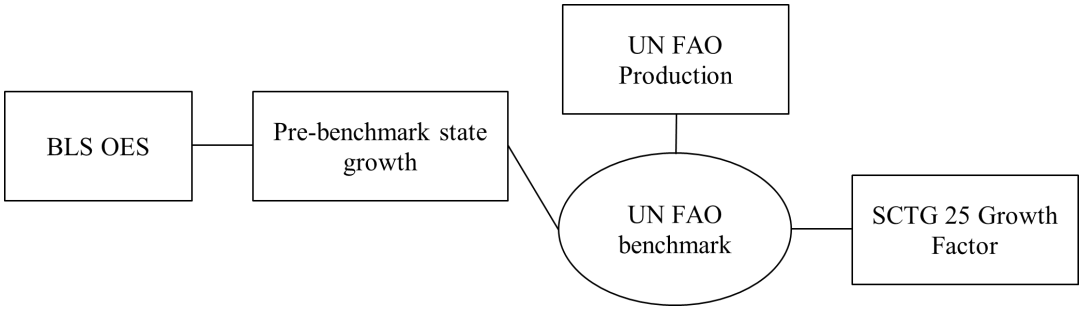
3. **Determine the growth factor for NG**—Data for NG movements are available at state level. Interstate and intrastate NG growth factors are calculated separately based on interstate movements and interstate outbound movements published by EIA. FAF zone level growth equals the growth in the associated state.
4. **Obtain the growth factor by combining NG and non-NG growth**—The interstate growth factor is then determined by combining non-NG growth with interstate NG growth based on NG and non-NG shares in the base year. The intrastate growth factor is calculated in the same way. The intrastate growth factor is applied when the origin and destination are in the same state, and the interstate growth factor is applied when they are in different states.

3.6. LOGS, WOOD PRODUCTS, TEXTILE, AND LEATHER (SCTGS 25–29)

3.6.1. Logs (SCTG 25)

BLS publishes annual employment statistics by industry for each state. The growth factor by origin state for logs (SCTG 25) is determined by growth for employment directly related to timber harvesting, including 45-4021 (fallers), 45-4022 (logging equipment operators), 45-4023 (log graders and scalers), and 45-4029 (logging workers, all other). This employment-based growth is then benchmarked by the national growth, which is calculated using log production data from the United Nations FAO. Figure 6 outlines the overall estimation process.

Figure 6. Estimation Process for Logs (SCTG 25)



Source: BTS 2025.

The detailed estimation process follows:

1. **Obtain pre-benchmark state growth factor**—For each state with at least one BLS OES data series available, the pre-benchmarked growth factor equals the employment growth in that state. For states without any BLS OES data series, the national growth factor from step 2 is directly used to represent the growth in that state.

2. **Obtain production-based national growth factor**—The national growth factor of SCTG 25 for benchmarking is determined by combining production growth of all FAO components, including pulpwood, sawlogs and veneer logs, wood fuel, and other industrial roundwood.
3. **Obtain benchmarked growth factor by state**—A single benchmark factor is calculated as the ratio of FAO component production growth (step 2) to the employment growth (step 1) aggregated to the nation. Applying this single benchmark factor to the state-level growth factors yields the benchmarked growth factors for each state.

3.6.2. Wood Products, Textile, and Leather (SCTGs 26–29)

The growth of SCTGs 26–29 in a target year is determined by the change in the total combined weight of the components from those in the base year at the national level (Equation 1). Volume and weight production data are obtained from FAO, then all volumes are converted to weights.

The components associated with each commodity are listed in Table 13.

Table 13. Selected Components to Represent the Overall Trend for SCTGs 26–29

SCTG	Components
26—Wood products	Oriented strand board; wood chips and particles; wood residues; wood charcoal; coniferous sawn wood; non-coniferous sawn wood; veneer sheets; plywood; hardboard; medium-density fiberboard and high-density fiberboard; other fiberboard; other agglomerates; particle board
27—Pulp, newsprint, paper, and paperboard	Recovered fiber pulp; uncoated mechanical printing and writing papers; uncoated wood-free printing and writing papers; coated printing and writing papers; mechanical wood pulp; semi-chemical wood pulp; chemical wood pulp; unbleached sulfite chemical wood pulp; bleached sulfite chemical wood pulp; unbleached sulfate chemical wood pulp; bleached sulfate chemical wood pulp; dissolving wood pulp; pulp from fibers other than wood; recovered paper; newsprint; printing and writing papers; other paper and paperboard; household and sanitary papers
28—Paper or paperboard articles pulp	Case materials; carton board; wrapping papers; other papers mainly for packaging; wrapping and packaging paper and paperboard; other paper and paperboard not elsewhere specified
29—Printed products	Newsprint; printing; writing papers

3.7. WASTE AND SCRAP (SCTG 41)

The trend in waste and scrap flows is based solely on the growth of the population in target years compared to the base year. The U.S. Census Bureau publishes population data at county level. These data are aggregated to FAF zones to obtain the growth factor (Equation 8).

$$Growth_{FAFzone\ ,y} = \frac{\sum Population_{FAFzone\ ,y}}{\sum Population_{FAFzone\ ,2017}} \quad (8)$$

Where:

- $Growth_{FAFzone,y}$ = population growth in for *y* for a FAF zone
- $Population_{FAFzone,y}$ = population in *y* for a FAF zone
- $Population_{FAFzone,2017}$ = population in 2017 for a FAF zone

3.8. REMAINING COMMODITIES EXCEPT MIXED FREIGHT (SCTGS 20–24 AND SCTGS 30–40)

The 16 commodities in this section (Table 14) use the value of shipments from ASM and/or M3 as the source data to estimate the growth from 2017–2021 and from M3 only after 2021.

Table 14. Commodities Estimated Based on ASM and M3

SCTG code	Commodity description
20	Basic chemicals
21	Pharmaceutical products
22	Fertilizers
23	Other chemical products and preparations
24	Plastics and rubber
30	Textiles, leather, and articles of textiles or leather
31	Non-metallic mineral products
32	Base metal in primary or semi-finished forms and finished basic shapes
33	Articles of base metal
34	Machinery
35	Electronic and other electrical equipment and components, and office equipment
36	Motorized and other vehicles (includes parts)
37	Transportation equipment, not elsewhere classified
38	Precision instruments and apparatus
39	Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs
40	Miscellaneous manufactured products

Based on using either shipment values from ASM or M3 or both, the commodities can be further classified into the following three groups:

- SCTGs 20–23, 33, and 40:
  - ASM is the primary data source up to and including 2021.
  - M3 is the primary data source starting in year 2022.
- SCTGs 24, 30, 32, and 35: M3 is the primary data source for these commodities for all years.
- SCTGs 34 and 36–39: These commodities used data from both ASM and M3. ASM is the data source for some of the signal components through 2021. The M3 program is the data source for the remaining components through 2021 and is the sole source starting in 2022.

The shipment values for industries associated with each commodity are gathered. The growth of SCTGs 20–24 and SCTGs 30–40 is determined by the change in the total combined 2017-dollar shipment values (constant value) in the target year from the total combined 2017-dollar values in the base year (Equation 9). The source data are in current dollars, and inflation is accounted for before calculating growth in tonnage.

$$Growth_y = \frac{Value_y}{Value_{2017}} \quad (9)$$

Where:

- $Value_y$ = shipment value (in 2017 dollars) in y
- $Value_{2017}$ = shipment value (in 2017 dollars) in 2017

Table 15 summarizes the ASM and M3 industry codes associated with each SCTG commodity. In general, industries are combined to obtain the shipment value for a commodity. In some cases, sub-industries are removed from the primary industry class to filter out the shipment values irrelevant to a commodity. As an example, for SCTG 20, the growth rate is obtained using the shipment values from industry NAICS 3251 subtracting out those from industry NAICS 32513 and 325193 [Census 2024b].

Table 15. Industries Associated With Each Commodity

		2018–2021		2022 and later:
Group	SCTG	ASM (NAICS code)	M3 (M3 code)	M3 (M3 code)
Group 1	SCTG 20	3251 (remove 32513 and 25193)	Not used	25S (remove 25A, 25B, and 25C)
	SCTG 21	3254	Not used	25B
	SCTG 22	32531	Not used	25A
	SCTG 23	32513, 3252, 3255, 32532, 3256, 3259	Not used	25S (remove 25B)
	SCTG 33	332 (remove 33299, 332992, 332993, and 332994)	Not used	32S
	SCTG 40	3399, 332992, 332993, 332994	Not used	39S, 32S
Group 2	SCTG 24	Not used	26S	26S
	SCTG 30	Not used	13S, 14S, 15S, 16S	13S, 14S, 15S, and 16S
	SCTG 31	Not used	27S	27S
	SCTG 32	Not used	31S	31S
	SCTG 35	Not used	34S, 35S (remove 34I, 34J, 34K)	34S, 35S (remove 34I, 34J, 34K)
Group 3	SCTG 34	32991	33S (remove 33G)	33S (remove 33G)
	SCTG 36	336414, 336415, 336419, 3369	36A, 36B, 36C, BTP	36A, 36B, 36C, BTP
	SCTG 37	3365	36Z, NAP, DAP	36Z, NAP, DAP
	SCTG 38	3391	33G, 34I, 34J, 34K	33G, 34I, 34J, 34K
	SCTG 39	335121	37S	37S

3.9. MIXED FREIGHT (SCTG 43)

Trends for mixed freight are based on observed trends from other SCTG categories. To determine the contribution of the other SCTG flows, mixed freight is further broken down into the following 5-digit SCTG codes:

- 43991: Items (includes food) for grocery and convenience stores
- 43992: Supplies and food for restaurants and fast-food chains
- 43993: Hardware or plumbing supplies
- 43994: Office supplies
- 43999: Miscellaneous

Within each of these five components, relevant SCTGs are selected, then the relative importance factors from the Producer Price Index (PPI) [BLS 2024b] are used to determine the shares within the high-level groupings. The final contribution of each commodity as a percentage of all mixed freight is summarized in Table 16.

Table 16. Percentage of Commodities Based on Their Contribution to Mixed Freight

SCTG code	Percent of total mixed freight by weight
03	9.7
04	6.3
05	13.6
06	6.0
07	25.8
08	3.3
09	2.5
23	10.2
24	4.2
28	1.4
29	0.7
33	3.5
34	6.3
35	3.3
38	1.0
39	1.0
40	1.3
Total	*100*

Then, the growth factor for SCTG 43 in the target year is computed using the growth factor for each commodity in that year and the commodity's associated percentage from Table 16. This computation is shown in Equation 10.

$$GrowthFactor_{43,y} = \sum \left(OverallWeight_{SCTG,2017} \times GrowthFactor_{SCTG,y} \right) \quad (10)$$

Where:

- $GrowthFactor_{43,y}$ = growth of SCTG 43 for *y*
- $OverallWeight_{SCTG,2017}$ = percent of total mixed freight by weight in 2017
- $GrowthFactor_{SCTG,y}$ = percent of total mixed freight weight in *y*

4. Foreign Trade Flows

This section describes the methods and data inputs for estimating foreign trade flows. The U.S. Census Bureau provides the primary inputs: foreign trade data tables. These tables include the value of imports and exports between each FAF foreign region and each U.S. state. Most records also provide weight, foreign mode, commodity type, and the FAF zone where the goods enter or exit the United States (referred to herein as the "entry or exit port"). The base year methodology report [Hwang et al. 2021] describes the input data in more detail.

Developing foreign trade flow estimates includes inferring missing details and adjusting certain details to better align with other data sources. For example, adjustments are made based on expert knowledge of the attribute combinations (e.g., if the input data mode and geography combinations are known to be impossible). While processing is similar for the FAF5 base year and annual estimates, at times, changes arise due to events such as the availability of new or more precise input data.

4.1. DISAGGREGATION OF GROUPED SCTG COMMODITIES

For most records, the Census foreign trade tables uses a 2-digit SCTG commodity code to describe the commodity type of the flow. However, some records are aggregated due to privacy requirements and, as such, are identified by one of nine commodity groups. BTS allocates flows from these nine groups to 2-digit SCTG codes as follows. BTS first obtains the total annual volume from USA Trade Online (USATO) for each combination of foreign region, U.S. state, and commodity type [Census 2024c]. BTS then subtracts the Census foreign trade volumes from the USATO totals and assigns the differences proportionally to commodity groups based on attribute combinations.

4.2. MODIFICATIONS TO TRADE DATA FILE

BTS modifies the Census foreign trade tables as follows:

1. **Records with foreign air mode and SCTG 16 or 19**: Foreign mode is changed to truck for Canada-based shipments and to water for all other foreign zones.
2. **Records with entry or exit port of Puerto Rico (981) or U.S. Virgin Islands (982)**:
   A. Records with unknown U.S. state are excluded. The assumption is that these goods remain within the territories.
   B. When the U.S. state is known, BTS changes the foreign zone to "Rest of Americas" and changes the entry or exit port based on the origin or destination state and foreign mode. The assumptions are as follows:
      i. **When the foreign mode is air or multiple modes and mail**: If the origin or destination state is in the Northeast United States (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, or Pennsylvania), then the entry or exit port is assumed to be FAF zone 363 (New York NY-NJ-CT-PA [NY Part]). Otherwise, the entry or exit port is assumed to be FAF zone 122 (Miami FL).
      ii. **For other foreign modes**: If the origin or destination state is Florida, then the entry or exit port is assumed to be FAF zone 122 (Miami FL). Otherwise, it is assumed to be FAF zone 121 (Jacksonville FL-GA CFS Area [FL Part]).

3. **Records with vessels moving under their own power (entry or exit port is 997)**: Foreign mode and port of entry or exit are changed depending on origin or destination state and classification as an import or export. Table 17 lists the foreign mode and entry or exit port assumptions for each combination of state and trade type.
4. **Records for masked SCTG 15 coal shipments (entry or exit port is 991)**: If the origin or destination state is Alabama, Arizona, Arkansas, California, Colorado, Florida, Louisiana, Mississippi, New Mexico, Oklahoma, Texas, Wyoming, or unknown, then the port of entry or exit is changed to Mobile, AL. Otherwise, it is changed to Virginia Beach-Norfolk VA-NC (VA Part).
5. **Air trade**: Two major shifts in air shipment ports were adopted to reflect the home location of major parcel companies.
6. **Foreign Trade Zone flows**: These records lack foreign mode. BTS assigns most to water, truck, or air based on foreign zone, entry or exit port, and origin or destination state. BTS also changes "unknown state" entries to the state that contains the record's entry or exit port. Lastly, BTS reassigns select cases to air, rail, water, or pipeline depending on commodity type in addition to foreign zone, entry or exit port, and origin or destination state.
7. **Records for incoming mail and low-value shipments (entry or exit port is 998)**: BTS assumes that the domestic origin (destination) and the exit (entry) port are in the same FAF zone. Furthermore, the following assumptions are used for these shipments:
   A. If the input data specifies the origin or destination state, then BTS assumes the domestic end is the most populous FAF region in that state.
   B. If the origin or destination state is unknown, then BTS assigns the record to a FAF zone using proportions. 2017 FAF5 benchmark flows where the domestic origin and domestic destination are the same form the basis of these proportions. The computation process follows:
      i. For exports, proportions are then calculated as follows. For each foreign destination and commodity type, the 2017 value for each dms_orig-dms_dest pair is divided by the total 2017 import value for that foreign destination and commodity type. The resulting proportion is multiplied by the total export value with unknown state, thereby apportioning the total export value across various dms_orig-dms_dest pairs.
      ii. For imports, proportions are then calculated as follows. For each foreign origin, the 2017 value for each dms_orig-dms_dest pair is divided by the total 2017 import value for that foreign origin. The resulting proportion is multiplied by the total import value with unknown state, thereby apportioning the total import value across various dms_orig-dms_dest pairs.

Table 17. Assumptions for Vessels Moving Under Their Own Power (Entry or Exit port is 997)

Foreign trade attributes		Assumptions	
State	Trade type	Foreign mode	Entry/exit port
AL	Imports and exports	3 (water)	12 (Mobile AL)
AK	Imports and exports	3 (water)	20 (Alaska)
AZ	Exports	5 (multiple modes & mail)	61 (Los Angeles CA)
AZ	Imports	5 (multiple modes & mail)	41 (Phoenix AZ)
AR	Exports	3 (water)	223 (New Orleans LA-MS (LA Part))
AR	Imports	3 (water)	50 (Arkansas)
CA	Imports and exports	3 (water)	61 (Los Angeles CA)
CO	Exports	5 (multiple modes & mail)	61 (Los Angeles CA)
CO	Imports	5 (multiple modes & mail)	81 (Denver CO)
CT	Imports and exports	3 (water)	91 (Hartford CT)

Foreign trade attributes			Assumptions
State	Trade type	Foreign mode	Entry/exit port
DE	Imports and exports	3 (water)	101 (Philadelphia PA-NJ-DE-MD (DE Part))
DC	Imports and exports	3 (water)	111 (Washington DC-VA-MD-WV (DC Part))
FL	Imports and exports	3 (water)	122 (Miami FL)
GA	Imports and exports	3 (water)	132 (Savannah GA)
HI	Imports and exports	3 (water)	151 (Honolulu HI)
ID	Exports	3 (water)	411 (Portland OR-WA (OR Part))
ID	Imports	3 (water)	160 (Idaho)
IL	Imports and exports	3 (water)	171 (Chicago IL-IN-WI (IL Part))
IN	Imports and exports	3 (water)	181 (Chicago IL-IN-WI (IN Part))
IA	Exports	3 (water)	223 (New Orleans LA-MS (LA Part))
IA	Imports	3 (water)	190 (Iowa)
KS	Exports	5 (multiple modes & mail)	486 (Houston TX)
KS	Imports	5 (multiple modes & mail)	201 (Kansas City MO-KS (KS Part))
KY	Exports	3 (water)	223 (New Orleans LA-MS (LA Part))
KY	Imports	3 (water)	212 (Louisville KY-IN (KY Part))
LA	Imports and exports	3 (water)	223 (New Orleans LA-MS (LA Part))
ME	Imports and exports	3 (water)	230 (Maine)
MD	Imports and exports	3 (water)	241 (Baltimore MD)
MA	Imports and exports	3 (water)	251 (Boston MA-RI-NH-CT (MA Part))
MI	Imports and exports	3 (water)	261 (Detroit MI)
MN	Imports and exports	3 (water)	279 (Rest of MN)
MS	Imports and exports	3 (water)	280 (Mississippi)
MO	Exports	3 (water)	223 (New Orleans LA-MS (LA Part))
MO	Imports	3 (water)	292 (St. Louis MO-IL (MO Part))
MT	Exports	5 (multiple modes & mail)	531 (Seattle WA)
MT	Imports	5 (multiple modes & mail)	300 (Montana)
NE	Exports	5 (multiple modes & mail)	486 (Houston TX)
NE	Imports	5 (multiple modes & mail)	311 (Omaha NE-IA (NE Part))
NV	Exports	5 (multiple modes & mail)	61 (Los Angeles CA)
NV	Imports	5 (multiple modes & mail)	321 (Las Vegas NV-AZ (NV Part))
NH	Imports and exports	3 (water)	331 (Boston MA-RI-NH-CT (NH Part))
NJ	Imports and exports	3 (water)	341 (New York NY-NJ-CT-PA (NJ Part))
NM	Exports	5 (multiple modes & mail)	61 (Los Angeles CA)
NM	Imports	5 (multiple modes & mail)	350 (New Mexico)
NY	Imports and exports	3 (water)	363 (New York NY-NJ-CT-PA (NY Part))
NC	Imports and exports	3 (water)	379 (Rest of NC)
ND	Exports	5 (multiple modes & mail)	363 (New York NY-NJ-CT-PA (NY Part))
ND	Imports	5 (multiple modes & mail)	380 (North Dakota)
OH	Imports and exports	3 (water)	392 (Cleveland OH)
OK	Exports	3 (water)	223 (New Orleans LA-MS (LA Part))
OK	Imports	3 (water)	402 (Tulsa OK)
OR	Imports and exports	3 (water)	411 (Portland OR-WA (OR Part))
PA	Imports and exports	3 (water)	421 (Philadelphia PA-NJ-DE-MD (PA Part))
RI	Imports and exports	3 (water)	441 (Boston MA-RI-NH-CT (RI Part))
SC	Imports and exports	3 (water)	451 (Charleston SC)
SD	Exports	5 (multiple modes & mail)	363 (New York NY-NJ-CT-PA (NY Part))
SD	Imports	5 (multiple modes & mail)	460 (South Dakota)
TN	Exports	3 (water)	223 (New Orleans LA-MS (LA Part))
TN	Imports	3 (water)	471 (Memphis TN-MS-AR (TN Part))
TX	Imports and exports	3 (water)	486 (Houston TX)
SD	Exports	5 (multiple modes & mail)	363 (New York NY-NJ-CT-PA (NY Part))
SD	Imports	5 (multiple modes & mail)	460 (South Dakota)
TN	Exports	3 (water)	223 (New Orleans LA-MS (LA Part))
TN	Imports	3 (water)	471 (Memphis TN-MS-AR (TN Part))
TX	Imports and exports	3 (water)	486 (Houston TX)
UT	Exports	5 (multiple modes & mail)	61 (Los Angeles CA)
UT	Imports	5 (multiple modes & mail)	491 (Salt Lake City UT)

Foreign trade attributes		Assumptions	
State	Trade type	Foreign mode	Entry/exit port
VT	Exports	5 (multiple modes & mail)	363 (New York NY-NJ-CT-PA (NY Part))
VT	Imports	5 (multiple modes & mail)	500 (Vermont)
VA	Imports and exports	3 (water)	512 (Virginia Beach-Norfolk VA-NC (VA Part))
WA	Imports and exports	3 (water)	531 (Seattle WA)
WV	Exports	3 (water)	223 (New Orleans LA-MS (LA Part))
WV	Imports	3 (water)	540 (West Virginia)
WI	Imports and exports	3 (water)	551 (Milwaukee WI)
WY	Exports	5 (multiple modes & mail)	61 (Los Angeles CA)
WY	Imports	5 (multiple modes & mail)	560 (Wyoming)
DU (Unknown)	Imports and exports	3 (water)	122 (Miami FL)

4.3. DISAGGREGATION FROM STATES TO FAF ZONES

For most commodities, BTS disaggregates foreign trade data from states to FAF zones based on population or employment payroll shares in the target year. Flows with known states are disaggregated to FAF areas by summing county-level data to FAF zones; dividing this result by the state-level total to determine the FAF zonal shares; then using these shares to allocate state-level values and weights. The following are export and import data sources:

- Exports: BTS uses payroll information for selected NAICS codes from 2017 Census Bureau county- and state-level business patterns [Census 2024d]. The known port of exit becomes the domestic destination.
- Imports: BTS uses 2017 county-level population estimates from the Census Bureau [Census 2024e]. The known port of entry becomes the domestic origin.

BTS uses a different process for SCTG 16. For SCTG 16 flows, BTS assumes the distribution among FAF zones within each state is the same in the base and target years. The base year distribution is applied to the target year data.

4.4. FIXING INFEASIBLE ATTRIBUTE COMBINATIONS

Some combinations of foreign mode and entry or exit ports are not feasible. Based on expert knowledge, BTS modifies the following flows as necessary to have feasible gateways:

- Truck, rail, and pipeline movements associated with Canada and Mexico
- Waterborne movements
- Truck, rail, and pipeline movements outside North America (these are also reassigned to water)

4.5. IMPUTING UNKNOWN STATES

Records with unknown states are assigned to states based on patterns in the rest of the foreign trade data. The patterns consist of shares to or from each domestic FAF area for each combination of other attributes. BTS allocates values and weights from the unknown-state records to domestic FAF areas based on these shares.

4.6. DOMESTIC MODE ASSIGNMENT

The process to impute domestic mode is as follows:

- **For foreign airborne shipments to or from Alaska or Hawaii**: When the foreign mode is air, flows between Alaska or Hawaii and the continental United States are assumed to be air. However, when the domestic leg of the journey is entirely within Alaska or Hawaii, the domestic mode is apportioned to truck and air-truck depending on the commodity type.
- **For foreign airborne shipments to or from other states**: For foreign airborne shipments to or from other states, the domestic mode is assumed to be truck if the routed highway distance is less than 270 miles and air otherwise. Expert judgment was used to further refine this assignment for select cases. BTS plans to improve this process in the future.
- **For foreign waterborne shipments**: The domestic mode depends on the domestic origin–destination pair. It also depends on commodity type: dry bulk, crude bulk, petrol bulk, liquid bulk, break bulk, or non-bulk. When more than one mode is plausible, the value is split based on the shares observed in FAF base year estimates. Air is not permitted.
- **For all other foreign modes**: The domestic mode is assumed to be the same as the foreign mode. This assumption is based on the general absence of intermodal transfer points at highway, rail, and pipeline border crossings.

4.7. VALUE AND WEIGHT IMPUTATION

The foreign trade dataset provides value in terms of current-year dollars. FAF also includes value in 2017 dollars. BTS estimates the year 2017 value using commodity prices for the current year and base year [BLS 2024a, BLS 2024b] to compute PPI factors that are specific to SCTG commodity types. BTS multiplies each value by its PPI to compute its 2017 constant dollar value, which is then used to impute weight in the next step.

Many foreign trade records have unknown weights. BTS imputes weight for these using value-to-weight ratios from the base year FAF flows in the following two cases:

- **Canada and Mexico trade with ground mode (truck, rail, multimodal, pipeline, other)**: Value-to-weight ratios are based on the average ratio for all flows with the same trade type (import versus export), SCTG, foreign region, and foreign mode. In some cases, the base year FAF does not have records with the same attributes. When this happens, the ratio is based on base year FAF records with the same trade type and commodity type.
- **Airborne flows or non-Canadian and Mexican trade with multimodal or other foreign mode**: Ratios are based on the average ratio for all flows with the same trade type, SCTG, port of entry or exit, and foreign region. In some cases, the base year FAF does not have records with the same attributes. When this happens, the ratio is based on base year FAF records with the same trade type, SCTG, and port of entry or exit.

Weights for waterborne flows use U.S. Army Corps of Engineers volumes as benchmark totals for each water gateway [USACE 2024].

Lastly, records with less than $1,000 or one ton of annual flow are removed from the data.

5. Summary and Limitations

BTS' procedures for estimating the base year (FAF5) and annual foreign and domestic trade flows are similar but include important differences. In each year, foreign trade flows are estimated anew, based primarily on import and export data from the U.S. Census Bureau. The domestic annual estimates development, on the other hand, mostly estimates commodity growth compared to the base year and assumes that all shipments from the same origin have the same growth factor regardless of their destination or transportation modes. This commodity-origin based estimation process has the following limitations:

- The potential variation in origin-destination patterns is not captured.
- Potential changes in mode shares from year to year are not captured. Mode shares for domestic flows are assumed to be the same as they are in the base year.
- New or emerging commodities (such as oil products from the fracking industry) are not captured.

Also, when estimating the growth of freight movements, shipment tonnages (weight) and values are the preferred data inputs. However, because of limited shipment data, alternative types of production data are used to estimate certain commodities (e.g., agriculture products and wood products).

BTS considers the foreign trade data to be a high quality input since the Census develops these data each year based on customs records. BTS considers the domestic annual estimates to be less reliable since they rely on patterns from the benchmark year. Moreover, data limitations in both foreign and domestic trade data require the use of assumptions, therefore both the foreign and domestic estimates have uncertainty due to this aspect as well.

The new FAF benchmark (FAF6) is currently being developed for year 2022. As an extension, BTS will compare the 2022 annual estimates to the FAF6 benchmark to identify potential areas for future improvement in the annual estimates methods. BTS welcomes other feedback from users regarding methods and source data that can improve FAF estimates.Users can share feedback by emailing FAF@DOT.GOV.

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Appendix A. SCTG Commodity Codes

Table 18 summarizes SCTG codes and their associated commodity descriptions [ORNL 2021].

Table 18. SCTG Commodity Descriptions by SCTG Code

Code	Commodity description
01	Animals and fish (live)
02	Cereal grains (includes seed)
03	Agricultural products (excludes animal feed, cereal grains, and forage products)
04	Animal feed, eggs, honey, and other products of animal origin
05	Meat, poultry, fish, seafood, and their preparations
06	Milled grain products and preparations, and bakery products
07	Other prepared foodstuffs, fats and oils
08	Alcoholic beverages and denatured alcohol
09	Tobacco products
10	Monumental or building stone
11	Natural sands
12	Gravel and crushed stone (excludes dolomite and slate)
13	Other non-metallic minerals not elsewhere classified
14	Metallic ores and concentrates
15	Coal
16	Crude petroleum
17	Gasoline, aviation turbine fuel, and ethanol (includes kerosene, and fuel alcohols)
18	Fuel oils (includes diesel, bunker c, and biodiesel)
19	Natural gas and other fossil products
20	Basic chemicals
21	Pharmaceutical products
22	Fertilizers
23	Other chemical products and preparations
24	Plastics and rubber
25	Logs and other wood in the rough
26	Wood products
27	Pulp, newsprint, paper, and paperboard
28	Paper or paperboard articles
29	Printed products
30	Textiles, leather, and articles of textiles or leather
31	Non-metallic mineral products
32	Base metal in primary or semi-finished forms and in finished basic shapes
33	Articles of base metal
34	Machinery
35	Electronic and other electrical equipment and components, and office equipment
36	Motorized and other vehicles (includes parts)
37	Transportation equipment, not elsewhere classified
38	Precision instruments and apparatus
39	Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs
40	Miscellaneous manufactured products
41	Waste and scrap (excludes agriculture or food)
43	Mixed freight

Appendix B. Assignment of Foreign Countries to FAF Foreign Zones

Table 19 summarizes the countries in each FAF zone [ORNL 2021].

Table 19. Countries by Region and FAF Zone

FAF zone	Foreign region	Countries
801	Canada	Canada
802	Mexico	Mexico
803	Rest of Americas	Anguilla, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Bonaire, Sint Eustatius and Saba, Brazil, British Virgin Islands, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Curacao, Dominica, Dominican Republic, Ecuador, El Salvador, Falkland Islands, French Guiana, Greenland, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Montserrat, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St. Barthelemy, St. Kitts and Nevis, St. Lucia, St. Martin, St. Pierre and Miquelon, St. Vincent and the Grenadines, Sint Maarten, Suriname, Trinidad and Tobago, Turks and Caicos Islands, U.S. Virgin Islands, Uruguay, and Venezuela
804	Europe	Aland Islands, Albania, Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Channel Islands (Guernsey, Jersey, and Sark), Croatia, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Gibraltar, Greece, Hungary, Iceland, Ireland, Isle of Man, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Moldova, Monaco, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Russia, San Marino, Serbia, Slovakia, Slovenia, Spain, Svalbard and Jan Mayen Islands, Sweden, Switzerland, Ukraine, United Kingdom, and Vatican City
805	Africa	Algeria, Angola, Benin, Botswana, British Indian Ocean Territory, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo (Brazzaville), Congo (Kinshasa), Djibouti, Egypt, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, French Southern and Antarctic Lands, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, St. Helena, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zambia, and Zimbabwe
806	Southern, Central, and Western Asia	Afghanistan, Armenia, Azerbaijan, Bahrain, Bangladesh, Bhutan, Cyprus, Georgia, India, Iran, Iraq, Israel, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Lebanon, Maldives, Nepal, Oman, Palestine, Pakistan, Qatar, Saudi Arabia, Sri Lanka, Syria, Tajikistan, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan, and Yemen
807	Eastern Asia	China, Hong Kong, Japan, Macao, Mongolia, North Korea, South Korea, and Taiwan
808	Southeastern Asia and Oceania	American Samoa, Australia, Brunei, Cambodia, Christmas Island, Cocos Islands, Cook Islands, East Timor, Federated States of Micronesia, Fiji, French Polynesia, Guam, Heard and McDonald Islands, Indonesia, Kiribati, Laos, Malaysia, Marshall Islands, Myanmar, Nauru, New Caledonia, New Zealand, Niue, Norfolk Island, Northern Mariana Islands, Palau, Papua New Guinea, Philippines, Pitcairn Islands, Samoa, Singapore, Solomon Islands, Thailand, Tokelau, Tonga, Tuvalu, Vanuatu, Vietnam, and Wallis and Futuna

List of Symbols

$CrudeProd_{I-IV,2017}$	total volume of crude petroleum produced in 2017 for PADDs I–IV
$CrudeProd_{I-IV,y}$	total volume of crude petroleum produced in a given year for PADDs I–IV
$CrudeProd_{V,2017}$	total volume of crude petroleum produced in 2017 for PADD V
$CrudeProd_{V,y}$	total volume of crude petroleum produced in a given year for PADD V
$CrudeProd_{state,\ I-IV,2017}$	total volume of crude petroleum produced in 2017 for a state in PADDs I–IV
$CrudeProd_{state,\ I-IV,y}$	total volume of crude petroleum produced in a given year for a state in PADDs I–IV
$CrudeProd_{state,\ V,2017}$	total volume of crude petroleum produced in 2017 for a state in PADD V
$CrudeProd_{state,\ V,y}$	total volume of crude petroleum produced in a given year for a state in PADD V
$EIAprod_{2017}$	total volume of coal produced in 2017
$EIAprod_{state,2017}$	total volume of coal produced in 2017 for a given state
$EIAprod_{state,y}$	total volume of coal produced in a given year for a given state
$EIAprod_{y}$	total volume of coal produced in a given year
$Growth_{FAFzone,y}$	population growth in for year for a given FAF zone
$Growth_{sctg,\ V,y}$	growth of an SCTG for a given year for the refining district PADD V
$Growth_{sctg,REFDIST,\ I-IV,y}$	growth of an SCTG for a given year for the refining districts PADDs I–IV
$Growth_{state,\ I-IV,y}$	growth of SCTG 16 for a given year for a state in PADDs I–IV
$Growth_{state,\ V,y}$	growth of SCTG 16 in for a given year for a state in PADD V
$Growth_{state,y}$	growth of an SCTG category for a given year for a given state
$Growth_{y}$	growth of an SCTG category for a given year
$GrowthFactor_{43,y}$	growth of SCTG 43 for a given year

$GrowthFactor_{SCTG,y}$	percent of total mixed freight weight in a given year
i	component
$OverallWeight_{SCTG,2017}$	percent of total mixed freight by weight in 2017
$PETROproduction_{sctg,\ I-IV,2017}$	total weight of petroleum produced in 2017 for PADDs I–IV
$PETROproduction_{sctg,\ I-IV,y}$	total weight of petroleum produced in a given year for PADDs I–IV
$PETROproduction_{sctg,\ V,2017}$	total weight of petroleum produced in 2017 for PADD V
$PETROproduction_{sctg,\ V,y}$	total weight of petroleum produced in a given year for PADD V
$PETROproduction_{sctg,REFDIST,\ I-IV,2017}$	total weight of petroleum produced in 2017 for a refining district in PADDs I–IV
$PETROproduction_{sctg,REFDIST,\ I-IV,y}$	total weight of petroleum produced in a given year for a refining district in PADDs I–IV
$Population_{FAFzone,2017}$	population in 2017 for a given FAF zone
$Population_{FAFzone,y}$	population in a given year for a given FAF zone
$Value_{2017}$	shipment value (in 2017 dollars) in 2017
$Value_y$	shipment value (in 2017 dollars) in a given year
$Weight_{i,2017}$	weight of a component in 2017
$Weight_{i,state,2017}$	weight of a component in 2017 for a given state
$Weight_{i,state,y}$	weight of a component in a given year for a given state
$Weight_{i,y}$	weight of a component in a given year
y	year