U.S. Department of Transportation
Office of the Secretary of Transportation
Bureau of Transportation Statistics

Comparison of Commodity Flow Survey (CFS) and Freight Analysis Framework (FAF) for 2017 Domestic Freight Flows

Recommended Citation

U.S. Department of Transportation, Bureau of Transportation Statistics. (2022-5-10). *Comparison of Commodity Flow Survey and Freight Analysis Framework for 2017 Domestic Freight Flows*. Technical Report. Washington, DC.

https://doi.org/10.21949/1526410

Acknowledgements

Bureau of Transportation Statistics

Patricia Hu
Director

Rolf Schmitt
Deputy Director

Produced under the direction of:

Cha-Chi Fan
Director, Office of Data Development and Standards

Project Manager

Julie Parker
CFS Program Manager

Visual Information Specialist

Alpha Wingfield

Major Contributor

Young-Jun Kweon

Special thanks to Cha-Chi Fan, Julie Parker, and Ryan Grube at the Bureau of Transportation Statistics for providing guidance, information, and discussion regarding the CFS and FAF throughout the project and review of the report; Hyeonsup Lim at Oak Ridge National Laboratory for providing information and discussion regarding the FAF; Rolf Schmitt at the Bureau of Transportation Statistics for providing background information on CFS domestic flows entering in the FAF and insightful review comments and suggestions; Jessica Young and James Hinckley at U.S. Census Bureau for providing historical information about SCTG16; Ed Strocko, Julianne Schwarzer (detailee from Volpe National Transportation Systems Center), Elijah Henley (detailee from Federal Highway Administration), and April Gadsby at the Bureau of Transportation Statistics, Ho-Ling Hwang and Majbah Uddin at Oak Ridge National Laboratory, and Berin Linfors, Grant Degler, and Christian Moscardi at U.S. Census Bureau for their thoughtful review and comments of the report.

Quality Assurance Statement

The Bureau of Transportation Statistics (BTS) provides high quality information to serve government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. BTS reviews quality issues on a regular basis and adjusts its programs and processes to ensure continuous quality improvement.

Notice

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for its contents or use thereof.

Table of Contents

Executive Summary

The Commodity Flow Survey (CFS) and Freight Analysis Framework (FAF) are two public databases capturing the national freight flows in the United States and they are closely related because the CFS serves as a major input to the FAF. There has been an interest in understanding differences between the CFS and FAF because a proper understanding of the differences would help data users understand correct use of each data source and analyze them properly. Also, examining the differences would help assure the quality of the FAF data products since the CFS is viewed as a benchmark of national freight flows.

This study is to understand differences in 2017 *domestic* freight flows between the CFS and FAF based on their most recent databases providing 2017 estimates. The comparison is performed in two estimates (weight and value) of freight by transportation mode, commodity, origin, and destination. Differences discovered lead to a clear understanding on where the differences exist and where they come from.

The study uses the most recent data, 2017 CFS Special Tables and the FAF 5.0. 2017 CFS Special Tables are select outputs from 2017 CFS estimates provided by U.S. Census Bureau exclusively for developing the FAF5 database. The FAF5.0 is the first released FAF5 database providing estimates of the base year 2017. It was developed using 2017 CFS Special Tables with other external freight data. Since the external data are beyond the scope of the CFS, they are called out-of-scope (OOS) data such as freight flows in transportation, construction, and most retail industries. In addition to the CFS Special Tables and FAF5.0, the study uses OOS analysis results produced by Oak Ridge National Laboratory to examine source(s) of the discovered differences.

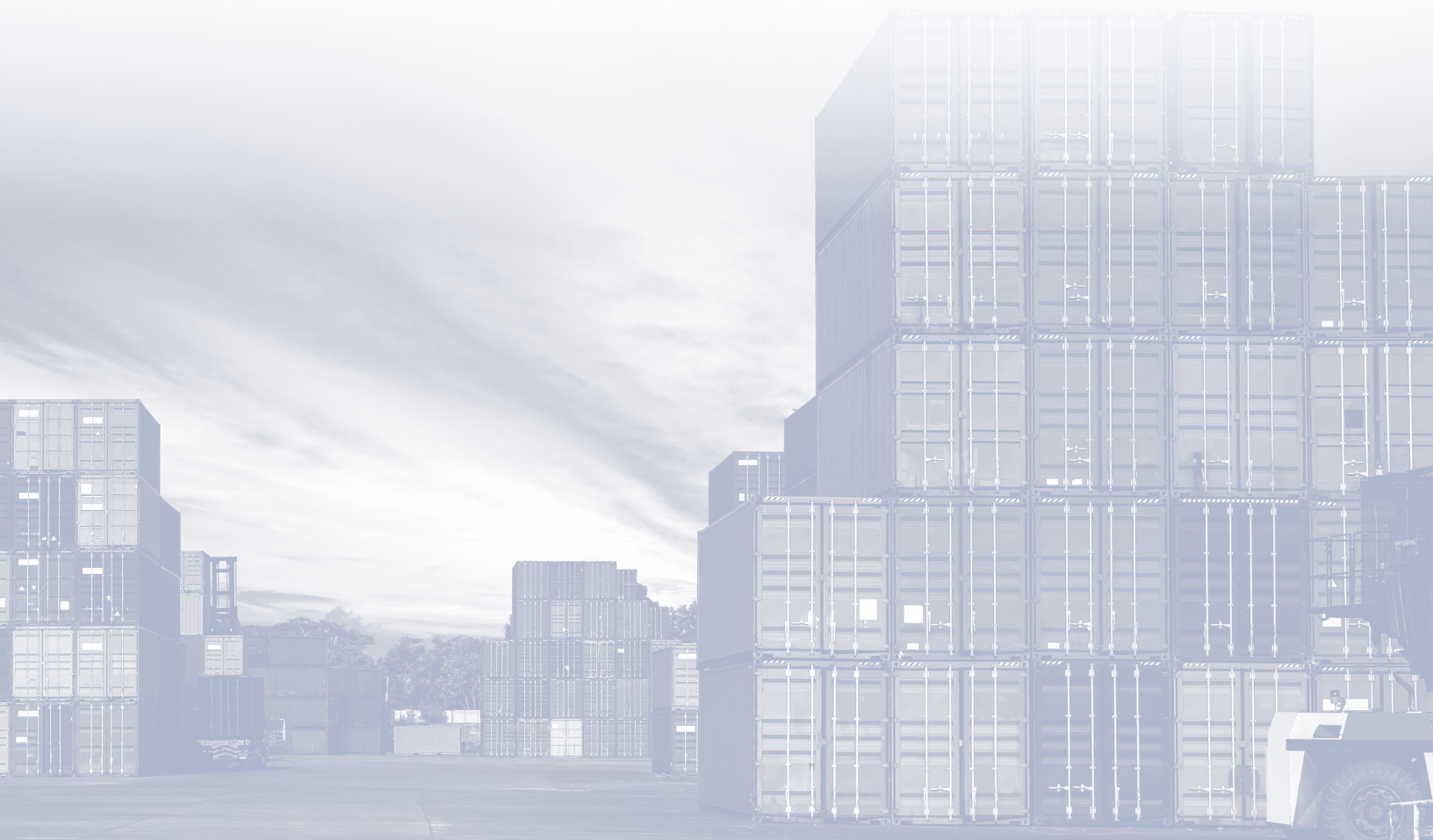
Two metrics, difference and percentage, are used to compare weight and value in the CFS with the FAF and the percentage, a main metric for comparison, calculates CFS estimate being expressed as a fraction of FAF estimate in percentage. Because the FAF was developed by adding the OOS freight to the CFS, the percentage ranges from 0% to 100%; 100% means all FAF freight come from the CFS data while 0% means all FAF freight come from the OOS data.

Comparison of 2017 *domestic* freight flows in the CFS and FAF leads to the following findings:

- The discrepancy between the CFS and FAF is attributable 100% to OOS freight flows (table 12), verifying the FAF process treats the CFS data properly in developing the FAF database.
- The CFS covers 68% in weight and 89% in value of the FAF (table 3) meaning the OOS data add weight more than value. Some OOS freight has very small or no value yet very large weight such as municipal solid waste.
- The CFS covers 22% and 74% of the FAF in weight of freight transported by pipeline and truck, respectively (table 4). Crude petroleum and natural gas mostly transported by pipeline are OOS, contributing to the low CFS percentage by pipeline. Since a majority of the domestic freight flows are transported by truck (74% in weight), analysis involving highway traffic could see sizable difference in its results between the CFS and FAF.

- The CFS covers at least 80% of the FAF in weight in 32 out of 42 commodities and 90% or higher in 22 commodities (table 6). Six commodities – SCTG Codes 16 (Crude petroleum), 25 (Logs), 01 (Live animals/fish), 19 (Coal-n.e.c.), 41 (Waste/scrap), and 03 (Other ag prods.) – see less than 50% in the CFS coverage and they are the main commodities impacted by OOS domestic freight flows.
- In the state-level comparison, the CFS covers between 35% and 80% of the FAF in weight of outgoing freight (table 8) and between 38% and 83% of the FAF in weight of incoming freight (table 10). This means caution should be exercised in using state-level estimates of domestic freight flows based on the CFS data, especially states with a lower percentage.
- In the area-level comparison, the CFS covers between 30% and 96% of the FAF in weight of outgoing freight (table 9) and between 33% and 91% of the FAF in weight of incoming freight (table 11). This means areas (i.e., zones for the FAF) with high percentages may not see much difference in area-level estimates of domestic freight flows between the CFS and FAF. Caution should be exercised in using area-level estimates of domestic freight flows based on the CFS data, especially areas with a lower percentage (see tables 9 and 11).

Freight data users should understand the differences between the CFS and FAF and choose the most appropriate data fitting for their analysis purpose. The data users must consider the greater detail in the CFS and the more complete coverage of the FAF when determining the data. If the detail (e.g., industry types) of the CFS is needed, the share of the CFS estimates compared to the FAF estimates should be considered when interpreting analysis results.



1. Introduction

1.1. Background

Several data related to freight in the United States are publicly available (Bureau of Transportation Statistics [BTS], 2021-02-21) such as various air cargo statistics (e.g., monthly cargo revenue tons enplaned[1] and cargo revenue ton-miles[2]) and transborder freight statistics (e.g., monthly values of freight by commodity type, origin, destination, and mode across the Canadian and Mexican borders[3]). Among them, two data provide a comprehensive multimodal picture of national freight flows in the United States, the Commodity Flow Survey (CFS)[4] and Freight Analysis Framework (FAF)[5]. These two data are closely related because the CFS serves as major input to the FAF[6]. The most recent versions of these data at the time of the study performed, the 2017 CFS and FAF5.0, provide 2017 estimates of freight flows in weights and values by transportation mode, commodity, origin, and destination.

BTS is mandated by Congress under Title 49 United State Code (USC), Section 6302[7] to collect economic data on transportation mode choice and goods movement. BTS established the CFS program to collect freight flows data through a partnership with the U.S. Census Bureau. The CFS is critical to understanding the use, performance, and condition of the nation's transportation system, as well as informing transportation investments. The data are also important for effective analyses of changes in regional and local economic development, infrastructure planning, safety issues, and environmental concerns and valuable for the private sector in making critical decisions on various issues such as market trend and segmentation.

The CFS is the only publicly available freight flow data for the highway mode (BTS, 2021-05-21) and has been collected every five years as part of the Economic Census conducted by the U.S. Census Bureau (BTS, 2021-02-24). The CFS is a shipper survey collecting data on shipments originating from business establishments located in the 50 states and the District of Columbia. The CFS collects shipment data from over 100,000 sampled establishments with paid employees in industries of mining, manufacturing, wholesale, auxiliaries (i.e., warehouses and distribution centers), and select retail and services trade industries. (BTS, 2020-11-02). Title 13 USC, Sections 224[8] and 225[9] require businesses and other organizations that receive the survey to respond to the U.S. Census Bureau.

The CFS program is designed to collect shipment data in industries where the concept of shipment is clear and has an effective sampling frame for those industries. However, there are commodities where the concept of shipment is not well aligned with the CFS program and crude petroleum shipped by pipeline is an example. Also, there are industries where the CFS sampling frame lacks a good coverage and farming industry is an example; the farming industry is covered predominantly by the Census of Agriculture[10]. The FAF attempts to compliment the CFS in such lacking aspects by integrating freight data from external sources and to provide more complete picture of the national freight flows estimates. However, the FAF

[1] https://www.transtats.bts.gov/freight.asp?20=D&qv52ynB=qn6nF.

[2] https://www.transtats.bts.gov/freight.asp?pn=0&display=data1.

[3] https://www.bts.gov/transborder.

[4] https://www.census.gov/programs-surveys/cfs.html.

[5] https://faf.ornl.gov/faf5/.

[6] The 2017 CFS covers over 70% of freight flows in FAF5 by value (BTS, 2021-03-04).

[7] https://www.govinfo.gov/content/pkg/USCODE-2019-title49/html/USCODE-2019-title49-subtitleIII-chap63-sec6302.htm.

[8] https://www.govinfo.gov/app/details/USCODE-2010-title13/USCODE-2010-title13-chap7-subchapII-sec224.

[9] https://www.govinfo.gov/app/details/USCODE-1994-title13/USCODE-1994-title13-chap7-subchapII-sec225.

[10] National Agricultural Statistics Service (NASS), the U.S. Department of Agriculture, conducts the Census of Agriculture every five years and collect agricultural data (e.g., farm product quantities by commodity) for every county (NASS, 2022-03-22).

estimates lack the industry types, commodity details, and selected shipment characteristics of the CFS.

The FAF takes the domestic portion of the CFS and adds international trade data from the U.S. Census Bureau, serving as the major building block of the FAF[5], and integrates data from various sources[11] including agriculture, resource extraction, construction, service, and other industry sectors (BTS, 2021-03-23). Specifically, the FAF collects additional freight data in out of scope (OOS) business sections of the CFS such as agriculture, aquaculture, logging, construction debris, and international trade (BTS, 2016-09-23a) to fill the data gaps in the CFS associated with OOS sectors. The FAF has been produced every five years and, in more recent years, in collaboration with Oak Ridge National Laboratory (ORNL) (ORNL, 2021-11-22).

The CFS provides direct estimates of freight data collected from a nationwide survey of shippers in the U.S. The CFS provides shipment-level data and various aggregate-level data and statistics[12] ranging from national totals by transportation mode[13] to totals by origin, destination, industry (i.e., North American Industry Classification System [NAICS]), and transportation mode[14]. Since the CFS is based on U.S. shippers, it does not capture the first leg of import shipments; however, the CFS captures successive legs of import shipments when the imported goods are further shipped to final destinations in the U.S. Furthermore, the CFS does not request respondents to specifically sample export shipments; in such, export shipments are not robust in the CFS. Although the CFS contains export freight flows, both the import and export freight flows are regarded as OOS in the FAF process leading to the decision of entering only domestic freight data into the FAF database; The 2017 CFS constitutes over 70% of freight flows in FAF5 by value (BTS, 2021-03-04).

The FAF process excludes export freight flows from the CFS data and takes in only domestic freight flows as basis for developing the FAF database because CFS export data do not capture the degree of exports that the international trade data do, resulting in CFS export estimates being lower than with export estimates in international trade statistics from the U.S. Census Bureau (see Appendix A for background information). Moreover, the CFS does not capture the first leg of import shipments from establishments in foreign countries. Therefore, the FAF process develops import and export freight flows entirely from the international trade statistics of the U.S. Census Bureau. It is noteworthy that the FAF total freight flows between domestic locations are the sum of domestic freight flows and the domestic leg of import and export flows. It should also be noted that the CFS export data are used to inform the FAF export estimates, especially the domestic leg, although the FAF export estimates are based on the international trade data.

The CFS and FAF both provide mode-specific shipment totals that do not necessarily align with direct measures of modal activity such as the rail waybill because they both report *multiple modes and mail* as a separate mode. The CFS further breaks the multiple modes such as truck-rail, truck-water, and rail-water. Thus, the totality of rail shipments includes rail-only and rail-intermodal (e.g., truck-rail and rail-water) shipment totals estimated by the CFS and FAF. The totality of truck shipments is a shipment total by three modes in the CFS and FAF: truck-only, truck portion of multiple modes and rail, and truck portion of air-truck mode. The CFS and FAF decides to merge mail (parcels less than 150 pounds) mode into multiple modes because the shipper does not always know what modes a mail carrier such as UPS and FedEx would use for a given shipment. It is worth emphasizing that the CFS is the only geographically specific freight data distinguishing for-hire truck from company-owned truck.

[11] Examples of data sources are Census Foreign Trade Statistics, Economic Census data, U.S. Department of Agriculture's Census of Agriculture, and U.S. Energy Information Administration (EIA). (BTS, 2021-03-04).

[12] A total of 65 aggregate-level tables are available at https://www.census.gov/data/tables/2017/econ/cfs/aff-2017.html.

[13] (e.g.) Table CF1700A04–Geographic Area Series: Shipment Characteristics by Mode of Transportation - Rail: 2017

[14] (e.g.) Table CF1700A25–Geographic Area Series: Shipment Characteristics by Origin Geography by Destination Geography by NAICS by Mode: 2017

The FAF process fills freight flows in OOS components (i.e., industry sections and export of which other better data are available or the CFS is not an adequate approach) by integrating freight data from various sources to create a more comprehensive picture of freight flows. The OOS freight flows are about 30% of FAF5 by value and the OOS components in FAF5 include: farm-based agriculture, municipal solid waste, construction and demolition debris, retail, services, household and business moves, crude petroleum, natural gas, international trades (import and export), fisheries, and logging (ORNL, 2021-12). The FAF provides aggregate-level data in two different geographic levels, State and zone[15] but does not provide shipment-level data. The most detailed aggregate level of the FAF data is by origin-destination zone pair, commodity, and mode.

The CFS and FAF data have been used for various purposes such as State/regional freight planning, freight production studies, economic analysis, supply chain analysis, and emissions modeling. The data have been analyzed by various users such as State and local highway agencies, metropolitan planning organizations (MPOs), transportation-related associations, the private sector, and various federal agencies such as Federal Highway Administration (FHWA), Pipeline and Hazardous Materials Safety Administration (PHMSA), Energy Information Administration (EIA), Environmental Protection Agency (EPA), and US Army Corp of Engineers, to name a few.

1.2 Study Motivation

The CFS has data gaps in terms of commodity (e.g., crude petroleum via pipeline) and industry (e.g., agriculture and aquaculture industries) and the FAF attempts to fill those gaps using external freight data. Therefore, there are differences between these two freight data sources. There has been an interest in understanding the differences between the CFS and FAF because a proper understanding of the differences would help data users understand in making correct use of each data and analyze them properly. In this respect, this study provides a context for using the detailed CFS data, showing how much of the total estimates of the FAF are covered by the CFS. It also indicates areas where FAF OOS estimates may have rooms for improvement when the differences between the CFS and the FAF are larger than expected.

Examining the differences would help assure the quality of the FAF data products since the CFS serves as a benchmark of the national freight flows estimates of the FAF. In this respect, the BTS performed a pilot study (Norton, 2020-10) examining the differences between the CFS and FAF for 2017 freight flows. The study compared the 2017 data estimated from FAF4 against the 2017 CFS data at state level. The 2017 estimates of FAF4 data are forecasts[16] for 2017 freight flows in that the base year of FAF4 is 2012; the 2012 CFS data were used as a baseline to develop the 2012 data of FAF4. Thus, the pilot study's purpose was to examine short-term forecasting capability of the FAF4 for 2017 freight flows using 2017 CFS data as a benchmark.

1.3 Study Purpose & Scope

The purpose of the study is to understand differences in 2017 *domestic* freight flows between the CFS and FAF by comparing 2017 estimates from the FAF5.0 against 2017 estimates from the 2017 CFS. The comparison is performed in based on two estimates (weight and value) by transportation mode, commodity, origin, and destination, and two geographic levels (State and area[17]) are used. Since the study focuses on *domestic* freight flows, its findings are expected to provide a clear understanding on where the differences exist and where they come from.

This study differs from the pilot study (Norton, 2020-10) in at least three aspects as below:

[15] A zone in FAF, called FAF zone, is a geography equivalent to an area in CFS, called CFS area. A FAF zone is also called a FAF region.

[16] In the FAF, estimates for six years following the base year (e.g., 2013-2018 for FAF4 whose base year is 2012) are called annual estimates while those for further future years in five-year increments (e.g., 2020, 2025, …, 2045 for FAF4) are called forecasts. Meanwhile, the current study calls estimates for any future years from the FAF base year as forecasts.

[17] An area in CFS corresponds to a zone in FAF, called a FAF zone and also called a FAF region.

- The pilot study did not separate domestic freight flows from total freight flows and the CFS and FAF include different trade types of freight flows. The CFS includes domestic and export freight while the FAF includes domestic, export, and import freight. Thus, the current study gets closer to a fair comparison between the CFS and FAF than the pilot study.
- The pilot study used the FAF4 while the current study uses the FAF5 for 2017 freight flows. Since the FAF4 and FAF5 were developed using the 2012 and 2017 CFS as their baseline, respectively, 2017 freight flows of the FAF4 are forecasts based on the 2012 CFS data while those of the FAF5 are estimates based on the 2017 CFS data.
- The pilot study was based on state-level aggregate statistics to compare the CFS and FAF while the current study is based on freight flows estimates at area and state levels.

2. Description of Data

The two data were used to form the analysis datasets for comparison, the CFS and FAF—more specifically, 2017 estimates of the CFS and 2017 estimates of the FAF5, respectively. The specific datasets of the two data are described here, separately.

2.1 CFS

The U.S. Census Bureau provided the special tabulation of 2017 CFS estimates, hereinafter called 2017 CFS Special Tables, per the BTS's request exclusively for developing the FAF5 database. These tables are different from 2017 CFS Final Tables (BTS and U.S. Census Bureau, 2020)[18] and 2017 CFS Public Use File (BTS and U.S. Census Bureau, 2020-08)[19]. There are two important differences as follows:

- 2017 CFS Special Tables separate exports from domestic shipments while publicly available tables and files do not. This separation is necessary for developing the FAF5 database. The FAF process regards export freight flows as OOS and takes only domestic freight data of the CFS into the FAF database.
- 2017 CFS Special Tables contain estimates with a high level of sampling error expressed in coefficient of variation (CV). All CFS public tables and files contain estimates within the Census Bureau's normal publication standard CV of 50% while 2017 CFS Special Tables include estimates exceeding the standard up to 100%. Thus, the estimates in the Special Tables should be used with caution and those with CV higher than 100% remain suppressed.

There are five tables in 2017 CFS Special Tables and Table 1, "Shipment Characteristics by Origin Geography by Destination Geography by FAF Mode by Commodity (non-export shipments only)," was used for this study. The table contains freight flow estimates at national, regional[20], divisional[21], state, and CFS area levels. It should be noted that all CFS data including all the public data files and special tables are protected with proper disclosure avoidance[22].

2.2 FAF5

Freight Analysis Framework Version 5, known as FAF5, has released a series of updates, and the first released FAF5, called FAF5.0, is the base-year 2017 regional database. FAF5.0 provides estimates for weight and value of the base year 2017 and its later versions (FAF5.1 through FAF5.4) mostly add other data products based on FAF5.0 but can also involve adjustments in FAF5.0. For example, FAF5.2 adds the

[18] Available at https://www2.census.gov/programs-surveys/cfs/data/2017/.

[19] Available at https://www.census.gov/data/datasets/2017/econ/cfs/historical-datasets.html.

[20] There are four U.S. Census Regions, West, Midwest, Northeast, and South. See details at https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf.

[21] There are nine U.S. Census Divisions. See details at https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf.

[22] For the 2017 CFS, the primary method of disclosure avoidance is noise infusion in which shipment-level quantities are perturbed prior to tabulation by applying a random noise multiplier to the quantitative data, such as the shipment value and shipment weight. For more details, see 2017 Commodity Flow Survey Methodology (BTS and U.S. Census Bureau, 2020-07).

forecast year estimates[23] (2020-2050) and state-level historical trend estimates (1997-2012) and FAF5.3 is expected to add ton-mile and recent year estimates (2018-2019) (ORNL, 2021-11-22).

FAF5.0 was developed using 2017 CFS Special Tables and international trade data from the U.S. Census Bureau as backbone with other ancillary external data such as data published by Forest Service of the Department of Agriculture, Federal Highway Administration of the Department of Transportation, and Energy Information Administration of the Department of Energy. The 2017 estimates of the FAF5.0 are accessible in several ways such as the Data Tabulation Tool (DTT) (ORNL, 2021-02-25)[24], summary statistics[25] at state and zone level, and two databases (regional and state) by origin-destination pair, commodity, and mode. Both regional[26] and state data were used for this study. Specifically, "FAF5.0 Regional database for 2017 in zipped CSV format" and "FAF5.0 State database for 2017 in zipped CSV format" were downloaded from the FAF5 website[27]. To extract domestic freight flows from the FAF data, trade type variable in the datasets was used. More details about the FAF5 such as data elements and definitions are found in FAF5 User's Guide (ORNL, 2021-01-20).

3. Method

3.1 Mapping CFS and FAF

To compare the CFS and FAF datasets, variables and code values need to be mapped and these mappings are described in this section. Table 1 shows variables of the two datasets with four pairs of variables mapped for this study: (1) origin, (2) destination, (3) transportation mode, and (4) commodity. Although the paired variables carry the same meaning in the CFS and FAF, their codes are not identical, requiring mapping the codes between the CFS and FAF datasets; for example, fafmode = 12 in CFS Special Tables indicates pipeline while dms_mode = 6 in FAF5.0 indicates pipeline.

Table 1[28] of 2017 CFS Special Tables contains only domestic freight flows while the FAF5.0 Regional and State databases includes not only domestic but also import and export freight flows. Domestic freight flows of the FAF5.0 can be extracted by selecting records with trade_type = 1 (Domestic Only).

Figure 1 shows mapping transportation modes between the CFS and FAF datasets. The FAF has seven modes (codes 1 through 7) while the CFS has 21 codes

[23] The forecast estimates present future freight flows at five-year increments under three economic growth scenarios (low, mid, and high growth) (FHWA, 2022-02-07).

[24] Available at https://faf.ornl.gov/faf5/dtt_total.aspx.

[25] Available at https://faf.ornl.gov/faf5/SummaryTable.aspx.

[26] It should be noted that "regional" for the FAF database is used to distinguish from "state." A zone in the FAF, called a FAF zone and also called a FAF region, refers to a geography equivalent to a CFS area while a region in the CFS refers to a U.S. Census Region – The U.S. is divided into four Census Regions, West, Midwest, Northeast, and South.

[27] Available at https://faf.ornl.gov/faf5/.

[28] Table 1: Shipment Characteristics by Origin Geography by Destination Geography by FAF Mode by Commodity (non-export shipments only)

Table 1. Mapping Variables Between CFS and FAF

Variable Name		
CFS Special Table[a]	**FAF5.0[b]**	**Variable Definition**
	fr_orig	Foreign origin of shipment
origin	**dms_orig**	Domestic origin of shipment
origin_description		Description of domestic origin
destination	**dms_dest**	Domestic destination of shipment
destination_description		Description of domestic destination
export_country	fr_dest	Foreign destination of shipment
export_country_description		Description of foreign destination
fafmode	**dms_mode**	Domestic transportation mode
fafmode_description		Description of domestic mode
commodity	**sctg2**	Commodity code (2-digit SCTG code)
commodity_description		Description of commodity
	fr_inmode	Foreign inbound mode
	fr_outmode	Foreign outbound mode
naics[c]		North American Industry Classification System
naics_description[c]		Description of NAICS
value_in_millions	**value_2017**	Shipment value (dollars in million)
value_cv		Coefficient of variation of value
tons_in_thousands	**tons_2017**	Shipment weight (tons in 1,000)
tons_cv		Coefficient of variation of weight
unwghtshpcnt		Unweighted shipment count
	trade_type	Type of trade[d]

NOTE: Variables marked in bold are used for this study. Precision measure (i.e., coefficient of variation) is not available in the FAF data.

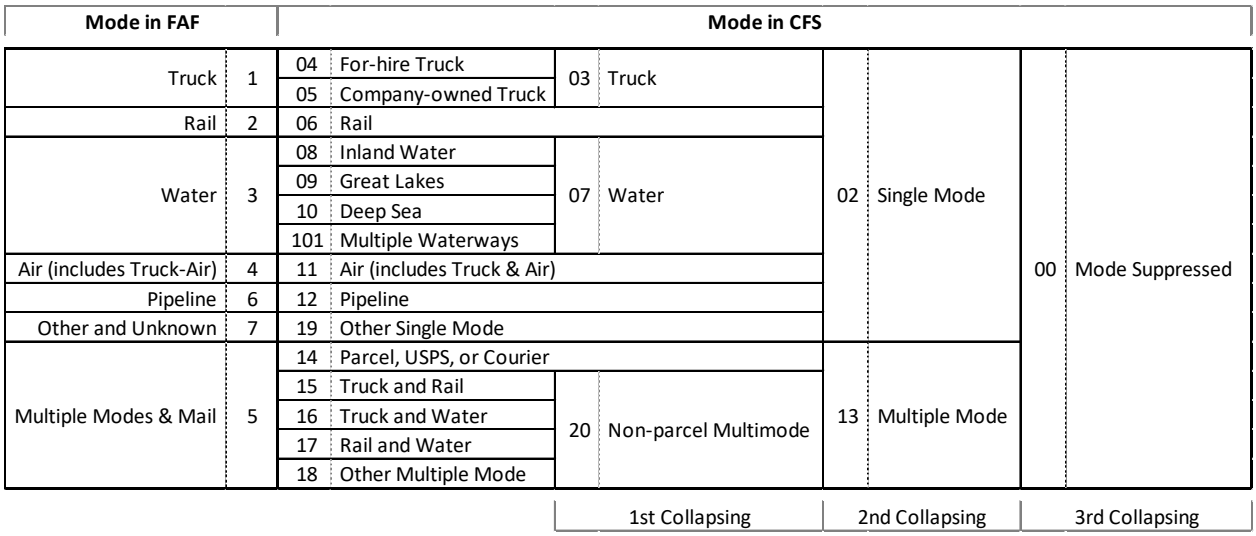
[a] 2017 CFS Special Tables.

[b] FAF5.0 Regional database for 2017 in zipped CSV format.

[c] Not available in the FAF data products.

[d] Three trade types exist: 1 (Domestic Only), 2 (Import), and 3 (Export).

Figure 1. Mapping Transportation Modes Between CFS and FAF



NOTE: CFS modes and collapsing information are found in 2017 Commodity Flow Survey (CFS) Public Use File (PUF) Data Users Guide (BTS and U.S. Census Bureau, 2020-08).

devised by a hierarchical scheme with three collapsing levels[29] where first collapsing occurs for Truck (code 03), Water (code 07), and Non-parcel Multimode (code 20), second collapsing occurs for Single Mode (code 02) and Multiple Mode (code 13), and third collapsing occurs for Mode Suppressed (code 00).

Rail (code 2), Air (code 4), Pipeline (code 6), and Other and Unknown (code 7) in the FAF are matched one-on-one with Rail (code 06), Air (code 11), Pipeline (code 12), and Other Single Mode (code 19) in the CFS, respectively. Truck (code 1) in the FAF corresponds to For-hire Truck (code 04) and Company-owned Truck (code 05) being collapsed into Truck (code 03) in the CFS. Water (code 3) in the FAF corresponds to Inland Water (code 08), Great Lakes (code 09), Deep Sea (code 10), and Multiple Waterways (code 101) being collapsed into Water (code 07) in the CFS. Multiple Modes & Mail (code 5) in the FAF corresponds to Parcel, USPS, or Courier (code 14) and Non-parcel Multimode (code 20) being folded into Multiple Mode (code 13) in the CFS. Non-parcel Multimode (code 20) includes Truck and Rail (code 15), Truck and Water (code 16), Rail and Water (code 17), and Other Multiple Mode (code 18). This mapping was used for creating aggregate statistics by mode for mode-specific comparison in the study.

Table 2 shows mapping between commodity in the CFS Special Tables and sctg2 in the FAF5.0. Since both variables (commodity and sctg2) provide the first-level SCTG[30], called SCTG2[31], they are identical except commodity = 0 being added to indicate a record containing total estimates of all commodities in the CFS Special Tables. It should be noted that sctg2 of FAF5.0 has a leading zero for a single digit.

[29] The three sequential collapsing scheme is used to protect confidentiality for shipment-level records in CFS Public Use File (PUF). For example, the mode of a specific shipment in the PUF would be recoded from Great Lakes (09) to the first collapsing, Water (07), the second collapsing, Single Mode (02), or even the third collapsing, Mode Suppressed (00) to protect confidentiality of the shipment.

[30] Standard Classification of Transported Goods (SCTG) coding system was created jointly be U.S. agencies and Canadian governments to address statistical needs regarding products transported. SCTG uses a five-digit numbering system with four levels of hierarchy and a higher level corresponds to more detailed classifications of commodity (BTS, 2015-07-13).

[31] SCTG2 is the first level, two-digit, SCTG and focuses on alignment between industries and their outputs. More details about SCTG is available at https://www.bts.gov/archive/publications/commodity_flow_survey/hierarchical_features.

Table 2. Mapping Commodities Between CFS and FAF

CFS Special Table commodity	FAF5.0 sctg2	Description
0		Commodity code suppressed (i.e., All Commodities)
1	01	Animals and Fish (Live)
2	02	Cereal Grains (includes Seed)
3	03	Agricultural Products (excludes Animal Feed, Cereal Grains, and Forage Products)
4	04	Animal Feed, Eggs, Honey, and Other Products of Animal Origin
5	05	Meat, Poultry, Fish, Seafood, and Their Preparations
6	06	Milled Grain Products and Preparations, and Bakery Products
7	07	Other Prepared Foodstuffs, and Fats and Oils
8	08	Alcoholic Beverages
9	09	Tobacco Products
10	10	Monumental or Building Stone
11	11	Natural Sands
12	12	Gravel and Crushed Stone (excludes Dolomite and Slate)
13	13	Other Non-Metallic Minerals, not elsewhere classified
14	14	Metallic Ores and Concentrates
15	15	Coal
16	16	Crude Petroleum[a]
17	17	Gasoline, Aviation Turbine Fuel, and Ethanol (includes Kerosene and Fuel Alcohols)
18	18	Fuel Oils (includes Diesel, Bunker C, and Biodiesel)
19	19	Other Coal and Petroleum Products, not elsewhere classified
20	20	Basic Chemicals
21	21	Pharmaceutical Products
22	22	Fertilizers
23	23	Other Chemical Products and Preparations, not elsewhere classified
24	24	Plastics and Rubber
25	25	Logs and Other Wood in the Rough
26	26	Wood Products
27	27	Pulp, Newsprint, Paper, and Paperboard
28	28	Paper or Paperboard Articles
29	29	Printed Products
30	30	Textiles, Leather, and Articles of Textiles or Leather
31	31	Non-Metallic Mineral Products
32	32	Base Metal in Primary or Semi-Finished Forms and in Finished Basic Shapes
33	33	Articles of Base Metal
34	34	Machinery
35	35	Electronic and Other Electrical Equipment and Components, and Office Equipment
36	36	Motorized and Other Vehicles (includes parts)
37	37	Transportation Equipment, not elsewhere classified
38	38	Precision Instruments and Apparatus
39	39	Furniture, Mattresses and Mattress Supports, Lamps, Lighting Fittings, and Illuminated Signs
40	40	Miscellaneous Manufactured Products
41	41	Waste and Scrap (excludes agriculture or food)
43	43	Mixed Freight

[a] Crude petroleum (code 16) is not included in the CFS data products although the CFS collects data in crude petroleum as commodity (See Appendix B for background information). The FAF adds estimates of crude petroleum based on statistics published by the U.S. Energy Information Administration (EIA)[1].

[1] For example, annual production of crude petroleum in Crude Oil Production table of PETROLEUM & OTHER LIQUIDS (https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm) served the primary source for state-level production of crude petroleum.

It is worth noting that the CFS does collect data on crude petroleum (code 16) but has opted to not publish crude petroleum flow estimates. The reason is basically that the CFS does not adequately capture shipments of crude petroleum mainly because crude petroleum industry's operation does not fit well with the CFS survey design (See Appendix B for background information). The FAF flow estimates of crude petroleum are calculated based on statistics published by the U.S. Energy Information Administration (EIA)[32].

3.2 Comparing CFS and FAF

Two metrics are used to compare estimates between CFS and FAF5.0 and they are difference and percentage and they are defined as below:

$$Difference = X_{FAF}^{Domestic} - X_{CFS}^{Domestic} \quad \text{..... Eq. (1)}$$

$$Percentage = \frac{X_{CFS}^{Domestic}}{X_{FAF}^{Domestic}} \times 100\% \quad \text{..... Eq. (2)}$$

where X = estimate, either weight (thousand tons) or value (million 2017$) of freight flows;

$X_{CFS}^{Domestic}$ = of domestic freight flows in the CFS; and

$X_{FAF}^{Domestic}$ = of domestic freight flows in the FAF.

The difference is an amount that a FAF estimate has more than a CFS estimate and should be non-negative since OOS freight flows are added to the CFS to develop the FAF. The percentage is a CFS estimate of an FAF estimate in hundredths and ranges from 0% to 100%. The percentage is used as the main comparison metric while the difference is used to complement when the percentage alone does not provide a full picture. 100% means all FAF freight come from the CFS data while 0% means all FAF freight come entirely from the OOS data implying the CFS makes no contribution to the FAF.

4. Results and Discussion

The FAF5.0 that was developed from 2017 CFS estimates and other external data provides 2017 estimates of freight flows. Since both CFS and FAF data include estimates, not forecasts, for 2017 freight flows and only domestic freight were used in the study, the comparison was anticipated to shed light on the extent of OOS domestic freight flows in the FAF.

4.1 National Totals

Table 3 shows 2017 estimates of total weight and value for domestic freight flows along with differences and percentages of the estimates. The calculated percentages imply that the national domestic totals of the CFS are 68% and 89% of corresponding totals of the FAF in weight and value, respectively. The discrepancy between the CFS and FAF estimates is attributable to OOS freight by design. The percentage in value, 89%, is much higher than that in weight, 68%, implying OOS domestic freight add weights much more than values because some OOS freight has very small or no monetary values yet very large weights. For example, municipal solid waste (MSW) products and construction & demolition debris (C&D) are assumed to have no dollar value (BTS, 2016-09-

[32] Ibid.

Table 3. National Totals of 2017 Domestic Freight Flows in CFS and FAF

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Trade Type	Weight[c]	Value[d]	Weight[c]	Value[d]	Weight[c]	Value[d]	Weight	Value
Domestic Freight	11,886,327	13,443,456	17,477,579	15,081,693	5,591,252	1,638,237	68%	89%

[a] $X_{FAF} - X_{CFS}$ where X = weight or value of domestic freight.

[b] $\{X_{CFS}/X_{FAF}\} \times 100\%$.

[c] tons in thousand.

[d] dollars in million (2017$).

23b) while their weight estimates are included in the FAF; The weight difference in waster/scrap commodity where the MSW and C&D fall into takes up about 15% of the weight difference found in the domestic freight between the CFS and the FAF.

4.2 National Totals by Transportation Mode

National domestic total weights and values were aggregated by transportation mode and Table 4 shows the totals along with the differences and percentages. Pipeline mode shows the smallest percentages, followed by truck mode. CFS domestic total weight and value of freight flows transported by pipeline are about 22% and 41% of corresponding FAF totals, respectively. Crude petroleum and liquified natural gas are mostly transported by pipeline and they are OOS freights. These two OOS commodities contribute to the low CFS coverage in the pipeline-shipped national freight totals. The large difference by pipeline is anticipated due to the fact that crude petroleum (SCTG=16) and liquefied natural gas (SCTG=19) are most likely transported by pipeline and they lacked CFS coverage meaning the OOS portion being considerable.

CFS domestic total weight and value by truck are 74% and 92% of FAF totals, respectively; Most of the OOS freight flows are transported by trucks. Other modes do not see much difference in totals between the CFS and FAF. As for multiple modes & mail, the percentages (i.e., 99.6% in weight and 99.8% in value) being very close to 100% mean that the FAF does not add much OOS shipments. Since the shipments by this mode include USPS and parcel delivery (e.g., UPS, FedEx, and local delivery services) shipments by households, government, retail, and service establishments, the percentage seems too high. This implies that the FAF may have not been able to add adequate amounts of OOS shipments especially shipped by mail.

In 2017 CFS, it is noteworthy that about 74%[33] of the CFS domestic freight in terms of weight were transported by truck mode, 10% by rail, 6% by pipeline, 5% by water, and 5% by the others. Since the majority of freight flows are transported by truck, analysis involving highway traffic could see sizable difference in freight flow estimates from the CFS data compared to those from the FAF data.

[33] (National Total Weight by Truck ÷ National Total Weight by All Modes) ×100% = (8,771,465 ÷11,886,327) ×100% = 73.8% ≈ 74%.

Table 4. National Totals of 2017 Domestic Freight of CFS and FAF by Transportation Mode

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Transportation Mode	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight**	**Value**
All Modes	**11,886,327**	**13,443,456**	**17,477,579**	**15,081,693**	**5,591,251.9**	**1,638,237.5**	**68.0%**	**89.1%**
Truck	8,771,465	10,189,437	11,848,259	11,296,584	3,076,794.2	1,107,147.0	74.0%	90.2%
Rail	1,178,808	223,038	1,202,016	227,296	23,207.8	4,257.5	98.1%	98.1%
Water	608,575	167,277	662,453	184,011	53,877.9	16,733.7	91.9%	90.9%
Air (including truck-air)	2,137	158,996	2,136	159,129	-0.8	133.4	100.0%	99.9%
Multiple Modes & Mail	533,930	2,358,255	536,088	2,361,901	2,157.6	3,645.7	99.6%	99.8%
Pipeline	697,778	344,357	3,132,993	850,678	2,435,214.9	506,321.1	22.3%	40.5%
Other and Unknown	93,634	2,095	93,634	2,095	0.4	0.0	100.0%	100.0%

[a] $X_{FAF} - X_{CFS}$ where X = weight or value of domestic freight.

[b] $\{X_{CFS}/X_{FAF}\} \times 100\%$.

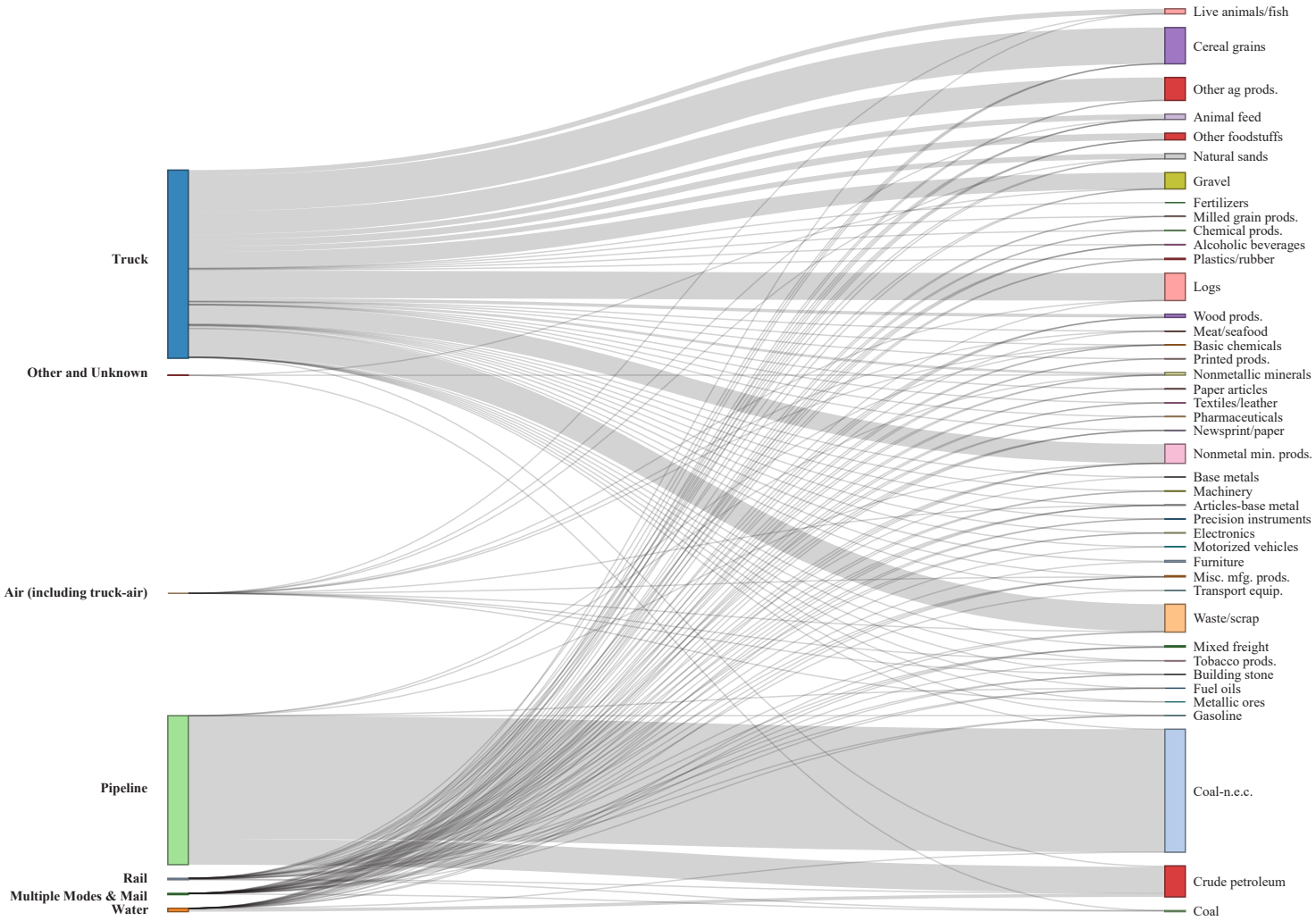
[c] tons in thousand.

[d] dollars in million (2017$).

4.2.1 Totals by Mode by Commodity

Differences in weight between the CFS and FAF by mode are further examined by commodity to understand where the differences by mode exist. Figure 2 shows a Sankey diagram providing an overall picture of the differences distributed across commodities. As seen in the figure, truck and pipeline (left end of the diagram) show large differences in total weights between the CFS and FAF; Please note that the bandwidth of flows between mode and commodity ends represents a difference in weight between the CFS and FAF. Among commodities transported by truck, six commodities (Cereal grains, Other ag. prods, Gravel, Logs, Nonmetal min. prods., and Waste/scrap) contribute the most to the difference. As for pipeline, two commodities (Coal-n.e.c. and Crude petroleum) contribute almost all the difference.

Figure 2. Sankey Diagram of Weight Difference between CFS and FAF by Mode by Commodity



NOTE: A bandwidth of a flow represents a difference in total weight between the CFS and FAF.

Table 5 shows commodities with CFS coverage being less than 80% and lists commodities for each mode in ascending order by percentage in weight.

4.3. National Totals by Commodity

Table 6 shows domestic totals, differences, and percentages of the CFS and FAF estimates by commodity and lists commodities in ascending order by percentage in weight. Crude petroleum is OOS in its entirety. Thus, the percentages in weight and value are zero meaning no CFS contribution to the FAF. The FAF process estimates freight flows of crude petroleum using petroleum statistics from the U.S. Energy Information Administration (EIA).

Table 5. Totals of 2017 Domestic Freight of CFS and FAF by Mode by Commodity

		CFS		FAF5.0		Difference[a]		Percentage[b]	
Mode	Commodity	Weight[c]	Valued	Weight[c]	Value[d]	Weight[c]	Value[d]	Weight	Value
Truck	Crude petroleum	0	0	16,669	5,236	16,669	5,236	0%	0%
	Logs	20,179	5,006	467,511	12,219	447,332	7,213	4%	41%
	Live animals/fish	4,512	10,203	88,489	174,081	83,977	163,878	5%	6%
	Waste/scrap	142,217	41,334	588,625	41,280	446,408	-54	24%	100%
	Other ag prods.	196,025	175,995	571,248	298,788	375,223	122,793	34%	59%
	Cereal grains	386,511	59,099	979,648	122,403	593,137	63,304	39%	48%
	Furniture	24,745	152,882	50,542	282,486	25,797	129,604	49%	54%
	Nonmetal min. prods.	860,270	180,672	1,174,204	223,321	313,934	42,649	73%	81%
	Animal feed	278,283	117,509	366,200	129,098	87,917	11,589	76%	91%
	Misc. mfg. prods.	71,843	308,958	90,697	397,570	18,854	88,612	79%	78%
	Nonmetallic minerals	161,253	18,585	201,862	19,998	40,609	1,413	80%	93%
Rail	Building stone	0	0	21	1	21	1	0%	0%
	Crude petroleum	0	0	13,487	4,236	13,487	4,236	0%	0%
	Waste/scrap	18,573	4,866	28,285	4,866	9,712	0	66%	100%
Water	Precision instruments	0	0	2	6	2	6	0%	0%
	Crude petroleum	0	0	54,719	17,427	54,719	17,427	0%	0%
Air (including truck-air)	Animal feed	0	4	0	4	0	0	0%	101%
	Metallic ores	0	443	3	441	3	-2	0%	100%
Multiple Modes & Mail	Live animals/fish	0	0	41	483	41	483	0%	0%
	Building stone	0	0	199	109	199	109	0%	0%
	Coal	0	0	17,994	310	17,994	310	0%	0%
	Logs	0	0	500	198	500	198	0%	0%
Pipeline	Crude petroleum	0	0	422,684	134,748	422,684	134,748	0%	0%
	Coal-n.e.c.	47,351	23,031	2,058,683	393,925	2,011,332	370,894	2%	6%

NOTE: Commodities with CFS coverage being less than 80% are presented.

[a] $X_{FAF} - X_{CFS}$ where X = weight or value of domestic freight.

[b] $\{X_{CFS}/X_{FAF}\} \times 100\%$.

[c] tons in thousand.

[d] dollars in million (2017$).

Table 6. National Totals of 2017 Domestic Freight of CFS and FAF by Commodity

	CFS Special Table		FAF5.0		Difference[a]		Percentage[b]	
Commodity (SCTG2)	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight**	**Value**
All Commodities	**11,886,327**	**13,443,456**	**17,477,579**	**15,081,693**	**5,591,252.0**	**1,638,237.4**	**68.0%**	**89.1%**
Crude petroleum	0	0	507,559	161,646	507,559	161,646	0.0%	0.0%
Logs	23,193	5,678	470,530	12,893	447,337.1	7,215.1	4.9%	44.0%
Live animals/fish	4,528	10,603	88,533	174,600	84,005.2	163,996.8	5.1%	6.1%
Coal-n.e.c.	526,851	250,171	2,538,185	621,066	2,011,333.9	370,894.7	20.8%	40.3%
Waste/scrap	185,805	52,589	642,278	52,536	456,472.7	-53.2	28.9%	100.1%
Other ag prods.	272,540	210,107	648,010	333,167	375,469.6	123,060.4	42.1%	63.1%
Furniture	26,197	172,586	52,116	302,793	25,918.8	130,207.3	50.3%	57.0%
Cereal grains	618,233	93,471	1,211,379	156,787	593,146.0	63,316.4	51.0%	59.6%
Nonmetal min. prods.	911,644	194,669	1,226,751	237,528	315,106.9	42,859.3	74.3%	82.0%
Animal feed	314,662	127,042	402,596	138,668	87,933.7	11,626.3	78.2%	91.6%
Misc. mfg. prods.	79,323	557,646	98,253	646,807	18,929.9	89,160.9	80.7%	86.2%
Other foodstuffs	517,715	592,481	628,505	636,313	110,790.3	43,832.3	82.4%	93.1%
Nonmetallic minerals	207,828	22,704	248,518	24,128	40,690.4	1,423.9	83.6%	94.1%
Precision instruments	6,580	319,292	7,778	340,992	1,197.9	21,699.7	84.6%	93.6%
Wood prods.	310,598	214,625	363,989	235,837	53,391.4	21,211.9	85.3%	91.0%
Building stone	13,937	7,060	16,261	7,119	2,324.3	58.9	85.7%	99.2%
Natural sands	525,160	11,663	612,614	11,760	87,453.8	97.2	85.7%	99.2%
Gravel	1,613,163	19,583	1,881,755	19,746	268,591.8	163.1	85.7%	99.2%
Electronics	52,644	968,044	59,742	1,062,478	7,097.9	94,434.3	88.1%	91.1%
Textiles/leather	36,350	488,082	40,962	521,513	4,612.4	33,431.0	88.7%	93.6%
Plastics/rubber	207,669	598,340	227,654	668,938	19,985.0	70,598.1	91.2%	89.4%
Chemical prods.	115,719	387,936	125,530	392,341	9,810.8	4,405.1	92.2%	98.9%
Machinery	87,580	767,622	93,886	813,526	6,305.6	45,904.0	93.3%	94.4%
Printed prods.	27,426	130,156	29,348	135,335	1,922.2	5,178.5	93.5%	96.2%
Articles-base metal	121,671	373,497	128,878	394,904	7,206.9	21,407.4	94.4%	94.6%
Mixed freight	402312	1436458	424,024	1,490,998	21,711.7	54,539.9	94.9%	96.3%
Paper articles	77,473	145,205	81,336	151,744	3,862.6	6,538.6	95.3%	95.7%
Milled grain prods.	127,851	193,799	132,182	200,636	4,330.5	6,836.9	96.7%	96.6%
Alcoholic beverages	109,482	222,441	113,083	229,276	3,601.0	6,835.0	96.8%	97.0%
Newsprint/paper	126,773	117,823	130,318	121,750	3,545.1	3,926.7	97.3%	96.8%
Meat/seafood	88,768	342,881	90,506	349,717	1,737.8	6,835.6	98.1%	98.0%
Motorized vehicles	157,113	1,124,600	159,192	1,140,258	2,079.2	15,657.8	98.7%	98.6%
Transport equip.	5,896	181,280	5,956	183,320	60.2	2,039.8	99.0%	98.9%
Tobacco prods.	4,579	78,760	4,624	80,097	44.9	1,336.9	99.0%	98.3%
Basic chemicals	392,924	254,691	396,358	257,501	3,433.8	2,809.7	99.1%	98.9%
Pharmaceuticals	18,546	1,046,145	18,689	1,048,982	143.0	2,837.4	99.2%	99.7%
Base metals	318,362	436,517	320,455	436,775	2,093.0	258.2	99.3%	99.9%
Metallic ores	53,538	19,517	53,538	19,517	0.2	0.1	100.0%	100.0%
Gasoline	1,366,719	734,578	1,366,725	734,582	5.6	3.6	100.0%	100.0%
Coal	790,369	25,380	790,372	25,380	3.3	0.1	100.0%	100.0%
Fuel oils	874,782	452,496	874,786	452,498	3.6	2.2	100.0%	100.0%
Fertilizers	163,827	55,241	163,827	55,241	-0.1	0.1	100.0%	100.0%

NOTE: Commodities are listed in ascending order by percentage in weight.

[a] $X_{FAF} - X_{CFS}$ where X = weight or value of domestic freight.

[b] $\{X_{CFS}/X_{FAF}\} \times 100\%$.

[c] tons in thousand.

[d] dollars in million (2017$).

The CFS covers more than 80% in weight and value for 32 and 35 out of 42 commodities, respectively. Differences in the CFS and FAF are attributable to the OOS freight. For example, the FAF collects data on farm-based products affecting five commodities (Live animals/fish, Cereal grains, Other ag prods., Animal feed, and Other foodstuffs) and fishery products affecting one commodity (Live animals/fish); thus, the differences in domestic freight flows between the CFS and FAF are attributable to data collected on OOS freight flows. For example of logs commodity where the CFS covers only 5% of the FAF in weight, the CFS surveys log processing establishments thus captures shipments of logs from a log processing facility such as a sawmill to the next destination such as timber warehouse. However, the CFS does not capture shipments of logs from logging sites to log processing facilities. The FAF uses multiple sources to capture OOS logs freight flows such as Forest Inventory and Analysis (FIA) data produced by the U.S. Forest Service[34].

Two commodities have negative differences. Waste/scrap commodity has the difference of -53.2 million dollars in its value and Fertilizers commodity has the difference of -0.1 thousand tons in its weight. In the waste/scrap commodity, OOS data on municipal solid wastes added weight to the CFS yet did not add any value; Much of added weight in the waste/scrap commodity would be conjectured to come from municipal solid wastes. By definition of Equation 1, a negative difference means that a FAF estimate is lower than a CFS estimate, which is not feasible in theory since the FAF adds OOS freights to the CFS.

However, the FAF process makes several adjustments on the CFS and OOS freight flows to develop the final FAF database and these negative numbers are believed to be a byproduct of these adjustments. Specifically, the FAF process makes imputation on suppressed cells in the CFS Special Tables due to confidentiality and the high level of sampling error (i.e., CV higher than 100%). Using marginal totals from the CFS Special Tables, the FAF process imputes those suppressed cells and adjusts all the cells for the marginal totals by applying Iterative Proportional Fitting (IPF), called raking, in series. In addition, the FAF process makes several additional adjustments such as adjustment for implausible mode combination for certain commodity or origin-destination pairs to produce final aggregate-level datasets and statistics.

The negative differences in the two commodities are about 0.1% or less of the CFS estimates and each of the two commodities constitutes less than 2% of the total estimates of all the commodities. Thus, they are unlikely to pose a concern in using the estimates for national or state-level analysis. It should be noted that these differences were found in FAF5.0, the first release of the FAF database[35].

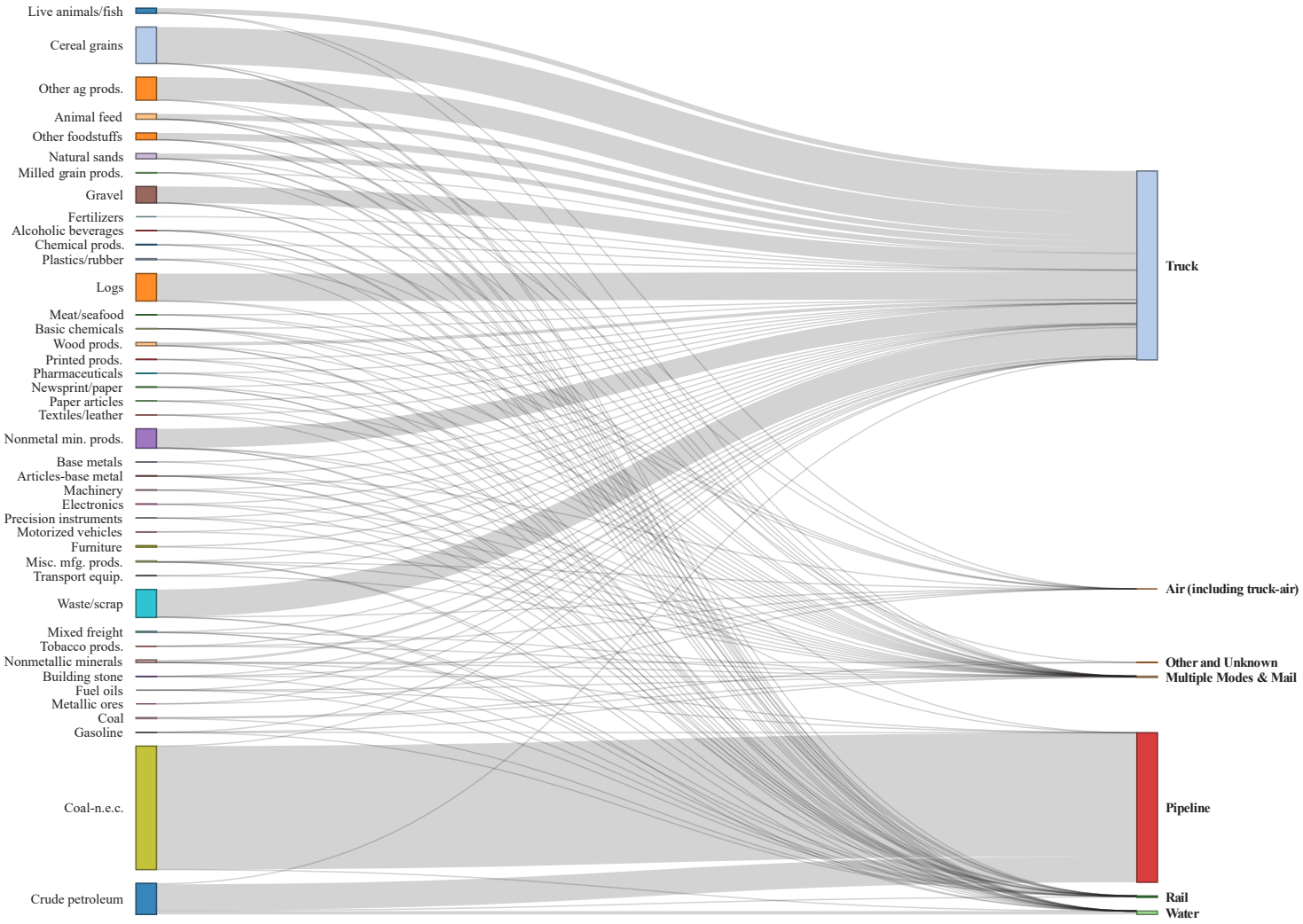
4.3.1 Totals by Commodity by Mode

Differences in weight between the CFS and FAF by commodity are further examined by commodity to understand where the differences by mode exist. Figure 3 shows a Sankey diagram providing an overall picture of the differences distributed across modes. It carries basically the same information as in Figure 2 (mirror image switching the ends horizontally) but is presented for easier understanding. Eight commodities (Cereal grains, Other ag. prods, Gravel, Logs, Nonmetal min. prods., Waste/scrap, Coal-n.e.c., and Crude petroleum) contribute the most to the difference. Coal-n.e.c. (i.e., Other Coal and Petroleum Products, not elsewhere classified: SCTG 19) shows the largest difference and is mostly liquefied natural gas via pipeline and asphalt by other modes. Cereal grains show the second largest difference among the commodities and its differenced weight was assigned mostly to truck mode.

[34] U.S. Forest Service. (2020-04-14). *Forest Inventory and Analysis*. U.S. Department of Agriculture, Washington, DC. Accessed 2021-06-21 from https://www.fia.fs.fed.us/.

[35] An adjustment of 53.2 million dollar increase was made to Waste/Scrap commodity (SCTG 41) in FAF5.3 release. This adjustment resolved the difference found in the value of the commodity between the CFS and FAF5.0.

Figure 3. Sankey Diagram of Weight Difference between CFS and FAF by Commodity by Mode



NOTE: A bandwidth of a flow represents a difference in total weight between the CFS and FAF.

Table 7 shows 10 commodities with CFS coverage being less than 80% found in Table 6 but further divides by mode. Modes for each commodity are listed in ascending order by percentage in weight and in descending order by difference in weight. Farm-based products are likely to be shipped by truck and/or rail. The differenced weights for these commodities (e.g., Cereal grains and Other ag prods.) are found to be assigned almost entirely to truck mode.

4.4 Totals by Origin State

Table 8 shows totals, differences, and percentages of the CFS and FAF weight and value estimates by origin state and lists states in ascending order by percentage in weight; District of Columbia is treated as a state in this analysis. The CFS coverage percentages in weight range from 35% (Mississippi) to 80% (Hawaii) while the percentages in value range from 49% (North Dakota) to 94% (New Jersey). A state with less than 50% in weight percentage comprises only up to 1% of the national domestic total weight of the CFS; For example, freight weights of Mississippi and Alaska are 0.8% and 0.2% of the national domestic total weight in the CFS, respectively. There is only one state with 80% or higher in weight percentage (Hawaii). This means that all 51 states including District of Columbia are quite substantially affected in freight totals at state level by OOS freight flows. This further implies that state-level analysis could potentially make a sizable difference in its results depending on which freight data source (CFS or FAF) is used for analysis, especially states with a lower percentage.

Table 7. Totals of 2017 Domestic Freight of CFS and FAF by Commodity by Mode

		CFS		FAF5.0		Difference[a]		Percentage[b]	
Commodity	Mode	Weight[c]	Valued	Weight[c]	Value[d]	Weight[c]	Value[d]	Weight	Value
Crude petroleum	Pipeline	0	0	422,684	134,748	422,684	134,748	0%	0%
	Water	0	0	54,719	17,427	54,719	17,427	0%	0%
	Truck	0	0	16,669	5,236	16,669	5,236	0%	0%
	Rail	0	0	13,487	4,236	13,487	4,236	0%	0%
Logs	Multiple Modes & Mail	0	0	500	198	500	198	0%	0%
	Truck	20,179	5,006	467,511	12,219	447,332	7,213	4%	41%
	Rail	2,520	476	2,519	476	-1	0	100%	100%
Live animals/fish	Multiple Modes & Mail	0	0	41	483	41	483	0%	0%
	Truck	4,512	10,203	88,489	174,081	83,977	163,878	5%	6%
	Air (including truck-air)	3	36	3	36	0	0	99%	100%
Coal-n.e.c.	Pipeline	47,351	23,031	2,058,683	393,925	2,011,332	370,894	2%	6%
	Truck	321,184	182,372	321,189	182,374	5	2	100%	100%
	Water	84,791	18,923	84,791	18,923	0	0	100%	100%
	Rail	50,507	14,277	50,506	14,277	-1	0	100%	100%
	Multiple Modes & Mail	23,014	11,550	23,013	11,550	-1	0	100%	100%
	Air (including truck-air)	3	17	3	17	0	0	100%	100%
Waste/scrap	Truck	142,217	41,334	588,625	41,280	446,408	-54	24%	100%
	Rail	18,573	4,866	28,285	4,866	9,712	0	66%	100%
	Water	12,014	3,350	12,368	3,350	354	0	97%	100%
	Multiple Modes & Mail	13,001	3,040	13,000	3,040	-1	0	100%	100%
Other ag prods.	Truck	196,025	175,995	571,248	298,788	375,223	122,793	34%	59%
	Multiple Modes & Mail	8,565	11,300	8,810	11,567	245	267	97%	98%
	Water	34,122	11,492	34,123	11,492	1	0	100%	100%
	Rail	33,804	11,126	33,803	11,126	-1	0	100%	100%
	Air (including truck-air)	25	194	25	194	0	0	100%	100%
Furniture	Truck	24,745	152,882	50,542	282,486	25,797	129,604	49%	54%
	Multiple Modes & Mail	1,418	19,136	1,539	19,736	121	600	92%	97%
	Air (including truck-air)	31	544	31	546	0	2	100%	100%
	Rail	3	21	3	21	0	0	100%	100%
	Water	1	4	1	4	0	0	100%	100%
Cereal grains	Truck	386,511	59,099	979,648	122,403	593,137	63,304	39%	48%
	Rail	146,234	21,637	146,241	21,637	7	0	100%	100%
	Water	50,949	7,236	50,951	7,236	2	0	100%	100%
	Multiple Modes & Mail	34,539	5,498	34,540	5,511	1	13	100%	100%
Nonmetal min. prods.	Truck	860,270	180,672	1,174,204	223,321	313,934	42,649	73%	81%
	Multiple Modes & Mail	18,964	10,731	20,137	10,910	1,173	179	94%	98%
	Pipeline	18	2	18	2	0	0	100%	100%
	Water	6,858	567	6,858	567	0	0	100%	100%
	Rail	25,109	2,066	25,109	2,066	0	0	100%	100%
	Air (including truck-air)	425	630	424	662	-1	32	100%	95%
Animal feed	Air (including truck-air)	0	4	0	4	0	0	0%	101%
	Truck	278,283	117,509	366,200	129,098	87,917	11,589	76%	91%
	Multiple Modes & Mail	20,559	6,988	20,575	7,026	16	38	100%	99%
	Water	4,344	568	4,344	568	0	0	100%	100%
	Rail	11,477	1,972	11,477	1,972	0	0	100%	100%

NOTE: 10 commodities with CFS coverage being less than 80% found in Table 6 are presented.

[a] $X_{FAF} - X_{CFS}$ where X = weight or value of domestic freight.

[b] $\{X_{CFS}/X_{FAF}\} \times 100\%$.

[c] tons in thousand.

[d] dollars in million (2017$).

Table 8. Totals of 2017 Domestic Freight of CFS and FAF by Origin State

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Origin State	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight**	**Value**
All States	**11,886,319**	**13,443,448**	**17,477,579**	**15,081,693**	**5,591,260**	**1,638,245**	**68.0%**	**89.1%**
Mississippi	90,014	132,632	258,021	169,408	168,007	36,776	34.9%	78.3%
Alaska	18,404	15,250	50,070	27,026	31,666	11,776	36.8%	56.4%
Idaho	58,145	47,385	145,840	63,158	87,695	15,773	39.9%	75.0%
North Dakota	123,139	42,901	298,911	87,700	175,772	44,799	41.2%	48.9%
Nevada	39,801	51,659	95,112	63,210	55,311	11,551	41.8%	81.7%
District of Columbia	2,724	2,273	6,393	3,877	3,669	1,604	42.6%	58.6%
New Mexico	56,793	32,209	132,394	52,518	75,601	20,309	42.9%	61.3%
Colorado	147,524	164,784	289,413	205,348	141,889	40,564	51.0%	80.2%
South Dakota	77,345	36,025	145,867	51,751	68,522	15,726	53.0%	69.6%
Alabama	191,025	216,308	354,396	248,762	163,371	32,454	53.9%	87.0%
Nebraska	183,535	104,817	325,863	140,945	142,328	36,128	56.3%	74.4%
Oklahoma	173,365	129,267	304,395	168,764	131,030	39,497	57.0%	76.6%
Oregon	120,386	132,076	210,063	151,399	89,677	19,323	57.3%	87.2%
Montana	67,996	24,303	117,700	35,126	49,704	10,823	57.8%	69.2%
Arkansas	140,641	111,632	235,277	136,746	94,636	25,114	59.8%	81.6%
Maine	38,436	35,362	64,251	40,337	25,815	4,975	59.8%	87.7%
South Carolina	123,180	186,094	199,992	202,939	76,812	16,845	61.6%	91.7%
Iowa	317,952	199,358	501,033	244,861	183,081	45,503	63.5%	81.4%
Louisiana	417,057	245,471	652,347	299,415	235,290	53,944	63.9%	82.0%
Kansas	217,740	184,890	340,209	221,822	122,469	36,932	64.0%	83.4%
Utah	108,055	121,938	166,353	139,486	58,298	17,548	65.0%	87.4%
Georgia	265,898	455,946	405,360	494,169	139,462	38,223	65.6%	92.3%
Minnesota	356,367	281,383	543,088	323,793	186,721	42,410	65.6%	86.9%
New York	312,589	543,476	474,440	599,434	161,851	55,958	65.9%	90.7%
Washington	235,656	299,100	356,453	331,772	120,797	32,672	66.1%	90.2%
Maryland	117,459	151,164	177,261	169,445	59,802	18,281	66.3%	89.2%
Pennsylvania	410,675	596,539	617,636	655,572	206,961	59,033	66.5%	91.0%
Arizona	113,345	165,331	169,708	187,053	56,363	21,722	66.8%	88.4%
Rhode Island	19,689	44,392	29,425	47,167	9,736	2,775	66.9%	94.1%
Vermont	14,785	22,850	21,978	25,002	7,193	2,152	67.3%	91.4%
New Hampshire	35,493	47,360	51,759	52,666	16,266	5,306	68.6%	89.9%
Florida	433,234	477,328	620,332	539,548	187,098	62,220	69.8%	88.5%
California	719,097	1,506,578	1,023,313	1,649,192	304,216	142,614	70.3%	91.4%
North Carolina	230,770	408,345	325,613	444,172	94,843	35,827	70.9%	91.9%
New Jersey	196,905	440,894	276,502	467,342	79,597	26,448	71.2%	94.3%
Tennessee	251,655	383,782	352,450	410,412	100,795	26,630	71.4%	93.5%
Connecticut	86,924	168,240	121,345	179,195	34,421	10,955	71.6%	93.9%
Virginia	230,601	248,081	316,926	276,442	86,325	28,361	72.8%	89.7%
Missouri	237,129	271,117	325,510	300,314	88,381	29,197	72.8%	90.3%
Kentucky	241,112	239,742	324,121	262,601	83,009	22,859	74.4%	91.3%
Ohio	486,745	574,727	651,206	624,270	164,461	49,543	74.7%	92.1%
Indiana	408,183	412,142	545,491	448,444	137,308	36,302	74.8%	91.9%
Delaware	28,946	52,490	38,618	56,585	9,672	4,095	75.0%	92.8%
West Virginia	168,859	51,652	224,987	63,015	56,128	11,363	75.1%	82.0%
Massachusetts	130,705	249,382	173,902	269,560	43,197	20,178	75.2%	92.5%
Illinois	663,398	767,161	860,589	824,016	197,191	56,855	77.1%	93.1%
Michigan	350,826	500,471	450,862	533,359	100,036	32,888	77.8%	93.8%
Texas	1,759,317	1,515,320	2,253,671	1,691,932	494,354	176,612	78.1%	89.6%
Wyoming	300,124	20,672	384,052	38,890	83,928	18,218	78.1%	53.2%
Wisconsin	339,461	308,367	433,366	335,745	93,905	27,378	78.3%	91.8%
Hawaii	27,115	22,782	33,715	25,987	6,600	3,205	80.4%	87.7%

NOTE: District of Columbia is treated as a state.

[a] $X_{FAF} - X_{CFS}$ where X = weight or value of domestic freight.

[b] $\{X_{CFS}/X_{FAF}\} \times 100\%$.

[c] tons in thousand.

[d] dollars in million (2017$).

4.5 Totals by Origin Area

There are 132 origin areas and these areas are the same in the CFS and FAF; the FAF calls them "Zones"[36] while the CFS calls them "Areas." Table 9 shows totals and fractions of CFS and FAF weight and value estimates by origin area and list areas in ascending order by percentage in weight. The percentages in weight range from lower 30% (e.g., Rest of Louisiana; Mobile, Alabama; Mississippi; and Alaska) to over 90% (e.g., Chicago IL-IN-WI, Indiana Part; Houston, Texas; and San Antonio, Texas). The percentages in value range from 49% (North Dakota) to 98% (Memphis TN-MS-AR, Tennessee part). Among the 132 areas, 37 areas have 80% or higher in weight and 14 areas have 50% or less. An area with a low percentage should be careful in analyzing freight flows using the CFS since analysis results could be considerably different from those using the FAF. An area with a high percentage may not see much difference in analysis based on the CFS data compared to that based on the FAF data.

[36] A FAF zone is also called a FAF region. It should be noted that a FAF region is different from a region in the CFS Special Tables since a region in the CFS Special Tables refers to a Census Region while a FAF region corresponds to a CFS area.

Table 9. Totals of 2017 Domestic Freight of CFS and FAF by Origin Area

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Origin Area	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight**	**Value**
All Areas	**11,886,328**	**13,443,457**	**17,477,579**	**15,081,693**	**5,591,251**	**1,638,236**	**68.0%**	**89.1%**
Rest of LA	67,235	52,349	228,173	86,979	160,938	34,630	29.5%	60.2%
Mobile AL	21,164	19,654	68,651	28,411	47,487	8,757	30.8%	69.2%
Mississippi	90,013	132,633	257,842	169,150	167,829	36,517	34.9%	78.4%
Alaska	18,408	15,250	50,070	27,026	31,662	11,776	36.8%	56.4%
Las Vegas NV-AZ (NV Part)	17,997	23,614	48,314	29,929	30,317	6,315	37.3%	78.9%
Idaho	58,148	47,382	145,840	63,158	87,692	15,776	39.9%	75.0%
North Dakota	123,139	42,898	298,911	87,700	175,772	44,802	41.2%	48.9%
Washington DC-VA-MD-WV (DC Part)	2,731	2,287	6,393	3,877	3,662	1,590	42.7%	59.0%
New Mexico	56,798	32,204	132,389	52,509	75,591	20,305	42.9%	61.3%
Rest of UT	33,506	16,662	77,001	28,080	43,495	11,418	43.5%	59.3%
Rest of OR	51,050	35,752	113,780	46,514	62,730	10,762	44.9%	76.9%
Rest of OK	86,454	44,875	186,275	72,480	99,821	27,605	46.4%	61.9%
Rest of NV	21,801	28,047	46,798	33,280	24,997	5,233	46.6%	84.3%
Denver CO	71,971	124,509	146,051	147,810	74,080	23,301	49.3%	84.2%
Rest of NE	132,010	70,893	263,003	103,646	130,993	32,753	50.2%	68.4%
Rest of WA	81,652	62,933	156,823	80,608	75,171	17,675	52.1%	78.1%
Rest of CO	75,556	40,278	143,362	57,538	67,806	17,260	52.7%	70.0%
Rest of MN	162,549	88,851	307,766	116,611	145,217	27,760	52.8%	76.2%
Laredo TX	15,207	8,599	28,767	11,581	13,560	2,982	52.9%	74.2%
South Dakota	77,343	36,028	145,867	51,751	68,524	15,723	53.0%	69.6%
Rest of CA	111,625	135,612	208,031	181,025	96,406	45,413	53.7%	74.9%
Rest of AL	109,849	130,335	202,745	148,815	92,896	18,480	54.2%	87.6%
Fresno CA	16,597	30,219	30,041	39,563	13,444	9,344	55.2%	76.4%
Rest of TX	423,324	275,853	762,560	391,022	339,236	115,169	55.5%	70.5%
Rest of NY	75,188	109,087	135,148	124,025	59,960	14,938	55.6%	88.0%
Kansas City MO-KS (MO Part)	42,872	57,226	76,986	66,311	34,114	9,085	55.7%	86.3%
Washington DC-VA-MD-WV (MD Part)	35,081	32,039	62,571	39,482	27,490	7,443	56.1%	81.1%
Rest of AZ	28,432	16,668	50,074	23,232	21,642	6,564	56.8%	71.7%

(continued next page)

Table 9. Totals of 2017 Domestic Freight of CFS and FAF by Origin Area (con't)

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Origin Area	Weight[c]	Value[d]	Weight[c]	Value[d]	Weight[c]	Value[d]	Weight	Value
Rest of SC	74,052	85,005	130,335	96,083	56,283	11,078	56.8%	88.5%
Nashville TN	73,482	106,461	129,052	118,851	55,570	12,390	56.9%	89.6%
Montana	67,996	24,303	117,700	35,126	49,704	10,823	57.8%	69.2%
Rest of KS	142,185	83,596	241,472	113,230	99,287	29,634	58.9%	73.8%
Rest of PA	199,604	272,093	334,247	304,875	134,643	32,782	59.7%	89.2%
Arkansas	140,644	111,632	235,259	136,723	94,615	25,091	59.8%	81.6%
Maine	38,436	35,363	64,251	40,337	25,815	4,974	59.8%	87.7%
Tampa FL	52,112	72,886	86,295	85,035	34,183	12,149	60.4%	85.7%
Rest of NH	6,933	7,647	11,403	8,505	4,470	858	60.8%	89.9%
Orlando FL	43,890	80,848	70,874	90,620	26,984	9,772	61.9%	89.2%
Rest of GA	117,566	126,744	189,499	142,619	71,933	15,875	62.0%	88.9%
Savannah GA	21,520	27,030	34,048	29,763	12,528	2,733	63.2%	90.8%
Iowa	317,956	199,357	501,027	244,852	183,071	45,495	63.5%	81.4%
Oklahoma City OK	31,821	39,167	50,058	46,388	18,237	7,221	63.6%	84.4%
New York NY-NJ-CT-PA (NJ Part)	126,694	344,245	199,121	366,696	72,427	22,451	63.6%	93.9%
New York NY-NJ-CT-PA (CT Part)	43,197	70,603	67,753	77,782	24,556	7,179	63.8%	90.8%
Rest of IN	195,979	165,044	299,823	188,428	103,844	23,384	65.4%	87.6%
Pittsburgh PA-OH-WV (PA Part)	89,000	99,619	135,767	112,099	46,767	12,480	65.6%	88.9%
Portland OR-WA (WA Part)	14,438	18,724	21,977	20,084	7,539	1,360	65.7%	93.2%
New York NY-NJ-CT-PA (NY Part)	120,738	300,056	183,016	328,204	62,278	28,148	66.0%	91.4%
Baltimore MD	44,026	94,488	66,708	101,932	22,682	7,444	66.0%	92.7%
Rest of OH	205,227	147,664	310,899	172,086	105,672	24,422	66.0%	85.8%
Boston MA-RI-NH-CT (RI Part)	19,691	44,391	29,424	47,166	9,733	2,775	66.9%	94.1%
Vermont	14,785	22,850	21,978	25,001	7,193	2,151	67.3%	91.4%
Rest of DE	7,616	9,320	11,315	10,811	3,699	1,491	67.3%	86.2%
Washington DC-VA-MD-WV (VA Part)	39,414	53,878	58,038	61,242	18,624	7,364	67.9%	88.0%
Buffalo NY	34,083	46,438	49,842	51,247	15,759	4,809	68.4%	90.6%
Rest of NC	108,819	142,328	158,946	160,418	50,127	18,090	68.5%	88.7%
Charlotte NC-SC (NC Part)	40,103	86,044	58,261	93,308	18,158	7,264	68.8%	92.2%
Charleston SC	18,798	26,808	27,291	28,994	8,493	2,186	68.9%	92.5%
San Diego CA	33,023	86,472	47,627	93,297	14,604	6,825	69.3%	92.7%
Greensboro-Winston-Salem-High Point NC	32,029	107,430	45,904	112,447	13,875	5,017	69.8%	95.5%
Atlanta GA	126,814	302,170	181,698	321,626	54,884	19,456	69.8%	94.0%
Rest of KY	172,266	127,755	245,010	146,148	72,744	18,393	70.3%	87.4%
Boston MA-RI-NH-CT (NH Part)	28,555	39,714	40,349	44,142	11,794	4,428	70.8%	90.0%
Rest of MI	152,532	133,338	215,462	148,224	62,930	14,886	70.8%	90.0%
Tucson AZ	13,865	15,417	19,546	17,934	5,681	2,517	70.9%	86.0%
Phoenix AZ	71,046	133,247	100,086	145,883	29,040	12,636	71.0%	91.3%
Rest of FL	166,176	117,751	234,048	136,440	67,872	18,689	71.0%	86.3%
Greenville SC	30,330	74,279	42,366	77,861	12,036	3,582	71.6%	95.4%
Kansas City MO-KS (KS Part)	34,174	59,183	47,727	63,765	13,553	4,582	71.6%	92.8%
Birmingham AL	60,013	66,319	83,568	72,564	23,555	6,245	71.8%	91.4%

(continued next page)

Table 9. Totals of 2017 Domestic Freight of CFS and FAF by Origin Area (con't)

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Origin Area	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight**	**Value**
Portland OR-WA (OR Part)	69,334	96,323	96,271	104,880	26,937	8,557	72.0%	91.8%
Virginia Beach-Norfolk VA-NC (VA Part)	21,902	37,426	30,263	41,683	8,361	4,257	72.4%	89.8%
Boston MA-RI-NH-CT (MA Part)	104,516	213,920	143,635	232,092	39,119	18,172	72.8%	92.2%
Sacramento CA	43,691	93,242	60,023	100,508	16,332	7,266	72.8%	92.8%
Miami FL	127,035	133,155	173,773	150,876	46,738	17,721	73.1%	88.3%
Rest of MO	124,461	100,412	169,599	114,775	45,138	14,363	73.4%	87.5%
Rest of VA	133,870	92,787	182,302	106,019	48,432	13,232	73.4%	87.5%
Rest of TN	94,934	122,529	128,429	131,593	33,495	9,064	73.9%	93.1%
Los Angeles CA	341,867	870,429	462,364	918,197	120,497	47,768	73.9%	94.8%
Rochester NY	41,084	42,787	55,473	47,361	14,389	4,574	74.1%	90.3%
West Virginia	168,858	51,658	224,987	63,013	56,129	11,355	75.1%	82.0%
Chicago IL-IN-WI (IL Part)	281,892	535,671	372,584	567,924	90,692	32,253	75.7%	94.3%
Rest of IL	306,572	192,787	404,353	214,425	97,781	21,638	75.8%	89.9%
Rest of WI	262,688	216,981	346,282	238,746	83,594	21,765	75.9%	90.9%
Richmond VA	35,413	63,989	46,324	67,497	10,911	3,508	76.4%	94.8%
Honolulu HI	15,816	16,397	20,522	18,283	4,706	1,886	77.1%	89.7%
Philadelphia PA-NJ-DE-MD (DE Part)	21,331	43,173	27,304	45,774	5,973	2,601	78.1%	94.3%
Wyoming	300,121	20,674	384,051	38,886	83,930	18,212	78.1%	53.2%
Grand Rapids MI	45,494	90,320	58,158	95,573	12,664	5,253	78.2%	94.5%
Seattle WA	139,563	217,441	177,653	231,079	38,090	13,638	78.6%	94.1%
Lake Charles LA	67,829	30,014	85,906	34,053	18,077	4,039	79.0%	88.1%
Indianapolis IN	72,408	132,249	91,258	140,140	18,850	7,891	79.3%	94.4%
Jacksonville FL-GA CFS Area (FL Part)	44,018	72,685	55,339	76,569	11,321	3,884	79.5%	94.9%
Raleigh-Durham NC	49,818	72,543	62,490	77,983	12,672	5,440	79.7%	93.0%
Rest of MD	38,355	24,637	47,982	28,030	9,627	3,393	79.9%	87.9%
San Francisco CA	172,292	290,604	215,228	316,602	42,936	25,998	80.1%	91.8%
Cleveland OH	90,807	128,329	113,352	138,042	22,545	9,713	80.1%	93.0%
Rest of CT	10,324	17,812	12,845	18,769	2,521	957	80.4%	94.9%
Philadelphia PA-NJ-DE-MD (PA Part)	91,249	149,916	113,251	161,491	22,002	11,575	80.6%	92.8%
Dayton OH	34,319	48,096	42,428	51,547	8,109	3,451	80.9%	93.3%
Tulsa OK	55,090	45,224	68,043	49,844	12,953	4,620	81.0%	90.7%
Wichita KS	41,382	42,108	50,982	44,753	9,600	2,645	81.2%	94.1%
Albany NY CFS Area	41,494	45,110	50,961	48,597	9,467	3,487	81.4%	92.8%
Hartford CT	33,401	79,825	40,747	82,643	7,346	2,818	82.0%	96.6%
Omaha NE-IA (NE Part)	51,526	33,927	62,844	37,254	11,318	3,327	82.0%	91.1%
Minneapolis-St. Paul MN-WI (MN Part)	193,819	192,533	235,322	207,179	41,503	14,646	82.4%	92.9%
Columbus OH	95,973	161,131	116,295	168,814	20,322	7,683	82.5%	95.4%
New Orleans LA-MS (LA Part)	165,169	94,282	198,844	104,729	33,675	10,447	83.1%	90.0%
Salt Lake City UT	74,550	105,276	89,344	111,399	14,794	6,123	83.4%	94.5%
Baton Rouge LA	116,824	68,825	139,421	73,648	22,597	4,823	83.8%	93.5%
Dallas-Fort Worth TX-OK (TX Part)	319,067	457,634	380,448	481,108	61,381	23,474	83.9%	95.1%

(continued next page)

Table 9. Totals of 2017 Domestic Freight of CFS and FAF by Origin Area (con't)

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Origin Area	Weight[c]	Value[d]	Weight[c]	Value[d]	Weight[c]	Value[d]	Weight	Value
Rest of HI	11,303	6,386	13,192	7,704	1,889	1,318	85.7%	82.9%
Detroit MI	152,799	276,816	177,243	289,563	24,444	12,747	86.2%	95.6%
Louisville KY-IN (KY Part)	50,175	83,149	58,083	86,420	7,908	3,271	86.4%	96.2%
Rest of MA	26,191	35,463	30,267	37,468	4,076	2,005	86.5%	94.6%
Knoxville TN	42,981	57,423	49,344	60,259	6,363	2,836	87.1%	95.3%
El Paso TX-NM (TX Part)	21,853	24,459	24,896	26,042	3,043	1,583	87.8%	93.9%
Milwaukee WI	76,770	91,382	87,075	96,987	10,305	5,605	88.2%	94.2%
Memphis TN-MS-AR (TN Part)	40,255	97,371	45,576	99,643	5,321	2,272	88.3%	97.7%
St. Louis MO-IL (MO Part)	69,798	113,475	78,923	119,218	9,125	5,743	88.4%	95.2%
Cincinnati OH-KY-IN (OH Part)	60,420	89,506	68,232	93,781	7,812	4,275	88.6%	95.4%
Cincinnati OH-KY-IN (KY Part)	18,672	28,834	21,028	30,033	2,356	1,199	88.8%	96.0%
Fort Wayne IN	61,727	67,038	69,416	69,595	7,689	2,557	88.9%	96.3%
St. Louis MO-IL (IL Part)	74,936	38,704	83,652	41,667	8,716	2,963	89.6%	92.9%
New York NY-NJ-CT-PA (PA Part)	30,821	74,911	34,371	77,106	3,550	2,195	89.7%	97.2%
Austin TX	146,591	99,149	162,723	105,033	16,132	5,884	90.1%	94.4%
Philadelphia PA-NJ-DE-MD (NJ Part)	70,212	96,648	77,381	100,646	7,169	3,998	90.7%	96.0%
Chicago IL-IN-WI (IN Part)	78,066	47,811	84,994	50,281	6,928	2,470	91.8%	95.1%
Houston TX	487,632	469,056	526,966	487,146	39,334	18,090	92.5%	96.3%
San Antonio TX	167,981	100,031	181,142	105,658	13,161	5,627	92.7%	94.7%
Corpus Christi TX	66,877	29,372	70,910	31,511	4,033	2,139	94.3%	93.2%
Beaumont TX	110,784	51,168	115,188	52,605	4,404	1,437	96.2%	97.3%

[a] $X_{FAF} - X_{CFS}$ where X = weight or value of domestic freight.

[b] $\{X_{CFS}/X_{FAF}\} \times 100\%$.

[c] tons in thousand.

[d] dollars in million (2017$).

It should be reminded that this study includes only domestic freight flows. Thus, if all freight flows including all three trade types (i.e., domestic, import, and export) were analyzed and an area carried large import and/or export freight, that area could see a sizable difference in analysis results between the CFS and FAF even if the area has a high CFS (domestic) coverage percentage reported in Table 9. For example, if Houston, Texas, imported and exported substantial shipments, it could see a large difference in analysis results based the entire freight data of the CFS (i.e., domestic and import) versus the FAF (i.e., domestic, import, and export) although Houston is found to have a very high CFS coverage (92.5%) of the FAF in domestic freight flows.

4.6 Totals by Destination State

Table 10 shows totals, differences, and percentages of CFS and FAF weight and value estimates by destination state and list states in ascending order by percentage in weight; District of Columbia is treated as a state. The CFS coverage percentages in weight range from around 40% (Mississippi, Idaho, and Nevada) to around 80% (Hawaii, Texas, and West Virginia) while the percentages in value range from 69% (Nebraska) to 94% (Vermont). All 51 states including District of Columbia are quite substantially affected in freight totals at state level by OOS freight flows. This means that state-level analysis could potentially make a sizable difference in its results depending on which freight data source (CFS or FAF) is used for analysis, especially states with a lower percentage.

Table 10. Totals of 2017 Domestic Freight of CFS and FAF by Destination State

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Destination State	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight**	**Value**
All States	**11,886,319**	**13,443,448**	**17,477,579**	**15,081,693**	**5,591,260**	**1,638,245**	**68.0%**	**89.1%**
Mississippi	105,721	135,664	276,124	170,270	170,403	34,606	38.3%	79.7%
Idaho	54,012	57,152	129,254	71,526	75,242	14,374	41.8%	79.9%
Nevada	47,898	91,629	112,674	107,418	64,776	15,789	42.5%	85.3%
South Dakota	61,592	39,662	127,670	55,754	66,078	16,092	48.2%	71.1%
Alabama	179,092	212,687	359,879	251,150	180,787	38,463	49.8%	84.7%
Nebraska	173,939	101,139	329,588	146,441	155,649	45,302	52.8%	69.1%
Montana	44,316	38,987	83,239	49,003	38,923	10,016	53.2%	79.6%
Wyoming	58,468	27,141	105,974	38,370	47,506	11,229	55.2%	70.7%
Maine	33,888	45,059	60,001	50,187	26,113	5,128	56.5%	89.8%
Oregon	126,799	155,707	219,056	173,608	92,257	17,901	57.9%	89.7%
North Dakota	108,864	43,426	187,903	58,896	79,039	15,470	57.9%	73.7%
Rhode Island	16,961	30,545	29,139	34,570	12,178	4,025	58.2%	88.4%
Louisiana	424,495	254,883	724,697	332,489	300,202	77,606	58.6%	76.7%
Minnesota	315,136	255,187	524,289	299,284	209,153	44,097	60.1%	85.3%
Colorado	154,406	185,365	253,646	215,530	99,240	30,165	60.9%	86.0%
Kansas	206,127	164,103	336,854	199,497	130,727	35,394	61.2%	82.3%
Iowa	292,162	174,198	468,791	217,462	176,629	43,264	62.3%	80.1%
Arkansas	147,905	118,500	234,889	142,330	86,984	23,830	63.0%	83.3%
District of Columbia	5,812	20,075	9,187	21,926	3,375	1,851	63.3%	91.6%
South Carolina	144,748	207,304	227,640	225,582	82,892	18,278	63.6%	91.9%
New York	341,874	573,683	525,895	633,066	184,021	59,383	65.0%	90.6%
Georgia	296,409	436,639	453,448	478,911	157,039	42,272	65.4%	91.2%
Utah	107,634	127,941	164,385	143,468	56,751	15,527	65.5%	89.2%
Maryland	123,313	189,109	185,810	207,783	62,497	18,674	66.4%	91.0%
Washington	265,118	289,399	398,996	327,288	133,878	37,889	66.4%	88.4%
Arizona	134,305	196,018	200,615	218,265	66,310	22,247	66.9%	89.8%
California	745,889	1,341,795	1,111,436	1,497,285	365,547	155,490	67.1%	89.6%
New Mexico	64,418	55,618	95,864	65,674	31,446	10,056	67.2%	84.7%
New Jersey	209,415	382,161	311,082	415,237	101,667	33,076	67.3%	92.0%
Delaware	26,678	42,287	39,524	47,341	12,846	5,054	67.5%	89.3%
Kentucky	207,213	227,281	304,332	253,495	97,119	26,214	68.1%	89.7%
Indiana	405,208	392,760	582,518	438,493	177,310	45,733	69.6%	89.6%
Virginia	237,774	272,798	341,109	304,933	103,335	32,135	69.7%	89.5%
Tennessee	249,362	320,032	357,286	349,188	107,924	29,156	69.8%	91.7%
Alaska	20,262	23,273	29,014	27,664	8,752	4,391	69.8%	84.1%
New Hampshire	43,662	62,406	62,421	68,362	18,759	5,956	69.9%	91.3%
Florida	508,489	647,050	726,299	715,416	217,810	68,366	70.0%	90.4%
Connecticut	88,968	156,665	126,649	167,930	37,681	11,265	70.2%	93.3%
Illinois	584,233	682,598	822,539	750,677	238,306	68,079	71.0%	90.9%
Oklahoma	193,727	162,427	270,692	189,053	76,965	26,626	71.6%	85.9%
Massachusetts	128,673	252,819	179,025	273,598	50,352	20,779	71.9%	92.4%
North Carolina	267,196	382,614	368,754	417,039	101,558	34,425	72.5%	91.7%
Missouri	255,350	253,314	348,942	282,145	93,592	28,831	73.2%	89.8%
Michigan	360,262	462,943	488,582	501,310	128,320	38,367	73.7%	92.3%
Vermont	14,647	23,859	19,735	25,445	5,088	1,586	74.2%	93.8%
Wisconsin	337,297	297,913	448,235	330,564	110,938	32,651	75.2%	90.1%
Ohio	527,571	596,717	686,017	645,223	158,446	48,506	76.9%	92.5%
Pennsylvania	439,802	540,769	560,192	581,148	120,390	40,379	78.5%	93.1%
Hawaii	29,316	39,275	36,585	42,713	7,269	3,438	80.1%	92.0%
Texas	1,848,127	1,585,998	2,284,678	1,748,066	436,551	162,068	80.9%	90.7%
West Virginia	121,786	66,874	146,424	73,618	24,638	6,744	83.2%	90.8%

NOTE: District of Columbia is treated as a state.

[a] $X_{FAF} - X_{CFS}$ where X = weight or value of domestic freight.

[b] $\{X_{CFS}/X_{FAF}\} \times 100\%$.

[c] tons in thousand.

[d] dollars in million (2017$).

4.7 Totals by Destination Area

Table 11 shows totals, differences, and percentages of CFS and FAF weight and value estimates by destination area and list 132 destination areas in ascending order by percentage in weight. The percentages in weight range from below 40% (e.g., Las Vegas NV-AZ, Nevada Part; Mississippi; and Mobile, Alabama) to slightly over 90% (e.g., El Paso TX-NM, Texas Part; and Laredo, Texas). The percentages in value range from 67% (Omaha NE-IA, Nebraska Part) to 99% (Laredo, Texas). Among the 132 areas, 18 areas have 80% or higher percentages in weight and seven areas have 50% or less. An area with a low percentage should be careful in analyzing freight flows using the CFS since analysis results could be considerably different from those based on the FAF. An area with a high percentage may not see much difference in analysis using the CFS data compared to that using the FAF data. However, as noted in Section 4.5, this study includes only domestic freight flows, and if all freight flows including all three trade types (i.e., domestic, import, and export) were included in analysis, an area even with a high percentage in Table 11 could see a sizable difference in analysis results between the CFS and FAF depending on the amount of import and/or export shipments processed by that area.

Table 11. Totals of 2017 Domestic Freight of CFS and FAF by Destination Area

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Destination Area	Weight[c]	Valued	Weight[c]	Value[d]	Weight[c]	Value[d]	Weight	Value
All Areas	**11,886,328**	**13,443,456**	**17,477,579**	**15,081,693**	**5,591,251**	**1,638,237**	**68.0%**	**89.1%**
Las Vegas NV-AZ (NV Part)	23,083	54,060	69,798	65,370	46,715	11,310	33.1%	82.7%
Mississippi	105,722	135,660	275,588	169,444	169,866	33,784	38.4%	80.1%
Mobile AL	22,226	25,213	57,002	33,161	34,776	7,948	39.0%	76.0%
Idaho	54,010	57,151	129,546	72,723	75,536	15,572	41.7%	78.6%
Rest of AL	91,957	115,089	204,526	140,208	112,569	25,119	45.0%	82.1%
South Dakota	61,591	39,659	127,670	55,751	66,079	16,092	48.2%	71.1%
Rest of OR	45,480	42,431	94,179	49,479	48,699	7,048	48.3%	85.8%
Rest of LA	75,792	72,526	150,782	87,523	74,990	14,997	50.3%	82.9%
Omaha NE-IA (NE Part)	50,203	36,734	98,531	55,230	48,328	18,496	51.0%	66.5%
Tucson AZ	10,756	26,672	20,814	30,151	10,058	3,479	51.7%	88.5%
Montana	44,313	38,989	82,942	47,771	38,629	8,782	53.4%	81.6%
Rest of NE	123,735	64,407	230,978	90,923	107,243	26,516	53.6%	70.8%
Washington DC-VA-MD-WV (MD Part)	33,818	59,665	61,489	66,521	27,671	6,856	55.0%	89.7%
Wyoming	58,468	27,144	105,852	37,924	47,384	10,780	55.2%	71.6%
New York NY-NJ-CT-PA (NY Part)	148,690	347,512	266,483	386,561	117,793	39,049	55.8%	89.9%
Rest of NH	8,714	11,468	15,486	13,119	6,772	1,651	56.3%	87.4%
Rest of MN	141,626	88,310	251,279	106,765	109,653	18,455	56.4%	82.7%
Maine	33,887	45,057	59,998	50,161	26,111	5,104	56.5%	89.8%
Kansas City MO-KS (KS Part)	39,605	49,276	68,668	55,757	29,063	6,481	57.7%	88.4%
Rest of NV	24,815	37,566	42,875	42,047	18,060	4,481	57.9%	89.3%
Rest of WA	79,298	70,680	136,951	86,483	57,653	15,803	57.9%	81.7%
Lake Charles LA	57,932	26,435	100,027	39,245	42,095	12,810	57.9%	67.4%
North Dakota	108,862	43,426	187,903	58,896	79,041	15,470	57.9%	73.7%
Denver CO	85,966	125,208	147,966	142,306	62,000	17,098	58.1%	88.0%
Boston MA-RI-NH-CT (RI Part)	16,960	30,546	29,139	34,570	12,179	4,024	58.2%	88.4%
Wichita KS	49,172	43,336	83,867	52,529	34,695	9,193	58.6%	82.5%
New Orleans LA-MS (LA Part)	164,114	87,951	275,857	121,715	111,743	33,764	59.5%	72.3%
Greenville SC	34,643	70,450	57,700	75,482	23,057	5,032	60.0%	93.3%

(continued next page)

Table 11. Totals of 2017 Domestic Freight of CFS and FAF by Destination Area (con't)

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Destination Area	**Weight[c]**	**Valued**	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight**	**Value**
Corpus Christi TX	52,578	27,125	86,948	38,726	34,370	11,601	60.5%	70.0%
Washington DC-VA-MD-WV (VA Part)	47,789	71,825	78,791	81,003	31,002	9,178	60.7%	88.7%
Beaumont TX	86,585	45,513	141,941	63,167	55,356	17,654	61.0%	72.1%
Nashville TN	81,727	106,969	132,539	117,359	50,812	10,390	61.7%	91.1%
Rest of CA	116,263	162,179	188,134	199,000	71,871	36,821	61.8%	81.5%
Rest of FL	160,511	176,195	259,660	201,368	99,149	25,173	61.8%	87.5%
Rest of SC	86,217	98,694	139,248	109,324	53,031	10,630	61.9%	90.3%
New York NY-NJ-CT-PA (NJ Part)	149,214	297,518	239,479	325,669	90,265	28,151	62.3%	91.4%
Iowa	292,161	174,201	468,776	217,410	176,615	43,209	62.3%	80.1%
Salt Lake City UT	84,940	111,250	135,105	124,288	50,165	13,038	62.9%	89.5%
Arkansas	147,907	118,496	234,916	142,426	87,009	23,930	63.0%	83.2%
Rest of KY	120,532	116,010	190,698	134,172	70,166	18,162	63.2%	86.5%
Washington DC-VA-MD-WV (DC Part)	5,813	20,075	9,187	21,926	3,374	1,851	63.3%	91.6%
Rest of GA	111,371	130,099	175,679	146,423	64,308	16,324	63.4%	88.9%
Minneapolis-St. Paul MN-WI (MN Part)	173,510	166,878	273,010	192,519	99,500	25,641	63.6%	86.7%
Rest of KS	117,349	71,489	184,298	91,131	66,949	19,642	63.7%	78.4%
Baton Rouge LA	126,658	67,973	198,016	83,980	71,358	16,007	64.0%	80.9%
Fresno CA	18,558	30,209	28,915	39,226	10,357	9,017	64.2%	77.0%
Rest of CO	68,440	60,159	105,916	74,080	37,476	13,921	64.6%	81.2%
Indianapolis IN	83,970	129,458	129,207	141,499	45,237	12,041	65.0%	91.5%
Richmond VA	41,259	61,549	63,482	67,445	22,223	5,896	65.0%	91.3%
Portland OR-WA (OR Part)	81,324	113,276	124,950	124,506	43,626	11,230	65.1%	91.0%
St. Louis MO-IL (IL Part)	65,964	47,327	101,183	56,245	35,219	8,918	65.2%	84.1%
Birmingham AL	64,906	72,380	99,521	79,892	34,615	7,512	65.2%	90.6%
Atlanta GA	164,379	282,125	250,520	306,122	86,141	23,997	65.6%	92.2%
Orlando FL	61,487	98,730	93,657	109,100	32,170	10,370	65.7%	90.5%
Tampa FL	65,518	98,274	99,267	108,695	33,749	10,421	66.0%	90.4%
San Francisco CA	165,059	295,614	249,715	329,040	84,656	33,426	66.1%	89.8%
Phoenix AZ	85,871	144,361	129,400	158,653	43,529	14,292	66.4%	91.0%
Rest of MI	121,158	125,102	182,127	140,131	60,969	15,029	66.5%	89.3%
Philadelphia PA-NJ-DE-MD (DE Part)	16,861	32,155	25,263	35,124	8,402	2,969	66.7%	91.5%
Hartford CT	28,798	53,833	42,909	57,644	14,111	3,811	67.1%	93.4%
New Mexico	64,418	55,619	95,849	65,639	31,431	10,020	67.2%	84.7%
Rest of IL	230,968	173,318	343,292	200,151	112,324	26,833	67.3%	86.6%
Sacramento CA	47,622	74,392	70,063	84,266	22,441	9,874	68.0%	88.3%
Baltimore MD	53,385	98,711	78,147	106,851	24,762	8,140	68.3%	92.4%
Rest of DE	9,818	10,129	14,362	12,371	4,544	2,242	68.4%	81.9%
Rest of IN	181,589	168,110	264,203	189,339	82,614	21,229	68.7%	88.8%
Los Angeles CA	352,093	667,647	511,085	726,182	158,992	58,535	68.9%	91.9%
Rest of MO	118,340	99,628	171,738	114,777	53,398	15,149	68.9%	86.8%
Rest of NY	78,844	91,839	113,907	101,325	35,063	9,486	69.2%	90.6%
Seattle WA	151,093	201,053	216,815	219,752	65,722	18,699	69.7%	91.5%
Alaska	20,261	23,273	29,014	27,664	8,753	4,391	69.8%	84.1%

(continued next page)

Table 11. Totals of 2017 Domestic Freight of CFS and FAF by Destination Area (con't)

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Destination Area	Weight[c]	Valued	Weight[c]	Value[d]	Weight[c]	Value[d]	Weight	Value
Rest of OK	71,445	46,431	101,734	58,917	30,289	12,486	70.2%	78.8%
Rest of NC	118,726	130,853	168,057	147,457	49,331	16,604	70.6%	88.7%
Rest of TN	89,581	105,944	125,738	116,539	36,157	10,595	71.2%	90.9%
Fort Wayne IN	51,936	46,590	72,794	50,739	20,858	4,149	71.3%	91.8%
New York NY-NJ-CT-PA (CT Part)	50,582	84,739	70,825	90,983	20,243	6,244	71.4%	93.1%
Boston MA-RI-NH-CT (MA Part)	110,752	222,047	154,992	240,096	44,240	18,049	71.5%	92.5%
Raleigh-Durham NC	64,690	67,099	90,205	74,110	25,515	7,011	71.7%	90.5%
New York NY-NJ-CT-PA (PA Part)	35,031	57,450	48,543	61,688	13,512	4,238	72.2%	93.1%
Tulsa OK	73,677	58,028	101,958	65,500	28,281	7,472	72.3%	88.6%
Oklahoma City OK	48,606	57,967	66,996	64,621	18,390	6,654	72.6%	89.7%
Philadelphia PA-NJ-DE-MD (PA Part)	91,685	139,553	125,951	151,857	34,266	12,304	72.8%	91.9%
San Diego CA	46,290	111,758	63,559	119,762	17,269	8,004	72.8%	93.3%
Columbus OH	90,364	177,209	123,653	187,062	33,289	9,853	73.1%	94.7%
Virginia Beach-Norfolk VA-NC (VA Part)	36,380	55,041	49,558	60,782	13,178	5,741	73.4%	90.6%
Rest of WI	248,048	205,561	337,346	230,623	89,298	25,062	73.5%	89.1%
Rest of CT	9,586	18,096	12,920	19,344	3,334	1,248	74.2%	93.5%
Vermont	14,648	23,865	19,735	25,445	5,087	1,580	74.2%	93.8%
Boston MA-RI-NH-CT (NH Part)	34,948	50,935	46,933	55,237	11,985	4,302	74.5%	92.2%
Charlotte NC-SC (NC Part)	47,809	98,962	64,125	105,684	16,316	6,722	74.6%	93.6%
Rest of MA	17,924	30,779	24,031	33,493	6,107	2,714	74.6%	91.9%
Rest of AZ	37,678	24,981	50,401	29,461	12,723	4,480	74.8%	84.8%
Jacksonville FL-GA CFS Area (FL Part)	50,783	69,499	67,850	74,531	17,067	5,032	74.8%	93.2%
Buffalo NY CFS Area	34,481	44,886	45,930	48,154	11,449	3,268	75.1%	93.2%
Memphis TN-MS-AR (TN Part)	30,997	65,096	41,220	68,400	10,223	3,304	75.2%	95.2%
Rest of VA	112,346	84,386	149,274	95,692	36,928	11,306	75.3%	88.2%
Chicago IL-IN-WI (IN Part)	87,713	48,603	116,168	56,745	28,455	8,142	75.5%	85.7%
Cleveland OH	117,205	130,853	154,716	143,136	37,511	12,283	75.8%	91.4%
Savannah GA	20,656	24,411	27,225	26,329	6,569	1,918	75.9%	92.7%
Chicago IL-IN-WI (IL Part)	287,303	461,951	378,254	494,619	90,951	32,668	76.0%	93.4%
Louisville KY-IN (KY Part)	62,952	82,329	82,697	87,783	19,745	5,454	76.1%	93.8%
Rest of OH	205,206	154,971	268,323	172,251	63,117	17,280	76.5%	90.0%
Detroit MI	179,072	267,394	233,790	285,670	54,718	18,276	76.6%	93.6%
Cincinnati OH-KY-IN (KY Part)	23,730	28,941	30,923	31,508	7,193	2,567	76.7%	91.9%
Honolulu HI	17,326	26,611	22,573	28,616	5,247	2,005	76.8%	93.0%
Portland OR-WA (WA Part)	34,726	17,666	45,122	20,485	10,396	2,819	77.0%	86.2%
St. Louis MO-IL (MO Part)	85,441	90,912	110,790	99,537	25,349	8,625	77.1%	91.3%
Rest of PA	184,508	242,874	238,064	259,733	53,556	16,859	77.5%	93.5%
Rest of UT	22,695	16,691	29,280	19,180	6,585	2,489	77.5%	87.0%
Greensboro-Winston-Salem-High Point NC	35,973	85,698	46,367	89,788	10,394	4,090	77.6%	95.4%
Kansas City MO-KS (MO Part)	51,573	62,775	66,414	67,831	14,841	5,056	77.7%	92.5%

(continued next page)

Table 11. Totals of 2017 Domestic Freight of CFS and FAF by Destination Area (con't)

	CFS		FAF5.0		Difference[a]		Percentage[b]	
Destination Area	**Weight[c]**	**Valued**	**Weight[c]**	**Value[d]**	**Weight[c]**	**Value[d]**	**Weight**	**Value**
Charleston SC	23,890	38,161	30,692	40,769	6,802	2,608	77.8%	93.6%
Rest of MD	36,112	30,737	46,078	34,268	9,966	3,531	78.4%	89.7%
Rochester NY	35,680	39,285	45,129	42,984	9,449	3,699	79.1%	91.4%
Houston TX	539,585	457,669	674,120	502,418	134,535	44,749	80.0%	91.1%
Milwaukee WI	89,255	92,356	110,844	99,774	21,589	7,418	80.5%	92.6%
Albany NY CFS Area	44,179	50,164	54,445	54,042	10,266	3,878	81.1%	92.8%
Knoxville TN	47,060	42,018	57,587	46,511	10,527	4,493	81.7%	90.3%
Dayton OH	42,496	57,399	51,812	60,692	9,316	3,293	82.0%	94.6%
Rest of TX	467,203	331,737	566,371	379,933	99,168	48,196	82.5%	87.3%
Cincinnati OH-KY-IN (OH Part)	72,299	76,286	87,513	82,081	15,214	5,795	82.6%	92.9%
Grand Rapids MI	60,033	70,447	72,664	75,509	12,631	5,062	82.6%	93.3%
Miami FL	170,187	204,352	205,486	220,922	35,299	16,570	82.8%	92.5%
West Virginia	121,785	66,874	146,424	73,618	24,639	6,744	83.2%	90.8%
Dallas-Fort Worth TX-OK (TX Part)	343,122	421,217	410,923	445,754	67,801	24,537	83.5%	94.5%
Philadelphia PA-NJ-DE-MD (NJ Part)	60,199	84,643	71,603	89,568	11,404	4,925	84.1%	94.5%
Rest of HI	11,991	12,665	14,012	14,097	2,021	1,432	85.6%	89.8%
Austin TX	147,827	108,244	170,105	115,218	22,278	6,974	86.9%	93.9%
Pittsburgh PA-OH-WV (PA Part)	128,580	100,893	147,634	107,869	19,054	6,976	87.1%	93.5%
San Antonio TX	165,129	115,045	183,735	121,359	18,606	6,314	89.9%	94.8%
El Paso TX-NM (TX Part)	30,163	45,293	33,071	46,862	2,908	1,569	91.2%	96.7%
Laredo TX	15,935	34,155	17,464	34,628	1,529	473	91.2%	98.6%

[a] $X_{FAF} - X_{CFS}$ where X = weight or value of domestic freight.

[b] $\{X_{CFS}/X_{FAF}\} \times 100\%$.

[c] tons in thousand.

[d] dollars in million (2017$).

4.8 Comparison with OOS Analysis Results of FAF

Oak Ridge National Laboratory (ORNL)[37] has performed analysis on OOS contributions in the FAF using the FAF5.0 dataset and calculated the OOS contributions as percentage of OOS freight flows among all freight flows in the FAF using the following equation:

$$Percentage = \frac{X_{FAF}^{OOS}}{X_{FAF}^{All}} \times 100\% \quad \text{..... Eq. (3)}$$

where X = estimate, either weight (thousand tons) or value (million 2017$) of freight flows;

X_{FAF}^{OOS} = *X* of out-of-scope (OOS) freight flows in the FAF; and

X_{FAF}^{All} = *X* of all freight flows in the FAF.

It was reported that the OOS contributions to all freight flows of the 2017 FAF5.0 are 39.7% in weight and 28.8% in value[38].

Using ORNL's results[39], analysis was performed to compare the percentages of the CFS in the FAF against percentages of OOS in the FAF. Because the differences between the CFS and FAF found in this study are conjectured to be attributable to OOS freight flows by the design of the FAF database, the comparative analysis is expected to verify source(s) of the found differences. However, the two percentages (Equations 2 and 3) are not compatible in their current forms on at least two accounts. First, Equation 2 is the CFS percentage in the FAF while Equation 3 is the OOS percentage in the FAF. Second, Equation 2 is for one specific trade type (domestic freight) while Equation 3 is for all three trade types (domestic, import, and export freight). To translate the OOS percentage (Equation 3) to one comparable to the CFS percentage (Equation 2), the following equation was derived:

$$\left[\left(\frac{X_{CFS}^{Domestic}}{X_{FAF}^{Domestic}}\right) = \frac{1}{c}\left(1 - \frac{X_{FAF}^{OOS}}{X_{FAF}^{All}}\right)\right] \equiv \left[(\text{Equation 2}) = \frac{1}{c}(1 - \text{Equation 3})\right]$$

Eq. (4)

where *c* conversion constant (0.89 for *X* = weight and 0.81 for *X* = value).

The conversion constant, *c*, was computed using trade type proportions in the FAF5.0 extracted using FAF5's online Data Tabulation Tool[40]. The percentage of domestic freight flows in the FAF is 89% in weight and 81% in value; thus, the conversion constant is the percentage in decimal. It should be noted that the conversion constants in Equation 4 are for total freight flows (i.e., freight flows in all commodities, all modes, all origins, and all destinations) and are most likely to be different for freight flows in a subpopulation such as a specific commodity, mode, origin, destination, or a combination of these. The derivation of Equation 4 is provided in Appendix C.

Table 12 shows results of the comparative analysis using Equation 4 and list four percentages. Percentage 1 is a CFS percentage in the FAF in domestic freight flows that was calculated in Section 4.1 (see Table 3 for calculation of the percentages in weight and value) while Percentage 2 is a comparable CFS percentage derived from an ORNL's OOS percentage. The two percentages (Percentages 1 and 2 in the table) are matched, meaning the differences found in this study between the CFS and FAF in domestic freight flows are attributable 100% to the OOS freight flows. This finding verifies that the OOS freight flows is the only source for the differences in domestic freight weight and value between the CFS and FAF at the national level.

[37] ORNL develops the FAF5 in partnership with Federal Highway Administration and Bureau of Transportation Statistics of the U.S. Department of Transportation (ORNL, 2021-11-22).

[38] Analysis results were presented at FAF5 Regular Meeting on April 26, 2021. The analysis was performed per the request from the FHWA.

[39] A spreadsheet file, 2017 OOS and Impacted SCTG.xlsx, was obtained from ORNL.

[40] Available at https://faf.ornl.gov/faf5/dtt_total.aspx.

Table 12. Results of Comparative Analysis of 2017 Total Freight Flows of CFS and FAF

	Percentage 1[b]	Percentage 2[c]	Percentage 3[d]	Percentage 4[e]
Total Freight Flows[a]	Equation 2	(1–Equation 3)/*c*	1–Equation 3	Equation 3
Weight	68.0%	68.0%	60.3%	39.7%
Value	89.1%	89.1%	71.2%	28.8%

[a] Total freight flows for all commodities, all modes, all origins, and all destinations combined.

[b] CFS percentage in the FAF in *domestic* freight flows (See Table 3).

[c] Derived CFS percentage in the FAF in *domestic* freight flows (c = 0.89 for weight and 0.81 for value).

[d] In-scope percentage in the FAF in *total* freight flows.

[e] OOS percentage in the FAF in *total* freight flows (from ORNL's analysis results).

Percentage 3 is translated to CFS (domestic only) coverage of the FAF in total freight flows (domestic, import, and export). The CFS covers 60% and 71% in weight and values of total freight flows in the FAF. However, these percentages do not account for export freight flows of the CFS data; with the entire CFS data including domestic and export freight flows, the CFS covers 63% and 77% of the FAF in total. As noted earlier, export freight flows of the CFS do not feed into the FAF database although the CFS collects and publish export freight flows in its final tables and public files (see Appendix A for background information).

Results in Table 12 are for total freight flows in all commodities combined. A further analysis by commodity found Percentage 1 and Percentage 2 are identical in their percentage values in weight in each of 42 commodities (see Table D1). This finding provides additional credibility to the conclusion on the source of the differences between the CFS and FAF in 2017 domestic freight flows. Appendix D presents results of comparative analysis by commodity.

5. Conclusions

This study compared the weight and value estimates of the 2017 domestic freight flows in the CFS and FAF, two national freight flow data. Using the difference and percentage, the two metrics used for comparison in the study, discrepancy between the two data was identified in estimate totals by transportation mode, commodity, origin state and area, and destination state and area. Based on the analysis results presented in Tables 3 through 12, the following conclusions regarding 2017 *domestic* freight flows are drawn:

- The differences between the CFS and FAF are attributable 100% to out-of-scope (OOS) freight flows (Table 12) verifying the FAF process treats the CFS data properly in developing the FAF database.
- The CFS covers 68% and 89% of the FAF in weight and value, respectively (Table 3). This means the OOS data add weight much more than value in freight flows. Some OOS freight has very small or no monetary value yet very large weight such as municipal solid waste and construction & demolition debris.
- The CFS covers 22% and 74% of the FAF in weight of freight flows shipped by pipeline and truck, respectively (Table 4). Crude petroleum and liquified natural gas contribute to the low CFS percentage in the pipeline totals. Most of the OOS freight flows are transported by trucks. Since a majority of domestic freight flows are transported by truck (74% in weight), analysis involving highway traffic could see sizable difference in its results with the CFS data compared to those with the FAF data.
- The CFS covers at least 80% of the FAF in 32 out of 42 commodities and 90% or higher in 22 commodities (Table 6). Six commodities—SCTG Codes 16 (Crude petroleum), 25 (Logs), 01 (Live animals/fish), 19 (Coal-n.e.c.), 41 (Waste/scrap), and 03 (Other ag prods.) —see less than 50% in the CFS coverage; these are main commodities impacted by OOS domestic freight flows.
- In all 50 states and District of Columbia, the CFS covers from 35% (Mississippi) to 80% (Hawaii) of

the FAF in weight of outgoing freight (Table 8) and from 38% (Mississippi) to 83% (West Virginia) of the FAF in weight of incoming freight (Table 10). This means caution should be exercised in using state-level estimates of domestic freight flows based on the CFS data, especially states with a lower percentage.

- Across 132 areas, the CFS covers from 30% (Rest of Louisiana) to 96% (Beaumont, Texas) of FAF in weight of outgoing freight (Table 9) and from 33% (Las Vegas NV-AZ, Nevada Part) to 91% (Laredo, Texas) of the FAF in weight of incoming freight (Table 11). This means areas with high percentages may not see much difference in area-level estimates using the CFS data compared to those using the FAF data. Caution should be exercised in using area-level estimates of domestic freight flows based on the CFS data, especially areas with a lower percentage.

The two national freight flow data, the CFS and FAF, have their own uniqueness. For example, the CFS provides observed shipment-level data and NAICS codes, which the FAF does not. Meanwhile, the FAF provides more complete export and import freight flows than the CFS. It should be noted that the CFS and FAF both treat reshipments of imported goods as a domestic freight rather than import. However, there are cases where domestic reshipments of imported goods are captured by the FAF yet missing from the CFS. For example, imported shipments through the Ports of Los Angeles-Long Beach directly loaded on a train to a domestic location is the domestic leg of an import in the FAF yet is missing in the CFS since this kind of shipments is not well aligned with the CFS sampling frame.

As this study found in domestic freight flows, the differences exist in totals of weight and value estimates between the two freight data. This means that, depending on analysis purpose and subpopulation, differences in analysis results of domestic freight flows between the two data could be considerable. For example, when a study is to compare total weights of 2017 domestic freight flows shipped by rail for States of California and Florida, using the CFS and FAF would likely lead to practically identical results since the national total freight flows shipped by rail were found to differ in weight by less than 2% between the CFS and FAF. However, when the study changes its focus on shipping mode to truck, the two data would probably lead to substantially different results in that the national total truck-shipped freight flows were different by 26% in weight between the two data.

Freight data users should understand the differences between the CFS and FAF and choose the most appropriate data fitting for their analysis purpose. The data users must consider the greater detail in the CFS and the more complete coverage of the FAF when determining the data. If the detail (e.g., industry types) of the CFS is needed, the share of the CFS estimates compared to the FAF estimates should be considered when interpreting analysis results.

6. Next Step

The CFS and FAF are to be compared in *total* freight flows in contrast to *domestic* flows compared in the current study. In full databases, the CFS includes domestic and export freight while the FAF includes domestic, export, and import freight. Thus, the comparison of total flows will discover overall differences between the CFS and FAF. Its findings would offer different insight from the current study's due to the fact that covered trade types (e.g., domestic, export, and import) of the CFS and FAF differ. They could be valuable to data users since some users would use the full database, not its domestic portion. Also, subdivision of the FAF modes could be worth to be examined such as the truck only modes of the FAF into for-hire and company-owned truck modes and the multiple modes and mail of the FAF into intermodal categories using the CFS data with detailed modes.

References

Bureau of Transportation Statistics (BTS). (2012-07-03). *Standard Classification of Transported Goods (SCTG) Codes*. U.S. Department of Transportation, Washington, DC. Accessed 2021-06-23 from https://www.bts.gov/archive/publications/commodity_flow_survey/hierarchical_features.

Bureau of Transportation Statistics (BTS). (2015-07-13). *Appendix D. Standard Classification of Transported Goods Code Information*. U.S. Department of Transportation, Washington, DC. Accessed 2021-06-23 from https://www.bts.gov/archive/publications/commodity_flow_survey/2012/united_states/appendixd.

Bureau of Transportation Statistics (BTS). (2016-09-15). *Estimation of Domestic CFS Shipments*. U.S. Department of Transportation, Washington, DC. Accessed 2021-04-02 from https://www.bts.dot.gov/archive/subject_areas/freight_transportation/faf/faf4/est.

Bureau of Transportation Statistics (BTS). (2016-09-23a). *Development of FAF4 Database*. U.S. Department of Transportation, Washington, DC. Accessed 2021-04-02 from https://www.bts.gov/archive/subject_areas/freight_transportation/faf/faf4/dev.

Bureau of Transportation Statistics (BTS). (2016-09-23b). *Municipal Solid Waste and Construction & Demolition Debris.* U.S. Department of Transportation, Washington, DC. Accessed 2021-12-30 from https://www.bts.gov/archive/subject_areas/freight_transportation/faf/faf4/debris.

Bureau of Transportation Statistics (BTS). (2020-11-02). *CFS FAQs*. U.S. Department of Transportation, Washington, DC. Accessed 2021-03-29 from https://www.bts.gov/cfs/faqs.

Bureau of Transportation Statistics (BTS). (2021-02-21). *Freight Data Sources*. U.S. Department of Transportation, Washington, DC. Accessed 2021-03-29 from https://www.bts.gov/topics/freight-transportation/freight-data-sources.

Bureau of Transportation Statistics (BTS). (2021-02-24). *Commodity Flow Survey*. U.S. Department of Transportation, Washington, DC. Accessed 2021-03-29 from https://www.bts.gov/cfs.

Bureau of Transportation Statistics (BTS). (2021-03-04). *Freight Analysis Framework Frequently Asked Questions*. U.S. Department of Transportation, Washington, DC. Accessed 2021-07-08 from https://www.bts.gov/faf/faqs.

Bureau of Transportation Statistics (BTS). (2021-03-23). *Freight Analysis Framework.* U.S. Department of Transportation, Washington, DC. Accessed 2021-03-29 from https://www.bts.gov/faf.

Bureau of Transportation Statistics (BTS). (2021-05-21). *Commodity Flow Survey.* U.S. Department of Transportation, Washington, DC. Accessed 2021-07-23 from https://www.bts.gov/cfs.

National Agricultural Statistics Service (NASS). (2022-03-22). Census of Agriculture. U.S. Department of Agriculture, Washington, DC. Accessed 2022-03-29 from https://www.nass.usda.gov/AgCensus/.

Norton, Richard. (2020-10). *2017 FAF/CFS Comparison Pilot Project*. Internal Report. Bureau of Transportation Statistics, U.S. Department of Transportation, Washington, DC.

Oak Ridge National Laboratory (ORNL). (2021-01-20). *FREIGHT ANALYSIS FRAMEWORK VERSION 5: User's Guide for Release 5.0*. U.S. Department of Energy, Oak Ridge, Tennessee. Available at ://faf.ornl.gov/faf5/data/FAF5%20User%20Guide.pdf.

Oak Ridge National Laboratory (ORNL). (2021-02-25). *Freight Analysis Framework Version 5 (FAF5)*. U.S. Department of Energy, Oak Ridge, Tennessee. Accessed 2021-06-09 from https://faf.ornl.gov/faf5/dtt_total.aspx..

Oak Ridge National Laboratory (ORNL). (2021-11-22). *Freight Analysis Framework Version 5*. U.S. Department of Energy, Oak Ridge, Tennessee. Accessed 2021-12-27 from https://faf.ornl.gov/faf5/.

Oak Ridge National Laboratory (ORNL). (2021-12). *Freight Analysis Framework Version 5 (FAF5) Base*

Year 2017 Data Development Technical Report. Technical Report ORNL/TM-2021/2154. U.S. Department of Energy, Oak Ridge, Tennessee, Oak Ridge, TN.

U.S. Department of Transportation, Bureau of Transportation Statistics; and, U.S. Department of Commerce, U.S. Census Bureau. (2020). *2017 Commodity Flow Survey Final Tables* [datasets]. 2017 Commodity Flow Survey. Accessed 2021-06-09 from https://www2.census.gov/programs-surveys/cfs/data/2017/.

U.S. Department of Transportation, Bureau of Transportation Statistics; and, U.S. Department of Commerce, U.S. Census Bureau. (2020-08). *2017 Commodity Flow Survey Datasets: 2017 CFS Public Use File (PUF)*. Accessed 2021-06-09 from https://www2.census.gov/programs-surveys/cfs/data/2017/.

U.S. Department of Transportation, Bureau of Transportation Statistics; and, U.S. Department of Commerce, U.S. Census Bureau. (2020-07). *2017 Commodity Flow Survey Methodology*. Available at https://www2.census.gov/programs-surveys/cfs/technical-documentation/methodology/2017cfsmethodology.pdf.

U.S. Department of Transportation, Bureau of Transportation Statistics; and, U.S. Department of Commerce, U.S. Census Bureau. (2020-08). *2017 Commodity Flow Survey (CFS) Public Use File (PUF) Data Users Guide*. Technical Documentation. Available at https://www2.census.gov/programs-surveys/cfs/datasets/2017/cfs_2017_puf_users_guide.pdf.

U.S. Department of Transportation, Bureau of Transportation Statistics; and, U.S. Department of Commerce, U.S. Census Bureau. (2020-08). *2017 Commodity Flow Survey Datasets: 2017 CFS Public Use File (PUF)*. Accessed 2021-03-19 from https://www2.census.gov/programs-surveys/cfs/data/2017/.

U.S. Department of Transportation, Bureau of Transportation Statistics; and, U.S. Department of Commerce, U.S. Census Bureau. (2020-08). *2017 Commodity Flow Survey (CFS) Public Use File (PUF) Data Users Guide*. Technical Documentation. Available at https://www2.census.gov/programs-surveys/cfs/datasets/2017/cfs_2017_puf_users_guide.pdf.

U.S. Department of Transportation, Bureau of Transportation Statistics; and, U.S. Department of Commerce, U.S. Census Bureau. (2020-07). *2017 Commodity Flow Survey Methodology*. Available at https://www2.census.gov/programs-surveys/cfs/technical-documentation/methodology/2017cfsmethodology.pdf.

U.S. Department of Transportation, Federal Highway Administration (FHWA). (2022-02-07). Freight Analysis Framework, Washington, DC. Accessed 2022-04-07 from https://ops.fhwa.dot.gov/freight/freight_analysis/faf/.

U.S. Energy Information Administration. (2021). *PETROLEUM & OTHER LIQUIDS*. U.S. Department of Energy, Washington, DC. Accessed 2021-06-09 from https://www.eia.gov/petroleum/data.php#summary.

U.S. Forest Service. (2020-04-14). *Forest Inventory and Analysis*. U.S. Department of Agriculture, Washington, DC. Accessed 2021-06-21 from https://www.fia.fs.fed.us/.

Appendix A. Only Domestic Freight Flows of CFS Entering Integrated in FAF Database

The CFS is a shipment-based survey on domestic establishments shipping products to the U.S. and foreign destinations. Thus, the CFS collects freight flow data on export shipments as well as domestic shipments. However, when the FAF is being developed, only domestic flow data of the CFS enter into the FAF database and export flow data do not. It should be noted that export flow data of the CFS are still used for developing the FAF database in that CFS export data are used to allocate domestic mode and domestic origin FAF zone of export freight flows obtained from international trade statistics[41]. Rolf Schmitt, Deputy Director of the Bureau of Transportation Statistics (BTS), provided background information for reasons for the FAF database taking in only domestic freight flows of the CFS as below[42]:

> The FAF covers all freight flows within the US and between the US and other countries. The FAF tabulation tool allows you to identify the domestic flow between US FAF region of origin and US FAF region of destination, the export flow from US FAF region of origin to US FAF region of exit to foreign destination, the import flow from foreign origin to US FAF region of entry to US FAF region of destination. The "total flows" part of the FAF tabulation tool adds the domestic portions of import and export flows to the domestic-only flows.
>
> The CFS is a survey of shipments originating from domestic establishments in mining, manufacturing, wholesale, and selected retail sectors. The CFS does not include imports because those are made by foreign establishments. The CFS does include exports, but the results do not match exports in foreign trade statistics because of CFS sample size, complications from transshipments, etc.
>
> If we take the CFS flows from domestic A to domestic B without removing exports and then use foreign trade statistics to estimate how much passed between domestic A and foreign C through domestic B, we end up double counting exports. As a consequence, we remove exports from the CFS to calculate domestic-only flows and use the distributions of exports in the CFS in conjunction with foreign trade statistics to estimate the domestic leg of export flows.

[41] The FAF obtains export freight data from international trade data of the U.S. Census Bureau for developing the export portion of the FAF database. Since the international trade data provide only domestic origin states, not FAF zones, and no domestic transportation modes, the FAF uses CFS export data to allocate domestic mode and domestic origin FAF zone of the export freight flows of the international trade data.

[42] Schmitt, Rolf. (2021-05-14). *RE: Before I forget*. [email].

Appendix B. Crude Petroleum Being Excluded from CFS Data Products

The CFS surveys establishments shipping crude petroleum and collects shipment data of crude petroleum. However, the CFS data products released so far do not include estimates of crude petroleum. James Hinckley, the former CFB branch chief at the U.S. Census Bureau provided historical background information for reasons as below[43]:

> From what I understand, it only makes sense for the Crude Petroleum product to come from NAICS 211. No other NAICS is legitimately shipping crude petroleum. Crude petroleum goes from a NAICS 211 location directly to refineries, I think. There is no other use for crude petroleum. That, at least, was the theory I'm familiar with. And, NAICS 211 is out of scope of the CFS. Therefore, the product Crude Petroleum is also out of scope.
>
> Why is 211 out of scope? I think, historically, there have been multiple reasons. For starters, my understanding is BTS gets good data on crude petroleum from another source and that's what they use in FAF. On the Census side, I think there might be BR and physical address issues. I believe oil fields can pop up one day and be gone fairly quickly, making it harder to sample. More importantly, I think the BR might not have addresses on all of these places. I think mining has allowed state-level reporting rather than estab-level, leading even to more trouble knowing the origin. And then there's offshore rigs and having to figure out how to deal with them. I think some of those issues lead to some mileage calculation problems that would have to be figured out. Given those complexities and BTS having data from another source, it just never seemed like a good idea to try to make it in scope of the CFS.
>
> Of course, things change over time. Like many things with the CFS, these were decisions based on issues that existed 20+ years ago. Maybe they still apply. Maybe they don't. I don't know.
>
> As for why we collect SCTG 16, I think it was to try and potentially identify any estabs that should be out of scope and, like you said, it might help get some shipments into their proper category in 17/18/19. I'm not sure we really know how helpful that is. I think it's definitely worth taking another look at whether SCTG 16 is worth collecting. In the grand scheme of things, it probably didn't help us clean up too much data, but I think it also didn't generate a ton of extra work for us (but I could be wrong on that).

Rolf Schmitt, Deputy Director of Bureau of Transportation Statistics (BTS), mentioned that a shipment-based survey does not really fit well with how this industry operates[44].

43 Jessica M. Young. (2021-05-18). *Re: SCTG 16 Re: Before I forget*. [email].

44 Ryan Grube. (2021-05-18). *RE: SCTG 16 Re: Before I forget*. [email].

Appendix C. Derivation of Conversion Equation between CFS and OOS Percentages

The following two percentages are used to derive the conversion equation:

- $\frac{X_{CFS}^{Domestic}}{X_{FAF}^{Domestic}}$: Equation 2 (CFS contribution in the FAFin domestic freight flows)
- $\frac{X_{FAF}^{OOS}}{X_{FAF}^{All}}$: Equation 3 (OOS contribution in the FAF in total freight flows including domestic,import, and export flows)

$$\left(1-\frac{X_{FAF}^{OOS}}{X_{FAF}^{All}}\right)=\left(\frac{X_{FAF}^{All}-X_{FAF}^{OOS}}{X_{FAF}^{All}}\right)=\left[\frac{\left(X_{FAF}^{In-Scope}+X_{FAF}^{OOS}\right)-X_{FAF}^{OOS}}{X_{FAF}^{All}}\right]$$

$$=\left(\frac{X_{FAF}^{In-Scope}}{X_{FAF}^{All}}\right)$$

$$=\left(\frac{X_{CFS}^{Domestic}}{X_{FAF}^{All}}\right)^{*}$$

$$=\left(\frac{X_{CFS}^{Domestic}}{\frac{1}{c}\times X_{FAF}^{Domestic}}\right)^{**}$$

$$=c\left(\frac{X_{CFS}^{Domestic}}{X_{FAF}^{Domestic}}\right)$$

where c is a fraction of the FAF's domestic freight flows in the FAF's total freight flows

* $X_{FAF}^{In-Scope}=X_{CFS}^{Domestic}$ because the FAF includes records in 2017 CFS Special Tables after excluding records of export shipments.

** $X_{FAF}^{All}=\frac{1}{c}\times X_{FAF}^{Domestic}$ because c × 100% of all FAF freight flows is domestic freight flows (i.e.,$\times X_{FAF}^{All}=X_{FAF}^{Domestic}$). For example of weight, domestic freight (17,477,579,000 tons) composes 89% of total FAF freight (17,719,332,000 tons) according to 2017 FAF statistics obtained from FAF5's Data Tabulation Tool[45], which is $0.89 \times X_{FAF}^{All}=X_{FAF}^{Domestic}$ where X = weight of national freight flows.

Based on the above derived relationship, Equation 4 is derived as follows:

$$\left[\frac{1}{c}\left(1-\frac{X_{FAF}^{OOS}}{X_{FAF}^{All}}\right)=\left(\frac{X_{CFS}^{Domestic}}{X_{FAF}^{Domestic}}\right)\right]\equiv\left[\frac{1}{c}(1-Equation\ 3)=(Equation\ 2)\right]$$

[45] Available at https://faf.ornl.gov/faf5/dtt_total.aspx.

Appendix D. Comparison with OOS Analysis Results of FAF in Weight by Commodity

Table D1 shows results of the comparative analysis on weight estimates using Equation 4 by commodity and list four percentages. Percentage 1 is a CFS percentage in the FAF in domestic freight flows that was calculated in Section 4.3 (see Table 6 for calculation of the percentages) while Percentage 2 is a comparable CFS percentage derived from an ORNL's OOS percentage. The domestic percentage in decimal format is used as the conversion factor (c) in calculating Percentage 2. Percentages 1 and 2 are matched for each of 42 commodities, meaning the differences found in this study between the CFS and FAF in domestic freight flows are attributable 100% to OOS freight flows. This finding verifies that OOS freight flow data are the only source of the differences in domestic freight estimates between the CFS and FAF.

Table D1. Results of Comparative Analysis of 2017 Freight Flows of CFS and FAF by Commodity (Weight)

Commodity	Domestic Percentage[a]	Percentage 1[b] Equation 2	Percentage 2[c] (1–Equation 3)/[c]	Percentage 3[d] 1–Equation 3	Percentage 4[e] Equation 3
Live animals/fish	98.5%	5.1%	5.1%	5.0%	95.0%
Cereal grains	91.6%	51.0%	51.0%	46.8%	53.2%
Other ag prods.	86.2%	42.1%	42.1%	36.2%	63.8%
Animal feed	89.1%	78.2%	78.2%	69.7%	30.3%
Meat/seafood	84.7%	98.1%	98.1%	83.1%	16.9%
Milled grain prods.	93.1%	96.7%	96.7%	90.0%	10.0%
Other foodstuffs	91.9%	82.4%	82.4%	75.7%	24.3%
Alcoholic beverages	88.5%	96.8%	96.8%	85.7%	14.3%
Tobacco prods.	96.2%	99.0%	99.0%	95.3%	4.7%
Building stone	98.4%	85.7%	85.7%	84.4%	15.6%
Natural sands	98.2%	85.7%	85.7%	84.1%	15.9%
Gravel	98.7%	85.7%	85.7%	84.6%	15.4%
Nonmetallic minerals	84.3%	83.6%	83.6%	70.5%	29.5%
Metallic ores	57.7%	100.0%	100.0%	57.7%	42.3%
Coal	86.2%	100.0%	100.0%	86.2%	13.8%
Crude petroleum	50.3%	0.0%	0.0%	0.0%	100.0%
Gasoline	92.6%	100.0%	100.0%	92.6%	7.4%
Fuel oils	83.1%	100.0%	100.0%	83.1%	16.9%
Coal-n.e.c.	94.8%	20.8%	20.8%	19.7%	80.3%
Basic chemicals	82.0%	99.1%	99.1%	81.3%	18.7%
Pharmaceuticals	78.0%	99.2%	99.2%	77.4%	22.6%
Fertilizers	78.4%	100.0%	100.0%	78.4%	21.6%
Chemical prods.	85.6%	92.2%	92.2%	78.9%	21.1%
Plastics/rubber	80.7%	91.2%	91.2%	73.6%	26.4%
Logs	97.7%	4.9%	4.9%	4.8%	95.2%
Wood prods.	89.3%	85.3%	85.3%	76.2%	23.8%
Newsprint/paper	76.6%	97.3%	97.3%	74.5%	25.5%
Paper articles	93.9%	95.3%	95.3%	89.4%	10.6%
Printed prods.	93.3%	93.5%	93.5%	87.2%	12.8%
Textiles/leather	64.3%	88.7%	88.7%	57.1%	42.9%

(continued next page)

Table D1. Results of Comparative Analysis of 2017 Freight Flows of CFS and FAF by Commodity (Weight) (con't)

Commodity	Domestic Percentage[a]	Percentage 1[b] Equation 2	Percentage 2[c] (1–Equation 3)/[c]	Percentage 3[d] 1–Equation 3	Percentage 4[e] Equation 3
Nonmetal min. prods.	96.2%	74.3%	74.3%	71.5%	28.5%
Base metals	84.5%	99.3%	99.3%	84.0%	16.0%
Articles-base metal	79.8%	94.4%	94.4%	75.3%	24.7%
Machinery	70.6%	93.3%	93.3%	65.8%	34.2%
Electronics	71.9%	88.1%	88.1%	63.4%	36.6%
Motorized vehicles	77.1%	98.7%	98.7%	76.1%	23.9%
Transport equip.	65.0%	99.0%	99.0%	64.3%	35.7%
Precision instruments	71.8%	84.6%	84.6%	60.8%	39.2%
Furniture	75.0%	50.3%	50.3%	37.7%	62.3%
Misc. mfg. prods.	91.1%	80.7%	80.7%	73.6%	26.4%
Waste/scrap	91.3%	28.9%	28.9%	26.4%	73.6%
Mixed freight	95.5%	94.9%	94.9%	90.6%	9.4%

[a] Percentage of domestic freight flows of total freight flows in the FAF5.0. The percentage point in decimal is used as the conversion factor, c, to calculate Percentage 2.

[b] CFS percentage in the FAF in *domestic* freight flows (See Table 6).

[c] Derived CFS percentage in the FAF in *domestic* freight flows.

[d] In-scope percentage in the FAF in *total* freight flows.

[e] OOS percentage in the FAF in *total* freight flows (from ORNL's analysis results).

U.S. Department of Transportation
Office of the Secretary of Transportation
Bureau of Transportation Statistics