THE FREIGHT ANALYSIS FRAMEWORK VERSION 3 (FAF3)

A Description of the FAF3 Regional Database And How It Is Constructed

PREPARED FOR THE:
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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 selected flows to the transportation network, and projects such freight flow patterns into the future. FAF3 is the third database of its kind, FAF1 provided estimates for truck, rail, and water tonnage for calendar year 1998, and FAF2 provided a more complete picture based on the Commodity Flow Survey for calendar year 2002. Since the first FAF effort a number of changes in both data products and in the sources of the data used to produce them have taken place. This present document can be found at the following website:

http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm

1.2 FAF3 DATA PRODUCTS

The FAF3 data products include both a regional database and network database with highway flow assignment. This document provides a detailed explanation of how the regional FAF3 data products were constructed from diverse data sources, using a variety of data modeling tools. Detailed documentation explaining the development and methodologies used to create both the FAF3 forecasts and network database are covered in companion technical reports. The regional FAF3 database includes a matrix of freight volumes, or freight 'flows', reported in both annual tons and dollar values for shipments to, from, and within regions for 2007, with provisional estimates for the current year, and forecasts to 2040 for The principal dimensions of this flow matrix are:

- shipment origination region (O)
- shipment destination region (D)
- the class of commodity being transported (C), and
- the mode of transportation used (M)

In total, this flow matrix contains 131 (O) x 131 (D) x 43 (C) x 7 (M) data cells. Chapter 2 of this document is devoted to describing how the tonnage and dollar values in these cells are estimated. This 2007 freight flow matrix is used as the starting point for a set of future year freight forecasts, projecting shipment volumes and values out to year 2040. It is also used as the basis for making short term, annual provisional updates to the flow table, starting with flows for calendar year 2009, as a means of filling the gap in such flow data prior to the next (scheduled

for 2012) U.S. freight shipper-based Commodity Flow Survey (CFS). As described in Chapter 2 below, FAF3 makes extensive use of the 2007 CFS, while supplementing it in a variety of ways in order to complete the full US freight movement picture. Chapter 3 describes both the long term and short range freight flow forecasts. Finally, Chapter 4 describes another widely used FAF data product: a set of U.S. highway network link- and route-assigned truck flow estimates, and their mapping onto the U.S. highway network. This includes both a year 2007 and a year 2040 assignment of truck traffic volumes to the nation's highway system.

All of the above data products can be downloaded at the previously listed FAF3 website, which also guides users to the FAF3 on-line Data Extraction Tool where they can find links to FAF3 Data Summaries and Data Mapping tools, and create and download their own tables directly from the FAF3 2007 Regional Database. Users can also download the entire FAF3 2007 and 2040 flows database in either Microsoft Access 2003 or CSV format by going directly to:

http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm

Figure 1.1 shows the functional linkage between these various FAF3 data products, starting with the creation of the calendar year 2007 FAF3 national freight flows:

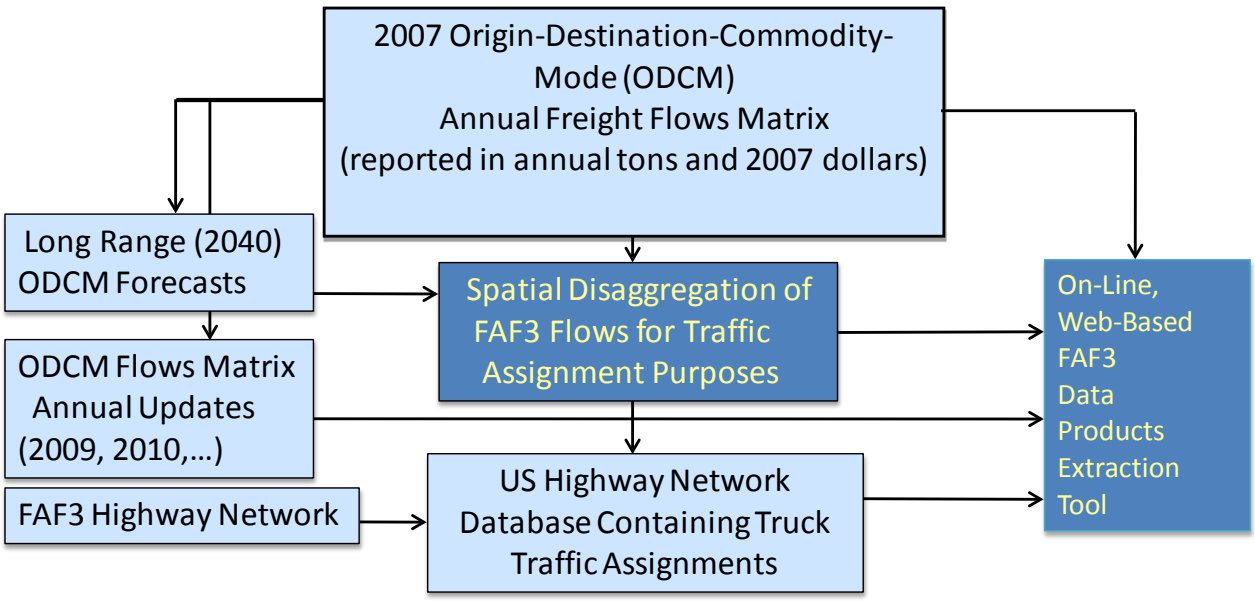

Figure 1.1 Principal FAF3 Data Products

2. FAF3 GEOGRAPHY, COMMODITY AND MODAL CLASSES

2.1 GEOGRAPHY

The 2007 CFS commodity flow tables are based on a revised geography that contains 11 additional traffic analysis regions, for a total of 123 domestic regions in all. FAF^3 uses the same geography. Figure 2.1 shows the boundaries of the 123 domestic FAF^3 flow analysis regions, also referred to as FAF^3 analysis zones.

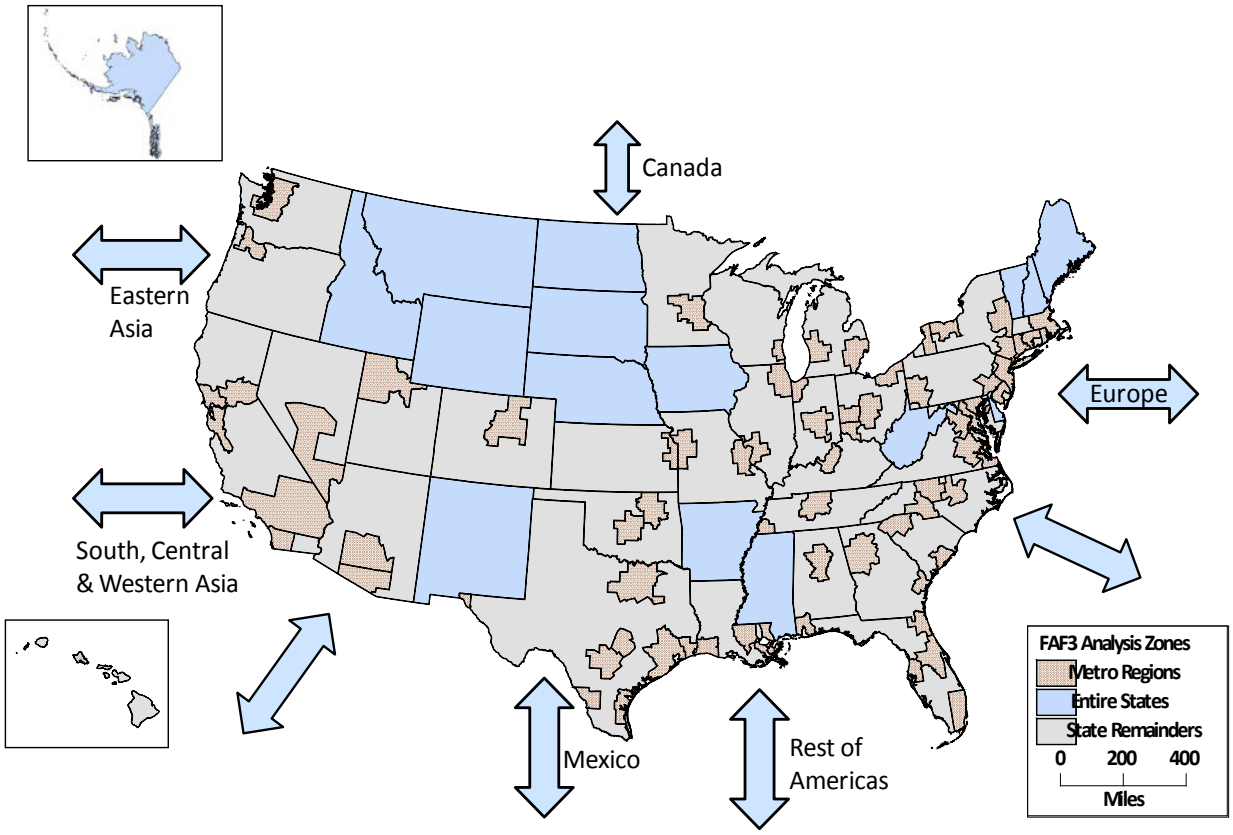

Figure 2.1 FAF3 Geography

Three subsets of regions are highlighted: 74 state specific pieces of metropolitan area regions, 33 regions made up of state remainders, which represent a state's territory outside these metropolitan regions, and 16 regions identified as entire states, within which no FAF^3 metropolitan regions exist.

Note that metropolitan regions do not cross State boundaries: so that the Chicago, Kansas City, Philadelphia, and St. Louis metros are split into two state-specific FAF3 regions, while the New York and Washington metropolitan areas are split into three distinct zones. To avoid crossing State boundaries the metropolitan areas of Atlanta (GA), Boston (MA), Charlotte (NC),

Louisville (KY), Memphis (TN), Minneapolis-St. Paul (MN), Portland (OR), Providence (RI), Sacramento (CA), and Virginia Beach (VA) are each defined by the state in which most of the metro areas' population resides and economic activity takes place. Also shown in Figure 2.1 are the 8 world regions that act as the origination and destination points for U.S. exported and imported freight (FAF3 regions 124 -131). In addition to flows between the U.S. and Canada and the U.S. and Mexico, flows between the U.S. and the remaining six foreign FAF3 regions are based on an allocation of countries to their respective United Nations geographic region.[1]

Table 2.1 FAF3 Commodity Classes

SCTG	Commodity	SCTG	Commodity	SCTG	Commodity
01	Live animals/fish	**15**	Coal	**29**	Printed products
02	Cereal grains	**16**	Crude petroleum	**30**	Textiles/leather
03	Other agricultural products.	**17**	Gasoline	**31**	Nonmetal mineral products
04	Animal feed	**18**	Fuel oils	**32**	Base metals
05	Meat/seafood	**19**	Natural gas and petroleum prods.	**33**	Articles-base metal
06	Milled grain prods.	**20**	Basic chemicals	**34**	Machinery
07	Other foodstuffs	**21**	Pharmaceuticals	**35**	Electronics
08	Alcoholic beverages	**22**	Fertilizers	**36**	Motorized vehicles
09	Tobacco prods.	**23**	Chemical prods.	**37**	Transport equipment
10	Building stone	**24**	Plastics/rubber	**38**	Precision instruments
11	Natural sands	**25**	Logs	**39**	Furniture
12	Gravel		Wood products	**40**	Misc. mfg. products.
13	Nonmetallic minerals	**27**	Newsprint/paper	**41**	Waste/scrap
14	Metallic ores		Paper articles	**43**	Mixed freight
				99	Commodity unknown

2.2 COMMODITY CLASSES

FAF3 reports annual tonnage and dollar valued freight flows (see Table 2.1) using the same 43

[1] See http://unstats.un.org/unsd/methods/m49/m49regin.htm for these country-to-region allocations

2-digit Standard Classification of Transported Goods (SCTG) classes used by the 2007 U.S. Commodity Flow Survey (CFS).

2.3 TRANSPORTATION MODES

FAF3 flows are also broken down by 7[2] modes of transportation. Table 2.2 lists these modes. The "multiple modes and mail" category includes truck-rail, truck-water, and rail-water intermodal shipments involving one or more end-to-end transfers of cargo between two different modes.

Table 2.2 FAF3 Mode Classes

Mode Identification	Mode Name	Mode Description
1	Truck	Includes private and for-hire truck. Private trucks are owned or operated by shippers, and exclude personal use vehicles hauling over-the-counter purchases from retail establishments.
2	Rail	Any common carrier or private railroad.
3	Water	Includes shallow draft, deep draft and Great Lakes shipments.
4	Air (includes truck-air)	Includes shipments typically weighing more than 100 pounds that move by air or a combination of truck and air in commercial or private aircraft. Includes air freight and air express. Shipments typically weighing 100 pounds or less are classified with *Multiple Modes and Mail.*
5	Multiple Modes and Mail	Includes shipments by multiple modes and by parcel delivery services, U.S. Postal Service, or couriers. This category is not limited to containerized or trailer-on-flatcar shipments.
6	Pipeline	Includes flows from offshore wells to land, which are counted as water moves by the U.S. Army Corps of Engineers.
7	Other and Unknown	Includes flyaway aircraft, vessels, and vehicles moving under their own power from the manufacturer to a customer and not carrying any freight, unknown, and miscellaneous other modes of transport.
	No Domestic Mode	A 'No Domestic Mode' category is used to capture petroleum imports that go directly from foreign, inbound ships to an on-shore US refinery. This is done to ensure a proper accounting when foreign and domestic flows are summed, while avoiding assigning flows to the domestic transportation network that do not use it.

Detailed SCTG code definitions can be downloaded at either of the following Census and Bureau of Transportation Statistics websites:

[2] An eight mode designation "No Domestic Mode" is used in some cases, see Table 3.1

http://www.census.gov/svsd/www/cfsdat/2002data/cfs021200.pdf
http://www.bts.gov/publications/commodity_flow_survey/survey_materials/pdf/sctg_booklet.pdf

Appendix A lists the differences between FAF2 (2002) and FAF3 (2007) modal definitions, based on the changes in these definitions implemented for the 2002 and 2007 U.S. Commodity Flow Surveys.

3.1 OVERVIEW OF THE FLOW MATRIX CONSTRUCTION PROCESS

Figure 3.1 shows the principal types of data used to construct the FAF3 four-dimensional ODCM freight flow matrix.

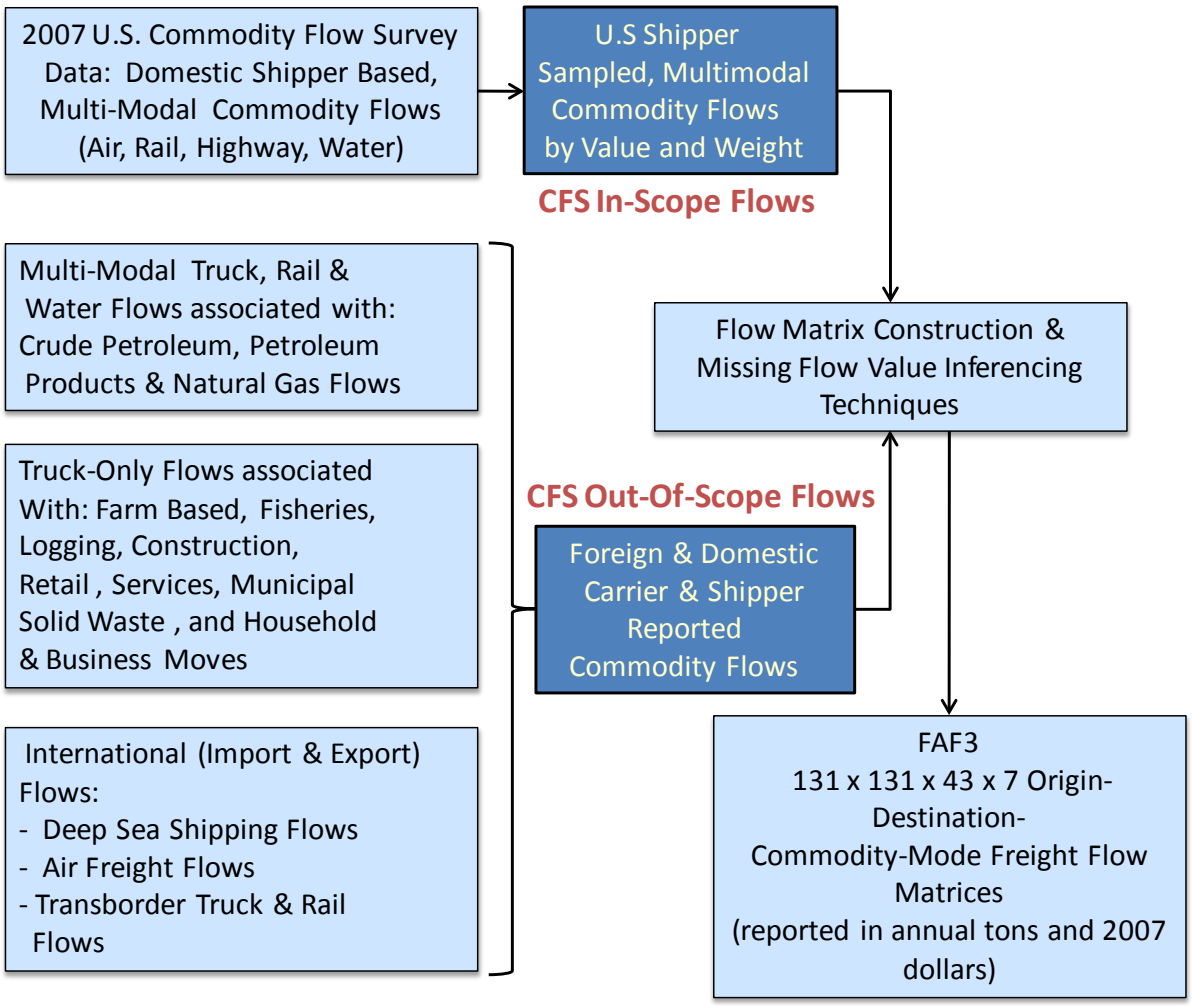

Figure 3.1 Overview of the FAF3 Freight Flow Matrix Construction Process

This matrix construction process begins with the data reported by the 2007 U.S. Commodity Flow Survey, or CFS[3], adopting both the CFS definitions for the 123 internal to the U.S. freight analysis zones and the same 43 SCTG 2-digit commodity classes, but using a modification of CFS modal definitions.

Each of these three data dimensions is elaborated on below. The CFS represents the best basis for FAF construction because it provides shipper sampled and subsequently expanded estimates of both tons shipped and dollar value trades within and between all US regions for all modes of freight transportation. However, the CFS has a number of well researched weaknesses that require considerable additional effort in order to construct a complete accounting of freight movements within the United States (see the papers in Meyburg and Rwanda, 2006). First, the CFS does not report imports, while CFS reporting of export flows is also subject to data quality issues resulting from limited sample size. Second, the CFS also either does not collect data from the following freight generating and receiving industries, or collects insufficient data to cover the industries in a comprehensive manner:

- Multimodal truck, rail and pipeline flows of crude petroleum, petroleum products and natural gas
- Truck freight shipments associated with farm based, fishery, logging, construction, retail, services, municipal solid waste, and household and business moves.
- Imported and exported goods transported by ship, air, and trans-border land (truck, rail) modes.

In FAF3 these industries produce what are referred to in Figure 3.1 as Out-Of-Scope to the CFS freight flows, or "OOS" flows for short. Their estimation required a great deal of data collection and integration into the larger flow matrix generation process. The data sources for these OOS flows are for the most part derived from freight carrier reported data sources, in some cases requiring the use of secondary or indirect data sources, such as location specific measures of industrial activity, employment or population, to allocate flows to specific geographic regions. These OOS flows represent some 32 percent of all U.S. freight movements, measured on an annual tonnage basis. Developing OOS flow estimates represents a good deal of effort, with different commodity classes requiring very different, typically multi-step treatments: including the use of both spatial and commodity class "crosswalks" that convert mode and industry class specific estimates from their native coding categories into FAF3 regional and commodity class breakdowns.

[3] See http://www.bts.gov/publications/commodity_flow_survey/index.html for details on the data content and method of data collection and data sampling used in the 2007 US Commodity Flow Survey.

3.2 FILLING GAPS IN THE CFS FLOW MATRIX

3.2.1 Nature of the Data Gaps

Table 3.1 shows the share of FAF3 tonnages and dollar valued freight that is derived from the 2007 Commodity Flow Survey. In total, the CFS accounts for 67.5% of the tons and 70.7% of the dollar valued freight reported by FAF3 for calendar year 2007.

Table 3.1: Commodity Flow Survey Share of FAF3.1 Tonnage and Value by Mode: 2007

Mode of Transportation	2007 Tons (thousands) CFS	FAF3.1	CFS Share of FAF3.1
Total, All modes	**12,543,425**	**18,580,982**	**68%**
Truck	8,778,713	13,343,701	66%
Rail	1,861,307	2,004,787	93%
Water	403,639	496,698	81%
Air (included truck and air)	3,611	12,769	28%
Pipeline	650,859	1,441,400	45%
Multiple modes	573,729	670,883	86%
Other and unknown modes	271,567	610,744	44%

Mode of Transportation	2007 Value (million $) CFS	FAF3.1	CFS Share of FAF3.1
Total, All modes	**11,684,872**	**16,536,446**	**71%**
Truck	8,335,789	11,566,154	72%
Rail	436,420	570,471	77%
Water	114,905	151,327	76%
Air (included truck and air)	252,276	1,079,037	23%
Pipeline	399,646	698,707	57%
Multiple modes	1,866,723	1,966,722	95%
Other and unknown modes	279,113	504,028	55%

As can be seen from the last column in the table, this percentage varies a great deal by mode of transportation.

Table 3.2 provides a comparison of the annual tonnages and dollar value of freight shipped in 2007, as reported by FAF3 and by the 2007 US Commodity Flow Survey.

Table 3.2: Commodity Flow Survey Share of FAF3.1 Tonnage and Value by Commodity Class

SCTG2	Commodity Class	FAF3 Tons (Thousands)	%	FAF3 2007 $ (Millions)	%	2007 CFS Tons (Thousands)	2007 CFS $ (Milllions)	CFS % of FAF3 Tons	CFS % of FAF3 $
1	Live animals and live fish	106,847	0.6	144,974	0.9	6,150	10,833	5.8	7.5
2	Cereal grains	1,475,294	7.9	196,222	1.2	514,151	84,851	34.9	43.2
3	Other agricultural products	436,395	2.3	268,135	1.6	211,890	143,637	48.6	53.6
4	Animal feed and products of animal origin, nec	270,355	1.5	96,458	0.6	246,436	90,472	91.2	93.8
5	Meat, fish, seafood, and their preparations	116,210	0.6	327,147	2.0	98,413	277,251	84.7	84.7
6	Milled grain products/preparations and bakery products	136,982	0.7	159,796	1.0	120,023	143,139	87.6	89.6
7	Other prepared foodstuffs and fats and oils	539,503	2.9	553,824	3.3	468,435	479,757	86.8	86.6
8	Alcoholic beverages	140,940	0.8	191,725	1.2	114,012	158,322	80.9	82.6
9	Tobacco products	4,624	0.0	94,712	0.6	3,289	70,551	71.1	74.5
10	Calcareous monumental or building stone	57,474	0.3	9,789	0.1	28,738	5,202	50.0	53.1
11	Natural sands	570,002	3.1	8,019	0.0	460,085	6,665	80.7	83.1
12	Gravel and crushed stone	2,263,164	12.2	23,525	0.1	2,039,457	21,167	90.1	90.0
13	Nonmetallic minerals nec	375,194	2.0	20,750	0.1	272,264	16,727	72.6	80.6
14	Metallic ores and concentrates	120,460	0.6	31,831	0.2	76,672	32,910	63.6	103.4
15	Nonagglomerated bituminous coal	1,444,441	7.8	40,208	0.2	1,416,187	38,228	98.0	95.1
16	Crude petroleum	558,340	3.0	252,339	1.5	0	0	0.0	0.0
17	Gasoline and aviation turbine fuel	1,005,354	5.4	690,982	4.2	959,161	663,194	95.4	96.0
18	Fuel oils	744,373	4.0	418,607	2.5	641,894	373,515	86.2	89.2
19	Coal and petroleum products, nec	1,276,698	6.9	506,607	3.1	578,188	268,163	45.3	52.9
20	Basic chemicals	463,260	2.5	340,719	2.1	412,581	271,469	89.1	79.7
21	Pharmaceutical products	20,948	0.1	879,544	5.3	19,076	771,252	91.1	87.7
22	Fertilizers	230,054	1.2	59,693	0.4	149,600	43,613	65.0	73.1
23	Chemical products and preparations, nec	148,208	0.8	403,828	2.4	123,537	331,750	83.4	82.2
24	Plastics and rubber	224,488	1.2	578,860	3.5	186,392	489,435	83.0	84.6
25	Logs and other wood in the rough	517,381	2.8	22,180	0.1	107,869	7,086	20.8	31.9
26	Wood products	416,602	2.2	231,734	1.4	323,773	183,868	77.7	79.3
27	Pulp, newsprint, paper, and paperboard	162,723	0.9	134,658	0.8	145,380	126,857	89.3	94.2
28	Paper or paperboard articles	105,188	0.6	143,075	0.9	82,233	118,070	78.2	82.5
29	Printed products	55,546	0.3	205,381	1.2	51,435	190,389	92.6	92.7
30	Textiles, leather, and articles of textiles or leather	70,250	0.4	696,450	4.2	46,728	473,610	66.5	68.0
31	Nonmetallic mineral products	1,392,495	7.5	247,759	1.5	1,156,790	196,993	83.1	79.5
32	Base metal forms & finished basic shapes	422,375	2.3	557,285	3.4	364,940	488,410	86.4	87.6
33	Articles of base metal	205,359	1.1	573,237	3.5	131,924	388,292	64.2	67.7
34	Machinery	186,013	1.0	1,761,782	10.7	66,728	628,267	35.9	35.7
35	Electronic & other electrical equip & comps & office e	78,159	0.4	1,431,968	8.7	47,528	1,046,495	60.8	73.1
36	Motorized and other vehicles (including parts)	190,729	1.0	1,268,592	7.7	133,126	907,288	69.8	71.5
37	Transportation equipment, nec	8,353	0.0	225,407	1.4	6,815	173,883	81.6	77.1
38	Precision instruments and apparatus	7,459	0.0	389,371	2.4	5,668	304,620	76.0	78.2
39	Furniture, mattresses & mattress supports, lamps, lightir	50,073	0.3	233,593	1.4	26,633	152,286	53.2	65.2
40	Miscellaneous manufactured products	111,837	0.6	688,642	4.2	91,844	490,305	82.1	71.2
41	Waste and scrap	1,322,591	7.1	130,905	0.8	305,878	82,243	23.1	62.8
43	Mixed freight	342,996	1.8	1,058,353	6.4	300,922	932,353	87.7	88.1
99	Commodity Unknown *(S= data suppressed in 2007 CI	205,014	1.1	237,675	1.4		1,453		0.6
	Total of All Commodities	**18,580,751**	**100.0**	**16,536,341**	**100.0**	**12,543,425**	**11,684,872**	**67.5**	**70.7**

Again, as can be seen from the last two columns in the table, this percentage varies a great deal by commodity class.[4]

A combination of data suppression for confidentiality reasons, limited sample size, large standard errors, and limitations to the scope of the CFS (across industrial sectors) mean that many cells where flows may exist are left empty. The question we must answer is not only what size each of these flows should be, but also, which cells ought to contain a positive flow at all. It should also be noted that even when we sum the data across a particular row or column in the CFS O-D-C-M matrix we sometimes find that we are missing data for these two as well as three dimensional margins: and not just data on the four-dimensional flows we are seeking. Study of the complete set of 2002 CFS data products indicates that we have a good many data matrices to work with. This includes the most detailed of the published matrices (TABLE CFS0725), which reports annual tons, dollar value and ton-miles shipped by state of origin, state of destination, mode and 2-digit commodity classes.[5] Other tables provide 1, 2 and 3 dimensional looks at this same data, including flows broken down to the 123 CFS/FAF intra-US geographic regions of interest. The major data gaps in current CFS coverage can be summarized as follows:

1. commodity specific annual shipment generation and attraction totals (i.e. Os and Ds) exist but there are no origin-to-destination (O-D) flow estimates, either by mode or summed over all modes
2. total annual O-to-D commodity flow estimates exist but without any modal breakdown.
3. modal share estimates exist but lack the geographic and/or commodity detail required of the FAF flows matrix.
4. data on shipment lengths exists, by mode and/or commodity, but with little or no linkage to O-to-D geography.

Where data suppression occurs in the CFS a cell value has been replaced by the letter 'S'. In some cases 'S' reported cells may represent quite large freight flows in the real world, because a large coefficient of variation does not necessarily mean that we have only small O-D flows to deal with. For FAF reporting purposes an estimate is desired for these suppressed cell values, and also for any zero valued cells where limited CFS sampling has failed to produce a positive flow estimate, but where freight is likely being shipped.[6] The question the FAF has to answer is

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[4] In the case of metallic ores and concentrates (SCTG 14) the CFS value (but not its tonnage) exceeds that of FAF3 (103.4%). This result is associated with an increase of more than 134% in the dollar value of commodities in this class when comparing the 2002 to the 2007 CFS tables, despite a 22% decline in total tonnage: a result that appears to be an over-valuation of exports shipments, a valuation that was not borne out by the export data used in FAF3. http://www.bts.gov/publications/commodity_flow_survey/final_tables_december_2009/index.html

[5] http://www.census.gov/svsd/www/02CFSdata.html

[6] Reporting of individual CFS cell values may be suppressed to avoid disclosing information about an individual company's activity. For the CFS, the primary method of disclosure avoidance is Noise Infusion: Noise infusion is a

not only what size each of these flows should be, but also, which of the many zero valued cells ought to contain a positive flow at all.

In many instances data is missing or suppressed at the 2- or 3-, as well as 4-dimensional level of flow resolution. That is, we have a flow matrix that contains a variety of levels of coverage, with many gaps needing to be filled.

3.2.2 The Matrix Generation Methodology

An ideal method for filling missing cells in the FAF flow matrix is considered to display the following characteristics:

1. the ability to make the most use of existing data within the matrix in the estimation of missing cell values,
2. the ability to fill in missing cell values while maintaining reported marginal flow totals and observed cell values across all dimensions of the matrix,
3. the ability to handle missing values at multiple levels of data aggregation, and
4. the ability to bring different, including non-CFS sources of flow estimates into the solution, including completely new one, two, and three-dimensional data tables.

A combination of log-linear modeling (LLM) and iterative proportional fitting (IPF) was applied to these featuresThe procedure is shown in Figure 3.2. First, missing 2007 CFS cell values are estimated using a six-dimensional log-linear model (LLM) of the form:

$$\begin{aligned}\mathrm{Ln}(F^{ODCMUS}) = {} & \lambda_0 + \lambda^{O} + \lambda^{D} + \lambda^{M} + \lambda^{C} + \lambda^{U} + \lambda^{S} + \lambda_j^{OD} + \lambda^{OC} + \lambda^{OM} + \lambda^{OU} + \lambda^{DC} + \\ & \lambda^{DM} + \lambda^{DU} + \lambda^{CM} + \lambda^{CU} + \lambda^{MU} + \lambda^{OS} + \lambda^{DS} + \lambda^{CS} + \lambda^{MS} + \lambda^{US} + \lambda^{ODC} + \lambda^{ODM} + \lambda^{ODU} + \\ & \lambda^{OCM} + \lambda^{OCU} + \lambda^{OMU} + \lambda^{DCM} + \lambda^{DCU} + \lambda^{DMU} + \lambda^{CMU} + \lambda^{ODS} + \lambda^{OCS} + \lambda^{OMS} + \lambda^{OUS} + \lambda^{DCS} + \\ & \lambda^{DMS} + \lambda^{DUS} + \lambda^{CMS} + \lambda^{CUS} + \lambda^{MUS} + \lambda^{ODCM} + \lambda^{ODCU} + \lambda^{ODCS} + \lambda^{ODMU} + \lambda^{ODMS} + \lambda^{ODUS} + \\ & \lambda^{OCMU} + \lambda^{OCMS} + \lambda^{OCUS} + \lambda^{OMUS} + \lambda^{DCMU} + \lambda^{DCMS} + \lambda^{DCUS} + \lambda^{DMUS} + \lambda^{CMUS} + \lambda^{ODCMU} + \\ & \lambda^{ODCMS} + \lambda^{ODMUS} + \lambda^{ODCUS} + \lambda^{OCMUS} + \lambda^{DCMUS} + \lambda^{ODCMUS} \qquad (1)\end{aligned}$$

The approach can also be used to update the FAF3 flow matrix on an annual or longer range basis, given reported or forecast changes in marginal flow totals.

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method of disclosure avoidance in which values for each shipment are perturbed prior to tabulation by applying a random noise multiplier. Disclosure protection is accomplished in a manner that causes the vast majority of cell values to be perturbed by at most a few percentage points. In certain circumstances, some individual cells may be suppressed on a case by case basis for additional disclosure avoidance purposes. Such cell values have their flow values replaced by the letter 'D' in published CFS tables.
http://www.bts.gov/publications/commodity_flow_survey/def_terms/index.html#samplingerror

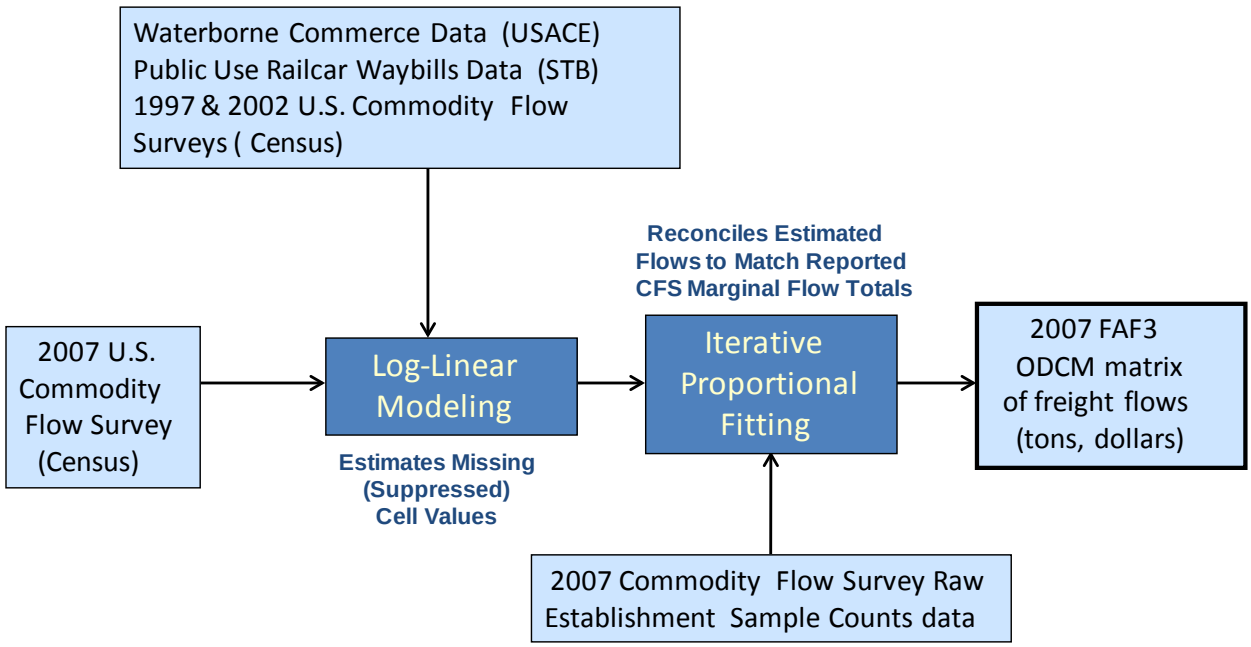

Figure 3.2 Estimation of Missing Cell Values in the 2007 US Commodity Flow Survey

where $Ln(F^{ODCMUS})$ is the model estimated natural log of the annual volume of commodity 'C' moved by mode 'M' between FAF^3 origin zone 'O' and FAF^3 destination zone 'D' in 2007, measured in units 'U' and found in data source 'S' . The first four of these dimensions are the ODCM flow elements that need to be produced, and reported to the public. To this process are added two additional data dimensions:

1. A 'freight metrics' dimension, U, defined by the three classes of metric reported by the CFS, i.e. tonnage, dollar value of freight moved, and ton-miles; and
   An 'alternative data source' dimension, S, that captures four different classes (= Sources) of freight flow estimates.

This latter innovation introduces a major enhancement to the flow modeling process in FAF3. Specifically, and in addition to the 2007 CFS flow data, additional data was introduced into the log-linear modeling process using the following four data sources:

1. Calendar year 2007 annual rail flow volumes (tonnages) reported in the Surface Transportation Board's (STB) public use railcar waybills[7], and
2. Calendar year 2007 annual flow volumes (tonnages) reported in the US Army Corps of Engineers Waterborne commerce dataset.[8]

[7] Accessible via http://www.stb.dot.gov/stb/industry/econ_waybill.html
[8] Accessible via http://www.iwr.usace.army.mil/ndc/data/data1.htm

3. Flow data from the calendar year 2002 and year 1997 U.S. Commodity Flow Surveys.

The λ's in equation (1) represent the model parameters to be estimated, often termed the (natural log of the) *effects* of the different dimensions, or combinations of dimensions, on the resulting flow estimates. For example, λ^{OM} represents the effect of shipment origin O and mode M, λ^{ODCM} represents a four-way, O, D, C, M interaction effect, and λ_0 represents the grand mean of all these effects. Parameters representing all possible levels and combinations of the matrix dimensions O, D, C, M, U, and S are used to fit the data to what is usually termed a *saturated* model that tries to get the most out of the statistical relationships represented by the data sources. The equation takes an additive, natural log form for solution (i.e. for computational) purposes, but represents a multiplicative solution to the problem of cell estimation. Appendix B provides a detailed description and numerical example of how the FAF3 log-linear modeling of missing cell values works.

The resulting, fully saturated matrix therefore reports a total of 123(O) x 123 (D) x 43 (C) x 7(M) x 3(U) x 4 (S) = 54,645,948 data cells that need to be accounted for, i.e. that need to be estimated, or suppressed as having a zero value. In practice, most of the λ's are set to a value of 0.0. For example, since both the 2007 railcar waybill and waterborne commerce flows are only reported in tons, all dollar valued λ's associated with these two data sources = 0.0 and play no further part in the estimation process. There are also many other instances where a particular ODCM combination is impossible in the real world. Such data cells (for example, truck commodity flows between Hawaii and mainland US regions) are termed "structural zeros". Many other zero valued cells exist, however, and result from the CFS sampling process. These cells include "sampling zeros" where no data was obtained by the 2007 CFS, but flows may exist in the real world. This includes cells where the sampling missed such flows, as well as cells where the flow volume sampled were so small that they fell below the CFS reporting threshold of 500 tons, or half a million dollars annually, and were therefore rounded down to '0' in the CFS published tables. Many additional CFS cells are also suppressed because their estimates resulted in a coefficient of variation (CV) of over 50%. The value of many of these cells may be quite large.

To improve further our ability to both identify and estimate these missing cell values a number of data modeling steps were taken:

To assist with filling in of missing CFS cell values, an additional dataset was provided by the U.S. Bureau of the Census. This is a matrix containing the number of establishments sampled within each ODCM cell in the matrix, i.e. a set of raw sample responses. If one or more positive responses are identified for a specific cell, then this is taken to imply the presence of some freight movement activity, and it is therefore treated as a sampling zero (rather than a structural zero) for the purpose of cell value estimation.

Even with this information the limited sample size used by the 2007 CFS can miss establishments, and hence flows, that should be reported in some flow cells. This led to a further search for possible reporting of flows within a specific ODCM cell among the other three databases listed above. Specifically, the 2007 Surface Transportation Board's (STB) public use railcar waybill data,[9] the U.S. Army Corp of Engineers' (USACE) 2007 waterborne commerce O-D-C data[10] and the 2002 CFS are brought into the cell value estimation process. This required a conversion of each dataset's flow values to FAF3's 43 SCTG commodity classes, as well as an assignment (apportionment) of rail flows reported at the BEA regional level and waterway flows reported at the state level, to their most likely FAF3 regions. If a specific O-D-C-M cell had a flow estimate reported in any of these databases this fact is picked up by the log-linear modeling estimation procedure.

The best way to combine these different datasets is not obvious, however. One option is to include the use of a simple additive weighting scheme, such as [(1-w)*CFS 2007 + w*Non-CFS 2007], or use more selective weighting schemes applied only to cells with questionable CFS values. In FAF3 non-CFS source data was used in this second manner, pending a more defensible form of general weighting process. In this approach, those 2007 CFS cells with zero values, but for which the one or more of the other three datasets reported a positive value, are assigned a small positive effects value to initiate the multiplications required by the log-linear model. The resulting, maximum likelihood value for that cell then becomes subject subsequently to the appropriate CFS marginal control totals when passed through the IPF routine.

3.2.3 Iterative Proportional Fitting (IPF) to CFS Marginal Totals

Once all of the log-linear model's λ *effects* have been computed, they are used to generate a positive value of each zero valued flow cell in the original 2007 CFS commodity flow matrix. In each case, where a zero valued cell is found it is replaced with an estimate based on the above multiplicative log-linear model. Two additional steps are then taken:

1. Cells considered to be structural zeros are returned to a value of 0.0.

2. A further modification involves the removal of unreasonable dollar per ton estimates caused by biased or limited sampling, in which either the tonnage or the dollar value allocated to a particular cell by the log-linear/IPF modeling process creates a dollar-per-ton ratio that exceeds expected values for the commodity class in question by a significant amount. To prevent this from occurring, a check is made every ten iterations

[9] Downloadable at http://www.stb.dot.gov/stb/industry/econ_waybill.html
[10] http://www.iwr.usace.army.mil/ndc/data/data1.htm

of the IPF to look for such outliers. If one or more are found, an adjustment is made to either the tonnage or dollar value in such a cell and the iterative process re-commenced.

The resulting matrix is adjusted through IPF to comply with known control totals from numerous CFS marginal tables. In practice, all of the CFS 2007 flow matrices containing data on any combination of O, D, C, or M flow totals were used in this multi-dimensional IPF process, to develop the FAF3 commodity flow estimates that are consistent with 2007 CFS flow totals at a number of different levels of disaggregation. These CFS tables include both domestic moves and the domestic portion of export flows. Appendix B describes how these CFS export flow estimates were subtracted to create a domestic ODCM matrix of CFS flows, which is then combined with export flow estimates derived from other, more complete data sources (as described in see Section 3.4.below).

3.3 ESTIMATION OF NON-CFS DOMESTIC FLOWS

3.3.1 Overview

U.S. freight shipping establishments in the following industrial sectors were not surveyed as part of the 2007 US Commodity Flow Survey. These out-of-scope ("OOS") industries therefore had to be assigned commodity and mode specific O-D flows using other methods:

1. Farm Based
2. Fishery
3. Logging
4. Construction
5. Services
6. Retail
7. Household and Business Moves
8. Municipal Solid Waste
9. Crude Petroleum
10. Natural Gas Products

These OOS flows were estimated in FAF3 using the following four step process:

- Step 1—Estimate national shipments totals for each industry by FAF3 commodity classes
- Step 2—Regionalize these national shipments (by ton and value) down to the level of U.S. counties
- Step 3—Estimate O-D flows at the county level
- Step 4—Aggregate the O-D estimates from counties back up to FAF3 region-to-region flows.

However, the specific details applied at each step in the above process varied a good deal across industrial sectors. Where an industrial sector produces O-D flows in more than one commodity class, data from national inter-industry input-output "use" and "make" tables was used to determine how much freight a sector contributed to a specific set of SCTG 2-digit commodity flows. State and county level data on volume of production, industrial or commodity specific sector sales, or industrial sector employment is then used to allocated flows between origins and destinations, and spatial allocation formulas are used to produce O-D flow volumes. The form of spatial interaction model used also varied a good deal by commodity class. Either a distance decay coefficient is calibrated against an empirically derived average shipping distance, or a simple allocation is made based on market potentials (i.e. on the relative size of a county's or region's demand for a specific commodity). County-level spatial interaction modeling here allows for cross-county flows to be captured that also cross-FAF3 regional boundaries.

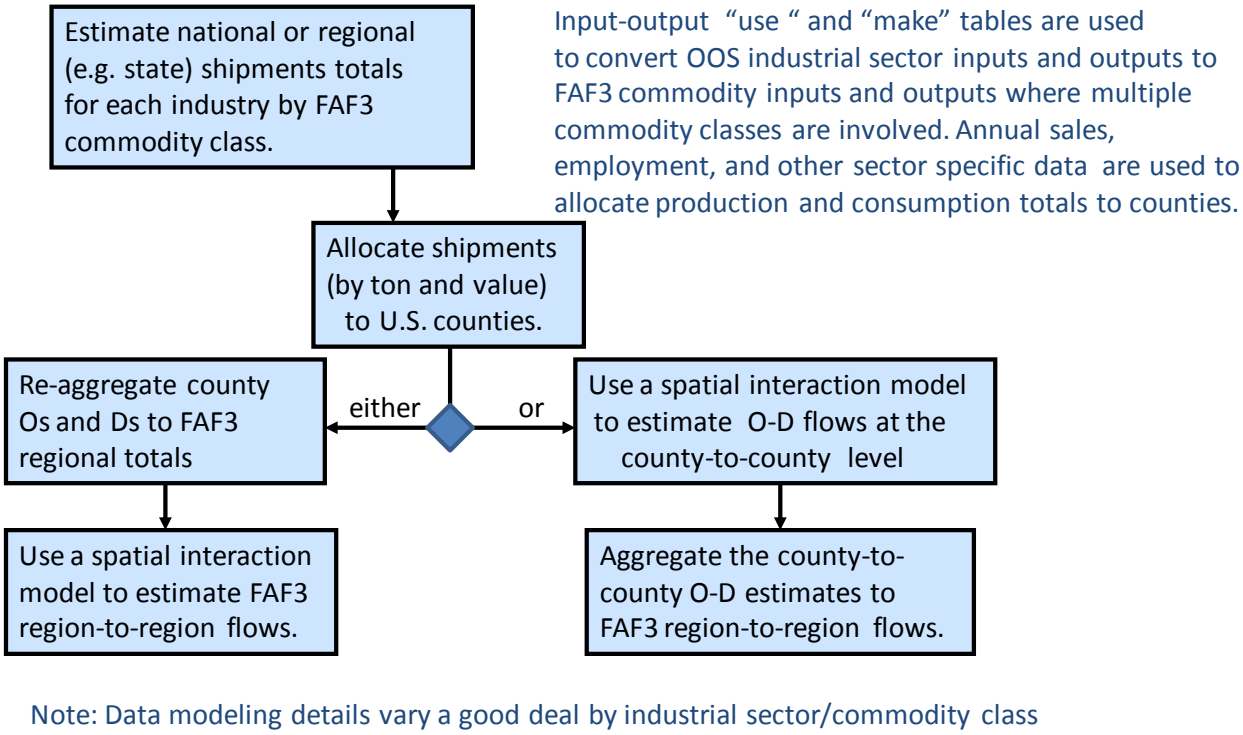

Figure 3.3 Four Step Process for Generating OOS Truck Freight Flows

Where truck movements were concerned this spatial interaction modeling occurred in one of two ways: 1) county origin and destination activity totals are determined, and a spatial interaction model is applied to these regional productions and attractions, with subsequent aggregation of inter-county flows back up to FAF3 region-to-region flow totals, or 2) county Os and Ds were

first of all estimated and aggregated to their FAF3 regional supply and demand totals. These regional totals are then used to estimate O-D flows directly at the FAF[3] region-to-region level. Use of regional O and D shipment totals prior to spatial interaction modeling occurred where data sources proved more reliable at this less detailed level or geography.

Figure 3.3 shows the general idea. In practice, each industrial sector has its own data gaps and idiosyncrasies that need to be dealt with.

3.3.2 Farm Based Flows

Data Sources

Farm-based agricultural shipments represent one of the most significant out-of-scope areas for CFS. These shipments are almost entirely moved by truck. The vast majority of these shipments represent farm-to-storage elevator (e.g., grains) or farm-to-distribution/processing center (e.g., fruit, livestock) trips, at which point further transportation of these products is captured as part of the CFS sample frame. At the fully national level, the total tonnage of farm-based shipments constitutes some 7% of the 2007 total tonnage moved within the nation, and over 9% of all truck tons shipped. County and state level data published in the U.S. Department of Agriculture's (USDA) *2007 Census of Agriculture* and the *2008 Agricultural Statistics* were used to generate FAF3 tons and dollars shipped estimates, supplemented with data from several of USDA's *Statistical Bulletins*.

The dollar values of these farm originating agricultural products were estimated using information obtained from the *2007 Census of Agriculture* and related publications. Specifically, data provided under the category of "Market value of agricultural products sold"[11] was used as an estimate for total farm-based agricultural shipments. However, the estimation of tonnages for these out-of-scope shipments was less straightforward. Commodity statistics published in the USDA's *2007 Census of Agriculture* use a variety of commodity specific units of measurement (e.g., pounds, bushels, hundredweight, barrels, tons, etc). Different conversion factors, all based on information obtained from *Agriculture Statistics 2008*, were needed for different types of commodity. For example, the approximate net weight for a bushel of wheat is 60 pounds, while a bushel of husked corn on the ear weights 70 pounds, and shelled corn weighs in at 56 pounds per

[11] 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 B, General Explanation and Census of Agriculture Report Form, in the *2007 Census of Agriculture* report for further explanation (http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_US/usappxb.pdf)

bushel, on the average. Following these unit conversions, each farm-based commodity is then placed within its 2-digit SCTG commodity class.

O-D Estimation Process

Where a State is divided into more than one FAF3 region, USDA county level production data was used and subsequently re-aggregated to FAF3 regional totals. This was done after filling gaps in this county-specific data, by using acreages devoted to a specific crop-growing activity as a surrogate for gaps in direct reporting of crop yields. O-D flows are then estimated, first by summing these county originations to their FAF3 regional totals, then sharing these totals to FAF3 destination regions on the basis of a) truck trip length distributions reported by the 2002 Vehicle Inventory and Use Survey (VIUS)[12], and b) using the volumes of agricultural commodity originations reported by the 2007 CFS to allocate these flows. That is, these CFS originations (from the distribution centers, grain elevators, processing centers, etc. located within a CFS region) constitute the first non-farm stop in the agricultural product's supply chain. Hence they represent a good surrogate for the destinations of farm-based shipments. Separate allocations are then made on the basis of tons shipped and dollar valued trades. As a result of this process, the annual tons and dollar valued flows between any two FAF3 regions are consistent with both VIUS truck trip length distributions for a specific FAF3 freight originating region and commodity class, and also create a consistency between OOS farm-based flows and the non-farm based agricultural commodity flows reported in the 2007 CFS.

3.3.3 Fishery Flows

Data Sources

The CFS omits fishery shipments that move from vessels at the dock/port to the first point of processing or distribution centers. Establishments involved in this data gap are within the NAICS category 114 (fishing, hunting and trapping). Industries in this NAICS sector harvest fish and other wild animals from their natural habitats and are dependent upon a continued supply of the natural resource. Based on statistics published in the *Fisheries of the United States 2008*[13], an annual report prepared by the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA), commercial landings by U.S. fishermen at ports in the 50 states were totaled at approximately 4.7 million tons and valued at over $4 billion

[12] http://www.census.gov/svsd/www/vius/products.html

[13] Information obtained from the *Fisheries of the United States 2008* report, published by National Marine fisheries Service, Office of Science and Technology in July 2009, was used to supplement its 2007 report under this analysis. Although 2007 statistics are available in the *Fisheries of the United States 2007*, many are in preliminary forms. The 2008 report provided updated information on statistics for 2007.

in 2007. In addition, catches of Alaska Pollock, Pacific whiting, and other Pacific ground fish that are processed at-sea aboard U.S. vessels in the northeastern Pacific (off Washington, Oregon, and Alaska) are credited as landing to the state nearest to the area of capture. According to NMFS, these at-sea processed fishery products accounted for a total about 1.4 million tons and valued approximately $19 million in 2007.

O-D Estimation Process

It is assumed that this freight activity is mostly local, and that all shipments involve intra-regional FAF[3] truck-only movements.[14]

3.3.4 Industry Flows Based on National Input-Output Tables

Estimation of commodity flows associated with the Construction, Services, Retail, and Household and Business Moves industrial sectors were developed for FAF3 by MacroSys, LLC and made use of the 2002 U.S. National Input-Output Accounts reported by the Bureau of Economic Analysis (BEA) in the U.S, Department of Commerce.[15] The procedure employs the BEA's "Make" and "Use" tables, which relate the dollar amounts of specific commodities that are produced by and input into specific industrial sectors. These dollar-valued commodity flows were then translated into tonnage estimates: using dollar per ton statistics from the 2007 CFS where the same or similar commodities are also produced by in-scope industries, and using other industry-specific data sources where they are not.

Figure 3.4 shows the top 5 SCTG 2-digit commodities associated with each of these four industrial sectors. These sectors are each defined in terms of their NAICS (North American Industrial Classification)[16] codes. The following paragraphs describe the linkages between FAF3 commodities and NAICS industrial sectors, and the methods used to translate these national tonnage estimates into commodity flows for the 2007 FAF3. For all four industrial sectors the commodity flows were only estimated for domestic freight shipments by trucks. Appendix D provides the crosswalk from SCTG commodities to NAICS industries as it was used in FAF3.

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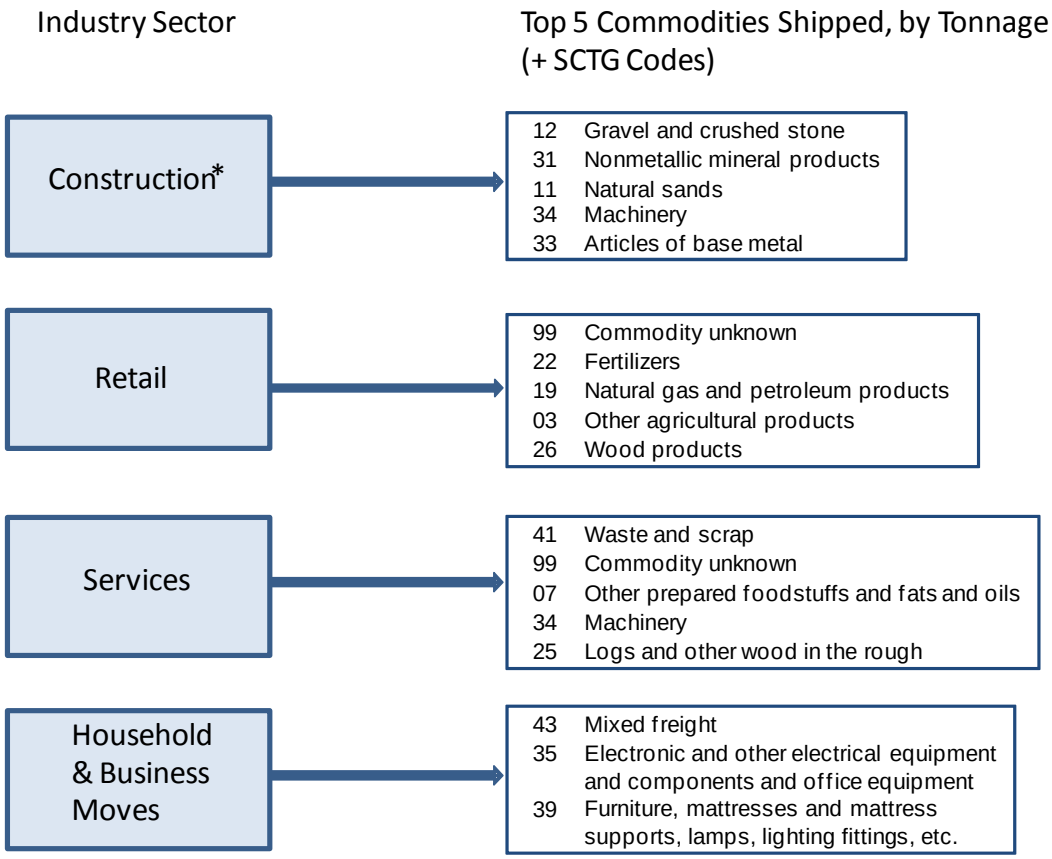
[14] Based on NMFS published statistics, total imported edible and non-edible fishery products were over 2.4 million tons and worth about $28.8 billion in 2007. Because imports are categorized as a separate out-of-scope area of the CFS (see Section 3.3.2 in this report), to avoid double counting, imported fishery is not included under this fishery shipment data gap study.

[15] http://www.bea.gov/industry/io_benchmark.htm

[16] http://www.census.gov/eos/www/naics/



** Debris is included in SCTG 41*

Figure 3.4 Principal Commodities Shipped by Tonnage in Four Out-of-Scope Industrial Sectors

3.3.5 Construction Industry Flows

Data Sources

Shipments originating from activities in the construction sector, including companies or establishments engaged in construction of residential and non-residential buildings, utility systems, roadways and bridges, and from specific trade contractors, are not in-scope for the CFS.

It is estimated that this industry transported just over one billion tons of freight over the course of 2007, valued at over $900 million. However, putting a dollar value on such freight is not straight-forward. The primary commodity shipped was debris (included in SCTG 41 under Waste and Scrap), for which the value would be relatively small unless recyclable materials are

separated and sold. An estimate of the amount of debris generated by the construction industry was developed based on publications by the U.S. Environmental Protection Agency (EPA) publications, [17] the National Demolition Association, Construction Materials Recycling Association, and Gershman, Brickner & Bratton, Inc. Similar dollar to ton conversions for other commodities are drawn from the CFS or other industry specific sources.

Shipment volumes were assigned to FAF3 regions using sales data from the 2007 Economic Census, where available, and using a combination of 2007 county level employment data from the Census Bureau's County Business Patterns (CBP) dataset, multiplied by Census-developed labor productivity rates by industry class, and available at the State level.

O-D Estimation Process

Data on shipment distances for the industry are limited at best for 2007, and in FAF3 all of these shipments are assumed to be short distance truck movements, most of which occur within a single county, and all of which occur within the same FAF3 zone.

3.3.6 Retail Industry Flows

Data Sources

The 2007 CFS also does not cover shipping activities originating from the vast majority of the nation's retail stores. It is estimated that 378.6 million tons of freight were shipped by the U.S. retail industry in 2007, valued at $624 billion. Based on the U.S. Bureau of Economic Analysis's National Input-Output Make and Use Tables, the retail industry generates commodity flows in most of the FAF3 commodity classes, and in particular freight moved by retailers selling the following commodities:

- Furniture
- Electronics and appliance
- Building materials
- Food and beverage
- Health and personal care
- Clothing, and
- Sporting goods, books and music

[17] http://www.epa.gov/osw/conserve/rrr/imr/cdm/pubs/cd-meas.pdf.

Excluded from this OOS category, because they are covered by the 2007 CFS establishment survey are fuel dealers, tire dealers, floor covering stores, nursery and garden centers, office supplies, stationary stores, and electronic shopping and mail-order houses.

O-D Estimation Process

Although most of the shipments from retail stores are within the same county, there is a possibility that retailers may transport large items purchased by customers from their warehouses, which may be located in other counties. At the county level this would be an issue, but is less likely to be of concern when aggregating O-D flows from counties up to FAF3 regional totals. Another issue with retail industry flows is whether some of these shipments are originated from retailer-owned warehouses that serve retail stores not covered by the CFS. In this case some inter-regional flows may be missing from FAF3 totals. These volumes are believed to be quite small in percentage terms.

3.3.7 Service Industry Flows

Data Sources

This sector covers a wide range of services, including services associated with:

- Finance and insurance
- Real estate
- Rental and leasing
- Professional, scientific and technical services
- Administrative support
- Waste management and remediation services
- Education services, and
- Health care and social assistance.

These industries are typically involved in providing services to the general public, local business establishments, and branches of government, and in total they originate freight shipments in a large number of FAF3 commodity classes.

Also not covered by the 2007 CFS are the mail shipments by these service industries. The sector as a whole is estimated to have generated almost 379 million tons of commodity freight in 2007, worth an estimated $505 billion. To this is added some 11.4 million tons of mail, valued at an additional $525.6 billion.

The availability of county level sales data varies by type of service offered. For example, the county level sales data for educational services are released for only 10 states. For real estate and food services, the sales data at the county level are available for 20 states. A first step was therefore to fill in this data gap for these services, then sum the sales of individual types of services to obtain an overall sales statistic for each county.

O-D Estimation Process

Shipment volumes between counties were then estimated as follows:

- For non-mail shipments, the county level demand for service sector products (i.e. the market potentials for these destination counties) was determined by two factors: (i) the amount of a commodity used by industries according to the Use table in the U.S. Input-Output Model and (ii) industrial employment at counties. Next, a spatial interaction ("gravity") model was used to distribute flows from each freight generating county to surrounding counties within or across FAF3 regional boundaries.

- For mail shipments, total employment in services at the county level served as a surrogate for market potentials. Since mail is known to be shipped over long as well as short distances across the county, and lacking any empirical data on this distribution, no distance decay effect was applied to this sharing process in FAF3.

3.3.8 Household and Business Move Flows

Data Sources

The trucking services provided by this industry (NAICS 484210) involve the shipping of used household and office furniture, electronic products, and other commodities not covered by the CFS. It is estimated that some 254.3 million tons of freight were moved by this industrial sector, nearly all of it by truck. The value of the goods moved is estimated at almost $31 billion. Several sources of data on the volumes of U.S. household and business moves were examined, including the U.S. Census Bureau's Annual Services Survey, and related studies conducted by the American Trucking Association and the American Moving and Storage Association.

O-D Estimation Process

All of these shipments are assumed to be truck moves in FAF3. These truck shipments were allocated to counties on the basis of CBP-reported sector employment totals. The shipments are then allocated spatially between county O-D pairs based on IRS reported county level in-

migration and out-migration totals. In the absence of available data on trip length distributions, a distance decay effect was not used in this allocation process.

3.3.9 Logging Flows

Data Sources

The logging sector is represented by NAICS[18] industrial sector 1113, a subsector of the Forestry Sector and covers the following activities: [19]

- Cutting and transporting timber
- Cutting timber
- Log harvesting
- Logging
- Pulpwood logging camps
- Rails, rough wood, manufacturing
- Stump removing in the field
- Timber piling
- Timber pole cutting
- Tree chipping in the field
- Wood chipping in the field

Some 372 million tons of logs, totaling almost $9.5 billion by value, are estimated to have been transported in the U.S. as a whole in 2007, of which the vast majority are transported by truck from domestic forests to nearby sawmills and other local sites.

O-D Estimation Process

County level logging products were estimated by multiplying the year 2007 employment in logging by an average tons-per-employee multiplier. This was obtained by dividing the logging tonnages reported in FAF2 by the employment in logging industries from the 2002 Census Bureau's County Business Patterns (CBP) database. To allow for logging products being transported across FAF3 regional boundaries, these products were assigned to counties located within a 75 mile radius of the producing county, based on the employment in wood product industries within each county, and upon data collected on the average haul to market distance of

[18] North American Industrial Classification System

[19] Other wood-related products produced by non-logging NAICS establishments remained in the CFS and are still in-scope in the CFS since they remained in manufacturing under NAICS 321 Wood Product Manufacture.

logging products (e.g. sawlogs, peeler logs, pulpwood and rustic fencing).[20] This result was then adjusted to 2007 CBP-based county employment totals, summed to their respective FAF3 regions. Obtaining dollar values for these logging industry shipments was problematic. Logging was an in-scope industry in the 1997 CFS but fell out-of-scope in the 2002 survey due to a classification switch from the previously used SIC (Standard Industry Classification) to NAICS. This change in scope persisted into the 2007 CFS. For the 2002 estimates used in FAF2 these 1997 CFS value per ton statistics were applied, subsequently adjusted with growth rates calculated from USDA tonnage data. In FAF3 these FAF2 reported dollar values per ton estimates were then further adjusted to 2007 values, based on the change in the Producer Price Index for lumber between 2002 and 2007.

3.3.10 Municipal Solid Waste Flows

Data Sources

Municipal solid waste (MSW) is not covered in the Commodity Flow Survey (CFS), and also does not have a specific code in NAICS. The main data sources used for estimating 2007 MSW shipments came from information compiled by Franklin Associates[21] in collaboration with the U.S. EPA,[22] supplemented by information in the *BioCycle* journal[23]. Additional, mode specific data was also obtained from the U.S Army Corps of Engineers Waterborne Commerce statistics, and from the Surface Transportation Board's Railcar Waybills sample. As defined by the US EPA, Municipal Solid Waste (MSW) includes the following 'Subtitle D wastes':

- Containers and packaging, such as soft drink bottles and cardboard boxes,
- Durable goods, such as furniture and appliances,
- Nondurable goods, such as newspapers, trash bags, and clothing, and
- Other wastes, such as food scraps and yard trimmings.

It is estimated that 413 million tons of MSW, as defined above, were transported within the U.S. in calendar year 2007. All of this MSW is collected at the source and transported to one of four types of processing facility: local landfills, local incineration facilities, local material recovery facilities, and waste transfer stations where garbage trucks unload MSW for accumulation and transfer to larger transport vehicles (truck, rail, or barge), for more economical long-distance hauling to a final disposal site (Curlee, 2009).

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[20] Anderson, N. and Germain, R (2007) Variation and trends in sawmill wood procurement in the Northeastern United States. *Forest Products Journal*. October 2007:36-44.
[21] http://www.fal.com/solid-waste-management.html
[22] http://www.epa.gov/epawaste/nonhaz/municipal/msw99.htm
[23] http://www.jgpress.com/biocycle.htm

Data on the flows between states was based on work done by McCarthy (2007) for the Congressional Research Service. Combining this work with data from other sources, it is estimated that more than 42% of total state-to-state transfers (i.e. state exports) come from three states—New York, New Jersey, and Illinois, whole several other states export more than 10% of the U.S. total across state lines. The District of Columbia exports all of its total MSW generation, while New Jersey exports over 45%, New York exports over 33%, and Maryland over 29%. Additional states that export more than 10% of their MSW include Connecticut, Illinois, Kansas, Massachusetts, Missouri, North Carolina, Vermont, Washington, and West Virginia. More than 46% of all these state exports go to three states—Pennsylvania, Virginia, and Michigan Only five additional states account for more than 4% of the national total shipments of inter-state MSW—Georgia, Illinois, Indiana, New Jersey, Ohio, and Oregon. Based on ORNL discussions with local officials for the previous, FAF3 effort, it appears that the large majority of shipments to adjoining states are essentially local shipments. For example, the city of Memphis ships MSW to Mississippi. Chicago ships tons to Indiana. The District of Columbia ships to Virginia. Also, small to medium sized towns near a state line may ship to an adjoining county across the state line. While these are truck movements, some longer distance shipments are by rail or (much less so) by inland waterway (i.e. by barge). It is estimated that just under 40% of inter-state shipments of MSW are by rail (mostly) or barge. This represents less than 4% of all MSW shipments.

The FAF3 MSW estimates also include significant tonnages moving from Maine to New Brunswick, Canada, from Ontario, Canada to Michigan, and a from Ontario to New York state (Curlee, 2009).

O-D Estimation Process

Allocation of (truck-only) MSW between FAF3 regions below the state level used county populations to distribute inter-state flows, with subsequent re-aggregation from counties to FAF3 regions. County-to-county O-D flows were estimated using a spatial interaction model, using an average O-D distance of just under 32 miles, derived from the MSW literature. These inter-county flows were then aggregated to their FAF3 region-to-region totals.

3.3.11 Crude Petroleum

Data Sources

It is estimated that the U.S. transported some 744.4 million tons of crude petroleum (crude oil) in 2007, using a variety of modes. This crude was valued at some $336.4 trillion dollars. These crude oil shipments begin either at domestic oil fields, or from large marine terminals that act as the first domestic storage and transfer point for foreign oil imports. The crude is delivered either

to refineries or to long-term storage facilities such as the Strategic Petroleum Reserve.. A great deal of this transport is accomplished by pipeline, and by marine vessels (inland barge and oceangoing tanker), but with significant tonnages also moved by rail tanker car and locally by tank truck.

National level crude oil shipment information by transportation mode is based on *Shifts in Petroleum Transportation* published annually by the Association of Oil Pipelines. This report's modal information is in turn based on several other data sources, including:

1. Oil Pipelines: Annual Report of oil pipeline companies provided to the Federal Energy Regulatory Commission (FERC Form 6);
2. Water Carriers: Waterborne Commerce of the United States, U.S. Army Corps of Engineers, (Part 5, Table 2-2);
3. Motor Carriers: Petroleum Tank Truck Carriers Annual Report, American Trucking Association, Inc. and Petroleum Supply Annual, Energy Information Administration (EIA) (Volume 1, Table 46); and
4. Railroads: Carload Waybill Statistics, Report TD-1, USDOT, Federal Railroad Administration, and Freight Commodity Statistics, Association of American Railroads (Table A3).

O-D flows of crude petroleum were derived using US DOE/EIA supplied data at various levels of geographic detail, ranging from five broad multi-state PADDs (Petroleum Administration for Defense Districts)[24] and individual States, to specific refinery locations. This includes data from EIA's Petroleum Supply Annual (EIA, 2010) on:

- Production of Crude oil by PAD District and State,
- Refinery Input of Crude Oil by Refining Districts, and
- Refinery Receipts of Crude Oil by Method of Transportation, by PADD.

O-D Estimation Process

The first step to produce an O-D table of domestic crude oil production was to estimate the production and domestic inputs at the FAF3 regional level. In the next step, estimates of O-D crude oil movements between FAF3 regions were obtained using a gravity model. Finally, the resulting movements were shared among the possible modes by an interactive proportional process.

[24] The New England, Midwest, East Coast, Gulf Coast, and West Coast PADDs. For specific state allocations to APDDs see: http://www.eia.gov/glossary/index.cfm?id=P#PADD_def

Crude oil production and domestic inputs by FAF zone

The U.S. crude oil production data is available from the EIA at the state level. This data contains both inland and offshore production. County level data on the total annual payroll of industries classified by the NAICS as 211111 – 'Crude Petroleum and Natural Gas Extraction' as reported in the County Business Pattern data by the U.S. Census Bureau, was used to estimate production at the FAF3 regional level. Total crude production by state was first disaggregated to the county level, proportionally to the annual payroll by county, and the results aggregated to their FAF3 regions.

Offshore production corresponds to offshore fields in the Gulf Coast (PADD III) and in the East Coast (PADD V). Based on geographical proximity, the offshore production in the Gulf Coast was proportionally added to the total production of the states of Texas (FAF zones 483, 482, 486, and 489), Louisiana (FAF zones 221, 222, 223 and 229), Mississippi (FAF zone 280) and Alabama (FAF zones 012 and 019). Offshore production on the West Coast was allocated to FAF3 regions in the state of California.

Data on refinery inputs of crude oil (EIA's Refinery Net Inputs) is available at the PAD refining district level. To obtain inputs at the FAF3 regional zone level, these PAD level data were apportioned, after subtracting foreign crude oil imports, to each refinery on the basis of its reported production capacity, with subsequent re-aggregation to the FAF3 regions.

Crude Oil Movements Between FAF Zones

From the results above, there were 80 producer FAF3 regions and 50 domestic input FAF3 regions. A doubly constrained gravity model of the following form was used to allocate O-D flow between each pair of FAF3 regions:

$$F_{ij} = A_i B_j O_i D_j f(u_{ij}) \qquad (2)$$

where,

F_{ij} is the estimated amount of crude oil flowing from zone *i* to zone *j*;
O_i and D_j are the total crude oil production and consumption at zones *i* and *j*, respectively;
$f(u_{ij})$ is the decreasing function of u_{ij}, where u_{ij} corresponds to the travel impendence between zones i and j; and A_i and B_j are balancing factors of the form:

$$A_i = 1 / [\sum_{j=1,Z} B_j * D_j * f(u_{ij})] \quad \text{for all } i \qquad (3)$$
$$B_{jm} = 1 / [\sum_i A_{im} * O_{im} * F(u_{ij})] \quad \text{for all } j \qquad (4)$$

which upon iteration to balance ensure respectively that:

$$\sum_j F_{ij} = O_i \quad \text{for all } i \qquad (5)$$

$$\sum_i F_{ij} = D_j \qquad \text{for all } j \qquad (6)$$

The travel impendence measure used was the great circle distance. In cases of movements that were not possible or very unlikely, a large impendence value was attributed to the corresponding (i, j) pair. An example of such movements would be the case of crude oil flowing from Alaska to refineries located in PAD District 1.

Mode of Transportation (Pipeline, Barge, Truck, Tank Cars, Tankers)

The EIA's Refinery Receipts table was used to share the amounts of domestically transported crude oil by O-D pair among the possible modes of transportation. Data from EIA's Movements of Crude Oil between PAD Districts was used in this process. [25]

The method of assigning the mode of transportation for each O-D pair was similar to the one used for foreign crude oil, as described above. For the highway system, an additional and arbitrary upper bound distance of 700 miles was established for truck trips. As for the railroad movements, besides the restrictions already imposed there were no further prohibitions. Once the mode was assigned, an iterative proportional fitting method was used to share each O-D flow volume among modes in order to match the given modal share by PAD District, as reported in the EIA's 2007 Refinery Receipts table.

3.3.12 Natural Gas Products

Data Sources

Delivering natural gas (principally methane, but also smaller volumes of ethane, propane, butane and pentane) is an enormous enterprise. This gas is transported to consumers through more than 300,000 miles of transmission pipelines with the help of vast storage reservoirs and thousands of compressors. The gas is sold to marketers, large commercial and industrial consumers, and distribution companies for delivery to consumers over a network of more than 1.1 million miles of local distribution pipelines.

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[25] As with most OOS procedures used in FAF3, manual adjustments to modeled output were required based on known conditions not programmed into the allocation models. For example:

- There is no receipt of crude oil by Tankers in PAD Districts 1, 2 and 4;
- Most of the crude oil comes by Pipeline in PAD Districts 2, 3 and 4;
- There is no receipt by Tank Cars in PAD Districts 2 and 4;
- It appears that there was no oil trade between PADD 5 and the other PAD Districts (this was considered in the gravity model).

National Natural Gas flow totals and O-D region-to-region flows were derived from the EIAs' Natural Gas Annual (EIA, 2010)[26], making use of data at various levels of geographic detail, including:

1. Gross Withdrawals and Marketed Production of Natural Gas by State and Gulf of Mexico,
2. Offshore Gross Withdrawals of Natural Gas by State and the Gulf of Mexico,

O-D Estimation Process

Spatial interaction models of the type described by equations (2) – (6) above were used to allocated flows to a State-to-State and FAF region-to-FAF region level.

3.4 ESTIMATION OF IMPORT AND EXPORT FLOWS

3.4.1 Overview

Imported as well as exported freight flows in FAF3 are constructed from mode specific data sources, each of which must have its flows converted from agency specific commodity codes to FAF3's 2-digit SCTG codes, as well as having its flows either spatially aggregated or disaggregated to match FAF3 regions. The procedures used are very much mode specific, using separately constructed airborne, waterborne and land-based (border-crossing, notably truck and rail) datasets that are then brought together into a single, multi-modal data matrix. The result is a set of estimated origin-to-destination tonnages and dollar valued imports and exports for calendar year 2007. Figure 2.6 provides a top-down view of this process.[27] The following sections describe each of these mode-specific data modeling procedures in more detail. Each section is divided into three parts: data sources, estimation method, and data quality issues.

3.4.2 Waterborne Imports and Exports

Data Sources

Import and export by water are derived in FAF3 using three different data sets, each of which provides a different look at the nation's international freight movements (see Figure 3.5):

1. The US Army Corps of Engineers (USACE) International Waterborne Commerce Database

[26] See http://tonto.eia.doe.gov/dnav/ng/ng_pub_publist.asp

[27] Although the 2007 CFS does also collect data on export shipments by US establishments, both coverage and statistical accuracy is limited by sample size issues. This data was not used for FAF3 export flow estimates.

2. The US Census Bureau's Foreign Trade Database[28]
3. A FAF3-specific extraction of data from the Port Import Export Reporting Service (PIERS) Import/Export Database

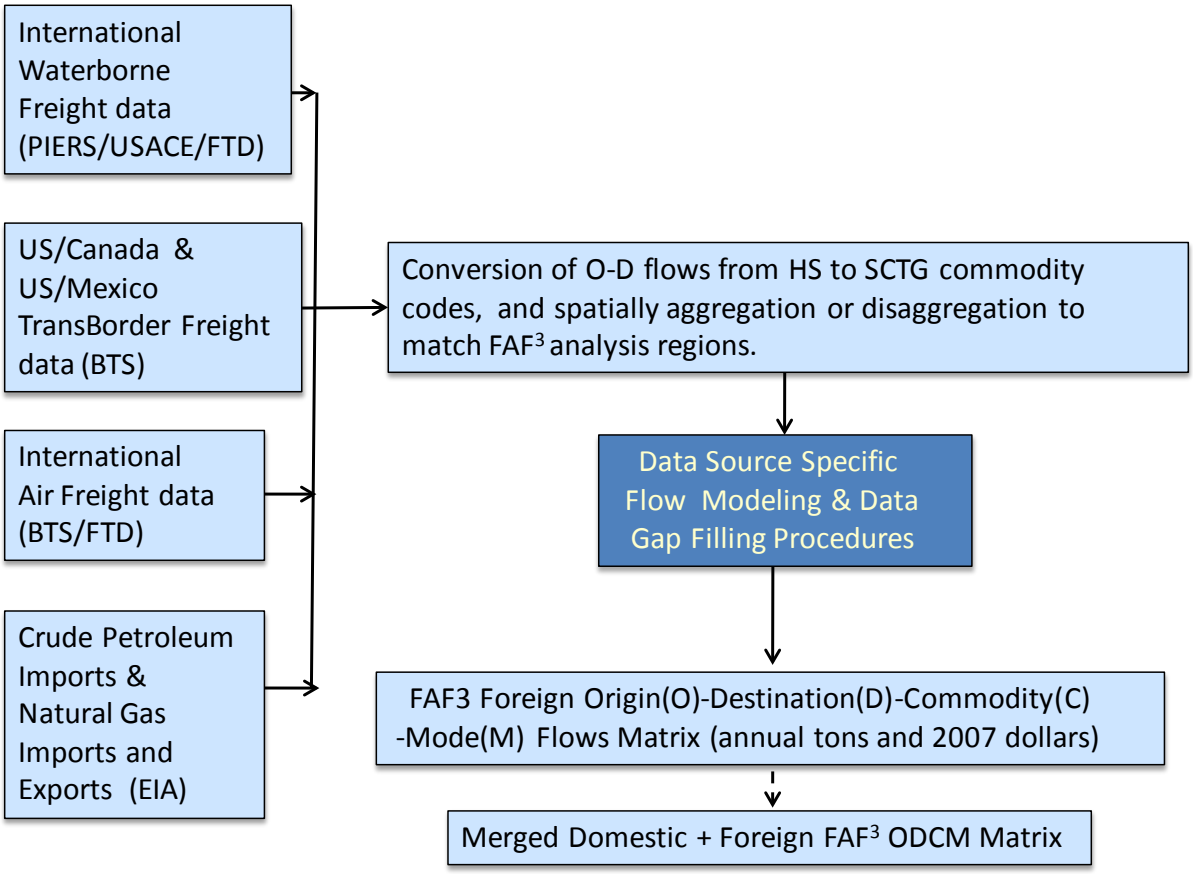

Figure 3.5 FAF3 International (Import/Export) Data Modeling

<u>The PIERS Import/Export Database</u>

This is a proprietary dataset, developed and marketed by the PIERS global import and export information service (©2011 UBM Global Trade). PIERS details can be found at:

http://www.piers.com/

The original data source here comes from shipment records collected by U.S. Customs and Border Protection.[29] A special run of PIERS was purchased for the FAF3 project, and the

[28] http://www.census.gov/foreign-trade/reference/products/index.html
[29] http://www.cbp.gov/xp/cgov/trade/automated/

availability and inclusion of this data source represents a significant enhancement of the FAF estimation process. In particular, the PIERS data provided geographic and modal information on the internal to the U.S distribution of imported and exported goods. In the case of exports, this data takes the form of annual tons and dollars of freight shipped from individual States into a U.S. seaport of embarkation. In the case of imports the data represents annual tons and dollars of freight moving from a U.S. port of debarkation inland to a final U.S. state of destination.

The USACE Waterborne Commerce Database
This public domain data is web-accessible at the following location:

http://www.ndc.iwr.usace.army.mil//data/dataimex.htm

The database reports annual tons (short tons) imported and exported between U.S. seaport and foreign seaports. Also reported are outbound and inbound in–transit tonnages through U.S. seaports. Tonnages are reported in broad 2-digit LPMS (Lock Performance Monitoring System) commodity classes. Additional geographic data on the domestic end of these annual shipments includes State, U.S. Customs District and USACE Waterway.

The Census Foreign Trade Database (FTD)
This data is web-accessible at the following location:

http://www.census.gov/foreign-trade/reference/products/index.html

O-D Estimation Process

A special run of the PIERS dataset forms the basis of foreign waterborne flows in FAF3. These data were subjected to a number of adjustments. In particular, PIERS total commodity tonnages were adjusted to be consistent with USACE waterborne tonnages, while PIERS total commodity dollar valued trades were adjusted to be consistent with Census FTD totals. Some additional adjustments were also necessary to shipments moving within the U.S., for both import and export shipments. While zip code level reporting of shipment originations or destinations within the continental U.S. was provided for most shipments, this level of geographic detail was missing and had to be inferred for many data records. There are also know issues with how shipment origination and termination data is reported to U.S. customs, and adjustments were made where it was deemed that a company's head office or other business location was reported that likely differed significantly from the actual point or departure or arrival. Also, for most shipments no mode of transportation within the U.S. was reported. An exception here was the identification of rail-inclusive container shipments, which were treated as truck-rail intermodal movements (i.e. 'multiple mode' movements) in FAF3. After extracting these intermodal shipments, shipments with no known or questionable origins and destinations were allocated

across domestic FAF3 zones in proportion to the distribution of these shipment volumes in the 2007 U.S. Commodity Flow Survey,

Data Quality Issues

Significant detail is currently missing from the above datasets on both the inland mode of transportation used, and the geographic specificity of a shipment's true origin or final destination within the continental U.S. This gap occurs for two reasons; first, there is limited public domain data on these locations; and second, even where data is available, the reporting of final destination for imports, or true point of origination for exports, is subject to errors caused by shippers reporting the location of the purchasers of the goods (e.g. the head office or other business location) rather than the actual physical location of the deliveries. Additional research is required to estimate the extent of this misreporting.

3.4.3 Air Freight Imports and Exports [30]

Data Sources

Data published by the Office of Airline Information, Bureau of Transportation Statistics, within the U.S. DOT's Research and Innovative Technology Administration provides the FAF3 estimates of total tons shipped annually between an originating airport (where the cargo is first loaded onto an aircraft) and a destination airport (where the cargo is unloaded for final land-based delivery, usually by truck).[31] This data was combined with data collected by U.S. Customs on the commodity class and value of international air shipments, as reported by the Foreign Trade Division of the U.S. Department of Commerce's Bureau of the Census (DOC/Census/FTD).[32] This FTD dataset includes information on the value,[33] quantity, method of transportation, and shipping weights for some 9,000 export commodities, 17,000 imported commodities, 240 trading partners, and 45 U.S. Customs Districts. Figure 3 displays a flow chart of this process.

<u>Bureau of Transportation Statistics T100 Data</u>

The OAI T-100 data is considered the definitive source of tons-shipped for the U.S. airline industry. OAI shipments are defined differently than FAF3 shipments, in that OAI shipments use an airport basis (from airport of origin to airport of destination) rather than an establishment

[30] Most of the narrative below is derived from a draft 2010 report completed by MacroSys Inc., and titled "Estimation of Exports and Imports by Air for FAF3".
[31] T-100 (foreign) market data. http://www.bts.gov/publications/freight_transportation/
[32] http://www.census.gov/foreign-trade/reference/products/index.html
[33] Export values are reported free-alongside-ship (F.A.S.) Import values are reported as customs-insurance-freight (C.I.F) values.

or origin and destination basis. In OAI market data, airport origin-destination refers to tons enplaned by a specific carrier at the origin airport and de-planed by the carrier at the destination airport. The T-100 market data will exclude the port-of-entry/exit whenever the port is an intermediate stop for the shipment. Origin-destination information for each record on the segment component of the T-100 data refers to a non-stop leg and reports tons transported rather than tons enplaned. The T-100 segment data includes the port of entry/exit for international shipments, but excludes the ultimate origin/destination when a shipment has multiple stops. Combining the market and segment data to obtain U.S airports-of-entry/exit was one of the main work tasks involved in creating the flow matrices.

The T-100 data covering freight shipments by U.S. carriers is publicly available approximately sixty days after the end-of-month, and the T100(f) data, covering foreign carriers, is publicly available approximately six months after the end-of-month. The data can be found at:

http://www.transtats.bts.gov/

Missing from the OAI data is information on the value and commodity-composition of shipments. This data was obtained from the U.S. Customs and then combined with the OAI data, as described in Section 3.2 below.

Bureau of the Census Foreign Trade Data

The Census Bureau's Foreign Trade Division (FTD) (http://www.census.gov/foreign-trade/reference/products/index.html) publishes two monthly paid subscription data series covering U.S. international air freight. The data is collected by the U.S. Customs Service and published as:

1. U.S. Exports of Merchandise – Monthly (information on the value, quantity, method of transportation, and shipping weights for 9,000 export commodities, 240 trading partners, and 45 Districts; and

2. U.S. Imports of Merchandise – Monthly (data on more than 17,000 commodities for 240 trading partners and 45 Districts.

The U.S. Exports/Imports of Merchandise series provide data on the value, quantity, mode of transportation, shipping weights, import charges, customs duties and much more. Shipments are for all merchandise between foreign countries and U.S. Customs Territories (50 states, District of Columbia, Puerto Rico, the U.S. Virgin Islands, and U.S. Foreign Trade Zones). The objective is to capture the physical movement of merchandise between foreign countries and the U.S. and includes government and non-government shipments and does not depend on the shipment being part of a commercial transaction.

A shipment's origin-destination is based on U.S. Customs Districts. For FAF3 purposes, such a District may include more than one state and a state may have more than one Customs District. The export data satisfies the need for mode-destination-port of origin-tonnage-dollar value data, but lacks port-of-exit data. The import data satisfies the need for mode-origin-destination-tonnage-dollar value, but defines port-of-entry as the port in which the shipment clears customs rather than the first port before/after crossing the border. Commodities are reported using the 10-digit Harmonized Tariff Schedule (Schedule B for exports) which must be translated to SCTG using a crosswalk developed for the purpose. (See Appendix E for this crosswalk from HS to SCTG commodity codes). Export values are reported free-alongside-ship (F.A.S.). Import values are available both by customs-import-value (C.I.V.) which excludes duties, freight, insurance and other costs of importation or by customs-insurance-freight, which adds freight and insurance to the C.I.V. For FAF3 the C.I.F. values were used, to better reflect the shipment's value at the border. Like FAF3, the Census data excludes in-transit shipments.

Other Data Sources Used: A number of geo-referenced datasets were used to place U.S. airports within U.S. Counties and Customs Districts, and to assign them to their respective FAF3 regions. This process required some manual editing to be carried out, making use of place and sub-district data found at:

http://www.census.gov/geo/www/gazetteer/places2k.html

supplemented by information gathered from U.S. Customs and the National Association of Counties websites.

O-D Estimation Process

The OAI and FTD data are combined into a single FAF3 air freight dataset by reconciling differences in the level of spatial and commodity detail. Where differences exist between the OAI and FTD flow totals, the OAI database is taken to be definitive for total tons shipped, and the FTD database is used to control the allocation of freight shipments across commodity classes and to assign value-to-weight ratios to these flows. Figure 3.6 shows this process:

First, differences between the Census and OAI weight data are removed, by factoring the FTD data to match OAI totals. Since the FTD data does not include transshipments, the largest differences occur for the most part at important transshipment ports: Anchorage, Miami and New York. For this purpose each OAI airport was assigned to a Customs Sub-District, a task complicated by the fact that a State may have multiple Customs Districts, no named Districts or Sub-Districts, or a Customs District may span more than one State. And while Customs Sub-

Districts also consist of places in the usual geographic sense of cities or regions, they may also be airports and business places (e.g. Federal Express processing centers).

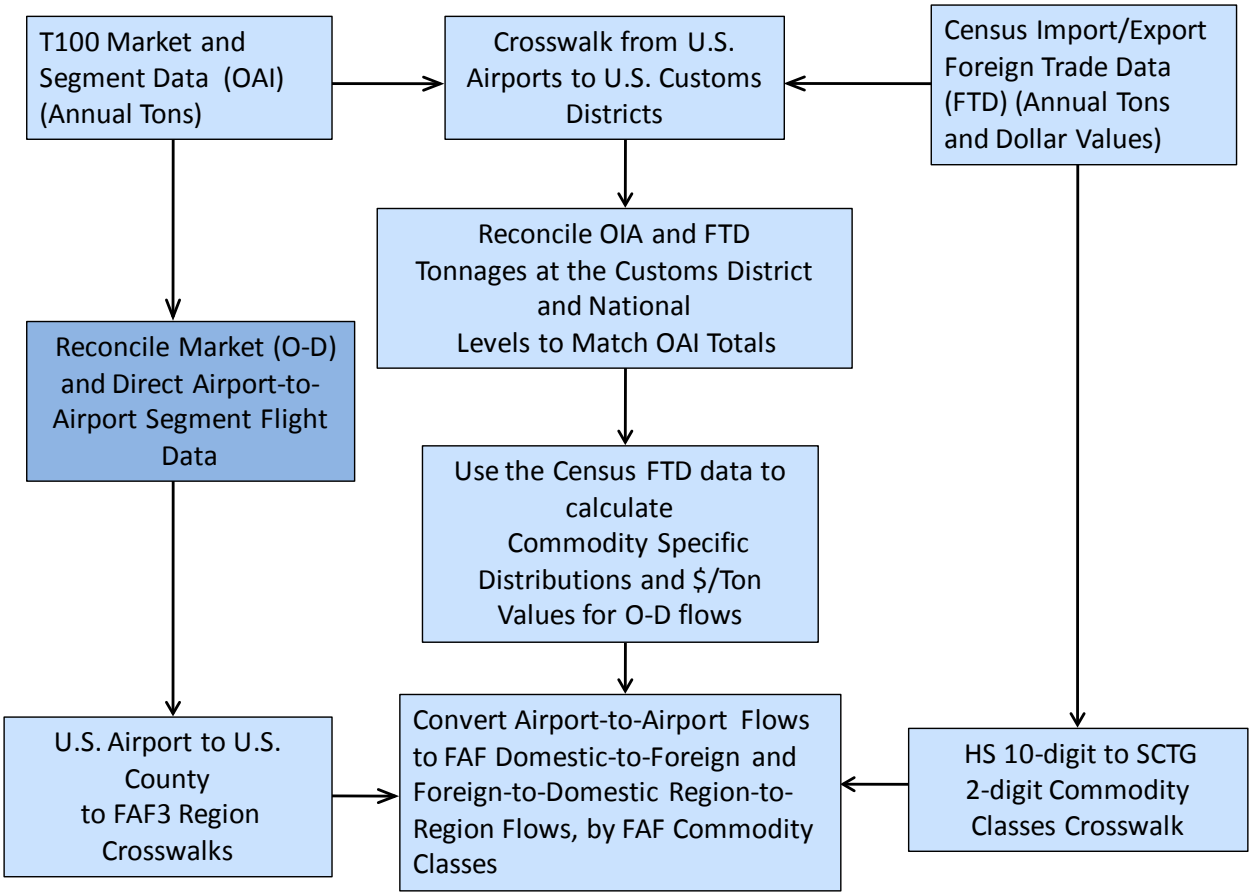

Figure 3.6 Building the International Air Freight Flows Matrix

Commodities are reported in the FTD dataset using the 10-digit Harmonized Tariff Schedule (Schedule B for exports). This data is therefore aggregated and translated to FAF3's 43, 2-digit SCTG commodity classes using a crosswalk developed for the purpose (see Appendix E). In a third matching process, OAI airports are matched to U.S. counties and each county then matched in turn to its FAF3 region. The result of these various data manipulations is a set of annual (2007) foreign-to-domestic and domestic-to-foreign FAF3 regional import and export flows by commercial air carriage.

Additional technical details on this estimation process, including formulas used in the major flow estimation, can be found in Appendix C to this document.

Data Quality Issues

The main sources of data used; the OAI T-100 and FTD datasets, are from government published data sources and are expected to be reasonably reliable. The OAI data is considered definitive for the weight of air shipments, while the Census FTD data is a building block for the U.S. balance of payments. However, the following data issues are worth noting:

1. Although the OAI T-100 market and segment data includes information on the largest air cargo carriers, it excludes information for some all-cargo airlines.

2. The methodology below can be applied to freight and mail either separately or together as freight and mail combined cargo. One concern with using freight and mail separately is an on-going dispute between Federal Express and OAI as to how U.S. mail should be reported. Federal Express lumps mail with freight due to concerns about disclosing the size of its contract with the U.S. Postal Service. Freight by itself will then tend to overstate actual freight shipments. For purposes of this report, combined freight and mail is used while recognizing that FAF3 treats parcels/mail as a separate mode.

3. The OAI dataset is carrier-based, so a shipment that involves more than one carrier will misrepresent the initial origin and ultimate destination of the shipment.

4. The OAI market data covers enplanements and deplanements of freight and mail by flight number. Although the public version of the dataset excludes in-transit shipments, it is likely that some in-transits are included since a shipment that changed either carriers or planes would not be excluded.

3.4.4 TransBorder U.S.-Canada and U.S.-Mexico Imports and Exports

Data Sources

BTS TransBorder Freight Database

Land mode (truck and rail) freight movements between the United States and its immediate neighbors, Canada and Mexico, are derived from the Bureau of Transportation Statistics (BTS) TransBorder Freight Database, itself constructed from trade data collected by the Census Foreign Trade Division. This data can be found at the following BTS website:

http://www.bts.gov/transborder/

Three calendar year 2007 data tables are made use of (the data is provided on a calendar month by month basis):

1. U.S. Trade with Canada and Mexico with State and Port detail (Table 1)

   This table provides the origin or destination state of U.S exports and imports by port of entry or exit. For trade with Canada, the table provides Canadian province of origin or destination. For trade with Mexico the table provides Mexican state of destination for U.S. exports.

2. U.S. Trade with Canada and Mexico with State and Commodity Detail (Table 2)

   This table provides the origin or destination state of U.S exports and imports by commodity. For trade with Canada, the table provides Canadian province of origin or destination. For trade with Mexico the table provides Mexican state of destination for U.S. exports.

3. U.S. Trade with Canada and Mexico with Port and Commodity Detail (Table 3)
   This table provides U.S. trade with Canada and Mexico by commodity and U.S. port of entry or exit.

Movements are reported by 99 two-digit Harmonized Series (HS) commodity codes indicated by Schedule B for U.S. export shipments and Harmonized Tariff Schedule of the United States for U.S. import shipments. Flows are reported by 34 Mexican States (including 'Unknown') and 14 Canadian provinces (including 'Unknown'). Ports are reported by Census Foreign Trade Division Schedule D Port and Port District codes. The flowing 'modes' are reported:

(1) Vessel (added in 2004)
(3) Air (added in 2004)
(4) Mail
(5) Truck
(6) Rail
(7) Pipeline
(8) Other and unknown
(9) Foreign Trade Zones (FTZs)

"Mail" represents U.S. Postal Service and courier shipments, and cannot be further subdivided into a mode such as, air, rail, or truck. "Other and unknown", includes flyaway aircraft, that is aircraft moving under their own power from the aircraft manufacturer to a customer and not carrying any freight, powerhouse (electricity), vessels moving under their own power, pedestrians carrying freight, unknown, and miscellaneous other. Although FTZ is being treated as a mode of transportation in this dataset, the actual mode for a specific shipment into or out of a foreign trade zone is unknown (Census does not collect this information).

Other Data Sources Used

U.S. County Business Pattern data for 2007 was used to allocate U.S. flows by individual States to their most likely counties of origination or destination (see below).

O-D Estimation Process

The major tasks involved in the estimation process for FAF3 purposes were (see Figure 3.7):

1. Remove vessel, air and pipeline movements from the dataset (leaving truck and rail 'land' border shipments);
2. Spatially allocate flows reported at the State level to their most likely FAF3 regions within the United States;
3. Convert Harmonized Series (HS) commodity classes to FAF3 SCTG classes.

From the above listed TransBorder data tables, four separate, four-dimensional ODCM tables of annual freight flows, by tonnage and dollar value, were constructed at both the U.S. port of entry or exit level and at the State level: one table each for Mexican Imports and Exports, and Canadian Imports and Exports from/to the United States.

When an FTD Port was not specified but an FTD Port District was known, flows were assigned to the most likely port for that District, on the basis of tons or dollars of a specific commodity passing through each port. When a U.S. Port of entry or exit was reported as unknown, these tons and dollar values were proportionally distributed across all U.S. border crossing ports of entry or exit that also reported handling vehicles transporting the same HS commodity and mode. For the internal to the U.S. shipment starting or ending points, these flows were allocated to U.S. counties. These county allocations were then summed to their respective FAF3 zones. For exports, the origin state total (ton & value) was distributed using annual payroll data in County Business Patterns (CBP) to those within-state counties that have industries that "produce" the specific type of commodity being shipped. For imports, the destination state payroll total was distributed, also using CBP data, to all counties within the state. In this instance these distributions are not commodity specific, since in general they can be "consumed" by many different businesses within a county.

All of the above allocations were carried out using the dataset's original 2-digit HS commodity codes. The resulting flows were then converted from 2-digit HS to 2-digit SCTG codes at the very last step in the computational procedure.

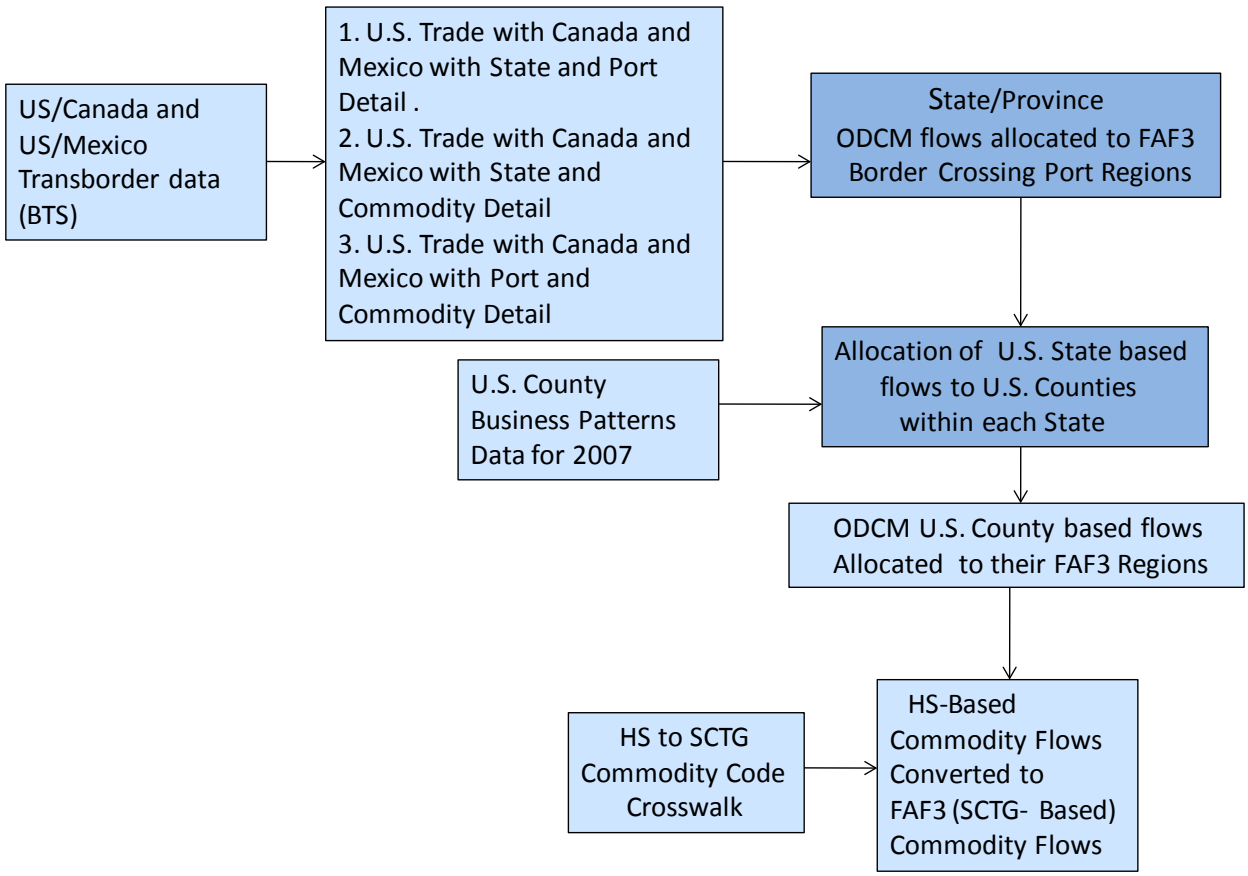

Figure 3.7 Building the US/Canada and US/Mexico TransBorder Freight Flows Matrix

Data Quality Issues

Of note, shipment weight data for exports to Canada and Mexico by land mode is not currently reported in the TransBorder dataset. These weights were estimated on the basis of average dollar/ton statistics generated from import shipments by specific HS commodity class, mode, and country.

3.4.5 Imports of Crude Petroleum

EIA databases were also used to estimate crude petroleum imports in FAF3, taking advantage of the fact that crude petroleum imports are reported to the EIA monthly at the company, U.S. seaport of entry/exit, and foreign country level, allowing the complete movement of imported crude oil from the foreign country (source of commodity), passing through the port (domestic origin), to the refinery (domestic destination) to be estimated. The allocation of these flows to specific modes of transportation was then based on EIA data on crude oil refinery receipts,

broken down by mode of transportation (ship, pipeline, rail, barge, truck), and further broken down by domestic versus foreign sources of production.

Form EIA-814: Monthly Imports Report

Data on the annual imports of crude oil and petroleum products in thousands of barrels, at the company level, was obtained at the following link:

http://www.eia.doe.gov/oil_gas/petroleum/data_publications/company_level_imports/cli.html

This dataset includes U.S. PAD District, state and port entry as well as the foreign country from which the imports are received.

EIA State Level Production

This dataset, constructed from reporting by state agencies, the U.S. Department of the Interior and the Minerals Management Service, contains the production of crude oil in thousands of barrels by U.S. state and PAD District. A 2007 table (Table 13) was obtained from the following website:

http://www.eia.doe.gov/oil_gas/petroleum/data_publications/petroleum_supply_annual/psa_volume1/psa_volume1.html

Form EIA-820, "Annual Refinery Report

This data contains the refinery receipts of crude oil in thousands of barrels by the following modes:

1. Pipeline – gathering and trunk pipeline network
2. Tankers – a large ship or vessel
3. Barge – a large boat carrying oil on rivers
4. Tank Cars – large cargo trains on railroads
5. Truck – a large roadway vehicle

The data is also classified by domestic or foreign receipts and was accessed via following link:
http://www.eia.doe.gov/oil_gas/petroleum/data_publications/refinery_capacity_data/refcapacity.html

EIA-810: Monthly Refinery Report and EIA-815: Monthly Terminal Blenders Report

This data contains the refinery inputs of crude oil and petroleum products in thousands of barrels by PAD and refining districts. To obtain a 2007 MS Excel (xls) table, go to the following link and search for previous tables at the historical page.

http://www.eia.doe.gov/oil_gas/petroleum/data_publications/petroleum_supply_annual/psa_volume1/psa_volume1.html

O-D Estimation Process

Company level import data was used to aggregate imported crude oil flows to their respective FAF3 regions. Each flow represents two FAF3 O-D flows: the first is based on its foreign country (i.e. source of commodity import), into a U.S. port (domestic FAF3 origin region), the second flow is then made from this port to a U.S. refinery (FAF3 domestic destination region). Each of these flows is then assigned to a mode of transport, using the following procedure:

<u>Mode of Transportation (Pipeline, Barge, Tankers)</u>

1. *From foreign countries to U.S. ports of entry* – it was assumed that, except for imports from Canada, the shipment of crude oil from foreign countries to U.S. was made by large, oceangoing ships (Tankers). It is also assumed that most of the shipments occurring on the border with Canada are made by pipeline, and correspond to oil coming from the oil sands deposits of northern Alberta, or the Western Canada Sedimentary Basin (WCSB). Canadian oil production also comes from offshore fields in the Atlantic Ocean, from where the oil can flow over the ocean to U.S. East Coast and U.S. Gulf Coast.
2. *From U.S. ports of entry to the U.S. refineries* – First, the EIA's Refinery Receipts table, which contains the modal share by PAD District, was used to share crude oil totals among the modes Tanker, Barge and Pipeline. In the Form EIA-820, which is used to obtain this data, the mode of transportation is entered using the following criteria: (a) the last method of transportation used if the distance traveled via this mode is equal to or greater than 100 miles (b) the mode which represents the greatest distance traveled is used if several methods of transportation are involved and no single method is equal to or greater than 100 miles. Allocating these model flows to O-D pairs is then something of a challenge, since there is no detailed information on the modes used to transport specific O-D flows of crude oil from U.S. ports to refineries. An assumption was made that there were no multimodal shipments (i.e. no modal changing from origin to destination zones) for foreign crude oil. This simplified the task to assigning possible modes of transportation for each port-refinery pair. This was done using the following procedure:

    a. Mode of transportation leaving the domestic origin zones (ports): determine if each FAF3 port-inclusive region intersect the pipeline or water way systems.
    b. Mode of transportation arriving at the refineries: determine if each U.S. refinery is near a major inland waterway and/or the pipeline system.
    c. Associate the two assignment lists above. It was assumed that if the water or pipeline systems touch both origin and destination points it is likely that the crude oil was transported through the corresponding modal network.

However, exceptions occur to this rule because either the pipeline or waterway network of interest is not fully connected for a specific O-D pair. These exceptions were manually eliminated. The water mode was then further divided between Barge and Tankers to comply with the method of transportation reported by the EIA receipts dataset. Since the only refineries that can accommodate large ships are the ones close to the coastline, a GIS and Google Earth KML files were used to analyze visually high resolution images of specific refinery locations, to confirm that each refinery is located on a waterway that provides access to large ships.

Once the mode was assigned, the next step was to apply an iterative proportional fitting process was used to share each port-refinery O_D flow among modes in order to match the modal shares by PAD District reported in the EIA's Refinery Receipts table.

3.4.6 Imports and Exports of Natural Gas

Data Sources

Liquefied Natural Gas (LNG) is imported or exported to/from the U.S. by large tanker ships. The US Department of Energy's Energy Information Administration (EIA) reports annual LNG imports/exports in millions of cubic feet by U.S. seaport of entry/exit. The EIA also reports the annual trade in pipeline supplied natural gas (NG) between the U.S. and Canada and the U.S. and Mexico, also in millions of cubic feet. Reporting here is both by State and by specific U.S. point (city) of entry/exit, requiring assignment of flows to point of entry-inclusive FAF3 regions.
Liquefied Natural Gas (LNG) is imported or exported to/from U.S. by large ships (tankers).
The EIA data provides LNG imports/exports in million cubic feet by port of entry. This data was available from:

a) Imports: http://tonto.eia.doe.gov/dnav/ng/ng_move_poe1_a_epg0_iml_mmcf_a.htm
b) Exports: http://tonto.eia.doe.gov/dnav/ng/ng_move_poe2_a_epg0_eng_mmcf_a.htm

There is also Natural Gas (NG) trade by pipeline between the U.S. and Canada or Mexico. The EIA data provides the total pipeline NG imports/exports in million cubic feet by port (city and state) of entry. The data was available from:

a) Imports: http://tonto.eia.doe.gov/dnav/ng/ng_move_poe1_a_epg0_irp_mmcf_a.htm
b) Exports: http://tonto.eia.doe.gov/dnav/ng/ng_move_poe2_a_epg0_enp_mmcf_a.htm

The same EIA database also provides the total imports/exports in million cubic feet by state. The data was available from:

a) Imports: http://tonto.eia.doe.gov/dnav/ng/ng_move_state_a_epg0_im0_mmcf_a.htm
b) Exports: http://tonto.eia.doe.gov/dnav/ng/ng_move_state_a_epg0_eex_mmcf_a.htm

Supporting data used in allocating flows to specific FAF3 O-D pairs came from the U.S. Census Bureau's County Business Patterns dataset, found at:
http://www.census.gov/econ/cbp/intro.htm.

O-D Estimation Process

Natural Gas flows were allocated to their FAF3 domestic regions based on U.S. port of entry or exit. Importing and exporting countries were similarly allocated to their respective FAF3 foreign regions. Comparing the two types of data aggregation on the U.S. domestic end of these shipments (i.e. by port of entry/exit and by state of destination/origin), it was concluded that that there were very few inter-regional movements of either imported or exported NG or LNG within the U.S. in 2007.

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Appendix A: Differences in the FAF3 and FAF2 Freight Flow Matrices

The FAF3 Analysis Zones are different from the FAF2 'zones. Since the FAF freight flow matrix is developed around the data supplied by the U.S Commodity Flow Surveys (CFS) the geography has changed with CFS geography. In 2007 the use of more CFS analysis zones (made possible by the much larger size of the CFS sample) allows the FAF to adopt these CFS zones while maintaining its focus on U.S. coastal analysis zones that both receive and pass on most U.S. imports and exports. This compatibility with the CFS geography should make future development of FAF flow estimates not only less time consuming but also prone to one fewer sources of possible estimation bias.

The FAF3 Mode Classes have also changed since 2002. Table A1 below shows the differences. Note that, due to the redefinition and changed reporting of intermodal/multimodal categories between the 2002 and 2007 CFS on which the FAF is based, there is no direct equivalence in the modal classes implied between these two sets of definitions, with the exception of the truck only and rail only modes. Differences in the way the 2007 versus the 2002 CFS assigned water-only versus water-inclusive intermodal shipments (typically, truck-water combinations) also means that direct comparisons of water only traffic volumes and modal shares is problematic.

Table A1. Modal Class Changes 2002 – 2007

FAF2 Modes (2002)	FAF3 Modes (2007)
Truck	Truck
Rail	Rail
Water	Water
Air, air and truck	Air,air and truck
Truck and rail	Multiple modes and Mail
Other intermodal[1]	Pipeline
Pipeline and Unknown	Other and Unknown

[1]Includes U.S. Postal Service and courier shipments and all intermodal combinations except air and truck.

FAF3 Modal definitions are given below:

1. Truck. Includes private and for-hire truck. Private trucks are owned or operated by shippers, and exclude personal use vehicles hauling over-the-counter purchases from retail establishments. For-hire truck—Trucks that carry freight for a fee collected from the shipper, recipient of the shipment, or an arranger of the transportation.

2. **Rail.** Any common carrier or private railroad.

3. **Water.** Includes shallow draft, deep draft and Great Lakes shipments.

4. **Air (includes truck-air).** Includes shipments typically weighing more than 100 pounds that move by air or a combination of truck and air in commercial or private aircraft. Includes air freight and air express. Shipments typically weighing 100 pounds or less are classified with *Multiple Modes and Mail*

5. **Multiple Modes and Mail.** Includes shipments by multiple modes and by parcel delivery services, U.S. Postal Service, or couriers. This category is not limited to containerized or trailer-on-flatcar shipments.

6. P**ipeline.** Includes flows from offshore wells to land, which are counted as water moves by the U.S. Army Corps of Engineers.

7. **Other and Unknown.** Includes flyaway aircraft, vessels, and vehicles moving under their own power from the manufacturer to a customer and not carrying any freight, unknown, and miscellaneous other modes of transport.

8. **No Domestic Mode.** A 'No Domestic Mode' category is used to capture petroleum imports that go directly from foreign, inbound ships to an on-shore US refinery. This is done to ensure a proper accounting when foreign and domestic flows are summed, while avoiding assigning flows to the domestic transportation network that do not use it.

FAF^2 Modal definitions are as follows:

1 – 4. Truck, Rail, Water and Air (including truck-air) definitions are the same as those used in FAF^3.

5. Truck-Rail Intermodal—Shipments that use a combination of truck and rail.

6. Other Multiple Modes—Includes Parcel (U.S. Postal Service or Courier), truck-water, and water-rail.

7. Other and Unknown Modes—Includes Pipeline and any mode not listed above.

The FAF3 Commodity Classes, like those in FAF^2, mirror the 43, 2-digit (i.e. most aggregate) SCTG classes reported by the 2007 CFS. Differences in the composition of these classes between 2002 and 2007 are relatively minor, with two exceptions:

- Printed product flows, which were absent from the 2002 CFS and hence modeled as OOS flows in FAF^2 were covered in the 2007 CFS.
- A second change for FAF^3 was the O-D specific treatment of natural gas products, which were evaluated only at the level of national or broad regional activity totals in FAF^2.

Appendix B: A How the FAF3 Log-Linear /Iterative Proportional Fitting (LL/IPF) Model Works

In FAF3, we build a 4-dimensional table of flows between origin and destination zones (O and D) by mode (M) and commodity (C). Each cell in turn contains 3 measures of that flow: tons, dollars, and ton-miles, essentially making the type of unit measure (U) a fifth dimension. Freight movements occur in different categories which may be independently estimated, namely, shipments from commercial establishments within the scope of the Commodity Flow Survey, from industries outside that scope (for example, construction, agriculture, services, retailing, petroleum and natural gas extraction), and imports and exports. (Shipments from the government and residential sectors are excluded from FAF3). The 2007 CFS and out-of-scope (OOS) components are added together for the complete movement matrix. Estimation of these OOS components, which include a number of sector-specific models and data sources for their estimation, are those described in Section 3.3 in the main body of this report.

The 2007 CFS accounts for is approximately 70% of FAF3 flows, and takes advantage of voluminous survey data not available for the other sectors. In essence, the 2007 CFS is a series of marginal totals of the fully disaggregate ODCM matrix. Some tables, for instance, may contain state-to-state flows, states being aggregations of FAF zones, while others contain commodity and modal totals aggregated over all origins. The CFS component of FAF is required to be consistent with each marginal total published by the 2007 CFS.

However, the CFS is bedeviled by several complicating factors that inhibit its use in constructing a complete ODCM matrix, including the following:

(1) There are a very large number of missing cells in every CFS table. This may be because there was a small volume in the cell, which was rounded to zero if less than half a kilo-ton or half a mega-dollar, or the value may have been suppressed for confidentiality reasons, or suppressed because of a high coefficient of variation in the flow estimate, implying low confidence in the expansion of the sample. At high levels of disaggregation--any marginal table with 3 or more dimensions--missing or zero valued cells far outnumber cells reporting positive flow values. But these quantities must still be estimated in the FAF3 ODCM table.

(2) The published CFS tables include both domestic and export shipments. Exports in FAF3 are independently determined, so they had to be removed from the CFS component. The process used estimated an ODCM table for all CFS shipments (called CfsAll), and then to removed export shipments, leaving a domestic CFS table that formed the CFS component of FAF3.

In addition to the published CFS marginal tables, the U.S. Census Bureau also provided the FAF3 project with an ODCM matrix of the count of raw shipments in the sample. This matrix was used to identify "true zeros," that is, cells where there was no movement of any type in the CFS. This does not mean that there was no activity in reality, for there could easily have been shipments that escaped the CFS sample. For instance, many zone pairs recorded no CFS shipments of any type. But the FAF objective was only to reproduce expanded CFS shipments, and not to estimate the probabilities of shipments occurring where none were observed.

A standard technique for producing a full disaggregate matrix when only aggregate marginal totals are known is to use Iterative Proportional Fitting (IPF) on a starting table. The marginal totals are here called "controls," i.e. marginal values that the final table must meet. IPF makes the minimal changes possible in the starting table necessary to match this set of control totals, as measured by the sum of weighted squared deviations between base and final tables. In practical terms, it preserves the patterns in the original table to the extent possible while still meeting measured control totals. IPF works by comparing the sum of cells in a region of the table covered by a particular control total to its measured value. If too high, all of the cells are reduced by the same percentage value so that their sum will equal the control. Of course, a later control total covering a region that overlaps a portion of this one will disrupt that equality, since different cells will be adjusted by different factors. However, these adjustments become smaller with each subsequent iteration, until factors become indistinguishable from a value of 1. This process is guaranteed to converge provided the control totals are not contradictory, and there is no zero region of the starting matrix covered by a positive control total.

As an example, assume the 2007 CFS reports 57 kilotons of machinery between Washington state and Idaho. At some iteration, suppose the ODCM table reports that the sum of the 14 cells where O={531,539}, D={160}, C={34}, M={1:7} has a value of 52. Then the values in each of these 14 cells will be multiplied by 57/52 to bring the sum into compliance. At some future step in the same cycle, there will be a control total for all machinery shipped by rail from Seattle, and this will be compared to the sum for all destinations: in this instance the 123 cells where O={531}, D={011:560}, C={34}, and M={2}. These cells overlap the first region at the single cell ODCM(531,160,34,2). If this step reduces its value, say from 19 to 17, then the sum of the first region will decline from 57 to 55. On the next cycle, 55 will be compared to 57, and each of the 14 cells will be multiplied by 57/55. These adjustments grow progressively smaller with each cycle.

IPF guarantees an output ODCM consistent with the CFS, that is, with every CFS value in every CFS published table. The issue is the starting matrix used, as individual cells covered only by wide-ranging, non-specific controls may vary dramatically, yet still be consistent. In particular, a starting matrix of all 1's may be used, which is a minimum information approach to IPF, positing an initial ODCM table with no internal pattern to be preserved by the IPF. But we can

do better than this by estimating an internal pattern from both CFS and external data on commodity flows.

A parsimonious method to describe the pattern of an activity matrix is to posit a set of multiplicative "effects" that are responsible for the observed activity. The model has the following form:

The value of cell ODCM(i,j,c,m) = K * grand mean scale factor, alias "e0" (e-zero)

* eO(i) * eD(j) *eC(c) * eM(m) first order (low level) effects

* eOD(ij) * eOC(ic) * eOM(im) * eDC(jc) * eDM(jm) * eCM(cm) 2nd order interaction effects

* eODC(ijc) * eODM(ijm) * eOCM(icm) * eDCM(jcm) * 3rd order interactions

* eODCM(ijcm) high level individual effects

Each of these effects are 0- to 4-dimensional matrices. eg. eOD is a 123 x 123 matrix of every CFS origin and destination zone pair. The cells of these matrices are the parameters of the effects model, and there are many more parameters than there are cells in the original ODCM matrix we are trying to describe. Note in particular that eODCM = ODCM, with every other effect equal to 1, meets the required equation. However, this is a solution that tells us nothing about the pattern within the table. Instead, we seek a set of effects that minimizes the information content of the model. That is the rationale of calling this description the most "parsimonious."

The information content of this system is sum | x(k) * ln(x(k)) | over all of the effects parameters. If we can make the large number of high level effects small, that is, close to 1, while the small number of low level effects are large, and still satisfy the basic equation, we will succeed in reducing the information content. We will also succeed in describing the structure of the table, as we can identify a small and understandable set of effects primarily responsible for the observed activity.

The solution procedure follows our common-sensical notion of the purpose of an effects model of transferring variation from high to low order effects. We start with eODCM = ODCM, with every other e=1. For every high level effects matrix, we extract as much variation as possible and pass it back to a lower level effect. Next, for a particular ODC combination, find the geometric mean over all modes of the cells comprising eODCM(ijc*). Then divide those cells by the geometric mean, making them closer to 1, while multiplying the single cell eODC(ijc) by the same quantity. This will not change the basic equation, but it will succeed in reducing |x ln(x)| for a large number of cells, while increasing it in only one. This action is repeated for every (ijc) combination. Similarly, pass variation from eODCM back to eDCM by passing the geometric

mean of eODCM(*jcm) back to the single cell eDCM(jcm). Then continue to the next level, passing variation from eODC back to eOD, eOC, and eDC. There is no requirement of order in this process, and levels may be jumped, for example, by going from eODCM straight to eO, but this will not affect the outcome.

To illustrate with a 2-dimensional OD matrix alone, suppose we know these flows between zones A, B, and C, for a total flow of 19,500 units (e.g. tons):

Origin	Destination				eO	eD			
	A	B	C	Sums					
A	2000	750	400	3150	1	1	1	1	
B	1500	2250	1800	5550	1				
C	1200	3600	6000	10800	1				K=1
Sums	4700	6600	8200	19500					

The ‘Sums’ here are the marginal row (Origin) and column (Destination) flow totals. Extracting variation for origin A, the geometric mean of row 1 is 843. Dividing that into the row, and multiplying eO(A) yields a row of [2.37, 0.89, 0.47]. Repeating for the other two origins:

Origin	Destination				eO	eD		
	A	B	C					
A	2.37	0.89	0.47	843		1	1	1
B	0.82	1.23	0.99	1825				
C	0.41	1.22	2.03	2959		K=1		

Next, we can extract variation from eO, which has a geometric mean of 1657, and pass it to the grand mean. Now pass variation from eOD to eD in the same way. The geometric mean of the first column is $(2.37*0.82*0.41)^{(1/3)} = 0.93$.

Origin	Destination				eO	eD		
	A	B	C					
A	2.54	0.81	0.48	0.51		0.93	1.10	0.98
B	0.88	1.12	1.01	1.10				

C	0.44	1.11	2.07	1.79	K=1657

If necessary, the cycle can be repeated, but when every original cell is filled (no missing values or structural zeros), one iteration is exact. Every subspace, every row, column, and square in every matrix, has a geometric mean of one, and no further extraction of variability is possible. Multiplying through by effects will recover the original matrix.

Now we have an interpretation of the original flows: eO and eD are the attractiveness of the zones for originations and terminations, while eOD are the factors specific to each pair of zones not accounted for by the nature of the zones themselves. The is similar to the foundation of a spatial interaction model that posits flows between i and j to be proportional to A(i)*B(j)*c(ij), where c is an inverse cost or distance function between zones.

Should it happen that the original matrix is for a base year, and that in a future year one wishes to estimate interzonal flows while knowing only the new marginal totals, one would use IPF to preserve the base pattern as much as possible while matching the new controls. Should it happen that margins are known without any disaggregate data, one estimates the pattern with a model of interaction effects, the c(ij) above, and uses that as the IPF seed.

For the CFS, we face a similar problem estimating the interaction effects in a matrix where most of the cells are missing. Even without knowledge of marginals, the known cells can still be used to estimate interaction effects. We do this by following the same extraction of variance procedure from the known cells, and bypassing the unknown cells. In a lower level interaction matrix, geometric means in any subspace are calculated from the known cells, and those are passed up to the next higher level interaction effect that covers the subspace. Again, this process does not disrupt the basic equation of cell values as the product of effects that cover it, but it does succeed in minimizing the system's information content within that constraint.

Returning to our OD matrix, suppose that "-" represents a missing value:

Origin	Destination				eO	eD		
	A	B	C	Sums				
A	2000	750	-	-	1	1	1	1
B	-	-	-	5550	1			
C	1200	3600	6000	10800	1	K=1		
Sums	4700	6600	-	-				

Passing variation from eOD to eO [$(2000*750)^{(1/2)=}1225$]:

Origin	Destination				eO	eD		
	A	B	C	Sums				
A	1.63	0.61	-	1225		1	1	1
B	-	-	-	-				
C	0.41	1.22	2.03	2959		K=1		

Passing variation on from eO to K and from eOD to eD:

Origin	Destination			eO	eD		
	A	B	C				
A	1.99	0.71	-	0.64	0.82	0.86	2.03
B	-	-	-	-			
C	0.50	1.42	1.00	1.55	K=1904		

Now passing variation from eD to K, $(0.82*0.86*2.03)^{(1/3)}$ =1.12, and 1904*1.12=2132. Then repeat from eOD to eO:

Origin	Destination			eO	eD		
	A	B	C				
A	1.67	0.60	-	0.76	0.73	0.77	1.81
B	-	-	-		-		
C	0.56	1.60	1.12	1.38	K=2132		

Similarly $(1.99*0.71)^{(1/2)}$ = 1.19, and 0.64*1.19= 0.76. Continuing through more iterations:

Origin	Destination			eO	eD		
	A	B	C				
A	1.69	0.60	-	0.76	0.69	0.73	2.00
B	-	-	-	-			

C	0.59	1.66	1.00	1.31	K=2255

If any effect is missing, that is, no data contributes to it, we take the minimum information solution and estimate it as 1, that is, "no effect." Multiplying through by effects, we reconstruct the original matrix with our estimates for missing values:

Origin	Destination				eO	eD		
	A	B	C	Sums				
A	2000	750	3428	-	0.76	0.69	0.73	2.00
B	1556	1646	4510	5550	-			
C	1200	3600	6000	10800	1.31	K=2255		
Sums	4700	6600	-	-				

This is now a seed matrix for the IPF to match the control totals. Examining the second row, (1556+1646+4510)=7712, so the adjustment factor will be 5550/7712.

Origin	Destination			
	A	B	C	Sums
A	2000	750	3428	-
B	1120	1185	3246	5550
C	1200	3600	6000	10800
Sums	4700	6600	-	-

Continuing to the first and second columns:

Origin	Destination			
	A	B	C	Sums
A	2176	894	3428	-
B	1219	1413	3246	5550
C	1306	4293	6000	10800
Sums	4700	6600	-	-

Then using the individual cells with known values as IPF controls, we recover those values, and repeat the second row on the next cycle. The adjustment factor is now 5550/5878, a substantial improvement over the first iteration:

Origin	Destination			
	A	B	C	Sums
A	2000	750	3428	-
B	1151	1334	3065	5550
C	1200	3600	6000	10800
Sums	4700	6600	-	-

Continuing through more iterations,

Origin	Destination			
	A	B	C	Sums
A	2000	750	3428	-
B	1500	2250	1800	5550
C	1200	3600	6000	10800
Sums	4700	6600	-	-

In this case, only one cell is not completely determined by the controls, OD(A,C), and it retains the estimate made by multiplicative effects. In the larger matrices of the CFS the indeterminate cells are vastly larger in number. The model of effects is called a log-linear model, due to the computational convenience of finding geometric means by averaging logarithms. We use it in the CFS both to understand the structure of the table and to establish a "most likely" seed matrix to use in the IPF stage.

Note that, for any matrix of effects, an initial set of effects can be specified, perhaps from a model (as the c(ij)), or from an independent estimation. The information content of the system will be higher, which is natural since we are introducing additional information. (However, this makes it more problematic to claim "maximum likelihood" estimated effects.) But the mechanics of extraction of variation do not change, nor will the basic equation setting any table value to the product of its contributing effects.

A particularly appealing opportunity to estimate higher order effects occurs when margins are known with greater precision than the fully disaggregate activity table. That margin table may be the starting point for extraction of variation to calculate effects. In the above OD table, the vector of destinations [4700, 6600, -] is used as the initial destination effects vector eD, leading via a geometric mean to 5570 to eD = [0.84, 1.18, -] and K = 5570. Then, to estimate the lowest level effects, the original table values must take into account the contribution from high level effects by dividing each cell by the product of already calculated effects above it: the new eOD'(ij) = eOD(ij) / [eO(i) * eD(j) * K].

Then upward extraction of variation may proceed in the usual way.
In the above example where eD is estimated from marginals:

Origin	Destination			eO	eD		
	A	B	C				
A	0.43	0.11	-	1	0.84	1.18	-
B	-	-	-	1			
C	0.26	0.55	1.08	1	K=5570		

Now extract eO from eOD:

Origin	Destination			eO	eD		
	A	B	C				
A	1.95	0.50	-	0.64	0.84	1.18	-
B	-	-	-	-			
C	0.48	1.02	2.00	1.57	K=1922		

and then extract further variation from eOD into eD:

Origin	Destination			eO	eD		
	A	B	C				
A	2.02	0.70	-	0.62	0.75	0.75	1.78
B	-	-	-	-			
C	0.50	1.43	1.00	1.57	K=2156		

This process continues until there is no more variation to extract:

Origin	Destination				eO	eD	
	A	B	C				
A	1.69	0.59	-	0.74	0.71	0.71	1.97
B	-	-	-	-			
C	0.59	1.68	1.00	1.35	K=2281		

Keep in mind that marginal matrices are not themselves direct estimators of higher order effects, since other interaction effects contributed to the marginal totals. Consequently, this method of estimation from marginals can be expected to skew the resulting estimation of all effects matrices in ways difficult to predict. But these adverse effects are probably minor compared to the confounding factor of large numbers of missing cells.

For the CFS, the first task is to estimate a seed matrix that has missing values estimated from patterns contained in regions where data is not missing. This is done through a log-linear model that estimates effects, and multiplies all effects that cover a cell to estimate a level of activity.

The complete FAF3 freight flows matrix actually contains 6 dimensions:

O - 123 origin zones

D - 123 destination zones

C - 43 commodity classes

M - 7 modes

S - 4 data sources

U - 3 activity unit types

The activity types are value (M$), weight (Ktn), and ton-miles (Mtmi). The sources are:

1 - CFS 2007

2 - CFS 2002

3 - CFS 1997

4 - Carrier activity from the public (state-to-state) 2007 Waybill Sample and a state-to-state interaction matrix from Waterborne Commerce. These two sources separately occupy the m=2 and m=3 levels of the s=4, u=2 activity matrix. The carrier data for other modes remains "missing" and therefore does not contribute to pattern identification. The complete activity matrix can be given as A(i,j,c,m,s,u). Including a provision for a level 0 in each dimension to hold marginal totals, this is approximately 100 million cells. The activity matrix does double

duty by holding the highest order interaction effects matrix, eODCMSU. In addition, there are effects matrices for each combination of dimensions, to wit:

K eO eD eC eM eS eU

eOD eOC eOM eOY eOV eDC eDM eDS eDU

eCM eCS eCU eMS eMU eSU

eODC eODM eODS eODU eOCM eOCS eOCU eOMS eOMU eOSU

eDCM eDCS eDCU eDMS eDMU eDSU eCMS eCMU eMSU

eODCM eODCS eODCU eODMS eODMU eODSU eOCMS eOCMU eOCSU
eOMSU eDCMS eDCMU eDMSU eCMSU

eODCMS eODCMU eOCMSU eDCMSU

However, these effects matrices are located in the zero'th levels of the highest order effects matrix. For example, eOCSU(icsu) is stored in A(i,0,c,0,s,u), and the interaction effect of Alaska and coal production tonnage in CFS 2007 will be in A(4,0,15,0,1,2). If this number is high, it is because coal is unusually important in Alaska, and not because coal is a high proportion of all shipments (which is accounted for by eC(15) or eCU(15,2)), and it's not because Alaska is a big shipper (accounted for by eO(4)). The reason for having multiple sources is the hope that if there is some region of the CFS 2007 matrix that contains missing values, there will be another source where it is not missing. If so, patterns detected in that area will shine through into CFS 2007 by contributing to interaction effects independent of source. For instance, if by chance no coal producers in Alaska were excluded in the CFS 2007 sample, but were included in CFS02, any mode or destination distributions would migrate into the interaction effects eODC or eOCM independent of source. Lacking CFS 2007-specific effects, these effects would determine the values that end up in the CFS 2007 level of the activity matrix.

There are serious issues in commodity code conversions and comparable zones. In general these were resolved rather crudely. For instance, West Palm Beach in CFS 1997 has been swallowed by Miami in CFS 2002 and CFS 2007, so it is simply ignored in the s=CFS 1997 level. And new zones that appeared in CFS2007, such as Mobile, are declared "missing" when filling in values for previous CFS datasets. Some Waterborne Commerce commodity codes map into a single SCTG, leaving the other commodity classes "missing" in the (s=carrier, m=water) level. And of course the carrier data includes bogus origins and destinations for what are actually intermodal trips. But the point here is to provide a starting point for the IPF. If the CFS 2007 really is missing the data, even crude patterns are considered better than none. To construct a CFS

ODCM activity matrix, we had to rely on the most disaggregate published CFS table, which is state-to-state rather than zone-to-zone by commodity and mode. For those states that contain a single zone, these values directly filled cells of the ODCM table. When there were multiple zones, the state values were divided evenly among zones comprising the state. Further, within each CFS and type level, each available 2-dimensional marginal total (OD, OC, OM, DC, and CM) was used to estimate initial interaction effects at that order. At the conclusion of the log-linear model's iterations, the final estimated effects were cross multiplied to produce an activity matrix for the CFS 2007, this time with missing values estimated. That matrix is input to IPF to match published CFS activity. The result is a CfsAll activity matrix that covers all movements within the scope of the 2007 CFS, both domestic and export. CfsAll is fitted by a further IPF to the few controls in the 2007 CFS that apply to exports only.

During this IPF stage additional care is taken that no result cell will exceed its input. The result is CfsExp. Subtracting CfsAll - CfsExp = CfsDms, an initial matrix that estimates domestic (non-export) shipments captured in the CFS. A further IPF is done on CfsDms using a special U.S. Census Bureau tabulation of domestic-only shipments by ODC. Another special tabulation is an ODCM table of raw shipments (no expansion factors) captured in the sample. Where zero, these values force the activity in that ODCM cell to zero as well.

Appendix C: Estimation of Air Freight Imports and Exports[34]

C1. General Description of Estimating International Air Cargo

The first step to estimating international air cargo is to develop crosswalks that reconcile the differing geographic and commodity information on the OAI, Census and CFS data. The flows at an aggregate level are estimated using OAI data to align the market data with the segment data (market data has enplaned/deplaned tons by flight number while segment data has tons transported on an airport-to-airport basis). The first step of the process matches market to segment data where they agree. The second step uses a two-leg process where the segment data is matched to the market data if it's the least distance route between market data end-points and flown by a single carrier. The third step is like the second, but the carrier is ignored as a criterion. The fourth step uses FAF Region to FAF Region irrespective of carrier.

C2. Method for Estimating the International Air Cargo Totals

Combining the OAI and Census data into a FAF3 dataset requires reconciling differences in the level of detail/aggregation for commodities and geographic entities. In the case of commodity-types and values, the OAI data is at a more general level than is required by FAF3 – a topic that is covered in the sections below on estimation. This section covers the cross-walks used to reconcile differences between the commodity-types on the Census and FAF3 datasets and the geographic information on all three datasets.

Several cross-walks were already available from FHWA. Commodity cross-walks between the Harmonized System used in the Census Foreign Trade files to the SCTG codes used in FAF3 are available at http://ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_tech_document.htm. Cross-walks between countries and foreign trade regions are available upon request from FHWA (contact Michael Sprung at Michael.Sprung@fhwa.dot.gov). A third cross-walk from U.S. counties to FAF regions was also provided by FHWA.

The cross-walks to be developed are translations between different levels of specificity for geographic information between the OAI data and Census/FAF3. The OAI geography is based on airports, the most specific level of detail, and is used as a link between the other two. Each

[34] The material in the Appendix is taken from a fraft report by MarcroSys, LLC. (2010) titled "Estimation of Exports and Imports by Air for FAF3"

airport is assigned to both a Customs District and a FAF3 region so that the relevant (dis)aggregation can be accomplished.

The first cross-walk developed for FAF3 International Aviation is from U.S. airports to counties, which is used in combination with the existing cross-walk from counties to FAF3 regions. The matching process requires two supplemental files: the Master Coordinates File (MCF) from OAI, available at :

http://www.transtats.bts.gov/Tables.asp?DB_ID=595&DB_Name=Aviation%20Support%20Tables&DB_Short_Name=Aviation%20Support%20Tables

and the county subdivision file from Census, available at :

http://www.census.gov/geo/www/gazetteer/places2k.html

Two other sources also proved useful when the assignment of an airport to a county was unresolved from the first round of processing: Both the MCF and County Subdivision files have information on the state and on latitude and longitude. Within each state, the airports are matched to the two closest county subdivisions. Two subdivisions are matched because airports are often near the border of their actual county and closer to the geographic center of another county subdivision. When the two closest subdivisions were in the same county, the airport was assigned to that county. When the two closest subdivisions were in different counties the conflict was resolved by further research under two criteria: 1) if the implied FAF region was different for the two counties, and 2) if the airport was in the top 150 airports for enplaned freight and mail. Various internet sources were used for this research, including: Wikipedia; Mapquest ® at:

http://www.mapquest.com/maps/;

and the National Association of Counties website at:

http://www.naco.org/Template.cfm?Section=Data_and_Demographics&Template=/cffiles/counties/city_srch.cfm.

The second cross-walk developed for FAF3 International Aviation is from U.S. airports to U.S. Customs Districts. As above, the MCF provides information on airports in the form of airport name, state, city name, and latitude and longitude. In order to assign airports to Customs Districts a hierarchical matching method is used. Matching airports to Customs Districts is more complicated because Customs Districts are less uniform than counties, i.e. a state may have multiple Customs Districts, no named District or Sub-District, or a Customs District may span

more than one state. While Customs Sub-Districts also consist of places in the usual geographic sense of cities or regions, they may also be airports and business places (e.g. FedEx processing centers).

Matching Customs Sub-Districts to Airports

For those Sub-Districts which are also airports, assign the airport to that Sub-District. A list of Customs Districts/Sub-Districts is available at:

http://www.census.gov/foreign-trade/schedules/d/dist.txt.

For the remaining Sub-Districts, match the Sub-District name to a Census Place Name (a list of census place names, that includes latitude and longitude, is also available at:

http://www.census.gov/geo/www/gazetteer/places2k.html).

This process required a great deal of manual editing and also the use of supplemental information from the CFR, customs, Mapquest ® and the National Association of Counties websites.

Use the latitude and longitude information available from both the Census Places file and the MCF to determine the closest Sub-Districts for each airport. Choose between the two based on the airport city name or additional information. Note that an airport may be, and often is, on the outskirts of its actual place, and therefore closer to a second place.

The matching process resulted in each U.S. airport being assigned to a Customs Sub-District.

C3. Method for estimating the regional statistics and origin-destination flows

International Routes

The estimation is based on individual airports which can be allocated to the county-level. The data can be provided at a more detailed level than is required under FAF3. The OAI market data for international shipments is missing the port-of-entry/exit while the Census foreign trade data is missing the port-of-exit for exports, while the port-of-entry for imports does not necessarily correspond to the FAF definition of port-of-entry. This section outlines a procedure for reconciling the differences between the two datasets and assigning a port-of-entry/exit to the OAI market data, based on the OAI segment data. The guiding philosophy behind the algorithm is to impose aggregate efficiency by minimizing the distance transported at each step. The specification of the algorithm is based on a port-of-exit. The extension to a port-of-entry is straight forward.

Notation:
Superscripts:
1st Position: M = market data, S = segment data, F = FAF3 results.
2nd Position: t = time period. Time periods are annual.
Subscripts:
1st Position: i = origin airport
Last Position: j = destination airport
Intermediate Position in the case of 3 nodes: k = port-of-entry/exit
T = tons shipped.

a) For market routes that match non-stop segment routes for both origin and destination and by carrier, assign the min($T^{Mt}_{ij,}$ $T^{St}_{ij,}$) to T^{Ft}_{ij} and reduce both T^{Mt}_{ij} and T^{St}_{ij} by T^{Ft}_{ij} to obtain residual tonnage for each market route and port.

b) Determine the remaining market and segment routes from the remainders from step a) and all market and segment routes that did not match in step a).

c) Create two-leg routes from the segment data in which the origin and destination match the origin and destination from the market routes in step b) with the intermediate stop restricted to be domestic: T^{St}_{ikj} = min($T^{St}_{ik,}$ T^{St}_{kj}) where {i, j} correspond to {i, j} from b) and k is domestic.

   i. For each carrier and each market route, find the best (based on shortest distance) intermediate stop. Let the distance for this route be given by dist(ik^1j).
   ii. For each carrier and each market route, find the second best intermediate stop with distance given by dist(ik^2j).
   iii. Calculate the cost-savings for each route of using the best intermediate stop = dist(ik^2j) - dist(ik^1j).
   iv. For each carrier, find the route which gives the greatest cost savings and denote this route (ikj)*. Then let T^{Ft}_{ikj*} = min($T^{Mt}_{ij,}$ T^{St}_{ikj*}).
   v. Bookkeeping: Reduce T^{Mt}_{ij}, $T^{S}_{ik.}$ and $T^{S}_{.kj}$ by T^{Ft}_{ikj*} for the carrier.
   vi. Repeat steps a-e until all market routes have been evaluated for all carriers.

d) Determine the remaining market and segment routes from the remainders from step b) and those routes for which no two-leg routes could be formed.

e) For each carrier, aggregate airports to their FAF region level. Recalculate distance as the ratio of ton-miles to tons transported rather than airport-to-airport distance.

f) Rerun step c) using the FAF region level rather than the airport level.

g) For the international routes that were unmatched in steps a, c, and f assign the port-of-entry/exit to be the domestic destination/origin.

h) Create an international dataset based on international routes from steps a, c and f, plus the international market routes from step g). (Note: Step h) is actually done in tandem with the assignment of commodity-type and value. This aspect is excluded here for simplicity.)

i) Aggregate the results over carriers and airports to FAF regions.

The result of this algorithm will be a dataset with shipment weights by origin-port of exit-destination. Matching is done at the carrier level to preserve the correspondence between market and segment data in the OAI datasets. Appendix B, Table B1, provides round-by-round results of the estimation. Round 1 corresponds to step a), round 2 to step c), round 3 to step f), and round 4 to step h). For imports (exports), rounds 2 and 3 assign a different port-of-entry (exit) than the domestic destination (origin). These two rounds accounted for about 17% of imports and 13% of exports. A large majority of the data, more than 70% for both imports and exports, is assigned its port-of-entry/exit in the first round where it is equal to the original port-of-entry (exit) for imports (exports).

Estimating Commodity Composition and Value

Commodity composition and value are available from Census for exports at the domestic origin, and for imports at the domestic destination based on the Census geographic definitions. The Census information is used to estimate commodity composition and value for the OAI data. The corresponding domestic origin for exports and domestic destination for imports from the OAI data will be referred to as the matching ports.

The first step in the estimation process is to determine whether it is reasonable to combine the two data sources. Evidence that combing the data is reasonable is given by the high correlation for tonnage values at the matching ports between the two data sources (see the bottom of Table B2 in Appendix B). Two caveats to this estimation need to be noted. The first is that the OAI data is about 20% larger than the Census data for both imports and exports. Although there are several differences between the data sources, the strongest explanation is that the difference is due to the OAI data including more in-transit shipments than the Census data. The OAI data is based on carrier reporting with market routes defined by enplanement and deplanement of the cargo. An in-transit shipment that switches carriers in the U.S., or which is transferred from one plane to another by the same carrier, would appear as an import/export on the OAI data. However, the same shipment would be more likely to be designated as in-transit in Customs' reporting to Census. Additional evidence that differences are due to in-transit shipments is that

the Customs Districts with the largest differences are also likely transshipment ports: New York, Miami, and Anchorage. The large-differences-for-a-few Customs Districts is the second caveat as this property affects whether it is reasonable to apply Census information to the OAI data on a district-by-district basis. The second caveat is addressed in the estimation process.

The estimation philosophy is to assign the Census commodity distribution and value-per-ton by commodity (prices) to the OAI data for each matching port while keeping the aggregate commodity distribution and prices equal to that for the Census data. Because of the differences in tonnage for some key ports a straight-forward port-by-port application would result in large differences at the aggregate level. The first step in the port-by-port estimation is to rescale Census exports/imports by the ratio of the respective OAI-to-Census aggregates. The approach taken here has two parts. For the portion of a matching port's tons that are on both the OAI and the rescaled Census data, the distribution and prices are taken directly from the Census data. The remainder can be either excess Census tons, or excess OAI tons. The commodities and values for matching ports with excess Census tons are then aggregated to define residual commodity shares and prices. The residual commodity shares and prices are then applied to the excess tons OAI tons. The result is an OAI-based dataset that reflects the Census commodity distribution and prices at the aggregate level and also captures a large share of Census port-level differences in commodities and prices.

More formally, the estimation algorithm can be written in terms of exports as follows:

Let α = a 33x1 vector of air-transported commodity shares, i.e.

$$\alpha^{Ct}_{ij} = (T^{Ct}_{ij} / \sum_{j=1,J} T^{Ct}_{ij}) = (T^{Ct}_{ij} / T^{Ct}_{iJ}) \quad \text{(D1)}$$

and p = a 33x1 vector of air-transported commodity prices, i.e.

$$p^{Ct}_{ij} = (V^{Ct}_{ij} / T^{Ct}_{ij}) \quad \text{(D2)}$$

and σ = the export scale factor = $[(\sum_{i=1,I} \sum_{j=1,J} T^{Ot}_{ij}) / (\sum_{i=1,I} \sum_{j=1,J} T^{Ct}_{ij})] = (T^{Ot}_{iJ} / T^{Ct}_{iJ})$

(D3)

So that:

$$T^{Rt}_{iJ} = T^{Ot}_{iJ} - \sigma T^{Ct}_{Ij} \quad \text{(D4)}$$

and let:

$$A = \{ T^{Rt}_{iJ} < 0 \} \text{ and } B = \{ T^{Rt}_{iJ} > 0 \} \quad \text{(D5)}$$

$$\alpha_{Aj} = (\sum_{i \varepsilon A} T^{Rt}_{ij} / (\sum_{i \varepsilon A} T^{Rt}_{iJ}) \quad \text{(D6)}$$

$$p^{At}_{ij} = (\sum_{i \varepsilon A} p^{Ct}_{ij} * \alpha^{Ct}_{ij} * T^{Rt}_{iJ}) / \sum_{i \varepsilon A} \alpha^{Ct}_{ij} * T^{Rt}_{ij} \quad \text{(D7)}$$

$$M^{t}_{iJ} = \text{Min}\,(T^{Ot}_{iJ}, \ \sigma\, T^{Ct}_{iJ}) \qquad \text{(D8)}$$

Then,

$$T^{Rt}_{ij} = \alpha^{Ct}_{ij} * M^{t}_{iJ} + \max\,(\alpha^{At}_{ij}\, T^{Rt}_{iJ}, 0) \qquad \text{(D9)}$$

Then,

$$\alpha^{Ft}_{ij} = (T^{Ft}_{ij} \ / \ T^{Ft}_{iJ}) \qquad \text{(D10)}$$

and,

$$p^{Ft}_{ij} = [\, p^{Ct}_{ij} * \alpha^{Ct}_{ij} * M^{t}_{iJ} + \max(p^{At}_{ij} * \alpha^{At}_{ij} * T^{Rt}_{iJ})] \ / \ T^{Ft}_{ij} \qquad \text{(D11)}$$

where T = tons shipped V = value, and where the following superscripts are being used:

1st Position: O = OAI data, C = Census data, , R = residual of the OAI minus Census value, and F = the FAF3 results.

2nd Postion: t = time period. Time periods are annual.

while subscripts have the following meaning:

1st Position: i=origin customs district, i=1,…,I, and I=41.

2nd Position: j= commodity j, j=1,…,J, and J=33

and when the capital of the subscript letter is used, it denotes the sum over all values of the subscript.

The resulting FAF commodity shares and prices are then applied at the airport level before aggregating to create tons and value at the FAF regional level.

C4. Data Quality Issues

Errors in the above estimates will be due to two reasons: 1) Neither the ultimate destination for imports nor the original origin for exports is available from the data source, and 2) The actual values and commodity make-up may differ because Census data on Imports/Exports does not cover low-value shipments nor in-transit shipments.

Appendix D: NAICS TO SCTG Commodity Code Crosswalk

212 - Mining (except oil and gas) (NAICS Code)
Relevant SCTG codes:
10 - Calcareous monumental or building stone
11 - Silica sands and quartz sands for construction use
12 - Limestone flux
13 - Non-metallic materials, n.e.c.
14 - Metallic ores and concentrates
15 - Coal

<u>31 - 33 Manufacturing (NAICS code)</u>
311 - Food Mfg (NAICS code)
Relevant SCTG codes:
01 - Live animals & fish
02 - Cereal grains
03 - Other agricultural products
04 - Animal feed and products of animal origin
05 - Meat, fish, and seafood
06 - Milled Grain Products and Preparation
07 - Other prepared foodstuffs
08 - Alcoholic Beverages and tobacco

312 - Beverage & tobacco product mfg (NAICS code)
Relevant SCTG codes:
07 - Other prepared foodstuffs
08 - Alcoholic Beverages and tobacco
09 - Tobacco products

313 - Textile mills (NAICS code)
Relevant SCTG codes:
30 - Textiles, Leather and Articles of Textiles or Leather

314 - Textile product mills (NAICS code)
Relevant SCTG codes:
30 - Textiles, Leather, and Articles of Textiles or Leather

315 - Apparel mfg (NAICS code)
Relevant SCTG codes:
30 - Textiles, Leather, and Articles of Textiles or Leather

316 - Leather & allied product mfg (NAICS code)
Relevant SCTG codes:
30 - Textiles, Leather, and Articles of Textiles or Leather

321 - Wood product mfg (NAICS code)
Relevant SCTG codes:
25 - Logs and Other Wood in the Rough
26 - Wood Products
27 - Pulp, Newsprint, Paper, and Paperboard
28 - Paper or Paperboard Articles
39 - Furniture, Mattresses and Mattress Supports, Lamps, Lighting Fittings and Illuminated Signs

322 - Paper mfg (NAICS code)
Relevant SCTG codes:
27 - Pulp, Newsprint, Paper, and Paperboard
28 - Paper or Paperboard Articles

323 - Printing and related support activities (NAICS code)
Relevant SCTG codes:
29 - Printed Products

324 - Petroleum & coal products mfg (NAICS code)
Relevant SCTG codes:
15 - Coal
16 - Crude petroleum oil & oils
17 - Gasoline including aviation (jet fuel)
18 - Fuel oils including diesel and Bunker C
19 - Coal and Petroleum Products, n.e.c.

325- Chemical mfg (NAICS code)
Relevant SCTG codes:
20 - Basic Chemicals
21 - Pharmaceutical Products
22 - Fertilizers
23 - Chemical Products & Preparations, n.e.c.
24 - Plastics & Rubber

326 - Plastics & rubber products mfg (NAICS code)
Relevant SCTG codes:
24 - Plastics & Rubber

327 - Nonmetallic mineral products mfg. (NAICS code)
Relevant SCTG codes:
31 - Non-Metallic Mineral Products
331 - Primary metal mfg (NAICS Code)
Relevant SCTG codes:
32 - Base Metal in Primary or Semi-Finished Forms and in Finished Basic Shapes
33 - Articles of Base Metal

332 - Fabricated metal products mfg (NAICS code)
Relevant SCTG codes:
32 - Base Metal in Primary or Semi-Finished Forms and in Finished Basic Shapes
33 - Articles of Base Metal
38 - Precision Instruments & Apparatus

333 - Machinery mfg (NAICS code)
Relevant SCTG codes:
34 - Machinery
35 - Electrons & Other Electrical Equipment and Components, & Office Equipment
38 - Precision Instruments and Apparatus

334 - Computer & electronic products mfg. (NAICS code)
Relevant SCTG codes:
35 - Electronic & Other Electrical Equipment and Components, and Office Equipment
38 - Precision Instruments and Apparatus

335 - Electronic equipment, appliances & component mfg (NAICS code)
Relevant SCTG codes:
34 - Machinery
35 - Electronic & Other Electrical Equipment and Components, and Office Equipment
38 - Precision Instruments and Apparatus

336 - Transportation equipment mfg (NAICS code)
Relevant SCTG codes:
36 - Motorized and Other Vehicles (including parts)
37 - Transportation Equipment, n.e.c.

337 - Furniture & related product mfg (NAICS code)
Relevant SCTG codes:
26 - Wood Products
30 - Textiles, Leather, and Articles of Textiles or Leather
39 - Furniture, Mattresses and Mattress Supports, Lamps, Lighting Fittings and Illuminated Signs

421 -wholesale - durable goods(NAICS code)
4211 - Motor vehicle & motor vehicle parts & supplies(NAICS code)
Relevant SCTG codes:
19 - Coal and Petroleum Products, n.e.c.
24 - Plastics & Rubber
35 - Electronics & Other Electrical Equipment and Components, & Office Equipment
36 - Motorized & Other Vehicles (including parts)

4212 - Furniture & home furnishing wholesalers (NAICS code)
Relevant SCTG codes:
26 - Wood Products
30 - Textiles, Leather, and Articles of Textiles or Leather

39 - Furniture, Mattresses and Mattress Supports, Lamps, Lighting Fittings and Illuminated Signs

4213 - lumber & other construction materials wholesalers (NAICS code)
Relevant SCTG codes:
19 - Coal and Petroleum Products, n.e.c.
22 - Fertilizers
23 - Chemical Products & Preparations, n.e.c.
24 - Plastics & Rubber
25 - Logs an Other Wood in the Rough
26 - Wood Products
28 - Paper or Paperboard Articles
31 - Non-Metallic Mineral Products 4214 - Professional & commercial equipment & supplies – wholesale (NAICS code)
Relevant SCTG codes:
34 - Machinery
35 - Electronic & Other Electrical Equipment & Components, & Office Equipment
36 - Motorized & Other Vehicles (including parts)
38 - Precision Instruments and Apparatus
40 - Miscellaneous Manufactured Products

4215 - metal & mineral (except petroleum) wholesalers (NAICS code)
Relevant SCTG codes:
14 - Metallic ores and concentrates
22 - Fertilizers
23 -Chemical Products & Preparations, n.e.c.
24 - Plastics & Rubber
31 - Non-Metallic Mineral Products
32 - Base Metal in Primary or Semi-Finished Forms and in Finished Basic Shapes
33 - Articles of Base Metal

4216 - electrical goods wholesalers (NAICS code)
Relevant SCTG codes:
34 - Machinery
35 - Electronic & Other Electrical Equipment & Components, & Office Equipment
36 - Motorized & Other Vehicles (including parts)
38 - Precision Instruments and Apparatus
40 - Miscellaneous Manufactured Products

4217 - Hardware & plumbing & heating equipment & supplies wholesalers (NAICS code)
Relevant SCTG codes:
22 - Fertilizers
23 - Chemical Products & Preparations, n.e.c.
24 - Plastics & Rubber
31 - Non-Metallic Mineral Products
32 - Base Metal in Primary or Semi-Finished Forms and in Finished Basic Shapes

33 - Articles of Base Metal
34 - Machinery
35 - Electronic & Other Electrical Equipment & Components, & Office Equipment
40 - Miscellaneous Manufactured Products

4218 - Machinery equipment & supplies wholesalers (NAICS code)
Relevant SCTG codes:
19 - Coal and Petroleum Products, n.e.c.
34 - Machinery
35 - Electronic & Other Electrical Equipment and Components, & Office Equipment
38 - Precision Instruments and Apparatus
40 - Miscellaneous Manufactured Products

422 - Wholesale - nondurable goods (NAICS code)
4221 - Paper & paper products wholesalers (NAICS code)
Relevant SCTG codes:
27 - Pulp, Newsprint, Paper, and Paperboard
28 - Paper or Paperboard Articles
29 - Printed Products

4222 - Drugs and druggists' sundries wholesalers (NAICS code)
Relevant SCTG codes:
04 -Animal Feed and Products of Animal Origin
06 - Milled Grain Products and Preparation
07 - Other Prepared Foodstuffs
08 - Alcoholic Beverages and Tobacco
21 - Pharmaceutical Products
29 - Printed Products

4223 - Apparel, piece goods, & notions – wholesalers (NAICS code)
Relevant SCTG codes:
28 - Paper or Paperboard Articles
30 - Textiles, Leather, and Articles of Textiles or Leathers

4224 - grocery & related products – wholesalers (NAICS code)
Relevant SCTG codes:

01 - Live Animals & Fish
02 - Cereal Grains
03 - Other Agricultural Products
04 - Animal Feed and Products of Animal Origin
05 - Meat, Fish, and Seafood
06 - Milled Grain Products and Preparation
07 - Other Prepared Foodstuffs
08 - Alcoholic Beverages and Tobacco
43 - Mixed Freight

4225 - Farm product raw materials – wholesalers (NAICS code)
Relevant SCTG codes:
01 - Live Animals & Fish
02 - Cereal Grains
03 - Other Agricultural Products Except for Animal Feed
04 - Animal Feed and Products of Animal Origin, n.e.c.
05 - Meat, fish, and Seafood and Their Preparation
06 - Milled Grain Products & Preparations, & Bakery Products

4226 - Chemical & allied products – wholesalers (NAICS code)
Relevant SCTG codes:
19 - Coal and Petroleum Products, n.e.c.
20 - Basic Chemicals
21 - Pharmaceutical Products
22 - Fertilizers
23 - Chemical Products & Preparations, n.e.c.
24 - Plastics & Rubber

4227 - Petroleum & petroleum products – wholesalers (NAICS code)
Relevant SCTG codes:
16 - Crude Petroleum Oil & Oils
17 - Gasoline including Aviation (jet fuel)
18 - Fuel Oils including Diesel and Bunker C
19 - Coal and Petroleum Products, n.e.c.

4228 - Beer, wine, & distillers alcoholic Bev. – wholesalers (NAICS code)
Relevant SCTG codes:
07 - Other Prepared Foodstuffs
08 - Alcoholic Beverages and Tobacco Products

Appendix E: HS to SCTG Commodity Code Crosswalk

HS Code	SCTG Code	HS Code	SCTG Code	HS Code	SCTG Code
0000.00.00	null				
101	1009	2905.3	20410	7801	32491
102	1001	2905.4	20410	7802	41130
103	1002	2905.5	20509	7803	32491
104	1009	2906	20509	7804	32491
105	1003	2907	20420	7805.00.10	33112
106	1009	2908	20509	7805.00.20	33122
201	5111	2909	20509	7805.00.90	33122
202	5112	2910	20509	7806	33999
203.1	5111	2911	20509	7901	32493
203.2	5112	2912	20420	7902	32493
204.1	5111	2913	20509	7902	41130
204.2	5111	2914.1	20420	7903	32493
204.3	5112	2914.2	20420	7904	32493
204.4	5112	2914.3	20420	7905	32493
204.5	5111	2914.4	20420	7906	33112
205	5111	2914.5	20420	7907	33999
206.1	5111	2914.6	20420	8001	32499
206.2	5112	2914.7	20509	8002	41130
206.3	5111	2915	20430	8003	32499
206.4	5112	2916	20430	8004	32499
206.8	5111	2917	20430	8005	32499
206.9	5112	2918	20430	8006	33112
207.11	5121	2919	20509	8007	33999
207.12	5122	2920	20509	8101.1	32499
207.13	5121	2921	20509	8101.91.10	32499
207.14	5122	2922	20509	8101.91.20	32499
207.24	5121	2923	20509	8101.91.30	32499
207.25	5122	2924	20509	8101.91.40	41130
207.26	5121	2925	20509	8101.92	32499
207.27	5122	2926	20509	8101.93	32499
207.32	5121	2927	20509	8101.99	33999
207.33	5122	2928	20509	8102.1	32499
207.34	5121	2929	20509	8102.91.10	32499
207.35	5121	2930	20509	8102.91.20	32499
207.36	5122	2931	20509	8102.91.30	41130
208	5111	2932	20509	8102.92	32499
209	5130	2933	20509	8102.93	32499

210	5130
301	1004
302	5201
303	5202
304.1	5201
304.2	5202
304.9	5202
305	5203
306	5204
307	5204
401	7111
402.1	7112
402.2	7112
402.9	7119
403	7199
404	7199
405	7191
406	7120
407	4191
408	7791
409	4199
410	4199
5	4199
601	3601
602	3601
603.1	3910
603.9	40999
604.1	3999
604.91	3999
604.99	40999
701	3100
702	3211
703	3212
704	3219
705.1	3213
705.2	3219
706	3219
707	3219
708	3214
709	3219
710	7210
711	7229

2934	20509
2935	20503
2936	20503
2937	20503
2938	20503
2939	20503
2940	20503
2941	20503
2942	20509
30	21000
3101	22010
3102	22020
3103.1	22039
3103.2	22031
3103.9	22039
3104.1	22049
3104.2	22041
3104.3	22049
3104.9	22049
3105	22090
3201	23121
3202	20509
3203	23121
3204	20504
3205	20504
3206.1	20261
3206.2	20262
3206.3	20262
3206.4	20262
3206.5	20262
3207	23121
3208	23110
3209	23110
3210	23110
3211	23121
3212	23121
3213	23121
3214	23121
3215	23122
3301	23201
3302	23201
3303	23202

8102.99	33999
8103.10.10	32499
8103.10.20	32499
8103.10.30	41130
8103.9	32499
8104.1	32499
8104.2	41130
8104.3	32499
8104.9	32499
8105.10.10	32499
8105.10.20	32499
8105.10.91	32499
8105.10.92	41130
8105.9	32499
8106.00.10	32499
8106.00.20	32499
8106.00.30	41130
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8107.10.20	32499
8107.10.30	41130
8107.9	32499
8108.10.1	32499
8108.10.20	32499
8108.10.3	32499
8108.10.40	41130
8108.10.50	32499
8108.9	32499
8109.10.10	32499
8109.10.20	32499
8109.10.30	41130
8109.10.40	32499
8109.9	32499
8110	32499
8111.00.1	32499
8111.00.4	32499
8111.00.92	33999
8111.00.93	41130
8112.11.10	32499
8112.11.20	32499
8112.11.30	41130
8112.19	32499
8112.20.10	32499

712	3229
713	3221
714.1	3219
714.2	3219
0714.90.21	3219
0714.90.22	3229
0714.90.23	3219
0714.90.30	3229
0714.90.40	3219
0714.90.91	3219
0714.90.92	3229
0714.90.93	3219
801.11	3342
801.19	3341
801.21	3341
801.22	3342
801.31	3341
801.32	3342
802.11	3341
802.12	3342
802.21	3341
802.22	3342
802.31	3341
802.32	3342
0802.40.10	3341
0802.40.20	3342
0802.50.10	3341
0802.50.20	3342
0802.90.11	3341
0802.90.12	3342
0802.90.91	3341
0802.90.92	3342
0803.00.10	3321
0803.00.20	3339
0804.10.10	3329
0804.10.20	3339
0804.20.10	3329
0804.20.20	3339
0804.30.10	3329
0804.30.20	3339
804.4	3329
0804.50.10	3329

3304	23202
3305	23202
3306	23202
3307	23202
3401	23300
3402	23300
3403	23909
3404	23909
3405	23300
3406	40999
3407	23909
3501.1	7199
3501.90.10	23909
3501.90.20	23901
3502.1	7791
3502.2	23909
3502.9	23909
3503.00.1	23909
3503.00.2	23909
3503.00.3	23901
3503.00.90	23909
3504	23909
3505.1	6293
3505.2	23901
3506	23901
3507	23909
36	23902
37	23400
3801	35995
3802	23903
3803	23909
3804	23909
3805	23909
3806	23909
3807	23909
3808	23500
3809	23909
3810	23909
3811	23904
3812	23909
3813	23909
3814	23121

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8112.20.30	41130
8112.30.10	32499
8112.30.20	32499
8112.30.30	41130
8112.40.10	32499
8112.40.20	32499
8112.40.30	41130
8112.91.1	32499
8112.91.2	32499
8112.91.30	41130
8112.99	32499
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8203	33321
8204	33321
8205	33321
8206	33321
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8208	33330
8209	33330
8210	33321
8211	33322
8212	33322
8213	33322
8214	33322
8215	33322
8301	33340
8302	33340
8303	33999
8304	33999
8305.1	33999
8305.2	33993
8305.9	33999
8306	33999
8307	33999
8308	40994
8309	33999
8310	33999
8311	34960
8401	34221

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0805.10.20	3339
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0805.20.20	3339
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0805.90.10	3319
0805.90.20	3339
806.1	3322
806.2	3331
807.1	3323
807.2	3329
808.1	3324
808.2	3329
809	3329
810	3329
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812	7239
813.1	3339
813.2	3339
813.3	3339
813.4	3339
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0813.50.30	3342
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901.9	7301
902.1	3991
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902.4	7302
903	7302
904	7303
905	7303
906	7303
907	7303
908	7303

3815	23909
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3817	23909
3818	35813
3819	23904
3820	23904
3821	23909
3822	23909
3823.1	23905
3823.7	20509
3824.1	23909
3824.2	23909
3824.3	23909
3824.4	23909
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3824.90.03	23909
3824.90.04	23909
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3824.90.5	23909
3824.90.6	23909
3824.90.81	23909
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3824.90.84	23909
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3824.90.87	23909
3824.90.91	23909
3824.90.92	23909
3824.90.93	23909
3824.90.94	23909

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8403	34221
8404	34221
8405	34999
8406	34211
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8407.2	34120
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8407.32	34120
8407.33	34120
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8407.9	34120
8408	34120
8409	34130
8410	34211
8411	34212
8412	34222
8413	34310
8414.1	34320
8414.2	34320
8414.3	34320
8414.4	34320
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8414.6	34330
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8414.90.2	34320
8414.90.3	34320
8414.90.40	34330
8414.90.50	34330
8414.90.61	34320
8414.90.62	34330
8415	34410
8416	34999
8417	34999
8418.1	34421
8418.2	34421
8418.3	34421
8418.4	34421
8418.5	34422
8418.6	34422

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910	7303	3824.90.96	23909	8418.91.20	34421
1001	2100	3824.90.98	23909	8418.91.30	34422
1002	2901	3824.90.99	23909	8418.91.40	34422
1003	2902	3901	24101	8418.99.00	34421
1004	2903	3902	24101	8418.99.14	34421
1005	2200	3903	24101	8418.99.15	34422
1006.1	2909	3904	24101	8418.99.16	34421
1006.2	6291	3905	24101	8418.99.17	34421
1006.3	6291	3906	24101	8418.99.18	34422
1006.4	6291	3907	24101	8418.99.19	34421
1007	2904	3908	24101	8418.99.2	34421
1008	2909	3909	24101	8418.99.3	34422
1101	6100	3910	24101	8418.99.4	34422
1102.1	6299	3911	24101	8419.1	34999
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1102.3	6291	3913	24101	8419.31	34999
1102.9	6299	3914	24101	8419.32.10	34999
1103.11	6100	3915	41299	8419.32.91	34999
1103.12	6299	3916	24212	8419.32.92	34991
1103.13	6292	3917	24221	8419.39	34999
1103.14	6291	3918	24222	8419.4	34999
1103.19	6299	3919	24213	8419.5	34999
1103.2	6299	3920	24213	8419.6	34999
1104	6299	3921	24213	8419.8	34999
1105	6299	3922	24223	8419.9	34999
1106	6299	3923	24224	8420.10.1	34999
1107	6210	3924	24225	8420.10.91	34999
1108.1	6293	3925	24229	8420.10.92	34991
1108.2	6299	3926	24229	8420.10.93	34999
1109	6299	4001	24102	8420.10.94	34999
1201	3400	4002	24102	8420.10.99	34999
1202	3501	4003	24102	8420.91.10	34991
1203	3509	4004	41299	8420.91.20	34991
1204	3502	4005	24102	8420.91.9	34999
1205	3503	4006.1	24310	8420.99	34999
1206	3504	4006.90.20	24310	8421.11	34999
1207.1	3509	4006.90.30	24399	8421.12	34930
1207.2	3505	4006.90.40	24399	8421.19	34999
1207.3	3509	4006.90.90	24399	8421.2	34999
1207.4	3509	4007	24399	8421.3	34999
1207.5	3506	4008	24399	8421.91.11	34930

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1207.9	3509
1208	7440
1209	3602
1210	3999
1211	3999
1212.1	3999
1212.2	3999
1212.3	7239
1212.91	3992
1212.92	3992
1212.99	3999
1213	4110
1214	4110
13	3999
14	3999
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1502	7410
1503	7410
1504	7410
1505	7410
1506	7410
1507	7421
1508	7429
1509	7429
1510	7429
1511	7429
1512	7429
1513	7429
1514.10.10	7422
1514.10.20	7429
1514.90.1	7422
1514.90.20	7429
1515.1	7429
1515.2	7423
1515.3	7429
1515.4	7429
1515.5	7429
1515.6	7429
1515.9	7429
1516	7439
1517.1	7431

4009	24391
4010	24399
4011	24310
4012	24310
4013	24310
4014	24399
4015	24399
4016	24399
4017	24399
4101	4192
4102	4192
4103	4192
4104	30501
4105	30501
4106	30501
4107	30501
4108	30501
4109	30501
4110	41299
4111	30501
4201	30503
4202	30502
4203.1	30503
4203.21	40220
4203.29	30503
4203.3	30503
4203.4	30503
4204	30503
4205	30503
4206	30503
4301	4192
4302	30501
4303	30503
4304	30200
4401.1	25091
4401.2	26100
4401.30.10	26909
4401.30.20	41210
4401.30.30	41210
4401.30.50	41210
4401.30.90	41210
4402	26909

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8421.91.19	34999
8421.91.20	34999
8421.91.30	34999
8421.99	34999
8422	34910
8423	34999
8424.1	34999
8424.2	34999
8424.3	34999
8424.81	34999
8424.89.10	34999
8424.89.20	34999
8424.89.30	34995
8424.89.90	34999
8424.9	34999
8425	34519
8426	34519
8427	34511
8428	34519
8429	34520
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8431.1	34519
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8431.3	34519
8431.4	34520
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8434	34920
8435	34920
8436	34920
8437	34999
8438	34999
8439	34991
8440	34992
8441	34991
8442	34992
8443	34992
8444	34930
8445	34930
8446	34930
8447	34930

1517.90.10	7439	4403.1	25092	8448.1	34930
1517.90.20	7432	4403.20.1	25093	8448.2	34930
1517.90.30	7439	4403.20.2	25093	8448.3	34930
1517.90.40	7439	4403.20.3	25010	8448.4	34930
1517.90.90	7439	4403.20.4	25020	8448.51	40994
1518	7439	4403.20.5	25020	8448.59	34930
1520	7439	4403.20.6	25020	8449	34930
1521	7439	4403.20.7	25020	8450	34930
1522	7439	4403.20.80	25020	8451	34930
1601	5310	4403.20.9	25020	8452.1	34930
1602.1	7720	4403.4	25020	8452.2	34930
1602.2	5310	4403.91	25020	8452.3	40994
1602.3	5310	4403.92	25020	8452.4	34930
1602.4	5310	4403.99.1	25010	8452.9	34930
1602.5	5310	4403.99.50	25093	8453	34999
1602.9	5310	4403.99.6	25020	8454	34999
1603.00.1	5310	4403.99.70	25020	8455	34999
1603.00.2	5320	4403.99.80	25020	8456.1	34940
1604	5320	4403.99.9	25020	8456.2	34940
1605	5320	4404	25093	8456.3	34940
1701.1	7501	4405	26909	8456.91	34995
1701.9	7502	4406	26909	8456.99.1	34940
1702.1	7509	4407.10.1	26211	8456.99.91	34995
1702.2	7509	4407.10.3	26212	8456.99.92	34940
1702.3	7503	4407.10.4	26212	8456.99.93	34940
1702.4	7503	4407.10.5	26212	8456.99.99	34940
1702.5	7509	4407.10.6	26212	8457	34940
1702.6	7509	4407.10.7	26212	8458	34940
1702.9	7509	4407.10.8	26212	8459	34940
1703	7509	4407.10.9	26212	8460	34940
1704	7611	4407.2	26212	8461	34940
1801	7620	4407.91	26212	8462	34940
1802	4199	4407.92	26212	8463	34940
1803	7620	4407.99.10	26211	8464.10.10	34940
1804	7620	4407.99.30	26212	8464.10.20	34940
1805	7620	4407.99.40	26212	8464.10.40	34940
1806.1	7620	4407.99.50	26212	8464.10.50	34995
1806.2	7620	4407.99.60	26212	8464.10.90	34940
1806.3	7612	4407.99.90	26212	8464.2	34940
1806.90.1	7612	4408	26310	8464.90.10	34940
1806.90.20	7620	4409	26221	8464.90.20	34940
1806.90.30	7620	4410	26320	8464.90.30	34940

1806.90.9	7620	4411	26320	8464.90.50	34995
1901.1	6399	4412	26330	8464.90.90	34940
1901.2	6391	4413	26909	8465	34940
1901.90.10	6399	4414	26909	8466	34940
1901.90.2	6399	4415	26901	8467	34950
1901.90.3	6399	4416	26901	8468	34960
1902	6310	4417	26909	8469	35520
1903	6399	4418.1	26401	8470	35520
1904.1	6320	4418.2	26401	8471	35510
1904.2	6320	4418.3	26409	8472	35520
1904.90.1	6392	4418.4	26409	8473.1	35520
1904.90.20	6320	4418.5	26222	8473.2	35520
1904.90.30	6320	4418.9	26409	8473.3	35510
1904.90.40	6392	4419	26909	8473.4	35520
1904.90.5	6399	4420	26909	8473.5	35520
1904.90.6	6399	4421	26909	8474	34999
1904.90.9	6392	45	26909	8475	34999
1905.1	6432	46	26909	8476	34999
1905.2	6432	4701	27110	8477	34999
1905.30.10	6432	4702	27191	8478	34999
1905.30.21	6432	4703	27120	8479.1	34999
1905.30.22	6420	4704	27199	8479.2	34999
1905.30.29	6432	4705	27199	8479.3	34999
1905.4	6431	4706	27199	8479.4	34999
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1905.90.20	6431	4801	27200	8479.6	34999
1905.90.3	6431	4802.1	27311	8479.81	34999
1905.90.4	6432	4802.2	27311	8479.82	34999
1905.90.51	6420	4802.3	27311	8479.89.1	34999
1905.90.52	6420	4802.4	27311	8479.89.2	34999
1905.90.53	6431	4802.51	27311	8479.89.51	34995
1905.90.61	6431	4802.52	27311	8479.89.52	34999
1905.90.62	6420	4802.53.11	27311	8479.89.53	34999
1905.90.63	6420	4802.53.12	27311	8479.89.54	34999
1905.90.64	6431	4802.53.13	27311	8479.89.55	34999
1905.90.65	6431	4802.53.14	27320	8479.89.59	34999
1905.90.66	6431	4802.53.19	27311	8479.89.61	34999
1905.90.67	6420	4802.53.90	27311	8479.89.62	34999
1905.90.69	6431	4802.6	27311	8479.89.63	34999
1905.90.7	6410	4803	27312	8479.89.64	34999
1905.90.82	6432	4804.1	27320	8479.89.65	34999
1905.90.83	6410	4804.2	27319	8479.89.66	34999

1905.90.84	6410	4804.3	27319	8479.89.67	34999
1905.90.85	6410	4804.41.1	27319	8479.89.68	34999
1905.90.91	6410	4804.41.2	27319	8479.89.69	34999
1905.90.92	6410	4804.41.30	27319	8479.89.71	34999
1905.90.99	6432	4804.41.40	27320	8479.89.9	34999
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2001.2	7229	4804.42.11	27320	8480	34993
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2001.90.20	7229	4804.42.19	27319	8482	34971
2001.90.30	7229	4804.42.90	27319	8483.1	34972
2001.90.90	7229	4804.49	27319	8483.2	34971
2002	7229	4804.5	27320	8483.3	34972
2003	7229	4805.1	27319	8483.4	34972
2004	7210	4805.2	27320	8483.5	34972
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2005.20.10	7229	4805.4	27319	8483.9	34972
2005.20.20	7229	4805.5	27319	8484	34999
2005.20.30	7221	4805.60.1	27319	8485	34999
2005.20.90	7229	4805.60.20	27319	8501	35110
2005.4	7229	4805.60.30	27319	8502	35110
2005.5	7229	4805.60.40	27320	8503	35110
2005.6	7229	4805.60.91	27319	8504	35120
2005.7	7229	4805.60.92	27320	8505	35999
2005.8	7229	4805.60.93	27319	8506	35911
2005.9	7229	4805.60.99	27319	8507	35912
2006	7611	4805.70.10	27320	8508	34950
2007.1	7720	4805.70.20	27320	8509	35220
2007.9	7231	4805.70.30	27320	8510	35220
2008.1	7232	4805.70.4	27319	8511	35991
2008.2	7239	4805.70.50	27319	8512	35992
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2008.4	7239	4805.70.92	27319	8514	34999
2008.5	7239	4805.70.99	27319	8515	34960
2008.6	7239	4805.80.10	27320	8516.1	35999
2008.7	7239	4805.80.20	27320	8516.2	35999
2008.8	7239	4805.80.3	27319	8516.3	35220
2008.9	7239	4805.80.91	27319	8516.4	35220
2009.11	7241	4805.80.92	27320	8516.5	35210
2009.19	7242	4805.80.99	27319	8516.6	35210
2009.20.31	7242	4806	27410	8516.7	35220
2009.20.32	7241	4807.1	27420	8516.8	35220
2009.20.33	7242	4807.9	27410	8516.90.1	35220

2009.20.34	7242	4808.1	27420	8516.90.20	35220
2009.20.35	7241	4808.2	27410	8516.90.3	35220
2009.20.36	7242	4808.3	27410	8516.90.41	35220
2009.20.37	7242	4808.9	27410	8516.90.42	35210
2009.20.4	7242	4809	27410	8516.90.43	35220
2009.30.71	7241	4810.11.11	27410	8516.90.44	35220
2009.30.72	7242	4810.11.12	27410	8516.90.45	35220
2009.30.73	7242	4810.11.13	27420	8516.90.46	35220
2009.30.74	7241	4810.11.19	27410	8516.90.47	35220
2009.30.75	7242	4810.11.20	27410	8516.90.48	35220
2009.30.76	7242	4810.12.1	27410	8516.90.49	35220
2009.30.8	7242	4810.12.20	27420	8516.90.50	35220
2009.40.10	7241	4810.21	27410	8516.90.6	35220
2009.40.2	7242	4810.29.10	27410	8516.90.90	35220
2009.40.30	7242	4810.29.2	27410	8517.1	35390
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2009.60.21	7241	4810.31.10	27420	8517.3	35310
2009.60.22	7241	4810.31.90	27410	8517.5	35390
2009.60.23	7242	4810.32.1	27420	8517.8	35390
2009.60.24	7242	4810.32.90	27410	8517.9	35390
2009.60.25	7242	4810.39.10	27420	8518.1	35400
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2009.90.13	7241	4815	28099	8524.31.1	35621
2009.90.14	7242	4816	28099	8524.31.90	35629
2009.90.15	7242	4817	28092	8524.32	35629

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2101.2	7302	4819.3	28021	8524.51	35629
2101.3	7301	4819.4	28021	8524.52.10	35621
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2706	19990	6307.90.70	30399	9002	38109
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2708	19990	6307.90.9	30399	9004	38101
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2710.11.9	19209	6802.29	31919	9012	38109
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2711.2	19330	6807.90.30	31929	9018.90.71	38492
2712	19990	6807.90.40	31929	9018.90.72	38420
2713.1	19912	6807.90.90	31929	9018.90.73	38420
2713.2	19920	6808	31999	9018.90.74	38420
2713.9	19990	6809.1	31931	9018.90.75	38420
2714	19990	6809.9	31939	9018.90.76	38420
2715	19930	6810.11	31951	9018.90.77	38420
2801.1	20291	6810.19	31959	9018.90.79	38492
2801.2	20299	6810.91	31953	9018.90.81	38492
2801.3	20299	6810.99.7	31952	9018.90.82	38492
2802	20210	6810.99.9	31959	9018.90.83	38492
2803	20292	6811	31994	9018.90.84	38492
2804.1	20242	6812	31994	9018.90.85	38420
2804.2	20242	6813	31994	9018.90.86	38420
2804.3	20242	6814	31999	9018.90.87	38420
2804.4	20242	6815.1	35995	9018.90.88	38420
2804.5	20299	6815.2	31999	9018.90.89	38499
2804.6	20299	6815.9	31999	9019	38499
2804.7	20299	6901	31299	9020	38499
2804.8	20299	6902	31229	9021	38491
2804.9	20299	6903	31210	9022	38410
2805	20293	6904	31229	9023	40999
2806.1	20221	6905	31229	9024	38591
2806.2	20229	6906	31221	9025	38599
2807	20222	6907	31221	9026	38599
2808	22020	6908	31221	9027	38599
2809.1	20299	6909	31299	9028.1	38593
2809.2	22039	6910	31291	9028.2	38593
2810	20229	6911	31230	9028.3	38510
2811.1	20229	6912	31230	9028.90.10	38593
2811.21	20241	6913	31230	9028.90.91	38593
2811.22	20299	6914	31299	9028.90.92	38593
2811.23	20299	7001.00.10	41291	9028.90.93	38593
2811.29	20299	7001.00.20	31399	9028.90.94	38510
2812	20299	7002	31399	9029	38599
2813	20299	7003	31310	9030.1	38592
2814	22020	7004	31310	9030.2	38510
2815.1	20101	7005	31310	9030.3	38510
2815.2	20102	7006	31310	9030.4	38510
2815.3	20259	7007	31391	9030.8	38510
2816	20269	7008	31399	9030.90.10	38510
2817	20269	7009	31399	9030.90.40	38592

2818.1	20231	7010	31320	9030.90.51	38592
2818.2	20232	7011	31399	9030.90.52	38510
2818.3	20232	7012	31399	9030.90.53	38510
2819	20269	7013	31392	9030.90.54	38510
2820	20269	7014	31399	9030.90.55	38510
2821	20269	7015	31399	9030.90.56	38510
2822	20269	7016	31399	9030.90.6	38510
2823	20261	7017	31399	9030.90.9	38510
2824	20269	7018	31399	9031	38599
2825.1	20299	7019.1	31393	9032.1	38599
2825.2	20269	7019.3	31993	9032.2	38599
2825.3	20269	7019.4	31399	9032.8	38520
2825.4	20269	7019.5	31399	9032.9	38520
2825.5	20269	7019.9	31399	9033	38599
2825.6	20269	7020	31399	91	40910
2825.7	20269	7101	40942	92	40992
2825.8	20269	7102	40942	9301	40110
2825.9	20269	7103	40942	9302	40110
2826.11.10	20299	7104	40942	9303	40110
2826.11.20	20259	7105	40942	9304	40110
2826.11.90	20299	7106	40941	9305	40110
2826.12	20269	7107	40941	9306	40120
2826.19.10	20259	7108	40941	9307	33322
2826.19.90	20299	7109	40941	9401.1	39029
2826.2	20259	7110	40941	9401.2	39029
2826.3	20259	7111	40941	9401.3	39019
2826.90.10	20269	7112	41130	9401.4	39019
2826.90.20	20299	7113	40942	9401.5	39019
2826.90.90	20299	7114	40942	9401.61.1	39019
2827.1	20299	7115	40942	9401.61.91	39019
2827.2	20269	7116	40942	9401.61.99	39029
2827.3	20269	7117	40991	9401.69.1	39019
2827.4	20269	7118	40942	9401.69.20	39029
2827.51	20259	7201	32102	9401.69.30	39019
2827.59	20299	7202	32101	9401.69.90	39029
2827.6	20299	7203	32102	9401.71.1	39019
2828.1	20269	7204	41120	9401.71.20	39029
2828.90.10	20259	7205	32102	9401.71.91	39019
2828.90.20	20259	7206	32102	9401.71.99	39029
2828.90.30	20269	7207	32102	9401.79.1	39019
2828.90.90	20299	7208	32200	9401.79.20	39019
2829.11	20259	7209	32200	9401.79.90	39029

2829.19.10	20259
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2830.9	20299
2831.1	20259
2831.9	20299
2832.1	20259
2832.20.10	20259
2832.20.90	20299
2832.30.10	20259
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2833.3	20269
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2834.21	20259
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2834.29.10	20269
2834.29.20	20269
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2835.25	20269
2835.26.10	20269
2835.26.20	20269
2835.26.90	20299
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2835.31	20259
2835.39.1	20259
2835.39.90	20299
2836.1	20299

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7225	32200
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7301	33209
7302	33991
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7304	33111
7305	33111
7306	33111
7307	33121
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7308.2	33209
7308.3	33201
7308.4	33209
7308.9	33209
7309	33992
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7312	33993
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7314.1	33993
7314.2	33993
7314.3	33993
7314.4	33993
7314.5	33999

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9401.90.13	39019
9401.90.14	39029
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9401.90.2	39019
9401.90.30	39029
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9403.20.94	39019
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9403.4	39019
9403.5	39019
9403.60.10	39019
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9403.60.40	39019
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9403.60.60	39019
9403.60.70	39019
9403.60.80	39019
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2837.11	20259
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2837.19.20	20259
2837.19.30	20269
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2837.19.90	20299
2837.2	20299
2838	20299
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2839.2	20259
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2840.1	20259
2840.2	20299
2840.30.10	20259
2840.30.90	20299
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2841.5	20269
2841.61	20259
2841.69	20269
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2842.1	20299
2842.90.20	20269
2842.90.50	20269
2842.90.60	20259
2842.90.70	20269
2842.90.80	20259

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7315.9	33993
7316	33999
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7320	33993
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7325	33999
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7326.2	33993
7326.9	33999
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7405	32411
7406	32411
7407	32412
7408	32412
7409	32412
7410	32412
7411	33112
7412	33122
7413	33993
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7415	33310
7416	33993
7417	33999
7418	33999
7419	33999
7501	32492
7502	32492
7503	41130
7504	32492
7505	32492
7506	32492

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9403.70.90	39029
9403.80.10	39019
9403.80.20	39019
9403.80.90	39029
9403.9	39019
9404.1	39011
9404.2	39011
9404.3	30399
9404.9	30330
9405	39030
9406	40920
9501	40210
9502	40210
9503	40210
9504.1	40210
9504.2	40220
9504.3	40210
9504.4	29999
9504.90.1	40210
9504.90.2	40220
9504.90.3	40210
9504.90.40	40210
9504.90.50	40210
9504.90.9	40210
9505	40999
9506	40220
9507	40220
9508	40999
9601	40999
9602	40999
9603	40993
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9607	40994

2842.90.90	20299	7507.1	33112	9608	40930
2843	20269	7507.2	33122	9609	40930
2844	20299	7508.1	33993	9610	40999
2845	20299	7508.9	33999	9611	40999
2846	20299	7601	32421	9612	40930
2847	20299	7602	41130	9613	40999
2848	20269	7603	32421	9614	40999
2849.1	20263	7604	32422	9615	40999
2849.2	20264	7605	32422	9616	40999
2849.90.10	20264	7606	32423	9617	40999
2849.90.90	20269	7607	32423	9618	40999
2850.00.10	20299	7608	33112	97	40995
2850.00.2	20299	7609	33122	No_HS	41901
2850.00.40	20299	7610.1	33201	No_HS	41909
2850.00.60	20259	7610.9	33209	No_HS	42100
2850.00.90	20299	7611	33992	No_HS	42201
2851	20299	7612	33910	No_HS	42202
2901	20501	7613	33992	No_HS	42209
2902	20300	7614	33993	No_HS	42310
2903	20502	7615	33999	No_HS	42320
2904	20509	7616.1	33310	No_HS	42330
2905.1	20410	7616.91	33993	No_HS	42390
2905.2	20410	7616.99	33999	No_HS	42400