ESTIMATING TEXAS-MEXICO NORTH AMERICAN FREE TRADE AGREEMENT TRUCK VOLUMES

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Miguel A. Figliozzi
and
***Robert Harrison**
Center for Transportation Research
The University of Texas at Austin
3208 Red River, Ste. 200
Austin, Texas 78705
Tel (512) 232-3113
FAX (512) 232-3153
figliozzi@mail.utexas.edu
harrison@mail.utexas.edu

and

John P. McCray
The University of Texas at San Antonio
6900 North Loop 1604 West
San Antonio, Texas 78249
Tel (210) 458-5384
FAX (210) 458-5783
jmccray@utsa.edu

*Corresponding author

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Miguel A. Figliozzi and Robert Harrison
Center for Transportation Research
The University of Texas at Austin
3208 Red River, Ste. 200
Austin, Texas 78705
Tel (512) 232-3113
FAX (512) 232-3153

and

John P. McCray
The University of Texas at San Antonio
6900 North Loop 1604 West
San Antonio, Texas 78249
Tel (210) 458-5384
FAX (210) 458-5783

ABSTRACT

North American Free Trade Agreement (NAFTA) truck traffic continues to grow on the international trade highway corridors linking the U.S. to Mexico. This creates planning challenges to accommodate and analyze NAFTA truck traffic along these highway corridors and at the U.S.-Mexico border ports of entry. Because of a lack of transportation data the numbers of trucks, particularly those carrying NAFTA trade to and from Mexico, are difficult to estimate. Two data sources that are available to estimate the number of trucks crossing the border are the counts of trucks crossing the bridges and U.S. International Trade Data. This paper develops two methods, each using one of these data sets. These methods are described and two separate truck flows derived from the models are explained and compared using a standardized truck type (equivalent trade truck) to represent truck flows. Interestingly, both methods provide useful outcomes.

INTRODUCTION

The total trade between the U.S. and Mexico continues to grow strongly and is expected to exceed $200 billion in 2000. Highway issues, both along trade corridors and at border crossings, continue to attract attention from federal and state planners. For example, the congestion along Interstate Highway 35 north of San Antonio in Central Texas is frequently attributed to the growth in North American Free Trade Agreement (NAFTA) truck traffic along that corridor segment. Yet the accurate measurement of truck volumes associated with international trade remains extremely challenging. Data collected at the bridges, at U.S. Customs, and U.S. International Trade Data are not structured to answer these questions with any specificity. This is complicated further at the border because much truck activity occurs that is not directly related to over-the-highway international trade trips. Earlier work showing NAFTA truck trade flows and the highway corridors carrying his flow was conducted by McCray (*1*). While estimating trade flows into truck volumes remains challenging (*2, 3*) it is essential to develop an understanding of the impact that NAFTA truck volumes have on trade highway corridors and port infrastructure. This is particularly true given the attention now being directed at both federal and state levels to identify and possibly fund NAFTA truck corridors.

STUDY

In 1998, the U.S. Department of Transportation Southwest Region University Transportation Centers Program sponsored an investigation into U.S.-Mexico trade corridors, particularly those most used by trade truck. The objective of the study was to develop a Global Information System (GIS) based U.S.-Mexico corridor map, using TransCad GIS software, of NAFTA truck flows based on currently available data sources. The estimation of trade used a two-stage approach which is fully described in the study report (*4*). Truck volumes leaving the border were first estimated—the focus of this paper—and then calibrated using weigh-in-motion (WIM) data—the focus of a previous paper (*5*). The study used the concept of a standardized loaded NAFTA truck and the truck volumes in this paper are expressed in this unit.

ALTERNATE METHODS TO ESTIMATE LOADED NAFTA TRUCKS

Two methods for determining standardized loaded truck volumes were evaluated in the study. The first concentrated on truck numbers derived from the border bridge systems and U.S. Customs, after adjusting for a variety of factors. The second takes the U.S. International Trade Data and uses commodity densities, truckload weights and volumes to determine truck flows. This paper analyzes truck flows at a port of entry (POE) level; therefore the methodologies developed aggregate flows at bridge or border crossing levels into POE levels, although they can also be applied at a bridge or crossing level when required.

Bridge Truck Volumes Method

This method is based on the bridge counts that are available from the bridge authorities and U.S. Customs. At the U.S.-Mexico border, a variety of economic activities influence truck volumes. These are associated with drayage practices (where international trailers are drayed across the border by local trucking firms), intermodal movements of empty and full trailers, freight consolidation at warehouses, and activities that supply and consume products and services at the border cities. Each of these factors has a different impact on NAFTA truck volumes. Drayage practices, involving tractors that often cross the border loaded and then return empty, tend to grossly overstate the number of trade trucks that are likely to be on NAFTA highway trade corridors. Intermodal movements from border ports to U.S. non-border cities, especially Trailer on Flat Car (TOFC) cross the bridges but do not use the trade corridors leading away from the border, contributing too to overstate the bridge crossing counts as a measure of NAFTA truck traffic on U.S. corridors. Freight consolidation means that there will be a reduction in the number of loads on the trade corridors as compared to loads crossing the bridges, WIM data at border crossing and highway corridors can be used to estimate this consolidation (*6*). Finally, border cities also receive an amount of freight by truck that is consumed locally and therefore does not impact NAFTA corridors.

Truck Volumes on the Bridges

The method comprises the steps shown Figure 1. The assumptions underlying this method, as applied to this border segment, are given in Table 1. These data can be obtained for southbound flows into Mexico from the U.S. bridge authorities that collect tolls and for northbound flows from U.S. Customs. They could also be provided by WIM or truck count and classification sites if installed at ports of entry. In the data available for this study northbound loaded trucks were available but southbound loaded trucks were only reported at the ports of Laredo and Eagle Pass. For all other ports, the percentage of southbound loaded trucks was assumed from the available southbound flows.

Loaded Trucks Crossing the Bridges

The number of loaded trucks must be estimated applying a factor for empty trucks to the total number of trucks. Data for empty and loaded trucks crossing the bridge were obtained for this study but may not be available on a consistent basis. Also, data availability may change as new facilities are built and new processes are implemented at border ports of entry. For example, new transportation data are to be required on export manifests from August 1, 2000 (*7*).

Equivalent Trade Trucks

This study chose to standardize the various truck types carrying international trade into equivalent 80,000-pound five-axle, 48-ft semi-trailer trucks (3S2), termed equivalent trade trucks (ETT). This truck type was chosen based on the results of an analysis of truck type and weight statistics that clearly indicated that 3S2 types dominated other vehicles types on NAFTA corridors (*6*) and national statistics which show that for long-haul trips, semi-trailer trucks dominate other classes because of their higher efficiency (*8*). It is important to notice that the weight of an ETT will depend on the commodity type being transported, in particular the total truck weight will be less than 80,000 pounds when carrying a commodity that cubes out as discussed in the truckload volume and weight section.

Since there are both semi-trailer trucks and single unit trucks transporting trade it is necessary to transform single-unit trucks into an equivalent number of ETT units. The equivalence between a single-unit truck and an ETT must be based on weight or volume capacity per truck. Truck weight limits are 32,000 and 46,000 pounds for two-axle and three-axle trucks, respectively, while for the 3S2 vehicle the gross limit is 80,000 pounds, giving a ratio between 2.5 and 1.7. The ratio between single-unit and combination truckloads for different commodities varies between 1.7 and 2.2, if hazardous materials (hazmat) commodities are not considered (*9*). A correction must also be applied for local traffic since some truck movements are supplying the needs of producers and consumers within each border city, and are not related to NAFTA trade. As shown in the origin/destination survey at border ports (*10*), origins or destinations not related with international trade were less than 10 percent. This study assumes that a percentage of single unit trucks carries local commerce, estimated at 33 percent in all the ports except Laredo, where it is assumed to be 25 percent due to much larger trade movements relative to the size of the city.

Correction for Intermodal Shipments

In ports where intermodal yards are present (truck-rail and truck-ship), some trailers that cross the border by truck may continue their journey by another mode, such as TOFC. The correction for intermodal movements is necessary, especially in Laredo and Eagle Pass, where there are significant TOFC movements.

Results

The total annual U.S.-Mexico truck volume of 2,070,226 NAFTA standardized ETT trucks is estimated to have crossed the Texas–Mexico border and traveled on Texas highways during 1997, as shown in Table 2. This produces an average of 7,660 ETT trucks per day. Laredo has the largest truck volume in Texas, with 47 percent and 53 percent of the truck volume in Texas for northbound and southbound movements, respectively. El Paso is next with 22 percent of the northbound trucks and 17 percent of the southbound vehicles. Surprising, Hidalgo is next with 14 percent and 12 percent of the north and southbound vehicles, supplanting Brownsville as the leading port of entry in the Texas Valley. This reflects the growth of maquiladora operations in the Hidalgo-Reynosa area, adding manufactured commodities to the traditional agricultural trade moved across the border.

The variations in number of trucks at Texas border ports of entry are due to both the volume of trade and the characteristics of the different commodities moved through them. While this method is truck count based the second method will develop numbers of trucks based upon the U.S. International Trade Data.

Trade Commodity Densities and Volumes Method

This method is based on a calculation of truckload weight per commodity, using commodity densities. It uses representative commodity group densities, which, multiplied by the truck capacity volume, gives the commodity group truckload. Other researchers have been using a similar approach to determine truck volumes on key highway corridors (*11*).

For a given truck type there is both a maximum volume and truckload weight, and there is a critical density when the commodity either weighs out or cubes out. A cubed-out commodity fills the volume of the trailer but does not reach the maximum weight. A weighed-out commodity reaches the weight limit but does not fill the whole volume of the truck. Considering the total volume of the truck, a weighed-out commodity density therefore equals the critical density. This value will be termed the maximum practical density per commodity and is used in this study to discriminate between the two types of loaded trucks.

Method

A flow chart detailing the steps of the commodity group density method is given in Figure 2. The first step is to separate commodities of high density, which will weight out from low-density commodities that will cube out. In the second step it is necessary to choose the truck type best suited to the movement of the commodity group, and to determine the truckload volume and weight.

The third step is to aggregate the commodities and obtain a representative density for each group. It is important to note that when commodities are aggregated, the representative density is not an average of the densities, but a nonlinear function of the weight proportion of each commodity, the density of each commodity, the truck capacity volume, and truck maximum weight. Using the representative density by group (Di), truck volume (Vi), and the total weight per group (Wi), the number of trucks per group is calculated (Ni).

Commodity Group Density

The formula used to obtain the representative density per group is as follows:

Commodity group i (Ci) comprises different commodities j (Cij).

For one commodity Cij with density Dij, the number of loaded trucks Nij (with volume V) needed to carry the commodity weight Wij is:

$$Nij = \frac{Wij}{Dij * V} \quad (1)$$

The total number of trucks (N) for all the commodities in the commodity group Ci will be:

$$Ni = \sum_{j} \frac{Wij}{Dij * V} \quad (2)$$

The average density (Di) per commodity group Ci will be:

$$di = \frac{Wi}{Ni * V} \quad (3)$$

where Wi is the total weight of commodity group Ci,

$$Wi = \sum_{J} Wij. \quad (4)$$

Replacing Ni from (2) in (3), result in:

$$di = \frac{1}{\sum_{j} \frac{Pij}{Dij}} \quad (5)$$

where Pij is the ratio of the weight of commodity j (Wij) and total weight per commodity group i (Wi).

The total number of trucks is the sum of Ni, which gives the total number of loaded trucks and a correction factor for empty trucks must be applied to obtain total number of trucks on the highway corridor. This method is based on two key assumptions, first that truckloads are represented as either weighing out or cubing out, and secondly, a single commodity per truck is considered.

There are a variety of commodities with different densities within each 2 digit harmonized classification. However for practical reasons it is convenient, and within acceptable accuracy, to categorize commodities for this work at the 2 digit harmonized level, such as electronics, chemicals, etc., and to use this density to determine whether a truck would weight out or cube out.

Application of the Method

Trucks were estimated using U.S. international Trade data and aggregating the data at the two-digit Harmonized System (HS) commodity level, which is the same commodity detail as used in the Transborder Surface Freight Database (TSFD) (*12*).

Densities. Densities by commodity are obtained from a National Highway Cooperative Research Project (NHCRP) (*13*). In this report, density data are reported in pounds per cubic feet, with the same units used hereafter. Some important problems appear with the application of these data, and include:

1. Commodity densities are given using the STCC (Standard Transportation Commodity Classification). Trade data are given in Standard International Trade Code (SITC) or HS commodity classifications and the match is not perfect.
2. Density data were compiled mostly during the 1970's. For commodities that have not been subject to changes in production methods or materials (e.g., agricultural or mineral products), the value is fairly accurate: however, for highly industrialized products such as electrical equipment, machinery, vehicles, and instruments, changes in density can be expected. As an example, there has been a trend to reduce weight by replacing metal components with lighter plastic components. These products are very important in U.S.-Mexico trade so we may expect to under predict volumes.

3. Many electronic and electric products are not included in this publication and their density must be obtained by other means (data provided by freight forwarders or brokers for example)

Truckload Volume and Weight. Truck volumes in ETT were estimated using trailer data provided by staff at the Laredo base of Schneider Inc., of 48 feet long by 102 inches high and 110 inches wide, giving a total of 3,740 cubic feet. Five percent of the volume was considered wasted, making the usable volume 3,560 cubic feet. The total weight limit per ETT is 80,000 pounds, with the weight of a tractor and an empty trailer ranging between 32,000 and 36,000 pounds, based on WIM data (*6*). The payload is therefore 46,000 pounds, and the critical density derived from 46,000 pounds and 3,560 cubic feet is 12.9 pounds per cubic foot. This is a critical part of the estimation process and deserves closer attention in future research. It may well be that trailer loads and densities, even for similar commodity groups, vary between ports. Ideally, these load weight/densities would be identified by port and region to permit a more accurate estimation of truck volumes. Employing the general method, as specified above, to all Texas ports probably over-estimates truck volumes—which is why calibration using WIM and other data is so important.

Commodity Weight Data. Weights by the two-digit HS commodity level have been obtained using the TSFD. The commodity value and weight correspond to all northbound movements, as there is no commodity detail at port level in the TSFD. Five-digit SITC data were obtained by special purchase from the U.S Department of Commerce (*14*). Using a concordance, these data were converted to two-digit Harmonized System (HS) data for each port. The Transborder Surface Transportation Data (TSTD) were then obtained from the Bureau of Transportation Statistics and used to prepare a table of weight to value relationships. This weight to value table was then used to produce the estimated weight of each two-digit commodity at each major U.S.-Mexico border port. Commodity modal split was calculated using TSFD data. Using these databases and estimated densities, the number of trucks can be estimated by port at two-digit HS commodity level.

Results

The study reports the values of density at two-digit HS used to calculate the number of equivalent trade trucks. It also gives the same values, but for loaded and empty trucks, since the average value per truck per commodity is useful to check the accuracy of the results. These tables are too voluminous to reproduce in this paper, but a section is reproduced in Table 3 for total northbound movements. Table 3 provides examples for 20 two-digit HS chapters, broken down by density, truckload weight, trade weight, truck numbers and truckload values.

As expected, the truckload values vary widely with commodity group. Northbound, agricultural products have an average value of $13,300 rising to $85,700 for instruments. Southbound, the range is from agricultural products at an average value of $16,700 to instruments at $102,900. Results by commodity group allow further calibration of the model as well as enhancing our basic knowledge about trade flows and modal choice. Truckload value might dramatically change when comparing northbound and southbound commodities even in the same HS chapter. For example, Chapter 27 of HS comprises mostly crude oil for northbound shipments, while southbound shipments comprises mostly refined oil sub products. This fact stress the need for a careful calibration, each port has its peculiarities in commodities traded as well as drayage and maquiladora impacts on truck volumes that sometimes the aggregated data cannot capture. Knowledge of trade port operations as well as contacts with carriers, brokers, customs and freight operators are important to calibrate the models at port level. The result of the Trade Commodity Density and Volume method is shown in Table 4.

The second method is close in aggregate to the first but offers a better method of estimating truck volumes, if more data on density and volumes, by commodity group, are collected at the various ports of entry. Because trucks are loaded out to high levels in the second method—a process not always possible in reality—the current ETT method probably under-estimates true truck volumes. However, as truckers strive to reach higher levels of productivity, through Intelligent Transportation System (ITS) and other means, we may expect actual truckloads to be close to those used in this paper.

Comparison of the two methods. The results were reasonably close given the aggregated nature of the data. The total number of estimated trucks crossing in the six most important ports in Texas differs no more than six percent; nonetheless, it is surprising that we can obtain virtually the same figures using two different paths with relatively aggregated data. Differences at some ports are more significant, which suggest that further worked is necessary to calibrate the results at the port level.

The two methods should not be seen as non-complementary; on the contrary, each contributes to a higher understanding of the problem and provides both a crosscheck and a basis for further analysis and comparisons at the port level.

SUMMARY

This paper presented the findings of an evaluation of two methods to develop standardized truck volumes carrying NAFTA trade to and from Mexico. The first, using border crossing volumes, is the weakest theoretically, due to the need to make numerous assumptions and the reliance on a wide variety of crucial, yet sometimes difficult to obtain, data. This method forces the practitioner or researcher to gain an understanding of the complex border crossing process and avoid the temptation to apply uncalibrated recipes or formulas.

The method employing densities and volumes shows promise and explains why results show that average value per truckload per port varies significantly. El Paso, for example, shows a higher truckload value due to the high proportion of electrical products. There is not a linear relation between trade value per port and number of trucks, or between trade value and average truck weight, which suggests that trade value alone is not enough to compare port characteristics and how trade can impact infrastructure. This method would benefit from an updating of commodity densities and a homogenization of transportation and trade commodity classifications.

Commodity disaggregation provides more insight in the planning analysis. Key commodity groups can be identified, allowing more flexibility to analyze impacts of NAFTA trade and forecast future scenarios. The methodologies developed can be successfully used to estimate commodity truck volumes, however a larger effort is still required to analyze, match and use the current trade statistics and calibrate the results. Again, the accuracy and detail of available data heavily affect the quality of the results. Finally, further analyses of trailer loads in terms of the commodity densities and volumes that are currently crossing the border ports will allow the determination of more accurate standardized ETT volumes. Such data are important because they can be incorporated into federal and state planning actions that address the maintenance, rehabilitation and reconstruction of designated international trade corridors in the U.S.

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Table Titles

Figure Captions

TABLE 1 MAIN ASSUMPTIONS USED IN ESTIMATING NAFTA TRUCK VOLUMES

I.	Percentage of empty trucks is similar for single-unit and combination trucks
II.	Non passing trade is considered not significant, which may overestimate the number of NAFTA trucks
III.	Annual volumes are estimated, seasonal peaks may occur
IV.	Equivalence between single-unit and combination trucks is based on truckload weight and volume capacity
V.	For long haul movements only combination trucks are estimated (3S2 type)
VI.	Percentage of empty trucks on a highway segment varies only with direction of travel and is the same for all ports
V.	Local trade (border intercity trade) is captured using a percentage of single unit trucks

TABLE 2 BRIDGE TRUCK VOLUME METHOD RESULTS

Port of Entry	Bridge Count Method		
	Northbound	Southbound	Total
Laredo	494,602	561,325	1,055,927
El Paso	226,462	178,290	404,752
Brownsville	112,487	104,404	216,891
Hidalgo	139,315	126,171	265,486
Eagle Pass	35,852	39,194	75,046
Del Rio	26,497	25,627	52,124
Total	1,035,215	1,035,011	2,070,226

TABLE 3 A SELECTION OF NORTHBOUND ETT BASED ON DENSITIES

HTS Chapter	Density lbs/ft3	Truckload Weight	Trade Weight lbs	Truck Number	Truckload Value
01	10.5	37,380	300,237,533	8,032	22,093
02	17.0	44,000	7,390,456	168	47,158
03	12.0	42,720	110,142,960	2,578	162,825
04	8.0	28,480	11,466,484	403	18,990
05	9.0	32,040	19,340,385	604	34,676
06	8.5	30,260	30,817,934	1,018	23,318
07	11.5	40,940	4,912,160,194	119,984	11,212
08	11.2	39,872	2,626,642,810	65,877	8,337
09	9.6	34,176	297,506,686	8,705	51,175
10	20.0	44,000	14,552,564	331	8,190
11	11.2	39,872	21,407,258	537	6,195
12	8.1	28,836	88,720,460	3,077	12,272
13	12.3	43,788	16,345,947	373	38,493
14	7.0	24,920	53,648,368	2,153	15,283
15	11.7	41,652	17,340,464	416	23,125
16	15.0	44,000	28,979,298	659	53,622
17	10.3	36,668	150,936,192	4,116	22,328
18	10.6	37,736	27,230,509	722	37,274
19	8.5	30,260	269,032,139	8,891	15,336
20	10.9	38,804	526,042,301	13,556	15,612

TABLE 4 TRADE COMMODITY DENSITIES AND VOLUME METHOD RESULTS

Port of Entry	Northbound	Southbound	Total
Laredo	468,910	671,034	1,139,944
El Paso	252,823	228,801	481,624
Brownsville	100,206	128,463	228,669
Hidalgo	116,969	89,343	206,313
Eagle Pass	40,474	39,827	80,301
Del Rio	26,517	27,066	53,583
Total	1,005,899	1,184,534	2,190,433

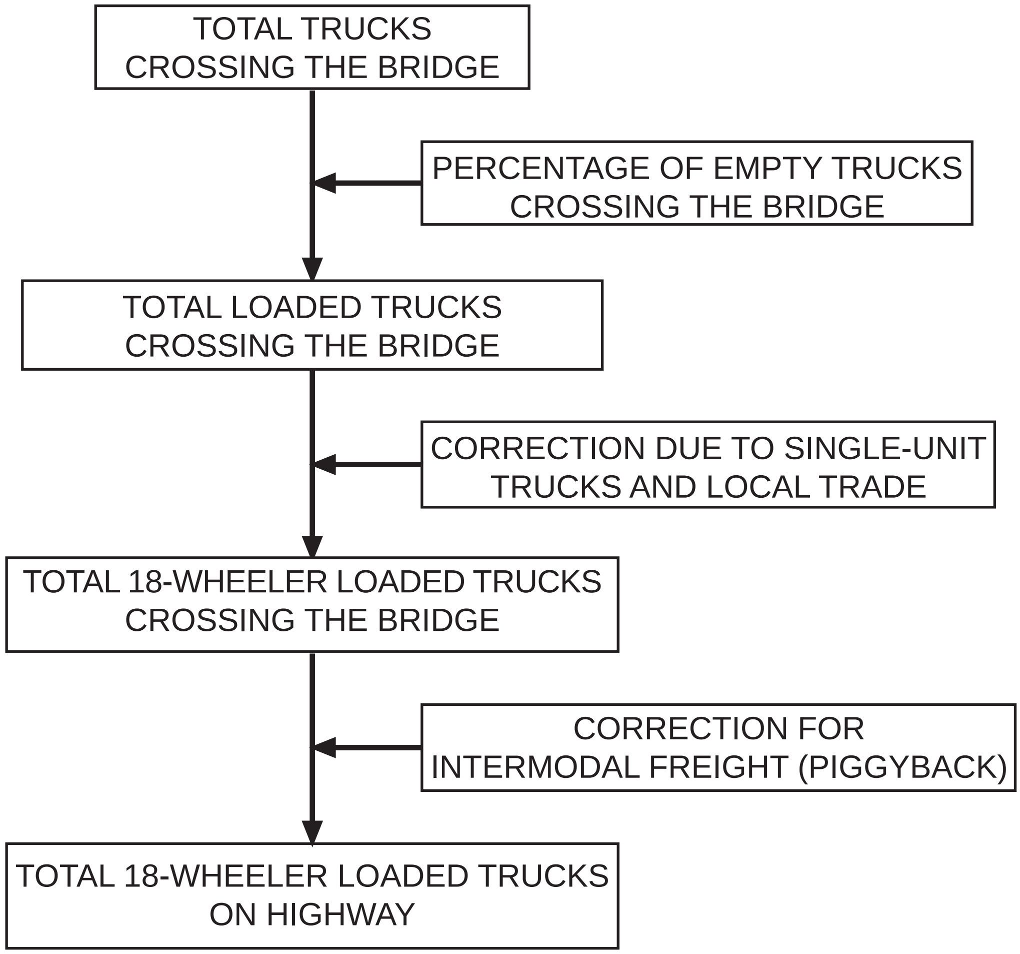

FIGURE 1 Estimation of NAFTA trucks by port on entry.

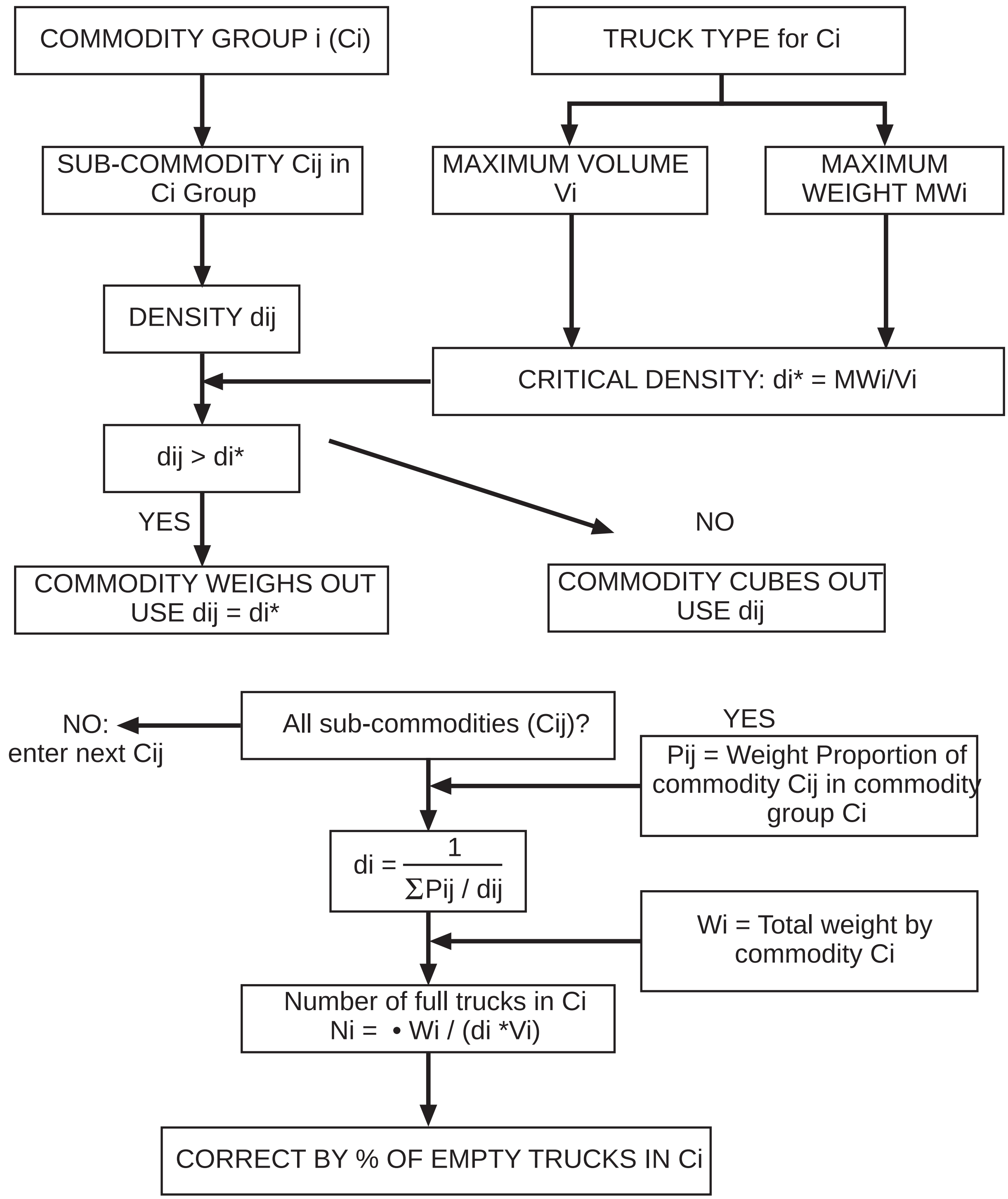

FIGURE 2 Truck weight estimation by commodity group.