Estimating State-Level Truck Activities in America

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ABSTRACT

For freight, the primary function of the nation's highway system is to link the economies of individual states together to form an integrated national economy. Data from the 1993 Commodity Flow Survey, the first comprehensive national survey of freight shipments since 1977, indicate that the shipment of freight by truck in the United States is predominantly an *interstate* phenomenon. In fact, interstate shipments comprise more than 70% of the total ton-miles and nearly 55% of the value of commodities shipped by truck in 1993. In addition, the proportions of truck freight shipments originating from, destined to, passing through, or occurring entirely within a state vary significantly from state to state. While interstate shipments make up the largest portion of shipments nationally, *intrastate* trucking is more significant in large states such as Texas and California, as well as in corner states such as Florida, Maine, and Washington. The proportion of through traffic also varies widely from state to state. These findings

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could have important implications for highway revenue allocations, since trucks carrying freight play a significant role in damage to highway pavement and structures.

INTRODUCTION

The nation's transportation system links U.S. businesses, industries, and consumers. More than 12 billion tons of freight were transported by the U.S. transportation system in 1993 (USDOT BTS 1996c). Shipments by truck (including for-hire and private trucks) accounted for more than half (53%) of the total tonnage, more than two-thirds (72%) of the total shipments by value, and nearly one-quarter (24%) of the total ton-miles shipped in 1993. Despite the vital role of freight in the U.S. economy, the 1993 Commodity Flow Survey (CFS) was the first comprehensive survey of the movement of commodities since 1977. This survey was conducted by the Bureau of the Census with funding and technical guidance provided by the Bureau of Transportation Statistics (BTS) (USDOT BTS 1996a).

The major objective of this study was to describe the geography of truck freight shipments in the United States and, in particular, to measure the degree to which highways serve as state and local versus interstate freight systems. This paper presents estimates of ton-miles of commodities shipped by truck within, to, from, and through each state and thereby provides a measure of the extent to which states' economies are linked together. These estimates were determined using CFS data augmented by including farm-based shipments from the 1992 Census of Agriculture (USDOC 1993a). The impact of imports on U.S. truck flows is also addressed using information from the Transborder Surface Freight database and U.S. Waterway Data (USDOT BTS 1996b; USDOT BTS 1994). Through truck shipments as well as all estimates of CFS shipment distances were determined by routing the truck traffic along the minimum impedance paths using the Oak Ridge National Highway Network (Peterson 1997).

DATA SOURCES

The 1993 CFS represents the most comprehensive survey to date of the shipment of commodities in the United States. Approximately 200,000 business establishments were surveyed; these establishments were selected to represent all 50 states and the District of Columbia. Manufacturing, mining, wholesale trade, and selected retail and service industries were included in the survey. Data collected for individual shipments include origin and destination, commodity code, shipment size (value and weight), mode of transportation, as well as indicators of whether the shipment was an export, hazardous material, or containerized. Each establishment reported a sample of shipment information for a two-week period in each of the four quarters of calendar year 1993. The results of the CFS have been published by the Bureau of the Census and are available on CD-ROM and as a series of printed reports (USDOT BTS 1996a). This study is based on zip code-level data from the CFS (USDOC 1994).

The following types of shipments were excluded from the CFS: 1) shipments with a foreign origin and destination that traverse the United States; 2) shipments originating outside of the United States; and 3) shipments from establishments classified as farms, forestry, fisheries, construction, transportation, oil and gas extraction companies, governments, households, and many retail and service businesses.[1]

Imports were included in the CFS only if they were shipped from the importer's domestic location to another location. Although farm-based agricultural shipments (i.e., shipments from the farm site to processing centers or terminal elevators) were excluded, agricultural shipments from processing centers and terminal elevators were included in the scope of the CFS.

In an attempt to account for as many of the shipments missed by the CFS as possible, data

[1] Considering only those truck types likely to transport commodities, data from the 1992 Truck Inventory and Use Survey indicate that 7% of total truck-miles result from trucks whose major use is retail trade. The retail share of vehicle-miles drops to 12% when only those trucks operated primarily locally within a radius of 50 miles are considered.

from several other sources were considered in this study:

1. the *1992 Census of Agriculture*, which provides statistical information about the nation's agricultural production at the county, state, and national level;
2. the *1992 Truck Inventory and Use Survey* (TIUS) microdata file, which furnishes information on the typical area of operation of trucks carrying agricultural products;
3. *1993 to 1994 Transborder Surface Freight* data, which provide information on the imports shipped by truck from Canada and Mexico;
4. the U.S. Army Corps of Engineers *1993 U.S. Waterway Data*, which include data on the tonnage and commodity code imported via maritime ports; and
5. the Census Bureau's *1993 County Business Patterns*, which provides information about the activity of U.S. businesses (USDOC 1995).

ESTIMATES OF U.S. TRUCK FLOWS

1993 CFS Data

The 1993 CFS data provide information about the value and weight of total shipments between states and National Transportation Analysis Regions (NTAR) by mode (USDOT BTS 1996a). Only freight shipments listing the mode as truck (either private, for-hire, or both) were utilized. Intermodal shipments involving modes other than truck were not considered in this study.[2] State totals for value, tonnage, and ton-miles were determined for four categories: shipments within the state; shipments from the state; shipments to the state; and shipments through the state.

This paper focuses on estimates of ton-miles of freight; estimates of the value of truck shipments by state have been published previously by BTS (USDOT BTS 1997). The tonnage of shipments to, from, within, and through each state as well as the distance estimates used to compute ton-miles were generated by assigning the CFS truck flows to routes predicted using the Oak Ridge National Highway Network, a geographically-based analytical network representing 400,000 miles of major roadways in the United States (Peterson 1997). The Oak Ridge National Highway Network has the same basic structure as the National Highway Planning Network maintained by the Federal Highway Administration (USDOT FHWA 1994), but the Oak Ridge network includes additional roads, attribute detail, and topological adjustments to produce an enhanced analytical network.

Shipments were routed between nodes on the highway network closest to the centroid of the origin and destination zip code. A shortest path algorithm was used to determine the minimum impedance route between the shipment origin and destination over a mathematical representation of the highway network. Impedance is a relative measure of the level of resistance or deterrence to traffic flow on a particular link in the highway network (Bronzini et al 1996). Truck impedance is calculated as a function of travel time and is designed to simulate the most likely choice of route. Each link's impedance is related to the distance, modified by the physical characteristics of the road relevant to truck use (i.e., whether the road is divided, access controlled, subject to congestion, a designated truck route, a toll road, or has truck restrictions). The impedance function is not capable of accounting for all traffic conditions. For example, the algorithm does not split traffic on beltways circling urban areas, but instead always selects the shortest path. In reality, some portion of the truck traffic may elect to take a slightly longer path in order to avoid local congestion problems. Although this may affect the distance calculations and consequently the estimate of ton-miles, it should not significantly affect the relative proportion of shipments to, from, within, and through a given state.

In addition to determining the minimum impedance route, the computer program determines the states traversed by each shipment and accumulates the tonnage and distance traveled in each state.[3]

[2] Work is currently underway to include the truck portion of intermodal shipments in the estimates of truck flows. Intermodal shipments constitute a relatively small proportion (<1.5%) of all CFS shipment records, thus their exclusion will not significantly impact the findings presented here.

[3] For detailed information on the programs used to generate these truck flow estimates, contact Dr. Chin (see title page of this article).

Ton-miles of shipments to, from, within, and through each state are determined as follows. If the minimum impedance route traverses only one state, the tonnage and ton-miles are accumulated as intrastate (i.e., within state) shipments. The intrastate shipment distance is calculated as the sum of the mileage of each individual link that comprises the minimum impedance path. Intrastate ton-miles are calculated by multiplying the shipment weight in tons by the distance in miles. If the minimum impedance route traverses two or more states (i.e., the shipment is an interstate shipment) the tonnage is accumulated in the origin state as *shipments from the state,* and in the destination state as *shipments to the state*. In addition, for those paths traversing more than two states, the tonnage is accumulated in each of the intermediate states as *shipments through the state*. The mileage of each *shipment from a given state* was determined by summing the mileage of all links along the minimum impedance path between the origin node and the origin state border. The *mileage of a shipment to a given state* was calculated by summing the mileage of links along the minimum impedance path between the destination state border and the destination node. The mileage of each *shipment passing through a particular state* is the sum of the mileage of all links along the minimum impedance path from the node where the shipment enters the state to the node where the shipment exits the state. The shipment weight in tons was multiplied by the distance traveled in a particular state to calculate the ton-miles resulting from that shipment.

Adjustment for Exports

The estimates generated by the methodology outlined above require an adjustment to the distribution of flows in port states, because the destinations listed for these export shipments are the U.S. port of exit locations. In order to correctly account for truck shipments designated as exports in the CFS, the following adjustments were made. Exports that originate in the same state as the port-of-exit state were shifted from the category of *within-state shipments* to the category of *shipments from the state*. Likewise, exports arriving in a port-of-exit state from another state were shifted from the category of *shipments to the state* to the category of *shipments through the state*. These adjustments were only required in the port-of-exit states and do not affect the distribution of truck flows in other states.

Adjustments for Agricultural Shipments

Farm-based agricultural shipments (i.e., products shipped from the farm site to processing centers and terminal elevators), were not included in the scope of the CFS. Although these shipments are generally thought to be short distance and thus primarily within-state shipments, they may represent a significant proportion of the value and tonnage of truck shipments particularly in midwestern states, where farming represents a large portion of the state's industry. Data from the 1992 Census of Agriculture[4] and *Agricultural Statistics, 1994* were used to estimate the value and tonnage of farm-based agricultural shipments. An estimate of the average trip length for farm shipments was made using information from the 1992 TIUS. Ton-miles were calculated by multiplying the average trip length of farm shipments for a particular state by the total agricultural tonnage for that state.

The total value of agricultural products produced in each state is reported in the Census of Agriculture, but no overall estimate of total agricultural tonnage is provided.[5] Data from the agricultural census was used to generate a rough estimate of the total tonnage of agriculture produced at U.S. agricultural establishments. Quantities of specific agricultural products reported in the 1992 Census of Agriculture were converted from a variety of different units (e.g., bushels, pounds, bales) to tons (short tons) using conversion factors provided in the 1992 Census of Agriculture or in *Agricultural Statistics, 1994*.[6] Once all of the quantities were converted to tons, they

[4] The Census of Agriculture is conducted every five years and provides statistical information about the nation's agricultural production at the county, state, and national level; all agricultural production establishments (i.e., farms, ranches, nurseries, greenhouses, etc.) are included.

[5] This category represents the gross market value before taxes and production expenses of all agricultural products sold or removed from the establishment in 1992.

[6] All of the quantities used in the estimation of total weight (with the exception of those for milk) are from the 1992 Census of Agriculture. The quantities of milk are from estimates for 1992 provided in *Agricultural Statistics, 1994*.

were summed to provide an estimate of the total agricultural tonnage for each state. The following products were not included in the estimate of tons: greenhouse products, specialty livestock, colonies of bees, and packaging materials.

An estimate of the average trip length for farm shipments is required in order to provide an estimate of ton-miles. Data on trucks that listed either farm products or livestock as the principle product carried were extracted from the TIUS microdata file (USDOC 1993b). Information on the typical area of operation of the truck was used to estimate the average distance of a farm-based agricultural shipment in each state. TIUS area of operation distances are grouped into categories ranging from 0 to 50 miles, to more than 500 miles. A *state radius* was calculated by dividing the state area in square miles by π (i.e., 3.1416) and taking the square root. This estimated radius was used to truncate the TIUS distance categories. For example, if the state radius is between 0 and 50 miles, categories greater than 50 miles were eliminated. Using the remaining frequency distribution, a weighted average distance was computed for each state assuming all of the observations are at the midpoint of their respective distance range(s). Estimates of distances of truck shipments for farm-based agricultural products ranged in length from 25 miles for small states (e.g., New Hampshire and Connecticut) to a high of 94 miles for Alaska.

Ton-miles were calculated by multiplying the estimated agricultural tons for a particular state as calculated above by the estimated trip distance for that state. All farm-based agriculture shipments were assumed to be primarily short distance and were considered as intrastate shipments. Therefore, CFS totals were modified by adding the estimated ton-miles of farm-based agricultural shipments to the CFS within-state shipments for each of the corresponding states. Estimates of tons and ton-miles for farm-based agriculture shipments are probably high for four reasons: 1) some agricultural products may never leave the farm (e.g., hay and silage); 2) the assumption that all observations are at the midpoint of their respective distance range may overestimate the average distance traveled, especially for smaller states; 3) all of the shipments are assumed to be intrastate, but some may in fact be interstate; and 4) it was assumed that all farm-based shipments were transported by truck.

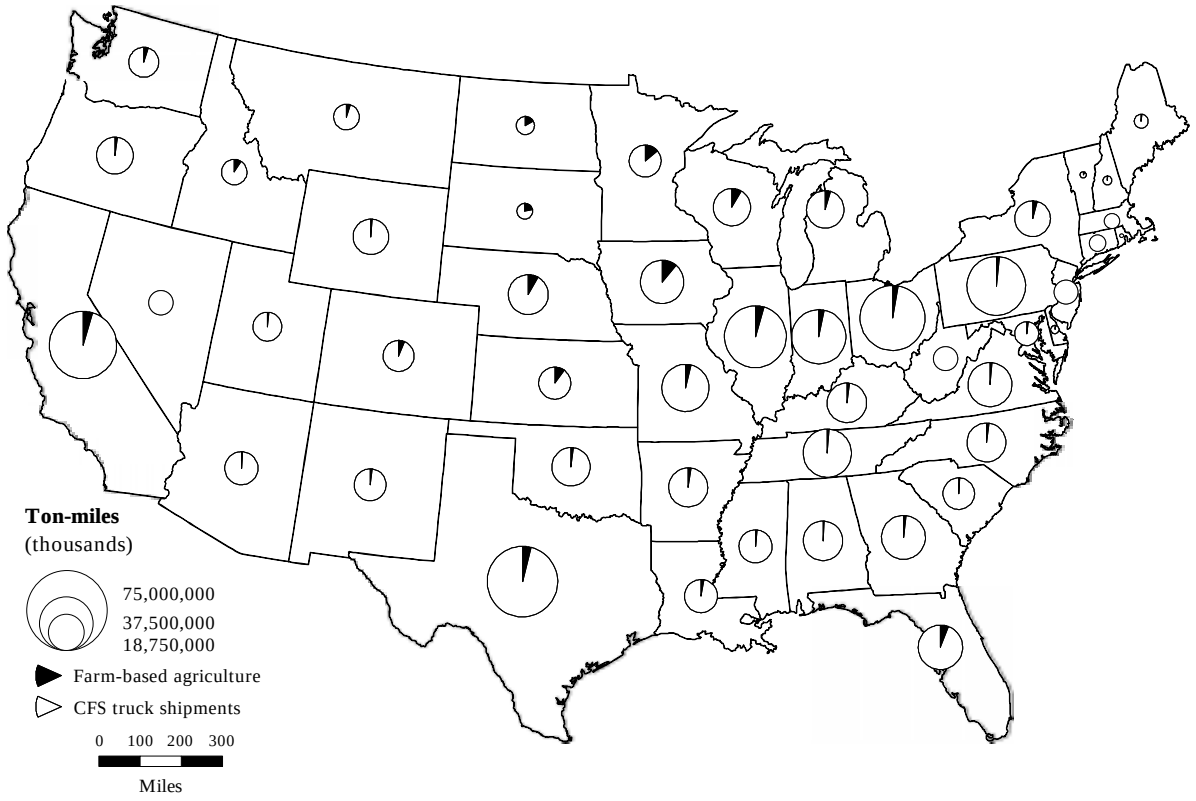
The addition of farm-based agricultural shipments primarily affects truck flows in midwestern states, where agriculture is the major industry in the state (see figure 1). Farm-based agriculture constitutes less than 2% of the total ton-miles in 21 states, but it makes up more than 10% of the ton-miles in seven states (North Dakota, South Dakota, Minnesota, Iowa, Kansas, Hawaii, and Vermont). The majority of these are midwestern states (five of seven). Among these states, the Dakotas have the highest proportion of farm-based agricultural truck flows, with these shipments accounting for roughly one-fifth of the total trucking ton-miles. Although farm-based agriculture results in substantial ton-miles in California and Texas, it constitutes a smaller proportion of the total truck flows (less than 5%) since truck flows resulting from other industries are substantial in these states. Farm-based agricultural ton-miles in Hawaii are probably overestimated, because it was assumed that all observations of average trucking distances from the TIUS were at the midpoint of the reported distance range (i.e., 25 miles for Hawaii).

Summary of Results

The CFS suggests that truck freight transportation on the nation's highway system is primarily between states (see table 1 and figure 2). Truck ton-miles account for 73% of interstate shipments of commodities. In general, the proportion of intrastate traffic is highest in noncentral states (e.g., Alaska, Hawaii, Florida, Maine, Michigan, Minnesota, New Hampshire, and Washington), as well as in large states such as California and Texas. Within-state shipments constitute greater than 50% of the truck ton-miles in only three states: Hawaii, Maine, and New Hampshire. Although this paper focuses on ton-miles of freight, similar patterns are observed if the shipment value is considered (USDOT BTS 1997).

Analysis of data from the CFS clearly demonstrates that the proportions of within, to, from, and through truck shipments vary significantly among states. In terms of ton-miles, through truck shipments account for more than 50% of the ton-

FIGURE 1 State-Level Farm-Based Agriculture Shipments and CFS Shipments



miles in 19 states. States with a high proportion of through traffic are typically those that are either interior states or states that are traversed by Interstates leading to major metropolitan areas in other states. The proportion of through traffic is highest (greater than 70%) in four western states: Nevada, New Mexico, Utah, and Wyoming. Since freight trucks are responsible for much of the damage to the nation's roadway structures, the marked variation in the proportion of ton-miles of through truck traffic among states may have important ramifications for highway revenue allocations.

Estimation of Import Truck Flows

Shipments originating outside the United States were excluded from the CFS. Thus, imports were included in the CFS only if they were shipped from the shipper's domestic location to another location. We relied primarily on foreign trade data from two sources coupled with information from the CFS and the Census Bureau's 1993 *County Business Patterns* to develop estimates of truck flows resulting from imports. The Transborder Surface Freight data from BTS provides information about the U.S. port of entry, destination state, shipment weight, shipment value, as well as the mode of transportation used to enter the U.S. port from Canada and Mexico. The Army Corps of Engineers' 1993 U.S. Waterway Data provides information on the total tonnage through maritime ports, but detailed information regarding the inland destination and mode of transportation is lacking (USDOT BTS 1996b). In order to estimate truck flows resulting from imports through maritime ports, a model was developed to predict the destination and mode split of imports. This model was based on the assumption that the destination and mode of transportation of imports would be similar to that of domestic 1993 CFS shipments.

Estimation of Imports by Truck from Canada and Mexico

Transborder surface freight data collected between April 1993 and March 1994 were analyzed in order to estimate the possible impact of imports by truck from Canada and Mexico on truck flows

TABLE 1 Ton-Miles of Truck Shipments by State: 1993 (In billions)

State	Total	Within	To	From	Through
Alabama	21.61	6.04	2.47	3.97	9.12
Alaska	1.66	0.67	0.20	0.79	—
Arizona	15.82	2.45	2.24	1.47	9.65
Arkansas	21.02	3.19	2.56	3.12	12.15
California	54.76	27.32	12.77	13.28	1.39
Colorado	14.10	3.93	2.16	1.43	6.57
Connecticut	4.79	0.68	0.66	0.48	2.97
Delaware	1.37	0.17	0.27	0.18	0.75
District of Columbia	0.05	0.00	0.02	0.01	0.02
Florida	26.37	13.11	7.77	4.75	0.73
Georgia	25.93	7.49	4.67	5.72	8.05
Hawaii	0.38	0.38	NA	—	NA
Idaho	9.97	2.36	0.93	0.89	5.80
Illinois	47.28	9.32	6.81	8.11	23.05
Indiana	37.51	6.22	4.10	5.12	22.08
Iowa	25.43	6.54	2.68	3.10	13.12
Kansas	14.98	5.11	2.36	2.80	4.71
Kentucky	21.56	4.57	2.58	2.68	11.73
Louisiana	15.79	5.39	2.13	2.50	5.77
Maine	3.45	1.80	0.49	1.15	0.02
Maryland	8.87	1.52	1.86	1.87	3.61
Massachusetts	4.28	1.24	1.22	0.77	1.05
Michigan	19.58	9.07	4.80	4.66	1.05
Minnesota	14.85	6.42	2.95	2.57	2.91
Mississippi	15.78	3.23	1.95	1.93	8.67
Missouri	29.34	5.27	4.47	3.78	15.81
Montana	10.03	2.82	0.86	1.52	4.82
Nebraska	21.90	3.68	1.29	1.74	15.19
Nevada	9.41	1.06	1.11	0.42	6.82
New Hampshire	1.57	0.93	0.23	0.14	0.27
New Jersey	9.19	2.22	1.97	2.22	2.78
New Mexico	14.71	2.33	1.28	0.61	10.49
New York	18.05	5.58	4.02	4.19	4.27
North Carolina	20.89	6.66	4.21	4.60	5.42
North Dakota	5.52	1.89	0.49	0.73	2.41
Ohio	51.34	12.24	7.86	10.34	20.90
Oklahoma	20.45	3.08	3.06	2.48	11.82
Oregon	18.92	5.92	3.78	3.51	5.72
Pennsylvania	42.97	7.99	7.40	7.36	20.21
Rhode Island	0.45	0.09	0.12	0.11	0.13
South Carolina	14.53	3.34	2.15	2.56	6.49
South Dakota	4.23	1.53	0.67	0.85	1.18
Tennessee	30.50	4.10	3.76	6.33	16.31
Texas	59.56	23.97	15.06	11.22	9.31
Utah	12.35	1.48	1.00	1.18	8.69
Vermont	0.88	0.25	0.23	0.20	0.20
Virginia	25.79	4.98	3.30	3.29	14.22
Washington	13.22	6.33	2.83	3.09	0.96
West Virginia	9.30	1.04	0.87	1.27	6.11
Wisconsin	19.42	5.82	3.29	4.14	6.17
Wyoming	17.90	3.59	0.47	0.86	12.98

NA Not applicable; — less than 10 million ton-miles.
Note: These data represent domestic and export shipments by truck from the 1993 Commodity Flow Survey, adjusted to include farm-based agricultural shipments using data from the 1992 Census of Agriculture.

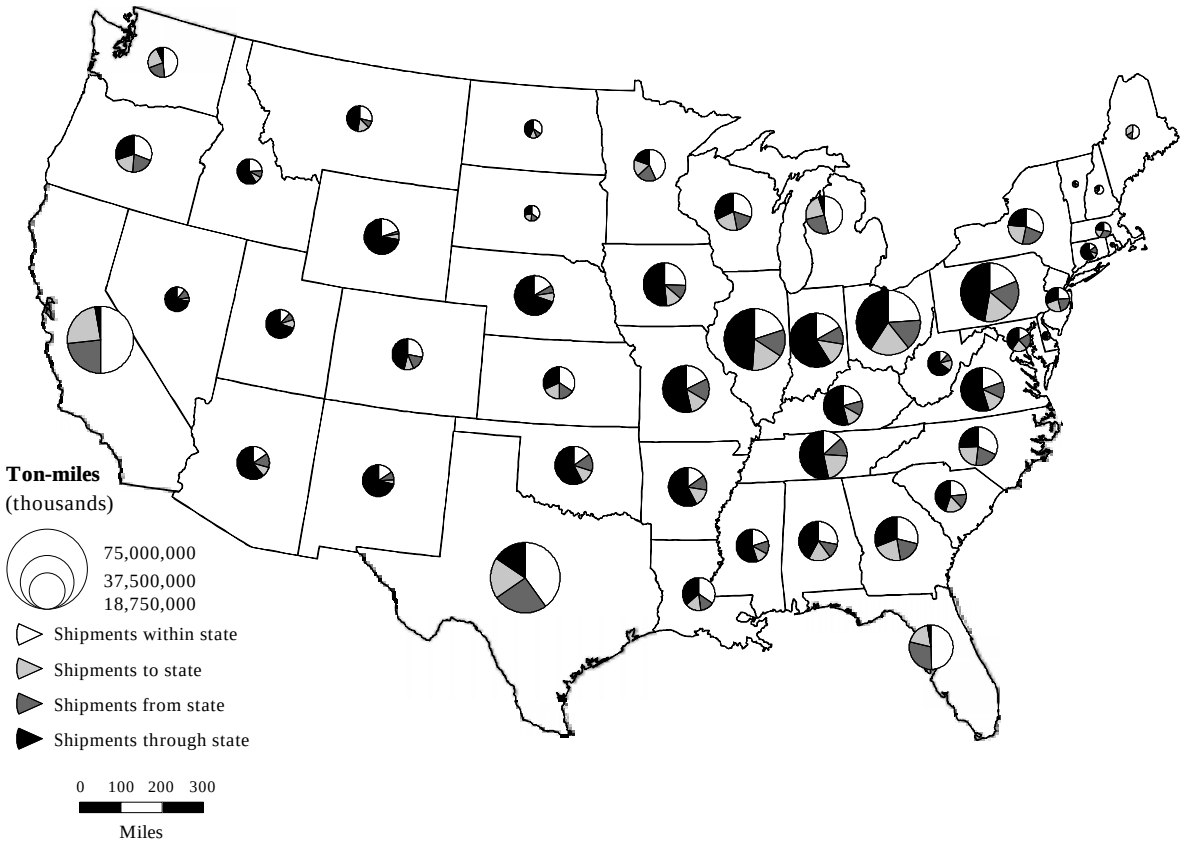
within the United States (USDOT BTS 1994).[7] These data include the value, weight, port of entry, import mode, and destination state of imports from Canada. Data on shipments from Mexico are similar, but shipment weight information was not available until after April 1995. Weight information from the transborder surface freight data for the period of April 1995 to March 1996 was used to estimate 1993 to 1994 shipment weights from Mexico. The weight-to-value ratio for 1995 to 1996 truck shipments from Mexico was determined for each port of entry-destination state pair. The 1993 to 1994 shipment weights were then estimated by applying the 1995 to 1996 ratio to 1993 to 1994 value of shipments from Mexico for the same origin port of entry and destination state pair.

Through traffic and shipment distances were determined by routing the shipments from the port of entry to the destination state on the Oak Ridge National Highway Network. Shipments with either an unspecified or nonborder port of entry, an unknown destination state, or a destination in Hawaii were eliminated. These shipments accounted for less than 4% of the total value. Truck route impedances on the network were modified to "force" import shipments to be routed in the United States. (For example, shipments originating in Maine destined to Minnesota typically would be routed through Canada based on a shortest path algorithm, but the impedance functions were altered to force all of the imports to be routed domestically from the port of entry to the destination state.) Import truck shipments were routed from the port of entry to the centroid of counties in the destination state with the highest percentage of the state's total annual salary as determined from the 1993 Census Bureau's *County Business Patterns.* The number of destination counties varies from state to state, but the sum of the annual salaries of counties selected for each state comprises at least 75% of the total annual salary for that state. Ton-miles for imports to and through each state were then estimated using the methodology as described above for the CFS truck flows.

A number of problems were observed in the

[7] Transborder surface freight data were not available for periods prior to April 1993.

FIGURE 2 State-Level Adjusted CFS and Farm-Based Shipments



transborder data set. In addition to the lack of information on the weight of shipments from Mexico for 1993 to 1994, the weight information on shipments from Canada is incomplete. Since individual shipment records are not provided in the public data set, it is difficult to determine the extent of this problem and how it may affect estimates of truck flows resulting from imports from Canada. Furthermore, no information on the domestic mode is available from these data sets, thus the import mode reported was assumed to be the only mode used (i.e., if the shipments were imported by truck, they were assumed to stay on a truck until these shipments reached their domestic destinations).

Perhaps the most significant problem with the transborder data concerns uncertainties regarding the actual destination of transborder shipments. In order to estimate truck traffic resulting from imports, it was assumed that the destination state listed in the transborder data file was the actual destination of the commodity. In fact, the transborder data tracks the flow of dollars or ownership, rather than the flow of commodities. Only if the "owner" is in the same location as the actual destination of the shipment will the destination reported in the transborder data set coincide with the shipment's destination. It is not possible to precisely ascertain the magnitude of this problem, but a 1996 survey conducted by the Michigan Department of Transportation of freight entering the United States at Ambassador Bridge may shed some light on the issue (Parsons Brinckerhoff Quade & Douglas, Inc. 1997, 65). This survey indicated that only 25% of import shipments entering the U.S. at Ambassador Bridge are destined to Michigan whereas trade flow statistics from Statistics Canada for the same period suggest that 44% of goods are destined to Michigan.

Imports Through Maritime Ports

Data from two sources were used to provide an estimate of truck flows resulting from imports through maritime ports. The total tonnage imported through each U.S. port by commodity is included in the Army Corps of Engineers' 1993 U.S.

Waterway Data. The CFS data were used to predict the destination state of import shipments as well as to estimate the share of imports shipped by truck, as explained below. Truck shipments were routed from the port of entry to the predicted destination using the Oak Ridge National Highway Network. Estimates of ton-miles resulting from imports through maritime ports were determined for each state using the methodology outlined above for the CFS truck shipments.

In order to utilize the Corps' waterway data in this study, a table provided by the Waterborne Commerce Statistics Center was obtained to convert the Lock Performance Management System Commodity Codes to the Standard Transportation Commodity Code used in the CFS data. All petroleum-related commodities were excluded from the import analysis, since most petroleum products are shipped by pipeline. The destination state of CFS shipments originating in counties adjacent to each port was determined for each two-digit commodity group using the CFS data. These data were used to share the import tonnage for a particular commodity group from each port to probable destination states. The truck share (private, for-hire, or both) of domestic shipments for each origin-destination pair was also determined for each two-digit commodity group using the CFS data. This information was used to estimate the truck share of import tonnage for a particular commodity group originating at each port shipped to a particular destination state.

Each port was assigned to the nearest node on the highway network. These nodes were used as the *origin* of import shipments. Shipments were routed from this origin to the centroid of counties within the destination state; the share of imports shipped to particular counties within the destination state was based on the proportion of shipments (by weight) received by that county in the CFS data. Ton-miles for imports to and through each state were then estimated using the method described above for the CFS truck flows.

Impact of Imports on Truck Flows

Despite the limitations of the foreign trade data, this analysis clearly indicates that the inclusion of imports may substantially affect the distribution of truck flows in many border or port states (see table 2 and figure 3). These estimates indicate that imports comprise greater than 10% of the ton-miles in 11 states. These states are primarily along the northern border (e.g., Michigan, North Dakota, Vermont, New York, and Maine), as well as states with large ports (e.g., California and Washington). Imports are estimated to result in nearly 13% of the ton-miles in Michigan with most of these imports from Canada. The transborder data indicate that nearly half of these shipments are destined to Michigan; the remainder of the shipments travel through Michigan to other states. Typically, shipments from Mexico make up a smaller proportion of the shipments to the United States and have less impact on truck freight flows in southern border states. Nonetheless, international trade (imports and exports) results in roughly 14% of truck flows in Texas.

RELIABILITY OF TON-MILE ESTIMATES

Estimates of ton-miles are based on data from three major sources: the 1993 CFS, the 1992 Census of Agriculture, and foreign trade data. Errors in each of these sources and in the estimation methods implemented by this study contribute to errors in the breakdown of ton-miles by inter- or intrastate categories.

The Bureau of the Census has estimated standard errors in CFS's national-level ton-miles transported by truck to be approximately 1.4% (USDOT BTS 1996a). Of course, this estimate was not broken into four categories, which would increase the error. Also, some errors were introduced by the route selection algorithm, although these are believed to be small. Similarly, errors in quantities reported in the Census of Agriculture are typically less than 0.5% (livestock range from 0.02% to 0.29% and crops range from 0.09% to 0.41%). It is believed that the mileage estimates for farm-based agricultural shipments are high (for reasons discussed earlier), but this has not been quantified. Additional errors in translation from reported quantities to tons might also exist. The size of these errors depends on how well categories were matched and the extent of regional variations. In our judgment, these errors are likely to be relatively small. Furthermore, distance (mileage)

TABLE 2 Ton-Miles of Commodities Moved by Truck: 1993

State	Total (billions)	CFS (billions)	Imports (billions)
United States	**973.13**	**909.61**	**63.51**
Alabama	22.44	21.61	0.83
Alaska	1.77	1.66	0.11
Arizona	17.24	15.82	1.43
Arkansas	21.72	21.02	0.70
California	61.84	54.76	7.08
Colorado	14.76	14.10	0.66
Connecticut	5.13	4.79	0.34
Delaware	1.53	1.37	0.16
District of Columbia	0.05	0.05	—
Florida	29.25	26.37	2.88
Georgia	26.97	25.93	1.03
Hawaii	0.39	0.38	0.01
Idaho	10.57	9.97	0.60
Illinois	48.90	47.28	1.62
Indiana	38.73	37.51	1.21
Iowa	26.18	25.43	0.75
Kansas	15.21	14.98	0.22
Kentucky	22.15	21.56	0.59
Louisiana	17.18	15.79	1.39
Maine	4.30	3.45	0.84
Maryland	9.69	8.87	0.83
Massachusetts	4.69	4.28	0.41
Michigan	22.50	19.58	2.93
Minnesota	15.82	14.85	0.97
Mississippi	16.49	15.78	0.71
Missouri	30.14	29.34	0.80
Montana	11.46	10.03	1.43
Nebraska	22.72	21.90	0.82
Nevada	9.91	9.41	0.49
New Hampshire	1.77	1.57	0.20
New Jersey	10.45	9.19	1.26
New Mexico	15.60	14.71	0.89
New York	22.67	18.05	4.62
North Carolina	21.79	20.89	0.90
North Dakota	6.70	5.52	1.18
Ohio	53.93	51.34	2.58
Oklahoma	21.17	20.45	0.73
Oregon	19.95	18.92	1.03
Pennsylvania	46.65	42.97	3.68
Rhode Island	0.49	0.45	0.04
South Carolina	15.39	14.53	0.87
South Dakota	4.41	4.23	0.18
Tennessee	31.48	30.50	0.98
Texas	65.07	59.56	5.50
Utah	13.19	12.35	0.84
Vermont	1.27	0.88	0.39
Virginia	27.28	25.79	1.49
Washington	15.79	13.22	2.57
West Virginia	9.57	9.30	0.27
Wisconsin	20.28	19.42	0.86
Wyoming	18.53	17.90	0.63

— total less than 10 million.

Notes: CFS column includes domestic and export CFS shipments within, to, from, and through each state, as well as farm-based agricultural shipments. Import ton-miles include estimated shipments to and through each state based on data from the Army Corps of Engineers' U.S. Waterway Data, the 1993 CFS, and the Census Bureau's *1993 County Business Patterns.*

estimates for farm-based agriculture shipments within the smallest states (e.g., Hawaii, Rhode Island, and Delaware) could be off by as much as a factor of two. Estimates for farm-based agriculture shipments within larger states are expected to be more accurate.

The transborder import data and import through maritime ports data are based on files compiled from copies of the Customs Service Entry Summary forms. These forms are required to be filed with Customs at the time the merchandise is released to importers. There is no statistical sampling error associated with these import data. Nonsampling errors such as reporting errors, however, might exist.

For the transborder import data, 4% (by value) of the merchandise imported by truck from Canada and Mexico were excluded from this study (for reasons outlined above). More importantly, the mileage estimates associated with the transborder data involve assumptions that are difficult to quantify. All tonnage information associated with imports through maritime ports were included in this study. Truck share and destination distribution for imports through maritime ports were assumed to have similar patterns as found in the CFS. To the extent that modal shares and shipment distances for out-of-scope imports differ from within-scope shipments from a port, there will be errors associated with the ton-mile information for imports through maritime ports that are presently difficult to quantify.

Because this study utilized multiple data sets collected under different methods and in several instances made assumptions of unknown accuracy, there is no way to precisely estimate the total error associated with the overall national ton-miles estimates. However, since imports by truck constitute less than 7% of the total ton-miles and farm-based agricultural shipments account for less than 4% of the total truck ton-miles, errors in these data cannot change the general patterns of U.S. truck freight movements. The total ton-mile error would be less than 7% nationally if 50% errors are assumed to be associated with both the import and farm-based agricultural data.

FIGURE 3 State-Level Domestic, Import, and Export Shipments

CONCLUSIONS

Analysis of recent data on U.S. freight movements reveals that truck freight transportation in the United States is primarily an interstate phenomenon. In terms of ton-miles, 73% of the ton-miles of truck freight were transported between states in 1993. The proportions of within, to, from and through truck shipments vary significantly from state to state. Within-state truck shipments are most important in large states and geographically noncentral states. Through-state shipments account for more than 50% of the truck ton-miles in 19 states. In addition, this study shows that the addition of farm-based agricultural shipments primarily affects truck flows in the midwestern states. The inclusion of imports also substantially alters the distribution of truck flows in states along the northern border and in major port states.

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