ORNL/TM-2016/489

THE FREIGHT ANALYSIS FRAMEWORK VERSION 4 (FAF4)

Building the FAF4 Regional Database: Data Sources and Estimation Methodologies

Ho-Ling Hwang, Ph.D.
Stephanie Hargrove, Ph.D.
Shih-Miao Chin, Ph.D.
Daniel Wilson
Hyeonsup Lim
Jiaoli Chen
Rob Taylor
Bruce Peterson
Diane Davidson

Approved for public release.
Distribution is unlimited.

September 2016

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

THE FREIGHT ANALYSIS FRAMEWORK VERSION 4 (FAF4)

Building the FAF4 Regional Database: Data Sources and Estimation Methodologies

Prepared for the
Bureau of Transportation Statistics
and
Federal Highway Administration
U.S. Department of Transportation

September 9, 2016

Prepared by
Ho-Ling Hwang, Ph.D.
Stephanie Hargrove, Ph.D.
Shih-Miao Chin, Ph.D.
Daniel Wilson
Hyeonsup Lim
Jiaoli Chen
Rob Taylor
Bruce Peterson
and
Diane Davidson
Oak Ridge National Laboratory

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, TN 37831-6283
managed by
UT-BATTELLE, LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 THE FAF PROGRAM

The Freight Analysis Framework (FAF) integrates data from a variety of sources to create a comprehensive national picture of freight movements among states and major metropolitan areas by all modes of transportation. It provides a national picture of current freight flows to, from, and within the United States, assigns the flows to the transportation network, and projects freight flow patterns into the future. The FAF4 is the fourth database of its kind, FAF1 provided estimates for truck, rail, and water tonnage for calendar year 1998, FAF2 provided a more complete picture based on the 2002 Commodity Flow Survey (CFS) and FAF3 made further improvements building on the 2007 CFS. Since the first FAF effort, a number of changes in both data sources and products have taken place. The FAF information, including documents and data files, can be found at the following websites: http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/subject_areas/freight_transportation/faf and http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm.

The FAF4 flow matrix described in this report is used as the base-year data to forecast future freight activities, projecting shipment weights and values from year 2020 to 2045 in five-year intervals. It also provides the basis for annual estimates to the FAF4 flow matrix, aiming to provide users with the timeliest data. Furthermore, FAF4 truck freight is routed on the national highway network to produce the FAF4 network database and flow assignments for truck.

1.2 FAF4 BASE-YEAR DATABASE

The first FAF4 product is the 2012 base-year Origin-Destination (OD) database, and subsequent products like forecasts and network flows are derived from that. The primary dimensions of this base-year FAF4 matrix are shipment origin (O), shipment destination (D), commodity class (C), and mode of transportation (M). Both domestic and foreign trade shipments are represented in FAF4 flows. The database includes estimates of freight volumes, in dollar values and tonnages for shipments to, from, and within regions for 2012. This document offers a description of the diverse data sources and modeling methods used in constructing the base year FAF4 Origin-Destination database.

The FAF4 is built upon the 2012 CFS; changes made to the CFS data inevitably affect the FAF. The 2012 CFS contains 132 areas, an increase of domestic regions from 123 areas in the 2007 CFS. Note that FAF4 adapted the same definitions of foreign regions and modes of transportation as those used in the FAF3. The FAF4 flow matrix contains; 132 (O) x 132 (D) x 43 (C) x 7 (M) of potential data cells for shipments moved within the U.S.

In addition to data from the 2012 CFS, FAF4 includes shipments from establishments that were out-of-scope (OOS) to the 2012 CFS sampling frame. This includes businesses classified in farms, fisheries, transportation, construction and demolition, most retail and service industries, foreign establishments (imports), crude petroleum and natural gas shipments, municipal solid waste, logging, as well as household and business moves. Discussions on specific OOS components of the FAF4 matrix are presented in Sections 5 through 11 in this report.

1.3 ORGANIZATION OF THIS REPORT

This report details the data sources and methodologies applied to develop the base year 2012 FAF4 database. An overview of the FAF4 components is briefly discussed in Section 2. Effects on FAF4 from the changes in the 2012 CFS are highlighted in Section 3. Section 4 provides a general discussion on the process used in filling data gaps within the domestic CFS matrix, specifically on the estimation of CFS suppressed/unpublished cells. Over a dozen CFS OOS components of FAF4 are then addressed in Section 5 through Section 11 of this report. This includes discussions of farm-based agricultural shipments in Section 5, shipments from fishery and logging sectors in Section 6. Shipments of municipal solid wastes and debris from construction and demolition activities are covered in Section 7. Movements involving OOS industry sectors on Retail, Services, and Household/Business Moves are addressed in Section 8. Flows of OOS commodity on crude petroleum and natural gas are presented in Sections 9 and 10, respectively. Discussions regarding shipments of foreign trade, including trade with Canada/Mexico, international airfreight, and waterborne foreign trade, are then discussed in Section 11. Several appendices are also provided at the end of this report to offer additional information.

2. DEVELOPEMENT OF FAF4 DATABASE

2.1 OVERVIEW

The FAF is built on the CFS data, while integrating additional data to estimate volumes of shipments from many industries that were not covered by the CFS. Because it is CFS-based, 2012 CFS definitions of the 132 domestic areas, the 43 commodity codes (SCTG 2-digit), and the modes of transportation were adopted by the FAF4. The only exception is a "no domestic" mode, which was added to represent imported crude petroleum that is processed at the "dock" thus not involving any mode transport domestically. Similar to previous releases, the 2012 CFS captured shipments that accounted for approximately 70% of the FAF4-estimated total volumes by dollar value. As shown in Figure 2–1, the FAF base-year matrix consists of shipment flows from two major groups: domestic shipments captured by the CFS and out-of-scope (OOS) shipments from many industry sectors or trade (both foreign and domestic). In addition to the 2012 CFS data, major data sources utilized in estimating flows of OOS shipments are also presented in Figure 2–1. These data were analyzed and, in most cases, coupled with sector-specific models and algorithms to generate freight flow details as required in producing the FAF database.

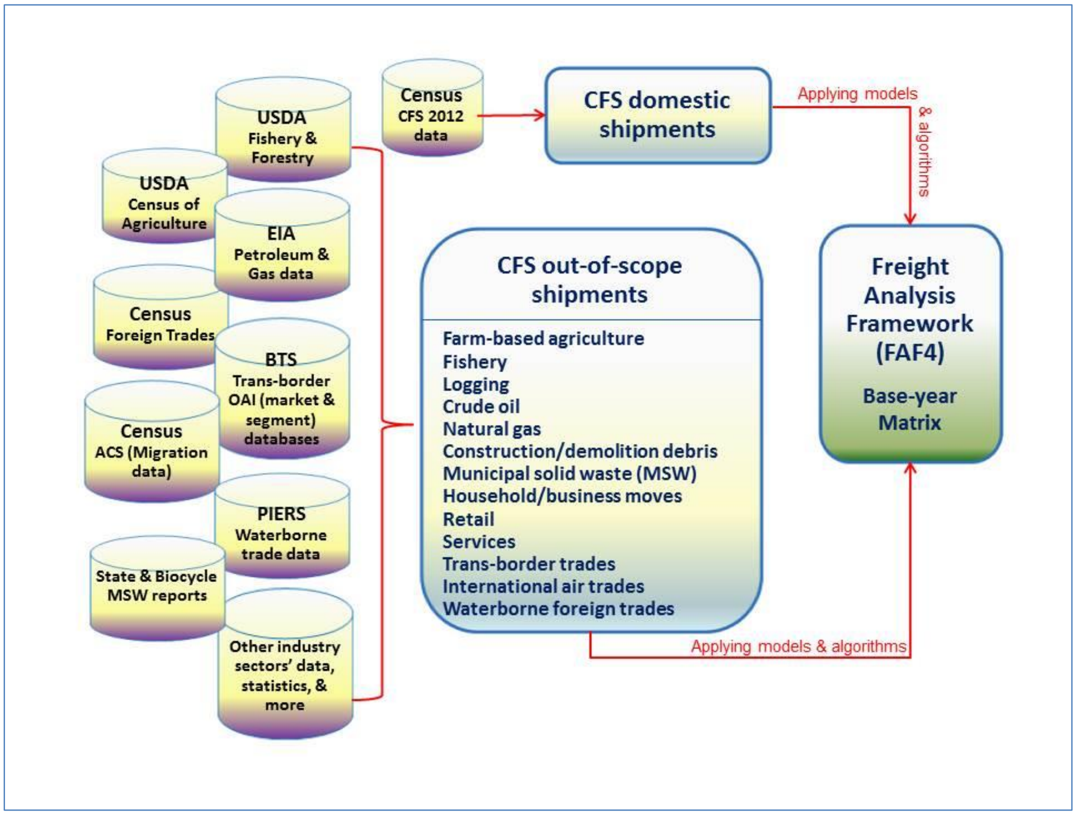

Figure 2–1. Components of the FAF4 database.

2.2 CFS DOMESTIC

Being a U.S. shipper-based survey, the CFS does not include imports. While the CFS does capture exports, there is a data quality concern on its exported shipment flows, mainly due to sample size limitations. As a result, only domestic shipments from the CFS were used in constructing the FAF.

Because of a combination of data suppression for confidentiality reasons, limited sample size, potential large standard errors in estimates, as well as limitations to the scope of the CFS (across industrial sectors), many cells in the CFS matrix where flows may exist were suppressed (i.e., missing). A prior study of the complete set of CFS data indicated that a good set of available data matrices could be used to estimate data gaps within the CFS matrix. This includes the most detailed information of the published matrices (Tables 25), which reports annual tons and dollar values shipped by origin, destination, mode, and 2-digit SCTG. Other CFS tables also provide various dimensional (e.g., 2- or 3-dimention) data, including flows broken down to the CFS-domestic geographic regions of interest. To separate domestic and exported shipments from the 2012 CFS data, the Census Bureau provided a set of special CFS tables that broke out domestic shipments from exports.

Detailed discussions on methodology developed for filling missing cells in the domestic CFS flow matrix, under the creation of FAF4 database effort, are further described in Section 4 of this document.

2.3 CFS OUT OF SCOPE AREAS

As pointed out previously, FAF4 takes into account shipments from establishments not covered by the 2012 CFS. This includes shipments from industries classified in transportation, construction, most retail and service industries, farms, fisheries, foreign establishments (imports), petroleum and natural gas extraction, municipal solid waste, logging, as well as household and business moves.

The OOS-component databases for FAF4 were constructed based on various data sources, including administrative records (e.g., Foreign Trade Data) and other industry-based data. For missing or suppressed data elements–either due to disclosure concerns or geographic limitations of the source data files–models and imputation techniques were employed to estimate those data components. Specifically, modeling approaches such as iterative proportional fitting (IPF), log-linear, and spatial interaction models were often used during the FAF4 estimation process. Several improvements, over the FAF3 process, were applied in estimating flows of commodities for OOS sectors in FAF4.

As seen in Figure 2–1, like its predecessors in 1993, 1997, 2002, and 2007, the 2012 CFS does not include shipments originating from several OOS business sectors, including:

- Farm-based Agriculture
- Fisheries
- Logging
- Construction and Demolition Debris
- Municipal Solid Waste (MSW)
- Services
- Retail
- Household and Business Moves
- Crude Petroleum
- Natural Gas

In addition to industry sectors listed above, foreign trade (i.e., imported and exported shipments) are also included as an OOS area in the FAF process. Data sources and flow estimation procedures for each of the OOS components are covered in several sections following the discussions of the domestic CFS component in this document.

3. EFFECTS OF CHANGES IN 2012 COMMODITY FLOW SURVEY

The changes in geography, commodities and modes in the 2012 CFS and their impacts on FAF4 in comparison to historical FAF data series are briefly discussed below.

3.1 CFS GEOGRAPHY

3.1.1 Domestic Regions

The CFS Areas are the smallest level of geographic detail for which the CFS produces estimates. The 2012 CFS contains 132 domestic areas[1]. There are 10 new CFS Areas in 2012, as identified in Table 3–1. Because all counties in the state of New Jersey are covered by 2012 CFS Areas, there is no longer a need for the "Remainder of NJ" area. Thus, the total net count for 2012 CFS Areas is 132, an increase of nine over the 2007 CFS.

Table 3–1. List of the New Areas for the 2012 CFS

CFS Area Name	State
Fresno-Madera, CA	CA
Philadelphia-Reading-Camden, PA-NJ-DE-MD (DE part)	DE
Fort Wayne-Huntington-Auburn, IN	IN
Wichita-Arkansas City-Winfield, KS	KS
Cincinnati-Wilmington-Maysville, OH-KY-IN (KY part)	KY
Omaha-Council Bluffs-Fremont, NE-IA (NE part)	NE
Boston-Worcester-Providence, MA-RI-NH-CT (NH part)	NH
New York-Newark, NY-NJ-CT-PA (PA part)	PA
Knoxville-Morristown-Sevierville, TN	TN
Portland-Vancouver-Salem, OR-WA (WA part)	WA

In addition to new CFS Areas, boundaries of many CFS Areas are also different from their corresponding 2007 CFS Areas. Figure 3–1 shows the boundaries for all regions in FAF3 (2007 CFS based) and FAF4 (2012 CFS based). New 2012 CFS Areas are shown as yellow-shaded regions; green-shaded areas represent FAF3 area boundaries, and red lines marks boundaries of FAF4 regions. Clearly, the creation of new areas (shown in yellow) affected the geographic boundary of their corresponding "remainder of state" areas. A crosswalk of the CFS area code and FAF4 zone ID is provided in Appendix A.

Geographic boundary differences in many CFS Areas between 2007 (FAF3) and 2012 (FAF4) are seen Figure 3–1. These differences are due to MSA/CSA boundary changes over the 5-year

[1] Commodity Flow Survey, Bureau of Transportation Statistics, U.S. DOT, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/commodity_flow_survey/index.html.

period from 2007 to 2012, which is mostly a reflection of changes in regional population or economic activity patterns during such time. Due to changes in geographic boundaries of FAF regions, only state-level 1997-2002-2007 data will be produced with state-level FAF4 for historical trending comparison purposes.

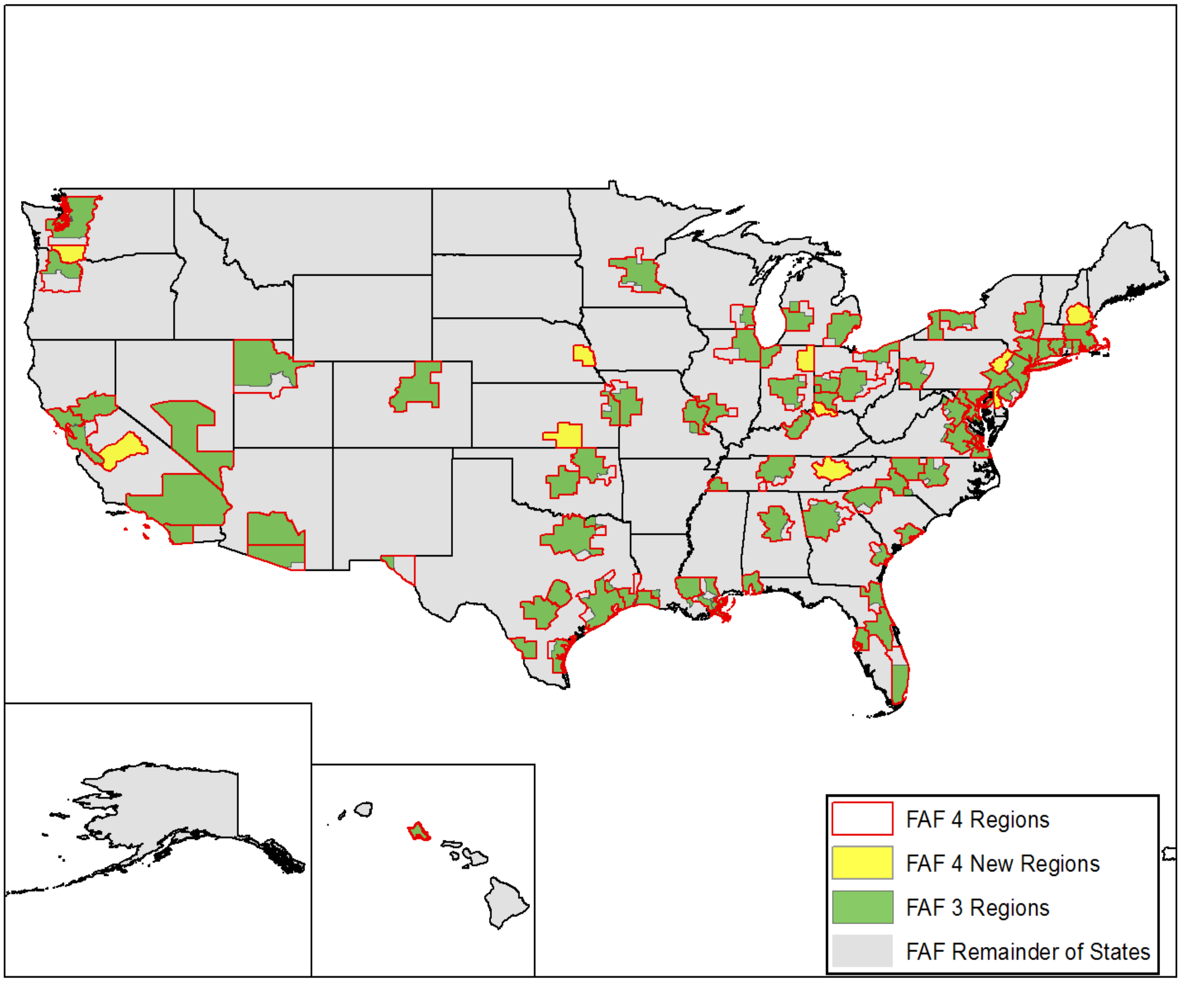

Figure 3–1. Comparison of FAF4 to FAF3 regions.

3.1.2 Foreign Regions

There are no changes to foreign region definitions in FAF4 from FAF3. The foreign regions are:

1. Canada
2. Mexico
3. Rest of Americas (including Puerto Rico and U.S. Virgin Island)
4. Europe
5. Africa
6. Southern, Central, and Western Asia

7. Eastern Asia
8. South-Eastern Asia and Oceania

3.2 CHANGES TO COMMODITY CLASSIFICATION CODES

3.2.1 Reclassification of Ethanol as Fuel

One of the major changes made in the 2012 Standard Classification of Transported Goods (SCTG) was to separate fuel ethanol from alcoholic beverages. Specifically, the 2007 SCTG code of 08310 "*Denatured ethyl alcohol, and un-denatured ethyl alcohol that is 80% or more alcohol by volume*" was revised in the 2012 version as "*Spirituous beverages and ethyl alcohol – Un-denatured ethyl alcohol that is 80% or more alcohol by volume.*" Two new codes were created (08410 and 08420) for "*Denatured ethyl alcohol, not for human consumption,*" which specified the exclusion of "ethanol for use as biofuel" from the SCTG 08. Because of this modification, new SCTG codes were created under SCTG17, including:

- SCTG 17500 for "*Alcohol and gasoline blends with more than 10% alcohol volume (includes E15, E20, E25, E70, E75, E85) and other blends of ethanol not elsewhere classified* " and
- SCTG 17600 for "*Ethanol, anhydrous ethanol (E100) denatured, and other denatured alcohols for use in blends of biofuel*"

At the 2-digit SCTG level (as used in FAF), fuel ethanol is now classified under SCTG 17 (Gasoline, aviation turbine fuel and ethanol) and is no longer included in SCTG 08 (Alcoholic beverages and denatured alcohol).

3.2.2 Changes in Kerosene and Biofuel Related Commodity Codes

Previously, kerosene was listed under SCTG 19 "*Other coal and petroleum products.*" Under the 2012 SCTG definition, it was reclassified into SCTG 17. Specifically, kerosene was changed from 2007 SCTG code of 19201 to the new code of 17202 "*Kerosene for heating and uses other than aviation fuel*" in the 2012 version of SCTG. This change aligns kerosene better with similar fuels.

To accommodate recent developments in biofuels, the 2007 SCTG code of 18000 was modified as "*Fuel Oils (includes Diesel, Bunker C, and Biodiesel)*" and is further broken down to subcategories as listed in Table 3–2.

Table 3–2. New SCTG 18 Categories in the 2012 Release of SCTG Definitions

2012-SCTG Code	Description
18100	Fuel oil (includes diesel, distillate heating oil, Bunker C excludes biodiesel)
18200	Blends of fuel oils (includes 5% or less biodiesel by volume, B5, or less)
18210	Blends of fuel oils with more than 5% biodiesel by volume, (excludes B100)
18220	Biodiesel (derived from vegetable oils or animal fats), B100 (excludes mixtures of biodiesel and diesel fuel)

3.2.3 Potential Effects of the SCTG Code Changes on FAF

The classifications of commodities for FAF4 allow better distinctions between fuel ethanol shipments and movements of alcohol beverages, and properly assign all kerosene flows into movements of fuels. These changes have effects on the FAF4 matrix.

First, a modified crosswalk table between the new SCTG and other commodity coding schemes, such as Harmonized System (HS) Codes and Standard Transportation Commodity Codes (STCC) had to be reestablished. The HS-SCTG crosswalk table is particularly crucial to the proper assignment of commodities during the process of foreign trade data (imports and exports).

A more challenging issue that FAF4 will have to resolve is the comparability with previous FAF datasets. Since FAF is designed based on published CFS data, its commodity detail is limited to 2-digit level SCTG codes. In order to generate compatible FAF data series for trending analysis, information (on shares/percentages or factors) to properly adjust prior FAF data will be used.

3.3 CHANGES IN CFS MODE CLASSIFICATION

Changes were also made to reassign shipments with “unknown” mode to other specific modes during the 2012 CFS mileage calculation processing. A shipment with an unknown mode was reassigned to truck mode if it was less than 2 truckloads or 80 thousand pounds; otherwise, it was assigned to rail. Furthermore, under the 2012 CFS processing, shipments of 150 pounds or more were reassigned to truck mode (for-hire truck), resulting in the shipments shifting out of the “Multiple Modes and Mail” category in FAF. Therefore, corresponding mode adjustments would be necessary for comparisons across different versions of FAF databases. Other than that, the 2012 CFS definitions of transportation modes are used in the FAF4. These modes, as described under the FAF4 context, are listed below, along with their corresponding codes:

1. ***Truck*** **–** Includes private and for-hire trucks. Private trucks are owned or operated by shippers, and exclude personal use vehicles hauling over-the-counter purchases from retail establishments.
2. ***Rail*** **–** Includes any common carrier or private railroad.
3. ***Water*** **–** Includes shallow draft, deep draft, Great Lakes shipments, and shipments operating over any combination of water modes.

4. ***Air (includes truck-air)*** **–** Includes shipments that are moved by air or a combination of truck and air in a commercial or private aircraft; includes airfreight and air-express.
5. ***Multiple Modes and Mail*** **–** Includes intermodal shipments, shipments by multiple modes, and shipments by parcel delivery services, U.S. Postal Service, and couriers; excludes shipments typically weighing more than 150 pounds that move by a combination of truck and air. This category is not limited to containerized or trailer-on-flatcar shipments.
6. ***Pipeline*** **–** Includes flows from offshore wells to land.
7. ***Unknown or Other*** **–** This mode is mostly conveyor belts.

Note that, even though there was no longer an "unknown" mode in the 2012 CFS data, the corresponding FAF4 has retained the "unknown or other" mode category (mode code 7) as in previous versions of FAF.

4. ESTIMATION OF DOMESTIC CFS SHIPMENTS

4.1 OVERVIEW

The 2012 CFS covers approximately 70% of the domestic freight volumes by dollar value that FAF4 intends to capture, the remaining 30% being shipped by businesses outside the CFS scope. The CFS reports origin, destination, commodity, and mode (ODCM) activity of covered sectors, by tons and dollar values, but not all data cells are released for two reasons. First, measured and expanded activity captured by the CFS survey may be suppressed from the published tables due to (a) protection of the confidentiality of identifiable shippers, and (b) statistical reliability problems in the estimates (namely coefficients of variation (CV) above 50%). These are cells with no quantities reported, but where activity did occur. Secondly, as a sample survey, a certain activity may not be captured by the CFS because it occurred in an establishment, or on a day, that was not sampled, which is a sampling limitation.

The FAF's intent with the CFS component is to reproduce those shipments actually captured by the CFS. It is not to estimate the quantity and location of missed shipments, nor to estimate the probabilities or potential of movements occurring, regardless of whether the shipments were ever realized. In other words, the FAF process is to estimate what the CFS would show if there were no suppression. At the most detailed ODCM level, more cells are suppressed for confidentiality or reliability reasons, or because expanded movements are rounded to zero, than there are filled cells, although the preponderance of U.S. movements (in terms of volume) do occur in unsuppressed cells.

For the FAF process, Census provided a special tabulation of domestic-only movements (i.e., excluding exports) with a looser CV threshold of 100%. This special dataset also included a count of shipments in each ODCM cell so that "zero cells" which had positive activity could be distinguished from the true zeros. The main effort in this component of FAF is to estimate suppressed cells for a comprehensive ODCM matrix on domestic CFS shipments.

4.2 ESTIMATION PROCESS

4.2.1 A Log-linear Model of Effects

The FAF process assumes that any value in the ODCM matrix is the product of a set of unknown but estimable effects. In the simplest model of independence, it is assumed that any ODCM tonnage is the product of four separate effects due to origin, destination, commodity, and mode, which can be mathematically expressed as:

$$U(o,d,c,m) = e[O](o) * e[D](d) * e[C](c) * e[M](m) \quad [1]$$

where U is the ODCM flow matrix (with measured or estimated values), capital letters (e.g., "O") are a particular dimension, and lower case letters are given categories in the dimension. For example, the tonnage of coal (SCTG 2-digit code of '15') shipped between West Virginia (FAF zone 540) and Baltimore (FAF zone 241) by rail (mode '2') would be

U(540,241,15,2) = e[O](540) * e[D](241) * e[C](15) * e[M](2).

Here, each effect, say e[O], is a vector with a cell for each of the possible 132 origin zones. Thus the term e[O](540) is the origin effect for West Virginia.

This first-level approximation is clearly inadequate because, by assuming independence, it fails to account for the interaction effects between categories. For instance, distant origins and destinations should typically have lower volumes than nearby ones. Thus, by considering a second-level interaction effect e[OD](o,d) that influences total flows, the flow model in [1] can now be expressed as

U(o,d,c,m) = e[O](o) * e[D](d) * e[C](c) * e[M](m) * e[OD](o,d) [2]

A spatial interaction model will estimate e[OD] with a specific functional form based on the cost of interaction between o and d, but the interest here is providing the best estimate of the e[OD] 2-dimensional matrix that will make the flow estimates U closest to measurements. Likewise, there may be an origin-commodity effect e[OC], or a commodity-mode interaction effect e[CM], etc., that also needs to be considered. Therefore, by including all possible 2-dimensional effects in the model, the equation becomes

U(o,d,c,m) = e[O](o) * e[D](d) * e[C](c) * e[M](m) *
e[OD](o,d) * e[OC](o,c) * e[OM](o,m) * e[DC](d,c) *
e[DM](d,m) * e[CM](c,m) [3]

Similarly, the third-order effects and a fourth-order interaction effect can also be considered in the model. In the FAF processing, a "grand mean" e0 is also introduced into the model, which serves as a scalar factor (e.g., the difference between measuring weight in tons or ounces). With this, a fully saturated model for U is shown as:

U(o,d,c,m) = e0 * e[O](o) * e[D](d) * e[C](c) * e[M](m) * e[OD](o,d) * e[OC](o,c) *
e[OM](o,m) * e[DC](d,c) * e[DM](d,m) * e[CM](c,m) * e[ODC](o,d,c) *
e[ODM](o,d,m) * e[OCM](o,c,m) * e[DCM](d,c,m) * e[ODCM](o,d,c,m). [4]

To explain the internal pattern within the flow matrix U, the task is to disentangle individual interaction effects, to see which are strong and which irrelevant (near 1). Knowing the pattern, values for any missing cell can be estimated by multiplying through the individual effects that supposedly comprise it.

4.2.2 Estimation of Effects

To determine whether there is some other set of effects that is superior for the FAF purposes, a set of effects that minimizes the informational content of the model, ∑ (e * ln e), summed over every effect in every level (that is, every model parameter), is selected. Roughly speaking, the goal is to find a set of effects that are as close to 1 as possible, and minimize the number of effects significantly different than 1. This is done by concentrating the variation (deviation from 1 = "no effect") found in high-order effects into a low-order effects matrix, reducing the deviation in a large number of cells in exchange for increasing deviations in a small number.

The FAF solution method starts with e[ODCM] = U, and cyclically finds variation that can be removed from a high-level matrix and passed to a low-order matrix, repeating the process until there is no more variation to be extracted. The extraction process proceeds from 3-dimensional effects into 2-dimensional, and then into 1-dimensional, and then into the 0-dimensional grand mean. The extraction cycle repeats from 4- to 3-dimsional effects matrices, until there is no more movement of effects parameters.

If a cell in e[ODCM] is unknown, or zero-valued, it will not participate in the extraction process, and geometric means will be taken only from those known cells. If all high-order cells are unknown, then an "unknown" will be passed down to the next level. In principle, cells could be called true zeros if there was no CFS activity there. In the FAF processing, they are referred to as "unknown" instead, in case someday it is desired to use the effects matrix to indicate probabilities of movement rather than measured CFS movements.

4.2.3 A Priori Estimation of Low-Order Effects

The CFS also provided lower-dimensional marginal tables that have less suppression (i.e., fewer suppressed cells). Estimates of lower-order effects can be made from these marginal tables and inserted into a lower-order effects matrix before the extraction process starts. For instance, a 2-dimensional origin-destination table exists, where every (o,d) cell has been summed over all commodities and modes. That table can be taken as an initial estimate of the OD effects matrix e[OD]. It is generally convenient to normalize these matrices by their geometric means. At every step, the equality between the product of effects and measured flows must be preserved, which means that, if a priori low-order effect is inserted, upstream next higher order effects must have their values (if known) divided by the same amount to preserve the equality. Real zeros in the 2-dimensional OM, DM, OC, and CM marginal CFS tables were accepted as true zeros. However, a zero in the OD cells was treated as a sampling zero, which did not preclude the possibility of such a movement in reality. Here, a sampling zero has the same practical effect as a missing value or suppression. In the final IPF step, “impossible” cells will be converted to absolute zeros, since the CFS controls are zeros.

4.2.4 Alternate Sources and Years

There are many cases where the 2012 CFS has sampling zeros or suppressions, but where an earlier CFS (i.e., 2002, 2007) had positive levels of movement. If any region is composed entirely of "unknowns" in the 2012 matrix, it will be impossible to extract a pattern. However, the previous CFS may supply one, which can be passed down the extraction chain. It also allows the detection of major pattern changes between successive CFS's. Because of differences in geographic zones (as discussed in Section 2 of this report), an equivalence table between different years' zones had to be manually established. In the case that no equivalence could be identified, the earlier year's zone had to be ignored. Note that this process (i.e., domestic CFS) ignores differences in mode and commodity definitions.

The 2012 rail Waybill Sample was also used as an alternate source, using a STCC to SCTG mapping, and converting county origins and destinations into FAF4 zones, while leaving shipment values unknown. Container shipments were excluded, so the sole mode involved was rail. As always, known values in the 2012 CFS are preserved, but unknown values may be imputed by a multiplication of effects estimated from other sources.

So far, the discussions have been on processes revolved around measuring tons. Of course, FAF also estimates dollar values of shipments. This was handled with a similar model formation, except for adding another dimension for the activity type (V), with two levels: tons and dollars. An interaction effect of V with each of the other dimensions was included into the model.

4.2.5 Computation

Although this is a multiplicative and not additive model, and the interest is in geometric means for minimizing variation, for practical purposes all values are converted into natural logs. This is because finding the arithmetic average of logs is much easier than calculating a geometric mean. This computational convenience is the sole reason for calling this process a "log-linear model." At the conclusion, logs are converted back to real numbers, and missing values in the final matrix for the 2012 CFS are replaced by a product of effects. That matrix then goes to the IPF stage for process.

4.2.6 IPF for CFS Processing

The marginal totals of the CFS form a set of control totals that the activity matrix U must conform to them. In addition, there are some state-level controls where summations over the contiguous zones that form the state should be matched. Note that many cells in the original CFS matrix either have absolute values in them, or else have absolute zeros due to a zero sample count, and those are controls as well. These marginal controls were provided by Census in a special CFS tabulation for domestic shipments only.

For every control value (every non-missing cell in a control matrix), the values in the cells of the disaggregate table that compose the aggregate cell are summed and compared to the control. If different, all the component cells are adjusted up or down by a common factor to match the control. Since CFS values are rounded to the nearest integer (in kilotons or million-dollars), a total that is within half of a unit is considered as a match, thus no need for further adjustments. For intermodal movements, several CFS modes must be summed to match the category. When some of the component modes have values, and others are missing, the values form a floor for FAF values, and exceeding the floor does not require adjustment.

This IPF cycle through controls is repeated until there are no more significant changes in the U cell values between subsequent iterations.

5. FARM-BASED AGRICULTURAL SHIPMENTS

Farm-based agricultural shipments represent one of the most significant OOS areas for the CFS. This sector covers farm-based agricultural shipments from the field (i.e., farm) to grain elevator, distribution or processing center, or slaughterhouse. These shipments are almost entirely moved by truck, therefore under FAF4, it is assumed that truck is the mode of transportation used for transporting all farm-based agricultural shipments.

5.1 DATA SOURCES

5.1.1 2012 Census of Agriculture

The *Census of Agriculture* is a census conducted every five years by the U.S. Department of Agriculture (USDA); it coincides with the Economic of Census, which occurs in years ending "2" and "7." The *Census of Agriculture* is the leading source of facts and statistics about U.S. agricultural production. It provides statistical information at the national, state, and county (or county equivalent) levels. All agricultural production establishments (e.g., farms, ranches, nurseries, greenhouses, etc.) are included[2] in the census. The latest available data from the Agriculture Census is for 2012.

5.1.2 Agricultural Statistics 2013

The *Agricultural Statistics* is an annual publication prepared by the National Agricultural Statistics Service (NASS) of the USDA. It provides information on agricultural production, supplies, consumption, facilities, costs, and returns. Weights, measures, and conversion factors are also published in this reference book. Information from the 2013-issue of this publication was used for FAF4, and includes preliminary estimates for 2012 and projection estimates for 2013.

5.1.3 USDA Statistical Bulletins

The NASS of the USDA issues a series of bulletins that contain final estimates for agricultural data series based on the review of the *2012 Census of Agriculture* and other information. A large number of bulletins covering all major types of agricultural commodities have been published by the NASS in this series.

[2] The definition of a farm in the Census of Agriculture is "any place from which $1,000 or more of agricultural products were produced or sold, or normally would have been sold, during the census year." This definition is consistent with the definition used for current USDA surveys.

5.1.4 2002 Vehicle Inventory and Use Survey (VIUS)

As a part of the Economic Census, the Bureau of Census collects information on the physical and operational characteristics of the private and commercial truck population in the U.S. The VIUS had been conducted in the same year as the CFS (also a part of the Economic Census). However, this program was terminated prior to the 2007 Economic Census, making the 2002 VIUS the latest available data in this series.

Note that in FAF3, 2002 VIUS data was used to estimate the average travel distance for farm-based agricultural shipments covered under this data gap. Although continued use of this decade old data set for FAF4 purposes was a concern, lack of recent and complete data makes the 2002 VIUS the best source. That is, without updated information, it is assumed that distributions of farm-based shipment distances (in terms of distance from field to the first-point processing center such as grain elevator, distribution or processing center, or slaughterhouse, etc.) remained the same over the last decade.

5.1.5 2012 CFS Published Statistics

Tonnage and value by origin information from the 2012 CFS for shipments of SCTG 01, 02, 03, 04, 05, 07, and 09 were used to determine associated farm-based shipment origin-destination flows. More details on the use of CFS 2012 data are discussed in the estimation methods section below.

5.2 ESTIMATION PROCEDURES

5.2.1 Estimating Agricultural Production at State Level

The dollar value of this OOS data gap at the national and state levels can be estimated using information obtained from the *2012 Census of Agriculture* and related publications. Specifically, data provided under the category of "Market value of agricultural products sold"[3] was used as an estimate for total farm-based agricultural shipments. The estimation of tonnages for these OOS shipments is not as straightforward, however.

The USDA's commodity tonnage statistics in the *2012 Census of Agriculture* are typically in different units of measurement (e.g., pounds, bushels, hundredweight, barrels, tons, etc.). Therefore, unit conversions were necessary. In many cases, the conversion factors[4] are different

[3] The "Market value of agricultural products sold" category represents the value of products sold which combines total sales not under production contract and total sales under production contract. It is equivalent to total sales. See Appendix A, General Explanation and Census of Agriculture Report Form, in the *2012 Census of Agriculture* report for further explanation.

[4] "Weights, Measures, and Conversion Factors" table in the Agricultural Statistics 2013 publication at: http://www.nass.usda.gov/Publications/Ag_Statistics/2013/Agricultural_Statistics_2013.pdf .

even though the "same" unit was used. For example, the approximate net weight for a bushel of wheat is 60 pounds, while a bushel of corn is 70 pounds for husked corn on the cob, and 56 pounds for shelled corn. All conversion factors used in this study are based on information obtained from *Agriculture Statistics 2013*.

Because the USDA does not use SCTG codes for its commodity categorization, agricultural commodities were regrouped into SCTG categories, to the extent possible and reasonable. A more detailed regrouping of SCTG commodities (than that used in FAF3) is established for FAF4. As a result, accuracy of estimates for this OOS area has improved. Note that categories of farm-based agricultural shipments considered in FAF4 are more comprehensive than that under FAF3 where only SCTG 01, 02, and 03 were included.

Results from the *2012 Census of Agriculture* data indicated that this farm-based OOS component involved nearly 1 billion tons valued at $385 billion in 2012. Table 5–1 shows the breakdown of this total by SCTG at the national level. Itemized farm-based agricultural products included in these national totals are provided in Appendix B.

Table 5–1. National Total for Farm-Based Agricultural Shipments in 2012

SCTG	Commodity Description	Weight (thousand ton)	Value (million $)
01	Animal and fish (live)	90,460	146,746
02	Cereal grains	451,736	88,797
03	Agricultural products (include tobacco)	257,583	111,073
04	Animal feed, eggs, honey and other animal products	55,472	3,261
07	Other prepared foodstuffs (milk)	104,171	35,501
Total		**959,422**	**385,378**

5.2.2 Estimating Agricultural Production at FAF-Zone Level (Origin of Shipments)

In addition to state-level statistics, a similar level of details in commodity weights can also be obtained at the county level for many agricultural commodities using data provided by USDA. Thus, the method used in estimating state-level tonnage statistics can be applied to generate estimates at the county level for those commodities.

For commodities that tonnage statistics cannot be directly estimated from USDA-published data, harvested acreages for those commodities are provided at the county level (instead of their weights). Although acreage does not necessarily mean production, it is clear that no production of a given agricultural commodity is possible if no acreage was designated for that. Under this study, when the weight information of a commodity was not given, a straightforward method of using the acreage data to proportional distribute the state-level total weight of the given agricultural product to counties involved (within the given state) was utilized. This proportional distribution method was used to disaggregate state-level total shipment value into county-level values as well. Clearly, this process is only necessary for states with sub-state FAF zones (i.e., CFS areas). County-level production estimates (tonnage and value) within each CFS area were summed to obtain the given zonal-level estimates.

5.2.3 Estimating Farm-Based Shipment OD Flows

Determining Destinations of Farm-Based Shipments

In order to estimate OD flows of farm-based agricultural shipments, destinations of those shipments had to be determined first. The criteria used in selecting potential destinations of farm-based shipments are different from FAF3. Under the FAF3 process, only CFS areas that shipped out the same commodity (i.e., SCTG) were used to determine the terminating geography of the given SCTG shipments from a farm. The FAF4 process expanded this destination selection process to consider CFS areas that shipped out products associated with the farm-based commodity. For example, CFS areas with shipments of "tobacco products" (SCTG 09) that originated from their locations were considered as potential destinations for "tobacco harvested" (SCTG 03) from a farm.

Estimating OD Flows of Farm-Based Shipments

As in FAF3, VIUS 2002 data was used in estimating the distribution of average shipment distances. Specifically, VIUS data provides information on the typical "area of operation" of trucks carrying agricultural products. This information is given in categories such as: off-the-road; 50 miles or less; 51 to 100 miles; 101 to 200 miles; 201 to 500 miles; 501 miles or more; not reported; and not applicable (i.e., vehicle not in use). Because the primary interest of FAF is on commodity movements on the national transportation systems, off-road activities were not applicable to this study. Furthermore, since farm-based shipments were generally assumed to be relatively local (shorter trips), the category of "501 miles or more" was also eliminated from the estimation process. Using mid-points of the remaining range categories and the distribution of operating ranges, a distribution of shipment length can be estimated for each of the associated SCTG commodity-carrying truck groups (i.e., principal product carried) by state. A brief discussion of a similar estimation procedure, at the state level, can be found in a 1998 *Journal of Transportation and Statistics* article[5].

When multiple destinations (CFS-based) are within the same distance range from a given "production" area (i.e., origin of the farm-based shipment), the estimated total of this shipment is divided proportionally among all involved destination regions, based on the tonnages of each

[5] Chin, S. M., J. Hopson, and H. L. Hwang, "Estimating State-Level Truck Activities in America," *Journal of Transportation And Statistics*, Volume I, No. 1, pp 63-74, January 1998.

associated commodity. The same method is applied to the estimation of dollar values on farm-based shipments.

As an illustration of this process, assume there are agricultural product (SCTG 03) shipments originating from the "Rest of IN" (FAF4 zone 189), which weights 100 thousand tons in total. (For simplicity of this example, it is assumed no tobacco-related products are involved.) Based on the 2002 VIUS data, 94% of Indiana-based trucks that moved agricultural shipments traveled within 50 miles. Thus, in this example, 94 thousand tons of these shipments will be moved within a 50-mile radius of the origin zone '189'.

With the aid of a Geographic Information System (GIS) tool, four CFS areas are identified as within the 50-mile range (measured from centroid to centroid of two zones) of zone '189.' These four zones along with their associated CFS tonnages (amount originating from each given zone) for the selected commodity are listed in Table 5–2.

Table 5–2. Total Tonnages Originated from CFS Areas within a 50-mile Distance Range of FAF4 Zone 189 for SCTG03

CFS Area	Destination	2012 CFS total from the given zone for SCTG 03 (1,000 tons)	Zone Share (%)
211	Cincinnati (KY Part)	3,852	12%
183	Fort Wayne, IN	4,817	14%
182	Indianapolis, IN	7,548	23%
189	Rest of IN	17,017	51%

Using the shares obtained from Table 5–2, the 94 thousand tons of SCTG 03 originating from zone '189' are proportionally distributed to four destinations zones: 211, 183, 182, and 189. As a result, four OD flows are created for this example case, all with commodity SCTG 03 and domestic mode of truck. Table 5–3 presents the assigned OD pairs and their shipment tonnages for the example case.

Table 5–3. Resulting OD Flows for the SCTG03 Shipment Example

Origin	Destination	Shipment Weight (1,000 tons)
189 - Rest of IN	211 - Cincinnati (KY Part)	11
189 - Rest of IN	183 - Fort Wayne IN	14
189 - Rest of IN	182 - Indianapolis IN	21
189 - Rest of IN	189 - Rest of IN	48
189 - Rest of IN Total		**94**

6. FISHERIES AND LOGGING

Fishery shipments that are OOS for the CFS are those that occurred prior to the first point of processing or before arrival at a distribution center. Once the fishery shipments reach these points, they become an in-scope commodity for the CFS. The commodity coverage for the fishery-related OOS shipments is SCTG 01. For the OOS logging industry shipments, the commodity coverage falls within commodity code SCTG 25. This covers shipments from field (forests) to processing facilities (timber cutting and/or transporting).

6.1 DATA SOURCES ON FISHERIES

The major data source used for tonnage and value estimates of fishery shipments is the annual publication of *Fisheries of the United States* by the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA). It contains statistics on commercial and recreational fisheries of the United States with landings from U.S. territorial seas, the U.S. Exclusive Economic Zone (EEZ), and on the high seas. The information reported in the *Fisheries of the United States* comes from field offices of the NMFS, with cooperation of the coastal states. Statistics on U.S. commercial landings are available for major U.S. ports, regions (i.e., New England, Middle Atlantic, Chesapeake, South Atlantic, Gulf, Pacific Coast, Great Lakes, and Hawaii), and states. The quantity (in million pounds) and value of these commercial fishery landings are also available. Both 2012 and 2013 released reports are utilized in FAF4 to estimate tonnages and commodity values from shipments associated with this OOS area.

6.2 ESTIMATION OF FISHERIES SHIPMENTS

6.2.1 Estimating State-Level Total

The state-level total estimates of tonnage and values for these FAF4 OOS shipments were based on statistics published in the *Fisheries of the United States* reports (2012 and 2013 reporting years)[6]. According to this published data, commercial fishery landings in the United States totaled approximately 4.8 million tons and were worth over $5.1 billion, in 2012. Although fishery activities are relatively small in most states, the fishery industry is rather important for the State of Alaska. To put this in perspective, Alaska's commercial landing amounted to about 6% in value, and over 10% in weight, of the 2012 CFS totals with respect to the total shipments of all commodities covered under the CFS in 2012.

[6] Data also can be downloaded at http://www.st.nmfs.noaa.gov/st1/commercial/index.html.

6.2.2 Estimating Regional Statistics and OD Flows

In addition to state-level information, statistics on tonnage and value for commercial fishery landings at major U.S. ports (top 104 by value) are also available from the NMFS reports[7]. As a reference, the list of top 104 ports is provided in Appendix C. This information is used in conjunction with the state totals to generate sub-state level estimates of tonnages and values for FAF.

Using the geographic location of these specific 104 ports, tonnage and value of associated fishery shipments can be aggregated into corresponding FAF4 zones. The residual amounts (i.e., difference between state total and the sum of major ports within the given state) were then allocated to the "rest of state" zones. Under FAF, fishery shipments are assumed to be local activities (i.e., around dock areas), thus shipments are assumed to be intra-zone movements. That is, the origin and the destination of a fishery shipment are assumed to be within the same FAF zone. Moreover, movements for all shipments from this OOS area are assumed via truck.

6.3 DATA SOURCES FOR LOGGING

6.3.1 Forestry Inventory Data Online

The *Forestry Inventory Data Online* (FIDO) is an online tool maintained by the USDA Forest Service under the Forest Inventory and Analysis (FIA) National Program[8]. The FIA database contains an extensive set of statistics, including total tree growth, mortality and removals by harvest. The quantity of the harvest removals (in board feet) is collected by location and species type to determine the weight of the logs heading to processing facilities.

The FIA is managed by the USDA Forest Service's Research and Development organization in cooperation with state and private forestry and national forest systems. The 2012 data is utilized for FAF4.

6.3.2 Timber Product Output (TPO) Reports

The *Timber Product Output (TPO) Reports*[9] are produced by the USDA Forest Service. For the states of California and Nevada, specifically, the TPO Reports are used to obtain the quantity of soft and hard wood from the published "2012 State Level Core Tables."

---

[7] See http://www.st.nmfs.noaa.gov/st1/commercial/landings/lport_yeard.html.
[8] "Data and Tools," Forest Inventory and Analysis National Program, USDA Forest Service, http://www.fia.fs.fed.us/tools-data/.
[9] http://srsfia2.fs.fed.us/php/tpo_2009/tpo_rpa_int1.php

6.3.3 State and Region Price Reports

The information on prices of soft and hard woods provided in various *State or Region Price Reports* are used to determine the value and tonnage of the OOS logging in FAF4. Examples of the sources include the *Timber Mart*, *Bureau of Business and Economic Research* at the University of Montana, and the Texas Forest Service's *Stumpage Prices Trends*.

6.4 ESTIMATING FLOWS OF LOGGING SHIPMENTS

The national, state, and county totals of board feet for OOS logging shipments can be estimated directly using statistics published in the FIDO and TPO reports. Conversions are required to determine green tonnage based on the location and type of wood, softwood or hardwood. The FIDO contains the board feet produced for both softwood and hardwoods at the county level. Since softwood and hardwoods can have different weights across the U.S., it is important to determine tonnage statistics based on available information from individual states, or use the state's regional numbers. These numbers are generally found in the *State and Region Price Reports*. Regions in this context include the South, Pacific Coastal, Rocky Mountains, and North.

The value of FAF4 OOS logging shipments was also determined based on information obtained from various state and region price reports. By gathering the cost of both softwood and hardwoods at the state and regional level, a more accurate calculation can be estimated for the value of shipments. Based on information published in the FIDO, OOS logging in the U.S. totaled to approximately 239 million tons worth over $6.4 billion during 2012. Among the total OOS shipments, softwoods comprised 144 million tons worth $3.65 billion, while hardwood was 95 million tons valued $2.75 billion in 2012.

In addition to state-level logging information, statistics for individual counties from the FIDO were used to estimate shipment statistics at the FAF4 zone level. Specifically, based on the geographic location of counties, tonnage and value of associated shipments can be aggregated into their corresponding FAF zones. Under FAF, the movement of OOS logging shipments is assumed to be local activity (i.e., travel from forests to local processing locations), thus shipments are assumed to be intra-zone movements.

It is expected that OOS logging activities from forests to processing facilities would likely be moved by truck. An examination of the Waybill Carload Sample data found that only about 2 million tons of rail shipments fall under the definition of this OOS category in 2012, which is less than 1% of the estimated total shipment tonnage for this OOS component. For simplicity, all OOS logging shipments were assumed by truck under the FAF4 process.

7. MUNICIPAL SOLID WASTE AND CONSTRUCTION & DEMOLITION DEBRIS

Estimation processes for OOS shipments of municipal solid waste (MSW) products and the construction and demolition debris (C&D) are similar. Discussions on data and methods used in estimating volumes of shipments associated with the MSW component are presented in the first part of this Section. Similar discussions on the C&D component are then follows.

7.1 OVERVIEW OF MUNICIPAL SOLID WASTE FLOWS

The MSW products, as defined by the U.S. Environmental Protection Agency (EPA) and generally accepted within industry, are typically disposed in landfills and to a lesser extent processed in incinerators and resource recovery facilities. The MSW data collected by the EPA was specified under the Resource Conservation and Recovery Act (RCRA) "Subtitle D" wastes. It is mostly common trash or garbage that consists of everyday items people dispose. The MSW is generally generated from homes, schools, hospitals, and businesses, it includes:

- Containers and packaging (e.g., soft drink bottles and cardboard boxes);
- Durable goods (e.g., furniture and appliances);
- Nondurable goods (e.g., newspapers, trash bags, and clothing); and
- Other wastes (e.g., food scraps and yard trimmings).

According to the EPA, Americans generated about 251 million tons of trash in 2012; which included waste being recycled and composted for almost 87 million tons. This is equivalent to about a 35% recycle-rate. Note that it is common for MSW and C&D to be disposed of in the same landfills. The C&D debris is covered under a separate OOS area and is discussed in the latter part of this section. To avoid double counting, estimates associated with C&D debris were eliminated from the MSW estimates. In addition, hazardous material wastes are not covered under the MSW. It should be pointed out that only the domestic portion of the MSW (as well as C&D) is of concern here, because shipments involving foreign trade are covered in a separate OOS component under the FAF (Section 11).

7.2 DATA SOURCES FOR ESTIMATING MSW FLOWS

7.2.1 State Solid Waste Management Reports

The majority of states reported annual statistics on their solid waste management facilities and activities, including information such as volume of waste and recycling generation, import and export of waste across state borders, and allocation of waste to landfills at the county and state levels. Some examples of these reports include Mississippi's *Status Report on Solid waste Management Facilities and Activities for Calendar Year 2012*[10] and South Carolina's *Solid Waste Management Annual Report*[11].

7.2.2 BioCycle - *State of Garbage in America*

A 2011 survey conducted by the Columbia University Earth Engineering Center (Shin, 2014) [12] on the MSW data produced information that serves as the continuation of *BioCycle*'s *State of Garbage in America* survey. Columbia University took over the *State of Garbage in America* series and surveyed the waste management agencies in all 50 states on the generation and disposition of MSW. Nine states did not respond, so their data was estimated by Columbia University based on information from earlier studies and their population growth. The state totals provided in that study were converted to per capita estimates for MSW generation by state. The 2011 survey data (occurred a year prior to 2012 CFS) was used to fill in any missing data for states that did not have published reports. This data did include C&D debris within the total tonnage of MSW, therefore, this tonnage was removed to avoid double counting for FAF4 purpose.

7.2.3 EPA *Municipal Solid Waste in the United States: 2012 Facts and Figures*

The EPA report, entitled *Municipal Solid Waste in the United States: 2012 Facts and Figures*[13], contains data on waste generation, recycling, and disposal. Data obtained from this report were used in estimating total national tonnage and value of MSW shipments for the FAF4 base year.

7.3. ESTIMATION METHODS FOR MSW FLOWS

7.3.1 Estimating the Movement of MSW at State Level

Thirty-four state-reports provided their total amounts of MSW generated at the county and state levels. For the remaining 17 states (including Washington D.C.), data from the 2011 *Biocycle* survey was used to generate 2012 totals, using their population growth factors. Because *Biocycle* data includes C&D debris with MSW, to avoid double counting, amounts of C&D debris need to be removed from the estimated 2012 state-level total volumes.

Based on an examination of state-provided C&D debris data (Section 7.6), C&D debris, on average, accounted for about 23% of *Biocycle*-reported state-level numbers. Using this factor

[10] https://www.deq.state.ms.us/MDEQ.nsf/pdf/SW_2012SolidWasteAnnualReport/$File/2012%20Annual%20Report.pdf
[11] https://www.scdhec.gov/HomeAndEnvironment/Docs/swm_FY12_ALL.pdf
[12] http://www.seas.columbia.edu/earth/wtert/sofos/Dolly_Shin_Thesis.pdf
[13] "Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2012, EPA, https://www.epa.gov/sites/production/files/2015-09/documents/2012_msw_fs.pdf.

(i.e., 23%), *Biocycle*-based state-estimates can be adjusted to remove the C&D portion of volumes, i.e., estimates of MSW are produced. Based on this process, FAF4 estimated a total of 309 million tons of MSW was landfilled and recycled in 2012. Note that MSW, as a commodity, was assumed to have no dollar value.

Because MSW can be moved to landfills across state borders, state reports were further used to determine the OD and associated tonnage of the MSW being moved. It was estimated that 23 million tons of MSW were transported by truck across state borders in 2012 and accounted for about 7% of the total 309 million. Clearly, most MSW materials are moved within states (i.e., intra-state movements).

7.3.2 Disaggregation to FAF Regional Level

All of the landfilled waste was assigned to SCTG commodity code "41." For the MWS shipments that crossed state boundaries, the state-reports provided information on their ODs, which allows for a proper assignment in FAF zones.

For shipments of MSW that moved entirely within a state, county-level data, if available, can be aggregated to produce the estimated volume at the FAF-zone level. When county-level data is not readily available, the state-level MSW tonnage can be disaggregated using population shares to produce associated FAF-zone level estimates. The 2012 population data as published by the Census was used for this process for FAF4.

7.4 OVERVIEW OF CONSTRUCTION AND DEMOLITION DEBRIS FLOWS

Debris generated from C&D activities is recognized as one of the largest components of the U.S. solid waste stream. Shipments originating from activities in this OOS sector include companies or establishments engaged in construction of residential and non-residential buildings, utility systems, roadways and bridges, and from specific trade contractors that are out-of-scope to the CFS. These types of shipment generally consist of often-bulky heavy material, such as concrete, wood, metals, glass, and salvaged building components. The majority of C&D debris is recycled, but the statistical tracking of tonnage has been limited in the past.

A recent white paper from the Construction and Demolition Recycling Association (CDRA), entitled *The Benefits of Construction and Demolition Materials Recycling in the United States*[14], estimated approximately 480 million tons of C&D debris was generated in the United States in 2012. The paper also stated that over 70% of the C&D debris was presumed to be "recovered

[14] https://www.mwcog.org/uploads/committee-documents/blxfXlxW20150715151756.pdf

and recycled" in 2012. The following is a breakdown of the components within the C&D debris stream:

- 100 million tons mixed C&D with a 35% recycling rate,
- 310 million tons bulk aggregate (primarily concrete) with a 85% recycling rate, and
- 70 million tons of reclaimed asphalt pavements with a 99% recycling rate.

7.5 DATA SOURCES FOR C&D DEBRIS

7.5.1 State Solid Waste Management Reports

Similar to the MSW process, available annual reports from states were used (e.g., the States of Alabama[15], South Carolina[16] and Florida[17]) to estimate the amount of debris generated by the C&D industry. While 24 states provided annual reports on their solid waste management facilities and C&D activities, few included the tonnage of C&D debris recycled.

7.5.2 BioCycle - *State of Garbage in America*

This is the same data source as used in the MSW estimation process discussed in Section 7.2.

7.6 ESTIMATION METHOD FOR C&D DEBRIS FLOWS

7.6.1 Estimating Volume of C&D at State Level

Based on the data from the 24 states providing the amount of landfilled C&D debris and the state-level information from the *Biocycle* report, it was estimated that, on average, C&D debris accounted for 23% of the *Biocycle*-reported state totals. Using this rate, estimates of total C&D landfilled waste streams in those "unavailable states" can be produced.

With information obtained from the CDRA paper, which suggests 70% of all C&D debris was recycled, individual state totals of C&D debris can be broken into two parts: where 30% of debris going to landfill and the other 70% recycled. Based on this assumption, it was estimated that a total of 80 million tons of C&D debris was landfilled, while 368 million tons were recycled in 2012. In other words, a total of 448 million tons of C&D debris were generated from all states in 2012. Note that, this total is different from the rough estimate of 480 million cited by the CDRA for the national level. The FAF team believes the estimates produced for FAF4

[15] http://www.adem.state.al.us/programs/land/landforms/SolidWasteReport10-12.pdf
[16] https://www.scdhec.gov/HomeAndEnvironment/Docs/swm_FY12_ALL.pdf
[17] http://www.dep.state.fl.us/waste/categories/recycling/SWreportdata/12_data.htm

(i.e., 448 million) which are based on information obtained from state reports and *BioCycle* are more accurate.

7.6.2 Estimating Volumes of C&D Flows

For states with available county-level information on C&D debris, the data for counties within each FAF region are aggregated to obtain the regional estimates for FAF4. Where county-level data is not available, the state-level tonnage of C&D was disaggregated to the desired FAF zones using population shares calculated from Census population data. The rationale of using population-based shares, instead of economic factors (e.g., sales or employment data), is that the use of economic factors might result in bias toward business locations, rather than locations where the demolition sites are located. It is common for construction companies to work outside the regions where their companies are located. Because of its better association with locations of C&D activities (where debris were generated), population data was applied for the disaggregation process in FAF4.

Since the primary commodity shipped by the construction industry is debris, it was expected that the majority of these OOS shipments are local (i.e., within zone moves). For C&D debris that moved across state borders, state reports typically specified O-D of those shipments, which allows one to identify FAF areas that are involved in these movements.

8. RETAIL, SERVICES, AND HOUSEHOLD/BUSINESS MOVES

Estimation processes for total shipments of retail establishments, services, or household/business moves are addressed in this section. Data sources and estimation methods applied in generating each set of flows are presented as well.

8.1 RETAIL

8.1.1 Data Sources for Retail Sector

Census Annual Retail Trade Survey

One of the main data sources used in generating retail sector estimates was the *Annual Retail Trade Survey*, published by the U.S. Bureau of Census (Census) in the table "U.S. Retail Trade Sales – Total and E-commerce: 2013-1998." The "2012 revised" sales estimates were extracted from this table by 3-digit NAICS code and used as national control totals for industries associated with the retail sector. Total retail trade sales in 2012 were estimated at $4,306 billion, including $229 billion from e-commerce. Businesses with or without paid employees are included in these Census estimates. The Census[18] defines e-commerce as "transactions sold online whether over open networks such as the Internet or proprietary networks running systems such as Electronic Data Interchange (EDI)."

2012 Economic Census Receipts

Estimates of state-level business data including sales receipts by NAICS are also published by the Census based on information collected under the *2012 Economic Census*[19]. Receipts are defined by the Census[20] as "operating revenue for goods produced or distributed, or for services provided … excludes local, state, and federal sales and other taxes collected from customers or clients." Because the *Economic Census* is conducted by the Census in a five-year interval, receipts data are available for years ending in "2" and "7" only. Using information from the *2012 Economic Census*, Census estimated a total of $4,238 billion in receipts was generated from the retail sector (NAICS 44-45). Note that, receipts data associated with the retail sector in all states and the District of Columbia (DC) are published at the aggregated 2-digit NAICS "44-45" level. Receipts data for retail sectors at the disaggregated 3-digit NAICS level, however, are

[18] Definitions, E-Stats, U. S. Census Bureau, https://www.census.gov/econ/census/help/sector/data_topics/e-commerce.html, accessed July 2015.
[19] *Economic Census*, http://www.census.gov/econ/census/ accessed July 2015.
[20] Definitions, Statistics of U.S. Business, U.S. Census Bureau, https://www.census.gov/econ/susb/definitions.html, accessed July 2015.

released only for 26 states and for most of the retail sectors in Washington D.C. (where NAICS 441 and 452 data were suppressed).

2012 County Business Patterns

Employment payroll data from Census' *County Business Patterns*[21] (CBP) is utilized in distributing state-level estimates to the CFS areas. The way this information was used in the FAF4 process is discussed in Section 8.1.3.

8.1.2 Assumptions on Percent of Retail-Sales Receipts Involving Truck Shipments

It is expected that most retail sales be made at store locations where customers carried goods purchased to home. Often, when delivery is made from the retail stores, the customer-purchased items are delivered via store-owned vans (or pickup trucks), or delivered by mail or package carriers. Certain large items purchased from the retail stores, such as furniture or appliances on the other hand, are more likely delivered by truck to a customer's home. Due to lack of data on actual share of sales associated with goods delivered versus carried out, a set of assumptions on percent of retail-sales receipts involving truck were made for the FAF4 process. Depending on characteristics of the industry (at 3-digit NAICS), their truck-share of receipts could be assigned with a different percentage ranging from 1% (e.g., clothing) to 70% (e.g., furniture).

8.1.3 Estimation Approach for Goods Movements in the Retail Sector

Estimating Total Retail Values Shipped by States at 3-digit NAICS-Level

As mentioned earlier, 2012 receipts data at the 3-digit NAICS for 26 states are published by the Census. Therefore, for these states, their total retail receipts associated with industry sectors involving truck deliveries (NAICS codes 442-446, 448, and 451-453) can be estimated directly using the assumed shares.

Estimating Total Retail Values Shipped by States at the Aggregated NAICS-Level

For states that Census does not publish receipts data at the 3-digit NAICS level, where only state-level receipts for the entire retail sector as a whole (NAICS 44-45) is available, patterns from the national total are applied. Specifically, total retail receipts in each individual state are reduced by 43% to remove the portion of receipts involving NAICS 441/447/454 sectors (i.e., to eliminate receipts from in-scope CFS sectors). The share of truck-delivery shipments for these states was assumed at 8.4%, as calculated based on combined totals from all known states (i.e.,

[21] County Business Patterns, U.S. Census, http://www.census.gov/programs-surveys/cbp.html.

dividing "shipped receipts" by "total in-scope receipts"). Applying this share to adjust receipts of individual states, state-level shipment values can be estimated.

Estimating State-Level Shipment Values and Weight by Commodity

Total state-level shipment values are distributed among commodities involved in each NAICS sector considered in this OOS area. A simple equal-share assumption was applied when more than one commodity could be involved within a specific 3-digit retail subsector. Once the shipment values are separated by commodity code, value-to-weight ratios by commodity, as calculated based on data for domestic shipments from the 2012 CFS Public Use Microdata (PUM), are applied to derive estimates for shipment weights at the state level.

Distribution of State Totals to FAF Zones

The state-level estimates of values and weights are distributed to each FAF4 zone within the given state using their shares of total annual payroll amounts obtained from the 2012 CBP dataset. Note that the calculation of shares considered only payroll information associated with the associated 3-digit NAICS codes for retail. For simplicity, this FAF-zone level distribution is conducted uniformly over all commodity codes.

Since most purchases at retail stores occurred in regions where the customers reside, the O-D FAF zones for the retail OOS sector are assumed the same. Note that shipments involved under this OOS area are assumed to be transported by truck. Based on the processes just described, it is estimated that a total of $206 billion, weighing 224 million tons, of CFS OOS retail goods were transported by truck in 2012.

8.2 SERVICES

8.2.1 Data Sources for Estimating OOS Shipments from Services Sector

2012 Service Annual Survey Data and Report

The Census conducts the *Service Annual Survey* (SAS) to provide national estimates of annual revenues and expenses of establishments classified in select service industries. The estimates published[22] by the Census are developed using data from a probability sample of firms located in the United States that have paid employees (i.e., employer firms). Consequently, Census-published estimates only include data for employer firms. The sample is regularly updated to reflect the universe of employer service businesses and covers both taxable firms and firms

[22] U.S. Census Bureau, *Annual & Quarterly Services* website at https://www.census.gov/services/index.html, accessed July 2015.

exempt from Federal income taxes. Furthermore, *2012 Service Annual Survey* data are summarized by industry classification based on the 2007 NAICS (same as the 2012 CFS). A table titled "Estimated E-Commerce Revenue for Employer Firms: 1998 through 2012" from the *Annual Services Report* was used and supplemented with other SAS tables from the same report to generate estimates for the OOS Services sector. The 2012 revenue information was extracted from that table and used as the national control totals for industries associated with the services sector, by 3- to 5-digit NAICS codes. The NAICS codes involved in this OOS component are listed in Table 8–1.

Table 8–1. NAICS Industries Involved in the OOS Services Sector

NAICS	Description
51912	Libraries and Archives
5322	Consumer Goods Rental
5324	Commercial and Industrial Machinery and Equipment Rental and Leasing
562	Waste Management and Remediation Services
6216	Home Health Care Services
7111	Performing Arts Companies
7112	Spectator Sports
71211	Museums
7223	Special Food Services
8123	Dry Cleaning and Laundry Services

2012 Economic Census

Similar to the retail sector, information collected under the *2012 Economic Census* was also used in the estimation process for the services OOS component. Census estimates a total of $11.7 trillion in receipts was generated from the services sector (NAICS 51-81) in 2012. Receipts data associated with the services sector in all states and DC are published by the Census at an aggregated 2-digit NAICS level. Receipts data for services subsectors and industries at the 3-digit to 5-digit NAICS level are released only for a limited number of states.

Census County Business Patterns

As in the retail OOS estimation process, the 2012 CBP data was used to disaggregate state-level estimates to the FAF zones.

8.2.2 Estimation Approach for Services Sector Goods Movements

Estimating Total Value by State

As mentioned previously, 2012 receipts data at the 3- to 5-digit NAICS level are available from Census for a select number of states. For each of these states, state-level receipts for relevant services industries (identified by NAICS in Table 8–1) can be estimated directly using Census-published data and adjusted with shares of truck shipment in a similar matter as for the retail sector.

For states that Census did not publish service-sector data at the detailed NAICS level (i.e., only state-level receipts for the entire sector are available), patterns from the national total were utilized. Specifically, each individual state's total services receipts were adjusted to remove the portion of receipts involving NAICS industries not involving truck deliveries. This adjustment was made with a factor calculated from all known states, where the "total receipts involving truck" is divided by the "total receipts from all in-scope industries." By applying this factor to adjust receipts of individual states within this group (i.e., those without detailed NAICS level data), their state-level shipment values can be estimated.

Estimation of State-Level Shipments by Commodity

As in the retail OOS component, the state-level shipment estimates obtained from above process are distributed among commodities involved in each involved-NAICS industry. The same simple even-share approach was applied to allocate shipment values among commodities within a given NAICS. Value-to-weight ratios by commodity, as calculated based on domestic shipments from the 2012 CFS PUM data, by service sector industry, are then applied to derive estimates for shipment weights at the state level.

Distribution of State Totals to FAF Regions

Using the same method as in the retail sector, state-level service-sector estimates of values and weights are distributed to FAF zones in the given state, based on their shares of payroll from the 2012 CBP data (considering service sector NAICS only).

Determination of OD Flows

To determine O-D flows for the above-estimated service sector shipments, additional processing is needed to identify destinations of service-related shipments. Depending on the type of service industries, the destinations of shipments are allocated differently in two ways.

Intra-Zone Movements

For most industries in this OOS sector, their "services" most likely occurred in regions where the customers are located. Therefore, it is reasonable to expect most of these activities are intra-zone movements, i.e., the O-D FAF zones would be the same. Note that shipments involved in this OOS area are all assumed to be transported by truck.

Inter-Zone Movements

On the other hand, the industries sectors under NAICS 7111, 7112, and 71211 (Performing Art

Companies, Spectator Sports, and Museums, respectively) are services requiring movements of goods to regions beyond their originating zones. It was assumed that these sectors would only be traveling to major metropolitan areas, typically in the same or neighboring state; therefore, "Rest of State" FAF zones were not included as potential destination choices. The share of truck shipments by average distance-range, calculated using the 2002 VIUS data, is used to estimate O-D flows for each of the involved NAICS sectors.

Based on the processes discussed above, the FAF4 estimates that a total of $119 billion weighing 71 million tons of services-associated shipments were transported by truck in 2012.

8.3 FLOWS OF HOUSEHOLD AND BUSINESS MOVES

Trucking services provided by the household and business (HH&B) moving industry is under the NAICS 484210, *Used Household and Office Goods Moving*. Note that NAICS 4842 is covered under the 2012 CFS. However, as a shipper-based survey, shipments of household and business goods in the moving industry are not captured by the CFS. This is because businesses that engaged in these moving activities do not typically produce freight or warehousing services.

8.3.1 Data Sources for Estimating Shipments from the Moving and Storage Industry

The primary data sources for the HH&B OOS component are the *American Community Survey* (ACS) *County-to-County Migration Files* published by the Census, the *Consumer Durable Goods Current-Cost Net Stock* from the Bureau of Economic Analysis (BEA), and information obtained from various publications of the American Moving and Storage Association (AMSA).

2008-2012 ACS County-to-County Migration Files

The ACS program combines consecutive yearly datasets to increase the sample size and provide reliable estimates for smaller geographic areas (e.g., county and Census tract). Although ACS estimates are produced for 1-year and 3-year datasets, only the 5-year datasets provide estimates for county-to-county migration flow[23]. For this HH&B OOS component, the 2008-2012 release of ACS county-level migration data[24] was used.

The data provided in the ACS county-to-county flow files include county of current residence, county of residence 1 year ago, and the number of movers between the two years. County-level total population and total number of housing units in 2012 are also obtained from the ACS. The

[23] *The 2008-2012 ACS 5-Year Summary File Technical Documentation*, U. S. Census Bureau, Version 2, February 2014. http://www2.census.gov/acs2012_5yr/summaryfile/ACS_2008-2012_SF_Tech_Doc.pdf

[24] *2008-2012 ACS County-to-County Migration Files Documentation*, U. S. Census Bureau, accessed July 2015, https://www.census.gov/hhes/migration/files/acs/county-to-county/2008-2012/2008-2012%20Migration%20Flows%20Documentation.pdf

population total and number of housing units by county are used in FAF4 to estimate average household size (i.e., number of persons in a household) for each FAF region.

Consumer Durable Goods, Current-Cost Net Stock

The BEA publishes national statistics on both fixed assets and consumer durables[25]. While fixed assets cover items that are used continuously in processes of production for an extended period, consumer durable goods are generally defined as tangible products that can be stored or inventoried that have an average life of three or more years. The BEA's *Current-Cost Net Stock* of consumer durable goods[26] in 2012 is used to identify commodities associated with moves and the value of goods being moved.

AMSA Published Statistics

Because the ACS data is population-based and the migration flows are estimated by considering changes in counties of residence, business moves are not captured. Statistics released online by AMSA[27] were used to adjust estimates produced from ACS in order to capture missing moves. According to 2014 statistics, AMSA stated that shipments from "corporate and other federal government" moves accounted for about 38% of total household goods shipments that occurred in that year. Furthermore, AMSA reported that about 40% of the interstate household goods moves were carried out by consumer themselves (i.e., not by professional movers or by use of rental truck). This percentage was used to adjust ACS-based estimates to remove unassisted moves.

CFS Value-to-Weight Factors

As mentioned earlier, current-cost net stock of consumer durable goods from BEA was used to estimate the volume of HH&B goods being moved. Thus, estimates generated from this process reflect only values of goods, not their weights. To estimate commodity weights for the HH&B goods, value-to-weight ratios calculated from the 2012 CFS PUM data, considering domestic shipments by commodity, are applied. Since most HH&B goods moved are typically "used" items, as compared to "new" CFS goods, a simple depreciation rate of 30% was applied to discount the CFS-based value-to-weight factors for estimating the associated weights of HH&B goods.

[25] "Detailed Data for Fixed Assets and Consumer Durable Goods," National Economic Accounts, Bureau of Economic Analysis, U.S. Department of Commerce, see http://www.bea.gov/national/FA2004/Details/Index.html.
[26] Table 8.1 Current-Cost Net Stock of Consumer Durable Goods, Fixed Assets Accounts Tables, National Data, http://www.bea.gov/iTable/iTable.cfm?ReqID=10&step=1#reqid=10&step=1&isuri=1, Bureau of Economic Analysis, accessed July 2014.
[27] American Moving and Storage Association ,About Our Industry, About AMSA, http://www.promover.org/content.asp?pl=1&sl=61&contentid=61, accessed June 2015.

8.3.2 General Assumption and Assignment of Commodity

In addition to the depreciation rate of value-to-weight factors discussed above, assumptions were applied in assigning commodity codes to the associated durable goods and in determining the share of specific commodities being moved by truck (versus items carried by the household members or left with the "old" house). Moreover, due to data limitation, intra-county moves were assumed to be self-moves that did not involve moving trucks.

The assignment of the commodity code is done by examining the types of consumer durable goods specified in the BEA *Current-Cost Net Stock* table. This process identified five SCTG codes that were involved in this OOS area, including codes 35 (electronic equipment), 36 (motorcycles & bicycles), 39 (furniture), 40 (sporting goods), and 43 (miscellaneous).

8.3.3 Estimation Process for Flows of HH&B Moves

The estimation process associated with flows for HH&B moves is straightforward. A brief description of the process is given below.

Estimating Total Number of Moves

The ACS county-to-county migration flows, measured in population, are aggregated to the FAF-zone level and converted to number of household moves by applying the average household size factors generated using Census population and housing unit data for each region. It is assumed that each household made one move as a whole. Under this assumption, the number of migrated households would be treated as equivalent to the number of "moves" or "OD flows".

The number of FAF zone-level moves is adjusted "upward" to include moves associated with "corporate and other federal government" and "downward" to exclude consumer non-assisted moves. The national average taken from AMSA, discussed above, was applied to all regions.

Estimating Total Value per Move by Commodity Code

The national total reported in the 2012 BEA *Current-Cost Net Stock* can be divided by the total number of households to derive a per-household value for each of the 5 commodity codes (at the national level) after adjustment to eliminate items not likely to be transported in a moving truck. These per-household values are then multiplied by the total number of mover-households from each region to obtain values of SCTGs associated with the HH&B OOS. Finally, the CFS-based value-to-weight factors described above are applied to the values to estimate shipment weights by SCTG.

National averages of per-household value by SCTG are applied to all moves regardless of the possible existence of regional differences. This is a current data limitation that could be further examined and improved upon in the future.

Finally, it is estimated that truck shipments worth over $128 million, and weighing about 29 million tons were generated from the HH&B sector in 2012. More than half (56%) of the total value of these shipments are for common household items of SCTG 39 (furniture) and 35 (electronic).

9. CRUDE PETROLEUM

Because the CFS does not include shipments from NAICS subsector 211: *Oil and Gas Extraction*, transportation of crude petroleum is an OOS commodity for the CFS. Only one commodity code is covered in this OOS segment, which is SCTG 16 Crude Petroleum Oil. This includes shipments from the field or marine terminals, international pipelines to refineries or long-term storage facilities. Unlike other OOS-components discussed thus far, foreign trade crude petroleum shipments in addition to domestic crude movements are also addressed in this section.

9.1 SIGNIFICANCE OF CRUDE PETROLEUM

Crude petroleum is one of the major OOS components for the CFS. As an example, Table 9–1 presents statistics for domestic and imported crude petroleum. Domestic production of crude petroleum has increased since 2007, with a 28% increase in domestic volume from 2007 to 2012. On the other hand, imported volumes showed a decline over time, as the 2012 volume was about 16% lower than that in 2007.

Table 9–1. Volume of Crude Petroleum (in million barrels)

Source	2007	2011	2012
Domestic production (EIA)	1,853	2,060	2,378
Imports – EIA report	3,661	3,261	3,121
Imports – Foreign Trade (non-seasonally adjusted)	3,690	3,322	3,097
Exports – EIA report	39	17	25

Although small, U.S. crude petroleum exports also have seen a slight increase in recent years. Note that the U.S. more commonly exports coal, gasoline, and natural gas to other countries. However, for the most part, U.S. companies are not allowed to export crude oil; due to a ban that was put in place in 1975[28]. There are exceptions in selected circumstances, thus some amounts for crude petroleum exports are seen in Table 9–1. For 2012, nearly all of the exported crude petroleum went to Canada, with only a small portion exported to Mexico in 2012.

[28] Energy Policy and Conservation Act of 1975, at: http://energylaw.uslegal.com/energy-policy-and-conservation/ and the Government Publishing Office PL94-163.

9.2 DATA SOURCES

As in FAF3, basic information on crude production, imports, exports, and related activities at refineries can be estimated using data collected by the Energy Information Administration (EIA), a part of the U.S. Department of Energy (DOE). Note that geographic regions for the EIA data are typically in the Petroleum Administration for Defense Districts (PADD). Figure 9–1 displays a map of the PADDs as defined by the EIA.

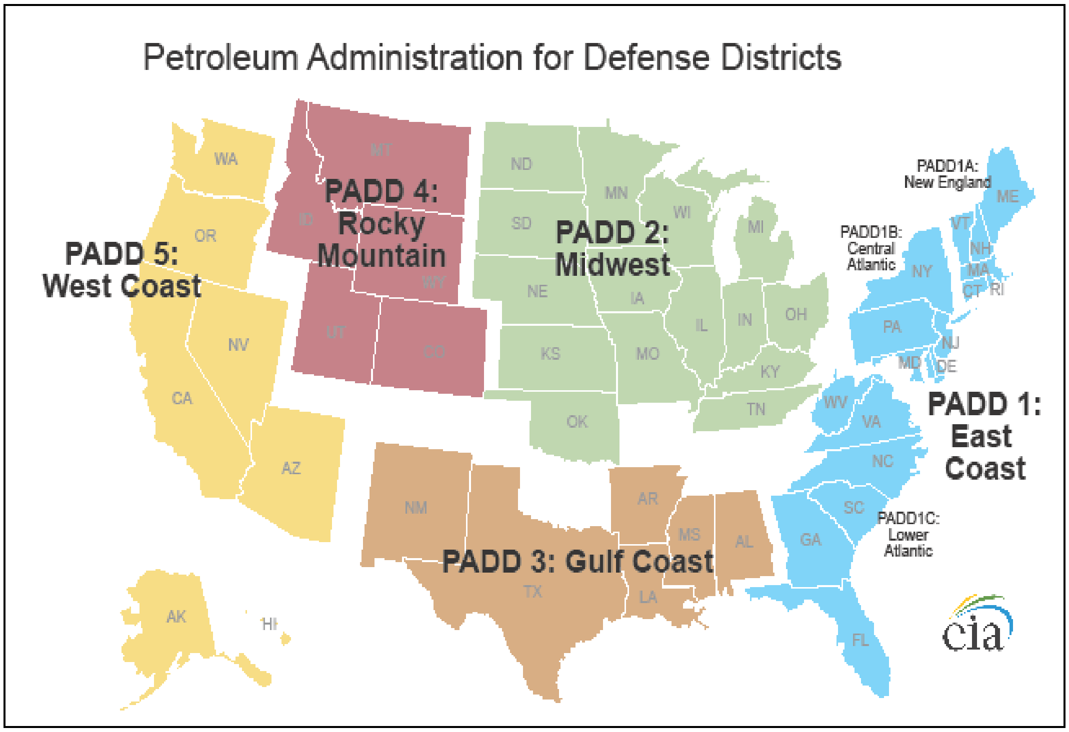

Figure 9–1. Definition of Petroleum Administration for Defense Districts (PADDs).

9.2.1 EIA Data

Several tables published by the EIA provide the fundamental statistics needed in estimating 2012 crude petroleum volumes and their flows.

Movement of Crude by Rail

The *Movement of Crude by Rail* table contains monthly and annual rail crude oil movements as well as providing crude movements regions[29]. This crude by rail table provides detailed

[29] Table "Movements of Crude Oil by Rail", Petroleum & Other Liquids, U.S. EIA, at: http://www.eia.gov/dnav/pet/PET_MOVE_RAILNA_A_EPC0_RAIL_MBBL_M.htm.

movements among PADDs as well as trade between PADDs and Canada. It provides control totals for domestic, U.S. exports to Canada, and U.S. imports from Canada on crude by rail.

Company-Level Imports

The *Company-Level Imports* database contains monthly statistics on imports of crude and petroleum products at the company level. Specific information provided in this database includes importing company name and country, product name, port of entry location (city, state, PADD), import quantity (in thousand barrels), and so forth. This database is available in Microsoft Excel spreadsheet format[30] from the EIA website. Because of reporting differences, the EIA noted that summation of volumes for PADDs 1-5 from the company-level imports would not equal aggregate import totals.

Crude Petroleum Production

The *Crude Petroleum Production* table contains the annual production of crude petroleum, in thousands of barrels by state and PADD[31]. The statistics published in this EIA table are based on amounts reported from states. The EIA notes that state production estimates reported by the EIA are normally different from those reported by state agencies. One explanation of this difference can be found in *Today in Energy*, released on July 10, 2015[32]. As that article pointed out, the reason for this difference was that the EIA's estimates accounted for expected revisions to data collected by the states.

Exports by Destination Country

In 2012, the only exported crude petroleum from the U.S. was a total of approximately 24.7 million barrels to Canada and about 5 thousand barrels to Mexico[33]. The U.S. crude petroleum exports have been restricted to (1) crude petroleum derived from fields under the State waters of Alaska's Cook Inlet; (2) Alaskan North Slope crude petroleum; (3) certain domestically-produced crude petroleum destined for Canada; (4) shipments to U.S. territories; and (5) California crude petroleum to Pacific Rim countries. Recently, the U.S. Congress has approved a measure to repeal the 40-year ban on crude oil exports, allowing energy companies to export U.S. crude petroleum.

---

[30] Data can be downloaded at EIA website: http://www.eia.doe.gov/oil_gas/petroleum/data_publications/company_level_imports/cli.html.

[31] Annual crude oil production statistics is available from EIA website at: http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm.

[32] "EIA's estimates for state crude oil production account for incomplete, lagged data," *Today in Energy*, EIA, http://www.eia.gov/todayinenergy/detail.cfm?id=22012

[33] Table "Exports by Destination", Petroleum & Other Liquids, U.S. EIA, at: http://www.eia.gov/dnav/pet/pet_move_expc_a_EP00_EEX_mbbl_m.htm.

Exports by PADD District

In addition to the country-level total, annual volumes of crude petroleum (in thousand barrels) exported from each PADD[34] is also available from the EIA. This provides control totals for exported crude by PADD.

Movements by Mode between PADDs

Annual volumes of crude petroleum movements (measured in thousand barrels) by different transportation modes (including pipeline, tanker, barge, and rail) between PADDs are published by the EIA[35]. The statistics published in this EIA table were based on information collected from state-reported EIA forms, specifically the EIA-813 (*Monthly Crude Oil Report*).

Refinery Net Input

The EIA also publishes annual data on refinery net inputs for crude petroleum by PADD and refining regions (sub-PADD level)[36]. These statistics represent total crude petroleum (domestic plus foreign) input to crude petroleum distillation units and other refinery processing units.

9.2.2 Carload Waybill Sample 2012

The Surface Transportation Board (STB) publishes and maintains the Carload Waybill Sample[37] database, which is a stratified sample of carload waybills for all U.S. rail traffic submitted by those rail carriers terminating 4,500 or more revenue carloads annually. The 2012 *Carload Waybill Sample* database captured over 623 thousand waybills reported electronically in 2012. In order to protect sensitive shipping and revenue information of rail companies reporting the Waybill, STB provides a public-use version of the Waybill data that contains aggregated data, in addition to the more detailed limited-access confidential version.

9.2.3 County Business Patterns

As in other OOS components, the 2012 CBP data is also used as a data source in the estimation process of this industry.

---

[34] Table on crude oil "Exports", Petroleum & Other Liquids, see EIA website: http://www.eia.gov/dnav/pet/pet_move_exp_dc_NUS-Z00_mbbl_m.htm.

[35] Table on *Movements by Tanker, Pipeline, Barge, and Rail between PAD Districts*, can be found at EIA website: http://www.eia.gov/dnav/pet/pet_move_ptb_a_EPC0_TNR_mbbl_a.htm.

[36] Refinery Net Input, Petroleum & Other Liquids, see EIA website: http://www.eia.gov/dnav/pet/pet_pnp_inpt2_a_epc0_YIY_mbbl_a.htm.

[37] For access of Carload Waybill Sample data visit Surface Transportation Board website at: http://www.stb.dot.gov/stb/industry/econ_waybill.html, or access the 2012 documentation at: http://www.stb.dot.gov/stb/docs/Waybill/2012%20STB%20Waybill%20Reference%20Guide%20-%20FINAL.pdf.

9.3 ESTIMATION PROCESSES

9.3.1 Domestic Crude Flows

The EIA data on movements between PADDs provided the control totals for estimating domestic movements of crude oil at the PADD level. The need here is to disaggregate crude petroleum movements from the PADD-level to the desired FAF-zone level. Since the crude petroleum flows have different OD patterns by transportation mode, the PADD-to-PADD crude petroleum flows are constructed in different matrices by each transportation mode. The basic process is described in the following steps:

1. Obtain PADD-level movements by different modes (pipeline, water, and truck) using the EIA "Movement between PAD Districts" table.
2. Estimate FAF-zone level crude production so that it can be used as a production factor in the gravity model (a spatial interaction model, see Step 4). According to the EIA crude petroleum production data, 31 states produced crude petroleum in 2012. The CBP payroll shares for "Crude Petroleum and Natural Gas Extraction" industry (NAICS code 211111) are used to disaggregate total state-level production volume to county-level, and then are aggregated to generate FAF–zone level crude petroleum production estimates.
3. Estimate refinery input (i.e., consumption) at FAF-zone level. These are used as an attraction factor in the gravity model. Note that the refinery input data provided by the EIA is at the state level. To estimate the FAF-zone level consumption, this state level consumption is distributed proportionally to the operation capacity of each crude petroleum refinery and aggregated to the corresponding FAF-zone level. The assignment of refineries to the associated FAF zone was done with the aid of a GIS tool. Refinery locations are geo-coded first and then spatially joined with the FAF zone data layer.
4. Execute rank-based gravity model and apply the IPF model to estimate FAF regional-level movements. This process used PADD-to-PADD movements as the control totals. With each PADD-PADD pair, the rank-based gravity model is used to generate an initial OD flow matrix, and then follow by IPF model to obtain final estimates. These processes are repeated for all PADD-PADD pairs by mode.

9.3.2 Flows of Imported Crude

Imports by Rail (Trans-Border Only)

The process of determining the flow of imported crude oil by rail began by deriving imported crude oil shipment patterns from the 2012 Waybill data. The Waybill data was used to determine foreign origin, domestic origin, and domestic destination for each imported shipment. It should be noted that the domestic origin of an import shipment was estimated based on the first "through state" from the Waybill. Assuming the Waybill data captured the import pattern (by rail), the waybill-estimated patterns (by weights) are used to distribute EIA-based control totals. Note that the shares are calculated based on Waybill estimates for each foreign origin-PADD pair and then applied to EIA numbers to get estimated shipment weights for the FAF.

Imports by Other Modes

The process of determining the flow of imported crude oil by all other modes began with subtracting imports by rail from EIA company-level imports data. Then the assignment of foreign-mode and domestic-mode for remaining imports was done. The foreign mode was determined by reviewing foreign country and port location for countries other than Canada (import mode was assumed to be water) and for Canada (import mode can be water or pipeline depending on port location's access to water network and pipeline network.) The domestic mode was the mode that can serve both port (domestic origin) and facility location (domestic destination). After the mode assignment, the company-level imports totals are aggregated into FAF regions. Finally, the value of crude oil is calculated using EIA data on imported crude oil price for each foreign region.

9.3.3 Flows of Exported Crude

According to the EIA data, crude oil was only exported to Canada and Mexico in 2012. Modes involved for these exported crude shipments are rail and truck.

Exports by Rail

A similar process as used for imported crude by rail is used for exports. Note that the weight shares are calculated based on Waybill estimates for each origin PADD- foreign country pair and applied to EIA numbers to get estimated weights for the FAF. The value of crude oil is calculated based on EIA data on reported crude price.

Exports by Truck

Besides the crude exports by rail, the remaining crude exports are assumed to be via truck. Based on EIA data obtained from the *Exports by Destination* table, only Canada and Mexico received crude petroleum from the U.S. in 2012. The domestic origin of exported crude is assumed to be in the FAF region that produces crude oil. The amount of originating flow was estimated using the product of the production share of its PADD and the total flow originating from the given PADD, as obtained from the *Exports by PADD* table. Both domestic mode and foreign mode are assigned as truck for these shipments. The value of crude oil is then calculated based on EIA-reported price to complete the resulting matrix.

10. NATURAL GAS

Like crude petroleum, natural gas is also an OOS commodity because NAICS 211 was not included in the CFS sampling frame. Information obtained from EIA publications, including the *Natural Gas Annual* and the *International Energy Annual*, served as the principal data sources used to generate tonnage and value estimates for shipments in FAF4. In addition, data collected by the Federal Energy Regulatory Commission (FERC) and published annually in *Pipeline Economics* by the Oil & Gas Journal was used as supplemental information.

10.1 DATA SOURCES

10.1.1 Domestic Natural Gas

Domestic movements of natural gas flows are separated into two groups, interstate and intrastate. Data sources, used in estimating volumes of shipments for the two groups, are slightly different.

Interstate Domestic Flows

The baseline state-level data for interstate movements of natural gas is obtained from EIA's published Table 12 of the *2012 Natural Gas Annual*[38] entitled *"*Interstate movements and movements across U.S. borders of natural gas by state.*"* For domestic shipments, only the interstate shares from this table are utilized. Data on movements across U.S. borders is covered in the imports and exports sections discussed later. To disaggregate interstate movements into FAF regions, a series of auxiliary data are also used. This includes the following:

- *Natural gas receipt/delivery points database*
  According to the EIA, the U.S. natural gas pipeline network consists of over 11,000 delivery points (transport to end-use customer), 5,000 receipt points (involved in "gathering" natural gas), and 1,400 interconnection points that transfer natural gas throughout the U.S. in 2008[39]. The FAF4 uses an updated dataset where the total number of natural gas receipt/delivery points reached nearly 17,800 according to the 2011/2012 database obtained by the FAF team.

  In the context of FAF4, these receipt/delivery points (usually at the beginning of a natural gas transport route) are treated as natural gas shipment starting locations (production). The sum of "scheduled capacity" from all receipt/delivery points located within a given

[38] http://www.eia.gov/naturalgas/annual/archive/2012/pdf/table_012.pdf.
[39] "About U.S. Natural Gas Pipelines – Transporting Natural Gas", Nature Gas, EIA website at: http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/index.html

FAF zone is used in calculating shares, and then applied to disaggregate interstate movements from state-level to FAF regions.

- *Natural gas consumption by end use*
  This statistic is obtained from the EIA's *Natural Gas* data website[40]. This annual data series contains total "volumes delivered to consumers" by state and end-use sectors of residential, commercial, industrial, vehicle, and electric power. Additional databases used in disaggregating state-level natural gas consumptions to FAF regions included: population data, CBP, vehicle population data, as well as data for electric generating units.

Intrastate Domestic Flows

Information on dry production and withdrawals from underground storage[41] by individual states is gathered from the EIA's *2012 Natural Gas Annual*[42] and used to create control totals for intrastate natural gas movements. The same auxiliary data used in the interstate case is also used to disaggregate intrastate movements.

10.1.2 Imported Natural Gas

U.S. Natural Gas Imports by Point of Entry

The major data source used in estimating imported natural gas flows is the *U.S. Natural Gas Imports by Point of Entry* from 2012 *Natural Gas Annual* published by the EIA. Specifically, Table 9, entitled *"Summary of U.S. natural gas imports by point of entry, 2008 – 2012"* of that report is used. The table provides volume (in million cubic feet), as well as price for natural gas transported by pipeline and liquefied natural gas (LNG). Except for natural gas transported by pipeline (from Canada or Mexico), mode of transportation on movements of LNG is not specified. It is expected that LNG imported from countries other than Canada/Mexico is transported to the U.S. by vessel.

U.S. Natural Gas Imports by State

In addition to imports by point of entry, the EIA also reports data on natural gas imports by state[43], which provides total imported volumes (in million cubic feet) and prices (dollars per thousand cubic feet) of natural gas at the state level. Total volumes by state from both tables

[40] http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SAL_a.htm.
[41] EIA table "Natural Gas annual Supply & Disposition by State", Natural Gas data, available at: http://www.eia.gov/dnav/ng/ng_sum_snd_a_EPG0_FPD_Mmcf_a.htm.
[42] *Natural Gas Annual 2012*, Office of Oil, Gas, and Coal Supply Statistics, EIA, U.S. Department of Energy, available at: http://www.eia.gov/naturalgas/annual/pdf/nga12.pdf.
[43] EIA statistics are available at http://www.eia.gov/dnav/ng/ng_move_state_a_EPG0_IM0_Mmcf_a.htm.

(one by point of entry and the other by state) are examined and the results assumed that an imported natural gas shipment is typically delivered to U.S. destinations within the same state where its point of entry is located. According to the EIA, natural gas is mostly transported by pipeline domestically.

A processing plant is the place where pipeline-quality natural gas is produced. Therefore, under FAF4 processing, it is assumed that the U.S. destination of imported natural gas would be a FAF region with processing plants in it, and within the same state as the port of entry of the given imported shipment. A database that contains natural gas processing plant locations is used to determine destinations of natural gas shipments.

10.1.3 Exported Natural Gas

Data sources used in the imported natural gas estimation process typically also contain information for exported natural gas shipments. Instead of point of entry for imports, exported shipments involve point of exit. Therefore, the list of data sources is fundamentally the same as those used for imports. Unlike imports, LNG exported to both Canada and Mexico can be transported by land modes, while exports to other countries are shipped only by vessel.

Similarly, an examination on the two sets of data on natural gas exports (i.e., one by point of entry and the other by state) suggested that an exported natural gas shipment typically originated in the same state as its point of exit. Based on the natural gas transportation process and flow, the natural gas enters the transmission system through a pipeline gathering system once it leaves the producing wells. Thus, the locations where gathering system connects to the transmission pipeline can be treated as the domestic origins for export flows.

Again, the natural gas receipt/delivery points database, briefly discussed above for imports, contains geographic information representing locations on interstate natural gas pipelines where natural gas gathering systems connect to the pipeline, or where natural gas local distribution systems and other end-users connect to the pipeline, within North America. These receipt points are used to identify originating domestic FAF zones for exported flows.

10.2 ESTIMATION PROCEDURES FOR NATURAL GAS FLOWS

10.2.1 Domestic Flows

Overview of Methods

The estimation methodology for domestic natural gas movements is more complex than for imports and exports. This is because the most detailed data available for domestic natural gas shipments is at state level, thus modeling approaches are needed in order to disaggregate movements into FAF zones. This disaggregation process involved two modeling efforts, the development of a spatial interaction model (e.g., gravity model) and an application of the IPF process. The spatial interaction model is applied to estimate the initial flow matrix of the natural gas movements. Once the initial natural gas flow matrix is produced, the IPF procedure is then applied to generate the final natural gas flow matrix for FAF.

The IPF is a procedure for adjusting a matrix (of data cells) so that they would add up to available control totals for both the columns and rows of the given matrix. The general process of IPF can be described as:

1. Each row of initial cells is proportionally adjusted to equal the marginal row totals;
2. Each column of (already row-adjusted) cells is proportionally adjusted to match the marginal column totals. This is the end of the first 'Iteration'; and
3. The above steps are repeated multiple times until a pre-determined level of convergence is reached.

Estimation Framework for Interstate Flows of Natural Gas

The general estimation process for interstate movements of natural gas is described in detail in the following steps. The state-to-state movements that came from state-level control totals are extracted from Table 12 of the EIA-published *2012 Natural Gas Annual*. The production estimations are calculated by aggregating scheduled capacity of receipt points into FAF regions based on geospatial joining of receipt point locations. Then, the attraction estimation for the flows is performed.

The attraction estimation process relied on available data from the EIA, which is the consumption by state and end-use sector. For each given end-use sector, the consumption data is disaggregated to county level and then added up to FAF zones by applying one of the following methods depending on the consumption type.

- Residential: Assuming the consumption is proportional to population, consumptions by state was disaggregated to county level.
- Industrial & Commercial: Assuming the consumption by industrial and commercial sector is highly correlated to payrolls in each industry, CBP data was used to disaggregate data into county level.
- Vehicle: Vehicle natural gas use is assumed as proportional to number of natural gas vehicles. Natural gas vehicle population data from Polk was used to disaggregate vehicle consumption data into county level.
- Electric Power: Natural gas cost information for electric generating units was used to disaggregate natural gas consumption by electric power to the county level.

The total consumption by FAF zone is obtained by combining estimates from all end-use sectors for counties within each FAF region. Note that a rank matrix of distance is used in this process instead of using distance matrix directly. Specifically, the initial assignment uses a gravity model by utilizing the production and attraction estimates applied to the spatial interaction procedure. Then, with the marginal control totals from EIA data for the given state-to-state pair, the assignment and IPF approach are repeated for all state-to-state records until the pre-determined level of convergence is met.

Intrastate Movements

The only difference for the intrastate movement estimation from the interstate process is in the preparation for the state-level data. Because this information is not directly available from the EIA, it was derived using statistics published in Tables S1–S52 in the *2012 Natural Gas Annual.* All subsequent steps are the same as those conducted for disaggregating interstate movement to FAF regional level.

10.2.2 Imported Natural Gas

Several processing steps are required to estimate flows of imported natural gas shipments. First, with the aid of a GIS tool, locations of entry points for the EIA-published *Natural Gas Imports by Point of Entry* data are assigned to FAF trade zones. Then, each processing plant is flagged in each FAF zone by conducting a spatial join between FAF-zone layer and the geographical locations of "natural gas processing plants." For each import record, a domestic destination area is assigned by pinpointing the FAF zone that has processing plant, which is also closest to the entry point of imported natural gas. The foreign mode (mode used to reach the U.S.) is then adjusted and added to the domestic mode. Mode assignment for the foreign mode from Canada is assumed truck, while all domestic modes are assumed pipelines. Finally, the data is aggregated to the FAF zones and natural gas volumes are converted to tons, and values of shipments are estimated.

10.2.3 Exported Natural Gas

Similar to the imports, data from the EIA -published *Natural Gas Exports by Point of Exit* data is used with the GIS tool to create spatial layers of exit points for the foreign countries involved. A spatial join is also performed to "connect" them with FAF4 zones. Then, each processing plant is flagged in each of the FAF zones by the spatial join between the FAF–zone layer and the geographical locations of "natural gas processing plants."

For each export record, a domestic destination area is assigned by pinpointing the FAF zone that has receipt points which is also closest to the exit point of exported natural gas. The foreign mode (mode used to exit the U.S.) is then adjusted and added to the domestic mode. Mode assignment for the foreign mode to Canada was assumed truck, while all domestic modes are assumed as pipeline. Finally, the data is aggregated to the FAF zones and natural gas volumes are converted to tons, and values of shipments are estimated.

11. FOREIGN TRADE

Unlike the construction of the domestic OOS commodity flows, with its diverse and sometimes partial data sources, the construction of estimates of annual import and export flows for FAF4 are generally based on a few highly developed datasets. Even so, lack of geographic details for inland movements creates significant gaps in the regional commodity flow picture. Because of this, procedures for generating domestic legs of foreign trade movements are required.

11.1 DEFINITION OF IMPORTS AND EXPORTS

Imports are defined as shipments originating in one of the eight foreign regions (see Section 2) and terminating inside the U.S. in one of the 132 domestic FAF zones. Upon entering the U.S., these imports pass through a port of entry, which logically divides these movements into foreign and domestic legs. Imports from Canada and Mexico are generally assumed to have entries at U.S. border crossings with no change of mode involved, unless an unreasonable domestic mode was encountered. Imports from other countries, other than Canada or Mexico, could only enter the U.S. via sea or air modes.

Similarly, exports are defined as shipments originating from one of the FAF zones, passing through a U.S. port of exit, and ending in a foreign country. There are domestic and foreign legs for exported shipments as well. As in the imports, domestic modes of exported shipments terminating in Canada/Mexico are assumed the same as their foreign modes, except for unreasonable modes.

11.2 CHALLENGES IN ESTIMATING FOREIGN TRADE FLOWS

As pointed out earlier, a significant gap in the freight movement of foreign trade becomes present in imports after they enter the country, or in terms of exports, before they exit the country. No readily available dataset covers these movements either by internal geographic details or by mode of transportation. Traditionally, for trade with Canada and Mexico, there is at least some state-level origination and destination data available with which to estimate their movements within the U.S., and by mode of transportation (generally assumed the same mode as used for the border-crossing legs). For seaborne/airborne shipments from other nations, however, this generally is not the case.

Compounding the problem, while the CFS does not capture imports, it may include movements of imported goods that change ownership as soon as they arrive in the United States. It seems reasonable to assume that most of the imports that remain within a port region are moved internally within such regions by truck. Longer distance imported goods shipments, including many non-truck movements, require some modeling or assumptions in order to distribute them among other FAF4 regions.

11.3 DATA SOURCES

11.3.1 Data Sources Prior to FAF4.1

Census Foreign Trade Public Data

The publically available Foreign Trade data[44] from the Foreign Trade Division (FTD) of the U.S. Census Bureau provides data on all air and vessels engaged in U.S. foreign trade, including information such as cargo data by type of service, U.S. and foreign ports involved, country of origin or destination, commodity, value and tonnage, for both bulk and containerized cargo. No specific U.S. origin or destination information on shipments is given in the public foreign trade data file. The commodity in this dataset is provided according to the Harmonized System codes (HS) classification and for waterborne trade it covers both seaborne and Great Lakes international commodity movements.

Transborder Surface Freight Data

For U. S. trade involving Canada and Mexico, under a special agreement with the Census, BTS offers the *Transborder Surface Freight* dataset[45] that gives more detail than what was released by the Census Foreign Trade. In addition to water and air shipments, border-crossing mode provided in the Transborder database includes truck, rail, vessel, air, pipeline, mail, and other. Furthermore, the geographic region given in the Transborder data specifies origin/destination of a trade shipment at the U.S. state level. As in the foreign trade data, Transborder data are reported using the HS code (2-digit only). The public Transborder data only provides two of the following three pieces of freight information in separate files: U.S. state (i.e., origin state of the exports and destination state of the imports), port of entry or exit, and commodity shipped. Traditionally, FAF has to rely on modeling approaches to “restructure” a complete state-port-commodity matrix as the first step in estimating ODCM flow involving Transborder OOS area.

[44] U.S. Census Bureau, Foreign Trade data products are listed at http://www.census.gov/foreign-trade/reference/products/index.html.
[45] Further information is available at http://transborder.bts.gov/programs/international/transborder/PDF/TransBorderFreightDataProgram.pdf, and http://transborder.bts.gov/programs/international/transborder/TBDR_QA.html.

County Business Patterns

As for other OOS sectors discussed in this report, payroll information from the 2012 CBP database is used to disaggregate state-level estimates to corresponding FAF regions within the given state, when appropriate.

PIERS Dataset

The PIERS dataset, available from the JOC Group (a division of IHS Inc.), contains detailed information obtained from Bills of Lading records of the cargoes on- and off-loaded in U.S. ports from ships in non-domestic movements. Recorded in the PIERS are shipment information such as the port (by customs district), tons, dollar value, the commodity (in 6-digit HS codes), a container count (if used), the foreign country involved (origin or destination), and the shipper. These PIERS data items allow a fairly precise determination of the dollar and ton for a given port region, foreign country, and commodity. Several crosswalk tables are used to convert from HS into SCTG commodity codes, allocate country to associated foreign zone, and assign port zone for every customs district. There is little ambiguity in the assignment of port zone, except that the Port of New York (district 1001) covers both northern New Jersey and New York City. Under FAF4, for simplicity, all activities involving custom district 1001 were assumed to be within New Jersey (FAF4 zone 341).

11.3.2 Data Sources for FAF4.1

Census Special Tabulation of 2012 FTD Data

Starting with the process in FAF4.1, at the request of the BTS, Census began to offer special tabulations that provide more details regarding domestic segments of foreign-trade shipments. In most cases, the data provided by the Census Foreign Trade Division includes the state-level origination/destination, commodity, and port of entry/exit at the FAF-zone level. No doubt, availability of such special datasets has greatly reduced the need of modeling in determining foreign trade flows for a given commodity between the state, port, and the foreign zones involved.

In addition to data on “direct” trade (shipments moved between a foreign country and the U.S.), Census also provided a second set of trade data on shipments transported from other countries via Canada or Mexico. As an example, a shipment that originated in Europe, moves across a portion of Canada, then terminated in Boston would be included in this second data file. For the purpose of FAF4, these “second-set” of shipments are considered as imports/exports between U.S. and Canada/Mexico, regardless of where they originated from or, in the case of exports where they ultimately ended up. Furthermore, since the mode of transportation indicated in this FTD dataset reflected only the movement between Canada/Mexico and that “other country”, all shipments in this file are coded with a "multiple mode" for their foreign segments (instead of water or air) in FAF.

To ensure the consistency with other parts of FAF4 data and to reduce potential disclosure concerns, SCTG (instead of HS) and FAF zones (instead of point of entry/exit codes) are provided by the Census in the special FTD datasets. Specifically, Census used a crosswalk conversion table prepared by the FAF team to convert the FTD data from its HS class to the SCTG commodity code. Similarly, Census assigned points of entry/exit locations and foreign countries to FAF4-defined zones based on a lookup table supplied by the FAF team.

The FAF4 has benefited from special tabulations provided by the Census FTD, which offered more detail information for domestic segments of foreign-trade shipments for trade with all countries, not just Canada/Mexico. In most cases, this FTD data included the state-level origination/destination, commodity in 2-digit SCTG, and port of entry/exit at the FAF-zone level. Clearly, it included more specific information than could be obtained from the public foreign trade data, and the need for the abovementioned "matrix-restructure" modeling effort was eliminated from FAF processing. Moreover, the new FTD data allows a consistent flow estimation method to be applied on all shipment data regardless of the country involved. That is, data on shipments involving trade with Canada, Mexico, or other countries could be handled with the same procedures under the FAF4 process, instead of applying two different processes as in the past.

As pointed out previously, the foreign trade data does not specifically track the domestic segments of imported and exported shipments. This situation remains the same in the new FTD datasets that are provided. Specifically, domestic modes of foreign trade shipments continued to be a major data-challenge in the FAF process.

11.4 ESTIMATION METHODS

In order to avoid disclosure issues, however, Census aggregates some commodities into less-detailed commodity groups, instead of the 2-digit SCTG as needed in FAF. In addition, some states of origination/destination are not revealed in the Census FTD file, either because that data is missing/unknown or to avoid a potential disclosure situation. Moreover, detailed information on the location of points of entry/exit (shown as a FAF zone) might not be available or non-specified (e.g., given by a special non-geographic-specific code) for certain trade flows. Therefore, the use of modeling approaches, as well as applying ad hoc procedures and assumptions, are inevitable during the processing of foreign trade data for constructing the final FAF4 flow matrix. The estimation procedures used to process the FTD data are briefly discussed in the following paragraphs.

11.4.1 Disaggregating A Commodity Group to Associated 2-digit SCTG Codes

As mentioned previously, Census aggregated commodity details whenever there is a potential concern of disclosure on releasing the FTD data at a 2-digit SCTG level. The definition of an aggregated commodity group (i.e., SCTG group) as applied by Census to the FTD data (for FAF4 uses) is presented in Table 11–1. For example, commodity group "1G" covers five SCTG codes (i.e., 01-05), while a code of "5G" could mean any commodities that fall between SCTG 20 and SCTG 24. The very first step in preparing the FTD data for FAF4 flow estimation processes, thus, was to disaggregate these SCTG-groups into their associated 2-digit SCTG codes. A straightforward simple approach is employed for this process.

Table 11–1. Definition of SCTG Group in the Foreign Trade Data File

SCTG group Code	SCTG 2-digit covered	DESCRIPTION
1G	01-05	Agriculture products and fish
2G	06-09	Grains, alcohol, and tobacco products
3G	10-14	Stones, non-metallic minerals, and metallic ores
4G	15-19	Coal and petroleum products
5G	20-24	Pharmaceutical and chemical products
6G	25-30	Logs, wood products, and textile and leather
7G	31-34	base metal and machinery
8G	35-38	Electronic, motorized vehicles, and precision instruments
9G	39-43, 99	Furniture, mixed freight, misc. manufactured products, and commodity unknown

Commodity shares for each given SCTG group (i.e., 1G – 9G) are generated using values ($) information published in the USA Trade Online[46] released by the Census. To account for regional variations in commodities being shipped, commodity shares are summarized by both foreign zone and the U.S. state involved. For simplicity, however, foreign zones outside Canada and Mexico were grouped together, i.e., assuming commodity shares were the same within these zones (FAF foreign zones of 803 through 808). Table 11–2 gives a few examples of the commodity shares calculated based on 2012 USA Trade Online data on imports. For instance, using information in Table 11–2, an imported shipment for commodity "1G" from Canada to Georgia would be split into three records (with SCTG code of 01, 03, or 05 in each), and their volumes calculated by multiplying the Census-reported volume ($/tons in the FTD file) with shares of 24.0%, 61.1%, and 14.9%, respectively.

[46] USA Trade Online, Census Bureau, https://usatrade.census.gov/

Table 11–2. Examples of Commodity Shares in Imports by Geographic Regions

Foreign Origin	U.S. Destination	SCTG group	SCTG 2-digit	USA Trade Online Value 2012	Share
801	GA	1G	01	13,568	24.0%
			03	34,563	61.1%
			05	8,396	14.9%
803-809	GA	1G	01	4,468,475	0.7%
			02	32,166,826	5.3%
			03	179,119,812	29.4%
			04	11,307,726	1.9%
			05	382,083,528	62.7%
802	IL	5G	20	248,558	0.8%
			21	23,669,504	76.0%
			22	6,146,022	19.7%
			23	1,077,145	3.5%

On the other hand, with the same commodity code (1G) and the same U.S. destination state (GA), if the imported region was changed to Europe (zone 804), then the original Census-reported record would be split into 5 records (with one each for SCTG codes 01-05). Their volume would then be split into these five records using shares of 0.6%, 5.3%, 29.4%, 1.9%, and 62.7% respectively.

The shares for exported shipments were calculated based on 2012 USA Trade Online statistics on exports (instead of imports). The exact same approach as described for imports is used to disaggregate exported shipment records that contain SCTG group coding.

11.4.2 Imputing Unknown State

A simple approach was used to account for shipment volumes from "unknown state" trades. Fundamentally, volumes from FTD records with unknown states are proportionally allocated to other trade records that share the same shipment characteristics, e.g., trade type (imports or exports), foreign region (FAF4 foreign zones), transportation mode used to enter or exit the U.S., commodity type (in 2-digit SCTG), and ports of entry/exit region (FAF4 zone).

As a simple example, assume an "unknown state" shipment of $1,000 is matched to two "known state" records (state-A and state-B valued at, say, $2,000 and $500, respectively). The amount of $1,000 from this unknown-state record would be divided between state-A and state-B with an 80-20% split. Using that ratio the $1,000 from the unknown state is split to state-A and state-B resulting in would be increases of $2,800 from $2,000 for state-A and $700 instead of $500 for state-B.

11.4.3 Issues Associated with Unspecified Port Zones

Census used several special codes for ports, in place of FAF-zone codes, on shipments that met certain conditions. Because of that, FAF-zone information for these shipments is not provided in the data file (i.e., missing) thus needed to be estimated. Generally, straightforward simple imputation methods are employed whenever possible. In some cases, commodity volumes from shipments with missing ports of entry/exit FAF zones were redistributed to other similar shipments as in the "unknown state" cases.

Port Zone Code 997 is used for "Vessel under its own power" in both imports and exports. Due to the nature of these vessels (i.e., has to be large enough to travel across countries), it is assumed for this FAF processing that the ports involved with these shipment would be fairly close to their origin/destination states. There are less than two dozen records of this kind in the Census FTD databases (imports and exports); all are manually assigned to selected FAF regions (e.g., Los Angeles for shipment to California, Miami for shipment to Florida).

Port Zone Code 998 is used to reflect low-value imports/exports and mail. It was assumed that these shipments could cover all types of shipments crossing at any ports. Therefore, volumes of these "998" shipments are distributed to others with similar characteristics (similar to the method used for "unknown state"). The only exception is for mail shipments, where their modes are coded as "multiple mode and mail" in FAF.

Port Zone Code 991 is used for certain coal shipments by vessels out of one of three ports, including Norfolk, Mobile, or Charleston, but no specific ports are identified for these shipments in the FTD data file. This code is used in only about three dozen of the exported records in 2012. A simple assignment by geographic location of originating state is applied to impute FAF-zone codes for these shipments (selected from one of the three ports). For example, Mobile is assigned to exported coal shipments originating from Alabama and Texas regardless of foreign zones involved. Mobile is also used for exported coal shipments that originated from Missouri heading to Mexico or the Rest of America; Norfolk is assumed for those coal shipments to other foreign regions.

11.4.4 Estimating Missing Shipment Weight or Value

Shipment weights are not available for many exported data and some records did not have information on values, thus, they needed to be estimated. The value-to-weight ratios estimated based on imports by foreign country, transportation mode, and commodity type, are applied.

11.4.5 Assignment of Domestic Mode

In most cases, it was assumed that domestic mode of a transborder shipment (i.e., U.S. trade with Canada/Mexico) remained the same as its border-crossing foreign mode. When impossible modes are encountered (e.g., no water access possible), assignment of another reasonable mode would be applied (e.g., truck or rail, or multiple mode). For sea-borne trade shipments, PIERS data as well as CFS domestic mode distributions are generally used in assigning their domestic modes. Airborne trade shipments are generally assumed to transfer by air domestically to its domestic destination, unless geographically not feasible (e.g., within the same city or considering the travel distances).

11.5 DISAGGREGATION OF STATE FLOWS TO FAF REGIONS

As in the processing of other OOS areas, CBP payroll data is utilized to disaggregate state-level flows estimated for the transborder shipments to associated FAF regions. Additional data quality checks, especially for adjustment of impossible modes, are performed on the resulting region-to-region flows. This completes the estimation process for FAF flows associated with U.S. trade shipments with Canada and Mexico.

For imports/exports with other foreign zones, OAI data (specifically the T-100 Market and Segment data[47]) from the BTS are used to determine domestic flows of air trade shipments. For trade by water, the main data source for determining FAF zone-level origins (exports) or destinations (imports) is the PIERS. This process is discussed briefly in the next section.

11.6 DETERMINING DOMESTIC SEGMENT OF WATERBORNE TRADE FLOW

The PIERS does not directly indicate the domestic destination of imports or origin for exports, but it does provide certain clues. Those clues include:

- For approximately 10% of movements, the ocean carrier has been contracted to arrange domestic cartage. In these cases, the domestic endpoint is explicitly indicated in the PIERS record by a place name, thus allowing for assignment to a FAF zone.
- A shipper name and location is given in PIERS. This shipper location was assigned to a FAF zone, which was considered as a possible destination in the hope that the shipper responsible for the import was at least nearby the shipment consignee. However, there are several reasons this assumption might not be correct. First, the "shipper" may be a broker located in a completely different city. Similarly, the shipper location may be a company headquarters (where a corporate transportation office is housed) that handles shipments for diverse and distant facilities operated by that company.

When the domestic destination of a shipment is unknown, the volume of this shipment would be distributed to U.S. destination zones in proportion to domestic shipments measured in the 2012

[47] http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/?sect=collection.

CFS (with the same 2-digit commodity code and port zone). Similarly, the associated domestic modes (based on the CFS) would be used for domestic segments of the U.S. trade (by water). A special condition was imposed on Hawaii, in that imports and exports were prohibited from using a trans-Pacific domestic leg. Therefore, imports that land in Hawaii stay in Hawaii. Note that the PIERS processing was applied to all water shipments, except for imports/exports of crude oil and natural gas (STCGs 16 and 19) where they are preferentially covered by EIA data.

11.7 ADJUSTMENT OF PORT ZONE LOCATIONS

Because the port information provided in the Census FTD data generally represents the port of unloading for a shipment by air or vessel, which is potentially different from the port of entry for the shipment. These “ports” (thus the matched FAF zones) were not necessarily located along the U.S. borders or coasts. As directed by the BTS, shipments with non-border and non-coastal port zones in the final FTD-based OD flows are reassigned to geographically logical border or coastal ports.

APPENDIX A: CFS AREA -FAF ZONE CROSSWALK TABLE

STPOSTAL	STFIPS	CFSMA	ST_MA	FAF	SHORTNAME
AL	01	142	01-142	011	Birmingham
AL	01	380	01-380	012	Mobile
AL	01	99999	01-99999	019	Rest of AL
AK	02	99999	02-99999	020	Alaska
AZ	04	38060	04-38060	041	Phoenix
AZ	04	536	04-536	042	Tucson
AZ	04	99999	04-99999	049	Rest of AZ
AR	05	99999	05-99999	050	Arkansas
CA	06	348	06-348	061	Los Angeles
CA	06	472	06-472	062	Sacramento
CA	06	41740	06-41740	063	San Diego
CA	06	488	06-488	064	San Francisco
CA	06	260	06-260	065	Fresno
CA	06	99999	06-99999	069	Rest of CA
CO	08	216	08-216	081	Denver
CO	08	99999	08-99999	089	Rest of CO
CT	09	25540	09-25540	091	Hartford
CT	09	408	09-408	092	New York (CT)
CT	09	99999	09-99999	099	Rest of CT
DE	10	428	10-428	101	Philadelphia (DE)
DE	10	99999	10-99999	109	Rest of DE
DC	11	47900	11-47900	111	Washington (DC)
FL	12	300	12-300	121	Jacksonville
FL	12	370	12-370	122	Miami
FL	12	422	12-422	123	Orlando
FL	12	45300	12-45300	124	Tampa
FL	12	99999	12-99999	129	Rest of FL
GA	13	122	13-122	131	Atlanta
GA	13	496	13-496	132	Savannah
GA	13	99999	13-99999	139	Rest of GA
HI	15	46520	15-46520	151	Honolulu
HI	15	99999	15-99999	159	Rest of HI
ID	16	99999	16-99999	160	Idaho
IL	17	176	17-176	171	Chicago (IL)
IL	17	476	17-476	172	St. Louis (IL)
IL	17	99999	17-99999	179	Rest of IL
IN	18	176	18-176	181	Chicago (IN)
IN	18	294	18-294	182	Indianapolis
IN	18	258	18-258	183	Fort Wayne
IN	18	99999	18-99999	189	Rest of IN
IA	19	99999	19-99999	190	Iowa
KS	20	312	20-312	201	Kansas City (KS)
KS	20	556	20-556	202	Wichita
KS	20	99999	20-99999	209	Rest of KS
KY	21	178	21-178	211	Cincinnati (KY)
KY	21	350	21-350	212	Louisville
KY	21	99999	21-99999	219	Rest of KY
LA	22	12940	22-12940	221	Baton Rouge
LA	22	29340	22-29340	222	Lake Charles

STPOSTAL	STFIPS	CFSMA	ST_MA	FAF	SHORTNAME
LA	22	406	22-406	223	New Orleans
LA	22	99999	22-99999	229	Rest of LA
ME	23	99999	23-99999	230	Maine
MD	24	12580	24-12580	241	Baltimore
MD	24	47900	24-47900	242	Washington (MD)
MD	24	99999	24-99999	249	Rest of MD
MA	25	148	25-148	251	Boston (MA)
MA	25	99999	25-99999	259	Rest of MA
MI	26	220	26-220	261	Detroit
MI	26	266	26-266	262	Grand Rapids
MI	26	99999	26-99999	269	Rest of MI
MN	27	378	27-378	271	Minneapolis
MN	27	99999	27-99999	279	Rest of MN
MS	28	99999	28-99999	280	Mississippi
MO	29	312	29-312	291	Kansas City (MO)
MO	29	476	29-476	292	St. Louis (MO)
MO	29	99999	29-99999	299	Rest of MO
MT	30	99999	30-99999	300	Montana
NE	31	420	31-420	311	Omaha
NE	31	99999	31-99999	319	Rest of NE
NV	32	332	32-332	321	Las Vegas
NV	32	99999	32-99999	329	Rest of NV
NH	33	148	33-148	331	Boston (NH)
NH	33	99999	33-99999	339	Rest of NH
NJ	34	408	34-408	341	New York (NJ)
NJ	34	428	34-428	342	Philadelphia (NJ)
NM	35	99999	35-99999	350	New Mexico
NY	36	104	36-104	361	Albany
NY	36	160	36-160	362	Buffalo
NY	36	408	36-408	363	New York (NY)
NY	36	464	36-464	364	Rochester
NY	36	99999	36-99999	369	Rest of NY
NC	37	172	37-172	371	Charlotte
NC	37	268	37-268	372	Greensboro
NC	37	450	37-450	373	Raleigh
NC	37	99999	37-99999	379	Rest of NC
ND	38	99999	38-99999	380	North Dakota
OH	39	178	39-178	391	Cincinnati (OH)
OH	39	184	39-184	392	Cleveland
OH	39	198	39-198	393	Columbus
OH	39	212	39-212	394	Dayton
OH	39	99999	39-99999	399	Rest of OH
OK	40	416	40-416	401	Oklahoma City
OK	40	538	40-538	402	Tulsa
OK	40	99999	40-99999	409	Rest of OK
OR	41	440	41-440	411	Portland (OR)
OR	41	99999	41-99999	419	Rest of OR
PA	42	428	42-428	421	Philadelphia (PA)
PA	42	430	42-430	422	Pittsburgh
PA	42	408	42-408	423	New York (PA)
PA	42	99999	42-99999	429	Rest of PA
RI	44	148	44-148	441	Rhode Island

STPOSTAL	STFIPS	CFSMA	ST_MA	FAF	SHORTNAME
SC	45	16700	45-16700	451	Charleston
SC	45	273	45-273	452	Greenville
SC	45	99999	45-99999	459	Rest of SC
SD	46	99999	46-99999	460	South Dakota
TN	47	368	47-368	471	Memphis
TN	47	400	47-400	472	Nashville
TN	47	314	47-314	473	Knoxville
TN	47	99999	47-99999	479	Rest of TN
TX	48	12420	48-12420	481	Austin
TX	48	13140	48-13140	482	Beaumont
TX	48	204	48-204	483	Corpus Christi
TX	48	206	48-206	484	Dallas
TX	48	238	48-238	485	El Paso
TX	48	288	48-288	486	Houston
TX	48	29700	48-29700	487	Laredo
TX	48	41700	48-41700	488	San Antonio
TX	48	99999	48-99999	489	Rest of TX
UT	49	482	49-482	491	Salt Lake City
UT	49	99999	49-99999	499	Rest of UT
VT	50	99999	50-99999	500	Vermont
VA	51	40060	51-40060	511	Richmond
VA	51	545	51-545	512	Norfolk
VA	51	47900	51-47900	513	Washington (VA)
VA	51	99999	51-99999	519	Rest of VA
WA	53	500	53-500	531	Seattle
WA	53	440	53-440	532	Portland (WA)
WA	53	99999	53-99999	539	Rest of WA
WV	54	99999	54-99999	540	West Virginia
WI	55	376	55-376	551	Milwaukee
WI	55	99999	55-99999	559	Rest of WI
WY	56	99999	56-99999	560	Wyoming

APPENDIX B: AGRICULTURAL COMMODITY CATEGORIZED BY SCTG GROUP

SCTG 01: Live Animal and Fish

Calves sold (number)
Cattle sold (number)
Hogs and pigs sold (number)
Any poultry sold, layers 20 weeks old and older (number)
Any poultry sold, pullet chicks (number)
Any poultry sold, broilers (number)
Any poultry sold, turkeys sold (number)
Sheep and lambs sold (number)
Horses and ponies, sales (number)
Miscellaneous livestock (number)
Mink and their pelts, sales (number)
Ducks, sales (number)
Geese, sales (number)
Pigeons or squab, sales (number)
Pheasants, sales (number)
Quail, sales (number)
Emu and ostrich, sales (number)
Miscellaneous poultry, sales (number)
Other poultry, sales (number)
Poultry hatched, sales (number)
Mules, burros, and donkeys - sales (number)
Goats, total sales (number)
Rabbits and their pelts -sales (number)
Catfish, pounds (1,000)
Trout, pounds (1,000)
Hybrid Striped Bass, pounds (1,000)
Other fish, pounds (1,000)
Crawfish, clam, mussels, oysters, snails, pounds (1,000)
Other aquaculture products, pounds (1,000)

SCTG 02: Cereal Grains

Corn for grain or seed (bushels), harvested	Rye for grain (bushels), harvested
Sorghum for grain or seed (bushels), harvested	Wild rice (cwt), harvested
Wheat for grain, total (bushels), harvested	Popcorn (pounds, shelled), harvested
Barley for grain (bushels), harvested	Proso millet (bushels), harvested
Buckwheat (bushels), harvested	Safflower (pounds), harvested
Emmer and spelt (bushels), harvested	Triticale (bushels), harvested
Oats for grain (bushels), harvested	Corn for grain or seed (bushels), harvested
Rice (hundredweight), harvested	

SCTG 03: Agricultural Products

Canola and other rapeseed (pounds), harvested	Lespedeza seed (pounds), harvested
Canola (pounds), harvested	Orchardgrass seed (pounds), harvested
Other rapeseed (pounds), harvested	Red clover seed (pounds), harvested
Flaxseed (bushels), harvested	Ryegrass seed (pounds), harvested
Mustard seed (pounds), harvested	Sudangrass seed (pounds), harvested
Sunflower seed (pounds), harvested	Timothy seed (pounds), harvested
Cotton (bales), harvested	Vetch seed (pounds), harvested
Tobacco (pounds), harvested	Wheatgrass seed (pounds), harvested
Soybeans for beans (bushels), harvested	White clover seed (pounds), harvested
Dry edible beans, excluding dry limas (hundredweight)	Other seeds (pounds), harvested
Dry limas beans (hundredweight), harvested	Vegetables harvested, harvested (acres)
Dry edible peas (hundredweight), harvested	Fruits Total Production in 1,000 tons
Dry cowpeas and dry southern peas (bushels), harvested	Dill for oil (pounds), harvested
Lentils (hundredweight), harvested	Ginger root (pounds), harvested
Potatoes, excluding sweet potatoes (hundredweight), harvested	Ginseng (pounds), harvested
Sweet potatoes (hundredweight), harvested	Guar (pounds), harvested
Sugar beets for seed (pounds), harvested	Sesame (pounds)
Sugar beets for sugar (tons), harvested	Herbs, dried (pounds), harvested
Sugarcane for seed (tons), harvested	Hops (pounds), harvested
Sugarcane for sugar (tons), harvested	Jojoba harvested (pounds), harvested
Peanuts for nuts (pounds), harvested	Mint for oil (pounds of oil), harvested
Alfalfa seed (pounds), harvested	Mint for tea
Austrian winter peas (hundredweight), harvested	Pineapples harvested (tons), harvested
Bahia grass seed (pounds), harvested	Sorghum for syrup (pounds), harvested
Bentgrass seed (pounds), harvested	Sweet corn for seed (pounds), harvested
Bermuda grass seed (pounds), harvested	Taro (pounds), harvested
Birdsfoot trefoil seed (pounds), harvested	Switchgrass
Bromegrass seed (pounds), harvested	Miscanthus
Crimson clover seed (pounds), harvested	Camelia
Fescue seed (pounds), harvested	Maple Syrup
Kentucky Bluegrass seed (pounds), harvested	Mushrooms
Ladino clover seed (pounds), harvested	

SCTG 04: Animal Feed, Eggs, Honey, and Other Products of Animal Origin

Hay-alfal, other tame, small grain, wild, grass silage grass (tons)
Haylage/Grass Silage/Greenchop (tons)
Corn for silage or green chop (tons, green), harvested
Sorghum for silage or green chop (tons, green), harvested
Salt hay (tons), harvested
Sheep and lambs shorn (pounds of wool)
Honey, sales (pounds)
Mohair, sales (pounds)

SCTG 07: Other Prepared Foodstuffs, Fats and Oils

Milk and milk fat (million pounds)

SCTG 09: Tobacco Products

Tobacco

APPENDIX C: 2012 COMMERCIAL FISHERY LANDINGS BY PORT RANKED BY VALUE

Rank	Port	Millions of Pounds	Millions of Dollars
1	New Bedford, MA	143.0	411.1
2	Dutch Harbor, AK	751.5	214.2
3	Kodiak, AK	393.0	170.3
4	Aleutian Islands (Other), AK	455.6	118.9
5	Honolulu, HI	27.1	100.1
6	Alaska Penninsula (Other), AK	191.0	98.8
7	Empire-Venice, LA	500.4	79.7
8	Bristol Bay (Other), AK	55.3	78.9
9	Naknek, AK	86.5	77.8
10	Galveston, TX	26.6	74.3
11	Cape May-Wildwood, NJ	27.8	71.7
12	Sitka, AK	67.1	66.2
13	Hampton Roads Area, VA	13.5	64.1
14	Dulac-Chauvin, LA	42.6	64.0
15	Seward, AK	54.0	62.1
16	Westport, WA	133.4	58.9
17	Gloucester, MA	82.6	57.4
18	Ketchikan, AK	74.1	54.4
19	Brownsville-Port Isabel, TX	23.0	53.6
20	Petersburg, AK	52.0	50.0
21	Port Arthur, TX	20.4	47.4
22	Stonington, ME	21.8	46.1
23	Intracoastal City, LA	344.7	43.9
24	Los Angeles, CA	161.9	43.6
25	Key West, FL	11.8	43.0
26	Point Judith, RI	46.4	42.6
27	Cordova, AK	83.8	40.0
28	Astoria, OR	169.5	38.9
29	Bayou La Batre, AL	20.8	37.5
30	Newport, OR	80.2	37.2
31	Reedville, VA	389.0	34.5
32	Portland, ME	59.0	32.8
33	Homer, AK	12.3	30.1
34	Long Beach-Barnegat, NJ	7.7	30.0
35	Kenai, AK	28.4	29.9
36	Shelton, WA	10.4	29.8
37	Vinalhaven, ME	13.4	28.3
38	Crescent City, CA	12.8	28.3
39	Point Pleasant, NJ	19.1	28.2
40	Provincetown-Chatham, MA	16.8	27.6
41	Coos Bay-Charleston, OR	32.4	26.9
42	Lafitte-Barataria, LA	19.7	26.6
43	Port Hueneme-Oxnard-Ventura, CA	69.3	26.4
44	Juneau, AK	18.2	26.1
45	Golden Meadow-Leeville, LA	17.1	25.9
46	Fairhaven, MA	7.5	25.2
47	Gulfport-Biloxi, MS	13.8	25.2

Rank	Port	Millions of Pounds	Millions of Dollars
48	Eureka, CA	13.0	24.7
49	Pascagoula-Moss Point, MS	249.9	24.1
50	Ilwaco-Chinook, WA	29.4	22.4
51	Atlantic City, NJ	27.5	21.7
52	Tampa Bay-St. Petersburg, FL	9.1	21.6
53	Palacios, TX	8.9	21.2
54	Montauk, NY	14.8	21.2
55	Wanchese-Stumpy Point, NC	16.7	21.0
56	Cameron, LA	228.2	20.6
57	Bellingham, WA	10.8	20.0
58	Seattle, WA	5.3	19.0
59	Boston, MA	13.9	18.7
60	Delacroix-Yscloskey, LA	12.8	17.4
61	Princeton-Half Moon Bay, CA	20.0	15.4
62	Mayport, FL	7.2	15.4
63	Rockland, ME	35.2	14.8
64	San Francisco Area, CA	8.1	14.7
65	Yakutat, AK	5.0	14.6
66	Fort Bragg, CA	8.1	14.5
67	Friendship, ME	5.8	14.2
68	Yukon Delta (Other), AK	9.7	14.2
69	Jonesport, ME	18.4	12.8
70	North Kingstown, RI	23.0	12.7
71	Fort Myers, FL	6.5	12.3
72	Accomac, VA	9.7	12.2
73	Newington, NH	4.7	11.9
74	Bodega Bay, CA	3.6	11.8
75	Brookings, OR	8.7	11.8
76	Beals Island, ME	5.0	11.5
77	Beaufort-Morehead City, NC	6.5	11.5
78	Apalachicola, FL	5.0	11.2
79	Upper Southeast (Other), AK	8.7	11.1
80	Santa Barbara, CA	6.7	10.4
81	Newport, RI	7.3	10.2
82	Anchorage, AK	9.3	10.2
83	Panama City, FL	3.8	10.1
84	Port Clyde, ME	6.2	9.6
85	Spruce Head, ME	4.0	9.6
86	New London, CT	5.0	9.5
87	Moss Landing, CA	29.4	9.3
88	Chincoteague, VA	4.8	9.1
89	Neah Bay, WA	5.6	9.0
90	Slidell-Covington, LA	7.4	8.3
91	Engelhard-Swanquarter, NC	6.9	8.0
92	Hampton Bay-Shinnicock, NY	7.9	7.7
93	Cape Canaveral, FL	4.3	7.7
94	Darien-Bellville, GA	4.8	6.8
95	Morro Bay, CA	5.2	6.2
96	Craig, AK	3.6	6.1
97	Morgan City-Berwick, LA	6.8	6.0
98	Ocean City, MD	6.0	5.8
99	Bon Secour-Gulf Shores, AL	3.9	5.5

Rank	Port	Millions of Pounds	Millions of Dollars
100	Belhaven-Washington, NC	3.3	3.1
101	Monterey, CA	6.9	3.1
102	Port St. Joe, FL	4.8	2.7
103	Haines, AK	0.4	0.4
104	Interior (Other), AK	0.6	0.2