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16. Abstract

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In this report, available data were analyzed to discern main U.S.-Mexico truck trade corridors and to estimate truck volumes. Several maps and tables of data were produced, as well as observations linking various areas of NAFTA truck trade. The capacity, congestion, performance, and operation of NAFTA-related truck corridors and their impacts on the transportation system were also analyzed, specifically within the context of multimodal transportation planning activities.

Because U.S.-Mexico trade is very dynamic and important changes continue to occur, the impacts of NAFTA may be quite extensive. Implementation of a NAFTA monitoring system that would follow trade statistics, corridors, traffic counts, and WIM data would provide a means of anticipating infrastructure problems and guiding investment policies. In addition, monitoring axle loads, truck volumes, and origins and destinations will be beneficial for planning purposes and pavement management on the NAFTA highway network.

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TRUCK TRADE CORRIDORS BETWEEN THE U.S. AND MEXICO

BY

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Robert Harrison

Research Report SWUTC/01/472840-00071-1

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Southwest Region University Transportation Center

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ABSTRACT

Since the implementation of the North American Free Trade Agreement (NAFTA) in 1994, U.S.-Mexico trade has continued to increase and so have the demands on the transportation system. The purpose of this project was to identify U.S.-Mexico trade corridors and determine the characteristics of truck traffic in these corridors, allowing for the provision of methodologies and figures leading to an increased understanding of NAFTA impacts on transportation.

In this report, available data were analyzed to discern main U.S.-Mexico truck trade corridors and to estimate truck volumes. Several maps and tables of data were produced, as well as observations linking various areas of NAFTA truck trade. The capacity, congestion, performance, and operation of NAFTA-related truck corridors and their impacts on the transportation system were also analyzed, specifically within the context of multimodal transportation planning activities.

Because U.S.-Mexico trade is very dynamic and important changes continue to occur, the impacts of NAFTA may be quite extensive. Implementation of a NAFTA monitoring system that would follow trade statistics, corridors, traffic counts, and WIM data would provide a means of anticipating infrastructure problems and guiding investment policies. In addition, monitoring axle loads, truck volumes, and origins and destinations will be beneficial for planning purposes and pavement management on the NAFTA highway network.

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The authors recognize that support was provided by a grant from the U.S. Department of Transportation, University Transportation Centers Program to the Southwest Region University Transportation Center. The authors would like to recognize the technical assistance provided by Professor John McCray at the University of Texas at San Antonio in the area of trade analysis. Professor Leigh Boske, at the Lyndon B. Johnson School of Public Policy at The University of Texas at Austin also provided insight and guidance in the area of transportation and logistics. We are grateful that these individuals, both experts in their field, took time from busy schedules to assist the progress of this report. We would also like to acknowledge the assistance of Jan Slack who administered the projects supporting this study, kept us on track and within budget and who formatted the report. Any errors and omissions are, of course, our responsibility.

EXECUTIVE SUMMARY

Since the implementation of the North American Free Trade Agreement (NAFTA) in 1994, U.S.-Mexico trade has continued to increase and so have the demands on the transportation system. A variety of research in this area has been undertaken at both federal and state levels, including two major federal studies and significant research in the four southern border states. Of the two major federal studies, the first was funded as part of the 1991 Intermodal Surface Transportation Efficiency Act and assessed border crossings and transportation corridors. The second, more recent Binational Border Transportation Planning and Programming Study focused on transportation issues at the U.S.-Mexico border from a binational perspective.

The aim of this project was to identify U.S.-Mexico trade corridors and determine the characteristics of truck traffic in these corridors, thus quantifying and providing methodologies and figures that could lead to an understanding of NAFTA impacts on transportation. In particular, this study looked at NAFTA truck characteristics, estimated the number of NAFTA-related trucks on U.S. highways, determined NAFTA truck corridors by value and commodity, and provided strategies to analyze the impact of NAFTA trucks on the infrastructure. This required a sequential analysis of trade statistics, truck border operation, truck characteristics, origins and destinations, truck corridors, and estimations of truck volumes. Available data were analyzed to discern main U.S.-Mexico truck trade corridors and to estimate truck volumes, as well as to produce maps and tables. This study also analyzed the capacity, congestion, performance, and operation of NAFTA-related truck corridors and their impacts on the transportation system, particularly in the context of multimodal transportation planning activities.

A major challenge of this study was to analyze all the available data to provide useful observations linking different areas of NAFTA truck trade. This was a difficult issue to deal with, as the problem subject was broad, complex, and equipped with few previous quantitative analyses. Data were generally scattered and often unsuitable for transportation analysis or were given in formats that made them difficult to use. Although some of the figures in this study might appear limited due to the accuracy of the original data or assumptions made, they help to clarify aspects of NAFTA truck trade and put them in the right perspective.

NAFTA trade between Mexico and the U.S. is expected to have high rates of growth in the coming years. Two issues influencing the transportation aspects of NAFTA are: 1) the second phase of NAFTA surface transportation legislation, which allows Mexican truckers to circulate in the border states of the U.S. and allows U.S. drivers to circulate in Mexican border states; and 2) the privatization of Mexican railroads, which has brought about interlining

agreements with U.S. class one railroads in Texas (UP, BNSF, and KCS). The consequences of opening the border in this manner are not clear and are difficult to predict.

U.S.-Mexico trade is very dynamic, and important changes will continue to take place. Implementation of a NAFTA monitoring system that would follow trade statistics, corridors, traffic counts, and WIM data would provide a means of anticipating infrastructure problems and guiding investment policies. Monitoring axle loads, truck volumes, and origins and destinations will be beneficial for planning purposes and pavement management on the NAFTA highway network, much of which is already congested and heavily utilized.

As a better understanding of NAFTA is reached and more data become available, further work may include integration of other modes as well as other countries in the analysis. The integration of trade generation and attraction, modal splits, trade distribution, assignment of trade to the networks, integration of freight trade demand work, modal split work, and this study would produce a complete multimodal planning analysis.

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CHAPTER 1. INTRODUCTION

BACKGROUND

Since the implementation of the North American Free Trade Agreement (NAFTA) in 1994, U.S.-Mexico trade has continued to increase, and, at the same time, so have the demands on the transportation system. The problems associated with the implementation of NAFTA have stimulated a range of research at both the federal and state levels. Two major studies have been undertaken at the federal level. The first was funded as part of the 1991 Intermodal Surface Transportation Efficiency Act (Ref 1) and assessed border crossings and transportation corridors (Ref 2). Most recently, the Binational Border Transportation Planning and Programming Study focused on transportation issues at the U.S.-Mexico border from a binational perspective (Ref 3). At the state level, significant research has been undertaken, especially in the four southern border states, since 1990.

Texas has funded research through a variety of agencies, including the Governor's Office, the Attorney General's Office, and the Texas Department of Transportation (TxDOT). TxDOT has funded research on a variety of subjects such as maquiladoras, border city operations, overweight/oversize vehicles, trade corridors, trade forecasting multimodal policies, and the impact of new logistical practices (Refs 24,25,26,2,4). In terms of methodologies to apply in NAFTA transportation planning, two studies undertaken at the Center for Transportation Research (CTR) at the University of Texas at Austin are of interest; the first study focused on methodologies to forecast the effects of NAFTA on the demand for freight transportation at the Texas-Mexico border; the second study used available data to forecast modal split among U.S. and Mexican regions Work undertaken by Professor John McCray at the University of Texas at San Antonio has also identified NAFTA corridors based on a proprietary model (Ref **5**).

Border crossings and, particularly, corridors to those crossings are likely to remain an area of interest in the near future because they make a critical impact on NAFTA trade flows and can attract state and federal funding for infrastructure investments. It is important to analyze the capacity, congestion, performance, and operation of NAFTA-related truck corridors and their impacts on the transportation system, especially in the context of multimodal transportation planning activities.

OBJECTIVES

This project aims to study NAFTA truck characteristics, estimate the number of NAFTA-related trucks on U.S. highways, determine NAFTA truck corridors by value and commodity, and provide strategies to analyze the impact of NAFTA trucks on the infrastructure. This study can be seen as a continuation of the efforts to provide data and methodologies that can be applied in NAFTA transportation planning (Refs 2, 4).

ORGANIZATION OF THE STUDY

Chapter 1 introduces the background, objectives, and structure of this study. In Chapter 2 the highlights of U.S.-Mexico trade are presented, placing the transportation problem into the larger picture of bi-national trade. Appendixes have been included to provide more detail for the reader interested in trade data sources, trade by port and state, and aspects of the maquiladora industry and commodity/employment classifications.

Chapter 3 describes trucking-related regulation at the border. An analysis of truck characteristics at the border and a comparison with truck characteristics on Texas highways using weigh in motion data (WIM) is presented in Chapter 4.

The subsequent three chapters deal with methodologies to estimate the number of trucks generated by NAFTA trade and to determine NAFTA corridors. Chapter 5 presents methodologies to estimate NAFTA truck volumes; Chapter 6 presents a methodology to identify related truck corridors; and Chapter 7 presents an analysis of the main corridors of NAFTA truck trade. Chapter 8 introduces elements that are useful in an analysis of the impact of NAFTA-related truck traffic on the highway infrastructure, specifically on pavements. This study finishes with conclusions and recommendations. The flowchart in Figure 1 presents the relationships among the chapters.

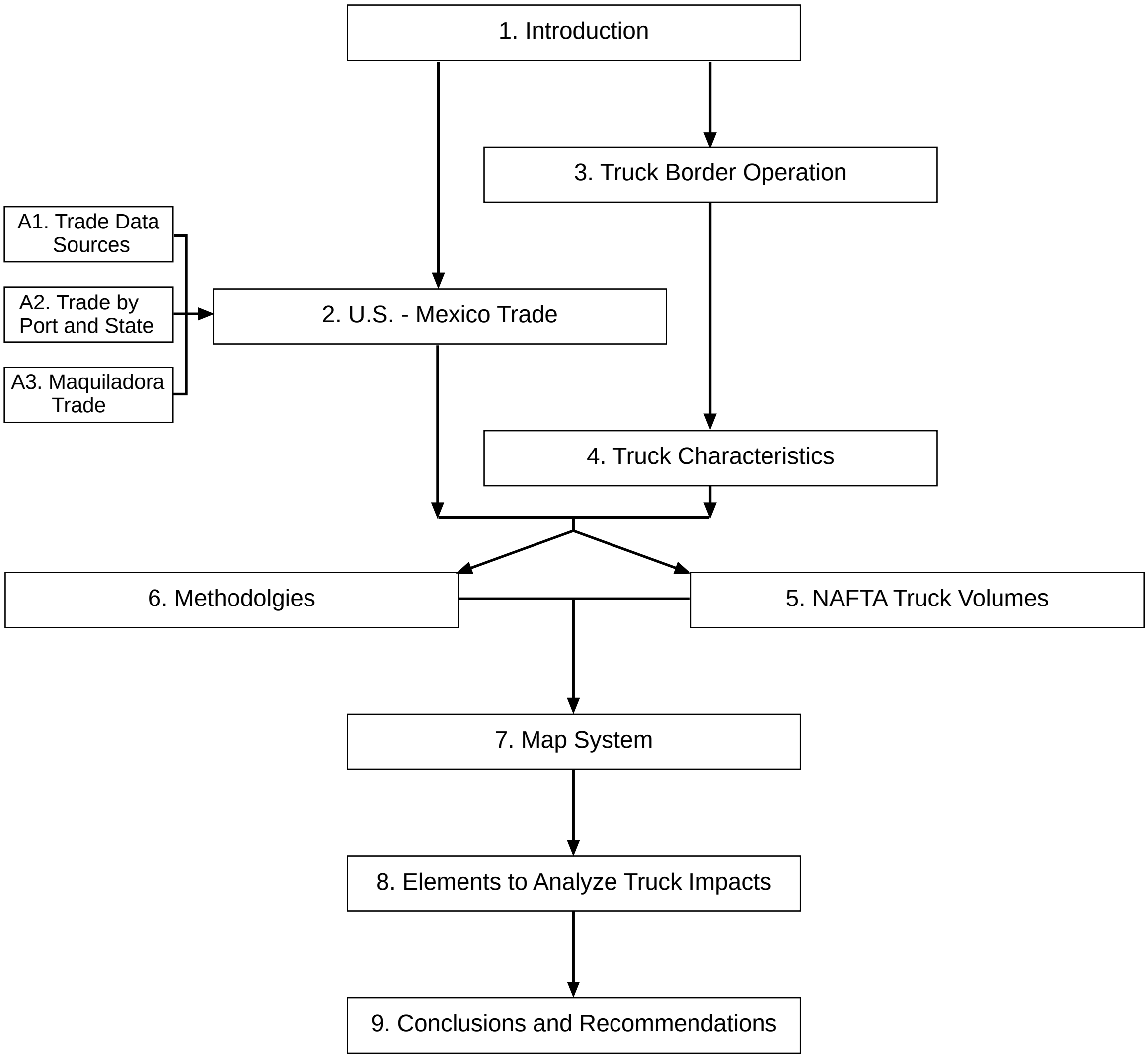


Figure 1. Organization of the Study.

CHAPTER 2. U.S.-MEXICO TRADE CHARACTERISTICS

International trade is created by the movement of goods from producers to consumers in different countries. This trade is moved by a variety of transportation modes such as highway, railroad, air, sea, and pipeline. It is therefore not surprising that the study of international trade statistics provides valuable information for the transportation analyst.

The transportation highlights of the recent U.S.-Mexico trade flows are presented. The chapter begins with a discussion of trade data availability and sources. It then gives a presentation of key data and figures derived from an analysis of U.S.-Mexico trade for the years 1996 and 1997, which are important because they follow the signing of NAFTA and the Mexican peso devaluation.

TRADE DATA

The purpose of this section is to provide a description of the available U.S.-Mexico trade data and their shortcomings and limitations. A more complete description of each data set is presented in Appendix 1.

Trade Data Characteristics

U.S.-Mexico freight transportation data have been significantly improved by the publication of the Transportation Surface Freight Database (TSFD), beginning in April 1993. The Bureau of Transportation Statistics (BTS) publishes these data monthly and bases them on declarations filed at U.S. Customs and processed by the Census Bureau.

Though these data sets introduce important improvements over previous data, the data available to study transportation aspects of U.S.-Mexico trade still have many shortcomings. Basic transportation data, such as origin, destination, or mode of transportation, are not always complete, accurate, or easy to analyze. More detailed data regarding cost, times, and reliability of transportation mode are either nonexistent or so fragmented and limited that it is not possible for the transportation modeler to create detailed or accurate models.

Many of the data's shortcomings stem from the data collection design. U.S.-Mexico trade data sets available to the public are collected by Mexico or U.S. Customs services. The main objective of customs is to control the incoming flows of merchandise, check rules of origin, and collect the corresponding taxes. Import duties are an important source of tax income, so import data are both reliable and detailed. Exports have traditionally been less regulated because many goods are tax exempt, and, as a result, the data are less accurate.

The collected data are based on import and export declarations filed at Customs Service districts and ports. Import declarations undergo several checks, while export declarations are just filed and delivered. In 1998, U.S. Customs began to enforce the timely and accurate filing of Shipper Export Declarations (SED), and more accurate export data may be expected from this date forward (Ref 6).

From the last point, it is clear that, for a given country, import statistics have a tendency to be more accurate than export statistics. U.S. Customs data sets, though limited, are offered regularly to the public domain either through direct publications or through third parties like BTS. Mexican data are not as easily accessible, as confirmed by a recent binational study: "This information is not available to the public, not necessarily because it is confidential, but because the sources do not normally process it for publication. As a result, the acquisition of statistical information in a usable form required more effort." (Ref 1)

On the other NAFTA border, Canada and the U.S. have a data exchange agreement. The U.S. obtains all of its data for U.S. exports to Canada from Statistics Canada, the agency in charge of trade statistics in Canada, and the U.S. export data to Canada are the same data that Canada reports for its U.S. imports (Ref 8). As we can see, idiosyncrasies exist at both borders, and tri-partite agreements to collect, check, and report trade data would lead to improved information for transportation planning.

The main shortcomings of trade data sets available from U.S. sources include:

1. The mode of transportation registered is the mode that crosses the border upon exit or entry to a country. If there was an intermodal movement before or after the crossing, this is not recorded.
2. The port of exit or entry is where the documentation is filed, not necessarily where the cargo crossed.
3. Maquiladoras (assembly plants) are an important and growing component of U.S.-Mexico trade. However, maquiladora data are not present in U.S. statistics. Only Mexican Customs collects these data.
4. "State of origin" data do not always represent the production site; they may be consolidation points.
5. "State of destination" data do not always represent the final destination of the cargo; they may represent the company headquarters.
6. Commodity data are presented in different classification systems, which makes analysis and comparison laborious.

7. Weight is not available for southbound shipments. This complicates estimation of truck volumes and loads for southbound movements, which are important factors in analysis of the impact of truck traffic on pavements.

More detailed data, such as time, cost, city of origin, city of destination, and reliability, are not available from public sources. This hinders the application of more accurate freight-generation and mode-choice models. Two reports (Refs 11, 12) that were produced at The University of Texas at Austin and that focus on freight-generation and mode-choice models reflect the difficulty of employing these approaches when there is a lack of basic accurate data.

Regarding classification, even within the U.S. it is difficult to have common classification systems. For example, trade data are reported in HTS system format (two or ten digits) or using Standard International Trade Classification (SITC) classification; employment data are published using Standard Industrial Classification (SIC) categories and commodity density is available using Standard Transportation Commodity Classification (STCC) data. Unfortunately, these systems are not fully compatible, which makes combined analysis difficult. To complicate the matter even further, Mexican data, when available, are often classified using different systems.

Another important issue related to information released by U.S. Customs is data privacy. Detailed data concerning city of destination, city of origin, ten-digit commodity classification, and port of entry/exit are not released to protect the identity of the importer/exporter.

Data Sources

Table 1 and Table 2 present a comparison among data obtainable from public data sources. Two data sets are produced directly by the U.S. Department of Commerce: import and export trade data sets and import and export trade data by port. The Bureau of Transportation Statistics publishes the TSFD, which contains import and export data sets. Mexico's Secretaria de Comercio y Finanzas (SECOFI) data is the source of Mexican import and export data sets. A comprehensive description of these data sets is presented in Appendix 1.

Table 1. Southbound Data

MAQUILADORA						*	*
CONTAINER							
WEIGHT		*	*				
VALUE		*	*	*	*	*	*
COMMODITY DETAIL	SIC						
	5-DIGIT SITC		*				
	10-D SCHED. B	*					
	2-DIGIT HST				*		*
	10-DIGIT HST	*					
PORT OF EXIT	BY DIST. RIC	*					
	BY PORT		*	*		*	
ORIGIN DESTINATIO	MEXICO	*	*				*
	MX STATE			*	*	*	
	US	*	*			*	*
	US STATE			*	*		
MODE	SURFACE	*	*				*
	VESSEL	*	*				*
	AIR	*	*				*
	OTHER			*	*		*
	PIPELINE			*	*		*
	RAIL			*	*		*
	TRUCK			*	*		*
DATABASE		U.S. DEPT. OF COMM. EXPORTS	U.S. EXPORTS BY PORT	TSFD EXPORTS GEOG. DETAIL	TSFD EXPORTS COMMOD. DETAIL	MEXICAN IMPORTS GEOG. DETAIL	MEXICAN IMPORTS COMM. DETAIL

Table 2. Northbound Data

MAQUILADORA						*	*
CONTAINER				*	*		
WEIGHT		*	*	*	*		
VALUE		*	*	*	*	*	*
COMMODITY DETAIL	SIC						
	5-DIGIT SITC		*				
	10-D SCHED. B						
	2-DIGIT HST				*		*
	10-DIGIT HST	*					
PORT OF EXIT	BY DIST. RIC	*					
	BY PORT		*	*		*	
ORIGIN DESTINATION	MEXICO	*	*	*	*		*
	MX STATE					*	
	US	*	*			*	*
	US STATE			*	*		
MODE	SURFACE	*	*				*
	VESSEL	*	*				*
	AIR	*	*				*
	OTHER			*	*		*
	PIPELINE			*	*		*
	RAIL			*	*		*
	TRUCK			*	*		*
DATABASE		U.S. DEPT. OF COMM. EXPORTS	U.S. EXPORTS BY PORT	TSFD EXPORTS GEOG. DETAIL	TSFD EXPORTS COMMOD. DETAIL	MEXICAN IMPORTS GEOG. DETAIL	MEXICAN IMPORTS COMM. DETAIL

As indicated in Table 1 and Table 2 complete information is not available from a single data set, which does not allow complete queries involving origin, destination, mode, value, weight, commodity, and border crossing at the same time. Overall, TSFD is the data set that presents the most valuable information from a surface transportation analysis point of view. The TSFD is the only database that contains both (1) surface modal split and commodity classification and (2) surface modal split by port of entry/exit. The other data sources are valuable because they complement and verify TSFD. For example, data regarding maquiladora trade are only available from Mexican sources.

While U.S. trade data are fragmented across several data sources, they substantially match when they are compared with one another because the U.S. data sets stem from the same basic customs documentation. The accuracy of the U.S. trade data heavily depends on the competent filing of the export/import documentation and, as was mentioned before, import data always tend to be more accurate and reliable.

The only field that appears in all the data sets is trade value, which may differ between U.S. and Mexican data. Disagreements may arise when planners compare U.S. and Mexican data, in part because of the different ways the goods are appraised at customs (Ref 1) and in part because of inaccuracies inherent in the trade data sets.

This section has described characteristics of the data sources available to the transportation planner for an examination of U.S.-Mexico trade. While these data are incomplete and need careful treatment in the development of trade flow information, they nevertheless can be usefully applied. The next section uses these data sources to detail the growth of trade between the two countries up to the present, in which Mexico is one of the leading trading partners with the United States.

MEXICAN ECONOMY, TRADE POLICIES, AND US-MEXICO TRADE

The evolution of U.S.-Mexico trade over the last two decades has been impressive. In 1980, total trade amounted to $28 billion. Ten years later, in 1990, total trade reached $58 billion; by 1997 (latest available data) the number reached $159 billion. Total trade over the past seventeen years has grown at an average annual rate of 10.7 percent. The rate of growth accelerated during the nineties. Between 1991 and 1997, imports grew 18.4 percent and exports 13.6 percent per year (Ref 8), which enabled Mexico to replace Japan as the second-largest trading partner of the U.S.

Several factors have contributed to this impressive boost in trade. Protectionism and control over foreign investment characterized postwar Mexican economic policy. The aim of this economic policy was to estimate the growth of the manufacturing sector, but it did so at the cost of decreased competitiveness. This policy continued until 1976, when the first economic crisis was created by a deficit of Mexican foreign reserves. In 1981, a drop in the price of oil, combined with the scarcity of international credit, caused the Mexican economy to collapse (Ref2).

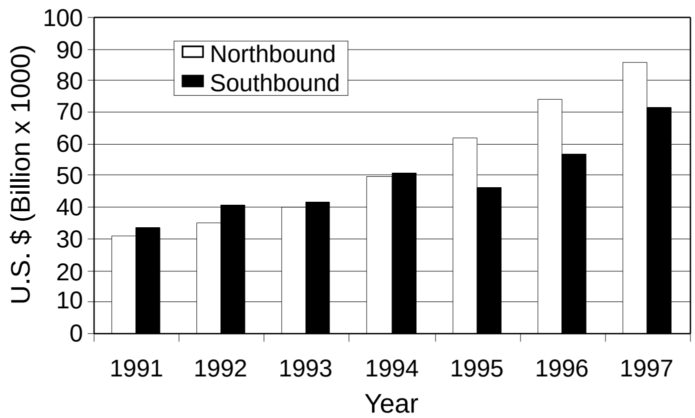


Figure 2. U.S. Trade with Mexico.

Since then, the Mexican economy has undergone a major transformation. In 1986 Mexico joined the General Agreement on Tariffs and Trade (GATT). This brought about an important reduction of tariff and non-tariff barriers and also relaxed restrictions on foreign investment. At the end of 1993 NAFTA was signed, further boosting trade (Ref 3).

Another important factor was the devaluation of the peso in 1981–1983 and again in December 1994. Devaluation was undertaken as part of the corrective measures instituted by the Mexican government, which further affected the terms of trade. As a result of peso devaluation, prices for Mexican consumers purchasing imported products increased and the demand for U.S. products decreased, which weakened southbound trade. On the other hand, devaluation made Mexican salaries cheaper in U.S. dollars, making maquiladoras and Mexican products more competitive in the U.S. and world markets. Consequently, northbound trade strengthened after the peso devaluation. This can be clearly seen in the import export figures for the years 1991–1994 (before devaluation) and 1995–1997 (after devaluation), as shown in Figure 2.

U.S.-MEXICO TRADE BY COMMODITY

Not only have the trade volumes changed substantially; so have the commodities traded. In the early 1980s, petroleum and agricultural products dominated trade (Ref 9). Today, these have been supplanted by manufactured goods. The fastest-growing commodity group is machinery and transport equipment (Ref 10), comprising 50.2 percent of total southbound trade by value (1997), up from 46.9 percent in 1996.

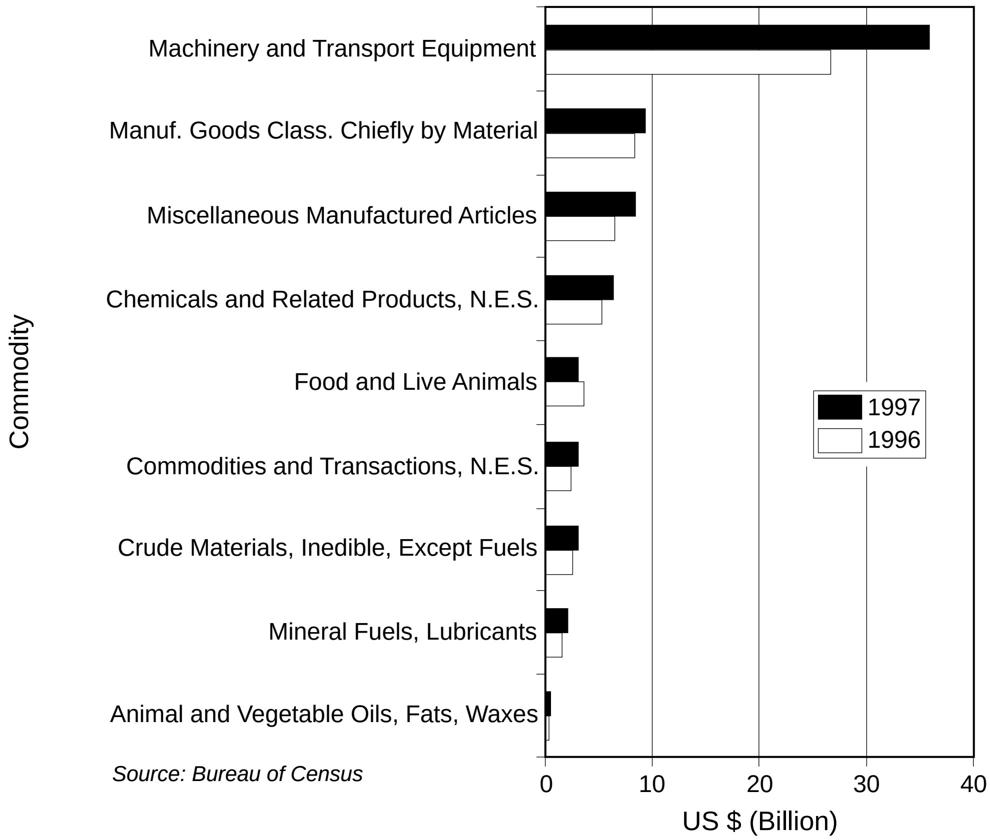


Figure 3. Total Southbound Trade.

For northbound trade, the share of machinery and transport equipment is even higher—55.1 percent in 1997. It is important to note that this corresponds to the value of the traded goods; if weight is used to determine each commodity group's percentage of the total, the share of petroleum, agricultural, and mineral commodities is much higher. Mineral fuels and petroleum, the main Mexican exports in the eighties, have fallen to third place, due in part to lower prices and to the increase in manufacturing exports.

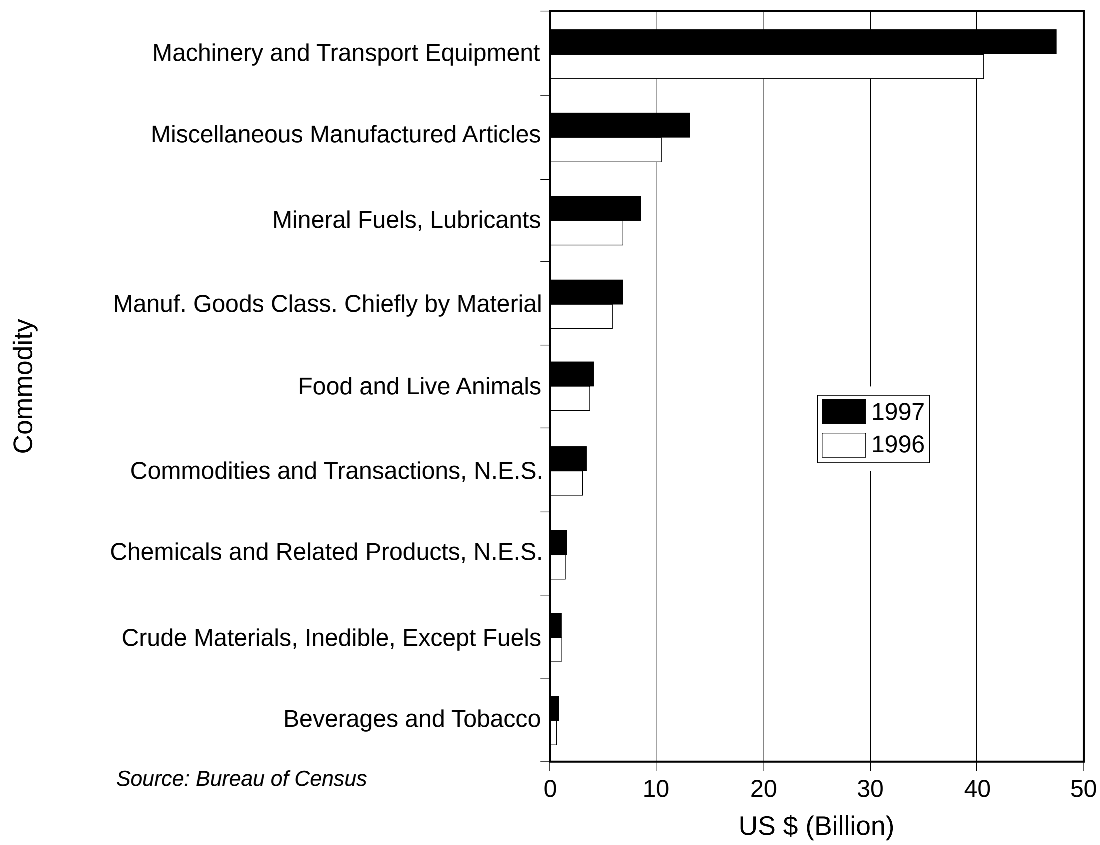


Figure 4. Total Northbound Trade.

TRANSPORTATION MODES

When trade is measured by the value of the goods transported, both southbound and northbound trades are dominated by surface transportation modes (90 percent southbound and 85 percent northbound). Southbound surface trade is dominated by transportation equipment, electrical, and industrial machinery. Other important commodities are chemicals, plastics, and metal products.

Table 3. Modal Split Southbound Trade

COMMODITY	SEA	AIR	SURFACE
Agricultural Products	1,025	7	1,831
Food Products	403	3	1,753
Minerals and Metals	808	41	5,674
Chemicals/Plastics	618	197	6,766
Wood/Paper/Pulp	50	33	2,895
Textiles/Apparel	90	59	3,189
Industrial Machinery	102	848	6,466
Electrical Machinery	23	744	12,769
Transport Equipment	13	75	5,613
Instruments	8	257	1,300
Miscellaneous	4	98	3,000
TOTAL	3,143	2,362	51,256
PERCENTAGE	5.54%	4.16%	90.30%

Source: U.S. Department of Commerce

As shown in Table 3 and Table 4, air cargo is concentrated in high-value commodities and accounts for 4 percent of southbound trade value and 3 percent of northbound trade. Southbound sea movements (6 percent by value) are mainly composed of agricultural products, minerals, metals, plastics, and chemicals listed in order of importance. Northbound sea movements are more important (12 percent of the total northbound trade value), due primarily to U.S. imports of oil products (Ref 11).

Table 4. Modal Split Northbound Trade

COMMODITY	SEA	AIR	SURFACE
Agricultural Products	124	40	2,942
Food Products	53	3	1,175
Minerals and Metals	7,268	25	3,932
Chemicals/Plastics	336	52	1,714
Wood/Paper/Pulp	15	11	2,582
Textiles/Apparel	113	168	4,794
Industrial Machinery	10	401	7,443
Electrical Machinery	30	621	18,051
Transport Equipment	806	19	13,375
Instruments	2	118	2,320
Miscellaneous	41	412	3,967
TOTAL	8,797	1,870	62,296
PERCENTAGE	12.06%	2.56%	85.38%

Source: U.S. Department of Commerce

SURFACE TRADE MOVEMENTS

Trucks are the predominant mode of transport in U.S.-Mexico surface trade. Considering trade value, 86 percent of southbound trade and 76 percent of northbound trade crosses the border by truck (Table 5).

Transportation equipment and food products are the commodities with higher railroad use. The railroad is significantly more important for northbound movements; it is used for 17 percent of northbound trade and 9 percent southbound trade, due to the shipment of assembled items like automobiles from Mexican plants.

Other modes include pipelines, mail services, and vehicles moved by their own power (self-propelled vehicles). For northbound movements, the value of Foreign Trade Zones (FTZ) is reported; the mode for FTZ is unknown (Ref 12). It is important to point out that data indicate the mode of transport used to cross the border but do not account for intermodal movements before or after the crossing.

Table 5. Modal Split Surface Trade

Commodity	NORTHBOUND				SOUTHBOUND			
	Truck	Train	Other	% Truck	Truck	Train	Other	% Truck
Agricultural Products	2,893	63	0	97.9%	1,252	574	8	68.3%
Food Products	872	280	31	73.7%	882	778	96	50.2%
Minerals and Metals	3,322	554	82	83.9%	4,914	750	28	86.3%
Chemicals/Plastics	1,509	227	4	86.7%	6,246	504	26	92.2%
Wood/Paper/Pulp	2,540	53	1	97.9%	2,597	300	2	89.6%
Textiles/Apparel	4,801	4	11	99.7%	3,053	149	7	95.1%
Industrial Machinery	6,288	652	660	82.7%	6,260	216	7	96.6%
Electrical Machinery	17,796	37	822	95.4%	12,644	129	5	99.0%
Transport Equipment	2,946	10,408	64	22.0%	3,957	1,683	357	66.0%
Instruments	1,957	0	382	83.7%	1,262	24	16	97.0%
Miscellaneous	3,427	18	607	84.6%	1,024	12	1,990	33.8%

Source: Bureau of Transportation Statistics

In surface movements, manufactured goods generate most of the value of U.S.-Mexico surface trade. Electrical machinery alone provides for 36.8 percent (northbound) and 28.7 percent (southbound) of the total truck trade value, as shown in Table 6. The next two important commodities are industrial machinery and transport equipment. These three groups together add up to 55.9 percent (northbound) and 51.8 percent (southbound) of the total trade.

Table 6. Commodity Shares By Truck Trade

DESCRIPTION	NORTHBOUND		SOUTHBOUND	
	Truck	% Truck	Truck	% Truck
Agricultural Products	2,893	6.0%	1,252	2.8%
Food Products	872	1.8%	882	2.0%
Minerals and Metals	3,322	6.9%	4,914	11.1%
Chemicals/Plastics	1,509	3.1%	6,246	14.2%
Wood Paper/Pulp	2,540	5.3%	2,597	5.9%
Textiles/Apparel	4,801	9.9%	3,053	6.9%
Industrial Machinery	6,288	13.0%	6,260	14.2%
Electrical Machinery	17,796	36.8%	12,644	28.7%
Transport Equipment	2,946	6.1%	3,957	9.0%
Instruments	1,957	4.0%	1,262	2.9%
Miscellaneous	3,427	7.1%	1,024	2.3%

Source: Bureau of Transportation Statistics

Trade by Port of Entry/Exit

Ports of entry

There are thirty-two U.S.-Mexico border crossings; eighteen of them are on the Texas border, although trade is highly concentrated. The top eight ports that accounted for 90 percent of the total U.S.-Mexico surface trade in 1997 are shown in Figure 6. Five of these ports are located on the Texas-Mexico border: Laredo, El Paso, Brownsville, Hidalgo, and Eagle Pass.

Border Crossing Network

Mexican States

- A Baja California
- B Sonora
- C Chihuahua
- D Coahuila
- E Nuevo Leon
- F Tamaulipas

California Border

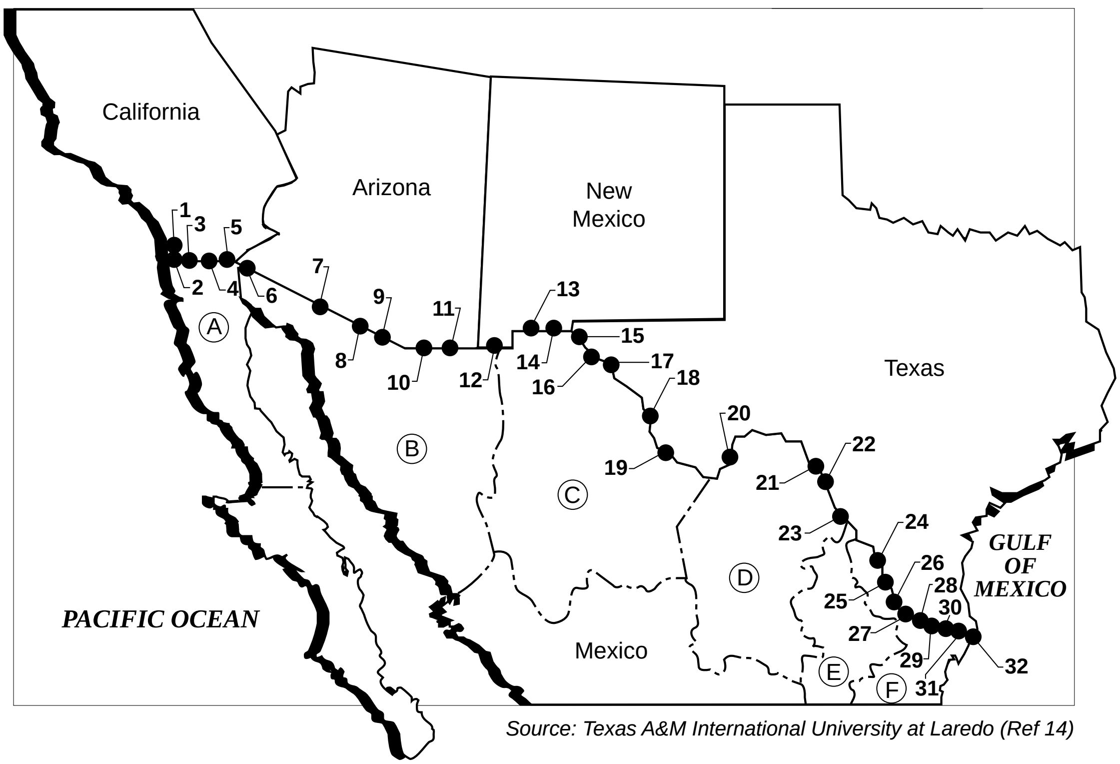
- 1 San Diego
- 2 Otay Mesa/San Ysidro
- 3 Tecate
- 4 Calexico
- 5 Andrade

Arizona Border

- 6 San Luis
- 7 Lukeville
- 8 Sasabe
- 9 Nogales
- 10 Naco
- 11 Douglas

New Mexico Border

- 12 Antelope Wells
- 13 Columbus
- 14 Santa Teresa



Source: Texas A&M International University at Laredo (Ref 14)

Texas Border

- 15 El Paso
- 16 Ysleta
- 17 Fabens
- 18 Fort Hancock
- 19 Presidio
- 20 La Linda
- 21 Amistad Dam
- 22 Del Rio
- 23 Eagle Pass
- 24 Laredo
- 25 Falcon Dam
- 26 Roma
- 27 Rio Grande City
- 28 Los Ebanos
- 29 Hidalgo
- 30 Progreso
- 31 Los Indios
- 32 Brownsville

Figure 5. U.S.-Mexico Border Crossings.

Laredo is the main port of surface trade at the southern border. In 1997, counting exports and imports, 40.7 percent of the total U.S.-Mexico surface trade crossed through Laredo. Laredo is also the fastest-growing port, and during the period 1995-1997 trade grew 74.7 percent.

El Paso is the second largest port by trade value with 23.1 percent of all surface trade, but it is one of the slower growing ports (from 1995 to 1997, trade grew 13 percent).

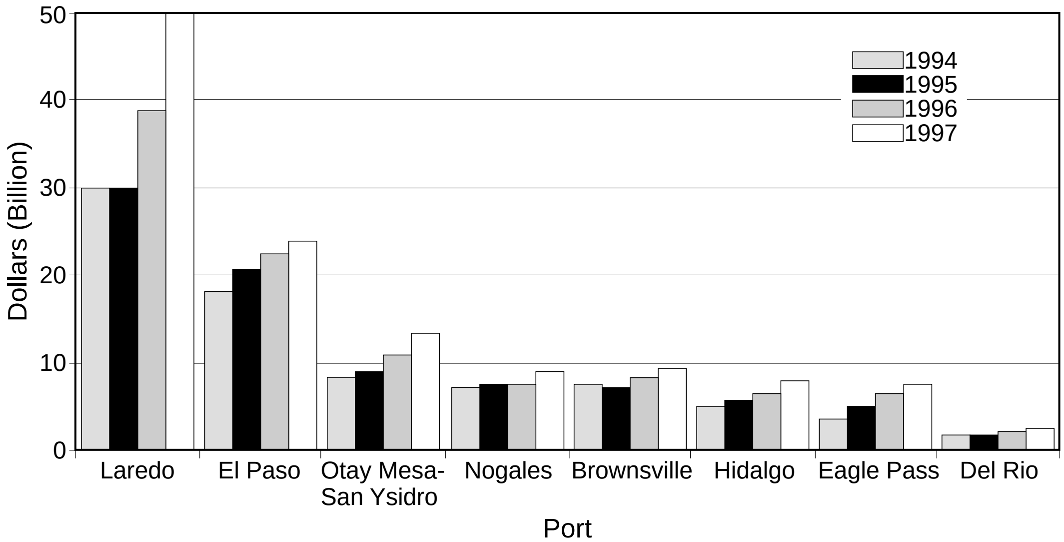


Figure 6. Total Surface Trade By Ports.

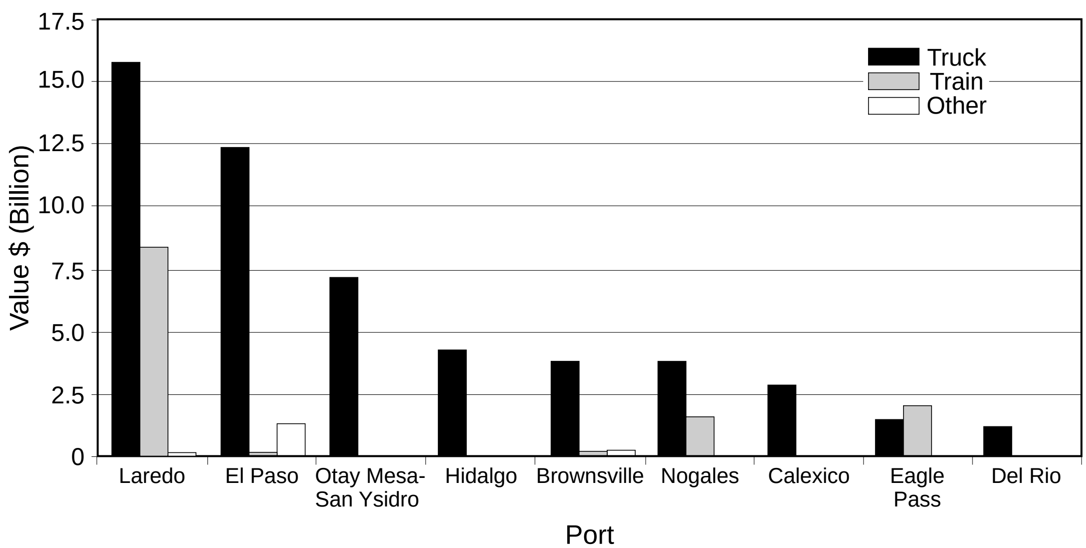


Figure 7. Mode Split By Port (1997 Northbound Movements).

Mode Split by Port

Trucks are the main mode of transportation in all main ports except the port of Eagle Pass.

Three ports—Laredo, Nogales, and Eagle Pass--have an important share of railroad traffic, as illustrated in Figure 7 and Figure 8. It should also be noted that for railroad surface trade, U.S. imports are much more important than U.S. exports. In the case of Nogales, railroad exports are almost insignificant. Other modes are practically insignificant and have only marginal importance in the ports of El Paso and Brownsville.

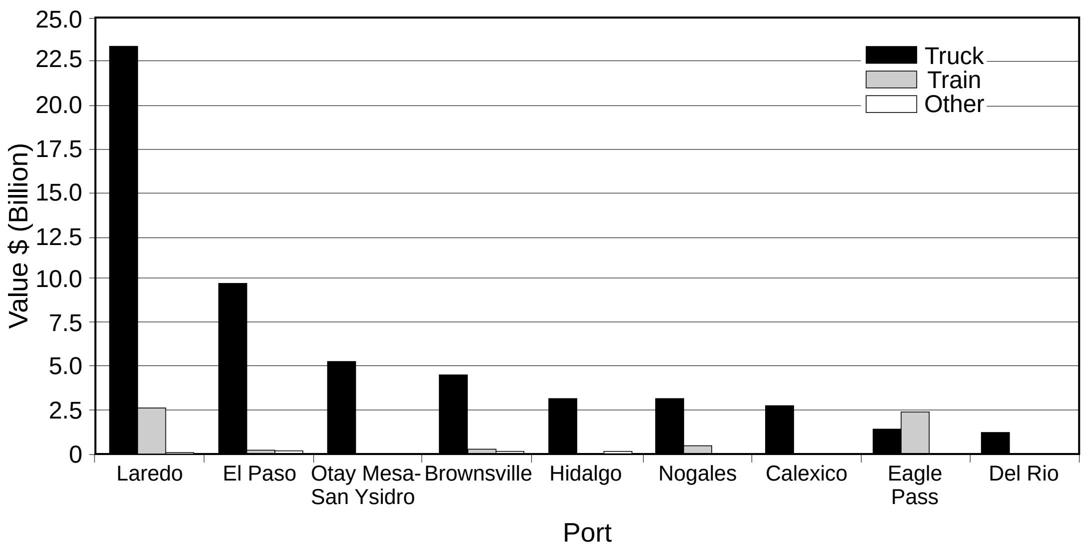


Figure 8. Mode Split By Port (1997 Southbound Movements).

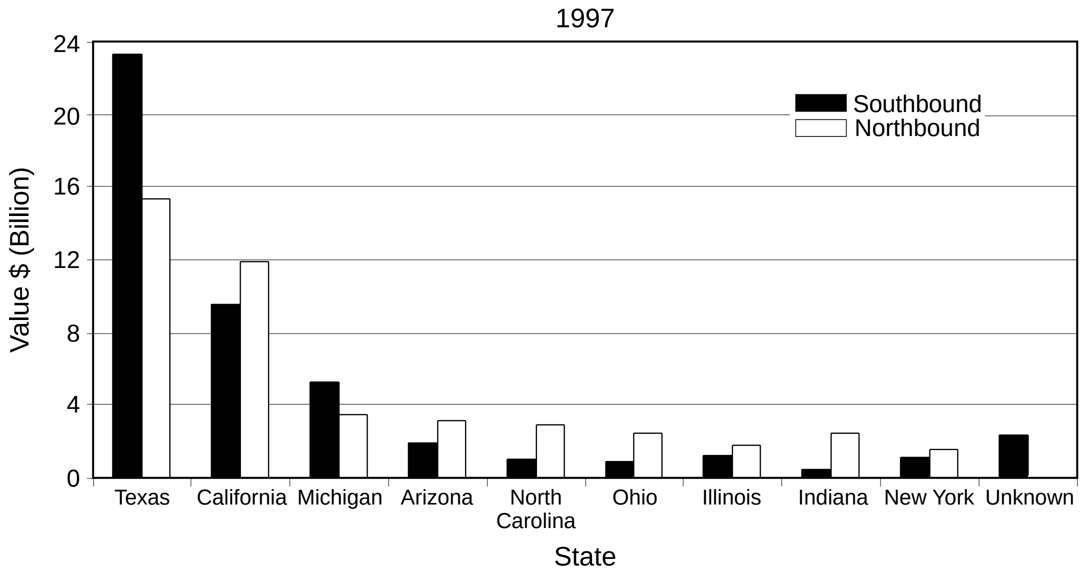


Figure 9. Trade By State (1997).

Commodities by Port

Commodity data have no mode split at the port level of detail. Therefore, data contained in this section correspond to all surface modes of transportation. Commodities at five-digit SITC were grouped into eleven groups, to represent the key classification into which all trade can be grouped (a discussion about commodity groups is presented in Chapter 7 – Methodologies).

The results are presented in Appendix 2. Certain commodity groups tend to dominate trade at the port level. Laredo differentiates itself from the rest; commodities traded are more diversified, hauls through the port are the longest, and the influence of maquiladora trade is small.

Maquiladoras (assembly plants) have a strong influence on the commodities traded, e.g., electrical products and machinery have a strong influence on maquiladora ports. There are two aspects of maquiladora trade that should be kept in mind; first, that manufactured parts (unfinished products) dominate the trade, and second, maquiladoras are generally located close to the U.S.-Mexico border. A detailed description and analysis of maquiladora trade is found in Appendix 3.

NORTHBOUND-SOUTHBOUND TRADE BY U.S. STATES

The border states (Texas, California, and Arizona) hold a significant position for trade with Mexico. Texas and California account for 37 percent and 19 percent, respectively of the total truck trade (Figure 9). Northbound trade is also more important than southbound trade in California and several non-border states.

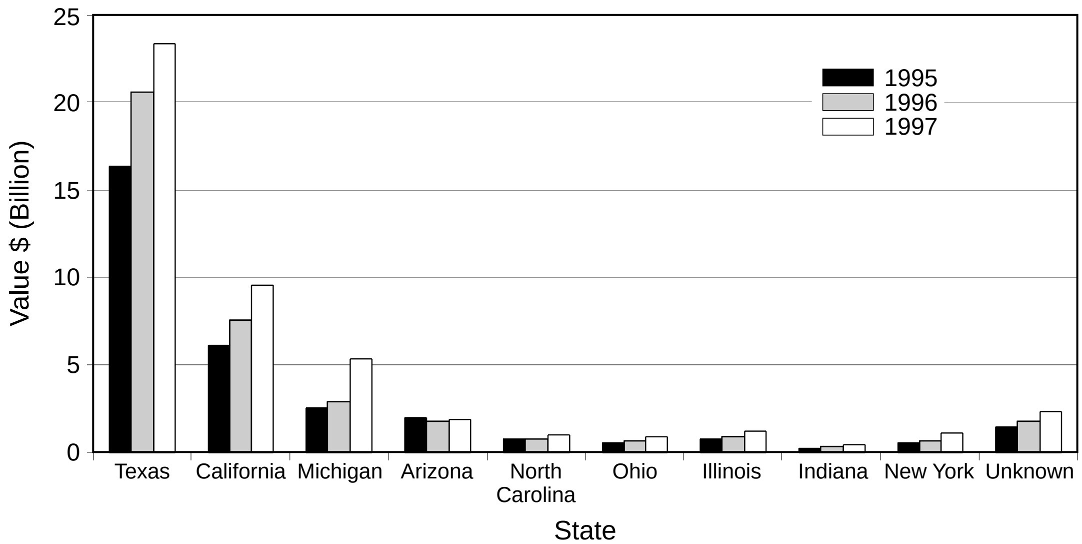


Figure 10. Southbound Trade By State (1995-1997).

Northbound data are more accurate. Unknown state participation in U.S.-Mexico trade is higher for southbound trade.

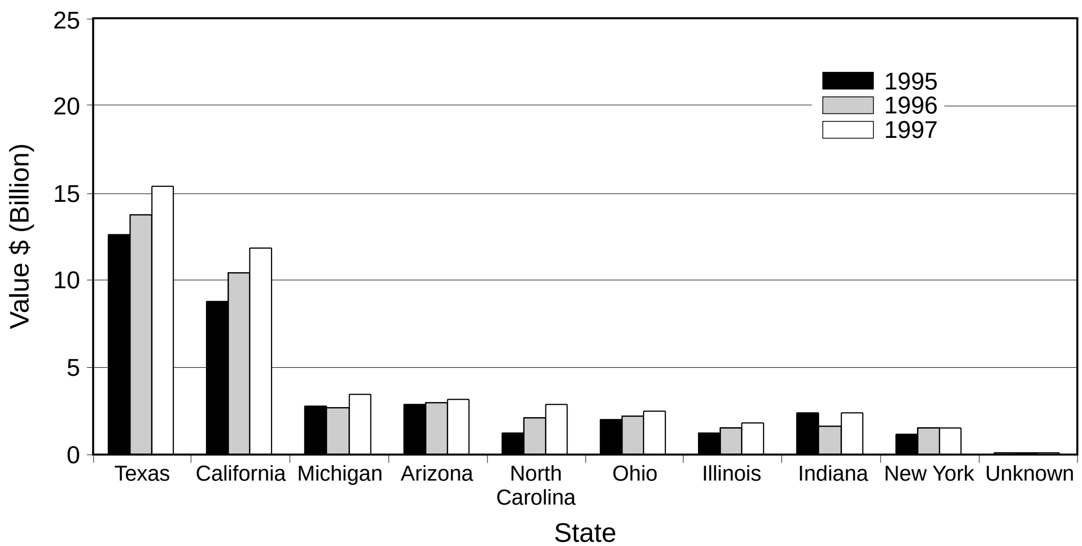


Figure 11. Northbound Trade By State (1995-1997).

COMMODITIES BY STATE

There is a clear commodity specialization by states. States with important industrial concentrations related to a commodity are important in that commodity trade, indicating that specialized industrial concentrations are the centers of goods production or consumption. For example, Michigan, where important auto-makers and heavy industries are located, is heavily involved with transportation equipment and industrial machinery; North Carolina shows heavy imports of industrial machinery and textile products. However, the same centers are not always the centers of attraction/production for the same commodity groups. The signifigant participation of maquiladoras (assembly plants) in the trade, further complicates the analysis.

Consolidation of exports/imports in border states may somewhat distort the representation of trade. It is also important to note that the level of aggregation of commodities is high. Appendix 2 contains the commodity distribution of the six more important states according to the value of the commodities. All states show some unbalance between imports and exports in each commodity group, but some states show serious imbalances in certain commodities. Arizona, which shows an imbalance in agricultural products and Ohio, which shows one in electrical products, are examples of this situation.

SUMMARY

Trade between the U.S. and Mexico has considerably increased in recent years to the point where Mexico is second only to Canada as a U.S. trading partner. Several data sets are available for the study of trade features, but these sets have important gaps and limitations that impede detailed transportation analysis.

U.S.-Mexico trade is highly concentrated in few ports, states, and commodities. Manufactured products, in which the participation of maquiladoras is key, dominate the trade. In almost all ports truck movements are the preferred mode and deserve careful evaluation by the transportation planner. The specific characteristics of border trucking operations are, therefore, the subject of the next chapter.

CHAPTER 3. TRUCKING OPERATIONS AT THE BORDER

INTRODUCTION

Trucking operations at U.S.-Mexico border zones have many unique characteristics. These characteristics need to be studied by the transportation analyst because they have great influence on the estimation of truck volumes and impacts on highway infrastructure resulting from NAFTA trucks.

Regulations at both sides of the border have strongly conditioned truck operations. The implementation of NAFTA trucking legislation has been stalled since 1995, but it is likely that many changes may occur in the future.

THE STATUS OF BORDER CROSSING

The signing of NAFTA in 1993 has not improved truck access across the U.S.-Mexico border. Mexican trucks are not presently allowed to circulate in the U.S., and U.S. trucks are not allowed to go into Mexico, except for a few miles from the border in a zone specified as the "border commercial zone."

Under provisions set forth by NAFTA, the six Mexican and the four U.S. border states were scheduled to have the border open to cross-border trucking operations on December 18, 1995. However, shortly before that date, the U.S. unilaterally decided to postpone the border opening, citing safety concerns. Since then, the two countries have been negotiating a solution. Full access for truck operations had been scheduled for January 2000 prior to postponement of the border opening.

Mexico has asked the North American Free Trade Commission to resolve this three-year dispute with the U.S. No solution is expected until Mexico can furnish more sophisticated, computerized data on safety, driver history, and company history (Ref 15).

NAFTA has established the Land Transportation Standards Subcommittee (LTSS) to work on a number of harmonized solutions to current problems, including compatible truck safety and operating standards among the countries. In those areas in which the LTSS cannot achieve compatibility, foreign trucks must comply with the host country requirements (Ref 16); this is the current status quo (as of August 1998).

BORDER CROSSING

Mexican trucks are generally only allowed to haul from Mexico to areas within the border commercial zone. The border commercial zone includes the municipality of the border city and the adjacent areas within a specific mileage (from 3 to 20 miles) that depends on the population size of the base municipality, as shown in Table 7. To operate in this border zone, carriers must obtain a certificate from the U.S. Department of Transportation Office of Motor Carriers when the carrier complies with U.S. equipment safety standards and U.S. tax regulations and has adequate insurance. This authority was previously the responsibility of the Interstate Commerce Commission (ICC) (Ref 17).

Table 7. Commercial Border Zone Limits (Refs 18, 19)

Population of Municipality	Commercial border zone size (miles)
Less than 2,500	3
2,500-24,999	4
25,000-99,999	6
100,000-199,999	8
200,000-499,999	10
500,000-999,999	15
1,000,000 or larger	20

BORDER CROSSING PROCESS

At present, U.S. carriers cannot operate in the interior of Mexico, and Mexican carriers cannot operate in the interior of the U.S. This situation has led to border traffic with particular characteristics, where drayage plays an important role in Texas. The process of truck border crossing takes several stages and will be analyzed first for truckloads moving to and from nonborder zones. In its description of the stages of truck border crossing, this study focuses on the movement of the transportation equipment and cargo; however, other steps have to be completed. Additionally, an exchange of information and documentation is necessary for carriers to comply with customs regulations. If this is not handled efficiently, it may cause serious delays. Usually a U.S. broker, working in coordination with a Mexican broker, handles northbound movements. The U.S. broker deals with U.S. Customs, and the Mexican broker deals with Mexican export documentation. In southbound movements, a Mexican broker deals with Mexican Customs; the U.S. shipper submits the Shippers Export Declaration to U.S. Customs.

Southbound movements

1. Shipment arrives at the U.S. border city via a U.S. carrier.
2. The trailer is delivered to the trucking company, shipper, or freight forwarder yards.

3. Shipment is consolidated or stays in the trailer.
4. Mexican import duties are paid and the cargo can enter Mexico.
5. Shipment is routed to Mexican Customs by a local drayage company.
6. After Mexican Customs is cleared, the truck proceeds to the Mexican carriers yard (on the Mexican side).
7. A Mexican carrier tractor picks up the cargo and delivers it to its final destination.

Northbound movements

A similar operation takes place for the northbound movement.

1. Shipment arrives at the Mexican border city via a Mexican carrier.
2. From the Mexican carrier's yard, the drayage tractor takes the trailer to U.S. Customs.
3. After customs is cleared, the trailer is delivered to the broker's yard or to the U.S. carrier's yard if the cargo does not need to be inspected or consolidated.
4. A U.S. carrier picks up the cargo and delivers it to its final destination.

Several entities are involved in the cargo border crossing process: the U.S. carrier, brokers, customs, the drayage company, the Mexican carrier, and warehouses. This system has often been criticized as highly inefficient and costly. An ideal, seamless operation would not require stopping truck movements at the border and handing over trailers; this would decrease travel time and cost.

One example of the present inefficiency is presented in "Bordering the Future" (Ref 20). Based on interviews with truckers, the report describes the steps necessary to carry computer parts from Chicago to Monterrey. While the time it takes to transport the shipment from Chicago to Laredo is 26 hours, and the time from Laredo to Monterrey is 12 hours, the crossing of the border (around 30 miles) consumes 35 hours. As described before, many binational entities and organizations are involved in the crossing. A great deal of time is required for them to prepare and submit the paperwork for customs; verify the cargo and prepare documents each time the trailer is handed off; cross customs; and move the trailer from the trucking terminal to the freight forwarder yard and finally to the Mexican carrier's yard. This inefficient situation has received numerous criticisms, although for border cities it is an important source of income. Transportation services in the Texas border region account for 24 percent of the total employment in transportation services in the state of Texas (Census employment data).

In the case of maquiladora shipments (trade movements to or from assembly plants), the process may involve fewer tractor shifts. The U.S. carrier may cross (southbound) and leave cargo at the maquiladora plant, within 17 miles from the border. However, drayage is the usual practice. For northbound movements, the maquiladora's trucks or a drayage company crosses the border, and then the cargo is switched to a U.S. carrier. Drayage is also performed for many maquiladora movements because U.S. trucking companies do not want to enter Mexico.

For Less Than Truckload (LTL) freight, there is one extra step. Loads must be broken down into different routes or consolidated in the carrier yard. Usually Truck Loads (TL) cross the border in the same trailer, requiring only the change to the carrier tractor once inside the border.

For intermodal shipments, two different situations may occur in the handling of Containers or trailers. Usually trailers (TOFC) are unloaded at the intermodal yard on the U.S. side; they are then picked up by a drayage company or a U.S. carrier that takes them to customs or to the carrier yard, respectively. This has an impact on the TSFD because these shipments are registered as truck shipments rather than intermodal shipments. Containers COFC generally cross the border on trains. The evolution of intermodal services should be watched closely. An improvement in railroad performance on both sides of the border could lead to a significant increase of the railroad share, especially in long-distance corridors, e.g., those which use Laredo as a port of entry/exit.

Usually Mexican-owned companies are in charge of the drayage. The case of Laredo is unique to that port of entry because U.S. carriers receive reciprocal treatment in the city of Nuevo Laredo. An informal agreement among companies allows each side's tractors to deliver trailers across the border, although they must return with an empty trailer or without a load. These empty back-hauls have an impact on the number of empty trucks crossing the border and are one of the more notorious characteristics of truck traffic crossing the U.S.-Mexico border at that site.

Truck operations are not homogenous across the four U.S. border states with Mexico because of different state regulations or particularities of trade at each border city. In California, for example, trucks have dual plates and operate on both sides of the border when serving maquiladoras.

SAFETY ISSUES

The presence of Mexican trucks on the U.S. side of the border has given rise to many safety concerns. According to a study by the U.S. General Accounting Office (Ref 16), the out-of-service rate for U.S. trucks stopped for inspection is 28 percent, while the rate for Mexican trucks reaches 63 percent (data collected in Arizona in 1994). Most of the problems are related to equipment (structural cracks, lights, brakes, steering), the driver (age, licenses, drug use, language problems), and cargo (mislabeled, misweighted, unsecured, or lacking insurance). Some of the major differences in Mexican and U.S. trucking regulations are shown in Table 8.

Trucks used in drayage operations are not usually the same ones used in long hauls. Older tractors are often used to cross the border and wait until the cargo is cleared by customs. These old trucks may cross the border several times a day but only travel a few miles each day. If they break down they can be quickly repaired or replaced without delay.

Table 8. Trucking Regulation Differences (Ref 4)

Regulation	United States	Mexico
Hours of Service	10 hours	No limits
Logbooks	Obligatory	Not required
Computerized driver records	Yes	No
Front brakes	Required	Not required
Maximum gross vehicle weight (5 axle)	80,000 lb.	97,000 lb.

INSURANCE

Insurance is another issue that hinders seamless transportation between Mexico and the U.S. When a Mexican truck enters the U.S., U.S. border officials demand proof of insurance from a company licensed to do business in the U.S. This insurance is not available from a Mexican provider. The reverse situation takes place when a U.S. truck enters Mexico, because Mexico bars foreign companies from providing liability insurance in Mexico.

One of the biggest obstacles to having uniform insurance on both sides of the border is the difference between the U.S. and Mexican laws related to accidents. In the U.S., an accident is a civil matter unless the driver is criminally negligent or intoxicated. In Mexico an accident that causes death or bodily injuries is automatically treated as both a criminal and civil matter, which may involve detention or impoundment of the vehicle (Ref 21). This situation hinders seamless transportation because a single truck that crosses the border needs double coverage.

TRUCK SIZE AND WEIGHT

Mexican and U.S. truck weight and size regulations are presently incompatible, a factor that hinders seamless trucking operations. Mexican truck weight limits are uniformly higher than those in the U.S. Furthermore, the lack of weight enforcement in Mexico has led to overloaded trucks, necessitating strict weight enforcement to allow Mexican trucks to operate in the U.S.

Two situations are possible with a shipment that weighs out:

1. The shipment is consolidated at the border. The truck operates with two different truckloads: one in Mexico (heavier) and another in the U.S. (lighter).
2. The shipment is not consolidated at the border; thus, to comply with U.S. laws the truck operates under the limits permitted by Mexican laws.

Truck length regulations are generally more restrictive in Mexico. For example, not all U.S. trailers are accepted in Mexico; 53-foot trailers are usually not allowed unless a short tractor pulls the trailer to comply with the 68.2 ft overall length requirement.

Table 9. Mexican And U.S. Truck Size And Weitht Limits (Refs 18, 22)

	MEXICO	**U.S.**
Single axle limit	14,330 lbs (steering axle)	20,000 lb
Tandem axle limit	42,990 lbs	34,000 lb
Tridem axle limit	49,604 lbs	42,000 to 43,500 lbs
Gross vehicle weight limit	Up to 136,600 lbs (vary with truck configuration)	80,000 lb
5 axles	91,300 lbs	80,000 lb
6 axles	101,200 lbs	80,000 lb
7 axles	135,300 lbs	80,000 lb
8 axles	143,000 lbs	80,000 lb
Vehicle height	13.6 ft	None specified
Vehicle width	102 in.	102 in.
Single-unit length	40 ft	None specified
Semitrailer length	48 ft	48 ft (min) in semitrailer combination
Tractor semitrailer length	68.2 ft overall length for semitrailer combinations	None specified
Twin trailer combination	102.7 ft overall length for double cargo unit combination	28 ft (min) for trailers in a twin trailer combination

SUMMARY

Truck operation across the border and in the border region needs to be studied with a binational perspective. Motor carrier regulations, truck size and weight, and insurance and customs operations on both sides of the border are the most important elements that constrain truck procedures. These characteristics make the estimation of NAFTA trucks volumes and their impact on the highway infrastructure more difficult. The next chapter presents an analysis of border and nonborder truck characteristics that will be used in Chapter 5 to estimate NAFTA truck volumes.

CHAPTER 4. TRUCK AND TRUCKLOAD WEIGHT CHARACTERISTICS

INTRODUCTION

The objective of this chapter is to compare truck traffic and truck weight characteristics obtained from a variety of Texas highway weigh in motion (WIM) stations, some located close to the border where NAFTA trade is significant, some located far from the border, and some located at Laredo and El Paso bridges. Truck characteristics will be used in Chapter 5 to estimate NAFTA trucks and in Chapter 8 to analyze the impact of NAFTA on infrastructure.

Previous Research

Using WIM systems installed specifically for the purpose of study, researchers obtained and studied truck axle loads, truck classification, and truck counts in Laredo and El Paso. WIM is the process of estimating the motionless (static) weight of a vehicle from measurements of the vertical component of dynamic tire forces applied to a sensor on a smooth, level road surface (Ref 23). WIM stations were installed in Laredo and El Paso near the northern end of the truck bridges over the Rio Grande at both ports of entry. The stations were part of a research project conducted by the CTR at The University of Texas at Austin in cooperation with the Texas Department of Transportation (TxDOT). The stations were in operation from August 1993 in Laredo and February 1994 in El Paso until the end of the project in August 1996 (Ref 24).

TPP WIM DATA

Collaboration between the Transportation Planning and Programming division (TPP) at TxDOT and The University of Texas at Austin's CTR made it possible to collect data at a variety of WIM stations. A database was created with information from nonborder WIM sites provided by TPP and with WIM data collected at the Laredo and El Paso ports by CTR researchers. TPP Data were collected during 1995 from a total of nine WIM stations listed in Table 10.

Table 10. TPP WIM Station Location

STATION	HIGHWAY	COUNTY	LOCATION
LW504	IH 20	NOLAN	IH 20 WEST OF SWEETWATER
LW507	IH 45	WALKER	IH 45 SOUTH OF HUNTSVILLE
LW509	IH 30	HUNT	IH 30 EAST OF GREENVILLE
LW510	IH 10	EL PASO	IH 10 NORTH OF EL PASO
LW512	IH 37	LIVE OAK	IH 37 NORTH OF THREE RIVERS
LW513	IH 35	BELL	IH 35 SOUTH OF SALADO
LW515	US 281	HIDALGO	US 281 NORTH OF EDINBURG
LW516	IH 35	BEXAR	IH 35 SOUTH OF LOOP1604
LW517	US 83	HIDALGO	US 83 WEST OF FM 1426

TPP Stations

The locations of the stations have been plotted on a map of Texas in Figure 12. Three stations are located close to the border and are therefore likely to capture the influence of NAFTA truck traffic. These stations are 510, 516 and 517.

Station 510 is located on IH 10 north of El Paso, in the corridor that connects El Paso with Los Angeles. It would have been more useful to count with data on IH 10 in the corridor that connects El Paso with Dallas. IH 10 is an important east-west connection that does not end in El Paso; it also has a significant amount of non-NAFTA crossing truck traffic.

The other two stations are both in the Texas Valley area. Station 517 is located on US 83 between the cities of McAllen and Harlingen, in the Hidalgo-McAllen area close to the ports of Pharr Bridge and Hidalgo Bridge. US 83 runs along the Valley border cities.

US 281 ends in Hidalgo and together with US 77 connects the Valley with key Texas and U.S highways. The influence of NAFTA trade is substantial in this area, and this study assumes that most of the truck traffic is directly or indirectly related NAFTA trade.

Station 516, located south of San Antonio, is on IH 35, the main corridor to the port of Laredo, and is also expected to have a significant part of its truck traffic related to U.S.-Mexico trade; in a similar way, Station 515 on US 281 is expected to carry truck traffic to and from the Hidalgo border crossings.

Station 504, on IH 20, an important corridor to El Paso, may also have important U.S.-Mexico trade influences, but it is not as important as those stations mentioned before because of the size of non-NAFTA truck flows.

The rest of the stations are located at sites where the influence of U.S.-Mexico surface trade may not be as important. The four stations are all located on rural interstate highways. Even when they have a large amount of NAFTA trade (as do IH 20, IH 30, and IH 35), they also carry even larger amounts of domestic trade to varying degrees according to the station location. For example, between San Antonio and Laredo, more than 90 percent of the combination trucks are expected to be NAFTA-trade-related; however, between San Antonio and Austin the ratio of NAFTA trucks is not higher than 40 percent (according to results of Chapter 5 and HPMS data provided by TxDOT). The further a station is from the border, the smaller the expected percentage of NAFTA trucks in the truck traffic, especially outside big urban areas (e.g., San Antonio, Austin, Dallas, Houston). Therefore, this study assumes that the stations reflect conditions of truck domestic trade in the state of Texas. The truck composition (as analyzed later) shows that only Station 517 has an important urban influence.

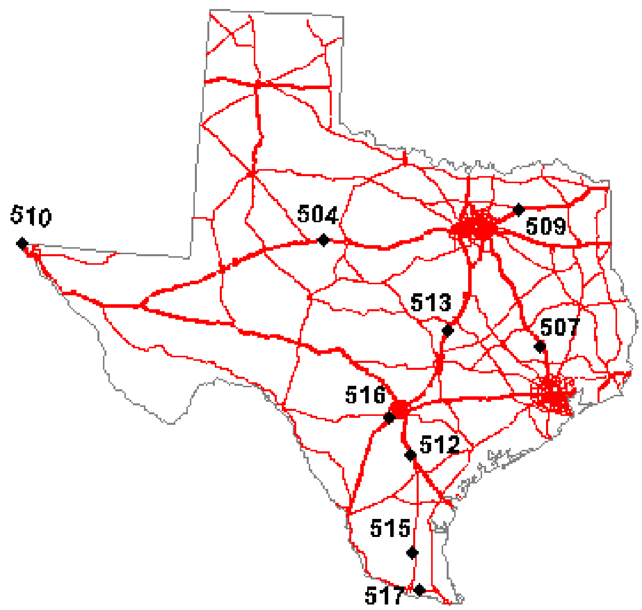


Figure 12. WIM Station Locations.

All the stations are located on rural highways except for Stations 515, 517, and 516, which are located on the outskirts of Edinburg, McAllen, and San Antonio, respectively.

No auto data are available; only bus and truck records are present in the data.

Time of Data Collection

Table 11 contains information regarding data collection times. The data collection was performed throughout the day (24 hours) on selected weekdays. The number of collection days varied between 2 and 8 days per station per year. No data were collected during weekends. There are no data available for a complete week, nor sufficient information to examine monthly variation.

Data Check

The number of trucks per day was averaged, and it was found that truck counts on two days deviated significantly from the average. One of these counts was taken on September 13 at Station 512, and the other was October 23 at Station 516. There are records for all the hours throughout the day on both days and at both stations, besides the total number of trucks is about half of the average; however, the average weight per truck and standard deviation are still consistent with the rest of the data. This was the only inconsistency found in the data, and it is shown in Table 11.

Table 11. WIM Station Location And Days Of Data Collection

STATION	HIGHWAY	COUNTY	LOCATION	YEAR	MONTH	DAY	RECRDS	ADT
LW504	IH 20	NOLAN	WEST OF SWEETWATER	95	2	13	3,809	
					2	14	4,786	4,298
LW507	IH 45	WALKER	SOUTH OF HUNTSVILLE	95	2	1	5,603	
					2	2	5,984	
					5	17	6,218	
					5	18	6,604	6,102
LW509	IH 30	HUNT	EAST OF GREENVILLE	95	6	14	6,875	
					6	15	5,421	6,148
LW510	IH 10	EL PASO	NORTH OF EL PASO	95	3	20	3,868	
					3	21	4,861	
					4	18	4,579	
					4	19	5,474	
					9	19	4,719	
					9	20	5,653	
					12	12	5,625	
					12	13	6,251	5,129
LW512	IH 37	LIVE OAK	NORTH OF THREE RIVERS	95	4	18	3,197	
					4	19	3,025	
					9	12	2,389	

					9	13	1,282	
					12	12	3,133	
					12	13	2,792	2,636
LW513	IH 35	BELL	SOUTH OF SALADO	95	2	21	6,071	
					2	22	6,223	
					6	21	6,538	
					6	22	6,598	
					7	10	5,310	
					7	11	6,130	
					12	13	6,518	
					12	14	6,636	6,253
LW515	US 281	HIDALGO	NORTH OF EDINBURG	95	2	27	2,195	
					2	28	2,501	
					5	17	2,419	
					5	18	2,401	
					7	17	1,659	
					7	18	1,816	2,165
LW516	IH 35	BEXAR	SOUTH OF LOOP 1604	95	5	22	3,459	
					5	23	3,388	
					10	23	1,281	
					10	24	3,428	

					10	25	3,564	
					10	26	3,729	3,142
LW517	US 83	HIDALGO	WEST OF FM 1426	95	2	27	4,711	
					2	28	4,935	
					5	22	3,758	
					5	23	4,108	
					7	10	3,546	
					7	11	3,633	
					12	11	4,277	
					12	12	4,558	4,191

VEHICLE CLASSIFICATION

Vehicles in this study are classified by the TxDOT coding system used to compile the data, as shown in Table 13. The first character corresponds to the vehicle type. The second character shows the number of axles on the power unit. The third character is the total number of axles on the first trailer. The fourth character is the total number of axles on the second trailer. The fifth character is the total number of axles on the third trailer. The sixth character is always zero and is not shown in Table 13.

For example, a three-axle tractor plus a two-axle semitrailer (eighteen wheeler) has a code of 332000.

According to the WIM data, only four truck types have a significant representation on Texas highways:

- Single-unit truck with two axles (code 220000)
- Single-unit truck with three axles (code 230000)
- Three-axle tractor + two-axle semitrailer (code 332000 or 3S2)
- Two-axle tractor + one-axle semitrailer + two-axle full trailer (code 521200)

Table 12. WIM Station Location And Days Of Data Collection

STATION	HIGHWAY	YEAR	MONTH	DAY		RECORDS	AV. WEIGHT	ST. DEV.
LW504	IH 20	95	Feb	Monday	13	2,854	57,911	17,581
			Feb	Tuesday	14	3,645	58,188	17,295
LW507	IH 45	95	Feb	Wednesday	1	3,937	54,874	17,821
			Feb	Thursday	2	4,116	54,646	17,804
			May	Wednesday	17	4,068	56,934	18,659
			May	Thursday	18	4,221	56,567	18,244
LW509	IH 30	95	Jun	Wednesday	14	5,065	56,241	17,921
			Jun	Thursday	15	3,701	55,909	18,067
LW510	IH 10	95	Mar	Monday	20	2,691	54,052	16,980
			Mar	Tuesday	21	3,546	55,210	16,786
			Apr	Tuesday	18	3,296	54,649	17,034
			Apr	Wednesday	19	4,157	55,778	16,525
			Sep	Tuesday	19	3,359	56,476	17,655
			Sep	Wednesday	20	4,250	58,554	17,142
			Dec	Tuesday	12	4,045	57,509	17,238
			Dec	Wednesday	13	4,701	58,668	16,949
LW512	IH 37	95	Apr	Tuesday	18	2,329	54,854	20,017
			Apr	Wednesday	19	2,045	54,119	20,072
			Sep	Tuesday	12	1,601	50,175	18,875
			Sep	Wednesday	13	**832**	51,754	19,158
			Dec	Tuesday	12	2,155	52,933	19,274
			Dec	Wednesday	13	1,887	53,798	18,770
LW513	IH 35	95	Feb	Tuesday	21	4,425	54,485	17,430
			Feb	Wednesday	22	4,603	54,367	17,393
			Jun	Wednesday	21	4,591	53,075	17,091
			Jun	Thursday	22	4,767	52,357	17,045
			Jul	Monday	10	3,781	51,494	16,965
			Jul	Tuesday	11	4,412	51,573	17,252
			Dec	Wednesday	13	4,851	52,435	16,456
			Dec	Thursday	14	4,903	52,158	16,635
LW515	US 281	95	Feb	Monday	27	1,365	52,705	18,783
			Feb	Tuesday	28	1,615	54,176	18,845
			May	Wednesday	17	1,550	52,927	19,801
			May	Thursday	18	1,463	51,953	19,588
			Jul	Monday	17	918	49,352	17,406
			Jul	Tuesday	18	1,023	50,473	18,142
LW516	IH 35	95	May	Monday	22	2,295	56,494	19,224
			May	Tuesday	23	2,258	56,412	19,230
			Oct	Monday	23	**854**	59,857	18,482
			Oct	Tuesday	24	2,398	55,585	18,208
			Oct	Wednesday	25	2,567	55,934	17,770
			Oct	Thursday	26	2,658	55,922	17,959

Table 12. WIM Station Location And Days Of Data Collection (Continued)

LW517	US 83	95	Feb	Monday	27	1,570	48,736	19,275
			Feb	Tuesday	28	1,558	48,599	19,237
			May	Monday	22	1,481	47,686	19,604
			May	Tuesday	23	1,693	49,564	20,829
			Jul	Monday	10	1,141	47,487	19,486
			Jul	Tuesday	11	1,178	46,856	19,730
			Dec	Monday	11	1,620	46,694	19,293
			Dec	Tuesday	12	1,751	47,474	20,038

Table 13. Vehicle Type Coding Chart

	1^{st} Character	2^{nd} Character	3^{rd} Character	4^{th} Character	5^{th} Character
Buses	Basic vehicle type = 1	9	0	Axle and tire modifier	0
Single-unit trucks or tractors	Basic vehicle type = 2	Total Axes	0	Light trailer modifier	0
Tractor + semitrailer	Basic vehicle type =3	Total axles on power unit	Total axles on first trailer	0	0
Truck + full trailer	Basic vehicle type = 4	Total axles on power unit	Total axles on first trailer	0	0
Tractor + semitrailer + full trailer	Basic vehicle type = 5	Total axles on power unit	Total axles on first trailer	Total axles on second trailer	0
Truck + full trailer + full trailer	Basic vehicle type = 6	Total axles on power unit	Total axles on first trailer	Total axles on second trailer	0
Tractor + semitrailer + 2 full trailers	Basic vehicle type = 7	Total axles on power unit	Total axles on first trailer	Total axles on second trailer	Total axles on third trailer
Truck + 3 full trailers	Basic vehicle type = 8	Total axles on power unit	Total axles on first trailer	Total axles on second trailer	Total axles on third trailer

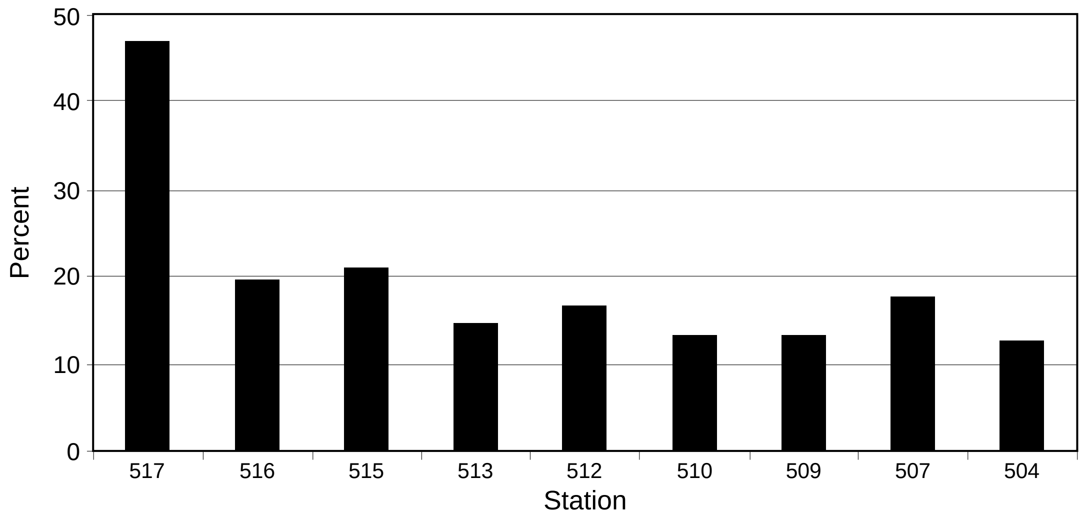


Figure 13. Vehicle Type 220000.

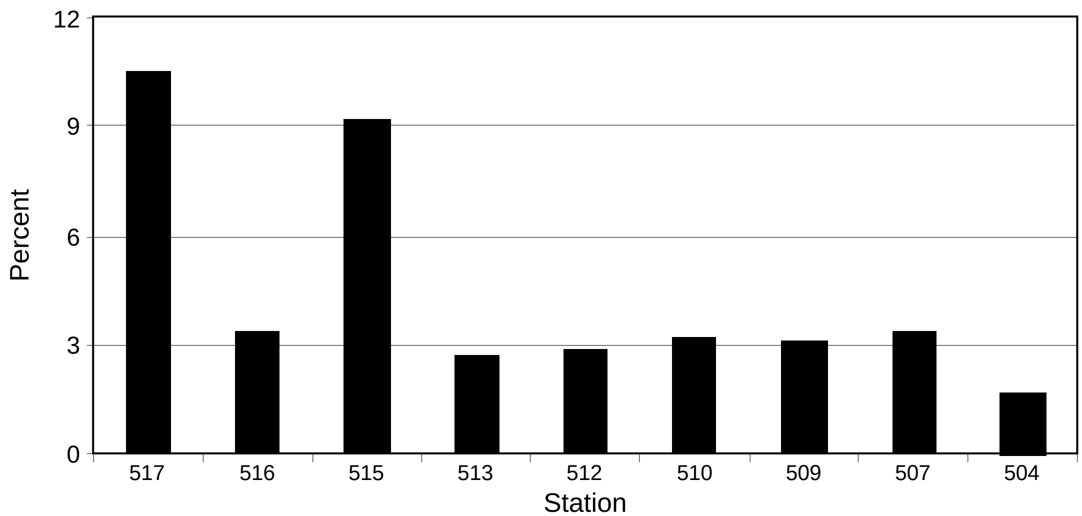


Figure 14. Vehicle Type 230000.

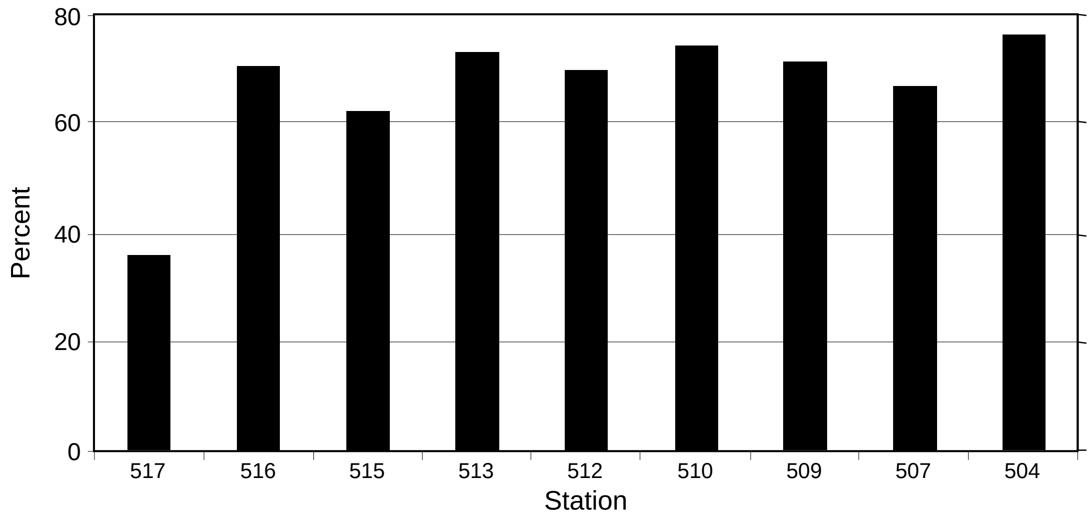


Figure 15. Vehicle Type 332000.

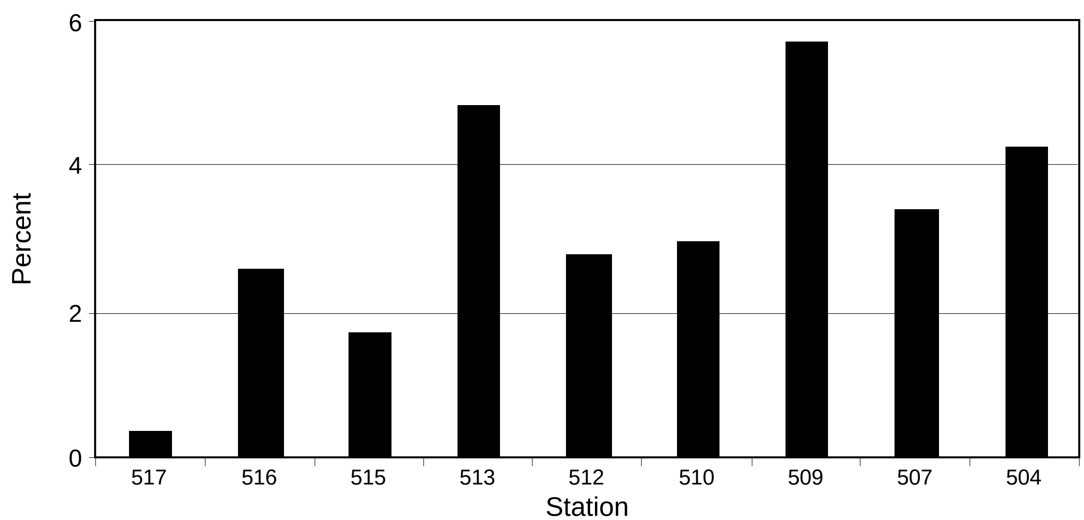


Figure 16. Vehicle Type 521200.

The percentage of these trucks found at the stations is shown in Figure 13 to Figure 16, where it is seen that these four truck types total more than 95 percent of the trucks by station.

Types 220000 and 230000 (both single-unit trucks) have special importance to Station 517 on US 83. These truck types are used for intracity or short-distance hauls. The location of Station 517, on the outskirts of McAllen and along the route to both Harlingen and Brownsville (30 and 56 miles, respectively), may explain this fact.

Combination trucks have a higher share on long-haul, intercity corridors. The importance of truck type 332000 (eighteen wheeler or 3S2) within the combination number and the total number of trucks is manifest on all the rural stations of the main NAFTA corridors (like IH 20 and IH 35). The importance of combination vehicles is even more meaningful when total weight is considered. Type 332000 trucks account in some cases for 88 percent (*) of the total weight moved on the highway; an example is Station 504. In Tables 14 to 22 there are detailed classifications of the nine stations with truck type count and maximum, minimum, and average weight.

Combination trucks clearly account for the highest proportion of weight even where single trucks outnumber them. At Station 517, 42 percent of the combination trucks account for almost 70 percent (*) of the total weight. Total weight is used as an indicator of pavement damage by truck type, although in order to analyze pavement damage precisely one must evaluate axle loads and repetitions by truck type.

The heaviest loads were encountered in connection with truck types 332000 and 333000. Very significant loads were registered for some truck-semitrailer-trailer combinations such as 533100, 541400, and 532400; however, the occurrence of these vehicles is very low. These tend to be operated within border commercial zones and generally comprise less than 2 percent of the truck traffic, but they also tend to be heavily overloaded unless U.S. enforcement personnel are in the area.

TRUCK WEIGHT HISTOGRAMS

Total truck weight is composed of two elements: the net weight of the tractor/trailer and the weight of the cargo. Net weights depend basically on the truck type and may vary from the average value due to particular characteristics that depend on the brand and model of the truck. Cargo weight basically depends on the density and the amount of the commodity carried. Three possible situations occur in the calculation of the total weight of a truck for planning purposes:

- The truck/trailer does not carry any load (empty)
- The truck/trailer carries a load, and the total weight is less than the weight limit (partial load or cube-out commodity)
- The truck/trailer carries a load, and the total weight is equal or over the weight limit (weigh-out commodity)

Histograms representing total truck weight versus frequency were plotted for vehicle type 332000, the truck type with the highest representation on highways and therefore the largest

(*) Total weight equals tractor and trailer net weight plus cargo weight.

(*) Total weight equals tractor and trailer net weights plus cargo weight.

number of records. Nine histograms with the weight distribution for vehicle type 332000 are shown in Figure 17 to Figure 25. As expected, all the histograms reflect the three possible situations for a truckload weight. Three different zones are found in the histograms:

1. A peak and distribution that corresponds to the tractor and semitrailer *net weight*
2. A peak and distribution around the truck *weight limit*
3. Observations that correspond to trucks that are partially loaded or that carry cube-out commodities (in between the two mentioned peaks)

Table 14 lists the values of the modes for the peaks of net weight (Mode 1) and of gross weight (Mode 2) for vehicle type 332000. The minimum feasible weight of an empty truck/trailer determines the lowest weight value; the heaviest truck on the road (a certain percentage over the weight limit) determines the highest weight value. Extreme values may be caused by

- Misclassification that leads to inclusion of a smaller vehicle in a bigger category or vice versa
- Overweighted trucks or exceptionally light vehicles
- Exceptionally heavy authorized vehicles
- Errors in the weight measure

Statistically, for truck type 332000, records with weight less than 26,000 lb and more than 92,000 lb are improbable and comprise less than 1 percent of the records in all the stations analyzed.

Table 14. Statistical Parameters Of Weigh Distribution (Vehicle Type 332000)

HIGHWAY	STATION	RECORDS	MEAN	ST DEV	MODE 1	MODE 2	DIFFERENCE
IH 10	LW510	42,438	59,699	17,499	35,000	78,100	43,100
IH 20	LW504	7,625	57,887	17,302	31,700	75,600	43,900
IH 30	LW509	8,766	56,199	17,761	33,200	72,600	39,400
IH 35	LW513	36,591	53,011	16,842	34,000	74,000	40,000
IH 35	LW516	4,005	56,129	18,608	32,000	70,400	38,400
IH 37	LW512	5,826	54,137	19,238	33,700	75,500	41,800
IH 45	LW507	8,982	53,940	17,268	33,700	74,000	40,300
US 281	LW515	7,934	52,641	18,624	31,400	75,000	43,600
US 83	LW517	3,407	48,362	19,735	34,700	75,500	40,800
AVERAGE			54,667	18,097	33,267	74,522	41,256
STANDARD DEVIATION			3,309	993	1,300	2,160	1,952

The boundaries among the three zones are fuzzy and overlapping, and it is difficult to establish precise limits to each zone. However, these limits are necessary if one is to quantify the incidence of each part and to compare weights and truck traffic characteristics among stations. Some limits can be drawn from observing the values of the modes and their standard deviations. For example, a value of 32,000 lb to 34,000 lb can be set as an upper weight limit for an empty tractor-semitrailer, and 72,000 lb to 76,000 lb can be set as a lower limit for trucks carrying heavy cargo that weighs out. Trucks partially full or with cube-out commodities will be between those limits.

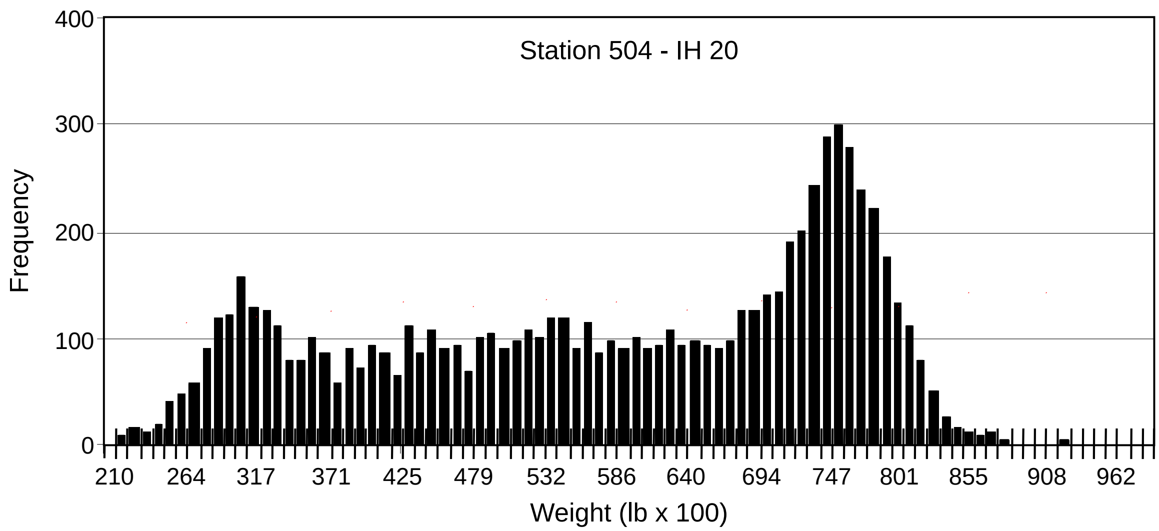


Figure 17. Weight Histogram (Truck 332000) Station 504.

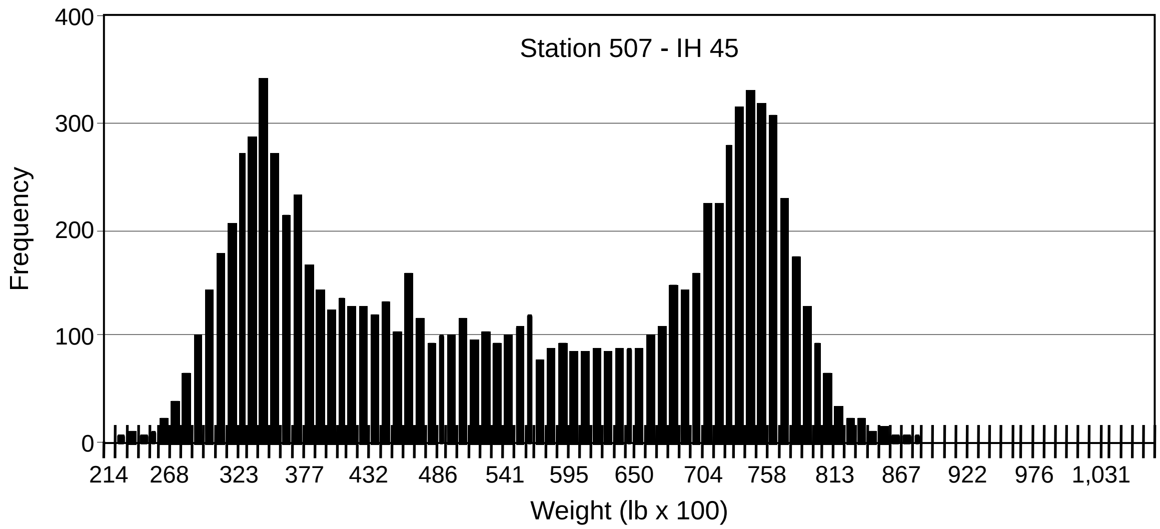


Figure 18. Weight Histogram (Truck 332000) Station 507.

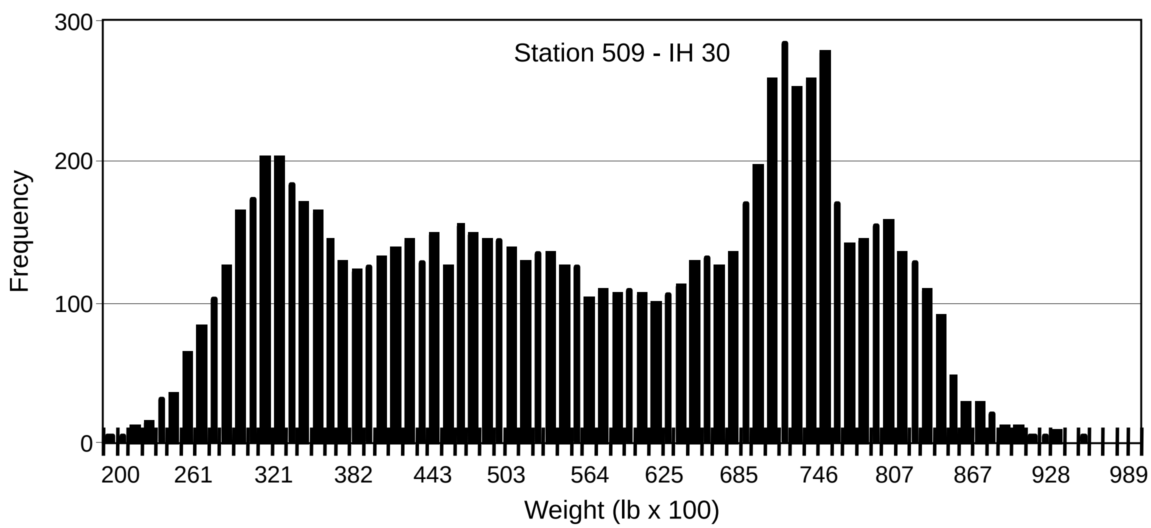


Figure 19. Weight Histogram (Truck 332000) Station 509.

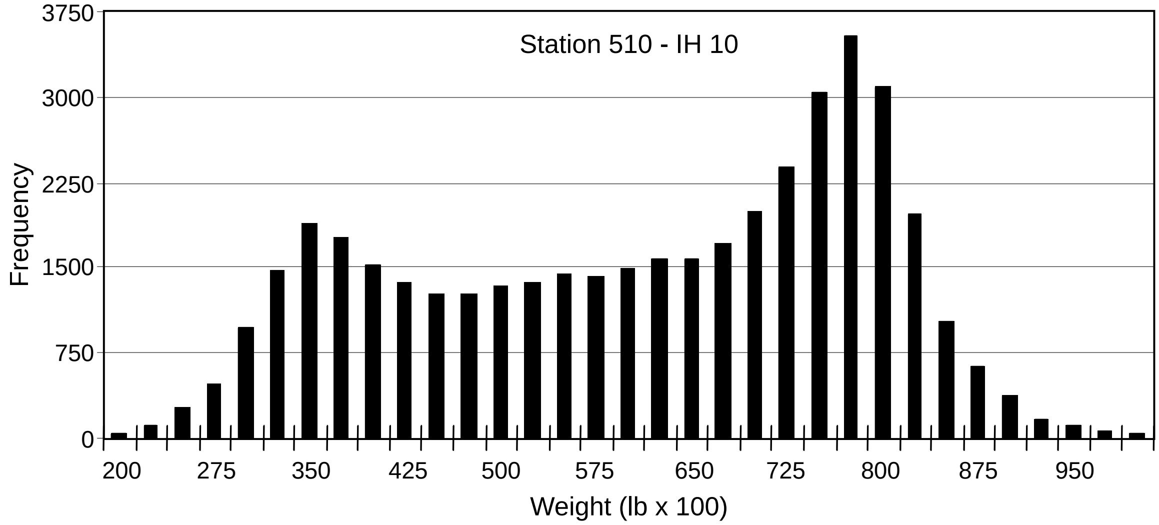


Figure 20. Weight Histogram (Truck 332000) Station 510.

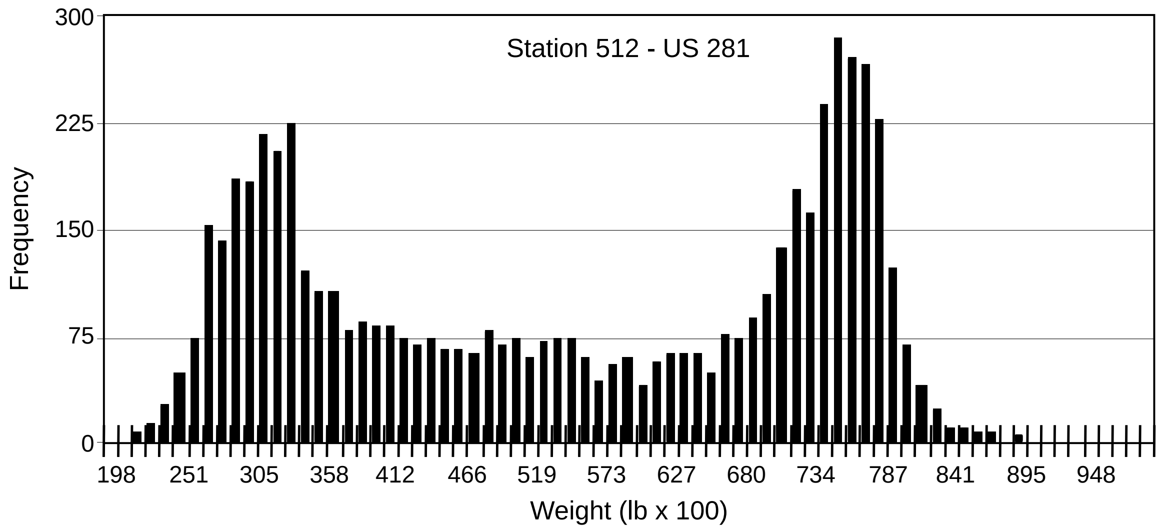


Figure 21. Weight Histogram (Truck 332000) Station 512.

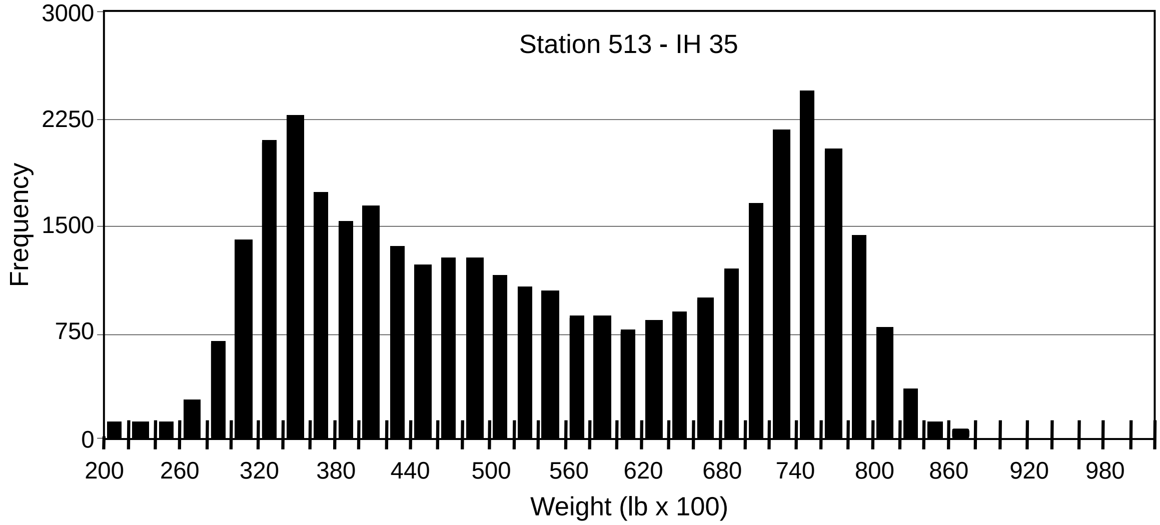


Figure 22. Weight Histogram (Truck 332000) Station 513.

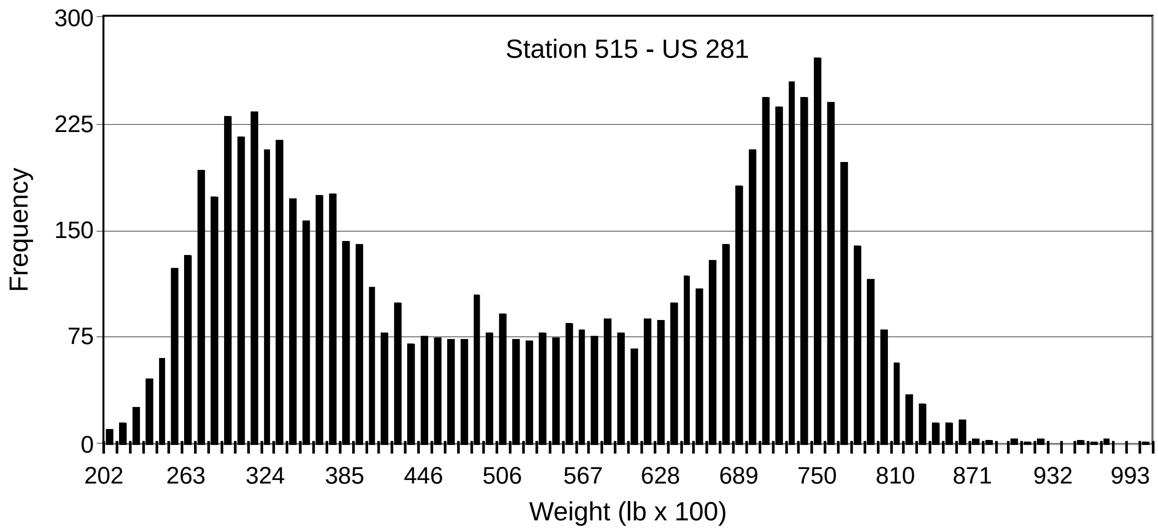


Figure 23. Weight Histogram (Truck 332000) Station 515.

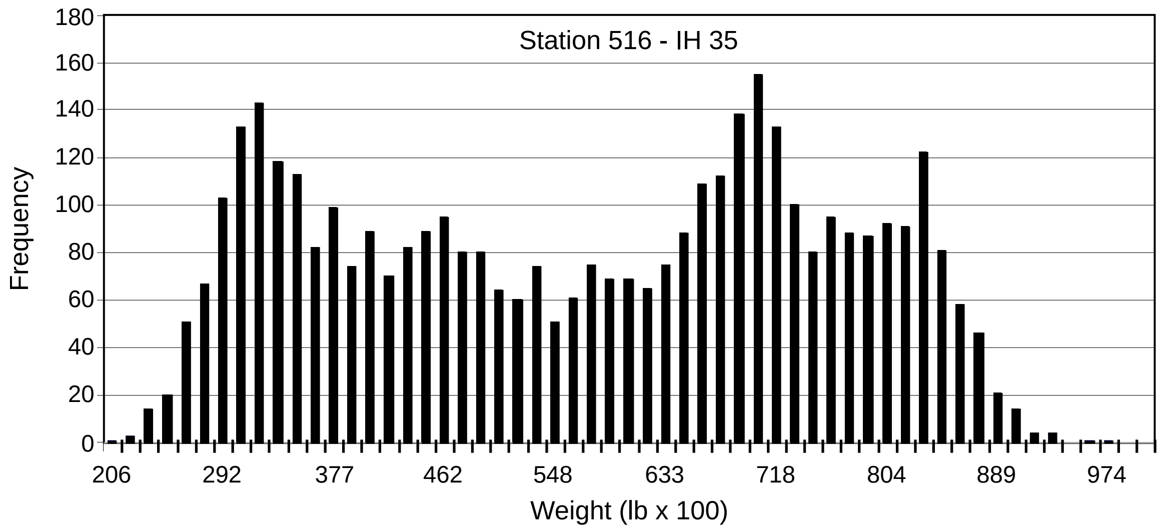


Figure 24. Weight Histogram (Truck 332000) Station 516.

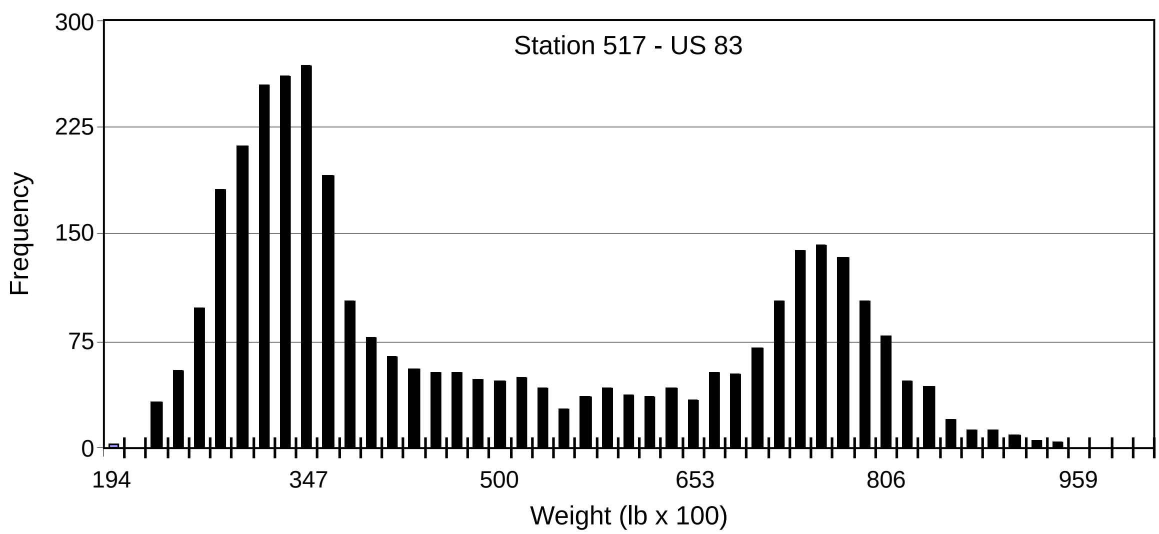


Figure 25. Weight Histogram (Truck 332000) Station 517.

TRUCK WEIGHT CLASSIFICATION

Table 15 shows the limits researchers adopted in this study to compare truck weights across different locations. The lower limit is the same as that established in the CTR study of Laredo and El Paso WIM stations (Refs 13,14,15). The lower limit for weigh-out trucks was established as 90 percent of the maximum load (80,000 lb). Overloaded trucks were those with gross weights greater than 80,000 lb, the U.S. truck-load limit on U.S. interstate highways.

Table 15. Weight Limits For Truck Categories (LB)

Truck Type	**Empty**	**Cube Out**	**Weigh Out**	**Overloaded**
Three-axle tractor w/semitrailer tandem axle (332000)	TW <32,000	32,000<TW<72,000	72,000<TW<80,000	80,000<TW
Three-axle tractor w/semitrailer tridem axle (333000)	TW <38,000	38,000<TW<72,000	72,000<TW<80,000	80,000<TW
Two-axle tractor w/semitrailer single axle w/trailer tandem axle (521200)	TW<40,000	40,000<TW<72,000	72,000<TW<80,000	80,000<TW

These weight limits were used to compare the truck weights among the different stations. The truck types analyzed are those that were found frequently overloaded at Laredo and El Paso: 333000, 332000, and 322000. Truck type 521200 is also analyzed because it is the second most frequent combination truck observed at the nine TPP stations.

OVERLOADED TRUCKS

Type 332000 (3S2)

This configuration is the most common both on the border bridges and on the rural state highways. The number of overloaded trucks in Hidalgo (Station 517) was slightly higher than the average for the data set. In a comparison of these results and those of the Laredo study, only 10.0% of the northbound trucks were overloaded (Ref 13), a figure that is clearly above the average for Texas highways in this data set (4.3 percent).

Station 516, located south of San Antonio on IH 35, shows the highest percentage of overloaded trucks (9.4 percent), as shown in Table 16. Because Station 516 lies on the main corridor to Laredo, it makes sense that this value is very close to the 10 percent obtained in Laredo.

Table 16. Type 332000 Truck Weight Categories (%)

Station	Highway	County	Empties	Cube Out	Weigh Out	Overload.	Count
LW504	IH 20	NOLAN	10.0%	57.2%	29.4%	2.9%	6,499
LW507	IH 45	WALKER	8.8%	61.8%	24.0%	5.1%	16,342
LW509	IH 30	HUNT	11.0%	62.5%	18.2%	8.0%	8,766
LW510	IH 10	EL PASO	10.4%	64.1%	22.9%	2.2%	30,045
LW512	IH 37	LIVE OAK	21.1%	49.8%	26.4%	2.3%	10,849
LW513	IH 35	BELL	12.5%	68.1%	17.9%	1.2%	36,333
LW515	US 281	HIDALGO	20.8%	57.6%	19.0%	2.3%	7,934
LW516	IH 35	BEXAR	12.7%	62.2%	15.3%	9.4%	13,030
LW517	US 83	HIDALGO	26.2%	52.6%	15.6%	5.6%	11,992
Average			14.8%	59.6%	21.0%	4.3%	

Type 333000 (3S3)

The percentage of overloaded trucks of type 3S3 (16.2 percent) is significantly higher than that for type 332000. This impact is diminished by the relative scarcity of 333000 trucks on the road. Figures for overloaded 3S3 trucks on Texas highways are much lower than for 333000 trucks on the border. The results show that as much as 60 percent of the 333000 are overloaded in Laredo (Ref 18), suggesting that NAFTA trucks of this type are considerably more overloaded than other types (see Table 17) .

Again, the stations with the highest percentage of overloaded trucks are located close to the border (Stations 517 and 516), but the highest percentage of overloaded trucks was found on IH 45 (Station 507).

Table 17. Type 333000 Truck Weight Categories (%)

Station	Highway	County	Empties	Cube Out	Weigh Out	Overloaded	Count
LW504	IH20	NOLAN	13.2%	60.5%	13.2%	13.2%	38
LW507	IH45	WALKER	7.3%	53.7%	17.7%	21.3%	164
LW509	IH30	HUNT	18.5%	35.4%	31.5%	14.6%	130
LW510	IH10	EL PASO	12.3%	59.4%	18.1%	10.3%	155
LW512	IH37	LIVE OAK	25.9%	44.4%	8.6%	21.0%	81
LW513	IH35	BELL	16.1%	51.8%	18.3%	13.4%	224
LW515	U.S.281	HIDALGO	16.1%	60.9%	11.5%	11.5%	87
LW516	IH35	BEXAR	7.8%	61.1%	10.0%	21.1%	90
LW517	U.S.83	HIDALGO	22.8%	41.4%	16.6%	19.2%	338
Average			15.5%	52.1%	16.2%	16.2%	

Table 18. Type 521200 Truck Weight Categories (%)

Station	Highway	County	Empties	Cube Out	Weigh Out	Overloaded	Count
LW504	IH20	NOLAN	12.9%	76.4%	9.9%	0.8%	364
LW507	IH45	WALKER	10.7%	76.9%	11.2%	1.0%	824
LW509	IH30	HUNT	6.8%	83.7%	8.8%	0.4%	695
LW510	IH10	EL PASO	11.7%	73.3%	12.9%	1.8%	1,195
LW512	IH37	LIVE OAK	21.8%	74.9%	3.0%	0.2%	435
LW513	IH35	BELL	18.9%	78.7%	2.1%	0.1%	2,376
LW515	U.S.281	HIDALGO	28.1%	67.0%	4.5%	0.4%	224
LW516	IH35	BEXAR	18.4%	59.0%	15.3%	7.1%	478
Average			16.2%	73.7%	8.4%	1.5%	

Types 521200 and 322000

Type 521200 is also included because it is important on highways carrying LTL loads and it is operated by large companies such as UPS. However, trucks of this type are rarely overloaded, except at the station in San Antonio (7.1 percent, compared with less than 1 percent average at the other stations). This truck type was not important in the traffic mix at stations located in Laredo and El Paso, as shown in Table 18.

A truck type that is seen operating at the Laredo and El Paso stations is type 2S2 (322000). These are two axle tractors pulling the regular two-axle trailer, a construction that would normally be configured as 332000 but is operating only across the border because the toll is lower for it than for 332000 trucks. On Texas highways 322000 trucks are seldom seen and are rarely overloaded at any of the stations, making up less than 1 percent.

Empty Trucks

The incidence of empty trucks increases close to the border. Station 517, located close to Hidalgo, has the highest number of empty 3S2 trucks (26.2 percent) and the second-highest number of empty 3S3 trucks. This increase may be caused by

- NAFTA drayage,
- Higher proportion of inter-warehouse trips, and
- Maquiladora trade where specialized parts or inputs are being delivered.

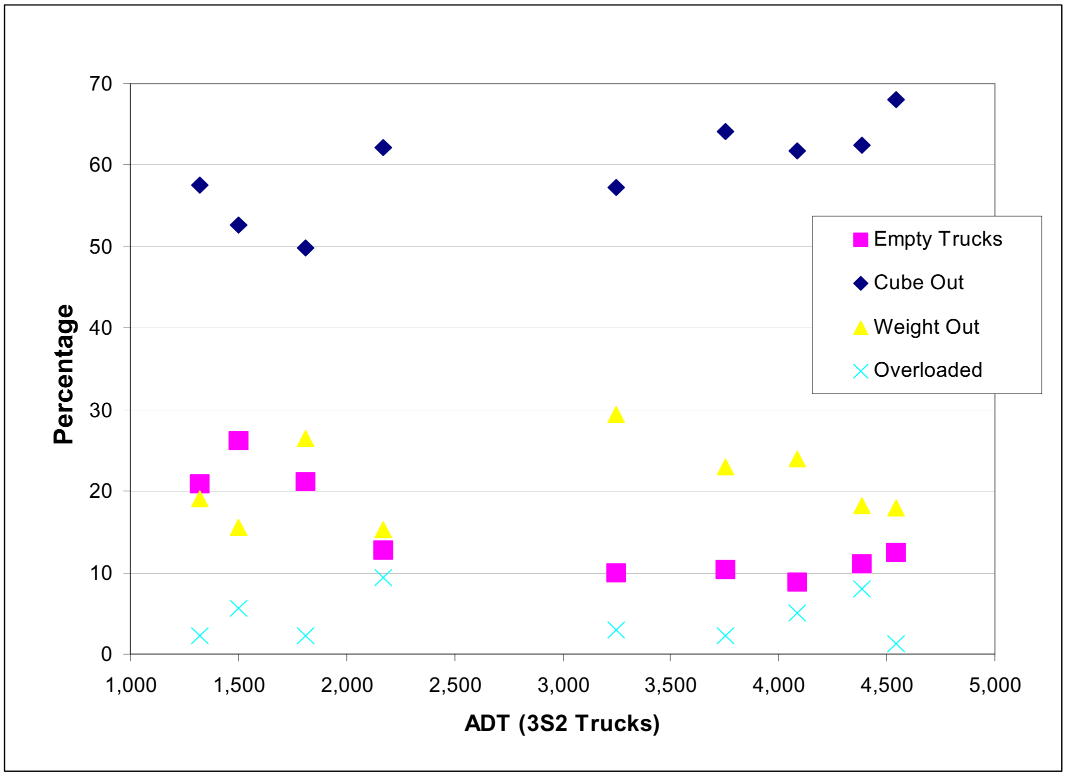


Figure 26. ADT Effect On Empty, Cube Out, Weigh Out And Overload Truck %.

Station 515 registers a lower number of empty trucks. Because this station is located on the corridor that connects the Hidalgo port with Texas, the number of empty trucks may be lower as a result of the consolidation of loads that occurs in the warehouses close to the ports of entry. This implies that the volume of NAFTA trucks close to the border and bridges may be different from the volume of NAFTA trucks in the rural main corridors. It is also important to notice that Station 515 on US 281 and Station 512 on IH 37 are both on the route serving Hidalgo NAFTA trade and have a ratio of empty trucks around 21 percent. This value is higher than the average of 14.8 percent. The lowest percentage of empty trucks is found on IH 45, which has only 8.8 percent.

Another explanation is related to the truck ADT. As shown in Figure 26, as ADT decreases the percentage of empty trucks tends to increase. This is reasonable, because as trip attractions and productions increase, the truck volume increases, and with it the possibility for a truck to quickly pick up another cargo.

Figure 26 shows the relationship between the average 3S2 truck ADT per station and the percentage of empty trucks, using all records of the station; Figure 27 shows the relationship between the daily 3S2 trucks ADT and the percentage of empty trucks per station per day for all sites in the database. In both figures, a slope change seems to occur around ADT equal to 2,500.

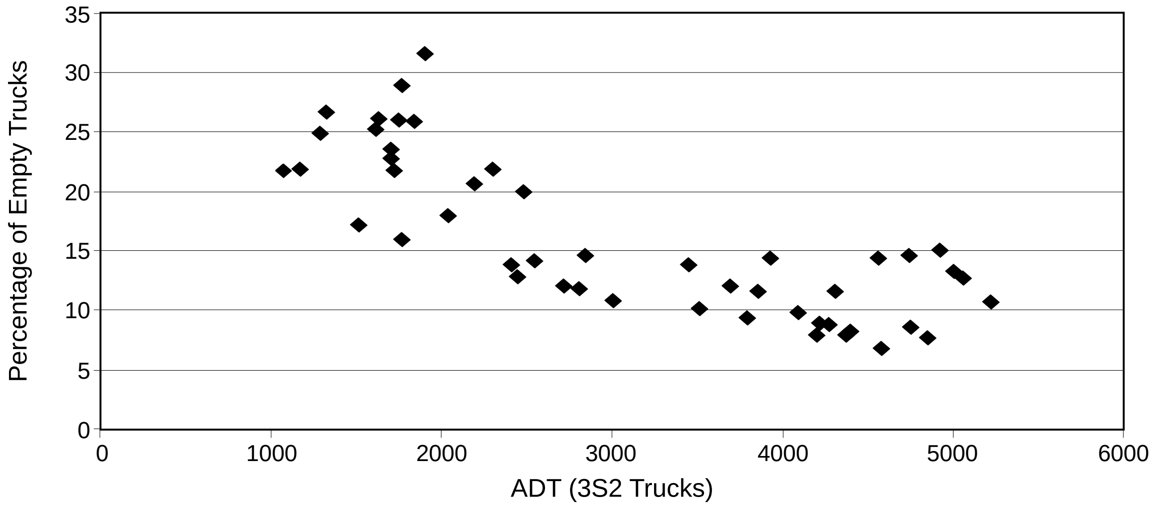


Figure 27. ADT Effect On Percentage Of Empty Trucks.

Cube out and Weight out Percentages

IH 35 has a higher-than-average percentage of cube-out vehicles than the average and IH 20 has a higher-than-average number of weigh-out vehicles than the average. Cube-out and weigh-out percentages are clearly related to the commodity transported, although the cube-out percentage seems to increase with ADT; weigh-out and overloaded percentages show an erratic response to ADT, as shown in Figure 27.

Truck type is also related to the commodity transported. Type 521200 has 73 percent cube-out cargo and only 9.9 percent weigh-out cargo. For cube-out cargo, truck type 521200 is more convenient; this type has higher volume, but they are more expensive and are generally operated only by large companies.

For heavy commodities, the 333000 type is used more often (52 percent cube-out and 32.4 percent weigh-out cargo) because of the heavier load limit allowed on tridem axles. The value for the 332000 truck type lies in between the two types previously analyzed.

Direction of Travel Effect

In this study, the two classes of overloaded vehicles, 3S2 and 3S3, are analyzed according to the direction of travel. The results show that the stations close to the border have an important difference in the percentage of overloaded trucks according to the direction of travel, as demonstrated in Table 19, Table 20, and Table 25.

Station 516, located on IH 35 close to San Antonio, shows the largest differences in percentage of overloaded trucks and direction of travel. Contrary to what might be expected, given the concern about Mexican truckloads, a higher percentage of overloaded trucks heads south than heads north. This occurs with both truck types (332000 and 333000). Perhaps carriers, knowing that Mexico is more flexible with truck weight limits, tend to overload trailers going into Mexico.

Regarding the CTR WIM stations in Laredo and El Paso, only data in El Paso were recorded for both directions. There, the southbound trucks were again heavier than the northbound trucks, with ESAL(equivalent single axle load) values higher for the southbound trucks, especially in the case of 3S3 (Ref 24).

As a general pattern, it is interesting to notice that north-northeast-bound movements in rural stations have a higher percentage of empty 3S2 trucks than do south-southwest-bound movements (with the exception of Station 510, which carries more east-west traffic). These north-south highways especially IH 20, IH 35, and US 281 are very important NAFTA corridors. This suggests that it is easier for southbound than northbound trucks to pick a cargo, as a result some trucks have to return north empty. Commodity type, maquiladora operation, consolidation at the border, and import/export value at the port level may have some influence in this phenomenon. Another explanation is related to railroad trade. Northbound railroad trade, which is substantially higher than southbound trade (see Table 5), may contribute to the high number of empty northbound trucks. As the system is unbalanced, a higher number of empty southbound railroad cars might be expected.

Another important difference occurs at Station 517, where the number of empty trucks is substantially higher going west (36 percent) than going east (19 percent), as shown in Table 19.

With some changes, 3S3 trucks follow the same trend as 3S2 trucks. The number of observations is significantly smaller, which provides less confidence in the results; see Table 20.

Table 19 Direction Of Travel Effect On Truck Weight Classification (3S2)

Station	Highway	Direction	Empties	Cube Out	Weigh Out	Overloaded	Count
LW504	IH20	NORTHEAST	14%	55%	29%	1%	3,199
		SOUTHEAST	6%	59%	30%	5%	3,300
LW507	IH45	NORTH	10%	63%	25%	2%	7,740
		SOUTH	8%	61%	23%	8%	8,602
LW509	IH30	EAST	13%	57%	16%	13%	4,204
		WEST	9%	67%	20%	3%	4,562
LW510	IH10	NORTH	8%	65%	23%	3%	11,089
		EAST	10%	71%	19%	0%	3,580
		SOUTH	11%	61%	25%	2%	11,503
		WEST	15%	65%	19%	1%	3,873
LW512	IH37	NORTH	23%	45%	30%	3%	5,654
		SOUTH	19%	55%	23%	2%	5,195
LW513	IH35	NORTH	16%	64%	19%	1%	17,556
		SOUTH	9%	72%	17%	1%	18,777
LW515	US 281	NORTH	24%	50%	24%	2%	4,321
		SOUTH	17%	67%	13%	3%	3,613
LW516	IH35	NORTHEAST	16%	71%	12%	0%	6,336
		SOUTHWEST	10%	54%	18%	18%	6,694
LW517	US 83	NORTHEAST	19%	55%	20%	6%	1,508
		EAST	19%	50%	21%	11%	4,272
		SOUTHEAST	25%	58%	13%	4%	1,620
		WEST	36%	53%	10%	1%	4,592

Seasonal Effect

To capture seasonal effects, it is necessary to have data that encompass or sample at least a full year; because such data were not available, this type of analysis is not possible. However, the following seasonal effects can be determined from the data available. First, the highest percentage of overloaded trucks for truck type 332000 was found during the months of May and June. The same tendency was found at border and nonborder stations. Truck type 333000 has peaks in April, May, July, and October, with the highest peak in May. Stations 507 (on IH 45), 516 (on IH 35), and 517 (on US 83) have the highest monthly peaks of both truck types. This coincides with the effect noticed in the WIM stations in Laredo and El Paso, where the highest loads and highest percentage of overloaded axles were found in the spring (see Table 24). The origin of this increase seems to be related to the movement of agricultural products. Agricultural products have three important characteristics: (1) they generally weigh out; (2) they are a relatively low-value commodity which makes overloading the trucks more appealing; and (3) they have important seasonal variations, in which spring is the peak season.

Table 20. Direction Of Travel Effect On Truck Weight Classification (3S3)

Station	Highway	Direction	Empties	Cube Out	Weigh Out	Overloaded	Count
LW504	IH20	NORTHEAST	15%	55%	10%	20%	20
		SOUTHEAST	11%	67%	17%	6%	18
LW507	IH45	NORTH	11%	55%	17%	17%	75
		SOUTH	4%	53%	18%	25%	89
LW509	IH30	WEST	27%	35%	30%	8%	88
		EAST	0%	36%	36%	29%	42
LW510	IH10	NORTH	11%	59%	18%	11%	61
		EAST	0%	76%	12%	12%	17
		SOUTH	19%	52%	20%	9%	54
		WEST	9%	65%	17%	9%	23
LW512	IH37	NORTH	35%	40%	7%	19%	43
		SOUTH	16%	50%	11%	24%	38
LW513	IH35	NORTH	9%	53%	22%	14%	116
		SOUTH	23%	50%	14%	13%	108
LW515	U.S.281	NORTH	17%	54%	17%	11%	46
		SOUTH	15%	68%	5%	12%	41
LW516	IH35	NORTHEAST	15%	64%	13%	8%	39
		SOUTHWEST	2%	59%	8%	31%	51
LW517	U.S.83	NORTHEAST	15%	30%	26%	30%	54
		EAST	4%	37%	26%	33%	114
		SOUTHEAST	32%	45%	13%	11%	47
		WEST	41%	50%	5%	5%	123

Figures 28, 29, and 30 show the effect of the direction of travel and the month on the number of trucks and average weight for Stations 515, 516, and 517. Seasonal impacts have an important effect on the number of trucks, and both time and direction of travel have an important effect on the average weight.

Hour of Day

The data captured by the WIM stations were plotted in histogram with the number of trucks on one axis versus the time of day on the other. For the two stations along the border, the influence of customs work hours is clearly defined, as shown in Table 25 and Figure 31 to 36.

Rural interstates with a high percentage of long trips show less variation around the mean. The effect of the hour of day is clear: it appears that the average truck weight decreases between 9:00 and 18:00 hours and increases during the night. Therefore, more empty-haul trips take place during the day or “regular” working hours. This phenomenon is clearly shown in the graph of Station 507.

The same trends can be observed with the percentage of empty trucks. The proportion of empties increases during working hours. This clear tendency is displayed by data at Stations 513 and 515 (see Figure 34, 35, 38, and 39).

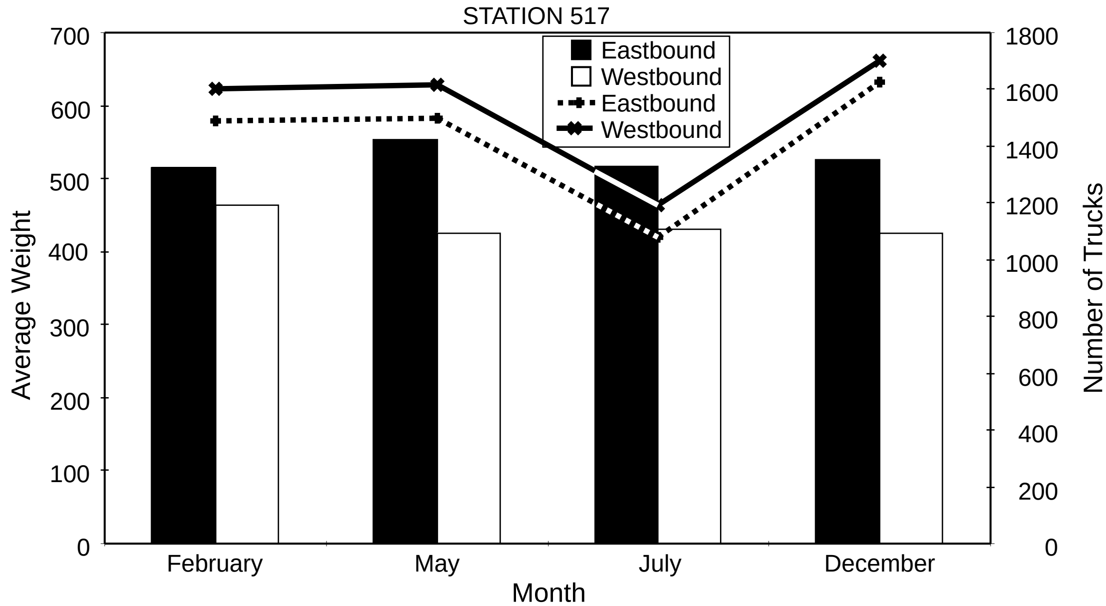


Figure 28. Month and Direction Effects on Station 517.

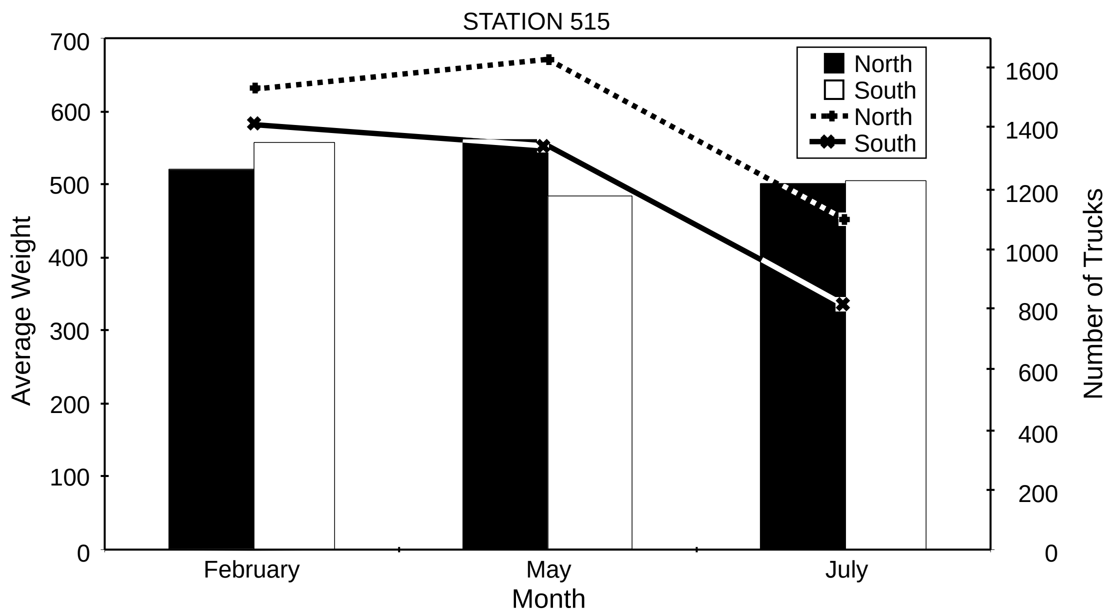


Figure 29. Month and Direction Effects on Station 517.

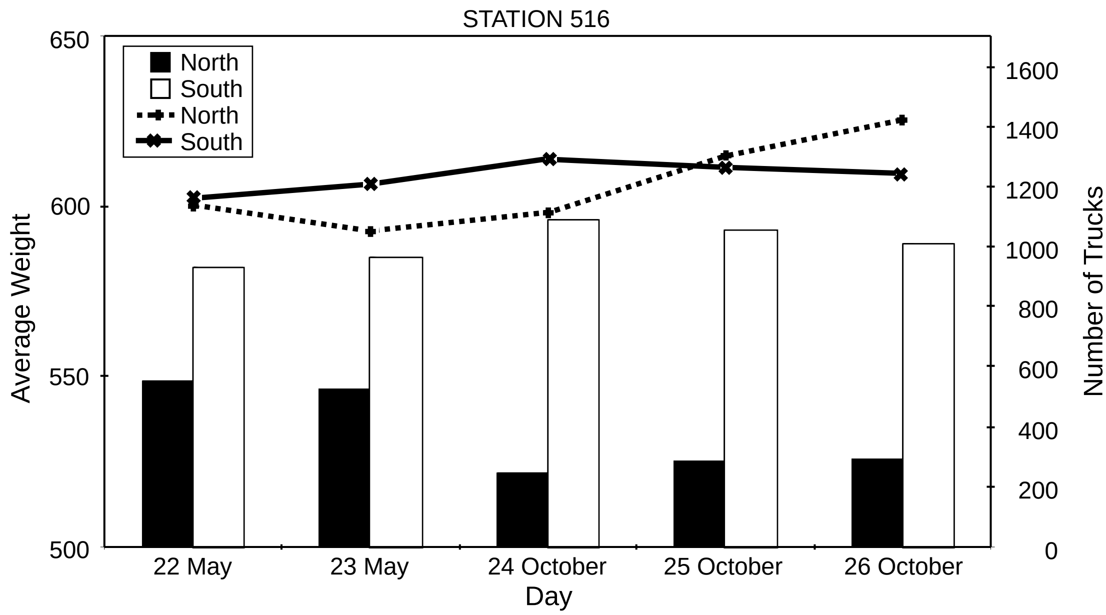


Figure 30. Month and Direction Effects on Station 516

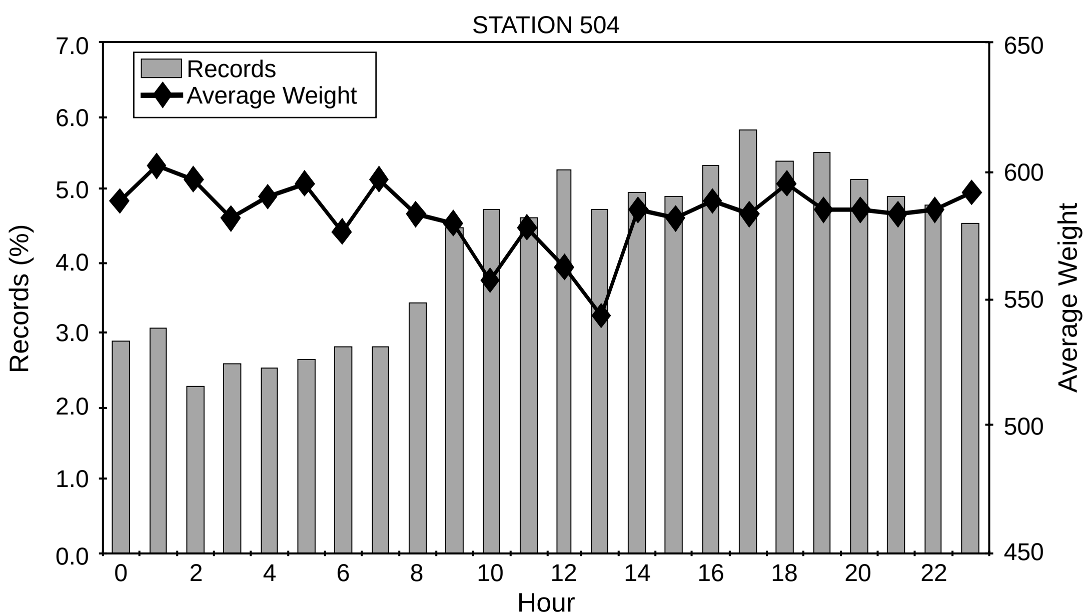


Figure 31. Hour Effect, Truck Type 332000 Station 504.

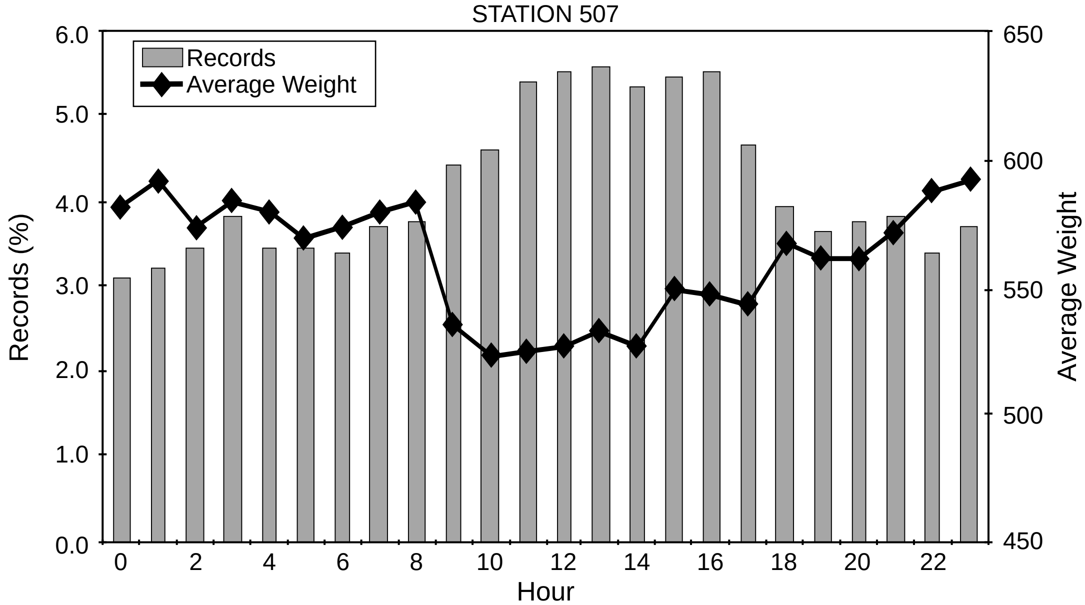


Figure 32. Hour Effect, Truck Type 332000 Station 507.

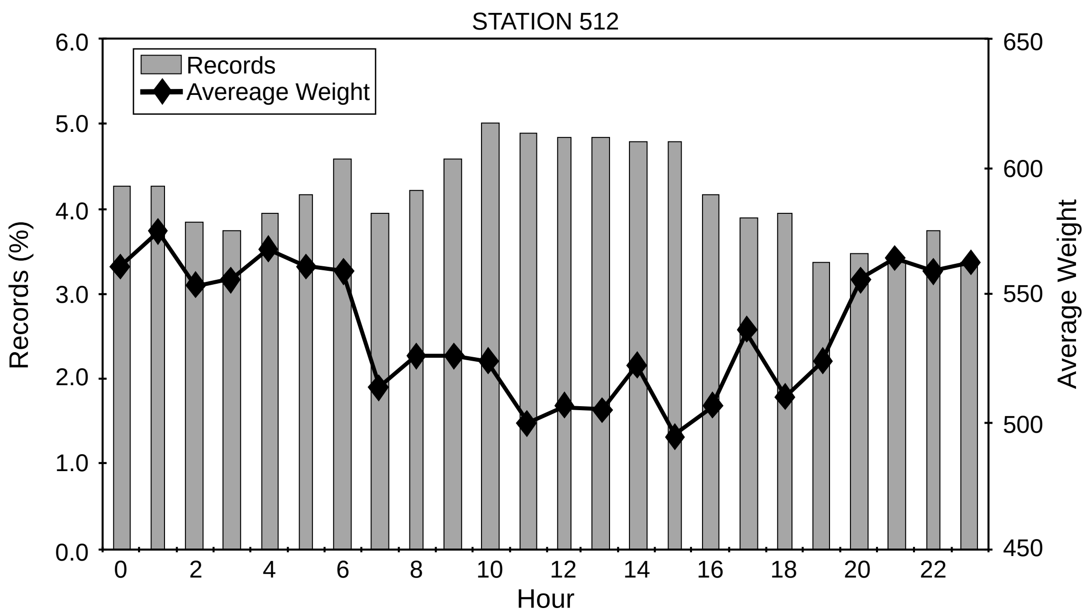


Figure 33. Hour Effect, Truck Type 332000 Station 512.

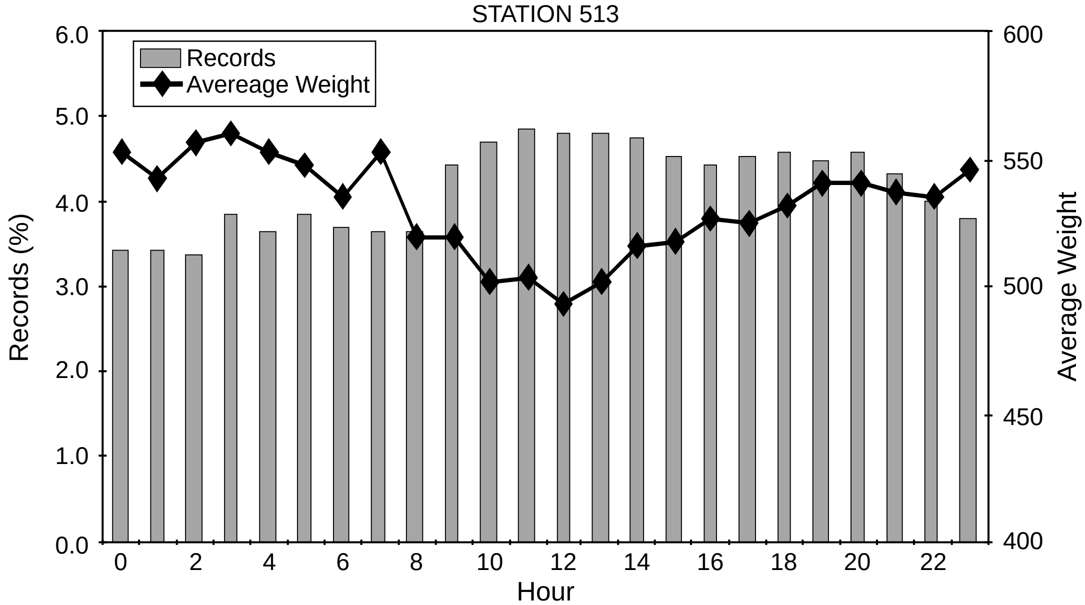


Figure 34. Hour Effect, Truck Type 332000 Station 513.

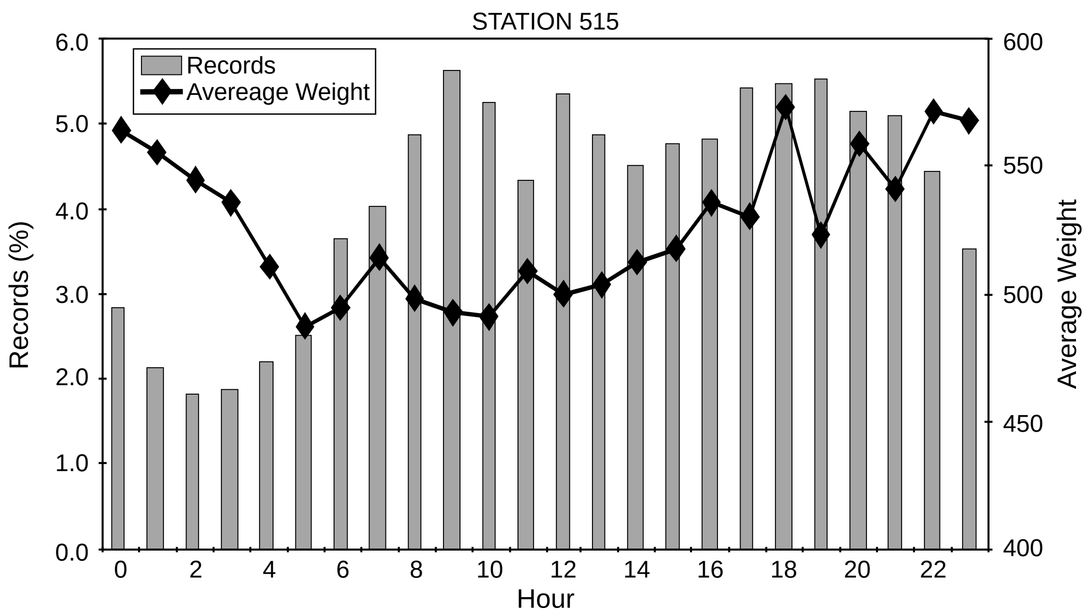


Figure 35. Hour Effect, Truck Type 332000 Station 515.

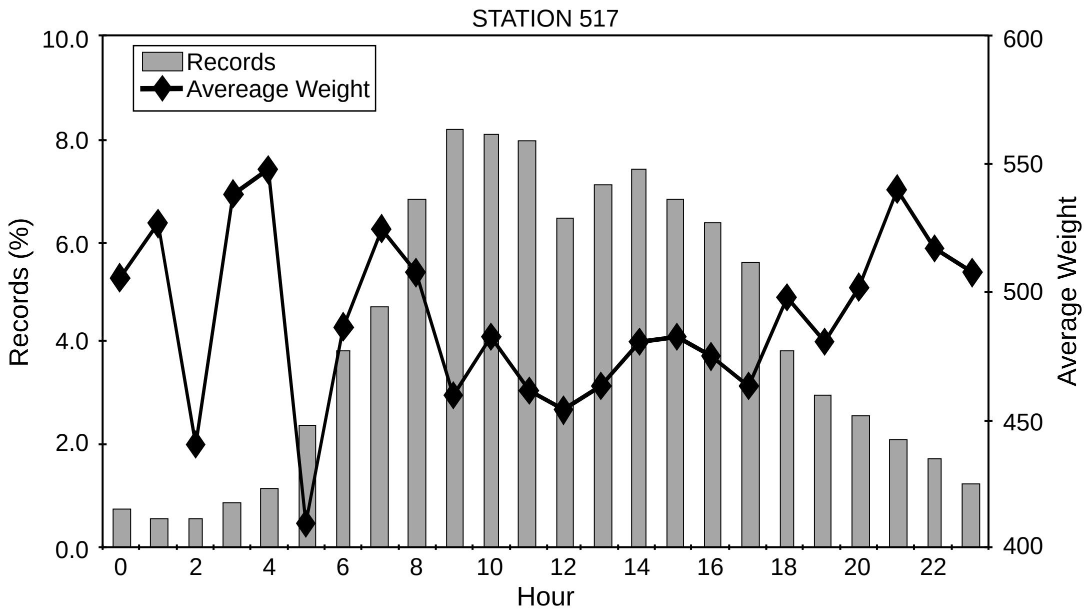


Figure 36. Hour Effect, Truck Type 332000 Station 517.

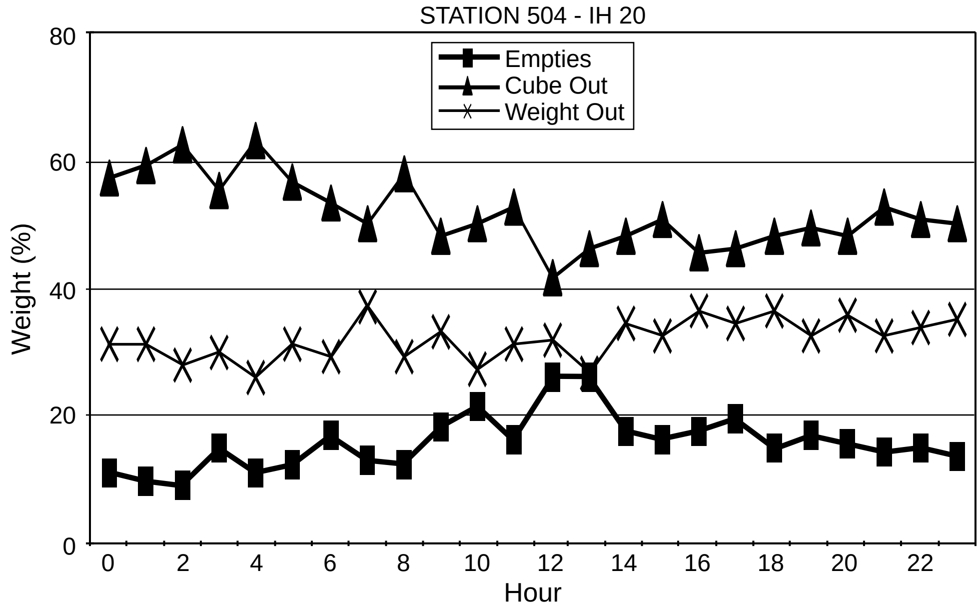


Figure 37. Hour Effect and Truck Weight Station 504.

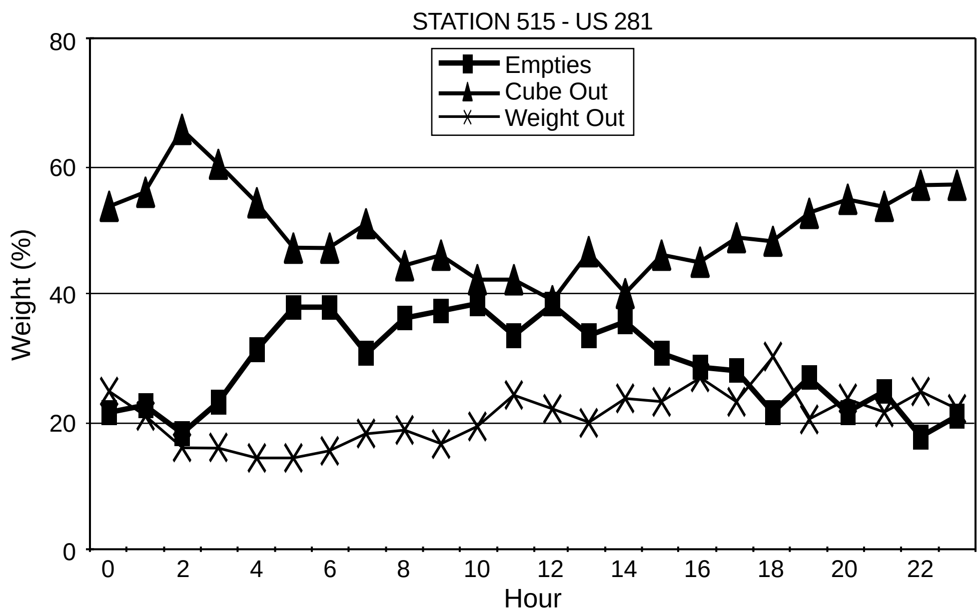


Figure 38. Hour Effect and Truck Weight Station 515.

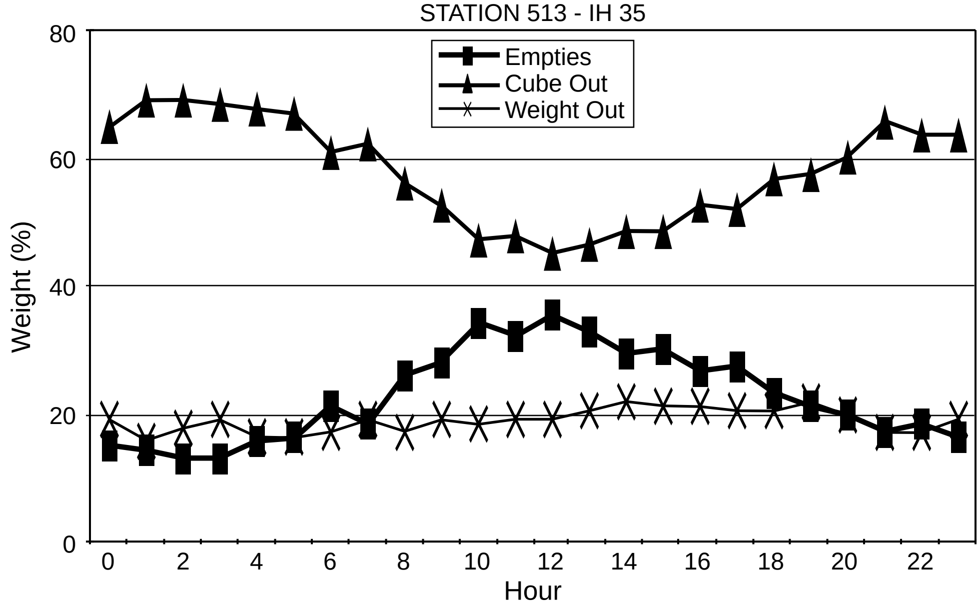


Figure 39. Hour Effect And Truck Weight Station 513.

Analysis of Overweight Axle Loads

The stations located at El Paso and Laredo captured a large number of overloaded trucks. The most notorious violators of the axle weight limits were tandem and tridem axles in 3S3 trucks. Although the presence of this truck type is very small in the total truck composition, more than 65 percent of the 3S3 trucks were overweight. .

The second most frequently overloaded axles were tandem axles of the 3S2 trucks. This truck type is the most predominant truck on the highways and accounts for a large percentage of ESALs.

Table 21 represents the percentage of overloaded axles found during the summer of 1996 (Ref 24). The load limit for a tandem axle in Texas is 34 kip, and the limit for a tridem axle is 42 kip (using the bridge formula). It is important to note that the northbound and southbound traffic in El Paso have almost equal percentages of overloaded trucks. At Laredo, WIM were installed only to collect northbound data from Mexico.

Table 21. Percentage Of Overloaded Axles

Station Location	Truck Type			
	3S2		**3S3**	
	Tractor Tandem	**Trailer Tandem**	**Tractor Tandem**	**Trailer Tridem**
El Paso Northbound	30%	23%	58%	55%
El Paso Southbound	37%	36%	60%	57%
Laredo Northbound	40%	39%	71%	57%

A unique situation was detected at Station 516, located on IH 35. Even though the total percentage of overloaded axles does not deviate far from the mean, the directional effect on the percentage of overloaded axles shows a different pattern. When each direction is analyzed, the northbound truck traffic appears to be composed of 0 percent overloaded trucks, and the southbound truck traffic shows it is composed of 18 percent overloaded trucks. Figure 40 and 41 show the different axle load distribution for both directions. Southbound trade tends to be heavier than northbound trade as a result of the transport of different commodities; however, this alone does not justify or explain such an important difference.

Station 516 is located on IH 35, the corridor that connects the east and northeast industrial U.S. centers with Laredo and the interior of Mexico. Mexico allows higher weight limits than the U.S. does. To take advantage of this situation, carriers may load trucks heavier than the U.S. weight limit.

Differences between axle loads at the border and on the highways are so significant that they suggest that a consolidation process must be taking place at the border. When an overloaded truck coming from Mexico enters the U.S., the trailer weight is reduced to meet U.S. standards. If this process takes place, it is only in trucks carrying weigh out commodities, because cube-out commodities (constrained by volume) do not produce overloaded axles.

For southbound movements, some trailers bound for Mexico are expected to be overloaded (by U.S. standards) either at the border or in the U.S. and this is confirmed by the analysis of the effect of direction of travel on truck weight.

The percentage of overloaded axles at the nine WIM stations located throughout Texas is presented in Table 22. While there are large numbers of overloaded axles on Texas highways (around 8 percent for 3S2 and 12 percent for 3S3), the percentage is considerably lower than it is the border stations. Overall, 3S3 trucks have a higher percentage of overloads than 3S2 trucks do. Axle load weight distributions for trucks 3S2 and 3S3 are shown in Figures 40 to 47.

Table 22. Percentage Of Overloaded Axles

Station Location	Truck Type	
	332000	
	Tractor Tandem	**Trailer Tandem**
Nine Stations [1]	8.6%	7.9%
LW516 IH 35	12.3%	9.7%
LW516 IH 35 Northbound	3.2%	1.5%
LW516 IH 35 Southbound	20.9%	20.6%

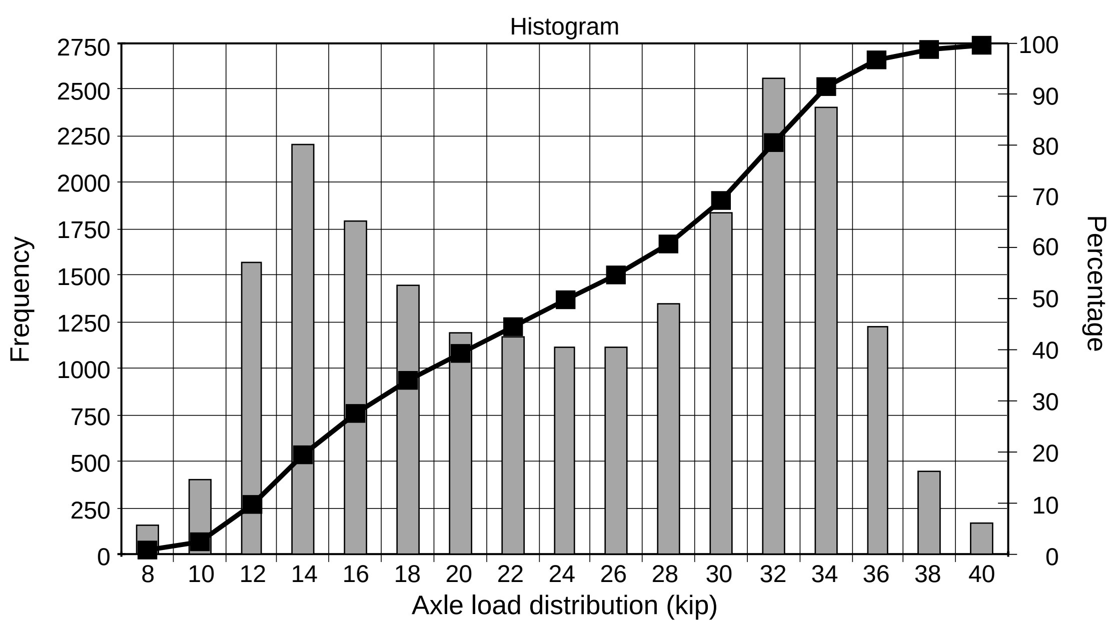


Figure 40. All Stations Vehicle Type 3S2 - Tractor Tandem Axle.

[1] Truck type 333000 has a 12% of overloaded tractor tandem axles and 13% of overloaded trailer tridem axles.

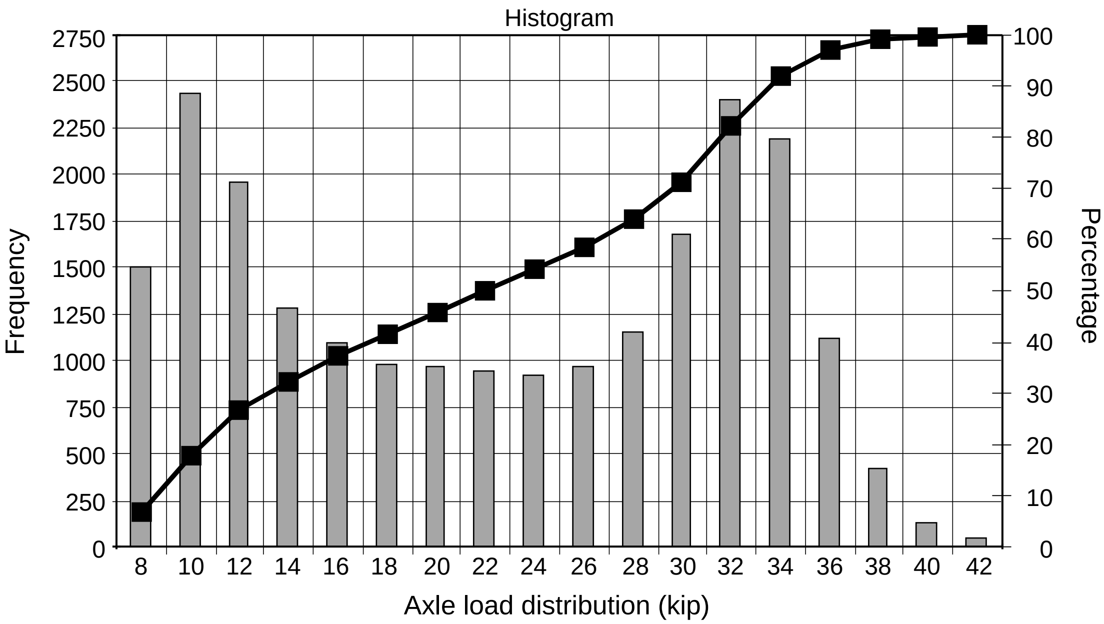


Figure 41. All Stations Vehicle Type 3S2 - Trailer Tandem Axle.

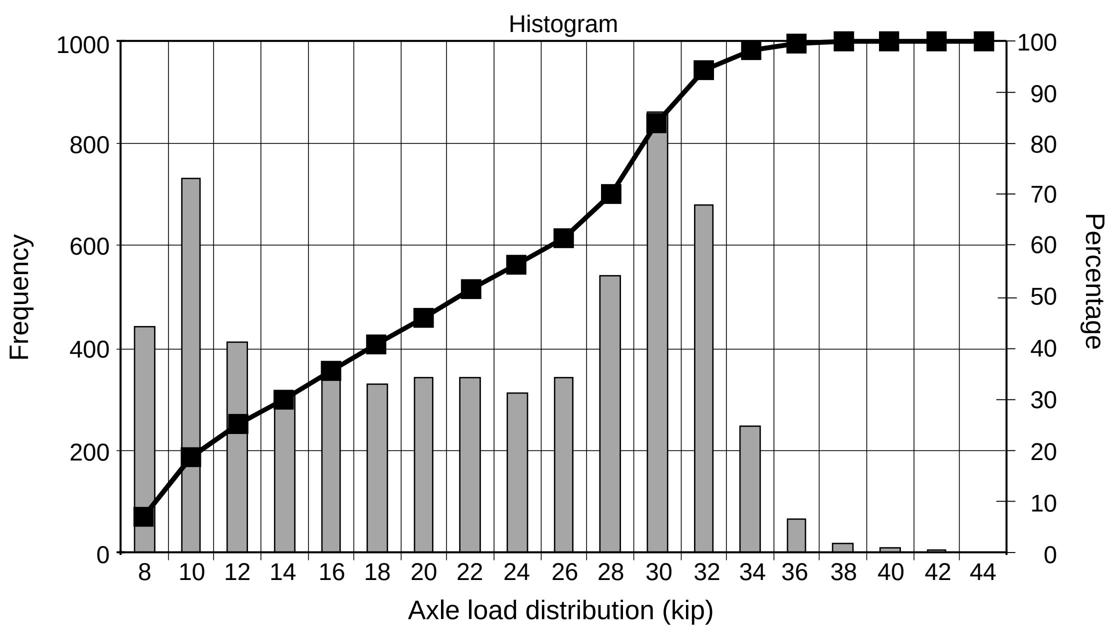


Figure 42. Station 516 Northbound Vehicle Type 3S2 - Trailer Tandem Axle.

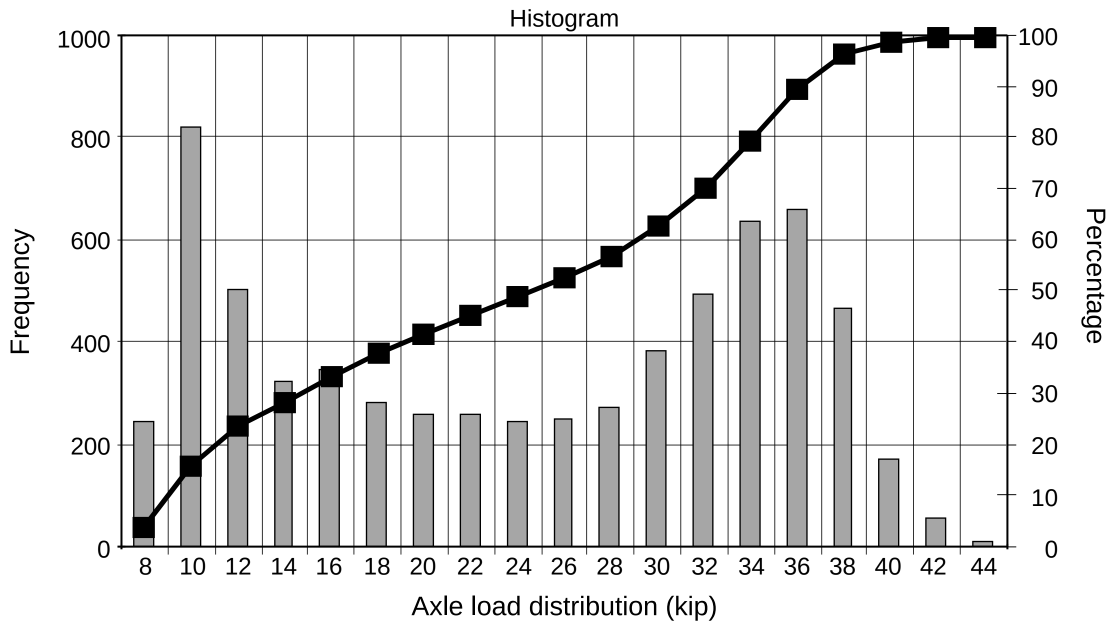


Figure 43. Station 516 Southbound Vehicle Type 3S2 - Trailer Tandem Axle.

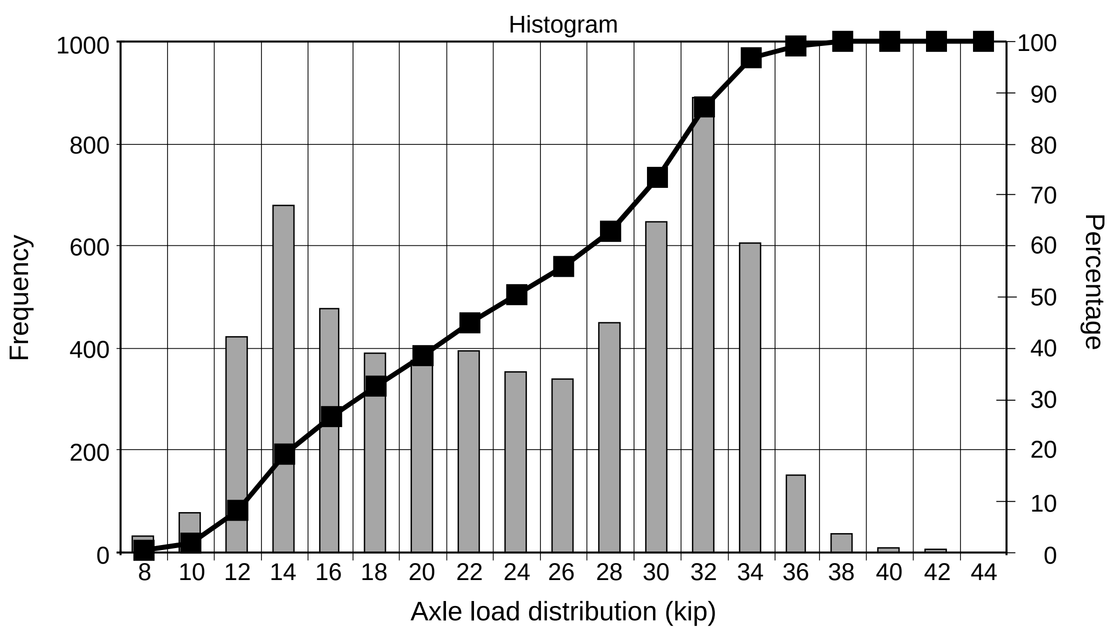


Figure 44. Station 516 Northbound Vehicle Type 3S2 - Tractor Tandem Axle.

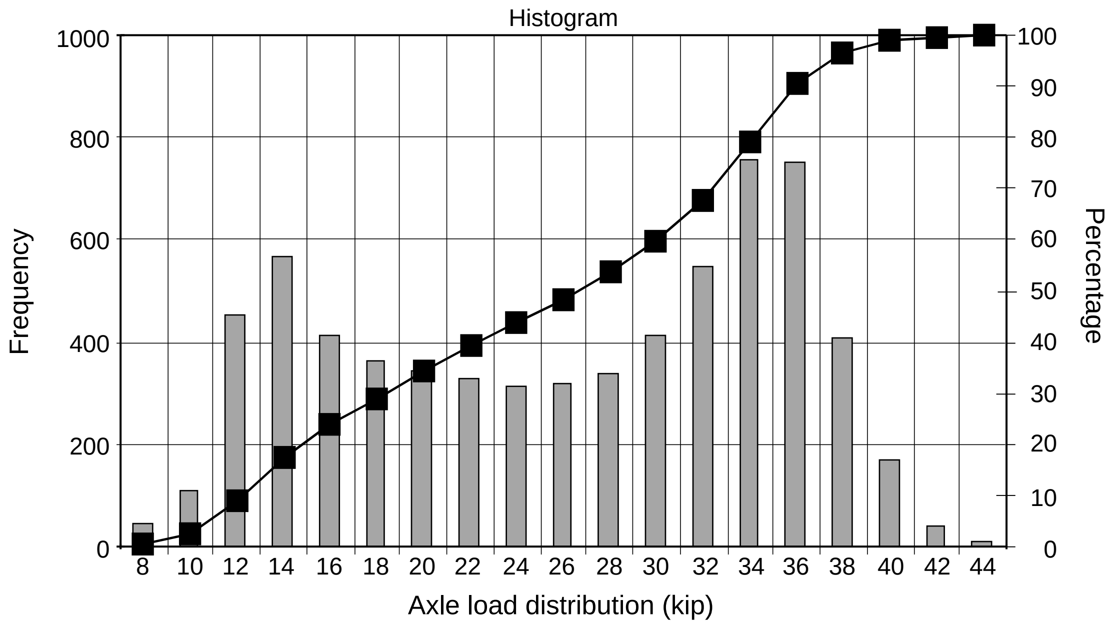


Figure 45. Station 516 Southbound Vehicle Type 3S2 - Tractor Tandem Axle.

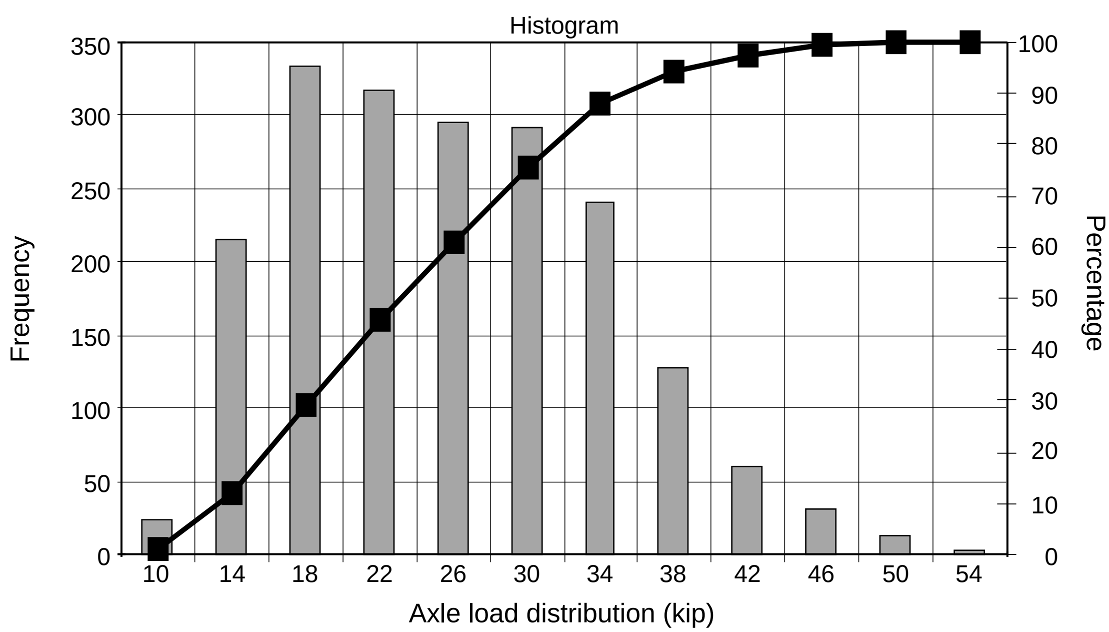


Figure 46. All Stations Vehicle Type 3S3 - Trailer Tridem Axle.

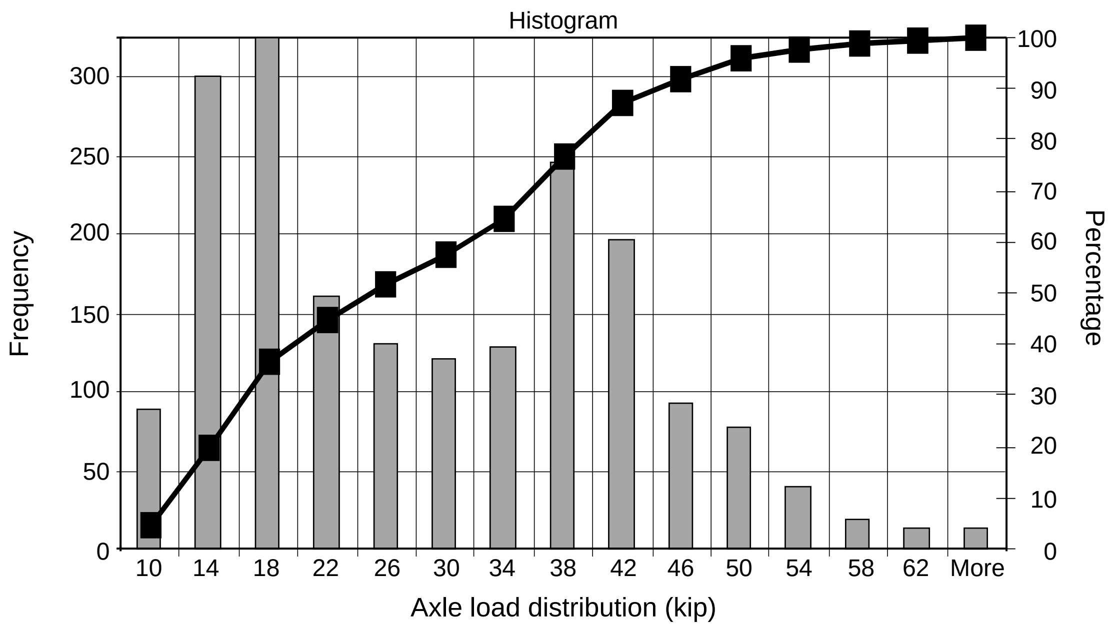


Figure 47. All Stations Vehicle Type 3S3 - Tractor Tandem Axle.

SUMMARY

WIM data provided by TxDOT were used to study truck characteristics on Texas highways. The considerable size of the databases made the analysis difficult, but such analysis has provided insightful information that can be useful in this study and other planning and traffic applications.

Type 3S2 trucks dominate truck volumes on both border and nonborder highways. If loads are analyzed, their share is even more significant, as they are the only truck type with a notable presence and with a serious percentage of overloaded axles. Type 3S3 has a higher percentage of overloaded axles, but its presence is very small. It is clear that in the border zone, truckloads are much heavier than they are on the interior highways of Texas.

Percentages of weigh out and cube-out trucks are related to the commodities transported. The percentage of empty trucks varies with location and truck ADT of the highway. Direction of travel, seasonal effects (by month), day, and hour affect both truck counts and truck weight.

Though the focus of this study is on trucks, it is important to note that NAFTA has created a complex transportation system in which rail may affect truck operation, as suggested by the higher percentage of empty northbound trucks. Other notable findings include the incidence of overloaded axles and its relation to the direction of travel on IH 35 south of San Antonio. The southbound 332000 truck (3S2) has a significant percentage of overloaded trucks, while the northbound 332000 category has virtually no overloaded trucks.

These characteristics are needed to estimate NAFTA truck volumes and therefore will be used in the next chapter, which considers the number of trucks carrying NAFTA trade.

CHAPTER 5. NAFTA TRUCK VOLUMES

INTRODUCTION

U.S.-Mexico trade is affecting both U.S. trade corridors and Texas highways, yet trade data related to trucking do not easily allow planners to identify the contribution of NAFTA to overall truck volumes. Truck data are typically collected in an ADT format, while trade data are collected in a value format with no direct truck counting. So the challenge is to use available trade data to identify clearly specified and derived NAFTA truck volumes in order to capture the impact of U.S.-Mexico surface trade on both U.S. and Mexican highway systems.

The objective of this chapter is to study different ways to estimate the number of NAFTA trucks in nonborder zones. An analysis of through and non-passing border flows, the definition of NAFTA trucks, and a description of the border system are presented first. Second, methods to estimate NAFTA truck numbers are discussed. The first method is based on truck count data at border crossings. Two further methods using commodity data are proposed with the objective of estimating the number of trucks. One method is based on commodity densities, while the other simulates truckload values per commodity.

BORDER AND THROUGH TRADE

Though trade may have positive effects at a macro economic level, the benefits and costs are not evenly distributed. Impacts of truck trade on pavements, congestion, and pollution are often concentrated in certain corridors or ports, while the major benefits are concentrated where employment and economic activity are created.

In an analysis of the state of Texas, it becomes apparent that an important share of trade uses Texas infrastructure without significantly contributing to its economy (through trade); on the other hand, trade originating in or with a destination in Texas contributes more to the economy, employment, and local consumer needs (non-passing border trade).

In an analysis of only a specific border region (an area of a few miles around a border city), most trade can be classified as through trade. The greater the population of the border city and its industrial activity, the more border trade value could be expected. However, at border regions, even through trade contributes to the local economy and employment through warehousing, drayage, brokerage, and customs activities.

NAFTA TRUCKS

NAFTA truck flows are defined in this study as the total number of *equivalent combination* trucks *on U.S. highways* generated through the movement of *passing cargo across the border*.

- *Equivalent combination trucks*: An important number of trucks crossing the border are single-unit trucks. Therefore, single-unit trucks are transformed into equivalent combination vehicles.
- *On highways*: The objective is to estimate the number of trucks on the main corridors, not within border cities or border crossings.
- *Passing cargo:* Goods used or consumed at the border region are considered non-passing because they become part of the domestic economy before using a significant length of U.S. transportation infrastructure.
- *Across the border*: The truck movements are related to imports or exports data.

THE BORDER SYSTEM

The border region, as described in Chapters 3 and 4 has special characteristics. Moreover, while small in size, it plays an important part in the binational transportation system. The border region can be analyzed as a subsystem of the binational transportation system. Figure 48 presents a schematic description of the border region system. It can be considered a system where there are inputs (inbound movements) and outputs (outbound movements) and a series of operations within the system. The inputs and outputs are flows of cargo or goods in trucks or trains. Within the border system the inputs can be modified or consumed, or they can just be passing cargo. Local populations, factories, and maquiladoras consume or modify inputs. Passing cargo, comprising goods not consumed or modified in the border region, can be consolidated in warehouses or switched to other transportation modes.

At the border system endpoints (points 1 and 2 in Figure 48), an equilibrium of trucks, trailers, and train cars (empties or loaded) can be established over a certain period of time. That is, the total number of vehicles coming in must be equal to the number of those coming out, assuming that no vehicles are consumed or fabricated in the border region.

Cargo equilibrium is not possible because of the potential production, consumption, or modification of cargo in the border region. However, where maquiladora operations, local factories, and population consumption are small compared with the amount of passing cargo, the cargo equilibrium could be reasonably established. For example, Laredo has a predominant passing trade and low population and maquiladora activity; on the other hand, El Paso contains important maquiladora operations and factories and a large population. With enough data about activities in the border zone, an analysis of input-output matrix flows can be accomplished, but even when equilibrium (of vehicles or cargo) can be established, the shares of NAFTA and non-NAFTA movements are undetermined, as are the shares of NAFTA passing and non-passing trade.

At the border crossing point (point 3 in Figure 48), the movement of cargo, trucks, and trains recorded by customs is assumed to be NAFTA-related. However, the number of trucks at the border is not the same as the number of NAFTA trucks found at the endpoints of the system (points 1 or 2 in Figure 48) due to drayage and other factors, as discussed in the next section. A methodology for estimating the number of NAFTA trucks based on border crossing counts is presented later in this chapter.

The objective of this chapter is to determine the number of NAFTA-related trucks in nonborder zones. NAFTA trucks can be estimated with trade data as shown later in this chapter using commodity densities or simulation.

The estimation of passing and non-passing trade would require analysis of truck-counting surveys and origin and destination surveys at border crossings and system endpoints; surveys that are expensive in terms of time and cost, especially when the number of bridges and highway and rail connections is high. This study assumes that all trade is passing, an assumption that is more valid when the border city population and industrial activity are small compared with the importance of international trade. Commodity type is certainly an element that also influences the share of passing and non-passing trade.

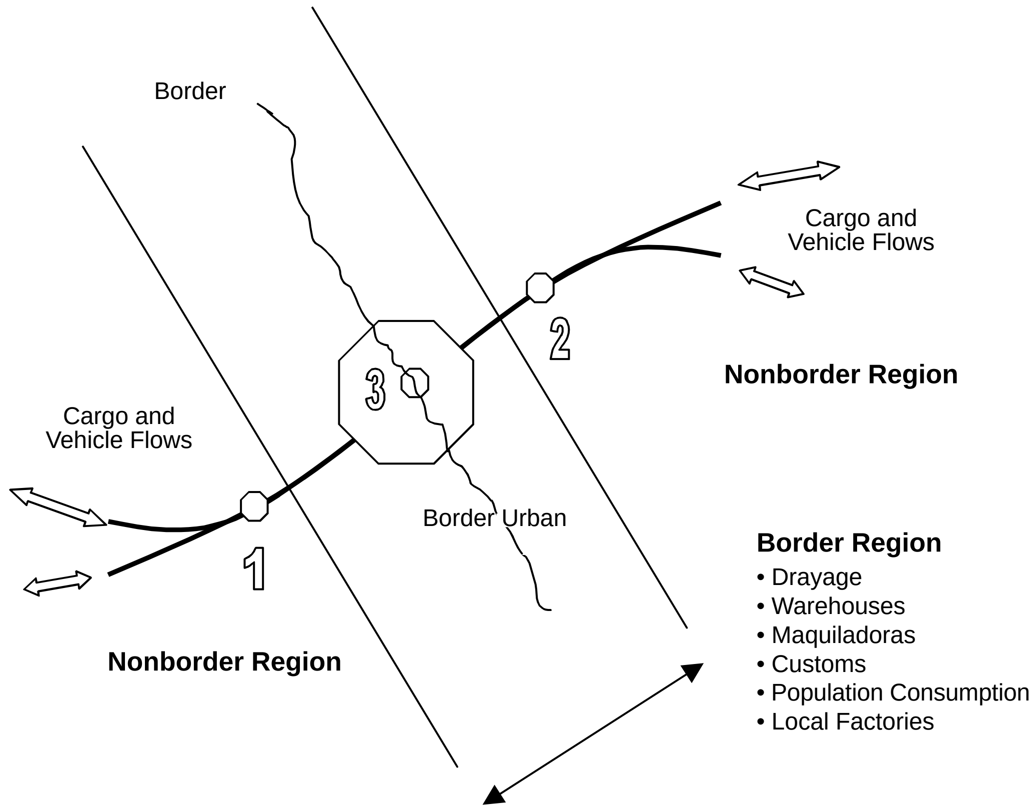


Figure 48. The Border Region System.

DIFFERENCES BETWEEN BORDER AND NONBORDER TRUCK OPERATION

Trucking within the border zone has special characteristics, which have a decisive influence on truck counts at the physical border crossing. Therefore, it is very important to note that truck traffic at border crossings does not necessarily represent U.S.-Mexico truck trade volumes outside the border zone. The main factors that differentiate truck operations within border and nonborder zones and affect the number of trucks that cross the border are

- Drayage and Haul length,
- Percentage of empty trucks,
- Truck classification,
- Truck gross and axle weights, and
- Consolidation of truckloads.

Drayage and Haul Length

Since truck regulations imposed on both sides of the border affect the border crossing process, drayage is frequently needed for trips between nonborder zones, particularly in Texas. Trailers are handed over at least twice, once at each side of the border. Drayage is characterized by the binational interlining of trucking companies at the border, the short drayage haul, and the considerable time spent crossing a few miles.

As will be shown next, drayage has a significant effect on the number of empty trucks crossing the border.

Percentage of Empty Trucks Crossing the Bridges

The percentage of empty trucks at U.S.-Mexico border crossings is significantly higher than the percentage of empty trucks found on U.S. highways. The reasons for this may have originated in drayage practices as well as in natural imbalances associated with trade. An empty truck generally falls into one of two categories:

1. Tractors crossing without a trailer

When there is no trailer to pick up at the other side of the border, the drayage tractor returns without a trailer (this is called the bobtail process). In Laredo, there is a tacit agreement whereby American drayage companies cross trailers south and return them empty and Mexican drayage companies cross trailers north and return them empty (Ref 18).

2. Tractors crossing with empty trailers

The balance of trade is also a factor that contributes to the circulation of empty trailers across the border. When truck traffic in one direction is larger than that in the opposite direction, there is a necessary return of empty trailers to the origin. Unlike drayage, this effect is basically unidirectional and seasonal. Trade conditions change the movement of empty trailers from the north to the south and vice versa. Other modes, especially rail, create imbalances in the number of trailers and containers.

The percentage of empty trucks at border crossings is calculated using the ratio of the total number of loaded trucks to the number of trucks crossing. Loaded trucks have to clear their loads at the border by going through customs. Empty trucks, having no cargo to declare, may proceed without being checked by customs, except for random drug inspections (on northbound movements).

The total number of northbound trucks crossing was obtained from data provided by U.S. Customs and published by BTS (Ref 23). The total number of loaded trucks crossing the border was obtained from Texas A&M International University at Laredo (Ref 24). Southbound data are not available, so the percentage of empty trucks going south cannot be determined. In Table 23, ports with data related to empty and loaded trucks are presented. Looking at all ports where data are available, we note that 49 percent of the trucks are empty. This percentage of empty trucks is clearly higher than the percentage found on interstate highways, where the average percentage of empties, according to WIM data in Texas, is around 15 percent (for truck type 332000).

Significant differences appear among ports of entry. Del Rio and Hidalgo have lower percentages of empty trucks (27 percent and 33 percent, respectively). Two other important ports, Laredo and Brownsville, show a high proportion of empty trucks (over 50 percent). In Laredo, this value is a logical reflection of the drayage mechanism. Each truck that crosses the border with a load returns empty, giving a high threshold value of 50 percent empty trucks. There are no data about loaded trucks in El Paso, the second-largest port in terms of trade value.

Why are there differences among ports? It is difficult to explain with the data at hand, and more detailed study at the port level is necessary to answer this question. One could speculate that it is related to maquiladora operations, warehousing, and drayage activities. However, the objective of this study is more macro in nature and does not address these issues.

Classification of trucks

Table 24 through Table 27 show truck classifications for the most important border crossings in Texas. TxDOT's TPP (Transportation Planning and Programming) division provided the data.

The percentages of single-unit trucks vary significantly among ports; however, border crossings include considerably higher percentage of single-unit trucks than the percentage found on rural NAFTA corridors. Because single-unit trucks are more efficient over short distances, local trucking companies use them the most. However, the number of single-unit trucks appears to be too high to be related only to local trade. At ports where there is a large share of maquiladora trade, single-unit trucks may be used to carry supplies and goods between maquiladoras, warehouses, and suppliers.

Table 23. Northbound Truck Crossings, U.S.-Mexico Border 1997

TOTAL TRUCKS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Brownsville	19,907	17,911	18,836	18,590	18,769	21,067	19,023	22,521	25,679	24,076	20,951	20,248	247,578
Del Rio	3,850	3,593	3,542	3,986	3,691	3,479	3,566	3,742	3,837	4,487	3,799	3,487	45,059
Eagle Pass	5,426	5,455	5,380	6,257	5,841	5,930	5,907	6,157	5,996	7,120	6,210	5,977	71,656
Laredo	99,092	90,387	94,043	100,407	99,105	101,619	110,279	107,525	113,790	123,192	102,727	109,199	1,251,365
Hidalgo	17,375	17,369	20,542	19,491	20,023	19,914	20,253	19,607	19,813	21,515	19,958	18,940	234,800
Progreso	1,004	1,158	2,183	2,176	1,398	1,163	1,316	1,737	1,460	1,586	1,499	2,246	18,926
Roma	878	991	911	1,154	1,041	1,059	1,015	917	840	979	886	888	11,559
TOTAL	147,532	136,864	145,437	152,061	149,868	154,231	161,359	162,206	171,415	182,955	156,030	160,985	1,880,943

LOADED TRUCKS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Brownsville	9,757	8,723	8,646	9,518	9,879	10,758	11,551	11,889	11,978	12,073	9,681	8,430	122,883
Del Rio	2,717	2,644	2,662	2,966	2,799	2,589	2,529	2,709	2,824	3,340	2,792	2,471	33,042
Eagle Pass	3,051	3,139	3,027	3,689	3,523	3,486	3,426	3,711	3,502	3,798	3,286	2,990	40,628
Laredo	45,510	41,249	44,438	48,359	48,011	48,226	50,046	40,626	56,099	56,867	48,243	48,978	576,652
Pharr	12,004	12,173	15,586	14,045	13,741	13,405	12,892	12,149	12,050	13,552	12,638	12,281	156,516
Progreso	400	623	1,543	1,152	414	554	817	836	556	370	400	329	7,994
Roma	389	447	434	596	566	548	515	473	408	498	425	448	5,747
TOTAL	75,348	69,837	77,707	81,844	81,169	80,740	82,956	73,196	88,552	92,246	78,735	77,138	959,468

PERCENTAGE OF EMPTY TRUCKS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Brownsville	51%	51%	54%	49%	47%	49%	39%	47%	53%	50%	54%	58%	50.4%
Del Rio	29%	26%	25%	26%	24%	26%	29%	28%	26%	26%	27%	29%	26.7%
Eagle Pass	44%	42%	44%	41%	40%	41%	42%	40%	42%	47%	47%	50%	43.3%
Laredo	54%	54%	53%	52%	52%	53%	55%	62%	51%	54%	53%	55%	53.9%
Hidalgo	31%	30%	24%	28%	31%	33%	36%	38%	39%	37%	37%	35%	33.3%
Progreso	60%	46%	29%	47%	70%	52%	38%	52%	62%	77%	73%	85%	57.8%
Roma	56%	55%	52%	48%	46%	48%	49%	48%	51%	49%	52%	50%	50.3%
TOTAL	48.9%	49.0%	46.6%	46.2%	45.8%	47.6%	48.6%	54.9%	48.3%	49.6%	49.5%	52.1%	49.0%

Table 24. Truck Classification, Brownsville Bridges

STATION NUMBER	MT140	MT141	MT160	TOTAL
HIGHWAY	US 77 N.bound	US 77 S.bound	FM 255	
BRIDGE	GATEWAY N.	GATEWAY S.	B&M RR	
SINGLE-UNIT TRUCKS				
2 AXLE (NO PICKUPS)	115	58	61	234
3 AXLE	61	55	28	144
4 AXLE	5	0	0	5
TOTAL SINGLE UNIT	181	113	89	383
COMBINATIONS SEMI-TRAILER				
3 AXLE	4	1	3	8
4 AXLE	1	7	10	18
5 AXLE	229	216	197	642
6 AXLE OR MORE	84	68	53	205
SUBTOTAL	318	292	260	870
SEMI-TRAILER-TRAILER				
5 AXLE OR LESS	0	0	0	0
6 AXLE	0	0	0	0
7 AXLE OR MORE	0	0	0	0
SUBTOTAL	0	0	0	0
TOTAL COMBINATION	318	292	260	870
TOTAL TRUCKS	499	405	349	1,253

STATION NUMBER	MT140	MT141	MT160	TOTAL
HIGHWAY	US 77 N.bound	US 77 S.bound	FM 255	
BRIDGE	GATEWAY N.	GATEWAY S.	B&M RR	
SINGLE-UNIT TRUCKS				
2 AXLE (NO PICKUPS)	23.0%	14.3%	17.5%	18.7%
3 AXLE	12.2%	13.6%	8.0%	11.5%
4 AXLE	1.0%	0.0%	0.0%	0.4%
TOTAL SINGLE UNIT	36.3%	27.9%	25.5%	30.6%
COMBINATIONS SEMI-TRAILER				
3 AXLE	0.8%	0.2%	0.9%	0.6%
4 AXLE	0.2%	1.7%	2.9%	1.4%
5 AXLE	45.9%	53.3%	56.4%	51.2%
6 AXLE OR MORE	16.8%	16.8%	15.2%	16.4%
SUBTOTAL	63.7%	72.1%	75.4%	69.7%
SEMI-TRAILER-TRAILER				
5 AXLE OR LESS	0.0%	0.0%	0.0%	0.0%
6 AXLE	0.0%	0.0%	0.0%	0.0%
7 AXLE OR MORE	0.0%	0.0%	0.0%	0.0%
SUBTOTAL	0.0%	0.0%	0.0%	0.0%
TOTAL COMBINATION	63.7%	72.1%	75.4%	69.7%

Table 25. Truck Classification, Laredo Bridges

STATION NUMBER	MT420	MT440	MT480	TOTAL
HIGHWAY	IH 35	IH 35A	FM 255	
BRIDGE	JUAREZ-LINCOLN	CONVENT ST.	COLOMBIA	
SINGLE-UNIT TRUCKS				
2 AXLE (NO PICKUPS)	930	87	45	1,062
3 AXLE	2,434	7	150	2,591
4 AXLE	1	4	0	5
TOTAL SINGLE UNIT	3,365	98	195	3,658
COMBINATIONS SEMI-TRAILER				
3 AXLE	33	0	0	33
4 AXLE	71	25	69	165
5 AXLE	2,453	397	565	3,415
6 AXLE OR MORE	40	0	7	47
SUBTOTAL	2,597	422	641	3,660
SEMI-TRAILER-TRAILER				
5 AXLE OR LESS	3	0	0	3
6 AXLE	1	0	0	1
7 AXLE OR MORE	1	0	0	1
SUBTOTAL	5	0	0	5
TOTAL COMBINATION	2,602	422	641	3,665
TOTAL TRUCKS	5,967	520	836	7,323

STATION NUMBER	MT420	MT440	MT480	
HIGHWAY	IH 35	IH 35A	FM 255	
BRIDGE	JUAREZ-LINCOLN	CONVENT ST.	COLOMBIA	
2 AXLE (NO PICKUPS)	15.6%	16.7%	5.4%	14.5%
3 AXLE	40.8%	1.3%	17.9%	35.4%
4 AXLE	0.0%	0.8%	0.0%	0.1%
TOTAL SINGLE UNIT	56.4%	18.8%	23.3%	50.0%
COMBINATIONS SEMI-TRAILER				
3 AXLE	0.6%	0.0%	0.0%	0.5%
4 AXLE	1.2%	4.8%	8.3%	2.3%
5 AXLE	41.1%	76.3%	67.6%	46.6%
6 AXLE OR MORE	0.7%	0.0%	0.8%	0.6%
SUBTOTAL	43.5%	81.2%	76.7%	50.0%
SEMI-TRAILER-TRAILER				
5 AXLE OR LESS	0.1%	0.0%	0.0%	0.0%
6 AXLE	0.0%	0.0%	0.0%	0.0%
7 AXLE OR MORE	0.0%	0.0%	0.0%	0.0%
SUBTOTAL	0.1%	0.0%	0.0%	0.1%
TOTAL COMBINATION	43.6%	81.2%	76.7%	50.0%

Table 26. Truck Classification, El Paso Bridges

STATION NUMBER	MT660	MT680	MT700	MT704	TOTAL
HIGHWAY	FC	IH 110	US 62 N.	US 62 S.	
BRIDGE	ZARAGOSA	CORDOVA	STANTON ST.	SANTA FE ST.	
SINGLE-UNIT TRUCKS					
2 AXLE (NO PICKUPS)	247	743	53	55	1,098
3 AXLE	205	665	5	4	879
4 AXLE	12	4	0	0	16
TOTAL SINGLE UNIT	464	1,412	58	59	1,993
COMBINATIONS SEMI-TRAILER					
3 AXLE	9	4	0	4	17
4 AXLE	26	24	0	0	50
5 AXLE	2,095	801	0	0	2,896
6 AXLE OR MORE	22	10	0	0	32
SUBTOTAL	2,152	839	0	4	2,995
SEMI-TRAILER-TRAILER					
5 AXLE OR LESS	17	0	0	0	17
6 AXLE	2	0	0	0	2
7 AXLE OR MORE	0	0	0	0	0
SUBTOTAL	19	0	0	0	19
TOTAL COMBINATION	2,171	839	0	4	3,014
TOTAL TRUCKS	2,635	2,251	58	63	5,007

STATION NUMBER	MT660	MT680	MT700	MT704	
HIGHWAY	FC	IH 110	US 62 N	US 62 S	
BRIDGE	ZARAGOSA	CORDOVA	STANTON ST.	SANTA FE ST.	
SINGLE UNIT TRUCKS					
2 AXLE (NO PICKUPS)	9.4%	33.0%	91.4%	87.3%	21.9%
3 AXLE	7.8%	29.5%	8.6%	6.3%	17.6%
4 AXLE	0.5%	0.2%	0.0%	0.0%	0.3%
TOTAL SINGLE UNIT	17.6%	62.7%	100.0%	93.7%	39.8%
COMBINATIONS SEMI-TRAILER					
3 AXLE	0.3%	0.2%	0.0%	6.3%	0.3%
4 AXLE	1.0%	1.1%	0.0%	0.0%	1.0%
5 AXLE	79.5%	35.6%	0.0%	0.0%	57.8%
6 AXLE OR MORE	0.8%	0.4%	0.0%	0.0%	0.6%
SUBTOTAL	81.7%	37.3%	0.0%	6.3%	59.8%
SEMI-TRAILER-TRAILER					
5 AXLE OR LESS	0.6%	0.0%	0.0%	0.0%	0.3%
6 AXLE	0.1%	0.0%	0.0%	0.0%	0.0%
7 AXLE OR MORE	0.0%	0.0%	0.0%	0.0%	0.0%
SUBTOTAL	0.7%	0.0%	0.0%	0.0%	0.4%
TOTAL COMBINATION	82.4%	37.3%	0.0%	6.3%	60.2%

Table 27. Truck Classification On Bridges

STATION NUMBER	MT240	MT360	MT380	MT520	MT540
HIGHWAY	US 281		SH 200	US 57	US 277
BRIDGE	PHARR	R. GRANDE	ROMA	E. PASS	DEL RIO
SINGLE-UNIT TRUCKS					
2 AXLE (NO PICKUPS)	119	5	4	87	215
3 AXLE	51	0	7	70	63
4 AXLE	0	1	0	2	8
TOTAL SINGLE UNIT	170	6	11	159	286
COMBINATIONS SEMI-TRAILER					
3 AXLE	3	2	2	0	0
4 AXLE	12	0	0	16	10
5 AXLE	310	48	27	265	334
6 AXLE OR MORE	7	80	6	16	0
SUBTOTAL	332	130	35	297	344
SEMI-TRAILER-TRAILER					
5 AXLE OR LESS	0	0	0	0	0
6 AXLE	0	0	0	0	0
7 AXLE OR MORE	0	0	0	0	0
SUBTOTAL	0	0	0	0	0
TOTAL COMBINATION	332	130	35	297	344
TOTAL TRUCKS	502	136	46	456	630

STATION NUMBER	MT240	MT360	MT380	MT520	MT540
HIGHWAY	US 281		SH 200	US 57	US 277
BRIDGE	PHARR	R. GRANDE	ROMA	E. PASS	DEL RIO
SINGLE-UNIT TRUCKS					
2 AXLE (NO PICKUPS)	23.7%	3.7%	8.7%	19.1%	34.1%
3 AXLE	10.2%	0.0%	15.2%	15.4%	10.0%
4 AXLE	0.0%	0.7%	0.0%	0.4%	1.3%
TOTAL SINGLE UNIT	33.9%	4.4%	23.9%	34.9%	45.4%
COMBINATIONS SEMI-TRAILER					
3 AXLE	0.6%	1.5%	4.3%	0.0%	0.0%
4 AXLE	2.4%	0.0%	0.0%	3.5%	1.6%
5 AXLE	61.8%	35.3%	58.7%	58.1%	53.0%
6 AXLE OR MORE	1.4%	58.8%	13.0%	3.5%	0.0%
SUBTOTAL	66.1%	95.6%	76.1%	65.1%	54.6%
SEMI-TRAILER-TRAILER					
5 AXLE OR LESS	0.0%	0.0%	0.0%	0.0%	0.0%
6 AXLE	0.0%	0.0%	0.0%	0.0%	0.0%
7 AXLE OR MORE	0.0%	0.0%	0.0%	0.0%	0.0%
SUBTOTAL	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL COMBINATION	66.1%	95.6%	76.1%	65.1%	54.6%

Table 28. Rural Truck Classifications In Main Corridors To Main Texas Trade Ports

STATION NUMBER	M1130	MS74	BC2101	BC2206	BC2405
HIGHWAY	US 57	US 77	US 281	IH 35	IH 10
SINGLE-UNIT TRUCKS					
2 AXLE (NO PICKUPS)	64	355	465	281	490
3 AXLE	15	35	55	110	188
4 AXLE	0	0	2	1	1
TOTAL SINGLE UNIT	79	390	522	392	679
COMBINATIONS SEMI-TRAILER					
3 AXLE	6	106	63	88	67
4 AXLE	5	118	78	234	61
5 AXLE	301	1,217	1,579	2,436	3,311
6 AXLE OR MORE	2	17	33	19	18
SUBTOTAL	314	1,458	1,753	2,777	3,457
SEMI-TRAILER-TRAILER					
5 AXLE OR LESS	4	73	30	79	129
6 AXLE	3	20	11	14	65
7 AXLE OR MORE	0	0	1	0	0
SUBTOTAL	7	93	42	93	194
TOTAL COMBINATION	321	1,551	1,795	2,870	3,651
TOTAL TRUCKS	400	1,941	2,317	3,262	4,330
STATION NUMBER	M1130	MS74	BC2101	BC2206	BC2405
HIGHWAY	US 57	US 77	US 281	IH 35	IH 10
SINGLE-UNIT TRUCKS					
2 AXLE (NO PICKUPS)	16.0%	18.3%	20.1%	8.6%	11.3%
3 AXLE	3.8%	1.8%	2.4%	3.4%	4.3%
4 AXLE	0.0%	0.0%	0.1%	0.0%	0.0%
TOTAL SINGLE UNIT	19.8%	20.1%	22.5%	12.0%	15.7%
COMBINATIONS SEMI-TRAILER					
3 AXLE	1.5%	5.5%	2.7%	2.7%	1.5%
4 AXLE	1.3%	6.1%	3.4%	7.2%	1.4%
5 AXLE	75.3%	62.7%	68.1%	74.7%	76.5%
6 AXLE OR MORE	0.5%	0.9%	1.4%	0.6%	0.4%
SUBTOTAL	78.5%	75.1%	75.7%	85.1%	79.8%
SEMI-TRAILER-TRAILER					
5 AXLE OR LESS	1.0%	3.8%	1.3%	2.4%	3.0%
6 AXLE	0.8%	1.0%	0.5%	0.4%	1.5%
7 AXLE OR MORE	0.0%	0.0%	0.0%	0.0%	0.0%
SUBTOTAL	1.8%	4.8%	1.8%	2.9%	4.5%
TOTAL COMBINATION	80.3%	79.9%	77.5%	88.0%	84.3%

Table 28 shows truck classifications for rural stations on the main rural corridors for the main ports in Texas. These corridors are the main connections to the most important Texas-Mexico surface ports: Laredo, El Paso, Brownsville, Hidalgo, and Eagle Pass. The percentage of combination trucks found on US 281 (77.5 percent) was the lowest found on these rural highways. In all cases, the percentage of single trucks at border crossings is higher than that on rural corridors. The ports of Laredo and El Paso, first- and second-largest by value, have a large share of single-unit trucks (50 percent and 40 percent, respectively). On the main corridors to these cities, IH 35 and IH 10, the percentages of single-unit trucks are only 12 percent and 15 percent, respectively.

Truck Weight

As shown in Chapter 4, axle weights per 3S2-truck type are considerably higher in the border zone. The results are displayed in Table 29.

Table 29. Average Axle Loads (3S2)

Location	Tractor Single	Tractor Tandem	Trailer Tandem	Total Weight	Truckload
Laredo (*)	9.7	30.04	29.88	69.62	37.62
Nonborder (**)	10	23.04	21.48	54.52	22.52
Ratio	0.97	1.28	1.39	1.28	1.67

(*) From Ref 1, only for northbound trucks

(**) Obtained from TPP WIM stations

The ratio between total vehicle weights is 1.28. If a net tractor-trailer weight is assumed to be 32,000 lb, the ratio among truckloads is 1.67.

Table 30. Northbound Truck Volumes (1997)

Trucks-North '97	Brownsville	Del Rio	Eagle Pass	Laredo
TOTAL	247,578	45,059	71,656	1,251,365
Loaded Trucks	122,883	33,042	40,628	576,652
% of empty trucks	50.4%	26.7%	43.3%	53.9%
%SU Trucks	30.6	45.4	34.9	50
Total 18W	97,815	23,041	31,175	432,489
Correction Intermodal				200
TOTAL LOADED				
3S2 TRUCKS	97,815	23,041	31,175	430,089
Correct by	15	15	15	15
% empty trucks				
Total	**112,487**	**26,497**	**35,852**	**494,602**
ADT 18W	**406**	**96**	**129**	**1,785**
Days per year=277				
TRADE VALUE	3,848,819,516	1,198,310,629	1,487,742,434	15,722,744,058
AVG. VALUE IN $	34,216	45,224	41,497	31,789
PER TRUCK				
TRADE WEIGHT	1,113,195,980	165,792,211	393,522,174	5,556,971,934
AVG. WEIGHT	21,772	13,765	24,148	24,718

Trucks-North '97	Hidalgo	Progreso	Roma	El Paso	Rio Grande
TOTAL	234,800	18,926	11,559	582,707	
Loaded Trucks	156,516	7,994	5,747	268,045	15,917
% of empty trucks	33.3%	57.8%	50.3%	54.0%	
% SU Trucks	33.9%	50%	23.9%	39.8%	4.4%
Total 18W	121,143	5,329	4,831	196,924	15,450
Correction Intermodal					
TOTAL LOADED					
3S2 TRUCKS	121,143	5,329	4,831	196,924	15,450

Table 30. Northbound Truck Volumes (1997) (Cont'd.)

Correct by	15	15	15	15	15
% empty trucks					
Total	**139,315**	**6,129**	**5,556**	**226,462**	**17,768**
ADT 18W	**503**	**22**	**20**	**817**	**64**
Days per year=277					
TRADE VALUE	4,256,818,377	43,529,127	56,443,799	12,342,837,252	63,746,034
AVG. VALUE IN $	30,555	7,102	10,159	54,503	3,588
PER TRUCK					
TRADE WEIGHT	1,445,351,475	75,597,128	30,695,324	1,741,398,524	94,566,027
AVG. WEIGHT	22,824	27,137	12,154	16,917	11,709
PER TRUCK (lb)					

Table 31. Southbound Truck Volumes (1997)

Trucks-South '97	**Brownsville**	**Del Rio**	**Eagle Pass**	**Laredo**
TOTAL	229,788	43,579		
Loaded Trucks	114,053	31,957	44,416	650,812
% of empty trucks	50.4%	26.7%		
% SU Trucks	30.6%	45.4%	34.9%	50.0%
Total 18W	90,786	22,284	34,082	488,109
Correction Intermodal				
	90,786	22,284	34,082	488,109
Correct by	15	15	15	15
% empty trucks				
Total	**104,404**	**25,627**	**39,194**	**561,325**
ADT 18W	**377**	**92**	**141**	**2,025**
Days per year=277				
TRADE VALUE	4,433,369,186	1,101,012,505	1,367,202,749	23,184,247,251
AVG. VALUE IN $	42,464	42,963	34,883	41,303
PER TRUCK				

Trucks-North '97	**Hidalgo**	**Progreso**	**Roma**	**El Paso**	**Rio Grande**
TOTAL	212,648	14,008	8,976		21,795
Loaded Trucks	141,750	5,917	4,463		10,898
% of empty trucks	33.3%	57.8%	50.3%		50.0%
% SU Trucks	33.9%	50%	23.9%		4.4%
Total 18W	109,714	3,944	3,752		10,578
Correction Intermodal					
	109,714	3,944	3,752		10,578
Correct by	15	15	15	15	15
% empty trucks					
Total	**126,171**	**4,536**	**4,314**	**178,290**	**12,165**

Table 31. Southbound Truck Volumes (1997)(Cont'd)

ADT 18W	**455**	**16**	**16**	**643**	**44**
Days per year=277					
TRADE VALUE	3,151,373,025	70,322,987	66,860,140	9,717,301,656	74,063,672
AVG. VALUE IN $	24,977	15,503	15,497	54,503	6,089
PER TRUCK					

Table 32. Axle, Truck, And Truckload Weights, Loaded Trucks

STATION	SINGLE AXLE	TRACTOR TANDEM	TRAILER TANDEM	TOTAL WEIGHT	TRUCKLOAD
504	10.32	25.99	25.06	61.37	29.37
507	9.84	25.19	23.32	58.35	26.35
509	10.38	25.42	23.74	59.55	27.55
510	10.14	25.35	24.47	59.96	27.96
512	9.98	25.88	24.06	59.91	27.91
513	9.99	24.10	22.10	56.19	24.19
515	9.81	24.95	23.97	58.73	26.73
516	10.30	26.00	24.06	60.35	28.35
517	9.58	23.93	21.59	55.10	23.10
AVERAGE	10.04	25.20	23.60	58.83	26.83
LOADED TRUCKS ONLY (TOTAL WEIGHT > 32 KIPS)					

Table 33. Axle, Truck, And Truckload Weights, All Trucks

STATION	SINGLE AXLE	TRACTOR TANDEM	TRAILER TANDEM	TOTAL WEIGHT	TRUCKLOAD
504	10.18	24.51	23.38	58.07	26.07
507	9.73	24.02	22.02	55.77	23.77
509	10.24	23.86	22.01	56.10	24.10
510	9.93	23.92	22.74	56.59	24.59
512	9.75	22.80	20.67	53.22	21.22
513	9.83	22.53	20.40	52.76	20.76
515	9.56	22.0	20.67	52.23	20.23
516	10.09	24.15	22.06	56.31	24.31
517	9.22	20.65	18.08	47.94	15.94
AVERAGE	9.84	23.16	21.34	54.33	22.33
WEIGHT IN KIPS					

Consolidation of truckloads

To a certain degree, a consolidation process may take place within the border zone. Two facts may indicate this: the difference between trailer weights at the border and on Texas highways, and the number of smaller trucks crossing at the border versus the number found on rural highways. Origin destination surveys at bridges (Ref 25), indicates that the predominant origins and destinations are warehouses, followed by manufacturing centers.

ESTIMATING NAFTA TRUCKS

The three methodologies proposed in this study for estimating NAFTA truck numbers have three steps, being step 2 and 3 the same for all three methodologies:

1. Obtain the number of equivalently loaded combination trucks
2. Assign those trucks to the network using origin-destination data
3. Obtain the total number of combination trucks per highway (loaded and empty)

1. Number of equivalently loaded combination trucks

This report proposes three methodologies for obtaining this number: one based on the number of trucks crossing the border, the second using commodity weights and densities, and the third using commodity values and truckload value distributions. Each one will be explained in detail in other sections of this chapter.

2. Assignment of trucks to the network

The total number of loaded combination trucks is then assigned to the network using origin-destination information contained within the trade data. This procedure is described in the next chapter.

3. Total number of combination trucks

Both loaded and empty trucks compose the truck flows found on highways. A correction factor to account for empty trucks is therefore applied to obtain the total number of trucks.

Theoretically, when the number of produced and attracted truck trips differs in a specified zone, empty hauls are needed to equalize the transportation system. For example, when the number of attracted trips is greater than the number of produced trips, there will be empty hauls in the outbound direction and fully loaded trips in the inbound direction. On a given highway segment, the percentage of empty trucks depends on the number of trips generated and attracted to the zones connected by the highway.

The percentage of empty trucks is a characteristic of each highway segment and may vary with time and direction, as was shown by the WIM data. A higher percentage of empty trucks was found for northbound movements, but this study will use the average value found for southbound and northbound movements. If WIM data collected at the main rural corridor to the ports were available, this study could apply a specific coefficient for each port instead of their average.

ESTIMATING NAFTA TRUCKS USING BORDER CROSSING COUNTS

The first method uses truck counts at border crossings to estimate NAFTA truck numbers. Border truck traffic counts are the main input, and then correction factors are applied to account for the differences between border and nonborder truck volumes. The sequence followed in the estimation process, the results of which are depicted in Figure 49, includes the following:

1. Trucks crossing the bridges.

These data can be obtained from customs or from operators of the toll bridges.

2. Loaded trucks crossing the bridges.

The number of loaded trucks is either obtained from available data or is estimated from the total number of trucks crossing the bridge with the number adjusted by a correction factor that accounts for the presence of empty trucks. The number of loaded trucks crossing the bridges is available only for northbound movements and for Laredo and Eagle Pass in southbound movements.

3. Equivalent combination trucks.

The next step is to obtain the number of equivalent loaded combination trucks. National statistics show that, for long-haul trips, combination trucks are used more often than single-unit trucks, owing to the combination truck's higher efficiency (Ref 4). Because combination vehicles outperform single-unit trucks over long hauls, it is a reasonable assumption that all long-haul trips utilize combination vehicles. Type 332000 or 3S2 was chosen as a representative combination truck due to its ubiquity on Texas highways and at border crossings.

A loaded truck may either weigh out or cube out. The equivalence between single-unit trucks and combination trucks must be based on weight or volume capacity per truck, respectively. Truck weight limits are 32,000 lb and 46,000 lb for two-axle and three-axle trucks, respectively, while for 18-wheelers the gross limit is 80,000 lb, resulting in a ratio between 2.5 and 1.7.

The ratio between single-unit and combination truckloads for different commodities is shown in Figure 49. The ratios vary between 1.7 and 2.2 (if hazardous material commodities are not considered).

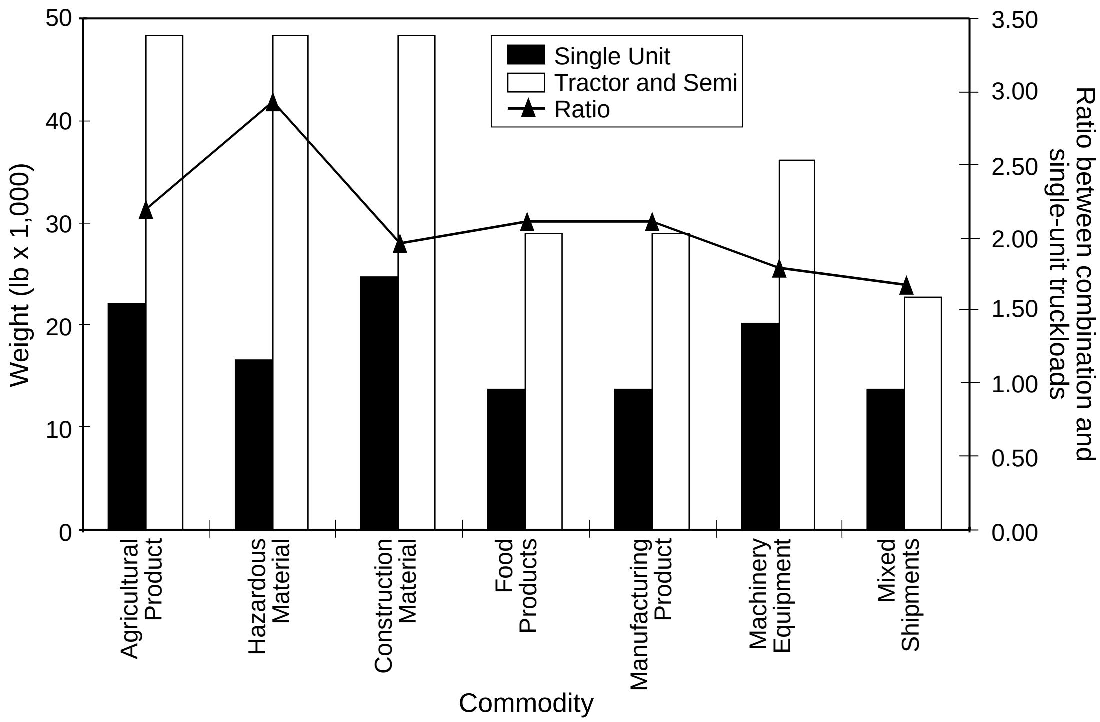


Figure 49. Truckload Ratio By Commodity And Truck Type.

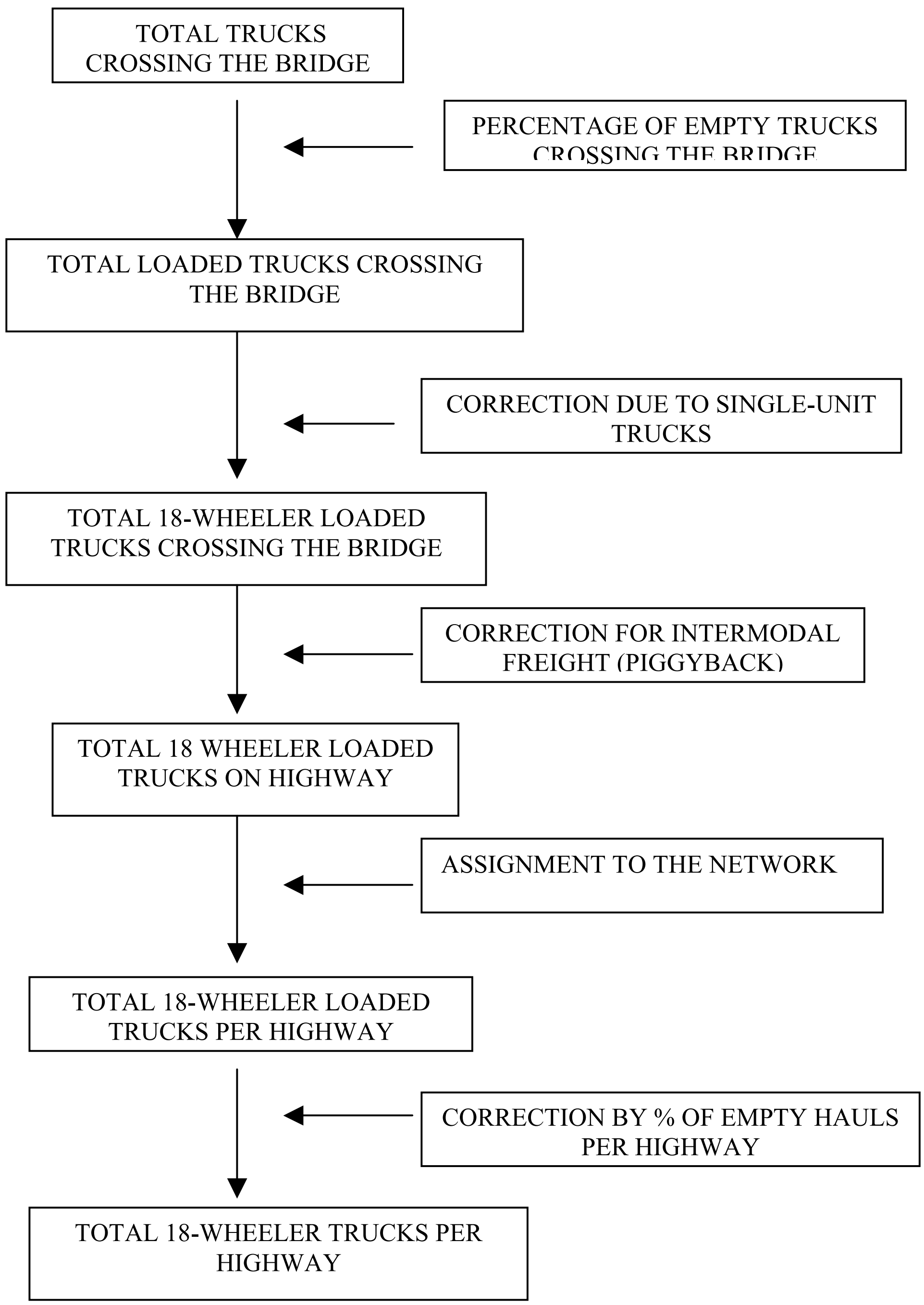


Figure 50. Estimation Of NAFTA Trucks By Port Of Entry.

4. Correction for local traffic.

Some truck movements are strictly related to the needs of producers and consumers within each border city. As shown in the origin-destination survey at border ports (Ref 25), origins or destinations not related to warehouse, maquiladora, or intermodal trade were less than 10 percent. A big portion of this trade may be captured by low value shipment in the trade commodity classification, which is a very small percentage of the total trade (1.9 percent).

This study assumes that a percentage of single-unit trucks carries local commerce. This percentage is estimated at 33 percent in all the ports except Laredo, where it is assumed to be 25 percent because of high truck volumes through Laredo and the relatively small size of the city.

5. 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 by piggyback on railroad cars (TOFC). This correction is necessary, especially in Laredo and Eagle Pass, where there is significant railroad business.

6. Truckload weight.

It was shown in Chapter 4 that truckloads have higher gross weights than typical weights on Texas highways. However, it is difficult to apply a correction factor to trucks carrying weigh out commodities because it is strongly commodity related. Any correction factor should be applied to commodity truck flows, and this level of disaggregation cannot be obtained from bridge truck counts. Truckload weight is used to check for consistency, at least for northbound movements, where weight is reported by port. The average truckloads in NAFTA corridors are then compared with the average truckload estimated by port; these comparisons are very valuable in estimations of the accuracy of the truck volumes obtained.

Average truckload weight may also be used in the other two methods to check for consistency.

Main Assumptions

The main assumptions used in estimating NAFTA truck volumes with this method are as follows:

- The percentage of empty trucks is similar for single-unit and combination trucks.
- Non-passing trade is considered insignificant, an assumption that may overestimate the number of NAFTA trucks.
- Annual volumes are estimated, seasonal peaks may occur; as shown in Chapter 7.

- The equivalence between single-unit and combination trucks is based on truckload weight and volume capacity.
- For long-haul movements, only combination truck (3S2 type) volumes, are estimated.
- The percentage of empty trucks on a highway segment varies only with direction of travel and is the same for all ports.
- Local trade (border intercity trade) is captured using a percentage of single-unit trucks.

Application of the Method

The method described in the previous section was applied to estimate northbound and southbound NAFTA truck volumes, and the results are shown in Table 30 and Table 31, respectively.

Northbound Volumes

- The total numbers of trucks and loaded trucks crossing the border northbound were obtained from Ref 1 and Ref 3, respectively.
- An equivalence value of 2 was used to translate single-unit trucks into combination trucks.
- Sixty-seven percent of the single-unit trucks were assumed to be associated with rural truckloads. In Laredo, 75 percent of the single-unit trucks were assumed to be connected with rural truckloads.
- The number of intermodal movements at Laredo was obtained from data provided by staff at the Laredo intermodal yard.
- The percentage of empty trucks was derived by averaging data from all the WIM stations in Texas.
- To calculate ADT, 277 days per year were used. Customs does not work on Sundays, and, according to WIM studies at Laredo, Saturday truck volumes are approximately one third the weekly volume.
- In El Paso, the number of loaded trucks is unknown because data are not reported. The percentage of empty trucks was assumed to be 54 percent (the same value as Laredo).

Southbound Volumes

- The total number of trucks crossing the border northbound was obtained from Ref 27
- The southbound number of loaded trucks is known for only Laredo and Eagle Pass
- When the percentage of empty southbound trucks was not available, the percentage of northbound empty northbound trucks at the border was used.
- An equivalence value of 2 was used to translate single-unit trucks into combination trucks.

- 67 percent of the single-unit trucks were assumed to be associated with rural truckloads. In Laredo, 75 percent of the single-unit trucks were assumed to be connected with rural truckloads.
- The number of intermodal movements at Laredo was obtained from data provided by staff at the Laredo intermodal yard.
- The percentage of empty trucks was derived by averaging data from all the WIM stations in Texas.
- To calculate ADT, 277 days per year were used. Customs does not work on Sundays, and according to WIM studies at Laredo, Saturday truck volumes are approximately one third the weekly volume.
- In El Paso, the number of trucks crossing south is unknown. The number of trucks was estimated using the average value per truck obtained for northbound movements.

RESULTS

The average weight per truck obtained was, in many cases, very close to the average truckload weight per truck obtained at the WIM stations in Texas highways. Results from Brownsville, Hidalgo, and Eagle Pass were close to the average truckload weight of 22.3 kips. Laredo's average truckload weight was very close to the average weight observed at the WIM station located south of San Antonio. Table 33 shows the average axle, truck, and truckload weights at WIM stations.

El Paso shows a low truckload average weight. This is expected because the percentage trade that weighs out is lower than that for the other ports, as will be shown in Chapter 8. Del Rio, Roma, and Rio Grande City estimates show a very low average weight per truck that differs greatly from the other ports average. Therefore, the estimated volumes in these three ports should be handled with caution because of this apparent inconsistency.

A total annual truck volume of 2,121,000 NAFTA trucks (type 3S2) is estimated to have traveled on Texas highways during 1997, which amounts to an average of 7,660 trucks per day. Figure 51and Figure 52 show the number of trucks obtained for northbound and southbound traffic, respectively.

Laredo is the main port in Texas, with 47 percent and 53 percent of the truck volume in Texas for northbound and southbound movements, respectively.

In the analysis of truck volume, El Paso shows a reduction in its importance as a port based solely on truck numbers. Higher-value commodities and electronic and electrical products characterize El Paso, and set it apart from Hidalgo and Brownsville. In comparison, lower-value and heavier commodities at Hidalgo and Brownsville create relatively higher numbers of trucks.

This methodology was used to estimate the total number of trucks per port. In the next section, a methodology is proposed to disaggregate truck volumes by commodity type.

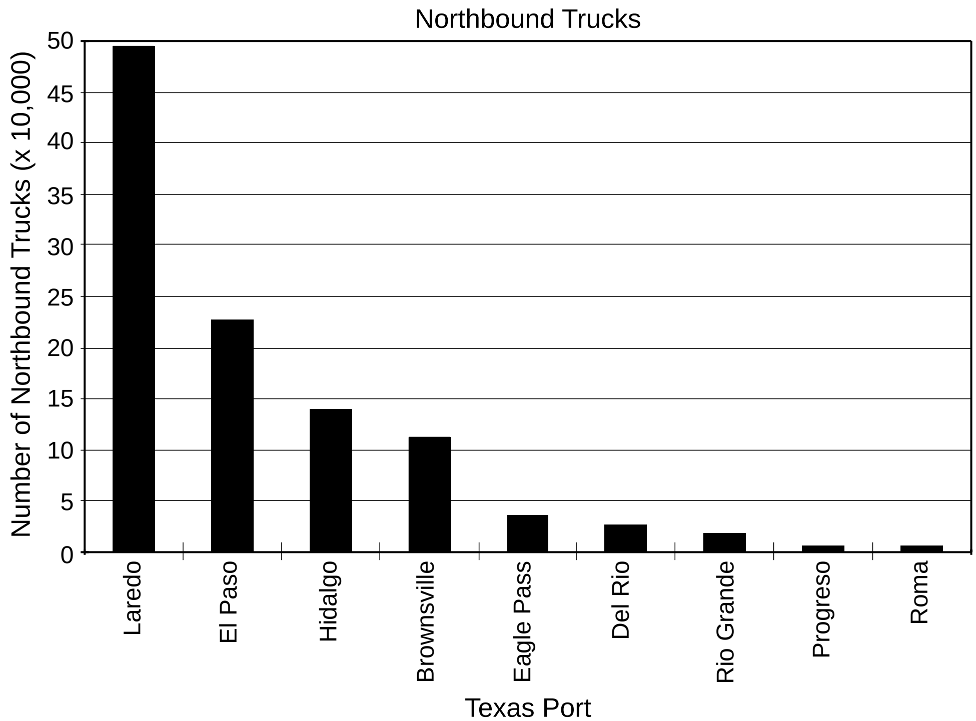


Figure 51. Total Northbound Trucks By Port (Texas).

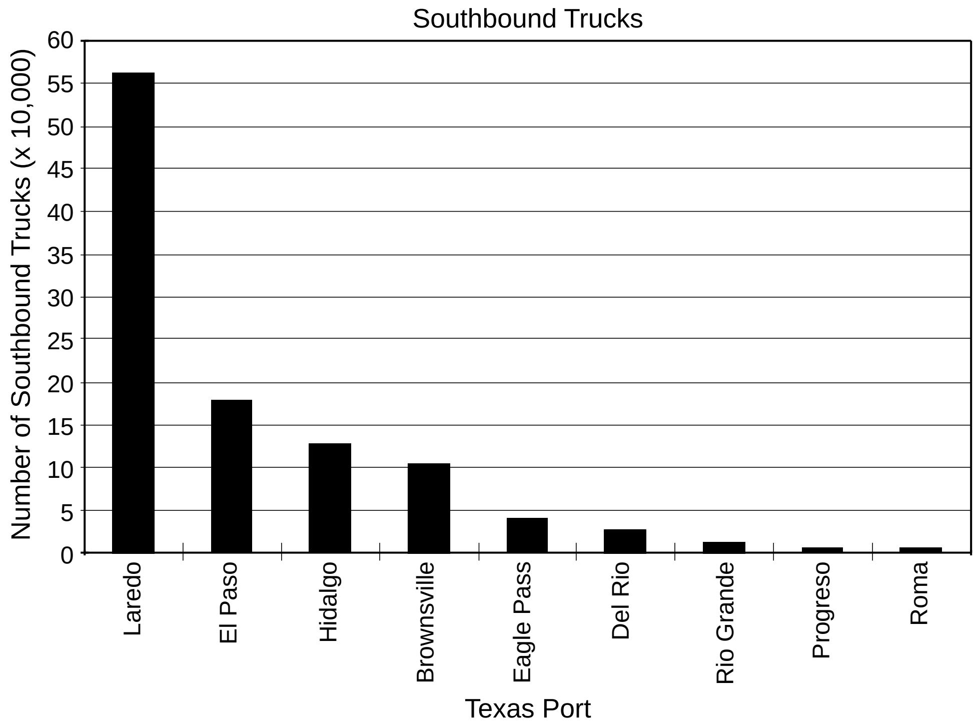


Figure 52. Total Southbound Trucks By Port (Texas).

ESTIMATION OF TRUCK VOLUMES USING COMMODITY DENSITY

In transportation planning studies focused on commodity flows, truck numbers alone are insufficient. The method used for estimating truck volumes is based on a calculation of truckload weight per commodity, using commodity densities. As the commodities are grouped, the method looks for a representative commodity group density, which, multiplied by the truck capacity volume, gives the commodity group truckload weight.

A fully loaded truck may:

- cube out when the commodities are light, or
- weigh out when the commodities are heavy.

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

PROCEDURE

The first step is to separate cube out from weigh out commodities using the criterion of critical density (Figure 55). In the second step it is necessary to choose a truck type according to 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 instead a nonlinear function of the weight proportion of each commodity, the density of each commodity, the truck's capacity volume, and the truck's maximum weight.

Using the representative density by group (di), the 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:

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

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

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

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

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

where Wi is the total weight of commodity group Ci,

$$W_i = \underset{J}{N} W_{ij}.$$

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

$$d_i = \frac{1}{\underset{j}{N} \dfrac{P_{ij}}{D_{ij}}}$$

where Pij is the ratio of the weight of commodity j (Wij) to the 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; a correction for empty trucks is necessary before the total number of trucks can be obtained. If disaggregate data by commodity are available, they can be used to correct Ni; otherwise the total number of loaded trucks is the sum of all the Ni, with a correction for the percentage of empty trucks.

This method is based on two key assumptions: First, a truckload either cubes out or weighs out (there are no trucks with partial cargo). Second, a single commodity per truck is considered (there are no mixed products in one truck).

Application of the method

Densities

This study will be performed at the two-digit HTS commodity level, which is the same commodity detail as is used in the TSFD.

Densities by commodity are obtained from National Cooperative Highway Research Program (NCHRP) 260 (Ref 28). In this report, density data are reported in pounds per cubic feet, and the same units used hereafter. Some important problems appear and the application of these data. These problems include:

- Commodity densities are given using the STCC. Trade data are given in SITC or HTS commodity classifications, and the match is not perfect.
- Density data were compiled mostly during the 1970s. 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. For 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, especially in maquiladora trade, so we may expect to underpredict volumes.
- Maquiladora trade, by nature, comprises the exchange of parts (not finished products). Recorded densities are expressed mainly for finished goods, and this makes it difficult to determine the accurate density.
- Some goods, especially electronic and mechanical machinery, do not have a match in the data. However, these commodities account for a very significant part of the trade.

Truckload volume and weight

One representative truck type (3S2) was used for all the commodities, owing to its high frequency on rural highways.

Truck volume was estimated using data provided by Schneider Inc. The representative trailer is 48 ft long, 102 in. high, and 110 in. wide. This gives a total of 3,740 cubic feet. Five percent of the volume was considered wasted, making the usable volume 3,560 cu ft.

The truck weight limit was set according to TxDOT and federal regulations. The total weight limit per combination truck is 80,000 lb. The weight of a tractor and an empty trailer ranges between 32,000 and 36,000 lb, according to WIM data analyzed in this study. The payload is therefore 46,000 lb. The critical density derived from 46,000 lb and 3,560 cu ft is 12.9 pounds per cubic foot.

Commodity Weight Data

Weights by the two-digit HTS commodity level have been obtained using the TSFD. The commodity value and weight correspond to all northbound movements (there is no commodity detail at the port level in the TSFD).

Results

Table 34 shows the values of density at two-digit HTS used to calculate the number of loaded trucks. Table 35 has the same values but these values are for loaded and empty trucks; the average value per truck per commodity is useful for checking the accuracy of the results.

CALIBRATION

Calibration is performed using the estimated number of northbound NAFTA trucks (1997). This number is obtained by applying the average Texas truck value to the total northbound truck value. Texas ports account for 70 percent of the total northbound truck value.

The average value per truck in Texas ports is $36,650. The calculated number of trucks was 15 percent higher than the number of loaded trucks calculated using densities. This difference accounts for the percentage of empty trucks on the highways. Thus the numbers of loaded trucks predicted from with methodologies were close, and while it does not mean that these numbers represent exact numbers of trucks, it is nonetheless surprising that we can obtain virtually the same figures using two different paths with relatively aggregated data.

As depicted in Figure 55, consistency of the results can be verified through analysis of the truckload value per truck. This is useful when some historic data is available that allows a comparison of truckload values per truck.

In all cases, NAFTA truck volumes obtained should be smaller than truck ADT counted in the corresponding corridors. The observed truck count ADT is an upper limit; additional information is necessary for researchers to obtain NAFTA truck volumes from traffic surveys and set upper and lower threshold values.

COMMODITY GROUP VALUES

By grouping the values obtained after calibration, one can obtain truckload commodity group values and weights. These values are obtained specifically for northbound movements during 1997.

Southbound truckload commodity group values are obtained using northbound commodity truckload values. The number of trucks obtained is corrected using the average southbound truckload value ($40,870) from Table 31 and applying it to the total southbound truck trade. Results for southbound and northbound movements are shown in Table 30 and Table 31. In this table, southbound movements have higher truckload values for most commodities. The same trend is observed for ports, as seen in Table 30 and Table 31.

The results are given in Figures 53 and 54. Inbound trade, electrical products, and machinery, as well as low-value and heavyweight commodities such as agricultural products, minerals, and metals, represent a significant share of truck volume.

In southbound trade, the minerals and metals group has the highest truck volume, followed closely by chemical products and electrical products and machinery.

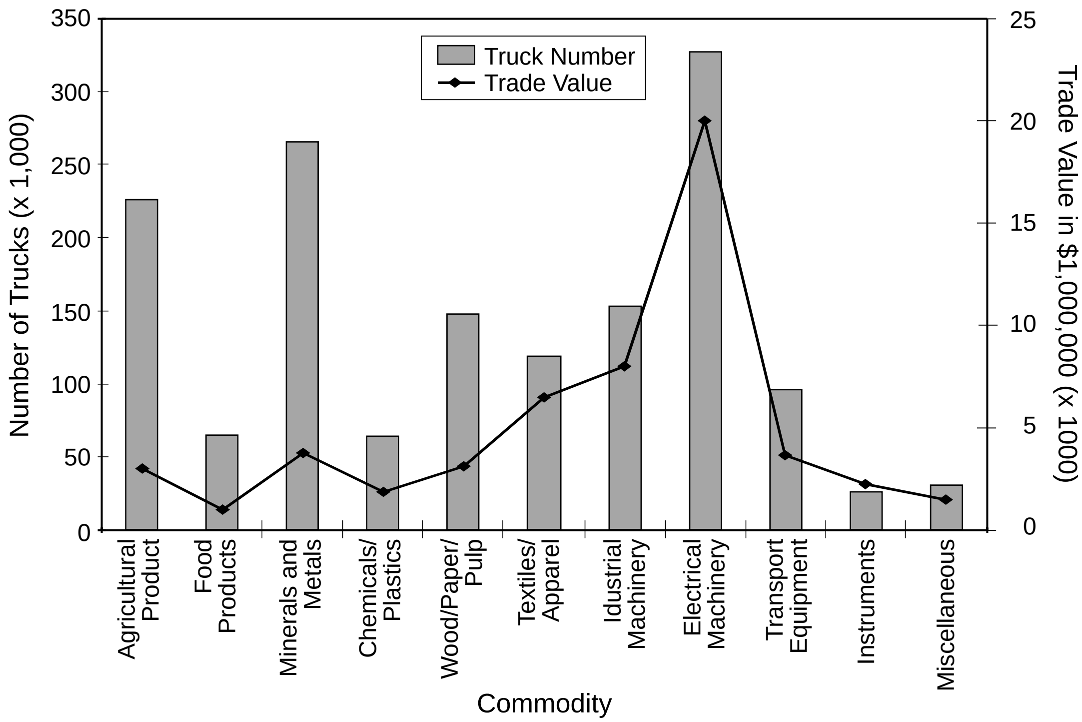


Figure 53. Commodity Value And Truck Volume (Northbound 1997).

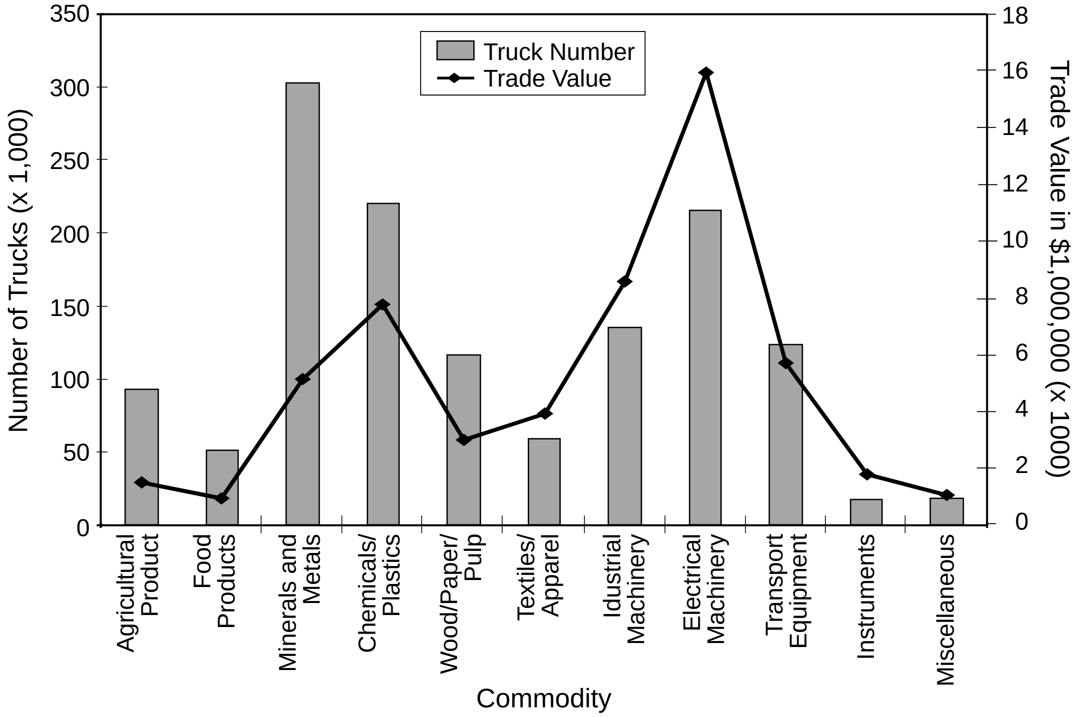


Figure 54. Commodity Value And Truck Volume (Southbound 1997).

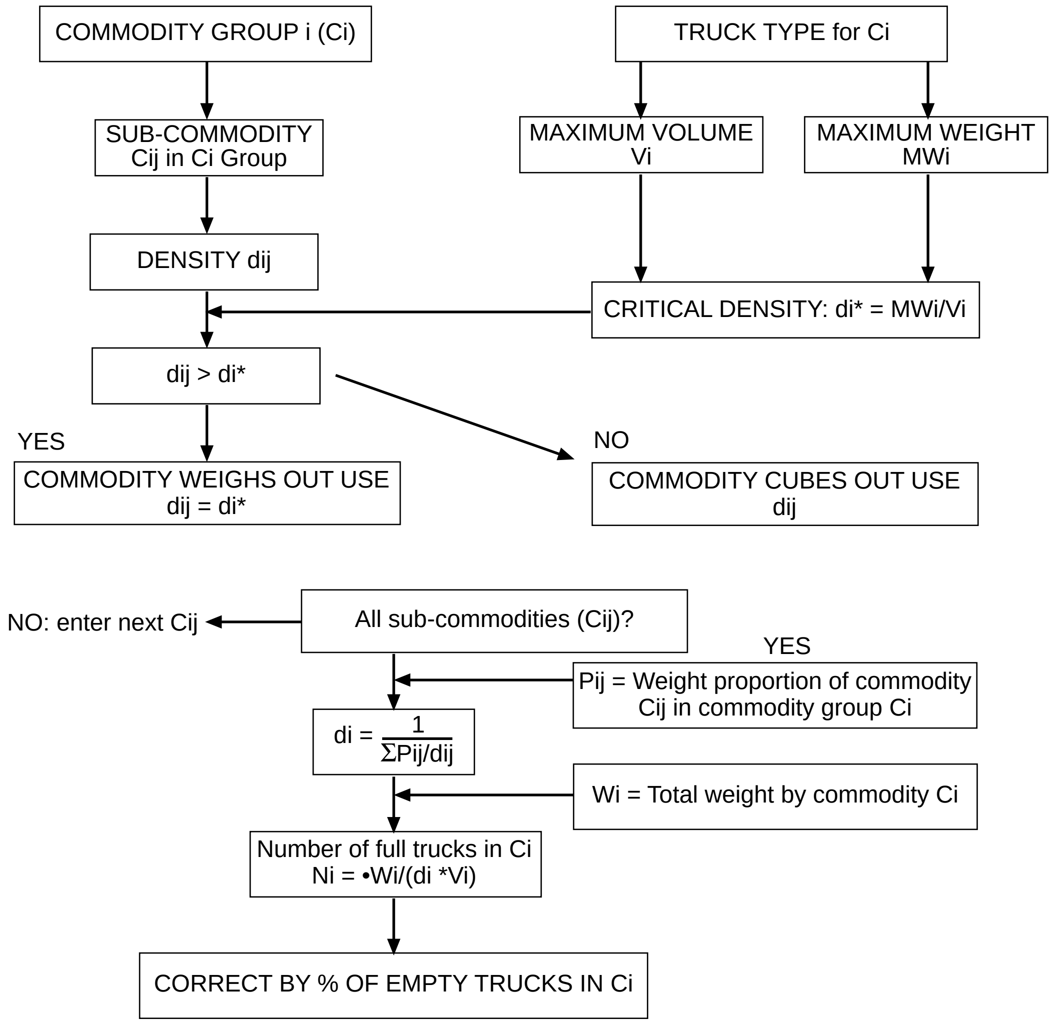


Figure 55. Truck Weight Estimation (By Commodity Group)

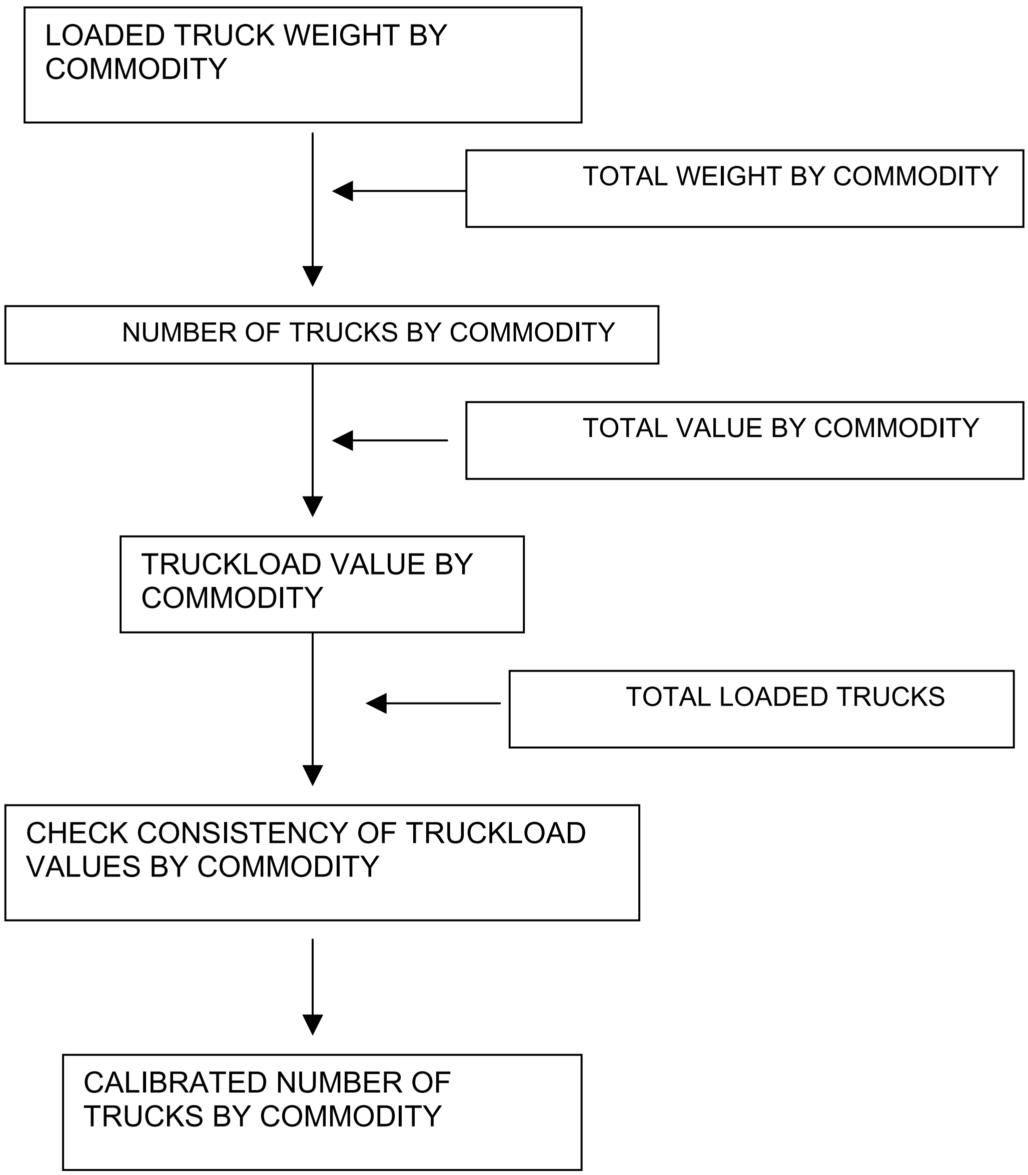


Figure 56. Consistency Of Truckload Value Per Commodity.

Table 34. Densities Used To Calculate Number Of Loaded Trucks Northbound

CHAPTER	DENSITY lbs/ft^3	TRUCKLOAD WEIGHT	TRADE WEIGHT	TRUCK NUMBER	TRUCKLOAD VALUE
01	10.5	39,480	136,471,606	7,605	23,335
02	17.0	43,992	3,359,298	168	47,149
03	12.0	43,992	50,064,982	2,504	167,674
04	8.0	30,080	5,212,038	381	20,057
05	9.0	33,840	8,791,084	572	36,624
06	8.5	31,960	14,008,152	964	24,628
07	11.5	43,240	2,232,800,088	113,602	11,842
08	11.2	42,112	1,193,928,550	62, 373	8,806
09	9.6	36,096	135,230,312	8,242	54,050
10	20.0	43,992	6,614,802	331	8,189
11	11.2	42,112	9,730,572	508	6,543
12	8.1	30,456	40,327,482	2,913	12,962
13	12.3	43,992	7,429,976	372	38,672
14	7.0	26,320	24,385,622	2,038	16,141
15	11.7	43,992	7,882,029	394	24,424
16	15.0	43,992	13,172,408	659	53,613
17	10.3	38,728	68,607,360	3,897	23,582
18	10.6	39,856	12,377,504	683	39,368
19	8.5	31,960	122,287,336	8,418	16,198
20	10.9	40,984	239,110,137	12,835	16,489
21	9.7	36,472	53,499,779	3,227	26,854
22	11.5	43,240	396,047,557	20,150	14,972
23	11.8	43,992	10,074,138	504	10,402
24	3.3	12,408	316,045	56	42,198
25	11.7	43,992	118,107,565	5,906	2,443
26	11.7	43,992	23,110,856	1,156	47,889
27	50.0	43,992	219,613,328	10,983	1,802
28	11.7	43,992	128,008,671	6,402	13,180
29	11.4	42,864	72,845,352	3,739	37,663
30	6.0	22,560	3,219,006	314	58,127
31	55.0	43,992	8,095,495	405	11,275
32	8.4	31,584	16,328,044	1,137	46,284
33	5.3	19,928	16,578,489	1,830	29,773
34	11.0	41,360	114,357,650	6,083	25,929
35	11.2	42,112	4,420,753	231	29,450
36	9.6	36,096	2,228,839	136	85,937
37	5.0	18,800	3,970,204	465	171,350
38	11.5	43,240	46,848,997	2,384	63,307
39	9.0	33,840	370,203,447	24,068	32,083
40	9.0	33,840	126,129,615	8,200	39,571
41	6.7	25,192	7,599,437	664	86,422
42	5.5	20,680	23,420,060	2,491	73,744
43	7.0	26,320	331,722	28	159,929
44	8.0	30,080	513,569,502	37,562	11,202
45	3.1	11,656	394,977	75	23,848
46	6.0	22,560	792,471	77	16,845
47	11.4	42,864	15,553,479	798	5,935
48	9.0	33,840	250,329,326	16,274	21,245

Table 34. Continued

CHAPTER	DENSITY lbs/ft³	TRUCKLOAD WEIGHT	TRADE WEIGHT	TRUCK NUMBER	TRUCKLOAD VALUE
49	9.5	35,720	22,774,719	1,403	88,034
50	4.0	15,040	3,795	1	440,536
51	7.5	28,200	987,123	77	185,574
52	8.8	33,088	60,857,817	4,046	55,366
53	9.0	33,840	357,231	23	11,936
54	8.8	33,088	44,826,568	2,980	43,046
55	9.6	36,096	68,710,397	4,188	25,497
56	6.2	23,312	20,070,908	1,894	38,593
57	5.5	20,680	9,097,161	968	20,587
58	7.0	26,320	2,697,035	225	133,136
59	7.0	26,320	5,959,317	498	57,307
60	6.0	22,560	4,585,266	447	93,948
61	3.6	13,536	201,465,965	32,744	63,135
62	3.9	14,664	217,955,608	32,699	88,751
63	4.0	15,040	103,910,223	15,200	30,030
64	3.0	11,280	29,897,945	5,831	56,737
65	3.0	11,280	6,263,485	1,222	39,217
66	6.0	22,560	155,287	15	48,505
67	4.5	16,920	974,867	127	29,953
68	9.9	37,224	292,489,788	17,287	9,728
69	21.0	43,992	606,377,460	30,324	10,338
70	7.0	26,320	482,633,138	40,342	12,623
71	6.9	25,944	1,904,485	161	1,638,238
72	11.7	43,992	1,063,776,874	53,199	10,428
73	10.3	38,728	714,900,384	40,611	22,575
74	9.1	34,216	133,152,627	8,561	35,993
75	9.1	34,216	260,685	17	34,969
76	8.5	31,960	132,428,609	9,116	32,687
78	11.5	43,240	11,406,822	580	14,666
79	7.7	28,952	18,679,682	1,419	31,955
80	6.0	22,560	877,061	86	21,586
81	9.5	35,720	2,870,713	177	58,178
82	5.6	21,056	17,691,050	1,848	62,508
83	4.5	16,920	75,481,045	9,814	39,203
84	4.5	16,920	1,025,551,960	133,346	59,968
85	4.2	15,792	2,043,587,989	284,694	70,296
86	11.2	42,112	65,634,572	3,429	41,335
87	5.0	18,800	685,381,468	80,204	43,477
88	3.0	11,280	321,969	63	531,475
89	5.0	18,800	105,985	12	43,113
90	3.0	11,280	108,485,219	21,158	100,182
91	2.6	9,776	2,660,680	599	54,900
92	4.0	15,040	5,080,375	743	77,513
93	9.0	33,840	1,174,821	76	148,123
94	3.5	13,160	433,594,534	72,485	30,591
95	3.6	13,536	121,995,225	19,828	38,660
96	3.6	13,536	20,680,126	3,361	52,237
97	4.0	15,040	202,316	30	49,533
TOTAL				1,322,963	

Table 35. Densities Used To Calculate Number Of Trucks Southbound

CHAPTER	DENSITY lbs/ft^3	TRUCKLOAD VALUE	TRADE VALUE	TRUCK NUMBER
01	10.5	24,380	205,925,308	8,447
02	17.0	49,260	693,860,116	14,086
03	12.0	175,181	31,218,640	178
04	8.0	20,955	110,328,067	5,265
05	9.0	38,264	46,727,751	1,221
06	8.5	25,731	27,512,138	1,069
07	11.5	12,372	76,367,624	6,173
08	11.2	9,200	130,156,926	14,147
09	9.6	56,470	26,343,969	467
10	20.0	8,556	147,775,119	17,272
11	11.2	6,836	44,715,322	6,541
12	8.1	13,542	222,638,800	16,440
13	12.3	40,403	13,556,691	336
14	7.0	16,864	2,807,943	167
15	11.7	25,517	81,176,384	3,181
16	15.0	56,013	48,410,617	864
17	10.3	24,638	48,762,345	1,979
18	10.6	41,130	40,163,775	976
19	8.5	16,923	68,211,250	4,031
20	10.9	17,227	62,836,168	3,647
21	9.7	28,056	162,173,500	5,780
22	11.5	15,642	46,352,040	2,963
23	11.8	10,868	107,153,396	9,860
24	3.3	44,087	13,476,911	306
25	11.7	2,552	59,501,736	23,312
26	11.7	50,033	34,163,134	683
27	50.0	10,448	504,109,635	48,251
28	11.7	13,770	297,705,407	21,620
29	11.4	39,349	736,056,602	18,706
30	6.0	60,729	70,082,528	1,154
31	55.0	11,780	35,991,192	3,055
32	8.4	48,356	326,160,743	6,745
33	5.3	31,106	166,322,982	5,347
34	11.0	27,090	132,003,325	4,873
35	11.2	30,768	115,957,897	3,769
36	9.6	89,784	11,081,386	123
37	5.0	179,021	242,219,197	1,353
38	11.5	66,141	500,616,366	7,569
39	9.0	33,519	4,157,735,631	124,040
40	9.0	41,343	986,263,051	23,856
41	6.7	90,291	340,742,529	3,774
42	5.5	77,045	40,439,003	525
43	7.0	167,089	3,854,880	23
44	8.0	11,703	270,375,578	23,102
45	3.1	24,916	1,646,685	66
46	6.0	17,599	624,196	35
47	11.4	6,201	115,760,659	18,669
48	9.0	22,196	1,484,058,097	66,861

Table 35. Continued

CHAPTER	DENSITY lbs/ft^3	TRUCKLOAD VALUE	TRADE VALUE	TRUCK NUMBER
49	9.5	91,975	191,307,778	2,080
50	4.0	460,258	1,644,423	4
51	7.5	193,882	11,937,368	62
52	8.8	57,845	418,902,465	7,242
53	9.0	12,470	871,014	70
54	8.8	44,973	316,100,972	7,029
55	9.6	26,638	137,375,664	5,157
56	6.2	40,321	192,692,346	4,779
57	5.5	21,509	71,715,897	3,334
58	7.0	139,096	154,459,678	1,110
59	7.0	59,873	134,743,116	2,250
60	6.0	98,154	83,093,399	847
61	3.6	65,961	971,379,658	14,726
62	3.9	92,724	1,153,309,385	12,438
63	4.0	31,374	157,277,659	5,013
64	3.0	59,277	97,685,252	1,648
65	3.0	40,973	10,385,950	253
66	6.0	50,677	2,608,486	51
67	4.5	31,294	4,741,988	152
68	9.9	10,164	91,020,454	8,956
69	21.0	10,801	72,801,679	6,740
70	7.0	13,188	290,159,915	22,002
71	6.9	1,711,580	84,934,608	50
72	11.7	10,895	702,799,339	64,507
73	10.3	23,586	1,456,970,892	61,774
74	9.1	37,604	424,150,914	11,279
75	9.1	36,535	17,359,012	475
76	8.5	34,150	778,561,704	22,798
78	11.5	15,323	10,403,850	679
79	7.7	33,386	14,529,977	435
80	6.0	22,552	18,369,759	815
81	9.5	60,783	16,266,305	268
82	5.6	65,306	214,244,069	3,281
83	4.5	40,958	429,001,475	10,474
84	4.5	62,653	8,559,280,183	136,615
85	4.2	73,443	15,949,333,811	217,166
86	11.2	43,186	51,750,832	1,198
87	5.0	45,423	5,570,069,717	122,626
88	3.0	555,268	54,353,881	98
89	5.0	45,043	9,346,266	207
90	3.0	104,667	1,700,214,328	16,244
91	2.6	57,358	33,824,925	590
92	4.0	80,983	17,880,431	221
93	9.0	154,754	7,970,820	52
94	3.5	31,961	910,213,664	28,479
95	3.6	40,391	362,188,477	8,967
96	3.6	54,576	210,425,556	3,856
97	4.0	51,751	5,461,324	106
TOTAL			55,268,243,904	1,352,108

Table 36. Truckload Value By Commodity

NORTHBOUND

GROUP DESCRIPTION	TRUCKS	TRADE VALUE	TRUCKLOAD VALUE
Agricultural Products	225,883	3,000,187,956	13,282
Food Products	64,983	993,686,562	15,292
Minerals and Metals	265,705	3,725,028,890	14,019
Chemicals/Plastics	63,597	1,858,474,197	29,223
Wood/Paper/Pulp	147,734	3,115,174,612	21,086
Textiles/Apparel	118,470	6,476,641,111	54,669
Industrial Machinery	153,098	7,996,505,002	52,231
Electrical Machinery	326,864	20,012,785,604	61,227
Transport Equipment	96,107	3,662,622,722	38,110
Instruments	25,921	2,221,475,282	85,702
Miscellaneous	30,562	1,456,031,127	47,642

SOUTHBOUND

DESCRIPTION	TRUCKS	TRADE VALUE	TRUCKLOAD VALUE
Agricultural Products	68,324	1,496,215,658	21,899
Food Products	56,766	948,958,231	16,717
Minerals and Metals	286,728	5,134,413,849	17,907
Chemicals/Plastics	222,210	7,778,196,307	35,004
Wood/Paper/Pulp	139,293	2,973,986,657	21,351
Textiles/Apparel	66,165	3,920,924,720	59,260
Industrial Machinery	136,615	8,559,280,183	62,653
Electrical Machinery	217,166	15,949,333,811	73,443
Transport Equipment	124,129	5,685,520,696	45,803
Instruments	17,106	1,759,890,504	102,881
Miscellaneous	17,605	1,061,523,288	60,295

ESTIMATION OF TRUCK VOLUMES USING SIMULATION

The second method employed in this study to estimate the number of trucks per commodity is based on simulation. Simulation is a quantitative method that seeks to determine the outcomes of a decision or process using a probability distribution. In this case, the objective is to apply simulation to estimate the number of trucks associated with NAFTA trade.

Truck shipments have different values and weights according to the commodity transported. For a specific commodity, truckload shipment values and weights will have a certain distribution. This distribution may result from the combined effect of stochastic and deterministic variables. The values that are present in the real world may be simulated and incorporated into the truck volume estimation model.

In theory, a single, well-defined commodity (one of the 16,000 commodities defined by U.S. Customs) will have a value (or weight) distribution that may be represented by a normal distribution. When hundreds of commodities are aggregated to constitute one of the ninety-seven two-digit chapters, it becomes impossible to foresee the shape of the distribution without knowing the participation of each individual commodity.

If the distribution of truckload value and the corresponding value traded are known, then the number of trucks can be estimated using simulation.

Simulation Model

The simulation model is based on the distribution values of truckloads by commodity. The number of trucks per commodity is obtained by dividing the total value by the distribution of the commodity truckload value. The total number of trucks is then obtained by aggregating all the predicted trucks for each group.

Truckload distributions should be obtained from shipment records where commodity, value, and weight are reported. The accuracy of the simulation will depend on the raw data and their accuracy, quality, and power to represent the particularities of each commodity group at a certain location and time.

This can be expressed in mathematical form by:

$$N = \underset{i}{N} \frac{V_i}{v_i}$$

where:

N = total number of trucks

Vi = trade value of commodity i

vi = value per truckload of commodity i

The total value reported by customs is accepted as deterministic; the monetary value of a commodity truckload is accepted to be stochastic. The distributions of truckload values are assumed to be independent, which means a commodity value distribution is not affected by changes in other distributions. Therefore, there is no correlation among the value distributions.

Characteristics

1. Simulation provides a better understanding of the possible outcomes.
2. Sensitivity analysis determines which input distributions have the biggest impact on the outputs. The sensitivity correlation coefficients (b) are "standardized" by the standard deviations of both the input and output data. Thus, the meaning of the coefficient is b=[(output change)/(output stdv)]/[(input change)/(input stdv)].
3. The results are port specific, accounting for value and weight characteristics of commodity trade of each port and reflecting particular trade characteristics of the port.
4. Data necessary to run the model are more difficult to obtain.

Application of the model

The simulation method was applied to northbound shipments through the port of Hidalgo during 1996, mainly because of data availability, which is explained in the next section.

Commodity Value Data

Trade value per commodity was obtained using customs data by five-digit SITC commodity code. These data were converted into two-digit HTS commodity classifications. Trade value is a deterministic variable, and in this case corresponds to the total 1996 northbound surface trade value moving through Hidalgo.

Values for forty-seven of the seventy-eight two-digit commodities were obtained. These forty-seven commodities account for more than 98 percent of the total value of northbound Hidalgo trade.

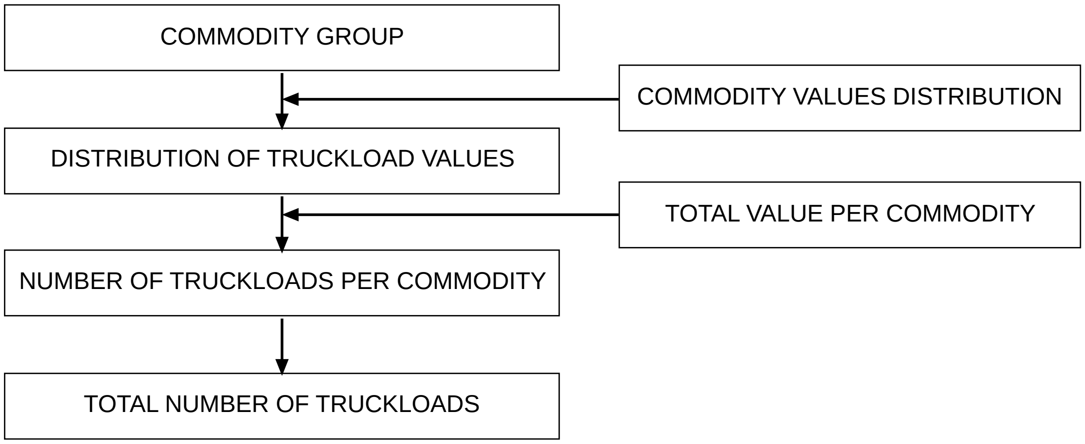


Figure 57. Simulation Process For Estimating NAFTA Truck Volumes.

Commodity Distribution Data

The distribution value for each two-digit HTS was obtained from a special set of data provided by U.S. Customs. Data came from northbound 1993 customs records and corresponded to four months: March, June, September, and December. Thus these data were not a complete representation of the year. Moreover, it is very important to note that the waybill corresponds to a single-truck shipment. The following is an example of an entry in the data set (Ref 2):

30 Mexico City 2210603059 1300 14000

This means a truck (mode=30) from Mexico City, with a commodity classified as 2210603059 (HTS ten-digit classification with 22 as the two-digit HTS), has a value of $1,300 and is part of a shipment that weighs 14,000 kg.

Unfortunately, there is no information regarding the number of trucks or type of load (LTL or TL). Values may be underestimated when they are LTL, or overestimated when a shipment of several trucks is recorded on one waybill. Consequently, the data must be "filtered" before use. Densities contained in NCHRP 260 (Ref 28) were used to orient truckload weights by commodity (obviously with some limitations, because those data for STCC codes that do not exactly match SITC code).

Filtering

Data were filtered using the following steps:

- Extreme figures of value and weight were filtered out.

- Upper truckload limits in WIM data total weight values of 90,000 lb and more are found in all the stations. A truckload of 56,000 lb was used as the upper truckload limit.
- The lower weight limit was set according to commodity type and using densities published in NCHRP 260 (Ref 28). The lower limit used was 15,000 lb.
- Value: low values (between $0 and $2,000 were filtered away). According to commodity type and distribution, the lower value was selectively raised.

Limitations

In conclusion, the filtering of the data may have included some bias. It should be remembered that this data set was not collected for transportation purposes, and this may create limitations. Although the data may not be very accurate, they serve to show the simulation methodology approach. Of course some conclusions can be drawn from the figures, but precautions should be taken because there are limitations with the original data. This especially applies to commodities with:

- A small number of observations; and
- No variance due to repeated observations with the same value.

Value Distributions

Statistical data from the forty-seven commodity groups are presented in Table 37 for values in U.S. dollars and in Table 38 for weights in pounds. There are some values that are somewhat suspicious, especially where the number of records is small. In Table 38 it is also possible to see which commodities weigh out and which cube out.

Once the observations were filtered it was necessary to look for the best fit for each of the two-digit HTS value distributions. All the commodities presented a left-skewed distribution: value<mode<mean<maximum value. For example, in Figure 58 it is possible to see the value distribution of commodity 87 (vehicle parts and accessories).

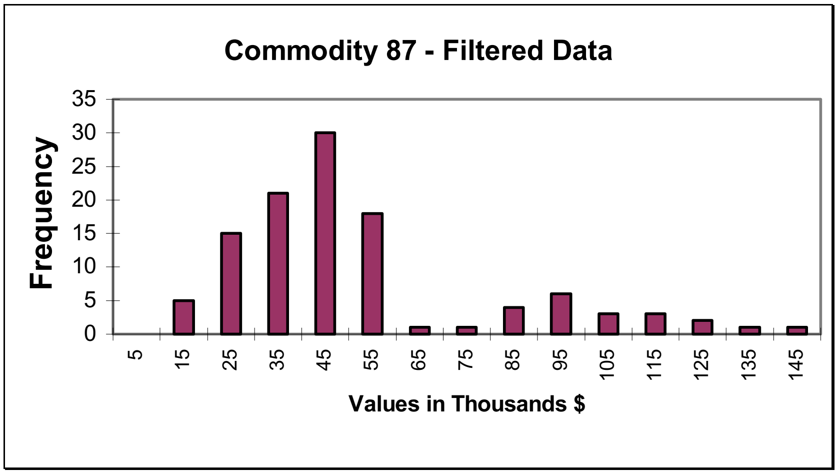


Figure 58. Distribution Values In Raw Data.

For modeling purposes, the beta distribution with four parameters was chosen. Beta has the following characteristics that make it very suitable for modeling this type of data:

- It limits of values both minimum and maximum. It is a bounded function; the values will go neither lower than the minimum nor higher than the maximum. Therefore, there is no possibility of negative or very extreme values (low or high).
- It has few parameters, which are also easy to obtain: minimum, mode, mean, and maximum values.
- Parameters are easy to interpret, and consequently, it is easier to check the suitability of their representation.
- It adequately represents the skewness of the value distribution.

BETA FUNCTION

In mathematical form this function may be represented as:

Density: $f(x) = f_{\beta}(x', \alpha_1, \alpha_2)$

where: f_{β} is the distribution of a Beta function

$$f_\beta = \frac{x^{(\alpha_1 - 1)} (1-x)^{(\alpha_2 - 1)}}{B(\alpha_1, \alpha_2)}$$

$$B(\alpha_1, \alpha_2) = \int_0^1 t^{(\alpha_1 - 1)} (1-t)^{(\alpha_2 - 1)} \, dt$$

$$x' = \frac{x - \min}{\max - \min}$$

$$\alpha_1 = \frac{(\text{mean} - \min)(2 * \text{most likely} - \min - \max)}{(\text{most likely} - \min)(\max - \min)}$$

$$\alpha_2 = \alpha_1 \frac{\max - \min}{\text{mean} - \min}$$

Figure 59 shows the distribution of commodity 87 and its final representation.

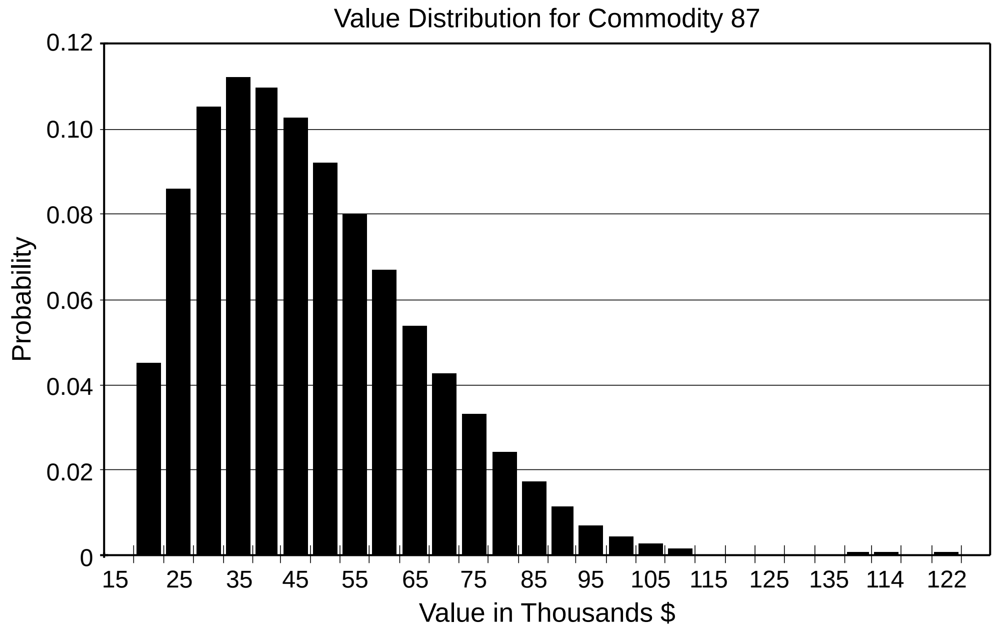


Figure 59. Simulated Distribution Values For Commodity 87.

Simulation Results

Figure 60 shows the probability distribution of the total number of trucks and the nine main commodities.

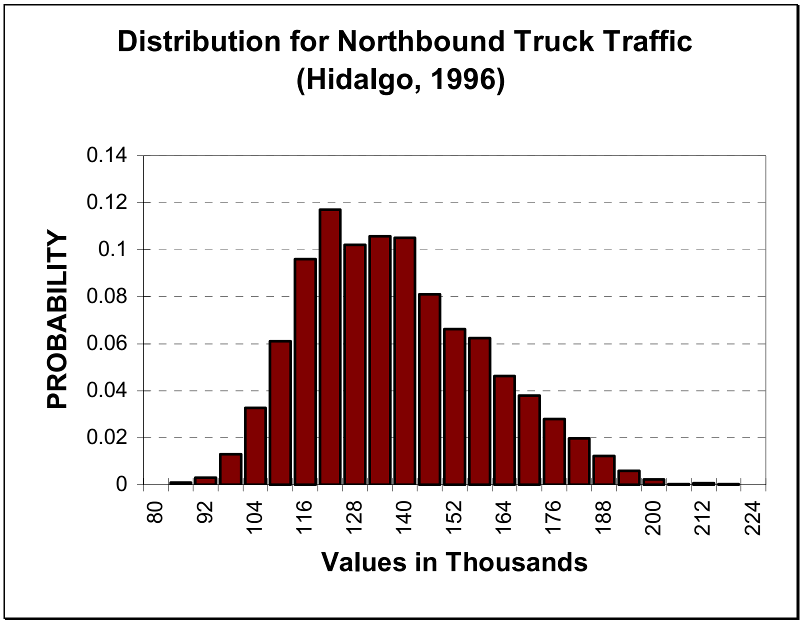


Figure 60. Simulation Results Total Truck Volume (Hidalgo Northbound 1996).

Table 37. Assumed Values For Beta Distribution In Dollars ($)

2-DIGIT	MINIMUM	MODE	MEAN	MAXIMUM
85	13,169	23,359	34,701	353,606
87	19,336	38,577	49,702	138,118
90	16,586	37,882	45,496	78,691
84	31,730	79,189	102,252	232,046
62	11,237	18,431	21,293	41,720
08	4,893	11,055	14,051	47,700
07	4,267	9,115	11,131	27,601
61	9,426	15,555	17,971	28,040
20	6,235	13,109	15,470	29,866
49	17,976	36,839	49,107	191,487
73	4,875	11,830	13,587	20,075
39	8,956	25,698	31,031	51,157
94	43,283	53,773	58,830	75,459
40	67,760	70,298	71,738	77,092
68	7,569	12,127	14,370	49,013
95	51,030	105,278	115,223	141,132
27	3,515	3,672	3,736	3,990
63	2,296	2,296	2,296	2,296
48	7,596	9,928	11,456	20,414
64	40,843	40,893	40,904	40,939
96	9,512	18,139	21,582	34,955
33	82,954	101,511	116,862	150,000
71	9,060	9,151	9,221	9,298
76	5,129	7,771	9,113	18,712
70	7,064	7,064	7,064	7,064
81	56,895	61,753	64,023	74,200
42	5,496	6,946	7,695	11,100
01	18,000	22,320	23,288	26,750
44	10,836	18,831	22,726	39,490
72	2,719	2,719	2,719	2,719
74	28,302	31,644	32,950	34,772
83	4,673	8,497	11,202	21,351
69	2,406	2,837	2,996	3,636
12	2,475	2,720	2,919	3,778
79	14,793	20,491	23,016	28,662
09	18,071	18,389	18,633	18,902
47	4,400	7,252	8,302	11,550
22	10,435	10,435	10,435	10,435
25	8,586	8,586	8,586	8,586
04	20,362	20,362	20,362	20,362
46	17,778	18,164	18,534	19,336
32	8,086	8,086	8,086	8,086
28	9,000	13,909	15,631	21,175
78	9,036	9,711	10,038	10,690
31	8,360	8,360	8,360	8,360
29	9,996	9,996	9,996	9,996
14	2,450	2,596	2,643	2,790

Table 38. Weight Parameters In Pounds

TSUSA	RECORDS	WT. MIN.	WT. AVG.	WT. SD.	WT. MAX.
85	949	3,736	16,952	4,980	40,586
87	137	3,685	13,373	3,973	37,400
90	47	3,637	8,567	5,423	40,973
84	120	4,070	16,648	7,775	43,204
62	99	3,667	8,415	4,418	25,872
08	846	5,280	40,888	9,864	54,914
07	401	10,692	38,198	7,947	54,886
61	10	3,553	4,847	1,147	7,165
20	262	8,679	30,756	10,942	51,808
49	61	3,947	18,113	9,426	39,488
73	17	3,590	22,262	13,806	43,142
39	76	3,982	23,506	12,187	40,445
94	11	18,018	22,023	4,107	29,077
40	8	38,170	39,240	1,691	42,284
68	104	3,511	7,808	6,207	46,200
95	16	19,180	37,164	8,892	52,001
27	117	51,139	52,000	582	54,934
63	5	24,985	30,721	3,206	32,155
48	11	8,824	17,565	13,108	54,604
64	15	38,157	38,309	105	38,478
96	22	4,147	11,268	3,054	14,223
33	3	11,975	15,008	4,324	19,958
71	2	6,101	6,208	152	6,316
76	16	5,551	12,538	3,480	18,671
70	1	6,750	6,750		6,750
81	13	43,815	47,386	3,249	53,832
42	15	5,322	7,409	1,734	10,644
01	29	28,442	36,472	5,211	47,014
44	10	3,960	10,616	8,772	31,401
72	1	42,541	42,541		42,541
74	4	35,640	40,212	3,705	43,265
83	7	7,997	16,470	7,057	25,711
69	7	38,051	48,552	5,444	53,440
12	12	43,560	44,447	3,074	54,208
79	10	28,987	41,996	10,820	54,538
09	2	11,596	15,961	6,173	20,326
47	15	17,160	42,860	7,480	46,884
22	2	41,004	44,421	4,833	47,839
25	1	31,625	31,625		31,625
04	1	42,662	42,662		42,662
46	3	11,662	13,209	2,301	15,853
32	1	12,027	12,027		12,027
28	24	30,800	43,476	4,163	48,840
78	4	44,700	47,838	3,411	51,212
31	1	9,768	9,768		9,768
29	1	40,715	40,715		40,715
14	11	17,248	18,410	797	19,642

Figure 61 shows commodities by value and truck trips. For the same value of trade, high-value commodities require fewer trucks than do low-value commodities. Commodities like fruits (08), vegetables (07), and prepared fruit and vegetable products (20) are shown as low-value commodities. The same may be said of mineral oils and fuels (27), articles of stone (68), and articles of iron and steel (73). Apparel and clothing (61, 62, and 63), as well as printed material (48), show the same low-value characteristic.

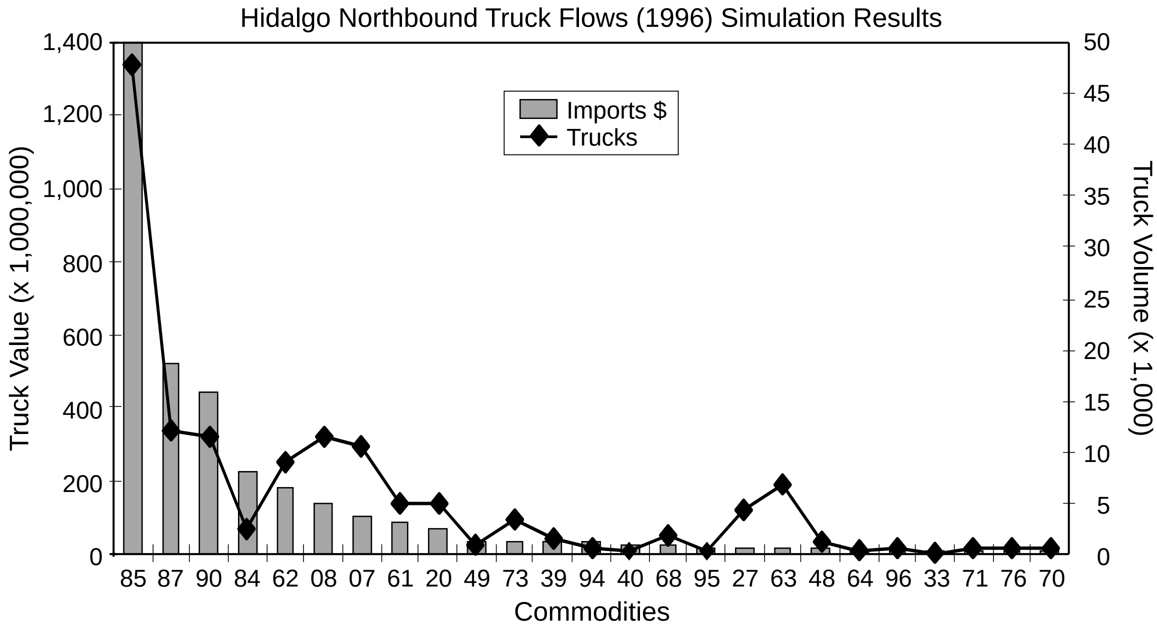


Figure 61. Truck Volume And Truck Value Per Commodity.

The model was calibrated with the estimated number of trucks moving northbound through Hidalgo in 1996. The simulated number of trucks was 17 percent higher.

Once calibrated, a simulation model may be used to estimate future truck volume. Simulation has the following advantages:

- Distribution parameters are easy to understand and may be changed to adjust to future conditions. Different scenarios may be studied without much difficulty.
- Trade forecasts carry an important degree of uncertainty. This uncertainty may be easily incorporated into the simulation model.

The main disadvantages of the simulation method include

- the requirement for more data and more parameters,

- the need for more time for analysis and calibration, and
- the need for specialized software.

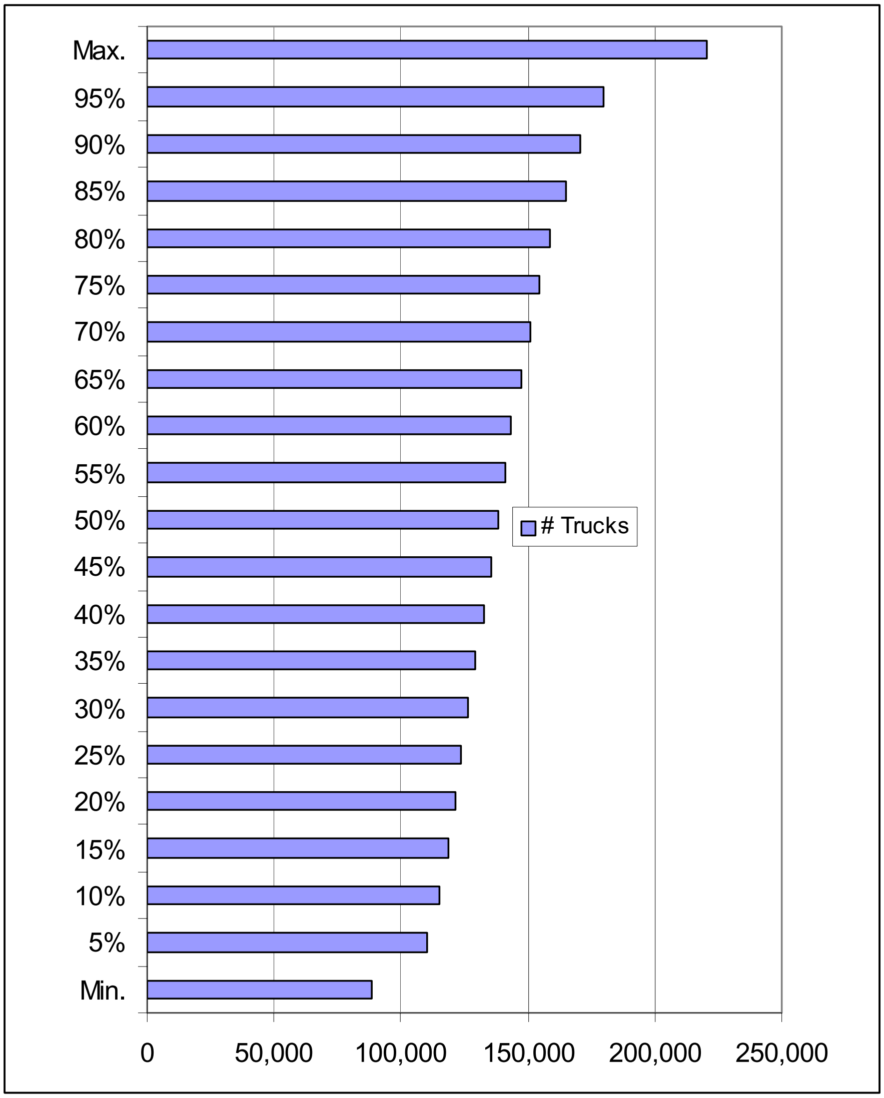


Figure 62. Distribution Of Simulated Number Of Trucks.

Table 39. Statistics Using Truckload Value Simulation

	TOTAL TRUCKS	Trucks per Commodity								
		85	87	90	84	62	8	7	61	20
Minimum =	88,595	10,722	4,242	5,690	977	4,581	3,726	4,146	2,964	2,312
Maximum =	220,685	104,761	26,554	26,955	6,905	15,830	27,391	23,826	8,791	10,774
Mean =	140,581	47,783	11,958	11,468	2,592	9,045	11,336	10,415	4,996	4,907
Std Deviation =	21,470	19,103	4,419	4,911	1,165	2,373	4,330	3,731	1,456	1,755
Variance =	4.61E+08	3.65E+08	1.95E+07	2.41E+07	1.36E+06	5.63E+06	1.88E+07	1.39E+07	2.12E+06	3.08E+06
Skewness =	0.48	0.59	0.77	1.08	1.14	0.51	0.87	0.84	0.68	0.90
Kurtosis =	2.77	2.71	3.04	3.41	3.88	2.56	3.40	3.26	2.51	3.22
Errors Calculated =	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mode =	132,221	34,967	8,774	6,546	1,654	7,511	8,461	7,744	3,442	3,374
5% Perc =	110,035	21,640	6,220	6,150	1,264	5,715	5,788	5,650	3,178	2,763
10% Perc =	114,848	25,165	6,927	6,509	1,390	6,169	6,487	6,229	3,336	2,985
15% Perc =	118,520	27,984	7,501	6,861	1,499	6,535	7,051	6,700	3,486	3,175
20% Perc =	121,600	30,489	8,025	7,221	1,602	6,865	7,555	7,130	3,635	3,355
25% Perc =	123,909	32,877	8,525	7,599	1,704	7,177	8,037	7,541	3,788	3,532
30% Perc =	126,725	35,183	9,018	8,000	1,808	7,480	8,506	7,945	3,947	3,711
35% Perc =	129,386	37,502	9,516	8,429	1,916	7,782	8,977	8,355	4,112	3,895
40% Perc =	132,600	39,841	10,024	8,895	2,029	8,084	9,459	8,772	4,288	4,084
45% Perc =	135,188	42,239	10,552	9,402	2,150	8,395	9,956	9,206	4,473	4,286
50% Perc =	138,355	44,738	11,102	9,963	2,279	8,716	10,479	9,662	4,673	4,499
55% Perc =	140,881	47,370	11,691	10,589	2,422	9,049	11,034	10,148	4,886	4,731
60% Perc =	143,588	50,165	12,325	11,292	2,578	9,405	11,629	10,672	5,120	4,982
65% Perc =	147,163	53,202	13,014	12,097	2,754	9,783	12,284	11,243	5,376	5,260
70% Perc =	150,820	56,511	13,779	13,018	2,957	10,192	13,010	11,883	5,658	5,571
75% Perc =	154,611	60,178	14,642	14,108	3,191	10,646	13,837	12,609	5,975	5,929
80% Perc =	159,045	64,418	15,650	15,413	3,474	11,157	14,808	13,455	6,332	6,349
85% Perc =	164,688	69,365	16,860	17,016	3,829	11,750	15,989	14,481	6,748	6,858
90% Perc =	170,738	75,575	18,407	19,089	4,303	12,482	17,533	15,821	7,239	7,510
95% Perc =	180,055	84,157	20,625	21,937	5,014	13,482	19,848	17,778	7,857	8,448

SUMMARY

The border crossing system was analyzed as part of the U.S.-Mexico trade-transportation system. The analysis of the border region system provides the theoretical framework for the estimation of NAFTA truck volumes. Although this study focuses on trucks, the analysis recognizes that they are a component of the binational transportation system that influences (and is influenced by) other system components such as railroads and maritime transport.

Elements that influence NAFTA truck volumes were identified. This study presents a methodology for estimating NAFTA truck volumes using the number of trucks that cross the border plus several correction factors. Of the three methodologies presented in this chapter, this is the weakest because of the numerous assumptions that have to be made and because the necessary data have to be obtained from many different sources. Data availability and accuracy are the biggest obstacles; data are usually not complete, and when the years of data collection are available, they may not match among the different databases. However, the methodology for estimating NAFTA trucks using truck counts at border crossings is useful, because an actual count of NAFTA trucks would be an expensive and difficult task.

Results show that the average value per truckload per port varies significantly. El Paso, for example, shows a higher truckload value because of its 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. The lack of a linear relationship suggests that trade value is not enough to formulate a comparison regarding port characteristics and how trade can impact infrastructure.

Two methodologies for disaggregating NAFTA trucks by commodity are also presented. Commodity disaggregation provides more insight into the planning analysis. Key commodity groups can be identified, which allows researchers more flexibility to analyze impacts of NAFTA trade and forecast future scenarios. The methodologies developed can be successfully used to estimate commodity truck volumes. Again, the accuracy and detail of the data available heavily affect the quality of the results.

The simulation method is found to be the most conceptually simple, elegant, and potentially accurate of the three methods presented. While distribution data are not available at the moment, they could be obtained from customs without disclosing private information.

Unfortunately, limited data availability does not allow the comparison of the three methodologies to actual values for a specific port or corridor. Coordinated efforts between transportation planning agencies and customs could significantly improve data collection and, thus, understanding of U.S.-Mexico trade transportation issues.

CHAPTER 6. NAFTA TRUCK TRADE MAP GENERATION METHODOLOGY

This chapter describes the methodologies used to map U.S.-Mexico truck trade corridors. The translation of trade statistics and truck volumes into truck corridors involves a series of steps that translate trade data into actual highway truck traffic flows. These steps, presented in this chapter, comprise zoning, network representation, assignment procedures, commodity grouping, and map generation. These now, will be described in more detail and in the same order.

ZONING

Transportation is a spatially distributed activity, with flows of people or freight moving from different zones or points. The level of detail in the definition of transportation zones strongly influences the output received. In the case of the present study of U.S.-Mexico trade transportation, zoning details are severely restricted by the available data. The most detailed data from the available sets have origins and destinations at the state level. Given this information, the first step is to define a zonal scheme that encompasses the forty-eight contiguous states in the U.S. and the thirty-two states in Mexico, for a total of eighty zones.

This eighty-zone scheme has important limitations. Texas alone has 46.6 percent of the exports and 28.5 percent of the imports. It is easy to see that using one zone for the whole state of Texas (and therefore, only one origin and destination for the whole state) would yield an extremely poor representation of highway truck flows. A similar situation occurs with California, which is the second-largest importer and exporter with 21.4 percent of total exports and 17.1 percent of total imports. Mexican border states also show important concentrations of trade. Higher accuracy can be obtained by using smaller zones, but when splitting a state into two or more zones it is necessary to have additional data or a methodology to assign origin and destination flows to each created zone.

How many states need to be split? In the U.S., Texas and California are split based on their trade importance. Splitting other important trade states (Michigan, Ohio, Illinois) according to trade share affects route selection locally but has no effect on the configuration of long-haul corridors. Texas' neighboring states have a small share in the truck trade and are, therefore, assigned one zone per state. Only Texas and California are split in the U.S.

Mexican border states are split based on their proximity to Texas and on the size of their maquiladora trade with neighboring U.S. cities. Interior states in Mexico do not need to be split because there is generally one important urban center per state. This is the case in the three Mexican nonborder states that have signifigant trade: Jalisco, Mexico, and Nuevo Leon.

Splitting Methodology

In performing the split, it would be ideal to include data at the county or city level of geographic detail; however, U.S. Customs will not provide more geographic detail because this may involve confidential information such as trade volume and markets of importers and exporters.

An alternative methodology for disaggregating geographic data (in this case, state trade) is suggested in NCHRP 260 (Ref 28). This method uses employment data to distribute trade flows within the state. The underlying premises of this procedure require the following conditions:

- Manufacturing plant output is correlated with the number of employees.
- All plants in the same industry (i.e., same SIC code) have equal productivity.
- All plants in the same industry share proportionately in resulting commodity flows.

A disadvantage to using employment to distribute trade production is that distance and highway characteristics are not factors in the distribution process. However, this is not a serious drawback because international trade takes place primarily between generally large industrial and consumption centers, which are small in number at the state level. The best example of this is the flow of transportation equipment between Mexico and the U.S. Southbound trade occurs between production centers in Michigan and Illinois and big consumption and production centers like Mexico City and Guadalajara.

Table 40 shows the relationships among economic sectors generating significant freight movements (Ref 28). In general, large manufacturing cities are big producers of freight shipments and are also big attractors of raw and intermediate goods. The heavy concentration of employment indicates a high population and, therefore, high demand for finished goods to satisfy personal needs.

Another drawback to using employment data in the U.S. or Mexico is that it is not possible to distinguish between NAFTA-related and non-NAFTA-related employment. The presence of big industrial centers (like Dallas or Houston in Texas) may be over-represented because an important part of the labor force is oriented toward the domestic market, whereas within the border zone, the proportion of employment directly related to international trade could be higher.

Table 40. Freight Movements Among Economic Sectors

FROM \ TO	MANUFACTURING	WHOLESALE TRADE (DURABLE)	WHOLESALE TRADE (NON DURABLE)
AGRICULTURE	X		X
MINING	X		
MANUFACTURING	X	X	X

Source: adapted from NCHRP 260 (Ref 28).

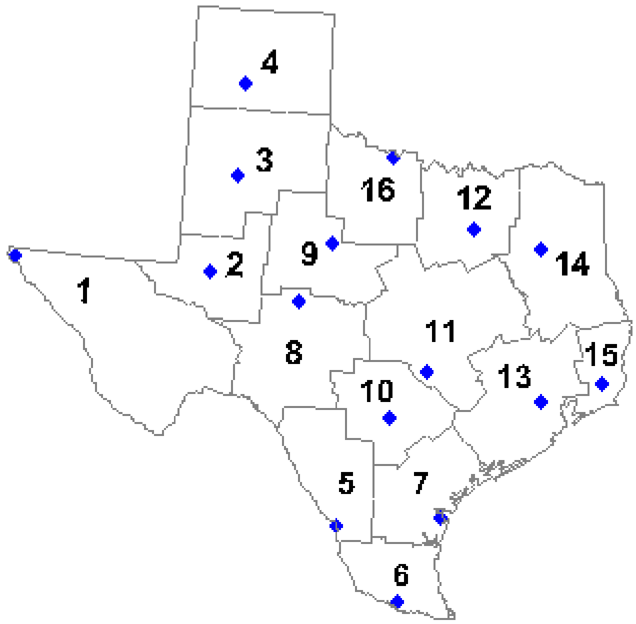
Method Used for State Splitting

In the U.S., 1995 Census Bureau employment data were incorporated into a GIS layer using TRANSCAD software. The employment data correspond to seventy different activities at the county level and employment is broken down using SIC categories.

Within the Mexican border states, maquiladora employment by "municipio" (the equivalent of a U.S. metropolitan area) is used. However, information about maquiladora employment classified by city and activity is not available. Therefore, a split, among maquiladora cities in one state is done on the basis of total maquiladora employment per city.

The 254 counties of Texas were grouped into sixteen zones chosen to represent the main centers of industrial activity within the state. Within each zone, a city was chosen to represent the centroid of the zone. Figure 63 displays the location of the main cities and the zones used.

Employment in some zones (especially in West Texas) is very low even though the geographic area may be considerably large. Zones with high-density population and manufacturing employment, such as Dallas, Houston, and Austin, are weighted heavier than low-density zones. Some industries show important concentrations in one or two centers. Industrial employment by sector tends to concentrate in one or two zones, such as chemicals in the Houston area, electronics in the Dallas-Austin corridor and textiles in El Paso.



CITY	NUMBER
El Paso	1
Odessa	2
Lubbock	3
Amarillo	4
Laredo	5
McAllen	6
Corpus Christi	7
San Angelo	8
Abilene	9
San Antonio	10
Austin	11
Dallas	12
Houston	13
Tyler	14
Beaumont	15
Wichita Falls	16

Figure 63. Texas Zones and Centroids

Like Texas, California was split into three zones, with centroids in San Francisco, Los Angeles, and San Diego. Most California trade with Mexico runs along the San Francisco-Los Angeles-San Diego-Tijuana-Mexicali corridor, which has little influence on Texas ports of entry.

In Mexico, the border states are split using total maquiladora employment by city. All cities, with the exceptions of Hermosillo and Chihuahua, are located along the border; see Table 41.

Table 41. State Split In Mexico

Mexican City Name	State
Tijuana	Baja California
Tecate	Baja California
Mexicali	Baja California
Hermosillo	Sonora
Nogales	Sonora
Chihuahua	Chihuahua
Juàrez	Chihuahua
Saltillo	Coahuila
Frontera	Coahuila
Piedras Negras	Coahuila
Nuevo Laredo	Tamaulipas
Reynosa	Tamaulipas
Matamoros	Tamaulipas

CENTROIDS

For assignment purposes, zones are represented as if all the attributes were concentrated at one point called a centroid. When a state is not split, the most important city in the state is chosen as the centroid. Manufacturing employment and population (two indicators of the production and attraction of freight movements) were used as criteria for centroid selection. When a state is split into smaller zones, important centers are the main criteria for determining zoning boundaries.

NETWORK ANALYSIS

For the purpose of this study, the highway system is used to satisfy the movement needs of producers and of intermediate and final consumers. Therefore, an accurate representation of the highway system is a key factor in identifying the main trade-flow corridors.

Highway networks differ in a wide variety of ways on each side of the border. The U.S. has the most extensive highway system in the world, with high standards of design and maintenance, while Mexico has historically neglected its highway system and only recently has made an effort to upgrade key links through public-private toll road initiatives.

For an accurate representation of trade flows on the U.S.-Mexico highway network, the following elements should be included:

1. The main highways in both countries,
2. The important freight corridors,
3. Network Connections between main production and attraction centers (cities) in both countries,
4. Main border ports connections to the network, and
5. Attributes to categorize the different links according to their importance.

The next two points present characteristics of the U.S. and Mexican highway networks.

U.S. Highways

The U.S. network used is that defined by the National Highway Planning Network version 2.1 (NHPNv2.1) of the Federal Highway Administration (FHWA) (Ref 30). The network is provided to the public by BTS (Ref 29) on CD-ROM. The network is provided in a GIS format (link and node topology) and contains 420,000 mi of centerline highway. The accuracy of the network is at a scale of 1:100,000 (precision of 80 mi). The network is loaded using TRANSCAD software. Estimates of length are calculated in miles and stored to two-digit precision and contain updated 1996 data (Ref 30).

While the NHPNv2.1 network includes many local and secondary highways, only the subset containing important highways and corridors are used (almost all of the hauls are 300 mi). This subset is known as the National Highway System (NHS) and includes the most important U.S. highways carrying a significant amount of people and goods (Ref 31).

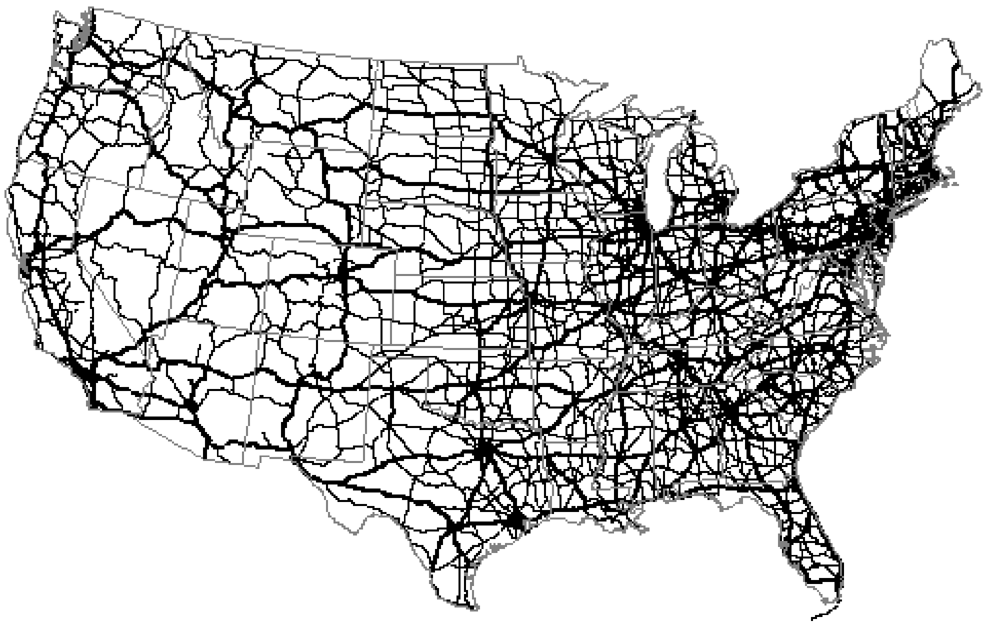


Figure 64. U.S. National Highway System (Ref 31).

Figure 64 shows the GIS layout of the NHS, with the interstate system represented by thicker lines. Note that higher highway densities and populations are located in the East, Northeast, and Midwest. In the central and western mountainous parts of the country the network becomes sparser. Trade between the U.S. and Mexico is concentrated mostly within highly industrial and populated areas in Texas, California, the Midwest, the East Coast, and Mexican maquiladoras and main cities.

In a count of the Interstate and access-controlled roads, the south-northbound corridors are reduced to five: the I 55-I57 corridor from Chicago to New Orleans, the I 35 corridor from Minnesota to Laredo, I 25 from Montana to El Paso, I 15 from Montana to San Diego, and I 5 from Washington State to San Diego. Only I 35 and I 5, when they reach Texas and California, respectively, carry significant U.S.-Mexico trade. I 15 and I 25 run through states with low levels of trade with Mexico, while I 55-I57 captures some traffic in its northern area.

The East Coast and Midwest are connected with Mexico mainly through northeast-southwest and east-west corridors. The main east-west corridors comprise parts of I 10, I 20, and I 40 and the main corridors that travel from north-east to south-west comprise parts of I 30, I 44, and I 81.

Five ports have direct access trough the interstate system: Laredo, El Paso, Nogales, Calexico and San Ysidro. U.S. routes connect Brownsville, Hidalgo, and Eagle Pass. Chapter 7 discusses NAFTA highway corridors and volumes.

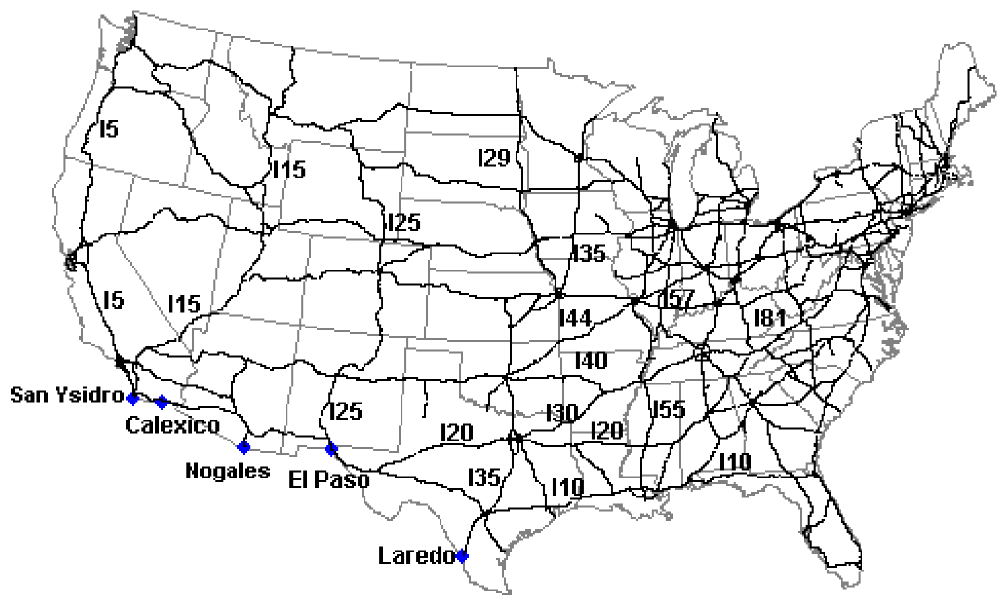


Figure 65. Main U.S. Corridors.

A small portion of U.S.-Mexico trade runs east-west from California to Texas, and the route that connects Texas and California is IH 10-IH 8.

Figure 66 shows Texas highways, the location of the main ports, and interstate highways (indicated by the thicker lines). The Texas network includes non-NHS highways to connect some ports (like Eagle Pass) and some cities to the NHS. All the important truck corridors in Texas were included in this map using data from the 1996 Texas Truck Traffic Flow Map produced by TxDOT.

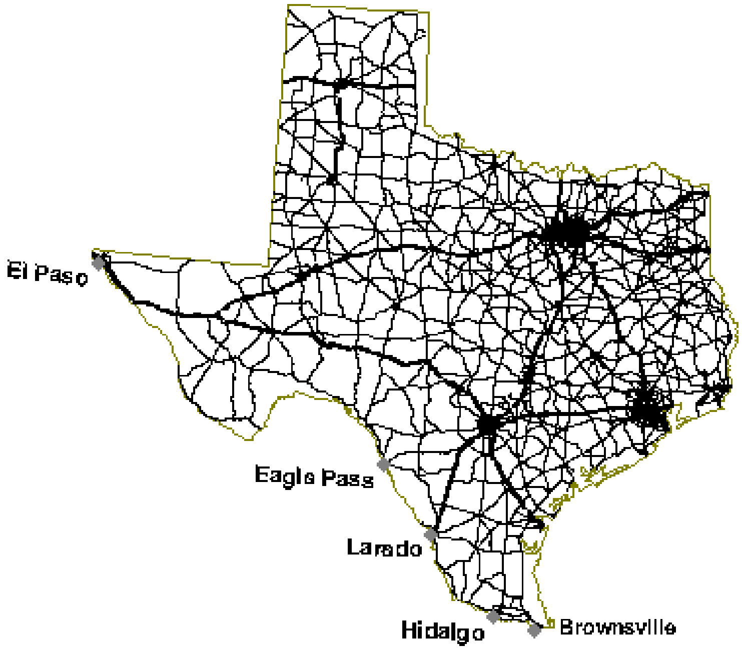


Figure 66. The Texas Highway Network.

NHS Characteristics. Table 42 shows the different components of the NHS, using data obtained by querying the NHPNv2.1. In Table 43 the NHS has been broken down into urban and rural components, with the latter comprising almost three-quarters of the network.

Table 42. NHS Components

COMPONENTS	Length (in miles)	%
Interstate system	44,919	28
ISTEA high priority corridors	6,209	4
STRAHNET (strategic highway network)	12,604	8
ISTEA/STRAHNET connector-corridors	2,962	2
Other highways	91,984	58

Table 43. NHS Urban/Rural.

CLASS	Length (in miles)	%
Rural	117,522	74
Small urban	7,638	5
Large urban	33,518	21

Table 44 presents the geometric characteristics of the rural portion of the NHS. The third column shows the percentage of the total that forms part of the interstate system. The interstate system comprises the biggest part of the network and has high geometric design standards.

Table 44. Rural NHS Characteristics

CHARACTERISTIC	Length (in miles)	Interstates %
Total Access Control	35,734	86
Divided Highway	47,826	65
Four or more lanes	48,804	64

Mexican Highways

The Mexican network contains 26,704 mi of highways, according to data provided by the Mexican Secretaria de Comunicaciones y Transportes (SCT) and published by BTS (Ref 29). The network is in the link-node format and was loaded using TRANSCAD software.

The densest highway system is found in the central part of Mexico, where the most important industry and consumption centers are located. The triangle connecting Mexico City, Guadalajara, and Monterrey contains the industrial heart of Mexico (especially the non-maquiladora part). The absence of highways in the north and northwestern mountainous zones, as well as in the south, is shown in Figure 67.

The Mexican highway system is strongly influenced by two factors:

- Topography: Two mountain chains run along the north-south corridor, hampering east-west communication, as seen in Figure 67, which depicts a topographical map of Mexico. The mountains run from Monterrey to the central mountain node in the eastern part of Mexico and from the Chihuahua-Sonora border to the central mountain node in the west.
- Highway condition: Mexican infrastructure is not as extensive and of as high quality as that found in the U.S. However, important improvements have taken place on Mexican highways

in the last several years. Many corridors have been or are being upgraded to four-lane or to four-lane divided highways.

Figure 67. Mexico Topography Map.

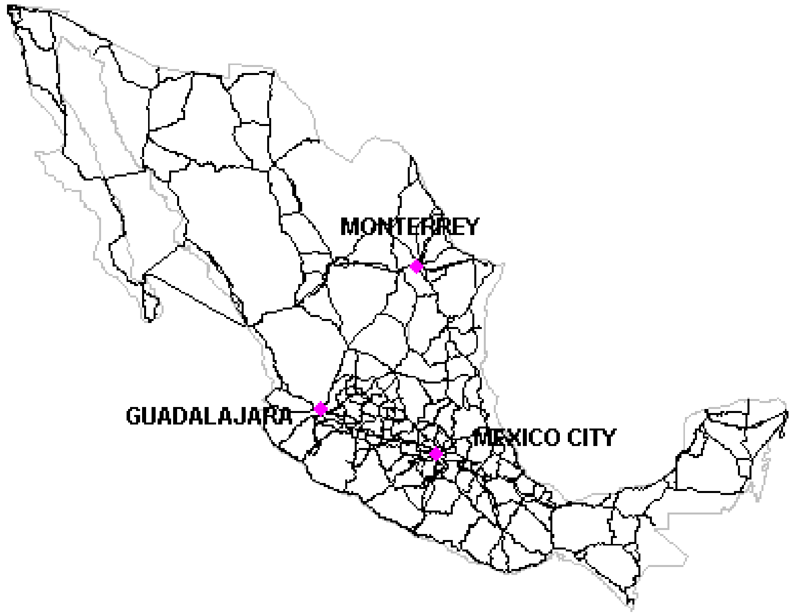


Figure 68. Mexican Highways

Mexican Truck Corridors.

A study by the Mexican Transportation Institute (Ref 39) identified the major truck corridors in Mexico. Table 45 lists the main corridors and their truck traffic density. The five corridors listed in bold are the direct main links for U.S.-Mexico trade. Six of the most important U.S.-Mexico ports are located at the end of these five Mexican truck corridors. These ports are Nuevo Laredo-Laredo, Ciudad Juarez-El Paso, Reynosa-Hidalgo, Matamoros-Brownsville, Nogales-Nogales, and Tijuana-San Ysidro (the first city on the Mexican side and the second on the U.S. side). The fact that six major freight corridors end at the U.S. border is not surprising, because binational trade accounts for almost 80 percent of Mexico's international trade.

As expected, the Mexico City-Guadalajara-Monterrey triangle, as expected, connects with most of the corridors. Veracruz, the most significant port and an industrial center, has important truck traffic with Mexico City. Tampico, the second most important port, also has important traffic with Mexico and Guadalajara. These two ports have a significant share of the U.S.-Mexico maritime trade.

Figure 69. Mexican Truck Freight Corridors.

According to the same study, these seventeen corridors, totaling nearly 8,700 mi, move 80 percent of the freight ton-kilometers transported by truck in Mexico. Table 45 shows the corridors by their importance in truck/day, the main cities, and main border ports.

Table 45. Main Freight Corridors In Mexico

CORRIDOR	LENGTH (in mi)	TRUCKS/ DAY	TONNAGE/ DAY	FREIGHT VALUE 10^6 $/DAY
Mexico-Queretaro	212	6,400	85,000	164
Queretaro-Nuevo Laredo	**1,058**	**3,500**	**50,200**	**119**
Mexico-Veracruz	446	3,460	33,200	90
Guadalajara-Monterrey	734	2,760	43,500	65
San Luis Potosi-Cd Juarez	**1,348**	**2,470**	**38,200**	**54**
Mexico-Campeche	1,447	2,800	25,000	47
Irapuato-Zacatecas	285	2,700	24,000	45
Queretaro-Guadalajara	380	1,900	19,900	40
Mexico-Tampico	522	2,100	21,000	38
Reynosa-Durango	**843**	**2,000**	**32,000**	**37**
Mexico-Guadalajara	624	3,000	30,200	33
Guadalajara-Nogales/Tijuana	**2,303**	**1,470**	**21,000**	**29**
Mexico-Monterrey	1,010	1,670	19,300	25
Reynosa/Matamoros-Tampico	**565**	**1,070**	**12,700**	**19**
Guadalajara-Tampico	806	1,330	14,300	16
Guadalajara-Manzanillo	306	1,580	10,500	12
Puebla-Oaxaca	419	2,100	11,600	11.5

Mexican Highway Characteristics

The following tables have been prepared using GIS network data. All lengths are expressed in miles (see Table 46). The length of the Mexican highway network is far shorter than that of the U.S. system, and most freeways have been built in recent years as toll roads. A ferry is used only to connect the Baja California peninsula (an underdeveloped area) to the central part of Mexico.

Table 46. Mexican Network By Type

TYPE	LENGTH
Freeway	3,482
Highway	23,221
Ferry	602

As noted previously, there are few important highways that carry trucks through the mountainous zones. Even when mountain routes are shorter in distance through the mountains, they are not chosen for construction because of low geometric design characteristics, which translate into higher operating costs, lower speeds, and greater safety risks (see Table 47).

Table 47. Mexican Highway Topography

CLASS	LENGTH
Hilly	13,207
Mountai	2,702
Flat	10,794

The urban network is very short, and most of the highways (over 80 percent) are two-lane roads, as shown in Table 48 and Table 49.

Table 48. Mexican Highways Rural/Urban Classification

TYPE	LENGTH
Rural	26,439
Suburban	198
Urban	65

Table 49. Number Of Lanes.

LANES	LENGTH
2	21,654
4	4,873
6	175

The more important routes in Mexico are owned and operated by the federal government. CAPUFE (Caminos y Puentes Federales) is the federal organization that operates many highways and bridges, most of them located at the U.S.-Mexico border. Toll roads have been built over the last decade and are typically four-lane facilities, both divided and undivided. (Table 50)

Table 50. Highway Operator

OPERATOR	LENGTH
Capufe	575
Toll Road	1,538
State	735
Federal	23,854
Total	26,704

ASSIGNMENT

In this study, the choice of the best route for moving trade from the state of origin to the port of crossing and then to the state of destination is largely made by the trucking company. Trucking companies, which we assume to behave rationally, seek the routes that minimize their costs.

Route choice has two important aspects that affect travel cost: length and time. Length is a direct factor in fuel, oil, maintenance, and tire costs. Time is important for vehicle utilization, driver wages, and cargo value. While length is related only to the route chosen, time is related to the route chosen and the speed on the route. Speeds are not uniform; they vary with the traffic and geometric characteristics of the highway. Time is chosen as the parameter to minimize because it is possible to account for the length of the route chosen and the characteristics of the path using speed.

Speed is basically a function of vehicle and driver characteristics, highway geometric characteristics, highway conditions, highway functional class, and congestion. As a function of highway geometric characteristics, highway functional class, and geometric characteristics, is used to measure the "relative impedance" of a highway link. Here speed does not necessarily represent the actual average speed on the highway; it is used only to simulate the route selection process based on the available data. A limitation of this approach is that congestion and delays at border crossings have been assumed to be equal across all border crossings, and, therefore, have not been considered. This important aspect of border crossing could be the subject of future research.

Capacity constraints can be a relevant factor in urban conditions but are less relevant for rural intercity trips. Capacity has not been considered in the assignment process; however, capacity and congestion are important factors in traffic assignment, and they will become even more important with the growth of NAFTA trade. The limited availability of traffic volume data may considerably hinder the inclusion of capacity in the assignment process.

Highway condition is a relevant factor, owing to its impact on vehicle costs. This factor plays a key role in Mexican trucking operations, in which the highway system does not have the same level of quality as that in the U.S. Operational factors, such as the location of warehousing centers and trucking terminals, may influence the route decision-making process.

Modeling Route Choice in U.S. Highways

All state DOT agencies were surveyed by the author and questioned about speed limits on interstates and other U.S. routes. Thirty-two out of the forty-eight contiguous states answered or have established criteria to assign speed limits according to highway characteristics. Well known trends were found, for example interstate highways have higher speed limits than state or U.S. routes. The difference, among interstate, state, and U.S.-route speed limits range between 5 and 15 miles per hour. In many cases, the difference is smaller when non-interstate highways have four lanes or are divided highways. Another identified trend is that urban highways have lower speed limits than rural highways.

In addition to the higher speeds allowed on interstates and main corridors, other important factors make them appealing for long freight hauls. While some of them are very difficult to model, they are certainly considered in the route selection process. Some of these factors include the following:

- Connection of distribution centers, trucking terminal hubs, and main industrial and consumer centers
- Continuous and high quality service along the route,

- Total access control, with no stops or substantial speed reduction in urban areas, and
- Number and width of lanes that facilitate the circulation of combination trucks, which have special requirements because of their length, width, and height.

Geometric characteristics and classification are used as the variables that affect speed (Table 51)

Table 51. U.S. Highway Speed (MPH)

Highway Type	Rural	Urban
Total access control	65	55
Partial access control (4 or more lanes)	55	45
No access control (fewer than 4 lanes)	45	35

In the U.S., the main NAFTA corridors use parts of the interstate system. But because the system is denser, the route choice is more complex because there is more than one feasible interstate route. For zones located in Texas, California, or the Midwest, the route choice is very straightforward. East Coast centers, e.g., New York-New Jersey, have two possible routes to follow: one through Nashville-Memphis-Dallas and the other through Birmingham-Houston. The difference in mileage is not significant, but the first route is slightly shorter than the one through Houston.

The routes obtained using the shortest path assignment with speeds shown in Table 51 were checked with logistics personnel at trucking companies. In interviews, they confirmed the validity of the results and the importance of interstate highways in the route selection process (Ref 32, 33).

Modeling Route Choice on Mexican Highways

On the Mexican side, the process of identifying NAFTA routes is made easier by the following factors:

- Maquila trade: Maquiladoras are generally located close to the border. The routing problem is trivial at the macro level (from a binational perspective) because usually there is a very short haul from the border to the maquiladora.

- Interior Trade: Interior trade is concentrated between Mexico City and Guadalajara. The main port of entry for interior trade is Laredo-Nuevo Laredo. Therefore, there are few important corridors that carry most of the U.S.-Mexico trade in Mexico.

In order to determine Mexican highway impedance, use the same approach used for U.S. highways. However, corridor information is also used to determine speed on the network. Speed has been established as a function of significant known data: topography and geometric characteristics (Table 52).

Table 52. Mexican Highway Speed (MPH)

	CORRIDOR		NON-CORRIDOR	
Topography	**4 Lane**	**2 Lane**	**4 Lane**	**2 Lane**
Plain	65	55	50	40
Hilly	55	45	40	30
Mountainous	45	25	20	15

The routes obtained using shortest path assignment in Mexico were also checked during interviews with logistics personnel at Mexican trucking companies. (Refs 32, 33).

COMMODITY GROUPS

The study of commodity movements in binational trade is one of the objectives of this study. While the study of flows for each port is important, the study of commodity movements is more useful for describing regional flow patterns; it is also a significant step in accurately estimating NAFTA truck volumes. In the TSFD, the origin-destination commodity data are presented as ninety-eight two-digit commodity classifications (HTS). This number of commodities is too high, and besides, some commodities have very low participation in the trade.

For the purpose of this study, commodities were grouped into a small number of categories that present similar characteristics while adequately representing the binational trade characteristics. This small number of commodity groups is used to represent north- and southbound trade and to map flows in the following chapter.

The following criteria were used to group the commodities:

1. Importance of each two-digit commodity in U.S.-Mexico trade;
2. Characteristics of the commodity, such as the type of product, volume/weight ratio, and value/weight ratio

3. Type and characteristics of the equipment required for the commodity
4. Use of few groups to keep the analysis simple

The selected groups are:

- Electrical products
- Industrial machinery
- Transport equipment
- Instruments
- Textile/apparel products
- Chemical/plastic/rubber products
- Food products
- Wood products
- Mining/metal/stone/ceramic/glass products
- Agricultural products
- Miscellaneous products

Appendix 2 shows the relationship between these commodity groups and the two-digit HTS system. Three two-digit commodities account for almost half of the trade value: electrical and electronic products, industrial machinery and mechanical appliances, and transportation equipment. These two-digit commodities, because of their importance in overall trade, remain ungrouped.

Commodity density is used to determine the number of trucks involved in U.S.-Mexico trade. For example, low-value but high-density commodities will significantly contribute to trips through their weight. This category includes items such as agricultural products, minerals, metal products, stone, glass, and ceramics.

Some commodities may require such special equipment as tankers (chemicals) and refrigerated trucks (certain food and agricultural products). These special requirements may lead to a higher percentage of empty hauls for trucks carrying those commodities. While there are no data available to account for this situation, it is important to remember that the percentage of empty hauls may vary considerably with commodity type.

MAP CONSTRUCTION PROCESS

This section describes the steps used to build U.S.-Mexico truck traffic maps for this study. Three different types of maps, presented in the next chapter, were developed. They include:

- Southbound flows through a border port,
- Northbound flows through a border port, and
- Southbound commodity flows.

Southbound Flows Through a Border Port

The southbound port movement flowchart is presented in Figure 70. For southbound movements, the U.S. origin state, border crossing port, Mexican destination state, and trade value (in dollars) are known. The process consists basically of two assignments, the first from a U.S. state to the border and the second from the border to the Mexican state. Assignment is performed using the shortest path method in TRANSCAD software. With the speeds from Table 51 and Table 52, times are calculated and the shortest time path is found.

Northbound Flows Through a Border Port

The northbound movement port flowchart is presented in Figure 71. For northbound movements, only the border port, the destination state, and the values are known. The process is similar to that used for southbound flows, but only one assignment is made. Total employment is used to assign values of freight attraction to Texas and California zones.

Southbound Commodity Flows

The flowchart for southbound commodity movements is presented in Figure 72. For southbound commodity movements, the U.S. state of origin and the Mexican destination state are known, as are the flow value and the commodity. In the BTS data set, the port value of commodity by truck is unknown.

One way to improve commodity assignment is to use customs port data, which include the surface value per commodity group per port. This value also includes rail and other transportation modes and provides an upper threshold for the commodity group crossing. Two problems arise:

- For ports that also have railroad crossings, the upper threshold is higher than the actual value (this applies to Laredo and Eagle Pass); and
- Certain commodities are more prone to use railroad than others, thus making the upper threshold more or less accurate according to the commodity.

These problems are not difficult to overcome and are closely related. The only commodity that has significant railroad movement is transportation equipment. Transportation equipment mainly goes through the ports of Laredo and Eagle Pass. The flow of this commodity is primarily from Michigan to Laredo or Eagle Pass to Mexico (see the transportation equipment flow map, Chapter 7).

The capacity for highway links is assumed to be unlimited, and as a result, costs are equal to the free flow costs used in the shortest time path assignment. The capacity for border crossings is equal to the value that crosses per port per group for surface modes.

The impedance function used in the border links is the following:

$t_t = t_f * (1 + \alpha\ (V/C)^{\beta})$ (1)

Where

t_t = total travel time in the highway link or port crossing

t_f = free flow travel time in the highway link or port crossing

V = flow crossing per highway link or port crossing

C = capacity of the highway link or port crossing

α and β are coefficients

It is important to mention that formula (1) is usually applied for hourly flows, but that here it has been adapted to assign annual flows and to create an impedance at border crossings when the annual trade by port is exceeded.

The results for user equilibrium (using formula (1) at the border links) and shortest path assignment of commodity flows between U.S. and Mexican states are very similar. This can be explained because trade heading to interior Mexico basically goes through Laredo to the industrial triangle in Mexico. Other ports trade is mainly related with maquiladora trade to border towns. The impedance used at border ports (the upper threshold established using customs port data) does not significantly change the distribution of flows. This would indicate that the network and zone representation is detailed and sufficiently accurate.

Northbound commodity flows

The representation of northbound commodity movements presents several difficulties. Maps for these movements were not drawn because there are no data combining Mexican states of origin with commodity classification. There are also no mode-split data and no commodity details at the state level. Simulation of freight generation could be performed using employment or monetary measures of industrial production and consumption, as presented in an earlier federally sponsored study (Ref 1). While Mexican employment data per state could be obtained, there are no maquiladora data combining industry sectors with geographic details. Maquiladoras account for almost 75 percent of the northbound trade, and without maquiladora trade data, it may be difficult to determine the in-state, out-of-state, and U.S. trade proportion of the freight generation.

Another important problem is modal split, because rail flows are important in some states. There is also an important sea trade, especially with the central part of Mexico through the ports of Veracruz and Tampico, which may grow with the use of containers.

The estimation of freight demand and modal share are not objectives of this study. Two previous studies produced at The University of Texas at Austin address these issues as they are shaped by the guidelines imposed by NAFTA (Ref 2, Ref 4, and Ref 52).

SUMMARY

This chapter presented the steps required to translate trade data (TSFD) into truck corridors which, when combined with the results obtained in Chapter 5, are used to compose the NAFTA truck maps that are presented in the next chapter. A binational highway system with connections to main ports and cities was modeled. Data details, especially origin-destination data, are the weakest part of the process and force the analyst to split trade flows within states, using assumptions that have not been fully validated. Assumptions regarding delays at the border, capacity, and congestion also have been made and could be the subject of further study.

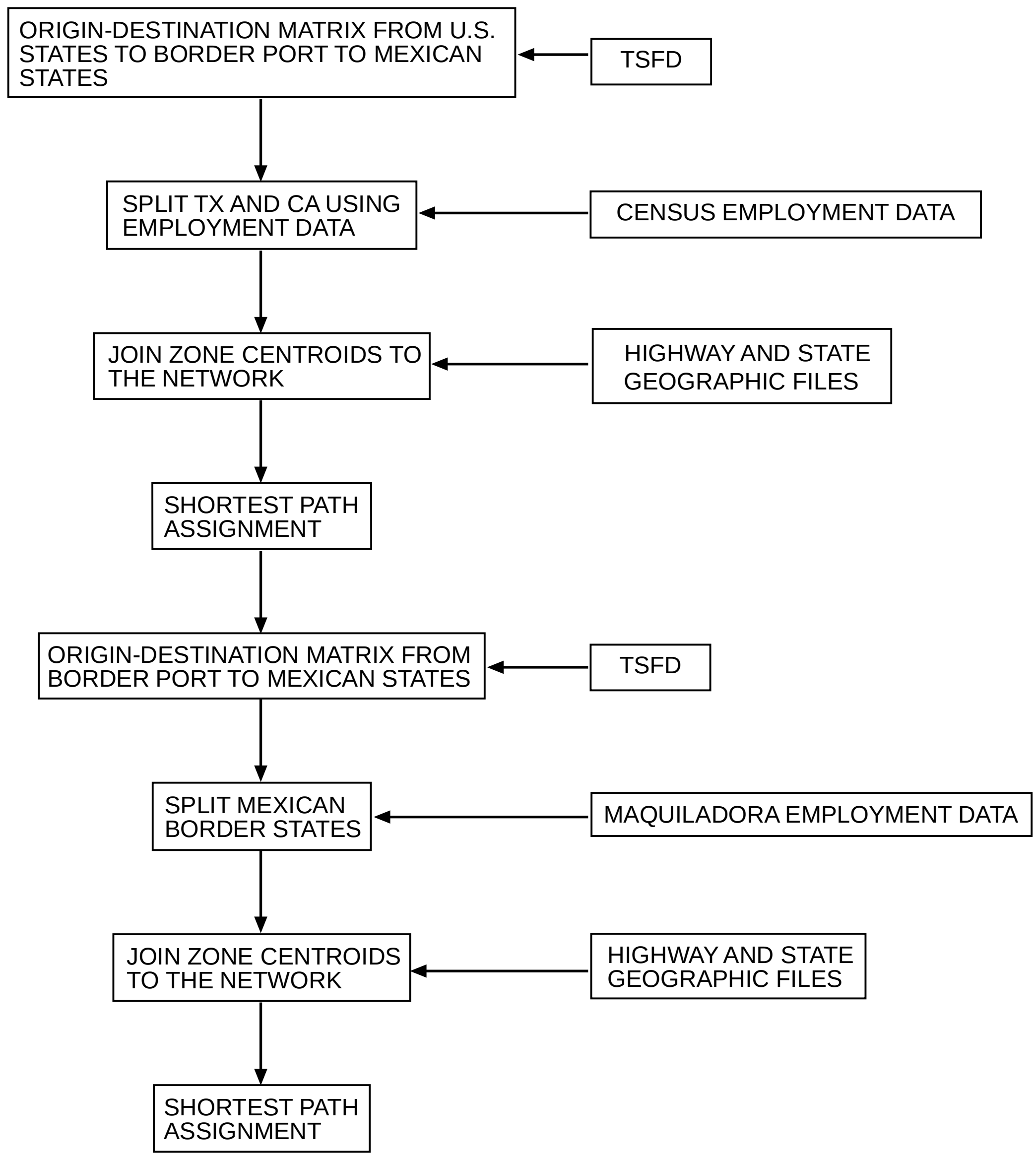


Figure 70. Southbound Flow By Port Flowchart.

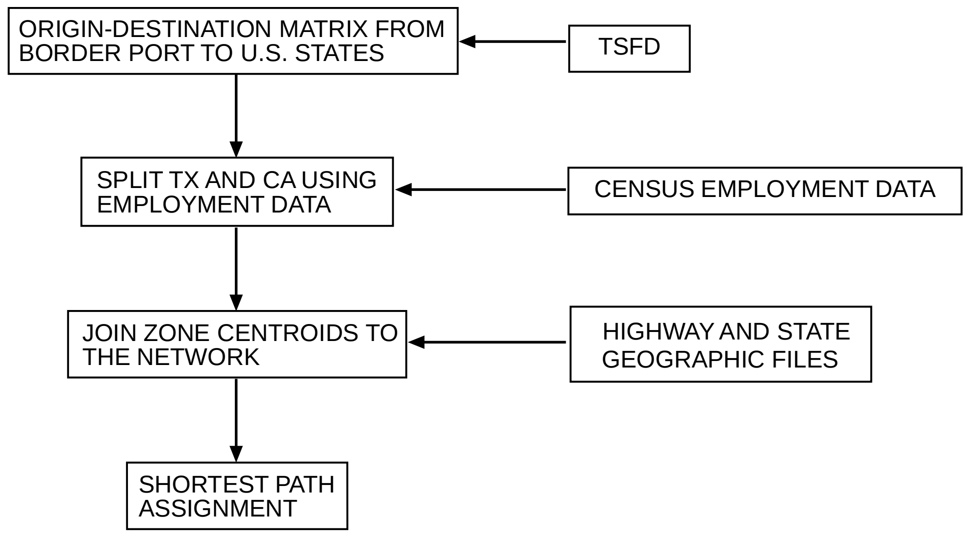


Figure 71. Northbound Flow By Port Flowchart.

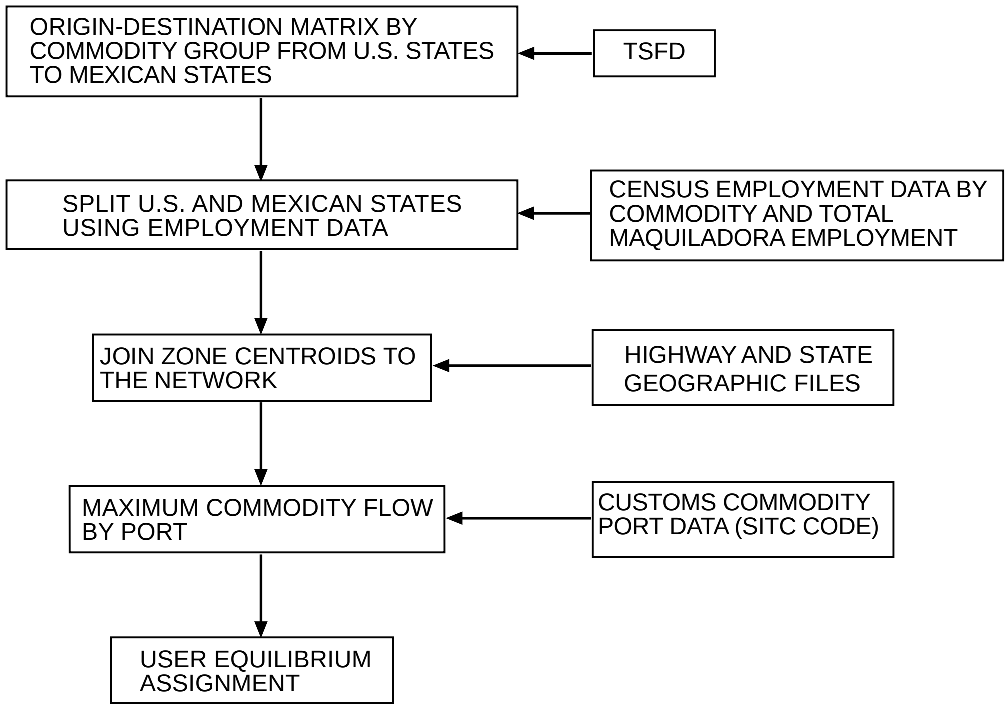


Figure 72. Southbound Commodity Flow.

CHAPTER 7. PORT AND COMMODITY TRUCK MAPS

Trade databases containing origin-destination details (TSFD) and NAFTA truck volumes obtained in Chapter 5 were used to apply the methodology developed in Chapter 6. Maps were produced using TRANSCAD GIS software.

This chapter identifies the main binational truck corridors carrying U.S.-Mexico trade. Seasonal effects are considered before annual truck volumes on the various corridors are determined. The main corridors are identified, and estimated numbers of trucks for northbound and southbound movements are presented.

SEASONAL EFFECTS

The maps in this chapter present annual volumes of NAFTA trucks from 1997. However, important seasonal variations occur at both port and commodity levels. The peaks caused by seasonal variations put higher demand on the transportation system and may strain the operation of the system at certain times during the year.

In Chapter 5 only annual volumes were obtained, so the appropriate correction factors (which need to be obtained using pertinent trade data) must be used to obtain monthly volumes by commodity or by port of entry.

Table 53. Seasonal Effect On Commodity Trade (1997)

COMMODITY DESCRIPTION	Southbound		Northbound		South. Ratio	North. Ratio
	AVERAGE	ST. DEV.	AVERAGE	ST. DEV.		
Agricultural Products	75,178,583	53,969,584	245,540,845	96,636,741	**0.72**	**0.39**
Food Products	76,292,315	17,244,000	77,719,486	8,099,404	**0.23**	0.10
Minerals and Metals	418,682,751	33,863,056	293,632,729	27,917,383	0.08	0.10
Chemicals/Plastics	584,357,350	81,485,016	140,294,822	18,940,949	0.14	0.14
Wood/Paper/Pulp	232,117,363	24,750,147	235,641,688	33,876,687	0.11	0.14
Textiles/Apparel	290,599,963	49,539,801	469,915,376	98,046,941	0.17	**0.21**
Industrial Machinery	617,457,601	119,170,829	595,179,112	102,899,279	0.19	0.17
Electrical Machinery	1,191,409,286	194,461,748	1,575,363,987	211,001,165	0.16	0.13
Transport Equipment	401,753,757	132,952,984	275,371,804	43,386,984	**0.33**	0.16
Instruments	125,908,406	24,848,899	174,092,708	21,624,931	0.20	0.12
Miscellaneous	100,429,636	21,656,813	121,384,123	16,685,016	**0.22**	0.14

Seasonal production or demand (or the combination of both) causes certain commodities to show significant monthly variations; good examples are agricultural products and food products. Table 53 shows the 1997 monthly average, standard deviation, and ratio between monthly standard deviation and monthly average by commodity group for both northbound and southbound trade.

Agricultural products exhibit the highest peaks for both southbound and northbound trade. The monthly variation of northbound agricultural products is shown in Figure 73; summer and spring months are where the extremes of trade are found. April and May are the peak months while August and July show the lowest trade values.

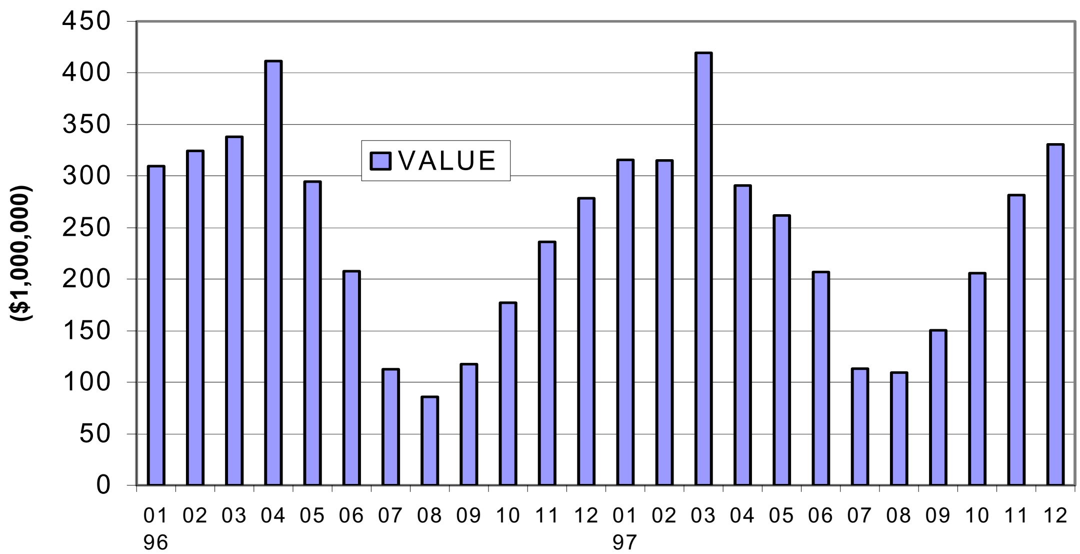


Figure 73. Northbound Agricultural Products (Seasonal Effects).

NAFTA trade continues to grow, as shown in Table 54, which plots the annual increase in trade by commodity group. Table 53 and Table 54 must be analyzed together to uncover seasonal effects; for example, transport equipment shows a high ratio in Table 53, but this must be attributed to the important trade increase shown in Table 54.

In other cases the growth of certain commodity groups is so large that the seasonal variation is concealed; an example is found in southbound movements of agricultural products that grew 385.7 percent from 1996 to 1997, as shown in Figure 74.

Agricultural products weigh out in general, and thus a higher percentage of weigh out and overloaded trucks can be expected during the spring. This fact coincides with results obtained from WIM data.

Table 54. Trade Increase By Commodity Group (1996-1997)

DESCRIPTION	Exports	Imports
Agricultural Products	385.7%	3.7%
Food Products	7.6%	14.0%
Minerals and Metals	4.5%	12.1%
Chemicals/Plastics	24.5%	23.2%
Wood/Paper/Pulp	14.5%	22.6%
Textiles/Apparel	28.4%	34.9%
Industrial Machinery	36.7%	27.2%
Electrical Machinery	26.1%	12.5%
Transport Equipment	43.7%	24.3%
Instruments	39.5%	13.5%
Miscellaneous	35.3%	-0.1%

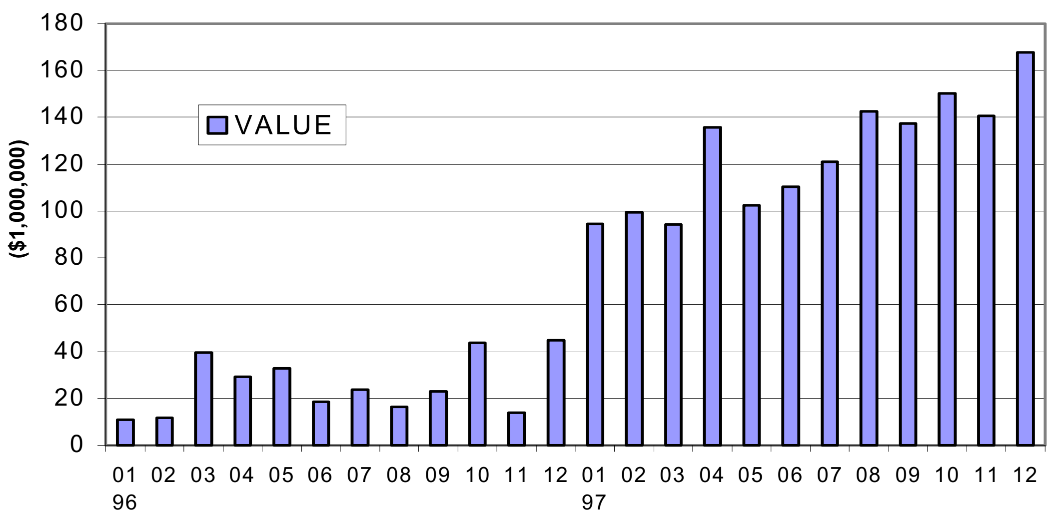


Figure 74. Southbound Agricultural Products (Seasonal Effects).

BY PORT

Significant monthly variations in truck volumes occur at certain ports and are related to seasonal commodity variations. Table 55 and Table 56 show the variation of northbound truck counts at border crossings for loaded trucks and all trucks, respectively.

Table 55. Northbound Loaded Trucks (1997)

PORT	AVERAGE	ST. DEV	RATIO
Brownsville	10,240	1,362	0.13
Del Rio	2,754	229	0.08
Eagle Pass	3,386	283	0.08
Falcon	7	5	**0.71**
Laredo	48,054	4,940	0.10
Hidalgo-Pharr	13,043	1,076	0.08
Progresso	666	368	**0.55**
Rio Grande	1,326	393	**0.30**
Roma	479	66	0.14
Total	79,956	6,204	0.08

The ratio between the standard deviation of the monthly truck count and the average monthly truck count is in all cases smaller for all trucks than for loaded trucks. Higher ratios are found where truck volumes are lower (except Roma). The important ports by value (Laredo, El Paso, Brownsville, and Hidalgo) have about a 0.09 ratio between the standard deviation of the monthly truck volumes and monthly truck volume average.

Table 56. Northbound All Trucks (1997)

PORT	AVERAGE	ST. DEV.	RATIO
Brownsville	20,632	2,388	0.12
Del Rio	3,755	281	0.07
Eagle Pass	5,971	470	0.08
El Paso	48,559	4,747	0.10
Fabens	14	8	**0.59**
Hidalgo	19,567	1,198	0.06
Laredo	104,280	9,019	0.09
Presidio	396	139	**0.35**
Progreso	1,577	426	**0.27**
Rio Grande	1,466	291	**0.20**
Roma	963	93	0.10

For southbound truck counts, the only bridges that carry significant volumes and show high ratios are McAllen-Hidalgo and Pharr Bridges. This is the result of traffic diversion from Hidalgo to Pharr Bridge; especially during October, November, and December, as shown in Figure 75. Considering the sum of the data regarding both bridges, the ratio obtained is 0.08. The other important ports where data are available (Laredo and Brownsville) have ratios around 0.09.

Hidalgo, where agricultural products are an important trade component, shows a variation pattern in truck volume that resembles the variation pattern of agricultural products. The variation is less prominent due to the presence of non-seasonal commodities.

Table 57. Southbound Trucks

PORT	AVERAGE	ST. DEV.	RATIO
Brownsville +	19,149	1,666	0.09
Del Rio +	3,632	407	0.11
Eagle Pass ++	3,701	562	0.15
Harlingen +	3,517	1,026	**0.29**
Laredo ++	54,234	5,682	0.10
McAllen-Hidalgo +	8,220	2,370	**0.29**
Pharr +	9,501	2,454	**0.26**
Progresso +	1,167	501	**0.43**
Rio Grande City +	1,816	301	**0.17**
Roma +	748	81	0.11
Total	105,686	9,017	0.09

+ All Trucks ++ Loaded Trucks

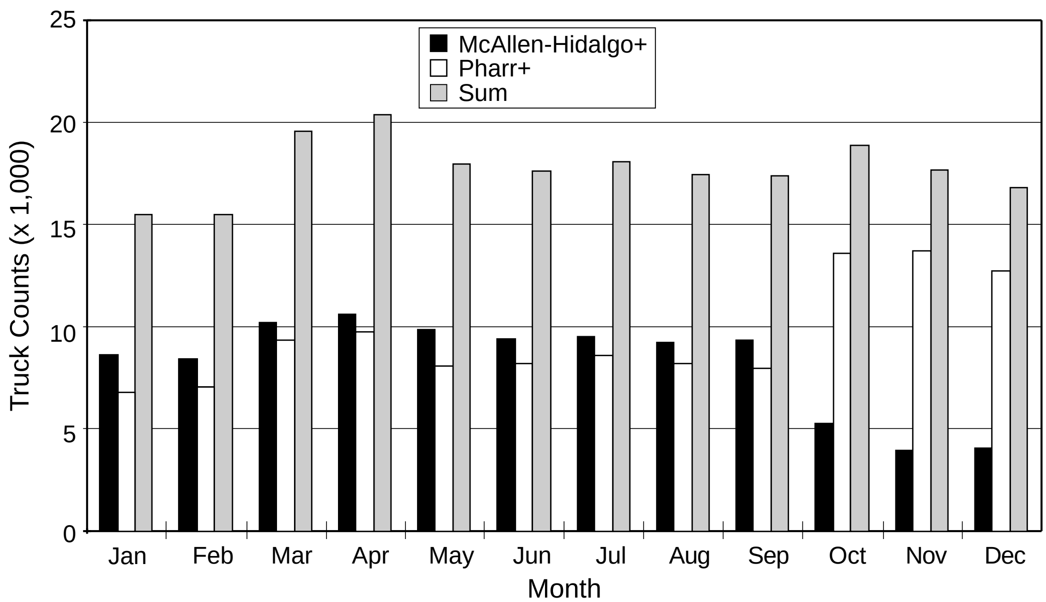


Figure 75. Truck Counts At Hidalgo Bridges.

AVERAGE HAUL LENGTH BY COMMODITY GROUP

A figure that may be interesting to analyze from the transportation point of view is the average length haul by commodity (see Figure 76). The values of Figure 76 reflect the average haul for each commodity after the commodity assignments. This figure provides valuable insight into modal split. Many factors influence mode choice, and distance is an important one. For example, transportation equipment has the longest haul and the highest rail participation. Because of the long haul length found in NAFTA trade, it is possible to speculate that with an efficient rail service all commodities could be transported in part by rail.

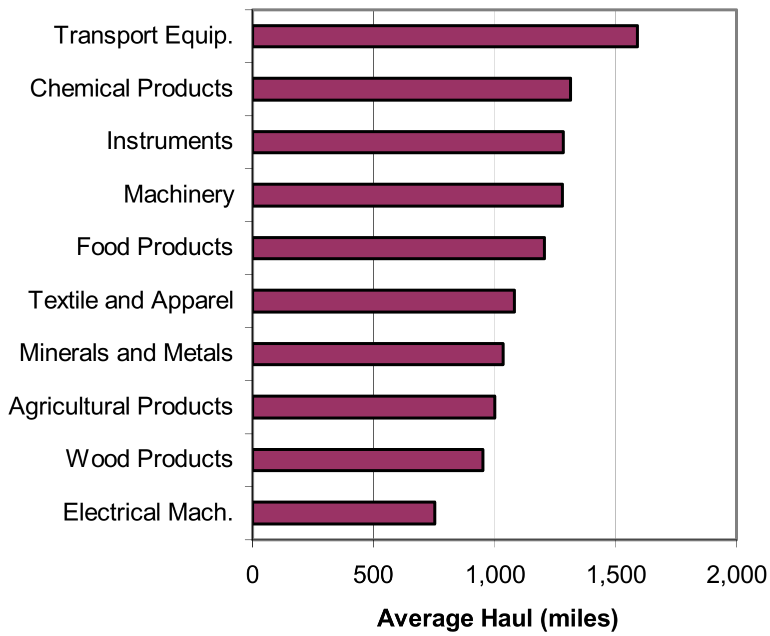


Figure 76. Average Length Haul By Commodity (Southbound 1997).

TRUCK MAPS

The identification of binational highway freight corridors is one of the objectives of this study. The maps contain annual volumes corresponding to the year 1997. Maps were created by converting annual trade into the annual number of trucks and assigning them to the network in the manner explained in Chapters 5 and 6.

The most important corridors reach from the border to important centers in the East Coast, Midwest, West Coast, and Texas.

U.S.-Mexico truck trade corridors are highly concentrated; a few highways carry significant portions of the trade. As corridor length to the border increases, corridors follow a path made by segments of the main interstate highways.

The main corridors identified are listed here, and Table 58 presents the estimated number of trucks.

1. IH 35 from Laredo to San Antonio-Austin-Dallas.
2. IH 30-IH 40 from Dallas to the Midwest East Coast through Nashville.
3. IH 10-IH 20 from El Paso to Dallas.
4. IH 10 from El Paso to Houston.
5. IH 5-IH 8 in the West Coast, from San Francisco to Los Angeles-San Diego-Tijuana-Tecate.
6. IH 19-IH 10 in Arizona, from Nogales to Phoenix and to El Paso.
7. IH 10 from Houston to New Orleans.
8. IH 59-IH 81 and IH 65-IH 85 from New Orleans to the East Coast
9. US 77 and US 281 from Brownsville and Hidalgo to Houston and San Antonio, respectively.
10. IH 25-IH 40 from Oklahoma to El Paso.

Figures 77 and 78 show the main corridors for northbound and southbound traffic respectively.

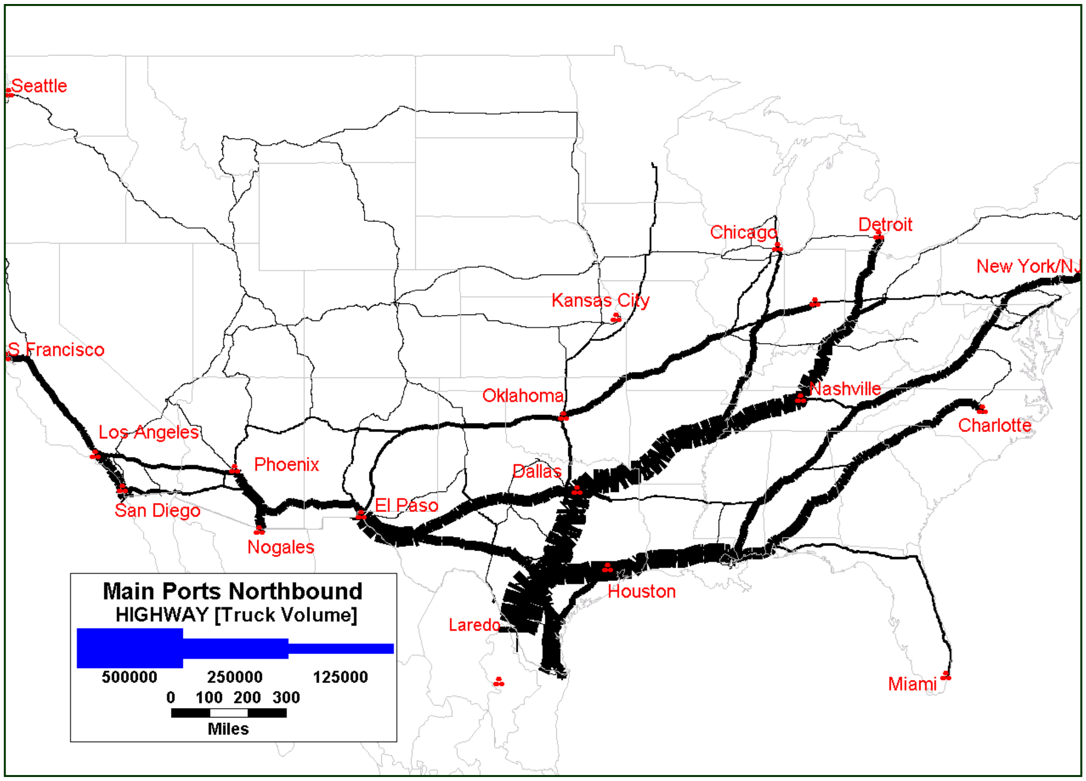


Figure 77. Northbound Truck Corridors.

In the U.S., highway corridors for southbound and northbound movements are essentially alike, although variations in volume can be found, as Table 58 demonstrates.

As shown in Figure 78, in Mexico there is only one dominant corridor: Laredo-Monterrey-Mexico City. This corridor connects with U.S. infrastructure at Laredo, from which it stems to Texas cities, the East Coast, and the Midwest. The other ports show an important maquiladora influence, and their trade share with nonborder states is small. This is particularly true with the ports of California. Appendix 7 presents maps by port and by commodity.

Table 58. Main Corridors In U.S.

HWY.	FROM	TO	SOUTHBOUND TRUCK VOLUME	NORTHBOUND TRUCK VOLUME
IH 35	Laredo	San Antonio Austin	585,649-554,097	523,120
	San Antonio	Dallas	419,666-419,666	386,912
IH 30	Austin	Little Rock	419,669-387,488	364,880
IH 40	Dallas	Nashville	219,494-219,494	296,384
IH 65	Little Rock	Louisville	174,031-174,031	216,931
IH 71	Nashville	Cincinnati	174,031-147,508	169,913
IH 75	Louisville	Detroit	147,508-147,508	147,068
IH 10	Cincinnati	IH 20 (TX)	121,822-121,822	91,545
	El Paso	San Antonio	276,046-276,046	246,285
	IH 20	Houston	139,306-139,306	109,409-110,443
	San Antonio	Beaumont	235,077-235,077	254,876
	Houston	IH 59 (LA)	170,954-170,954	241,318
IH 20	Beaumont	Dallas	155,079-149,178	230,657
IH 37	IH 10	US 281	90,062- 90,969	136,376-111,117
	San Antonio	US 77	156,373-156,373	172,275-
US 281	US 281	McAllen	68,732- 68,732	73,816
US 77	IH 37	Brownsville	121,494-124,494	186,631
US 77	IH 37	Houston	100,885-100,885	109,535
US 59	Corpus Christi	San Diego	68,213- 68,213	75,309
IH 805	San Ysidro	Los Angeles	197,806	194,519
IH 5	San Diego	San Diego	114,064	131,877
IH 8	Calexico		140,149	39,677

As shown in the figures, Texas highways are heavily used to connect trade regions in the East and Midwest to Mexico, while central, mountain, and Pacific regions of the U.S. have less impact on Texas highways through trade.

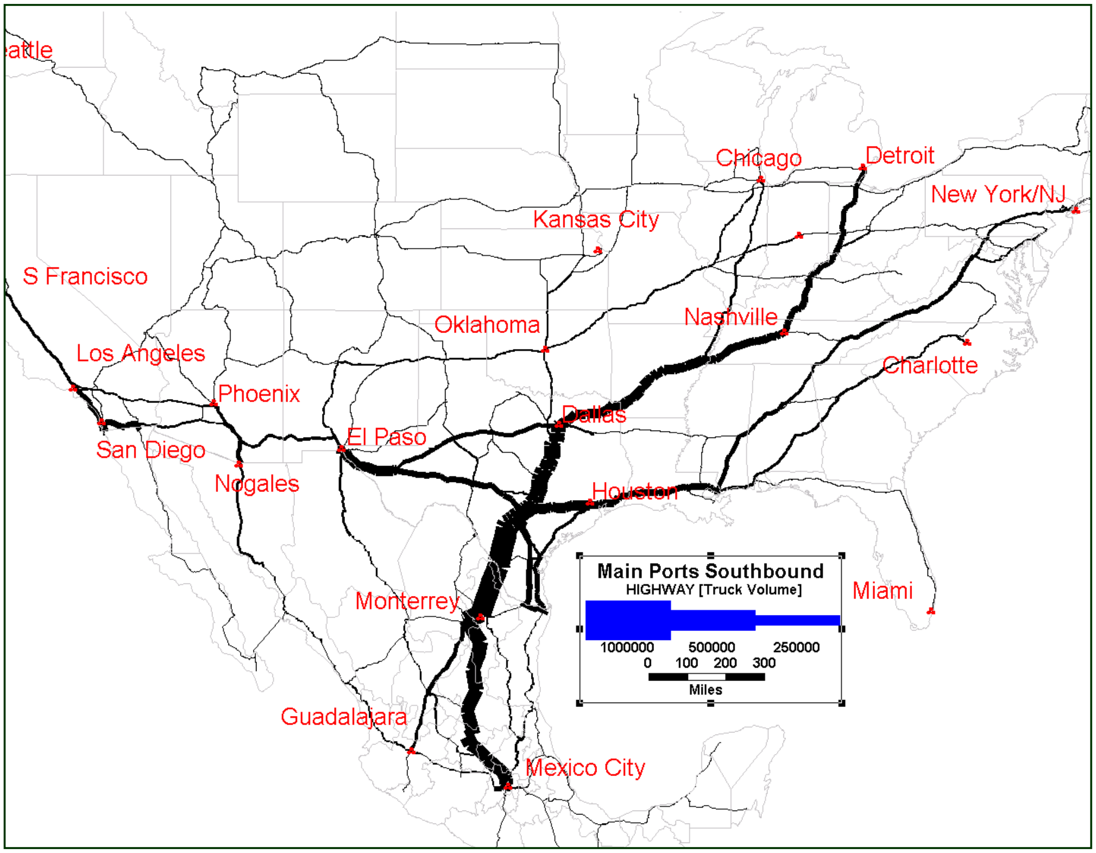


Figure 78. Southbound Truck Corridors.

As shown in Appendix 7 (Figure 109 to Figure 118) commodity maps present very distinctive characteristics. Each commodity shows a different proportion of border and through trade through Texas. An extreme example is transport equipment, which shows a clear corridor between the industrial Midwest and the central part of Mexico. Textile products also show major movement between the East Coast and central Mexico. Commodity maps are important tools for understanding the nature of trade, and, as is shown in Chapter 8, analyzing the impact of NAFTA trade, because commodities vary in their impact on infrastructure and their value/weight ratio.

SUMMARY

This chapter has identified truck corridors for southbound and northbound trade. Texas, situated in the middle of the largest industry and population centers in Mexico and the U.S., generates truck traffic that is in transit to other states (passing truck traffic). California, on the other hand, has a truck volume coming from other states; its trade is mostly with Baja California.

Laredo is the main port and is unique because it carries most of the out-of-state trade, being the preferred connection between the East Coast and Midwest to interior Mexico. Maquiladora trade, and to a different extent, characterizes the other important ports, which include El Paso, Brownsville, Hidalgo, San Ysidro, Calexico, and Nogales.

Seasonal variations were also analyzed in this chapter, although maps were produced for annual volumes. By commodity, agricultural products show the more important variations. However, trade is so dynamic that seasonal variations may be hidden. Ports with high truck volumes tend to be more stable and show less variation than small ports do.

CHAPTER 8. NAFTA TRUCKLOADS ON TEXAS HIGHWAY INFRASTRUCTURE

It has been feared that if Mexican trucks are allowed to circulate on the Texas highway system, they may cause serious damage to the infrastructure. The main concern is with overloaded trucks, which may also be linked to safety problems. Indeed, safety concerns about Mexican trucks were the reasons cited by the U.S. government for the postponement of the second phase of NAFTA.

This chapter will focus on elements that allow the evaluation of the damage that NAFTA truckloads cause to Texas pavements. The CTR at The University of Texas at Austin has undertaken three projects focusing on truckload impacts along the Texas-Mexico border (Refs 18,23,24) using WIM data. This study, involving the three projects has a section that describes overweight truck axle loads at both border and nonborder locations in Chapter 4. This chapter will use some of these the findings from both sources to study possible impacts on border ports based on commodity and vehicle classification.

Pavement Damage Concepts

Truckloads are transmitted to the pavement structure through the truck axles and, accordingly, wear out the pavement structure. When experimentally studying the effect of different loads, AASHTO researchers developed the concept of equivalent single-axle load (ESAL). The standard-axle load was established as the load of a single axle with dual tires and a weight of 18,000 lb, the legal limit at the time the research was undertaken. A series of mechanical-empirical equations was developed to evaluate the damage of ESALs. According to studies performed by AASHTO, the level of damage on a pavement is affected by pavement structural capacity, initial and terminal pavement condition, axle configuration, axle load, and axle load repetitions (Ref 34).

An important product of those studies is the "fourth power" rule. For a given pavement, axle configuration, and axle weight, the damage to the pavement roughly coincides with the fourth power of the change in axle load.

Overloaded Axles by Truck Type

The effect of the fourth power rule is so great that an axle overload of 20 percent will cause damage equivalent to the passage of two legal axle loads. Pavement engineers design pavement structures to endure a projected number of ESALs, and overloaded axles considerably shorten the life of the pavement structure.

A ranking of axle types with the highest percentage of overloads was obtained from the WIM stations in Laredo and El Paso (Ref 24).

Overloaded Axles at Border Stations

1. 3S3 trailer tridem
2. 3S3 drive tandem
3. 3S2 tractor tandem
4. 3S2 trailer tandem
5. 2S2 drive single
6. 3S1 tractor tandem
7. 2S2 trailer tandem
8. Three-axle single-unit truck (tandem)
9. 3S1 trailer single
10. Two-axle truck (drive)

In order to compare the damage caused by different truck types, one must express truckloads in ESALs. Figure 79 was created from data contained in Ref 3, using a single 18 kip axle to determine ESALs. The six-axle truck was found to be the most damaging. As many as 80 percent of six-axle trucks were found to be overloaded (Ref 24); yet, as previously mentioned, only a small number of trucks crossing the border were of this type.

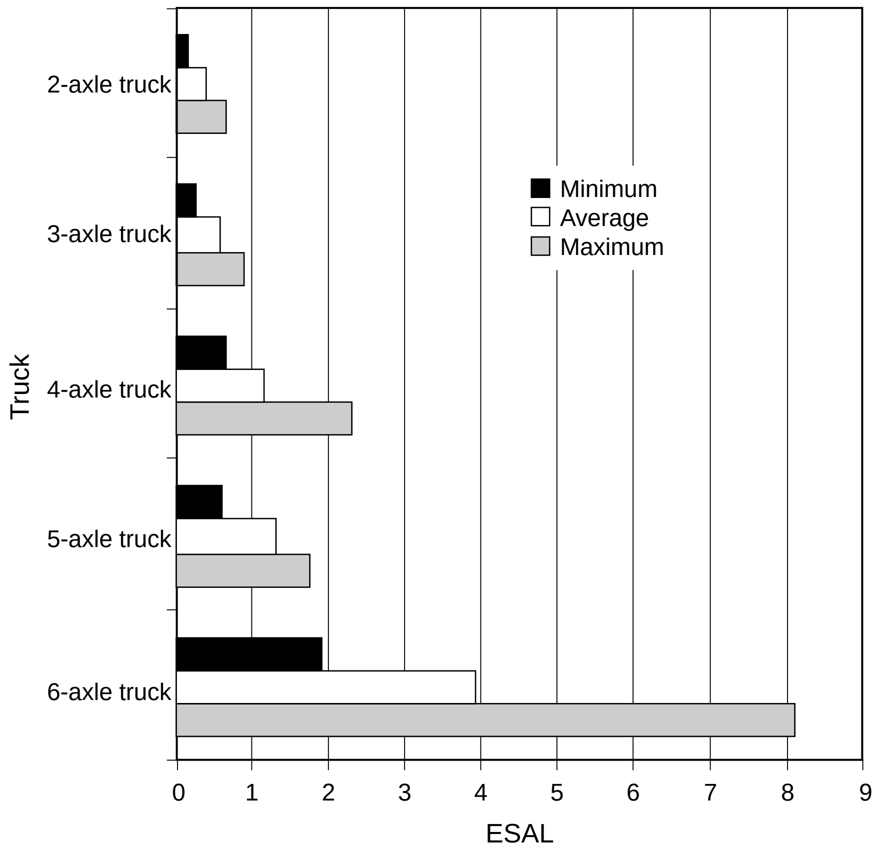


Figure 79. ESAL By Truck Type.

It is important to notice the influence of load in the ESAL. In Laredo, 2 percent of the truck population (six-axle trucks) accounted for 9 percent of the total ESALs. In the same way, 48 percent of the population (five-axle trucks) accounted for 60 percent of the ESALs, and 21 percent of the empty trucks accounted for only 1 percent of ESALs (Ref 18). Figure 80 contains these data for the weekday traffic in the northbound direction at Laredo for 1994.

If this relationship holds for other ports along the border, then ports with a high percentage of six-axle trucks would be more susceptible to pavement damage. Five-axle trucks are important at all the ports, while six-axle trucks are unusually common at Brownsville (16.4 percent), Rio Grande (58.8 percent), and Roma (13 percent). The presence of four-axle trucks is low in all ports and is decreasing.

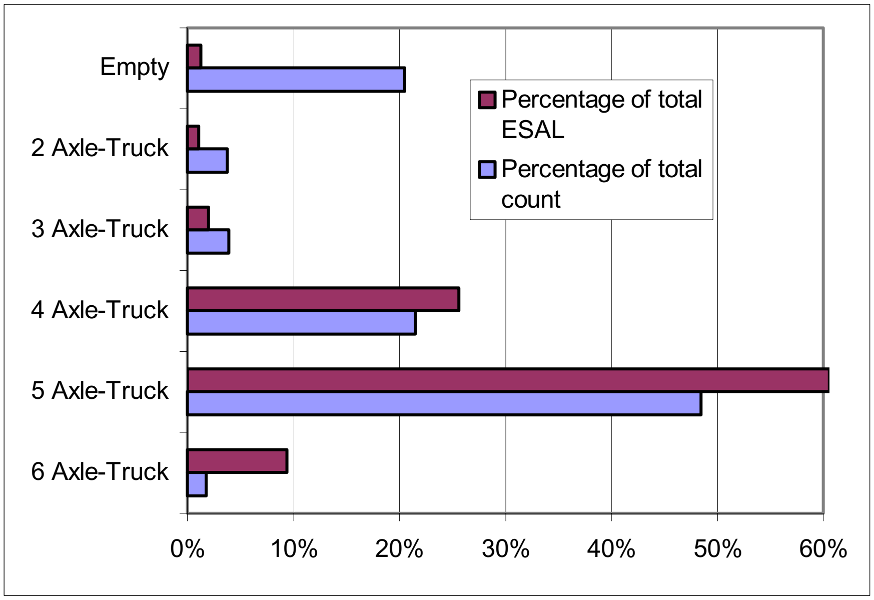


Figure 80. ESAL And Truck Count.

Commodities' Effect on ESAL

The effect of loaded trucks on pavement is really important. Total truck weight is dependent on the commodity being carried. A truck carrying weigh out commodities may weigh 60 percent more than a fully loaded truck carrying light cube out commodities. This weight difference translates into different ESALs per truck carrying different commodities. Using the fourth power formula, and assuming that the weight is evenly distributed on all the axles, a truck that weighs 60 percent more will have almost the same damaging effect as seven lighter trucks.

The following graph shows the influence of commodity type on truck weight (Figure 81). The data for Figure 81 were obtained from a study of commodity movements on the Texas highway system (Ref 35). With a tractor-semitrailer dead weight of 32,000 lb and a truck total limit of 80,000 lb., the maximum payload is 48,000 lbs. This number fully agrees with the weight shown in Figure 81. Using these values, the fourth power formula, and the value of mixed shipments as a reference, the researchers calculated the values in Table 59. The effect of a commodity that weighs out (such as agricultural, construction, or hazardous materials) is equivalent to 4.6 trucks with mixed commodities.

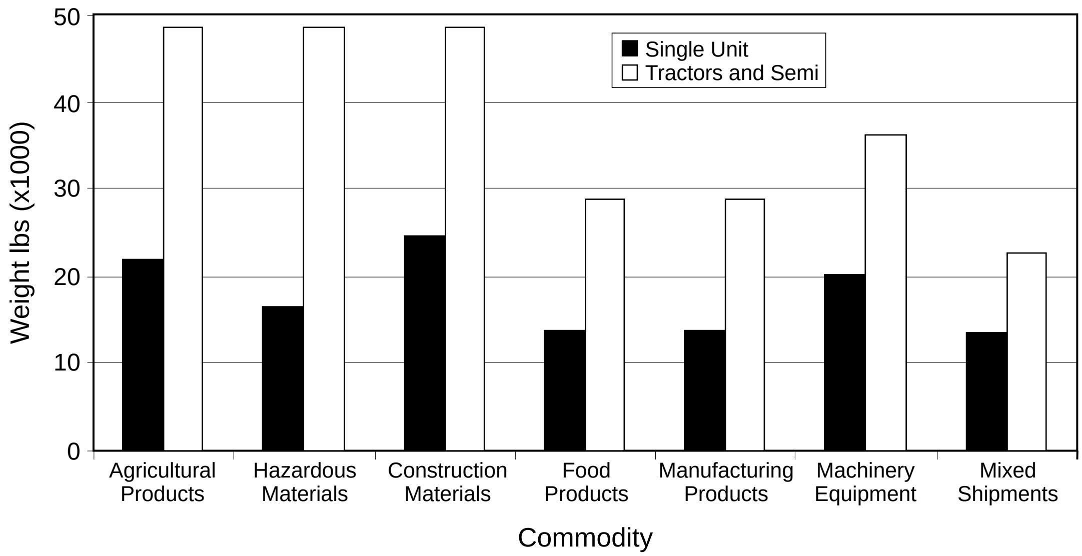


Figure 81. Truckload Commodities By Truck Type.

Table 59. ESAL By Commodity Type

Commodity	ESAL
Agricultural Products	4.64
Hazardous Materials	4.64
Construction Materials	4.64
Food Products	1.53
Manufacturing Products	1.53
Machinery Equipment	2.40
Mixed Shipments	1.00

Of course, ports that handle commodities that weigh out will tend to suffer more pavement and bridge deterioration than will ports that handle cube out commodities. A list of commodity densities contained in the NCHRP 260 is used to classify commodities as cube out and weigh out. (Ref 28). The list is broken down using the five-digit Standard Transportation Commodity Code (STCC). Table 60 lists the classification of the commodities as cube out or weigh out. Exceptions may occur and the table only provides a general picture.

Table 60. Commodity Classification

Commodity	Classification
Agricultural Products	Weigh Out
Minerals and Metals	Weigh Out
Food Products	Weigh Out
Chemicals	Weigh Out
Wood/Paper/Pulp	Cube/Weigh Out
Metal Products	Cube/Weigh Out
Transport Equipment	Cube Out
Plastics	Cube Out
Industrial Machinery	Cube Out
Miscellaneous	Cube Out
Textiles/Apparel	Cube Out
Electrical Machinery	Cube Out
Instruments	Cube Out

NAFTA TRADE WEIGHT BY COMMODITY AND PORT

Figure 82 shows weight data by commodity group. These data correspond to 1997 northbound movements for all ports and were produced using the TSFD. Agricultural products, as well as minerals and metals, are a large share of all the weight shipped by truck (49 percent of the total northbound weight). These commodities hold an even greater share in the pavement damage because they weigh out, and all the trucks carrying these commodities reach the total weight limit and in some cases are overloaded.

Because these commodities have a high weight/value ratio, their share in the northbound movement by value reaches only 12.3 percent. Weight by commodity group is not available by port, but value by commodity group is.

Table 61 shows a list of ports by weigh out commodity value order. Included are the values of the following commodities: minerals, agricultural products, chemicals, and food products. Nogales (Arizona) has the highest percentage of weigh out commodity in northbound movements owing to the important movement of agricultural products. Brownsville shows an important share of chemicals, agricultural products, metals, and minerals. Overall, Laredo has the highest value, and therefore the highest number of weigh out trucks. Main commodities through Laredo are chemicals, agricultural, and food products. El Paso, usually the second port in importance, is relegated to the fourth position.

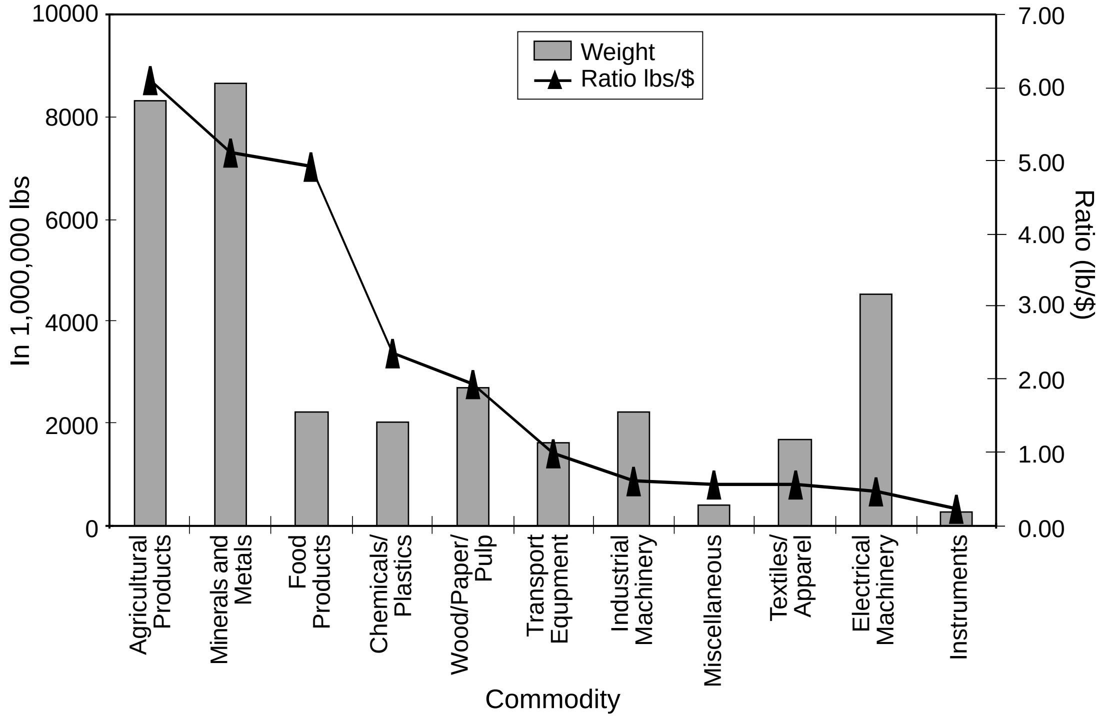


Figure 82. Northbound Commodities Weight (1997).

Table 61. Weigh Out Commodities By Port

PORT	Value % by port	Value
Laredo	12.2%	4,544,713,630
Nogales	20.2%	1,435,150,979
Brownsville	15.5%	1,136,344,211
El Paso	3.7%	799,897,867
San Ysidro	7.0%	722,634,553
Hidalgo	9.3%	562,685,829
Calexico	12.2%	517,321,562
Eagle Pass	6.4%	378,212,351
Del Rio	3.1%	56,420,997

SUMMARY

Commodities transported, truck type, percentage of overloaded trucks, and ESAL per truck are strongly related. The combination of commodities, truck types, and numbers of trucks make some ports and highway corridors more prone to suffer infrastructure damage due to NAFTA trade. In future research it would be helpful to combine the results of this chapter with commodity and port maps presented in Chapter 7 to identify corridors where NAFTA trucks could create negative impacts and evaluate infrastructure damage.

CHAPTER 9. CONCLUSIONS AND RECOMMENDATIONS

In this study U.S.–Mexico truck trade corridors were identified and the characteristics of the truck traffic in these corridors were determined. The scope and magnitude of the topic, even when restricted to transportation aspects, required a sequential analysis of trade statistics, truck border operation, truck characteristics, origins and destinations, truck corridors, and estimations of truck volumes. Available data were analyzed to discern main U.S.-Mexico truck trade corridors and to estimate truck volumes, and to produce maps and tables.

Even before its implementation in 1993, NAFTA sparked many heated discussions about its benefits and costs. These discussions were often not based on sound analysis or reliable data that could back up the arguments. One objective of this study was to quantify and provide methodologies and figures that could lead to an understanding of NAFTA impacts on transportation. The production of maps with trade volumes and origins and destinations had the objective of providing decision makers with meaningful data in an easily comprehensible form.

NAFTA truck trade was a difficult issue to deal with, as the problem subject was broad, complex, and equipped with few previous quantitative analyses. Data were generally scattered and are often unsuitable for transportation analysis or were given in formats that made them difficult to use. One of the big challenges of this study was to analyze all the available data to provide useful observations linking different areas. Although the figures provided in some chapters might appear limited due to the accuracy of the original data or assumptions made, they help to clarify aspects of NAFTA truck trade and put them in the right perspective.

NAFTA trade between Mexico and the U.S. is expected to have high rates of growth in the coming years. Two issues may have an important influence on the transportation aspects of NAFTA. One of them is the second phase of NAFTA surface transportation legislation, which will allow Mexican truckers to circulate in the border states of the U.S., and allow U.S. drivers to circulate in Mexican border states. This was scheduled to take place in December 1995 but was unilaterally postponed by the U.S. Department of Transportation. Although it is still delayed, there is growing evidence that this phase may be implemented by 2001. The consequences of opening the border in this fashion are not very clear and are also very difficult to predict. The other issue is the privatization of Mexican railroads, which has brought about interlining agreements with U.S. class one railroads in Texas (UP, BNSF and KCS). Heavy investments are currently under way to upgrade some lines of the Mexican railroad system to equivalent standards of American class one railroads. Custom pre-clearances will also contribute to more seamless rail operations between the two countries. The long-haul characteristics of NAFTA trade make rail shipments a very competitive alternative to the highway mode, especially to highways reaching the Midwest, Northeast, and Canadian regions.

U.S.-Mexico trade is very dynamic, and important changes will continue to take place. TxDOT implementation of a NAFTA monitoring system that would follow trade statistics, corridors, traffic counts, and WIM data would provide a means of anticipating infrastructure problems and guiding investment policies. As the second phase of NAFTA trucking legislation approaches, it is very important to monitor axle loads, truck volumes, and origins and destinations. This is beneficial for planning purposes and pavement management on the NAFTA highway network, much of which is already congested and heavily utilized. To provide a multimodal planning perspective it is also important to keep track of rail trade and railcar crossings, as well as their origins and destinations. This study provides insights by explaining data analysis issues, analyzing trends, and providing methodologies used to estimate truck volumes and study corridors. Customs collaboration with TxDOT would give TxDOT access to valuable commodity and origin-destination data and would substantially improve our understanding of trade flows.

As a better understanding of NAFTA is reached and more data become available, further work may include the integration of other modes (rail and sea) as well as other countries (especially Canada) in the analysis. Furthermore, the integration of the freight trade demand work of Strong (Ref 2), and the modal split work of Fang (Ref 52), together with this study would produce a complete multimodal planning analysis comprising trade generation and attraction, modal splits, trade distribution, and assignment of trade to the networks. Further work could also include the evaluation of NAFTA impacts on pavements, congestion, and pollution in Texas highways.

APPENDIX 1. ANALYSIS AND DESCRIPTION OF DATA SOURCES

This section will address only those databases that can be used to study the surface trade movement between Mexico and the U.S. A complete discussion of all U.S. transportation data can be found in "Directory of Transportation Data Sources," BTS (Ref 50). An analysis of Mexican data sources is presented in Task 8 of the Binational Border Transportation Planning and Programming Study (Ref 1).

U.S. DEPARTMENT OF COMMERCE DATA

Exports and Imports Data

These data can be purchased from the Department of Commerce. Two CDs are issued every month, one for import data and the other for export data. The cost of each CD is $150.00 (April 1998 price).

These statistics show merchandise shipped between the U.S. and to about 200 other countries in the world. Merchandise shipped in transit through the U.S. to another country is not included.

Note that only those fields of the data set that have any significance to the purpose of this study (origin-destination, mode of transport, port of entry exit, weight, value, and commodity classification) are retained. A complete discussion is presented in the U.S. Bureau of the Census publication "Guide to Foreign Trade Publications" (Ref 55)

Source of Information

Export information is obtained either from the shipper export declarations (SEDs) or from the automated export system (AES). Copies of SEDs are made by customs officials at the port of export. Each SED represents a shipment of one or more kinds of merchandise from one exporter to one foreign importer on a single carrier. Qualified exporters, forwarders, or carriers submit the SED data by automated means directly to the Census Bureau using the AES. Approximately 42 percent of the export entries are processed through SEDs (more than 6 million entries). The rest are processed using the AES or the data exchange program with Canada (Ref 60).

Published import information is mainly compiled through U.S. Customs' automated commercial system. About 97 percent of the formal entry summaries processed by customs use the automated broker interface (ABI). This system permits qualified participants to electronically file the required information for U.S. Customs. Only 1,650 operational clients accounted for 97 percent of the 14.4 million entries during 1995 (U.S. Customs, Customs Automated Broker Interface, (Ref 58).

Value Reported

The FAS (free alongside ship) value is the value of exports at the U.S. seaport, airport, or border port of export. It is based on the transaction price (including inland freight, insurance, and other charges incurred while placing the merchandise along side the carrier at the U.S. port of exportation).

The customs value is the value of imports as appraised by the U.S. Customs Services in accordance with the legal requirements of the amended Tariff Act of 1930. This value is generally defined as the price actually paid, or payable, for merchandise when sold for exportation to the U.S. It does not include U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise to the U.S. (Ref 55).

It is important to note that this value may be different from the value collected in other countries, because it includes duties, insurance, and transport costs. Usually exports do not include any tax, but when the merchandise enters another country, the same export has a different value if transportation, insurance, and import duties are added.

Commodity Classification

Exports and imports are classified using different systems. Approximately 8,000 commodity classifications are used to compile export statistics. These classifications are contained in the Schedule B Statistical Classification of Domestic and Foreign Commodities Exported from the U.S., a U.S. Census Bureau publication.

Import statistics are compiled using the approximately 14,000 commodity classifications contained in the Harmonized Tariff Schedule of the United States Annotated for Statistical Reporting Purposes (HTSU.S.A). This is an official publication of the U.S. International Trade Commission. The import classification system is more extensive than the export classification system.

Both classification systems have ten-digit levels. The first four digits are called “heading,” the next four “subheading,” and the last two “suffix.” For example, the code “8463.30.00.40” indicates the following:

- Heading: “8463” Other machine tools for working metal, sintered metal carbides, or cermets, without removing materials
- Subheading: “30.00” Machines for working wires
- Suffix: “40” Used or rebuilt

Shipments with a value smaller than $2,500 (exports) or $1,500 (imports) are aggregated under the denomination of “low-value shipments” and therefore are not classified under any commodity code. These shipments represent almost 1.5 percent of exports and imports to Mexico.

District of Exportation and Importation

For exports using surface mode transportation (rail, truck, pipeline, or other), the district of exportation is the customs district through which the merchandise crosses the U.S. border into foreign territory (Ref 56). For exports using vessel and air modes, the customs district is the place where the merchandise is loaded on the vessel or aircraft that takes it out of the country; for imports, the district is that in which merchandise clears customs for entry into consumption channels, bonded warehouses, or foreign trade zones.

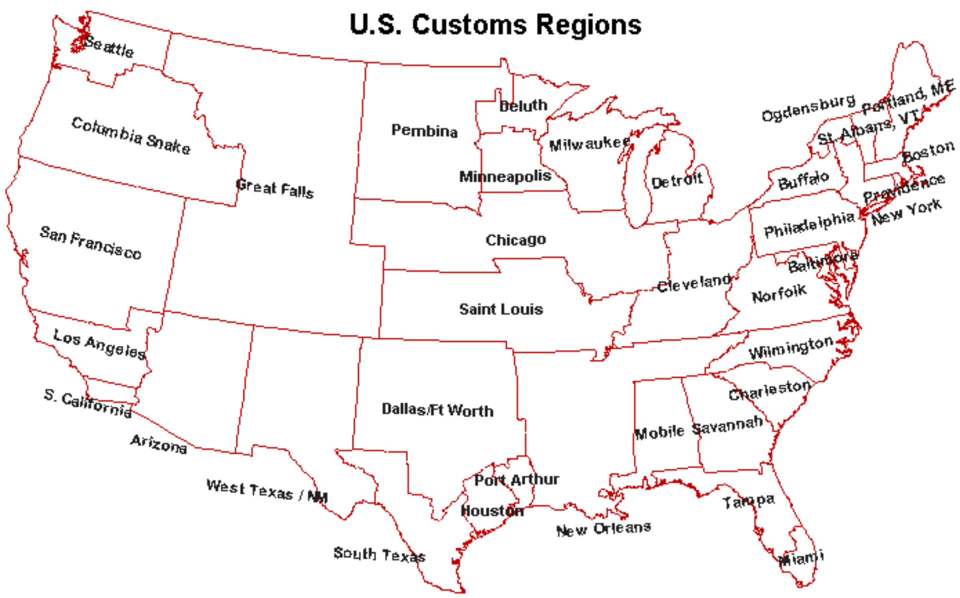


Figure 83. U.S. Customs Districts.

It is important to point out that the district of exportation or importation may not necessarily be the actual district where the merchandise crosses the border. The documentation may be filled in at a port different from the port where the merchandise actually crosses.

There are thirty-eight customs districts (see Figure 83) in the U.S. and only four along the border between the U.S. Mexico. These four districts are South Texas/Laredo, West Texas N. Mexico/El Paso, Arizona/Nogales, and South California/San Diego. Each district is identified with two digits (e.g., the Laredo district code is 23), and each district contains several ports. This aggregation of ports is very important. For example, the district of South Texas/Laredo contains the following border ports: Laredo, Brownsville, Hidalgo, Eagle Pass, Del Rio, Progreso, Rio Grande City, and Roma. Each of these ports is identified with four digits; the first two correspond to the district and the last two to the city (e.g., the Brownsville code is 2301).

Import Country of Origin and Export Country of Destination

The destination country is the country where the merchandise is to be consumed or processed, or it is the ultimate destination of the shipper at the moment of the shipment. The country of origin is where the merchandise is produced or processed. When this cannot be determined, the origin is said to be the country of shipment (which results in data limitations).

Mode of Transportation

"The data for all modes of transportation include exports and general imports by vessel, air, truck, rail, air mail, parcel post, and other methods of transportation. The data for vessel and air exports and general imports represent waterborne and airborne shipments only (merchandise actually leaving or arriving in the U.S. aboard a vessel or an aircraft). Imports and exports of vessels moving under their own power or afloat and aircraft flown into or out of the U.S. are included in the "all methods" data but excluded from the vessel and air statistics"(Ref 55). Thus, there is no modal split between truck and rail or pipeline.

Shipping Weight

The shipping weight represents the gross weight in kilograms of the shipments, including containers, wrapping, moisture, crates, and boxes. This information is available only for air and sea shipments. The total weight exported or imported by all modes is not available.

In summary, the information available in the data set includes

- Two-digit district data classification
- Ten-digit HTSU.S.A or Schedule B commodity classification
- Total value
- Air value
- Vessel value
- Air weight
- Vessel weight

Customs Port Data

The U.S. Department of Commerce also provides these data by special request. The data are basically the same as the import and export data except for two important differences:

- The data set contains the four-digit custom port data. This means that data can be broken down at the district and port level, e.g., we can know the total amount shipped through the Laredo district (as with the Commerce Data) as well as through Brownsville, Hidalgo, Laredo, and other towns.
- Commodity data are provided with five-digit SITC codes. This classification code has been adopted by the United Nations and is fully described in "Standard International Trade Classification, Revision 3." (Ref 54). While SITC codes can be converted into HTSU.S.A code, the procedure is not straightforward. The HTSU.S.A code is more extensive than the SITC. It is possible to convert a HTSU.S.A classification into SITC; however, when data move from SITC to HTU.S.A some data remain undetermined. The aggregation of the data into a smaller number of digits reduces the indetermination. At two digits (HTSU.S.A.), the indetermination is hardly significant for most commodities.

The rest of the information contained in this data set has the same meaning as described for export and import data. Concluding the data contained are:

- Four-digit port data classification
- Five-digit SITC commodity classification
- Total Value
- Air Value
- Vessel Value
- Air Weight
- Vessel Weight

BUREAU OF TRANSPORTATION STATISTICS DATA

Transborder Surface Data

The BTS has been publishing the TSFD since April 1993. The data are published for each month, usually with a delay of five to six months between the data collection and their publication. The Mexico-U.S. data are contained in six monthly files available for free from BTS via the Internet or CD-ROM.

Although the TSFD is published by BTS, the provider of the data is the Department of Commerce through the Census Bureau, which furnishes the data. The source of the data is either import or export paper documents collected at the port of entry/exit or those collected electronically through the ABI.

BTS says that, “The TSFD includes all the shipments entering or exiting U.S. by surface modes of transport: truck, rail, pipeline, mail, and other” (Ref 51). “Shipments which neither originate nor terminate in the United States (i.e., intransits) are beyond this data set because they are not considered U.S. international trade shipments” (Ref 51).

Changes in the Data set

Changes introduced in the data set beginning in 1993 have improved its accuracy. The following are the main changes in the data set (Ref 51):

- April 1994: Commodity detail and geographic detail increased
- April 1995: The shipping weight for Mexican imports was added
- January 1996: The shipping weight for transhipments through water was added
- January 1997: Transshipments through a third country were removed. Some additional inland ports were identified.

File Detail

For U.S. exports to Mexico it is possible to obtain the following information for the following categories:

- Exports to Mexico with U.S. state of origin and commodity detail: mode of transportation, commodity classification at the two-digit level, U.S. origin state, Mexican state of destination, value, month, and year (file D3A)
- Exports to Mexico with U.S. state of exporter and commodity detail: mode of transportation, U.S. state of exporter, Mexican state of destination, commodity classification, and value (file D3B).
- Exports to Mexico with U.S. state of origin and geographic detail: mode of transportation, U.S. state of Origin, U.S. port of export, and Mexican state of destination for value, by month since April 1994 (file D5A).
- Exports to Mexico with U.S. state of exporter and geographic detail: mode of transportation, National Transportation Analysis Region (NTAR) of Exporter, U.S. port of Export, and Mexican state of destination for value, by month since April 1994 (file D5B).
- Imports from Mexico with commodity and geographic detail mode of transportation, U.S. destination state, commodity information, value, weight, and container information (file D09).
- Imports from Mexico with geographic detail, mode of transportation, U.S. destination state, U.S. port of import, value, weight, and container information (file D11).

Note:

- In the case of U.S. imports, there is no information regarding the Mexican state of origin.
- Files 3B and 5B have an exporter state and NTAR of exporter, instead of origin of the shipment. For that reason they will not be considered in the analysis.
- Weight and container information is available only for imports.

Data Detail

The following is a description of the list contained in the six files.

- Mode of Transportation: truck, rail, pipeline, mail, other. Aircraft and vessels moving under their own power but not carrying cargo are included in "other," as are electricity, pedestrians carrying freight, and unknown modes. For imports, foreign trade zones are also included.
- Commodity code: two-digit Harmonized Tariff Schedule of the United States Annotated (HTSU.S.A.) commodity classification number for imports. Two-digit Schedule B, Statistical Classification of Merchandise Exported from the United States for exports. Even though these two classification systems are different, at the two-digit level they are essentially equal. These data should match commerce import and export data at the two-digit commodity level.
- Origin of U.S. exports:
  - State from which the shipment starts its journey to the port of export
  - State of the U.S. exporter who is responsible for initiating the export shipment
  - NTAR of the exporter's address
- Mexican state of destination (only for U.S. exports): the Mexican state in which the ultimate consignee is located.
- Destination of U.S. imports: the U.S. state of destination is taken from the importer's address.
- District and port of entry: the customs port where the entry documentation was filed with customs and the duties were paid.
- District and port of export: the customs port where the shipment is cleared for export.
- Value: for imports, it is the customs value or the value of merchandise for duty purposes. For exports, it is the value of the merchandise, usually the selling price plus insurance and freight, at the U.S. port of export. This excludes the cost of loading the merchandise aboard the exporting carrier; freight; insurance; and any charges or transportation costs beyond the U.S. port of exportation.
- Charges (for U.S. imports only): the cost of freight and insurance from the origin in Mexico to the U.S. border.
- Container code (for import data only): containerized and non-containerized shipments for truck and rail can be disaggregated.

- Shipping weight (for U.S. imports only): the gross weight of shipments in kilograms, including packing.
- Statistical month: the month and year when the goods entered or exited the U.S.

MEXICAN DATA

As in the U.S., Mexican data are mostly gathered by customs, though they are not as accessible as U.S. data. There are no regular publications or files with significant transportation data available for purchase. Obtaining data from Mexican agencies could be a difficult and time-consuming process. As stated in the binational study, “This information is not available to the public, not necessarily because it is confidential, but because the sources do not normally process it for publication. As a result, the acquisition of statistical information in a usable form required more effort” (Ref 1)

A unique characteristic of the Mexican data is the fact that Mexican officials distinguish between usual trade and maquiladora trade. Maquiladora trade is a very important component of U.S.-Mexico trade and has special characteristics (as discussed in another appendix). For some border ports, maquiladora trade accounts for more than 90 percent of the total trade. U.S. Customs does not publish any data on maquiladora trade; thus the only sources available for these data are from Mexico.

The commodity data are provided at the two-digit HTSHTS level and therefore can be compared with BTS and Commerce data. The Mexican state of exportation was obtained from the address of the exporter. In a similar fashion, the Mexican state of importation was obtained from the address of the importer. This may lead to an over-representation of Mexico City because many companies are headquartered there.

The information available for imports and exports for 1995 includes the following:

- Mexican state of destination, total value, and port of importation
- Mexican state of origin, total value, and port of exportation
- Commodity at the two-digit-level HTS, mode of transport, and value

The information is provided for general trade and for maquiladora trade. Unfortunately, the origin-destination data are aggregated for all modes of transport (including air, sea, and land). It is not possible to build an origin-destination matrix because data about U.S. states are not reported. Only a matrix between Mexican states and Mexican ports for all modes of transportation can be built.

APPENDIX 2. PORT AND STATE TRADE BY COMMODITY

PORT OF LAREDO

In Laredo, the transport equipment moving through the port makes up 36 percent of the trade, much of which is by railroad. Industrial machinery, chemicals, and plastics are also important. Laredo is the only large port where electrical machinery does not have the highest trade value.

Another important characteristic of the port of Laredo is the destination of the commodities. Long-distance movements characterize this port. It is important to note that the percentage of maquiladora trade is very small.

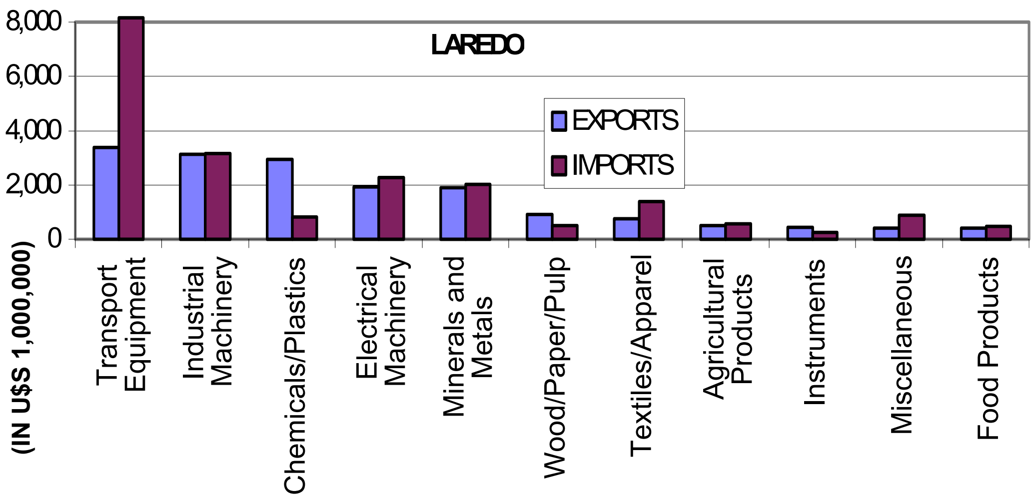


Figure 84. Commodity Groups (Laredo 1996).

PORT OF EL PASO

Unlike Laredo, El Paso (second port by value) has an important maquiladora influence, and the railroad is almost insignificant. Electrical machinery clearly prevails with 50 percent of the trade.

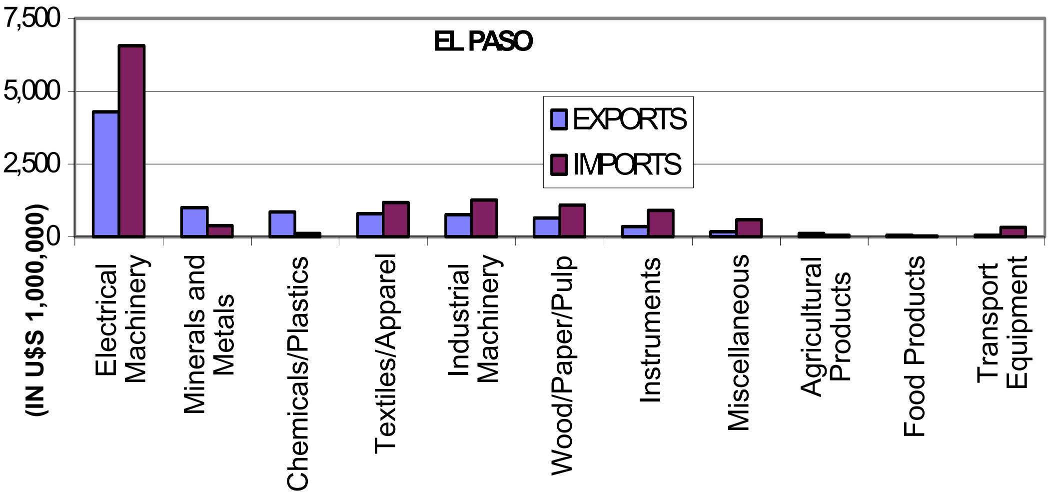


Figure 85. Commodity Groups (El Paso 1996).

PORT OF SAN YSIDRO

The port of San Ysidro is the third-largest port and the most important on the West Side. San Ysidro has an important maquiladora influence, especially in the electric machinery sector, which accounts for almost 41 percent of the total trade.

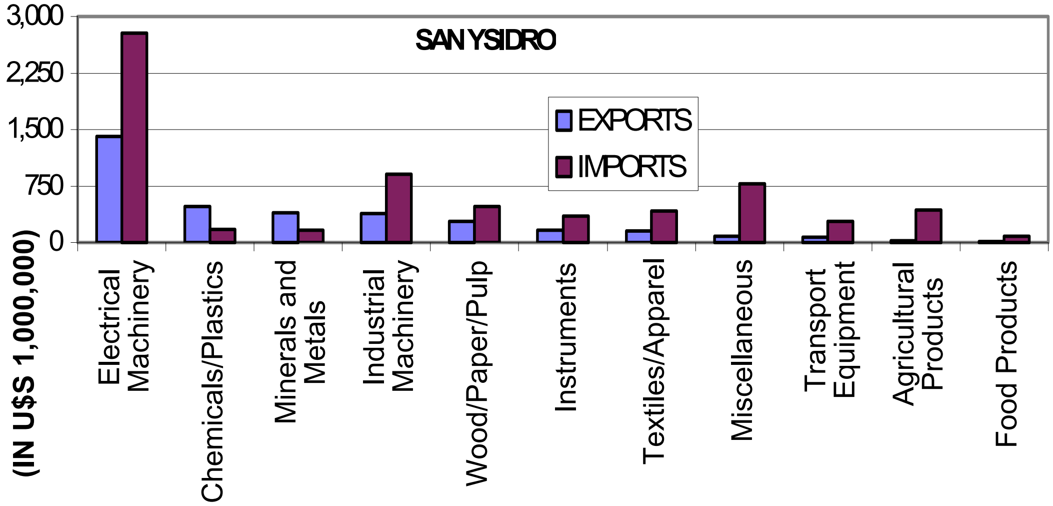


Figure 86. Commodity Groups (San Ysidro 1996).

PORT OF BROWNSVILLE

The port of Brownsville is located on the Gulf of Mexico and is another important maquiladora port. Electrical machinery is the largest commodity by value, capturing 44 percent of the trade. Chemicals/plastics and minerals/metals are also important.

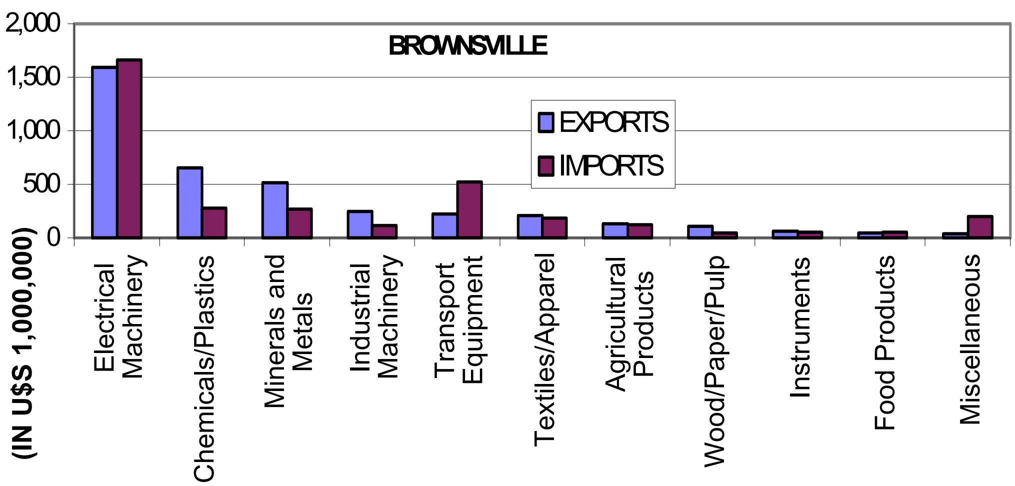


Figure 87. Commodity Groups (Brownsville 1996).

PORT OF NOGALES

The port of Nogales has the characteristics of a port where maquiladora trade is somewhat important. Northbound agricultural products are very important, as are transport equipment and electrical machinery. Nogales presents unbalanced trade in several commodity groups: agricultural products, transportation equipment, chemicals/plastics, and electrical machinery.

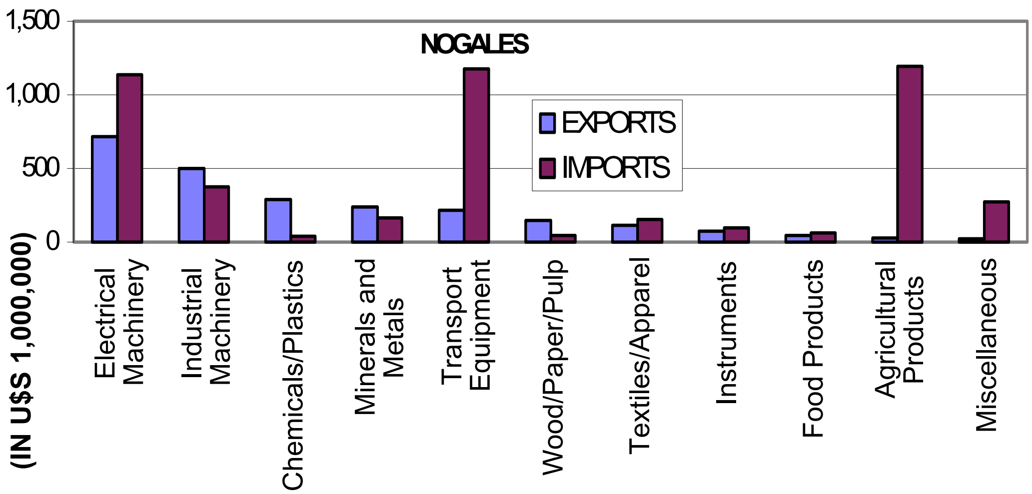


Figure 88. Commodity Groups (Nogales 1996).

PORT OF HIDALGO

The port of Hidalgo is fourth in value in Texas. This is also a maquiladora port, with an important share of the electrical machinery trade. There are substantial northbound movements for instruments, agricultural products, and apparel. Like Nogales, Hidalgo shows significant imbalances between northbound and southbound trade in agricultural products, instruments, and transport equipment.

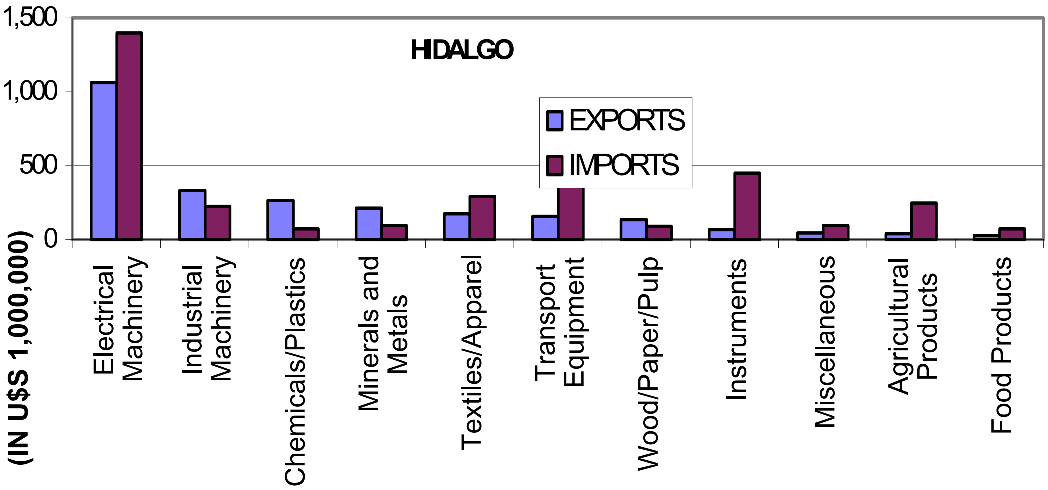


Figure 89. Commodity Groups (Hidalgo 1996).

PORT OF EAGLE PASS

Eagle Pass is the only port where the railroad moves the highest share of trade. Trade at Eagle Pass has many characteristics in common with Laredo. As in Laredo, transport equipment is the most important commodity group; railroad has a significant participation; electrical machinery does not have the highest trade value; maquiladora trade is not dominant; and long-distance movements dominate the trade. However, trade values are considerably smaller than they are in Laredo, as are the numbers of trucks crossing.

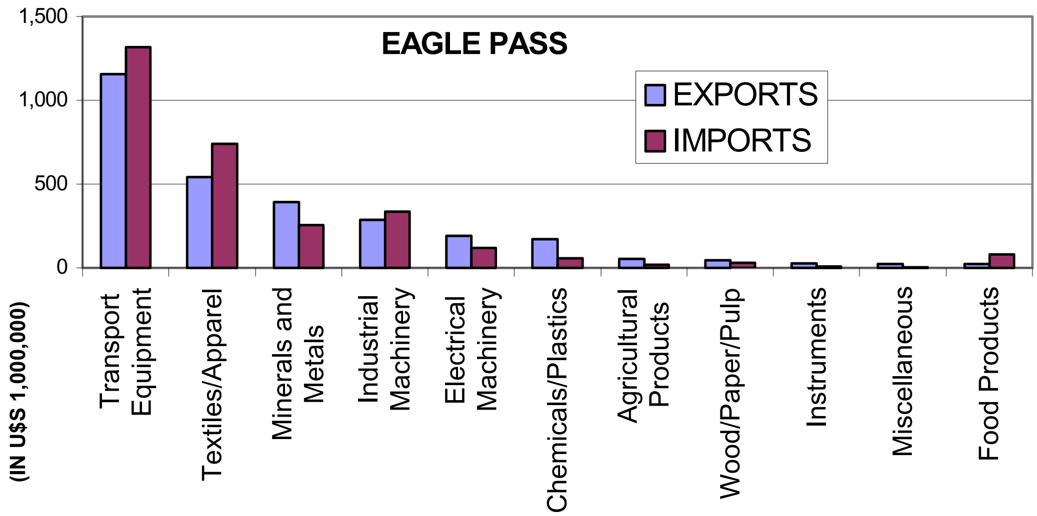


Figure 90. Commodity Groups (Eagle Pass 1996).

TEXAS

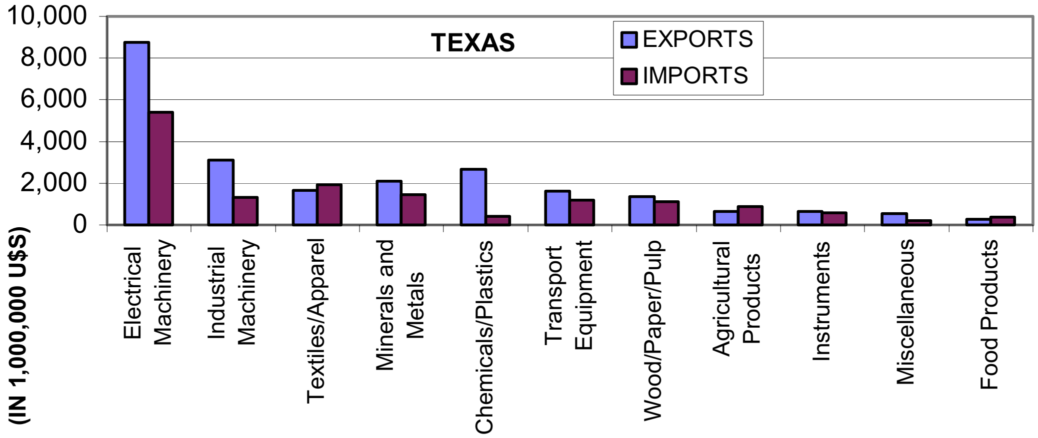


Figure 91. Commodity Groups (Texas 1997)

CALIFORNIA

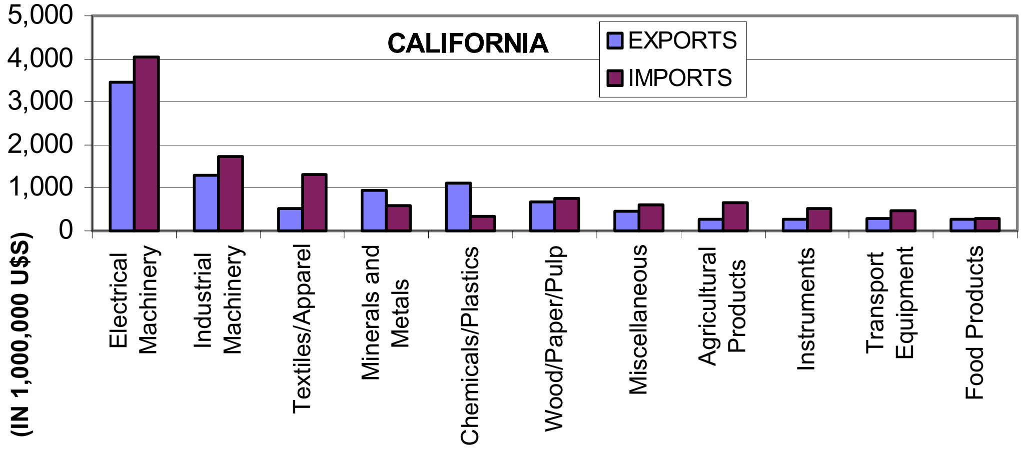


Figure 92. Commodity Groups (California 1997).

MICHIGAN

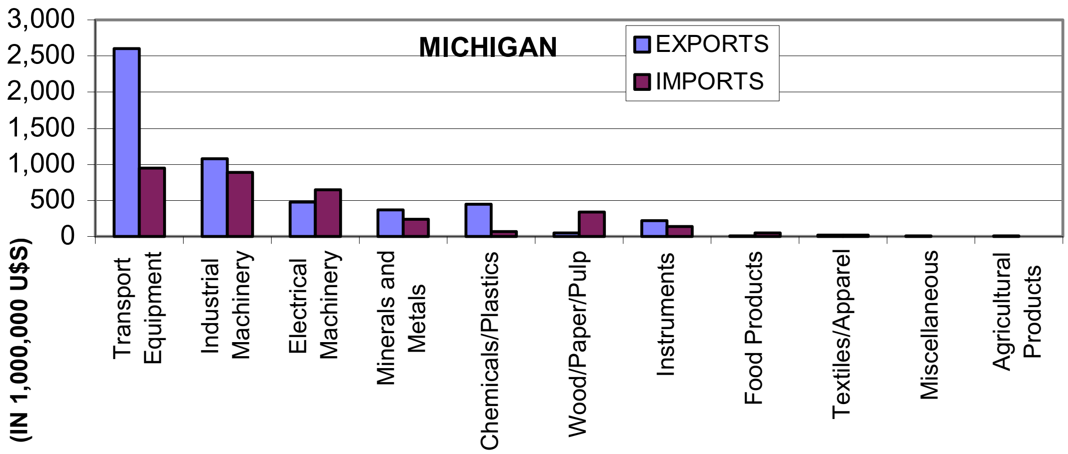


Figure 93. Commodity Groups (Michigan 1997).

ARIZONA

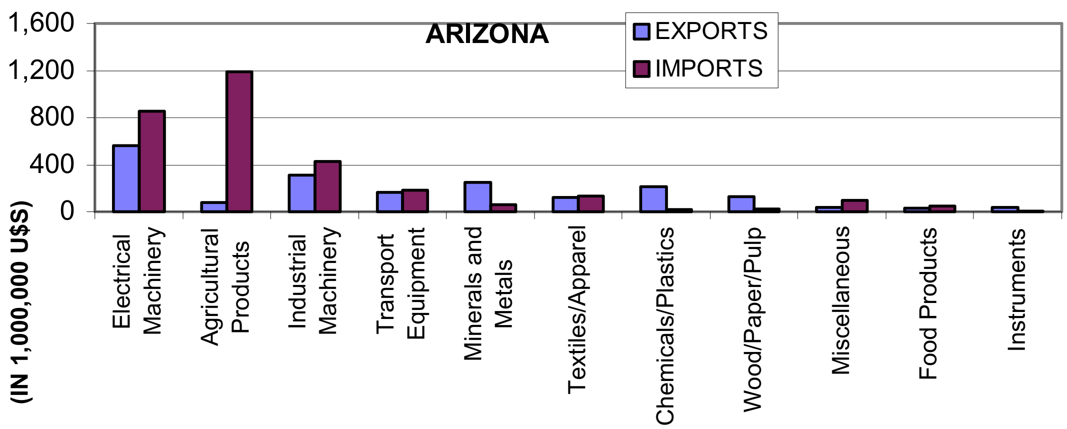


Figure 94. Commodity Groups (Arizona 1997).

NORTH CAROLINA

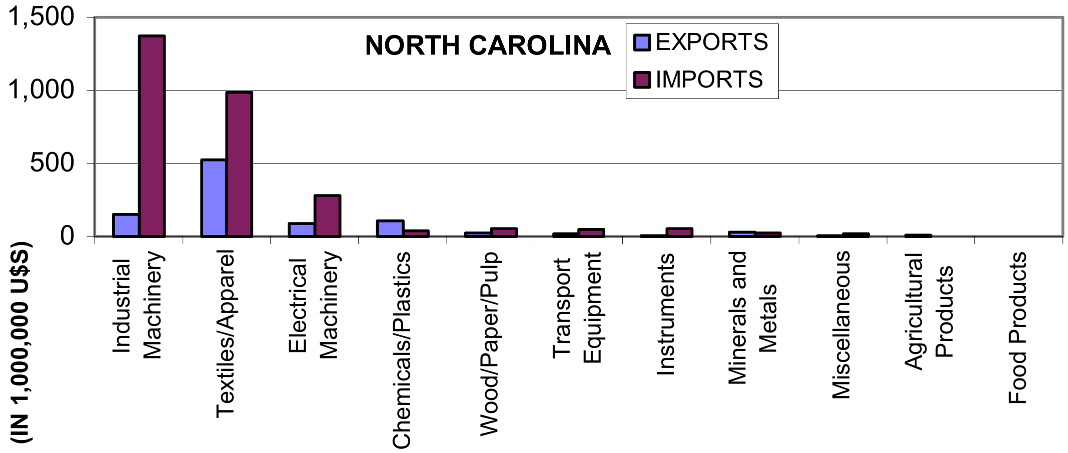


Figure 95. Commodity Groups (North Carolina 1997).

OHIO

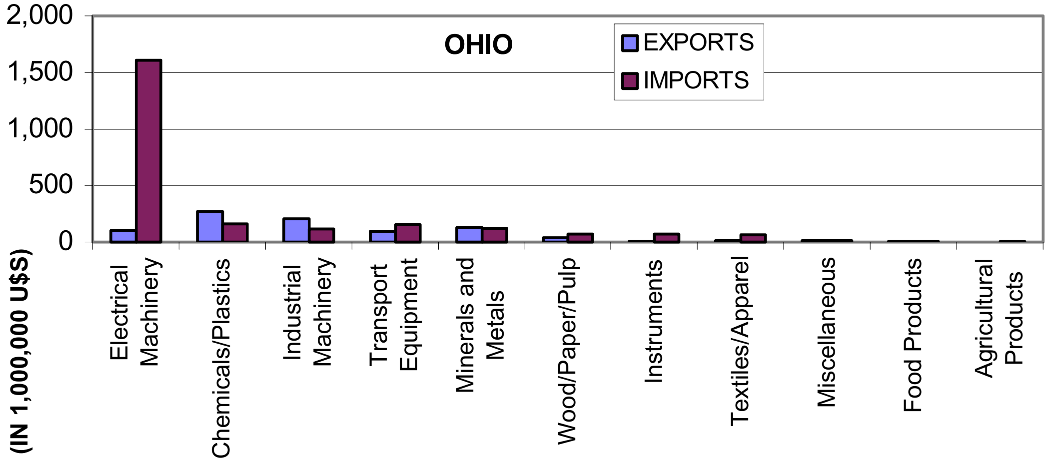


Figure 96. Commodity Groups (Ohio 1997).

APPENDIX 3. MAQUILADORA INDUSTRY

INTRODUCTION

An important aspect of U.S.-Mexico trade is the maquiladora industry. Maquiladoras, also known as "twin plants" or "in-bond companies," are Mexican assembly or manufacturing plants that produce products mainly for exports and that operate under special provisions of both Mexican and American law. Mexico allows duty-free imports of equipment for manufacturing and components for assembly in bond (Refs 40, 42). In return, a certain percentage of the plant's total production has to be exported to the U.S. The limit has been decreasing since the signing of NAFTA in December 1993. In 1994, only 20 percent of the maquiladora output could be sold in Mexico; today the limit is set at 75 percent of the output (Ref 46). Maquiladora products assembled in Mexico and imported into the United States pay duties only on the value added in Mexico.

In addition to providing the important tax reduction, the maquiladora industry is competitive because it offers Mexico's lower labor wages but in close proximity to the U.S. market. Labor-intensive manufacturing and assembly operations found in maquiladoras substantially reduce costs. The proximity to the U.S. market translates into lower transportation costs and travel times than are offered by Asian maquiladoras.

From a transportation point of view, it is very important that most of the maquiladora trade move by surface modes, especially by truck. The importance of maquiladoras in trade is evident. In 1995 maquila trade accounted for 65.7 percent of northbound trade and 58.8 percent of southbound trade (data source: SECOFI-La Empresa). Because of the growth of maquiladora employment in the period from 1994 to 1998 and the increase of northbound trade, this percentage may be higher now.

HISTORY OF THE MAQUILADORA INDUSTRY

The maquiladora program began in 1965. The objective of the program was to attract investments and generate employment in the border zone. In the first seventeen years of the program the development of maquilas was slow. The cheap labor force in places like Taiwan, South Korea, and Singapore reduced the international competitiveness of the Mexican labor force. After the devaluation of the Mexican peso in 1983, the maquiladora industry received an important boost. Since then, the maquiladora industry has followed the same ups and downs of the Mexican economy. The maquila industry has experienced important growth and change in the last 16 years. The evolution of total employment (Figure 97) shows four different periods. From 1980 to 1983, there was a slow annual growth of 3.1 percent. This was followed by an important growth from 1983 to 1989. Devaluation of the Mexican peso in 1983 made the maquiladora more competitive and boosted the growth of employment. The annual growth rate during 1983 to 1989 was 21.1 percent. During the next five years, from 1989 to 1994, there was a slowdown in growth, with the average annual growth being 6.8 percent. From 1994 to the present there has been an important growth of 15.1 percent. The signing of NAFTA in December 1993 certainly helped this increase. Another peso devaluation in 1994 also boosted the maquilas. The current outlook for maquiladoras is positive, since the Mexican peso lost value against the American dollar in 1998 (Ref 46). The latestt statistics show maquila employment reaching one million. Today the maquiladora industry has not only become a very important source of employment, but has also replaced oil exports and tourism as Mexico's main source of foreign currency.

Employment data presented in Figure 97 to Figure 100 were obtained from the Mexican agency in charge of official statistics, INEGI (Ref 49).

CHARACTERISTICS OF MAQUILADORA TRADE

International trade movements usually take place between production centers and consumption centers (generally large or important cities). Trade comprises either finished goods or intermediate goods consumed or processed for the domestic market.

Maquiladora trade is a double-directional trade in the sense that raw or intermediate goods go southbound, and, after a labor intensive manufacturing process, they are mostly shipped back north.

The destination of the maquiladora output depends on the product and its degree of completion. Three basic alternatives may exist:

1. The product is ready for consumption and goes to a final consumption center.
2. The manufacturing is almost completed at the maquiladora, and the process is finished in a plant located in the U.S. and close to the border (a twin plant).
3. A substantial part of the manufacturing process has to be finished in a U.S. industrial plant.

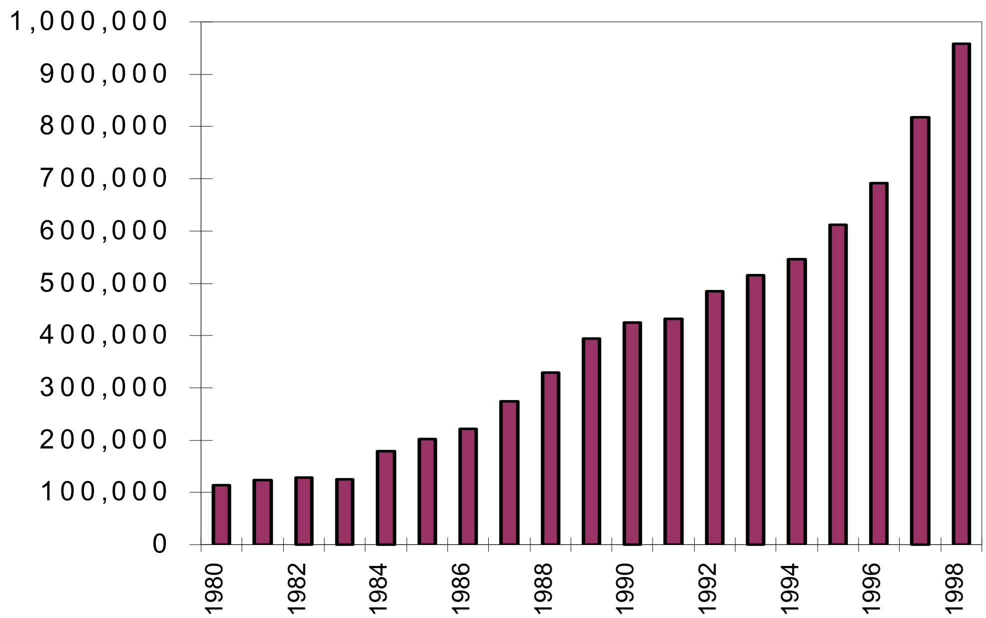


Figure 97. Total Maquiladora Employment (1980-1998).

This type of operation obscures the study of U.S.-Mexico trade. This is aggravated by the absence of Mexican origin- and U.S. destination data for northbound movements. There is also a lack of research regarding maquiladora output destinations. Truck survey results on Texas port bridges with origin-destination data in the border area are contained in Ref 8. These data correspond to those collected in 1992 and encompass only the border city area (origins or destinations outside the border city are not specified).

Most maquiladoras acquire the majority of their supplies from U.S. sources; less than 2 percent are purchased locally (Ref 40). According to a survey of 128 maquiladora factories adjacent to Laredo, Eagle Pass, and Del Rio, these plants purchase the following (Refs 40, 43):

- Raw maquilas primarily from nonborder suppliers
- Industrial supplies from border cities
- Services from the closest city

However, for maquiladoras located in the interior of Mexico, the percentage of local suppliers is higher (some studies show that maquiladoras n Monterrey buy 20 percent of locally made supplies, compared with the 5 percent that are purchased by maquiladoras at the border) (Refs 1, 5).

LOCATION OF MAQUILADORAS

In the beginning most maquiladoras were located in the San Diego-Tijuana area; later, because of a shortage of labor and high land costs, maquiladoras began to appear along the Texas-Mexico border (Refs 1, 4). Several logistical and strategic reasons contributed to this:

- Easy access to U.S. materials and market
- Low transportation costs
- Easy access to U.S. infrastructure
- Opportunity for executives to live in the U.S.

Nonborder state maquiladoras have grown significantly in the 90s. Figure 98 shows a trend toward more nonborder maquiladora employment. Maquiladoras located in the interior of Mexico have grown faster than border state maquiladoras during the period from 1980 to 1998 (2,756 percent). Coahuila and Baja California (1,068 percent and 936 percent) have also grown more than the Mexican national average (741 percent). At the present time (1998), the percentage of nonborder employment has reached almost 20 percent. The interior location has several advantages:

- More stable and better educated labor force
- Lower wages
- Superior infrastructure
- Stronger local supplier base

Maquiladora growth in nonborder states can be attributed to the Mexican government allowing an increase in the percentage of sales in the domestic market. In a complete free market, maquiladoras will be allowed to sell 100 percent of their products in Mexico, but they will no longer enjoy duty or tax exemptions. The complete liberalization of the maquiladora quota will be reached in the year 2001.

Although Mexican transportation infrastructure has substantially improved in recent years, it still remains an obstacle to a seamless binational industrial operation. The cost of Mexican toll roads is also high, and many truckers prefer not to use them (Ref 46).

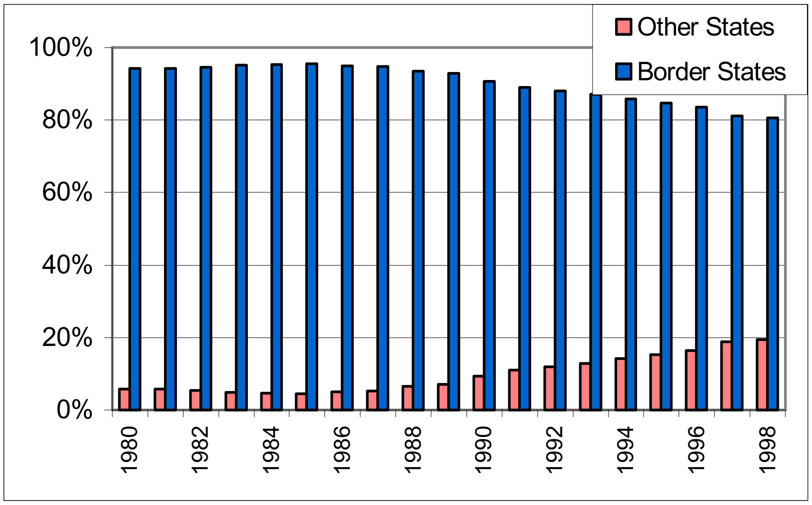


Figure 98. Maquiladora Border And Nonborder Employment.

The most important concentration of maquilas is found in Chihuahua. In 1997, Chihuahua had 28.3 percent of the total maquila employment; this value was down from a peak of 44 percent in 1986 (Figure 99). Baja California follows with 21.1 percent.

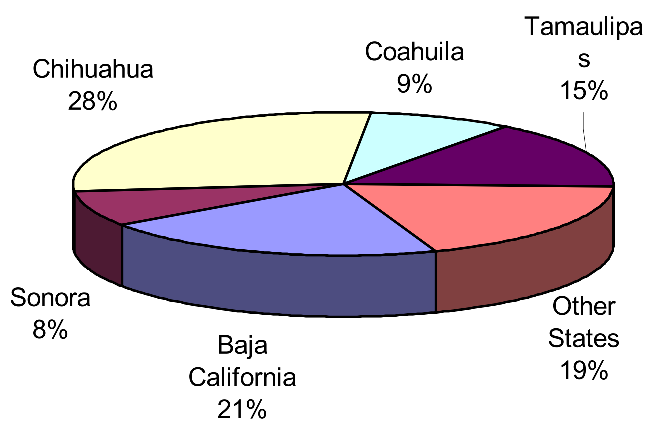


Figure 99. Maquiladora Employment By State (1997).

The geographic distribution may be more precise if it is shown by “municipio," the equivalent of a metropolitan area in the U.S. Ciudad Juarez, El Paso’s “neighbor city,” is the biggest maquila city by employment with 23 percent of the total. Tijuana, San Diego’s neighbor city, follows with 15 percent. Matamoros (Brownsville) and Reynosa (Hidalgo) follow with 6 percent and 5 percent. Nuevo Laredo, Laredo’s “neighbor city,” accounts for only 2 percent of the maquila employment.

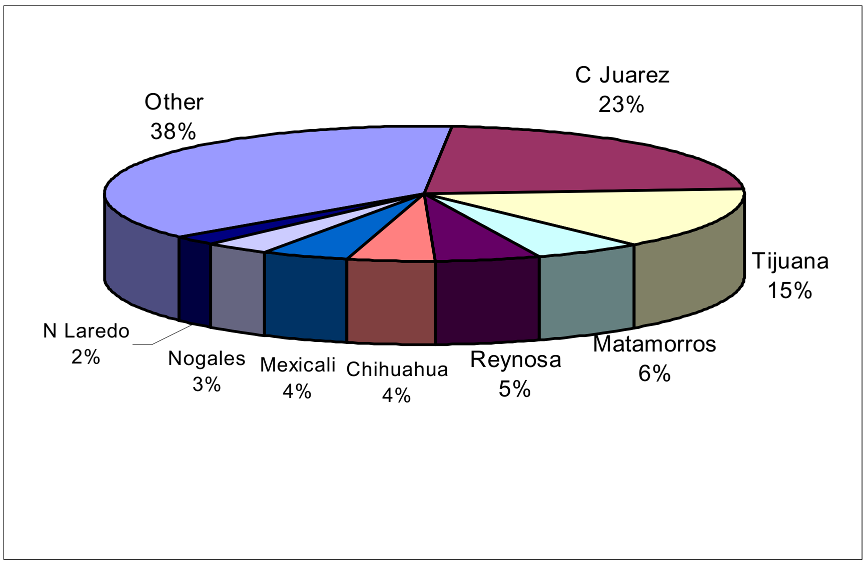


Figure 100. Maquiladora Employment By Municipio (1997).

MAQUILADORA EMPLOYMENT BY INDUSTRY

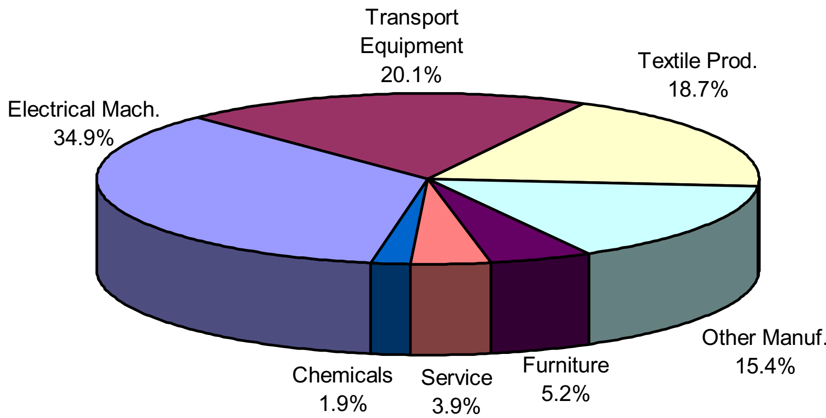


Figure 101. Maquiladora Employment By Industry (1997).

Electrical machinery is the most important group and also the commodity group that accounts for the highest trade value. Manufacturing employment is also high. Electrical machinery, transportation equipment, and textile production make up 73.7 percent of the total employment. Service employment accounts for only 3.9 percent of the maquiladora employment (Figure 99).

U.S. Employment in the Border Zone

The transition between Mexican and U.S. economies takes place in the border zone. The per capita personal income and average annual salary in the border region rank among the lowest in the U.S. (Ref 45). This situation has attracted labor-intensive manufacturers such as apparel and food-processing industries. Census employment data (1995) show that textile and apparel industries account for half of the manufacturing employment in the border region and around half of the Texas employment in the sector.

The actual trucking practices used to cross the border are also reflected in the employment statistics. Employment in transportation services is significant in the border zone compared with Texas's total employment in the sector (25 percent), while wholesale employment is an important source of jobs in the region.

According to projections by the Texas comptroller of public accounts (Ref 45), there will be a shift in the labor force in the next 20 years. With the consolidation of NAFTA, employment in the Texas border region will go from manufactured nondurable goods (food and apparel) to the production of manufactured durable goods such as televisions and automobiles. Most of the new production will be related to the production of parts for maquiladoras on the other side of the border. Actual employment in textiles and food will go south of the border, where cheaper labor force conditions will prevail in the near future.

FUTURE OF THE MAQUILADORA INDUSTRY

The next few years may bring an important transformation to the maquiladora industry and, subsequently, to the demand on the transportation system. The implementation of NAFTA will change the regulatory framework of maquiladoras. Maquiladoras are scheduled to lose tax benefits in 2001, when import duties in U.S.-Mexico trade will be at their smallest. Maquiladoras will have the same benefits as a plant located in the interior of Mexico.

This situation may lead to an increasing number of maquiladoras in nonborder states. This in turn may increase the percentage of purchases made in Mexico and the consumption of local supplies, decreasing the movement of raw materials and components into Mexico from the U.S.

Some maquiladoras are pressuring their Asian supplier to switch to North American-based alternatives (Ref 48). This would reduce the imports of non-NAFTA products that now enjoy some duty drawback provisions that would end in 2001. If the supplier is forced to move to North America in order to enjoy tax benefits, the movement of goods across the border may increase. The location of new suppliers may be along the border region or in the interior of Canada or the U.S. This will certainly increase maquiladora trade between Mexico and the U.S.

Future maquiladoras will be located where companies will find the lowest cost and highest efficiency for their operational and strategic needs. These will vary from maquiladora to maquiladora and will depend on the company's products and market. Some issues that are common to all companies are:

- Physical infrastructure: the condition, user costs, and connection of the Mexican transportation system to the U.S. system.
- Proximity to suppliers and consumers: products oriented only to the U.S. or Canadian markets would tend to be located close to the border.
- Legal and tax considerations: NAFTA provisions regarding imports, local and state tax benefits, and trucking regulations.

- International conditions: the value of Mexican currency compared with Asian currency may determine the location of maquiladora plants.

IMPORTANCE OF THE MAQUILADORA INDUSTRY IN U.S.-MEXICO TRADE

Maquiladora trade data are only available from Mexican authorities. SECOFI collects the data. La Empresa, a Mexican consulting firm that participated in the U.S.-Mexico binational study, provided these data to The University of Texas at Austin. The data presented in these points correspond to those from 1995. Data presented in Figure 102 to Figure 109 are based on this data set.

COMMODITIES

Figure 102 and Figure 103 show the importance of the maquiladora industry by commodity group and the importance of the group in total trade. Electrical products not only have the highest trade volume but also have the highest proportion of maquiladora trade. Apparel products are also important.

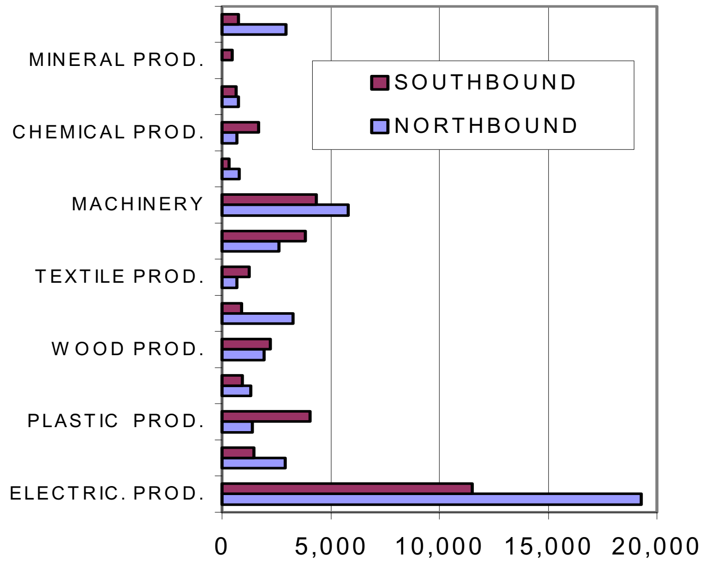


Figure 102. Trade In Millions By Commodity (Highway, 1995).

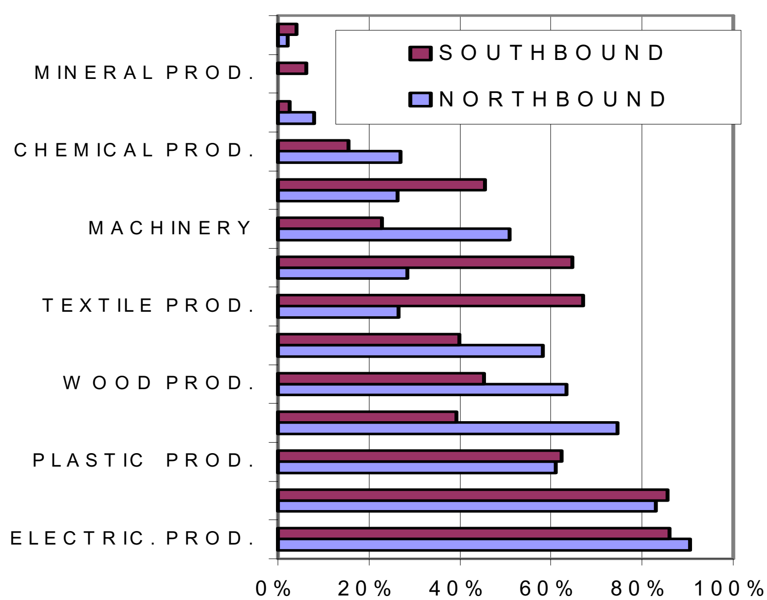


Figure 103. Maquiladora Share By Commodity (Highway, 1995).

The shares of maquiladora products in textiles, metals, stone, ceramic, and glass are significantly higher for southbound movements than for northbound movements. These are raw or intermediate goods used for other sectors such as the textile industry, transportation equipment, and machinery, which show a higher proportion of the northbound maquiladora share. In general, commodities where assembly operations may take place show a higher share of the northbound maquiladora goods. On the other hand, commodities where assembly or manufacturing is not important show a very low maquiladora participation. Food, mineral, and agricultural products fall into this category.

Table 62. Commodity And Maquiladora Participation In The Trade

COMMODITY	HIGH	MEDIUM	LOW
Electric Machinery	X		
Apparel	X		
Plastics	X		
Instruments	X		
Wood Products (paper, furniture)	X		
Transport Equipment	X		
Textile Products		X	
Metal Products		X	
Machinery		X	
Chemicals		X	
Stone, Glass, Ceramics		X	
Food Products			X
Minerals			X
Agricultural Products			X

PORT AND MAQUILADORA TRADE

Figure 104 and Figure 105 display data comparing port trade volumes and percentages of maquiladora trade. It is clear that the most important port, Laredo, has non-maquiladora trade. This is confirmed when the geographic distribution of Laredo's trade is mapped. Most of the trade that goes through Laredo is for a nonborder state. The other ports, headed by El Paso in Texas and San Ysidro/San Diego in California, have a sizeable maquiladora influence. This fact will translate to high trade with border states (where more than 80 percent of the maquiladora employment is located).

Nogales is the only port that shows an important difference between the southbound and northbound maquiladora shares. This difference is explained by the important northbound flow of agricultural products, which reduces the northbound maquiladora share.

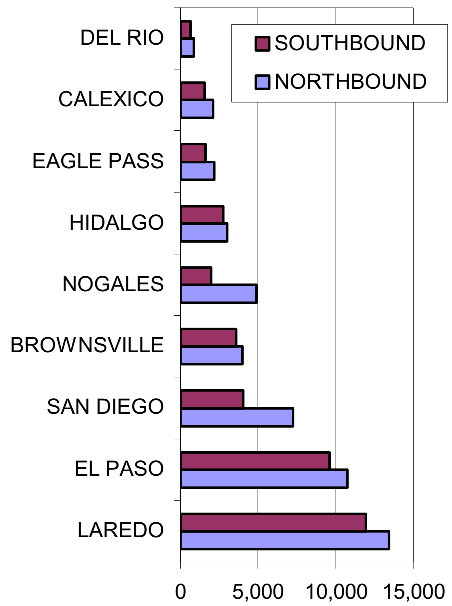


Figure 104. Trade By Port (Highway, 1995).

Figure 106 and Figure 107 show the participation of Mexican states in trade and their maquiladora proportion. Again, border states show a high maquiladora share, and nonborder states, such as Mexico City, Mexico State, and Jalisco (states with the biggest concentrations of industrial and consumption centers in Mexico), show very low maquiladora participation. Nuevo Leon's maquiladora participation is neutralized by a heavy industrial concentration in Monterrey.

Table 63. Port And Maquiladora Participation In The Trade

COMMODITY	HIGH	MEDIUM	LOW
El Paso	X		
San Diego	X		
Brownsville	X		
Hidalgo	X		
Del Rio	X		
Nogales		X	
Eagle Pass		X	
Laredo			X

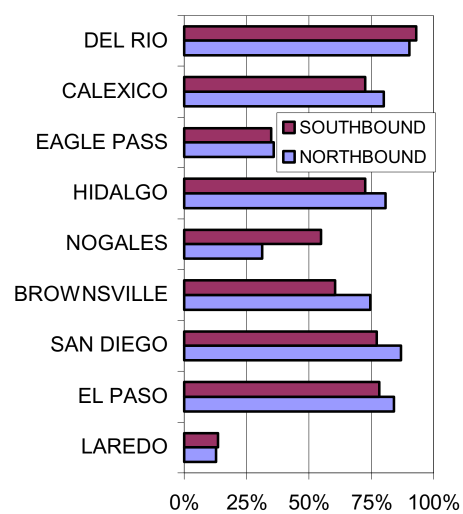


Figure 105. Maquiladora Share By Port (Highway, 1995).

Table 64. Mexican State And Maquiladora Participation In The Trade

COMMODITY	HIGH	MEDIUM	LOW
Tamaulipas (*)	X		
Baja California (*)	X		
Chihuahua (*)	X		
Coahuila (*) Sonora (*)	X		
Nuevo León (*)		X	
Jalisco			X
Federal District			X
Mexico State			X

(*) Border States

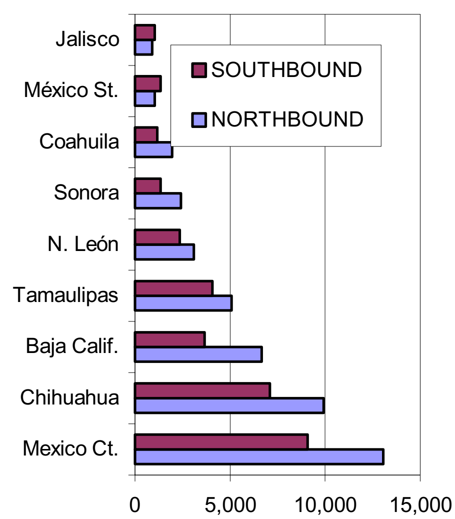


Figure 106. Trade By Mexican State (Highway, 1995).

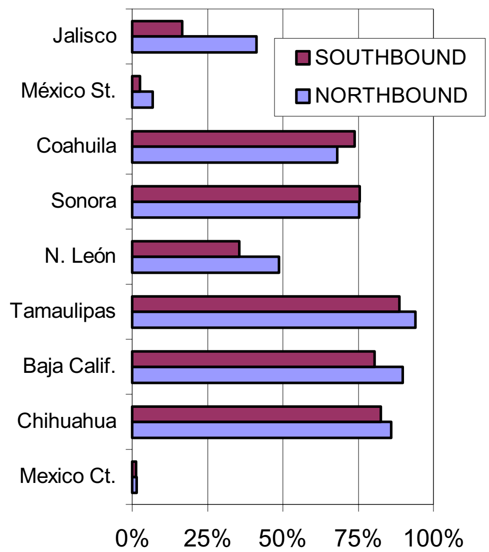


Figure 107. Maquiladora Share By Mexican State (Highway 1995).

MAQUILADORA AND RAILROAD TRADE

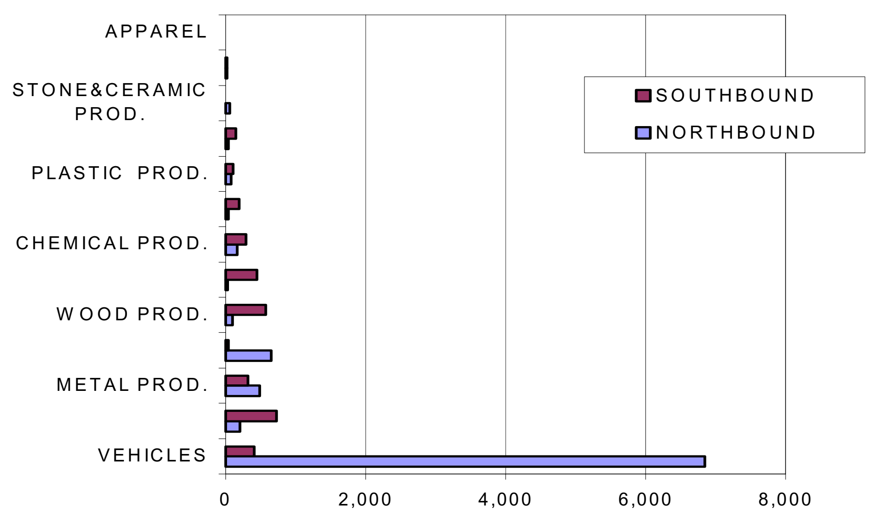


Figure 108. Commodity Trade (Railroad 1995).

Maquiladora trade moves mostly by highway. The participation of the railroad is not important, as shown in Figure 108 and Figure 109. This may change if maquiladoras begin to locate in the interior of Mexico and if improvements are made in railroad performance at both sides of the border.

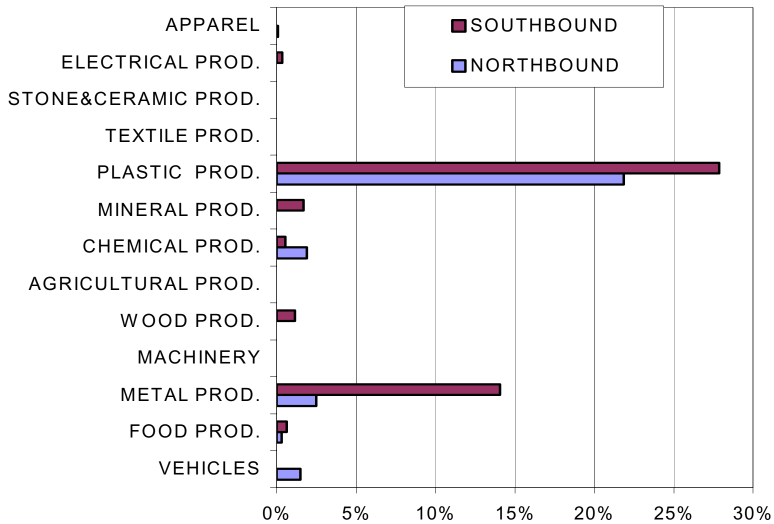


Figure 109. Commodity Share (Railroad, 1995).

APPENDIX 4. COMMODITY GROUPS BY TWO-DIGIT CHAPTER HTS

COMMODITY GROUP	CHAPTER	CHAPTER DESCRIPTION
Agricultural Products	01	LIVE ANIMALS
	02	MEAT AND EDIBLE MEAT OFFAL
	03	FISH AND CRUSTACEANS, MOLLUSCS AND OTHER AQUATIC INVERTEBRATES
	04	DAIRY PRODUCE; BIRDS EGGS; NATURAL HONEY; EDIBLE PRODUCTS OF ANIMAL ORIGIN, NOT ELSEWHERE SPECIFIED OR INCLUDED
	05	PRODUCTS OF ANIMAL ORIGIN, NOT ELSEWHERE SPECIFIED OR INCLUDED
	06	LIVE TREES AND OTHER PLANTS; BULBS, ROOTS AND THE LIKE; CUT FLOWERS AND ORNAMENTAL FOLIAGE
	07	EDIBLE VEGETABLES AND CERTAIN ROOTS, AND TUBERS
	08	EDIBLE FRUIT AND NUTS; PEEL OF CITRUS FRUIT OR MELONS
	09	COFFEE, TEA, MATÉ, AND SPICES
	10	CEREALS
Chemicals/ Plastics	28	INORGANIC CHEMICALS; ORGANIC OR INORGANIC COMPOUNDS OF PRECIOUS METALS, OF RARE-EARTH METALS, OF RADIOACTIVE ELEMENTS, OR OF ISOTOPES
	29	ORGANIC CHEMICALS
	30	PHARMACEUTICAL PRODUCTS
	31	FERTILIZERS
	32	TANNING OR DYEING EXTRACTS; TANNINS AND THEIR DERIVATIVES; DYES, PIGMENTS, AND OTHER COLORING MATTER; PAINTS AND VARNISHES; PUTTY AND OTHER MASTICS; INKS
	33	ESSENTIAL OILS AND RESINOIDS; PERFUMERY, COSMETIC, OR TOILET PREPARATIONS
	34	SOAP, ORGANIC SURFACE-ACTIVE AGENTS, WASHING PREPARATIONS, LUBRICATING PREPARATIONS, ARTIFICIAL WAXES, PREPARED WAXES, POLISHING OR SCOURING PREPARATIONS, CANDLES AND SIMILAR ARTICLES, MODELING PASTES, "DENTAL WAXES" AND DENTAL PREPARATIONS WITH A BASIS
	35	ALBUMINOIDAL SUBSTANCES; MODIFIED STARCHES; GLUES; ENZYMES
	36	EXPLOSIVES; PYROTECHNIC PRODUCTS; MATCHES; PYROPHORIC ALLOYS; CERTAIN COMBU.S.TIBLE PREPARATIONS
	37	PHOTOGRAPHIC OR CINEMATOGRAPHIC GOODS
	38	MISCELLANEOU.S. CHEMICAL PRODUCTS
	39	PLASTICS AND ARTICLES THEREOF
	40	RUBBER AND ARTICLES THEREOF

COMMODITY GROUP	CHAPTER	CHAPTER DESCRIPTION
Electrical Machinery	85	ELECTRICAL MACHINERY AND EQUIPMENT AND PARTS THEREOF; SOUND RECORDERS AND REPRODUCERS, TELEVISION IMAGE AND SOUND RECORDERS AND REPRODUCERS, AND PARTS AND ACCESSORIES OF SUCH ARTICLES
Food Products	11	PRODUCTS OF THE MILLING INDUSTRY; MALT; STARCHES; INULIN; WHEAT GLUTEN
	12	OIL SEEDS AND OLEAGINOUS FRUITS; MISCELLANEOUS GRAINS; SEEDS AND FRUIT; INDUSTRIAL OR MEDICINAL PLANTS; STRAW AND FODDER
	13	LAC; GUMS; RESINS AND OTHER VEGETABLE SAPS AND EXTRACT
	14	VEGETABLE PLAITING MATERIALS; VEGETABLE PRODUCTS NOT ELSEWHERE SPECIFIED OR INCLUDED
	15	ANIMAL OR VEGETABLE FATS AND OILS AND THEIR CLEAVAGE PRODUCTS; PREPARED EDIBLE FATS; ANIMAL OR VEGETABLE WAXES
	16	PREPARATIONS OF MEAT, OF FISH, OR OF CRUSTACEANS, MOLLUSCS OR OTHER AQUATIC INVERTEBRATES
	17	SUGARS AND SUGAR CONFECTIONARY
	18	COCOA AND COCOA PREPARATIONS
	19	PREPARATIONS OF CEREALS, FLOUR, STARCH, OR MILK; BAKERS WARES
	20	PREPARATIONS OF VEGETABLES, FRUIT, NUTS, OR OTHER PARTS OF PLANTS
	21	MISCELLANEOUS EDIBLE PREPARATIONS
	22	BEVERAGES, SPIRITS, AND VINEGAR
	23	RESIDUES AND WASTE FROM THE FOOD INDUSTRIES; PREPARED ANIMAL FEED
Industrial Machinery	84	NUCLEAR REACTORS, BOILERS, MACHINERY, AND MECHANICAL APPLIANCES; PARTS THEREOF
Instruments	90	OPTICAL, PHOTOGRAPHIC, CINEMATOGRAPHIC, MEASURING, CHECKING, PRECISION, MEDICAL OR SURGICAL INSTRUMENTS AND APPARATUS; PARTS AND ACCESSORIES THEREOF
	91	CLOCKS AND WATCHES AND PARTS THEREOF
	92	MUSICAL INSTRUMENTS; PARTS AND ACCESSORIES OF SUCH ARTICLES
	93	ARMS AND AMMUNITION; PARTS AND ACCESSORIES THEREOF
Minerals and Metals	25	SALT; SULFUR; EARTHS AND STONE; PLASTERING MATERIALS, LIME, AND CEMENT
	26	ORES, SLAG, AND ASH
	27	MINERAL FUELS, MINERAL OILS, AND PRODUCTS OF THEIR DISTILLATION; BITUMINOUS SUBSTANCES; MINERAL WAXES

COMMODITY GROUP	CHAPTER	CHAPTER DESCRIPTION
	68	ARTICLES OF STONE, PLASTER, CEMENT, ASBESTOS, MICA, OR SIMILAR MATERIALS
	69	CERAMIC PRODUCTS
	70	GLASS AND GLASSWARE
	72	IRON AND STEEL
	73	ARTICLES OF IRON OR STEEL
	74	COPPER AND ARTICLES THEREOF
	75	NICKEL AND ARTICLES THEREOF
	76	ALUMINUM AND ARTICLES THEREOF
	77	RESERVED FOR POSSIBLE FUTURE U.S.E
	78	LEAD AND ARTICLES THEREOF
	79	ZINC AND ARTICLES THEREOF
	80	TIN AND ARTICLES THEREOF
	81	OTHER BASE METALS; CERMETS; ARTICLES THEREOF
	82	TOOLS, IMPLEMENTS, CUTLERY, SPOONS AND FORKS OF BASE METAL; PARTS THEREOF OF BASE METAL
	83	MISCELLANEOUS ARTICLES OF BASE METAL
Miscellaneous	00	UNKNOWN
	24	TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES
	41	RAW HIDES AND SKINS (OTHER THAN FUR SKINS) AND LEATHER
	42	ARTICLES OF LEATHER; SADDLERY AND HARNESS; TRAVEL GOODS, HANDBAGS AND SIMILAR CONTAINERS; ARTICLES OF ANIMAL GUT (OTHER THAN SILKWORM GUT)
	43	FUR SKINS AND ARTIFICIAL FUR; MANUFACTURES THEREOF
	71	NATURAL OR CULTURED PEARLS, PRECIOUS OR SEMIPRECIOUS STONES, PRECIOUS METALS; METALS CLAD WITH PRECIOUS METAL, AND ARTICLES THEREOF; IMITATION JEWELRY; COIN
	95	TOYS, GAMES, AND SPORTS EQUIPMENT; PARTS AND ACCESSORIES THEREOF
	96	MISCELLANEOUS MANUFACTURED ARTICLES
	97	WORKS OF ART, COLLECTORS PIECES, AND ANTIQUES
	98	SPECIAL CLASSIFICATION PROVISIONS
	99	(IMPORTS ONLY) TEMPORARY LEGISLATION; TEMPORARY MODIFICATIONS ESTABLISHED PURSUANT TO TRADE LEGISLATION; ADDITIONAL IMPORT RESTRICTIONS ESTABLISHED PURSUANT TO SECTION 22 OF THE AGRICULTURAL ADJUSTMENT ACT, AS NEEDED
Textiles/Apparel	50	SILK
	51	WOOL, FINE OR COARSE ANIMAL HAIR; HORSEHAIR YARN AND WOVEN FABRIC
	52	COTTON

COMMODITY GROUP	CHAPTER	CHAPTER DESCRIPTION
	53	OTHER VEGETABLE TEXTILE FIBERS; PAPER YARN AND WOVEN FABRICS OF PAPER YARN
	54	MAN-MADE FILAMENTS
	55	MAN-MADE STAPLE FIBERS
	56	WADDING, FELT, AND NONWOVENS; SPECIAL YARNS; TWINE, CORDAGE, ROPES, AND CABLES, AND ARTICLES THEREOF
	57	CARPETS AND OTHER TEXTILE FLOOR COVERINGS
	58	SPECIAL WOVEN FABRICS; TUFTED TEXTILE FABRICS; LACE; TAPESTRIES; TRIMMINGS; EMBROIDERY
	59	IMPREGNATED, COATED, COVERED, OR LAMINATED TEXTILE FABRICS; TEXTILE ARTICLES OF A KIND SUITABLE FOR INDUSTRIAL USE
	60	KNITTED OR CROCHETED FABRICS
	61	ARTICLES OF APPAREL AND CLOTHING ACCESSORIES, KNITTED OR CROCHETED
	62	ARTICLES OF APPAREL AND CLOTHING ACCESSORIES, NOT KNITTED OR CROCHETED
	63	OTHER MADE-UP TEXTILE ARTICLES; NEEDLECRAFT SETS; WORN CLOTHING AND WORN TEXTILE ARTICLES; RAGS
	64	FOOTWEAR, GAITERS AND THE LIKE; PARTS OF SUCH ARTICLES
Textiles/Apparel	65	HEADGEAR AND PARTS THEREOF
	66	UMBRELLAS, SUN UMBRELLAS, WALKING STICKS, SEATSTICKS, WHIPS, RIDING CROPS, AND PARTS THEREOF
	67	PREPARED FEATHERS AND DOWN AND ARTICLES MADE OF FEATHERS OR OF DOWN; ARTIFICIAL FLOWERS; ARTICLES OF HUMAN HAIR
Transport Equipment	86	RAILWAY OR TRAMWAY LOCOMOTIVES, ROLLING STOCK, AND PARTS THEREOF; RAILWAY OR TRAMWAY TRACK FIXTURES AND FITTINGS AND PARTS THEREOF; MECHANICAL (INCLUDING ELECTROMECHANICAL) TRAFFIC SIGNALING EQUIPMENT OF ALL KINDS
	87	VEHICLES, OTHER THAN RAILWAY OR TRAMWAY ROLLING STOCK, AND PARTS AND ACCESSORIES THEREOF
	88	AIRCRAFT, SPACECRAFT, AND PARTS THEREOF
	89	SHIPS, BOATS, AND FLOATING STRUCTURES
Wood/Paper/ Pulp	44	WOOD AND ARTICLES OF WOOD; WOOD CHARCOAL
	45	CORK AND ARTICLES OF CORK
	46	MANUFACTURES OF STRAW, OF ESPARTO, OR OF OTHER PLAITING MATERIALS; BASKETWARE AND WICKERWORK
	47	PULP OF WOOD OR OF OTHER FIBROUS CELLULOSIC MATERIAL; WASTE AND SCRAP OF PAPER, OR PAPERBOARD

COMMODITY GROUP	CHAPTER	CHAPTER DESCRIPTION
	48	PAPER AND PAPERBOARD; ARTICLES OF PAPER PULP, OF PAPER OR OF PAPERBOARD
	49	PRINTED BOOKS, NEWSPAPERS, PICTURES, AND OTHER PRODUCTS OF THE PRINTING INDUSTRY; MANUSCRIPTS, TYPESCRIPTS, AND PLANS
	94	FURNITURE; BEDDING, MATTRESS SUPPORTS, CUSHIONS AND SIMILAR STUFFED FURNISHINGS; LAMPS AND LIGHTING FITTINGS, NOT ELSEWHERE SPECIFIED OR INCLUDED; ILLUMINATED SIGNS, ILLUMINATED NAMEPLATES AND THE LIKE; PREFABRICATED BUILDINGS

APPENDIX 5. SIC CODES

Description	SIC CODE
AGRICULTURAL SERVICES, FORESTRY, AND FISHING	**07--**
Agricultural services	0700
Forestry	0800
Fishing, hunting, and trapping	0900
MINING	**10--**
Metal mining	1000
Coal mining	1200
Oil and gas extraction	1300
Nonmetallic minerals, except fuels	1400
CONSTRUCTION	**15--**
General contractors and operative builders	1500
Heavy construction, except building	1600
Special trade contractors	1700
MANUFACTURING	**20--**
Food and kindred products	2000
Tobacco products	2100
Textile mill products	2200
Apparel and other textile products	2300
Lumber and wood products	2400
Furniture and fixtures	2500
Paper and allied products	2600
Printing and publishing	2700
Chemicals and allied products	2800
Petroleum and coal products	2900
Rubber and miscellaneous plastic products	3000
Leather and leather products	3100
Stone, clay, and glass products	3200
Primary metal industries	3300
Fabricated metal products	3400
Industrial machinery and equipment	3500
Electronic equipment	3600
Transportation equipment	3700
Instruments and related products	3800
Miscellaneous manufacturing industries	3900
TRANSPORTATION AND PUBLIC UTILITIES	**40--**
Local and interurban passenger transit	4100
Trucking and warehousing	4200
Water transportation	4400

Transportation by air	4500
Pipelines, except natural gas	4600
Transportation services	4700
Communication	4800
Electric, gas, and sanitary services	4900
WHOLESALE TRADE	**50--**
Wholesale trade - durable goods	5000
Wholesale trade - nondurable goods	5100
Description	**SIC CODE**
RETAIL TRADE	**52--**
Building materials and garden supplies	5200
General merchandise stores	5300
Food stores	5400
Automotive dealers and service stations	5500
Apparel and accessory stores	5600
Furniture and home furnishings stores	5700
Eating and drinking places	5800
Miscellaneous retail	5900
FINANCE, INSURANCE, AND REAL ESTATE	**60--**
Depository institutions	6000
Nondepository institutions	6100
Security and commodity brokers	6200
Insurance carriers	6300
Insurance agents, brokers, and service	6400
Real estate	6500
Holding and other investment offices	6700
SERVICES	**70--**
Hotels and other lodging places	7000
Personal services	7200
Business services	7300
Auto repair, services, and parking	7500
Miscellaneous repair services	7600
Motion pictures	7800
Amusement and recreation services	7900
Health services	8000
Legal services	8100
Educational services	8200
Social services	8300
Museums, botanical, and zoological gardens	8400
Membership organizations	8600
Engineering and management services	8700

Services, n.e.c.	8900
UNCLASSIFIED ESTABLISHMENTS	**99--**

APPENDIX 6. WIM DATA TABLES AND FIGURES

Table 65. Station 504 Vehicle Classification And Weight

Station	Veh. Type	Count	Max. Weight	Min. Weight	Ave. Weight	St. Dev. Wt.	Weight %
504	190200	1	188	188	188		0.0%
504	190300	51	532	263	335	42	0.4%
504	220000	1,084	353	48	118	57	3.0%
504	230000	137	509	60	237	97	0.7%
504	321000	16	321	75	210	71	0.1%
504	322000	113	308	85	176	41	0.5%
504	323000	2	314	215	265	70	0.0%
504	331000	39	444	170	283	73	0.3%
504	332000	6,499	1,071	127	581	174	87.1%
504	333000	38	959	352	604	176	0.5%
504	421000	59	438	85	198	91	0.3%
504	423000	1	481	481	481		0.0%
504	431000	23	373	169	252	40	0.1%
504	521200	364	813	296	575	125	4.8%
504	522100	5	612	208	450	208	0.1%
504	531200	82	783	340	544	122	1.0%
504	532400	1	1,410	1,410	1,410		0.0%
504	533100	2	514	426	470	62	0.0%
504	632100	78	787	373	623	94	1.1%

Table 66. Station 507 Vehicle Classification And Weight

Station	Veh. Type	Count	Max. Weight	Min. Weight	Ave. Weight	St. Dev. Wt.	Weight %
507	190200	6	188	176	182	4	0.0%
507	190300	85	508	61	309	72	0.2%
507	220000	4,265	438	46	126	64	4.8%
507	230000	826	662	79	268	116	2.0%
507	240000	1	402	402	402		0.0%
507	321000	44	401	90	212	71	0.1%
507	322000	1,085	680	93	311	111	3.0%
507	323000	2	192	188	190	3	0.0%
507	331000	150	701	131	310	101	0.4%
507	332000	16,342	1,233	109	558	182	81.8%
507	333000	164	1,250	248	636	202	0.9%
507	421000	211	466	69	223	103	0.4%
507	422000	1	210	210	210		0.0%
507	423000	3	632	134	422	258	0.0%
507	431000	116	574	114	304	79	0.3%
507	521200	824	835	162	587	121	4.3%
507	522100	2	276	251	264	18	0.0%
507	531200	230	911	233	606	139	1.3%
507	532100	6	1,181	316	560	318	0.0%
507	532300	1	1,079	1,079	1,079		0.0%
507	533100	15	1,192	368	652	244	0.1%
507	543100	2	1,446	1,407	1,427	28	0.0%
507	632100	27	1,145	263	567	209	0.1%
507	731310	1	556	556	556		0.0%

Table 67. Station 509 Vehicle Classification And Weight

Station	Veh. Type	Count	Max. Weight	Min. Weight	Ave. Weight	St. Dev. Wt.	Weight %
509	190200	1	173	173	173		0.0%
509	190300	51	460	155	322	58	0.3%
509	220000	1,616	368	48	114	55	3.1%
509	230000	385	651	69	293	138	1.9%
509	240000	1	335	335	335		0.0%
509	321000	18	242	84	175	41	0.1%
509	322000	316	664	117	296	110	1.6%
509	323000	1	207	207	207		0.0%
509	331000	70	531	160	254	57	0.3%
509	332000	8,766	1,029	89	561	180	82.9%
509	333000	130	1,140	281	618	199	1.4%
509	421000	73	448	67	210	96	0.3%
509	423000	1	332	332	332		0.0%
509	431000	64	464	193	277	47	0.3%
509	521200	695	819	120	585	109	6.9%
509	531200	60	840	308	522	128	0.5%
509	532100	2	311	195	253	82	0.0%
509	532100	2	311	195	253	82	0.0%
509	533100	1	1,140	1,140	1,140		0.0%
509	543100	1	1,184	1,184	1,184		0.0%
509	632100	44	779	301	636	104	0.5%

Table 68. Station 510 Vehicle Classification And Weight

Station	Veh. Type	Count	Max. Weight	Min. Weight	Ave. Weight	St. Dev. Wt.	Weight %
510	190200	152	250	168	207	23	0.1%
510	190300	769	657	124	356	62	0.9%
510	220000	10,984	438	46	118	61	4.3%
510	230000	1,969	701	63	258	105	1.7%
510	240000	4	568	280	420	122	0.0%
510	321000	30	533	109	239	89	0.0%
510	322000	2,270	715	88	231	109	1.7%
510	323000	158	468	132	231	59	0.1%
510	331000	121	718	123	369	131	0.1%
510	332000	42,443	1,431	106	598	178	83.2%
510	333000	261	1,109	282	614	180	0.5%
510	421000	591	571	80	255	106	0.5%
510	422000	199	201	106	172	19	0.1%
510	423000	22	801	268	608	152	0.0%
510	431000	108	754	109	462	153	0.2%
510	432000	1	173	173	173		0.0%
510	521200	2,103	993	205	638	129	4.4%
510	522100	61	811	377	662	96	0.1%
510	531200	350	1,006	213	598	132	0.7%
510	532100	33	848	329	632	136	0.1%
510	532400	9	1,815	996	1,496	228	0.0%
510	533300	2	1,365	1,219	1,292	103	0.0%
510	542300	5	1,546	767	1,221	314	0.0%
510	543200	2	1,008	908	958	71	0.0%
510	632100	521	945	208	653	129	1.1%
510	721230	1	608	608	608		0.0%
510	731220	1	679	679	679		0.0%
510	732210	5	1,495	715	1,291	325	0.0%

Table 69. Station 512 Vehicle Classification And Weight

Station	Veh. Type	Count	Max. Weight	Min. Weight	Ave. Weight	St. Dev. Wt.	Weight %
512	190200	23	221	173	190	13	0.1%
512	190300	277	495	126	312	38	1.0%
512	220000	2,585	376	46	120	57	4.5%
512	230000	435	541	74	249	94	1.6%
512	321000	32	338	100	212	62	0.1%
512	322000	564	670	104	279	115	2.3%
512	323000	7	244	156	205	33	0.0%
512	331000	95	594	138	264	70	0.4%
512	332000	10,849	991	93	534	195	83.9%
512	333000	81	1,139	140	587	245	0.7%
512	421000	174	491	77	212	98	0.5%
512	423000	2	266	196	231	49	0.0%
512	431000	132	592	177	258	55	0.5%
512	521200	435	816	182	495	118	3.1%
512	522100	4	491	177	298	147	0.0%
512	531200	153	774	219	487	119	1.1%
512	533100	6	1,052	438	724	215	0.1%
512	543100	3	1,505	1,393	1,464	61	0.1%
512	632100	10	770	370	608	132	0.1%
512	732210	1	1,398	1,398	1,398		0.0%

Table 70. Station 513 Vehicle Classification And Weight

Station	Veh. Type	Count	Max. Weight	Min. Weight	Ave. Weight	St. Dev. Wt.	Weight %
513	190200	28	193	170	183	8	0.0%
513	190300	438	475	142	323	53	0.6%
513	220000	7,262	457	49	122	57	3.9%
513	230000	1,356	690	64	253	104	1.5%
513	240000	3	604	275	478	178	0.0%
513	321000	105	427	68	205	71	0.1%
513	322000	356	354	84	170	43	0.3%
513	323000	8	315	163	232	48	0.0%
513	331000	216	631	118	294	81	0.3%
513	332000	36,333	990	92	528	171	84.9%
513	333000	224	1,107	149	576	203	0.6%
513	421000	463	488	77	226	94	0.5%
513	423000	7	418	152	303	87	0.0%
513	431000	114	550	125	285	79	0.1%
513	444000	3	1,385	357	1,007	565	0.0%
513	521200	2,376	826	111	514	116	5.4%
513	522100	9	630	196	331	134	0.0%
513	531200	536	878	200	514	127	1.2%
513	632100	1	562	562	562		0.0%
513	532300	6	433	332	394	39	0.0%
513	532400	2	918	675	797	172	0.0%
513	533100	18	1,166	319	816	269	0.1%
513	533300	3	468	442	456	13	0.0%
513	541300	4	432	372	402	25	0.0%
513	542300	2	513	452	483	43	0.0%
513	543100	8	1,334	555	1,136	250	0.0%
513	622200	1	382	382	382		0.0%
513	632100	124	793	273	485	116	0.3%
513	723310	3	439	356	392	43	0.0%
513	731310	1	327	327	327		0.0%
513	731410	1	341	341	341		0.0%
513	732210	6	422	346	386	29	0.0%
513	732220	1	374	374	374		0.0%
513	732310	4	1,702	1,586	1,637	48	0.0%
513	741310	2	497	395	446	72	0.0%

Table 71. Station 515 Vehicle Classification And Weight

Station	Veh. Type	Count	Max. Weight	Min. Weight	Ave. Weight	St. Dev. Wt.	Weight %
515	190200	35	193	170	182	7	0.1%
515	190300	177	480	59	297	45	1.0%
515	220000	2,724	440	45	129	72	6.7%
515	230000	1,168	723	65	303	138	6.8%
515	321000	58	312	73	177	45	0.2%
515	322000	103	393	88	178	50	0.4%
515	323000	3	251	207	224	24	0.0%
515	331000	136	562	110	245	72	0.6%
515	332000	7,934	1,003	101	522	190	79.1%
515	333000	87	1,123	194	584	202	1.0%
515	421000	154	535	73	207	99	0.6%
515	422000	1	336	336	336		0.0%
515	423000	2	695	667	681	20	0.0%
515	431000	101	489	122	255	63	0.5%
515	521200	224	824	167	491	135	2.1%
515	531200	74	806	307	520	104	0.7%
515	533100	7	1,148	619	767	196	0.1%
515	541400	1	1,535	1,535	1,535		0.0%
515	543100	1	558	558	558		0.0%
515	632100	1	267	267	267		0.0%

Table 72. Station 516 Vehicle Classification And Weight

Station	Veh. Type	Count	Max. Weight	Min. Weight	Ave. Weight	St. Dev. Wt.	Weight %
516	190200	11	193	170	183	9	0.0%
516	190300	361	518	126	330	59	1.4%
516	220000	3.597	401	47	108	57	4.5%
516	230000	623	656	74	243	110	1.8%
516	321000	24	357	90	203	72	0.1%
516	322000	224	686	88	288	142	0.8%
516	323000	6	475	246	295	89	0.0%
516	331000	83	598	127	280	95	0.3%
516	332000	13,030	1,119	93	563	185	85.9%
516	333000	90	1,338	285	627	201	0.7%
516	421000	153	521	78	238	109	0.4%
516	423000	1	265	265	265		0.0%
516	431000	53	491	127	268	62	0.2%
516	521200	478	888	195	580	164	3.2%
516	522100	4	447	156	318	120	0.0%
516	531200	104	902	263	537	152	0.7%
516	532400	2	1,365	1,310	1,338	39	0.0%
516	543100	2	1,273	1,021	1,147	178	0.0%
516	632100	3	716	399	569	160	0.0%

Table 73. Station 517 Vehicle Classification And Weight

Station	Veh. Type	Count	Max. Weight	Min. Weight	Ave. Weight	St. Dev. Wt.	Weight %
517	190200	138	248	170	188	17	0.3%
517	190300	138	423	123	287	45	0.4%
517	220000	15,727	435	43	113	56	19.2%
517	230000	3,496	717	71	292	141	11.0%
517	240000	1	220	220	220		0.0%
517	321000	63	402	91	182	66	0.1%
517	322000	504	773	93	249	123	1.4%
517	323000	3	321	245	279	39	0.0%
517	331000	201	471	120	264	65	0.6%
517	332000	11,992	1,044	91	479	197	61.9%
517	333000	338	1,390	193	585	225	2.1%
517	421000	686	541	73	261	97	1.9%
517	423000	2	154	146	150	6	0.0%
517	431000	66	579	121	263	78	0.2%
517	521200	128	765	237	459	114	0.6%
517	531200	28	679	276	431	106	0.1%
517	533100	7	1,183	534	832	251	0.1%
517	533200	674	674	674	674		0.0%
517	632100	6	554	417	474	51	0.0%
517	732210	1	1,000	1,000	1,000		0.0%

Table 74. Effect Of Direction On Truck Weight

TRUCK TYPE 333000							
Station	**Highway**	**Direction**	**EMPTIES**	**CUBE OUT**	**WEIGH OUT**	**OVERLOADED**	**COUNT**
LW504	IH 20	NORTHEAST	15%	55%	10%	20%	20
		SOUTHEAST	11%	67%	17%	6%	18
LW507	IH 45	NORTH	11%	55%	17%	17%	75
		SOUTH	4%	53%	18%	25%	89
LW509	IH 30	WEST	27%	35%	30%	8%	88
		EAST	0%	36%	36%	29%	42
LW510	IH 10	NORTH	11%	59%	18%	11%	61
		EAST	0%	76%	12%	12%	17
		WEST	9%	65%	17%	9%	23
LW512	IH 37	NORTH	35%	40%	7%	19%	43
		SOUTH	16%	50%	11%	24%	38%
LW513	IH 35	NORTH	9%	53%	22%	14%	116
		SOUTH	23%	50%	14%	13%	108
LW515	US 281	NORTH	17%	54%	17%	11%	46
		SOUTH	15%	68%	5%	12%	41
LW516	IH 35	NORTHEAST	15%	64%	13%	8%	39
		SOUTHWEST	2%	59%	8%	31%	51
LW517	US 83	NORTHEAST	15%	30%	26%	30%	54
		EAST	4%	37%	26%	33%	114
		SOUTHEAST	32%	45%	13%	11%	47
		WEST	41%	50%	5%	5%	123

TRUCK TYPE 33200							
Station	**Highway**	**Direction**	**EMPTIES**	**CUBE OUT**	**WEIGH OUT**	**OVERLOADED**	**COUNT**
LW504	1H 20	NORTHEAST	14%	55%	29%	1%	3.199
		SOUTHEAST	6%	59%	30%	5%	3,300
LW507	IH 45	NORTH	10%	63%	25%	2%	7,740
		SOUTH	8%	61%	23%	8%	8,602
LW509	IH 30	EAST	13%	57%	16%	13%	4,204
		WEST	9%	67%	20%	3%	4,562
LW510	IH 10	NORTH	8%	65%	23%	3%	11,089
		EAST	10%	71%	19%	0%	3,580
		SOUTH	11%	61%	25%	2%	11,503
		WEST	15%	65%	19%	1%	3,873
LW512	IH 37	NORTH	23%	45%	30%	3%	5,654
		SOUTH	19%	55%	23%	2%	5,195
LW513	IH 35	NORTH	16%	64%	19%	1%	17,556
		SOUTH	9%	72%	17%	1%	18,777
LW515	US 281	NORTH	24%	50%	24%	2%	4,321
		SOUTH	17%	67%	13%	3%	3,613
LW516	IH 35	NORTHEAST	16%	71%	12%	0%	6,336
		SOUTHWEST	10%	54%	18%	18%	6,694
LW517	US 83	NORTHEAST	19%	55%	20%	6%	1,508
		EAST	19%	50%	21%	11%	4,272
		SOUTHEAST	25%	58%	13%	4%	1,620
		WEST	36%	53%	10%	1%	4,592

Table 75. Seasonal Effects On Truck Weight

TRUCK TYPE 332000							
Station	**Highway**	**Month**	**EMPTIES**	**CUBE OUT**	**WEIGH OUT**	**OVERLOADED**	**COUNT**
LW504	IH 20	2	10%	57.2%	29.4%	2.9%	6,499
Lw507	IH 45	2	9.3%	63.8%	23.9%	2.7%	8,053
LW507		5	8.4%	59.9%	24.1%	7.4%	8,289
LW509	IH 30	6	11.0%	62.5%	18.2%	8.0%	8,766
LW510	IH 10	3	13.2%	68.4%	17.6%	0.5%	6,237
LW510		4	12.6%	67.7%	18.9%	0.5%	7,453
LW510		9	9.1%	60.4%	26.8%	3.5%	7,609
LW510		12	7.8%	61.3%	26.8%	3.7%	8,746
LW512	IH 37	4	20.3%	45.0%	31.3%	3.2%	4,374
LW512		9	24.5%	54.0%	19.8%	1.2%	2,433
LW512		12	20.1%	52.4%	24.9%	2.1%	4,042
LW513		2	7.7%	66.5%	22.9%	2.6%	9,028
LW513	IH 35	6	14.8%	66.6%	17.7%	0.5%	9,358
LW513		7	14.4%	68.2%	15.9%	1.2%	8,193
LW513		12	13.0%	71.0%	15.2%	0.5%	9,754
LW515	US 281	2	16.5%	62.0%	17.8%	3.3%	2,980
LW515		5	24.3%	49.6%	23.8%	1.9%	3,013
LW515		7	21.8%	63.2%	13.5%	1.4%	1,941
LW516	IH 35	5	13.4%	61.2%	13.9%	11.3%	4,553
LW516		10	12.3%	62.8%	16.0%	8.4%	8,477
LW517	US 83	2	22.3%	56.6%	16.2%	4.8%	3,128
LW517		5	26.0%	50.5%	16.4%	6.9%	3,174
LW517		7	25.7%	54.45	13.3%	6.5%	2,319
LW517		12	30.3%	49.5%	15.8%	4.4%	3,371

TRUCK TYPE 33300							
Station	**Highway**	**Month**	**EMPTIES**	**CUBE OUT**	**WEIGH OUT**	**OVERLOADED**	**COUNT**
LW504	1H 20	2	13.2%	60.5%	13.2%	13.2%	38
LW507	IH 45	2	8.7%	60.9%	14.1%	16.3%	92
LW507		5	5.6%	44.4%	22.2%	27.8%	72
LW509	IH 30	6	18.5%	35.4%	31.5%	14.6%	130
LW510	IH 10	3	17.2%	58.6%	6.9%	17.2%	29
LW510		4	5.0%	70.0%	15.0%	10.0%	40
LW510		9	12.5%	50.0%	27.5%	10.0%	40
LW510		12	15.2%	58.7%	19.6%	6.5%	46
LW512	IH 37	4	8.6%	51.4%	14.3%	25.7%	35
LW512		12	48.4%	29.0%	6.5%	16.1%	31
LW513	IH 35	2	13.5%	57.7%	13.5%	15.4%	52
LW513		6	9.6%	57.7%	19.2%	13.5%	52
LW513		7	19.7%	47.5%	18.0%	13.1%	61
LW513		12	20.3%	45.8%	22.0%	11.9%	59
LW515	US 281	2	20.0%	55.0%	10.0%	15.0%	20
LW515		5	10.7%	64.3%	14.3%	10.7%	28
LW515		7	17.9%	61.5%	10.3%	10.3%	39
LW516	IH 35	5	8.0%	68.0%	8.0%	16.0%	25
LW516		10	7.7%	58.5%	10.8%	23.1%	65
LW517	US 83	2	22.8%	36.6%	19.8%	20.8%	101
LW517		5	23.1%	46.2%	16.5%	14.3%	91
LW517		7	25.3%	36.0%	14.7%	24.0%	75
LW517		12	19.7%	47.9%	14.1%	18.3%	71

Table 76. Hour Effect On Truck Weight And Volume (Stations 504 And 507)

TRUCK TYPE 332000							
STATION	HIGHWAY	COUNTY	HOUR	EMPTIES	CUBE OUT	WEIGH OUT	ALL
LW504	IH 20	NOLAN	0	11.2%	57.2%	31.0%	187
			1	9.5%	59.5%	31.0%	200
			2	9.4%	62.4%	28.4%	28.2%
			3	14.8%	55.0%	30.2%	169
			4	11.0%	63.2%	25.8%	163
			5	12.1%	56.3%	31.0%	174
			6	17.1%	53.5%	29.4%	187
			7	13.0%	50.3%	36.8%	185
			8	12.2%	58.1%	29.3%	222
			9	18.3%	48.1%	32.9%	289
			10	21.8%	50.3%	27.3%	308
			11	16.1%	52.5%	31.4%	299
			12	26.0%	41.5%	31.9%	342
			13	26.1%	46.4%	26.5%	306
			14	17.4%	47.8%	34.5%	322
			15	16.5%	50.9%	32.6%	316
			16	17.6%	45.5%	36.6%	347
			17	19.4%	45.9%	34.2%	377
			18	15.1%	48.0%	36.6%	350
			19	17.1%	49.3%	32.8%	357
			20	15.8%	48.2%	35.5%	330
			21	14.2%	52.8%	32.3%	316
			22	14.8%	51.0%	33.9%	310
			23	13.9%	50.3%	35.4%	294
LW507	IH 45	WALKER	0	13.4%	58.0%	28.0%	507
			1	11.2%	57.5%	30.8%	520
			2	15.2%	58.6%	26.0%	573
			3	14.0%	55.4%	30.4%	628
			4	13.8%	54.7%	31.3%	565
			5	16.5%	55.4%	28.1%	565
			6	15.3%	56.1%	28.5%	554
			7	17.6%	48.8%	33.5%	603
			8	18.2%	46.6%	35.1%	616
			9	27.9%	44.0%	27.9%	718
			10	28.4%	45.6%	25.9%	754
			11	27.9%	44.8%	27.1%	881
			12	29.0%	42.0%	29.0%	905
			13	28.1%	45.3%	26.1%	918
			14	25.1%	50.2%	24.4%	866
			15	25.8%	43.7%	30.2%	890
			16	23.8%	48.0%	28.0%	900
			17	24.6%	48.0%	27.1%	756
			18	21.3%	47.4%	30.8%	647
			19	20.4%	48.8%	30.6%	588
			20	18.6%	52.1%	29.1%	612
			21	17.0%	52.8%	29.9%	618
			22	15.3%	50.1%	34.1%	555
			23	11.8%	54.9%	33.0%	603

Table 77. Hour Effect On Truck Weight And Volume (Stations 509 And 510)

TRUCK TYPE 332000							
STATION	HIGHWAY	COUNTY	HOUR	EMPTIES	CUBE OUT	WEIGH OUT	ALL
LW509	IH 30	HUNT	0	11.1%	59.7%	28.9%	325
			1	11.3%	66.0%	22.0%	309
			2	10.3%	64.1%	24.6%	301
			3	7.0%	68.6%	24.4%	287
			4	8.6%	63.1%	27.7%	314
			5	12.8%	61.0%	26.2%	336
			6	14.1%	54.2%	31.1%	312
			7	18.0%	52.3%	28.2%	411
			8	22.2%	51.0%	26.4%	406
			9	26.4%	49.3%	24.3%	481
			10	24.8%	48.5%	26.5%	495
			11	28.0%	46.0%	25.8%	507
			12	24.9%	50.7%	23.7%	582
			13	24.3%	48.8%	26.7%	486
			14	25.9%	48.3%	25.3%	478
			15	23.7%	49.4%	25.9%	451
			16	21.3%	53.4%	25.4%	564
			17	22.8%	52.7%	24.6%	452
			18	22.3%	51.4%	25.9%	247
			19	16.3%	54.3%	29.5%	258
			20	16.2%	51.4%	32.4%	179
			21	11.7%	59.5%	28.3%	205
			22	9.9%	63.0%	26.5%	181
			23	9.5%	66.8%	23.1%	199
LW510	IH 10	EL PASO	0	11.5%	61.5%	26.7%	667
			1	9.8%	64.8%	25.1%	634
			2	8.9%	64.6%	26.2%	584
			3	19.6%	54.6%	25.3%	672
			4	16.0%	59.1%	24.7%	699
			5	14.0%	58.9%	26.2%	755
			6	22.3%	56.4%	20.8%	973
			7	20.6%	57.0%	22.2%	1,159
			8	22.6%	56.7%	20.6%	1,391
			9	23.2%	55.6%	21.0%	1,727
			10	23.0%	54.8%	22.0%	1,823
			11	20.6%	55.0%	24.2%	1,853
			12	21.0%	55.5%	23.3%	1,745
			13	20.5%	53.4%	25.9%	1,728
			14	17.6%	55.4%	26.4%	1,844
			15	20.3%	54.0%	25.5%	1,712
			16	20.1%	54.0%	25.3%	1,562
			17	17.2%	55.1%	27.3%	1,467
			18	12.9%	59.9%	26.6%	1,415
			19	12.9%	60.0%	26.8%	1,294
			20	12.0%	59.7%	28.1%	1,189
			21	11.2%	61.5%	27.0%	1,187
			22	11.1%	59.0%	29.5%	1,012
			23	12.1%	55.6%	31.9%	953

Table 78. Hour Effect On Truck Weight And Volume (Stations 512 And 513)

TRUCK TYPE 332000							
STATION	HIGHWAY	COUNTY	HOUR	EMPTIES	CUBE OUT	WEIGH OUT	ALL
LW512	IH 37	LIVE OAK	0	23.4%	46.8%	29.4%	462
			1	19.5%	47.1%	33.2%	461
			2	22.5%	49.4%	27.8%	417
			3	24.1%	46.9%	28.7%	407
			4	20.9%	46.0%	32.6%	426
			5	24.2%	41.2%	34.1%	451
			6	25.5%	40.9%	33.0%	494
			7	35.6%	38.6%	25.1%	430
			8	31.0%	43.1%	25.4%	452
			9	32.7%	39.3%	27.9%	499
			10	36.3%	33.9%	29.7%	543
			11	41.2%	32.7%	26.1%	529
			12	38.8%	33.9%	26.9%	528
			13	36.6%	37.5%	25.8%	528
			14	34.4%	37.0%	28.2%	524
			15	41.0%	35.2%	23.8%	520
			16	37.5%	37.9%	24.1%	456
			17	30.2%	40.0%	29.0%	420
			18	35.4%	39.8%	24.8%	427
			19	34.1%	36.0%	29.7%	364
			20	23.6%	45.4%	30.2%	377
			21	22.5%	44.0%	32.7%	364
			22	19.2%	47.8%	32.3%	402
			23	22.8%	45.4%	31.5%	368
LW513	IH 35	BELL	0	14.8%	65.3%	19.5%	1,247
			1	14.7%	69.2%	15.5%	1,248
			2	13.1%	68.8%	17.6%	1,226
			3	12.7%	68.1%	18.8%	1,390
			4	15.6%	67.6%	16.5%	1,313
			5	16.7%	66.9%	16.1%	1,404
			6	21.3%	61.1%	17.4%	1,336
			7	18.3%	62.3%	19.2%	1,326
			8	26.3%	56.1%	17.3%	1,318
			9	28.0%	52.5%	19.0%	1,617
			10	34.2%	47.0%	18.8%	1,695
			11	32.5%	47.9%	19.3%	1,755
			12	35.2%	45.3%	19.4%	1,737
			13	33.0%	46.4%	20.5%	1,756
			14	29.3%	48.4%	22.0%	1,726
			15	29.8%	48.5%	21.5%	1,644
			16	26.5%	52.6%	20.9%	1,606
			17	27.4%	51.7%	20.7%	1,646
			18	23.0%	56.4%	20.4%	1,655
			19	20.9%	57.2%	21.7%	1,628
			20	19.9%	59.9%	19.9%	1,654
			21	17.0%	65.6%	16.8%	1,572
			22	18.5%	63.7%	17.2%	1,451
			23	16.7%	63.6%	19.3%	1,383

Table 79. Hour Effect On Truck Weight And Volume (Stations 515 And 516)

TRUCK TYPE 332000							
STATION	HIGHWAY	COUNTY	HOUR	EMPTIES	CUBE OUT	WEIGH OUT	ALL
LW515	US 281	HIDALGO	0	21.3%	53.8%	24.4%	225
			1	22.7%	55.8%	20.9%	172
			2	18.1%	66.0%	16.0%	144
			3	23.1%	60.5%	15.6%	147
			4	31.0%	54.0%	14.4%	174
			5	37.8%	47.3%	14.4%	201
			6	37.6%	46.9%	15.2%	290
			7	30.8%	51.1%	17.8%	325
			8	35.9%	44.5%	18.8%	384
			9	37.5%	46.3%	16.2%	445
			10	38.4%	42.2%	19.3%	419
			11	33.6%	42.1%	24.3%	342
			12	38.6%	39.1%	21.6%	425
			13	33.2%	46.5%	20.0%	385
			14	35.6%	40.3%	23.6%	365
			15	30.7%	46.3%	22.8%	378
			16	28.5%	44.9%	26.7%	390
			17	27.9%	48.8%	23.0%	426
			18	21.2%	48.0%	30.3%	429
			19	27.0%	52.4%	20.3%	433
			20	21.3%	54.9%	23.8%	408
			21	24.8%	53.5%	21.5%	400
			22	17.8%	57.0%	24.6%	349
			23	20.9%	56.8%	21.9%	278
LW516	IH 35	BEXAR	0	12.1%	61.5%	26.5%	431
			1	10.1%	60.4%	29.3%	386
			2	9.7%	62.6%	27.7%	372
			3	11.5%	56.8%	31.1%	366
			4	11.3%	50.7%	37.7%	406
			5	13.8%	51.5%	34.3%	501
			6	16.1%	52.3%	31.2%	597
			7	18.2%	52.3%	29.3%	512
			8	23.0%	47.2%	29.2%	521
			9	28.8%	48.5%	22.4%	548
			10	25.9%	49.7%	24.1%	630
			11	37.2%	43.1%	19.2%	640
			12	30.2%	46.5%	23.2%	665
			13	31.9%	49.2%	18.6%	646
			14	27.3%	51.8%	20.5%	649
			15	23.4%	50.3%	25.8%	628
			16	27.8%	49.9%	21.8%	611
			17	22.4%	56.3%	21.2%	655
			18	22.8%	55.9%	20.8%	631
			19	16.7%	61.9%	20.7%	609
			20	18.3%	58.4%	22.9%	584
			21	15.7%	63.4%	20.5%	536
			22	13.9%	60.4%	25.4%	460
			23	15.5%	59.6%	24.4%	446

Table 80. Hour Effect On Truck Weight And Volume (Station 517)

TRUCK TYPE 332000							
STATION	**HIGHWAY**	**COUNTY**	**HOUR**	**EMPTIES**	**CUBE OUT**	**WEIGH OUT**	**ALL**
LW517	US 83	HIDALGO	0	37.9%	36.8%	25.3%	87
			1	36.2%	37.7%	26.1%	69
			2	49.3%	38.0%	12.7%	71
			3	27.7%	43.6%	28.7%	101
			4	30.7%	36.4%	32.9%	140
			5	63.4%	23.1%	13.4%	290
			6	41.9%	33.7%	24.2%	454
			7	36.6%	32.9%	30.4%	566
			8	34.4%	39.1%	26.5%	819
			9	43.7%	39.1%	17.1%	975
			10	38.5%	39.4%	21.8%	968
			11	45.4%	34.9%	19.7%	964
			12	47.0%	36.1%	16.6%	775
			13	42.8%	38.0%	19.2%	845
			14	40.3%	36.9%	22.6%	885
			15	40.3%	37.8%	21.9%	827
			16	41.5%	38.6%	19.9%	764
			17	42.2%	41.0%	16.7%	669
			18	34.2%	46.4%	19.4%	459
			19	37.2%	42.5%	20.1%	358
			20	35.3%	42.2%	22.2%	306
			21	27.1%	44.9%	27.5%	247
			22	32.5%	47.0%	20.5%	200
			23	35.3%	44.0%	20.7%	150

APPENDIX 7. PORT AND COMMODITY TRUCK FLOW MAPS

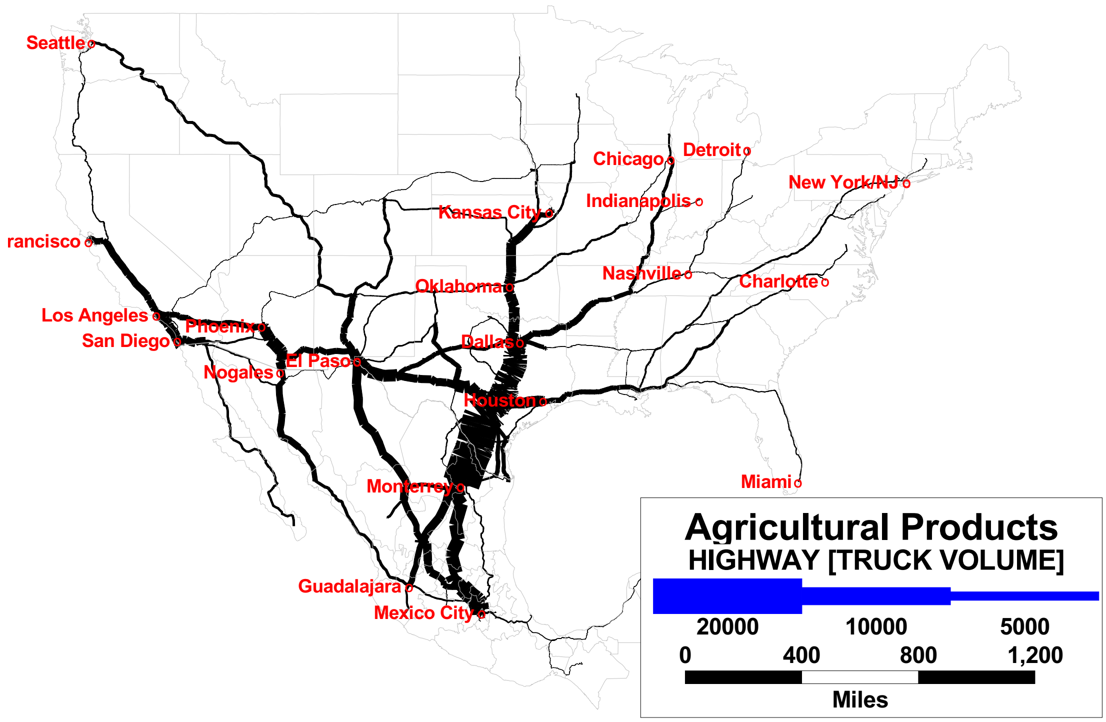


Figure 110. Agricultural Products (Southbound).

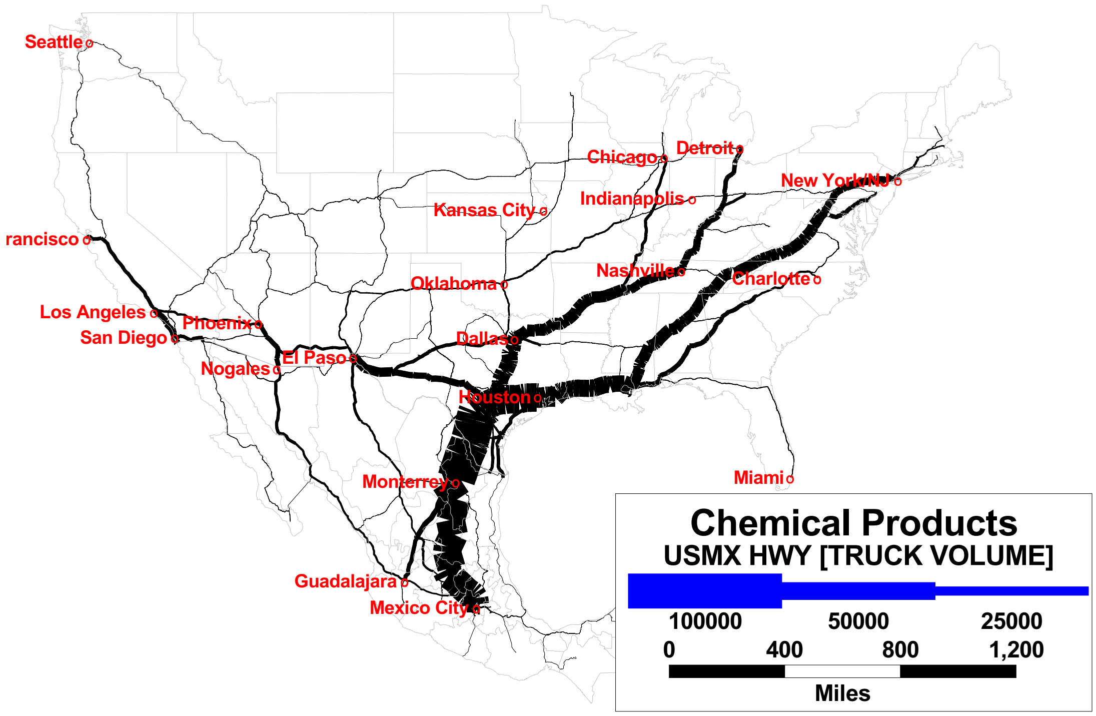


Figure 111. Chemical Products (Southbound).

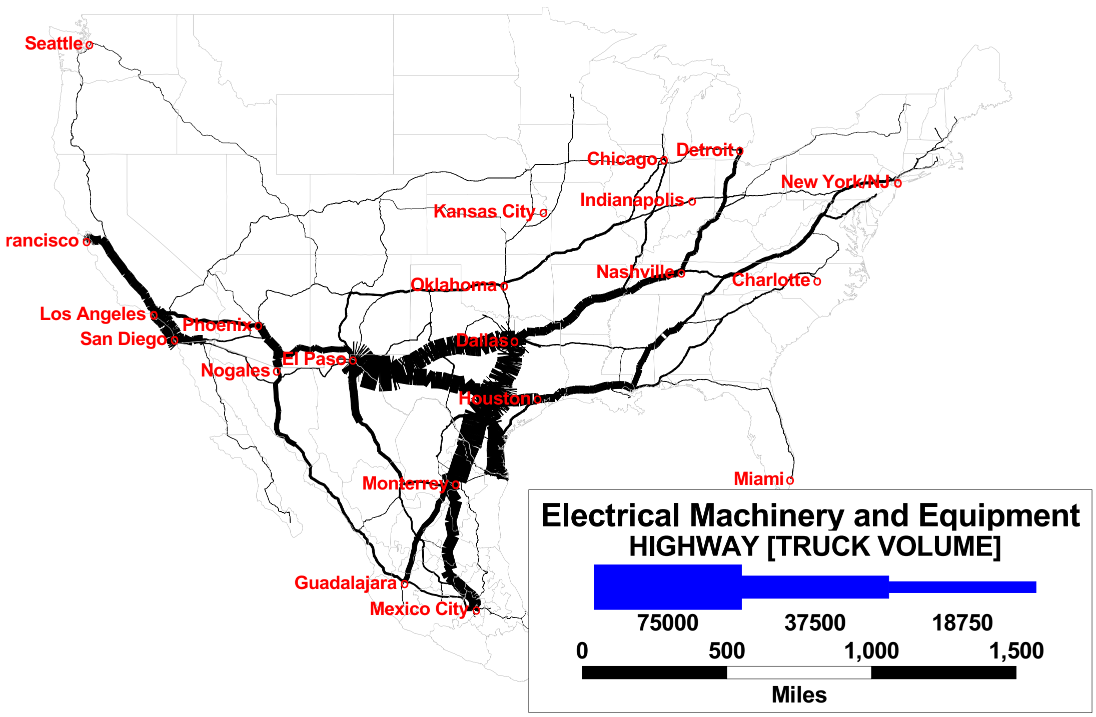


Figure 112. Electrical Products (Southbound).

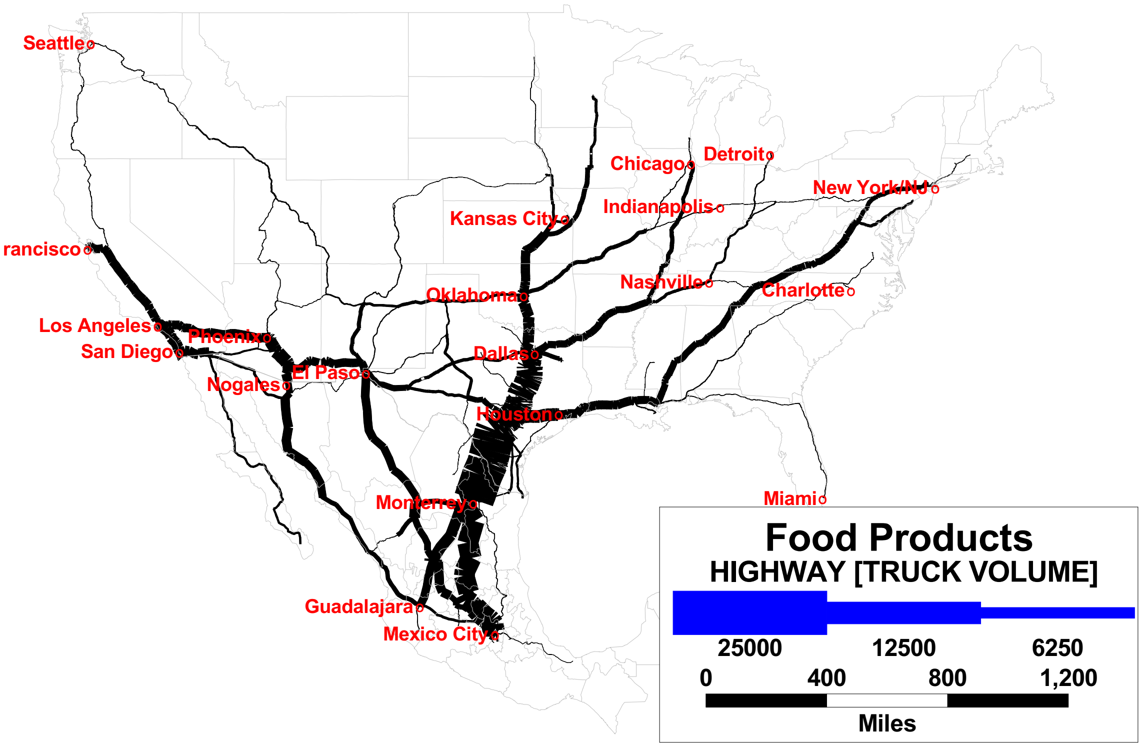


Figure 113. Food Products (Southbound).

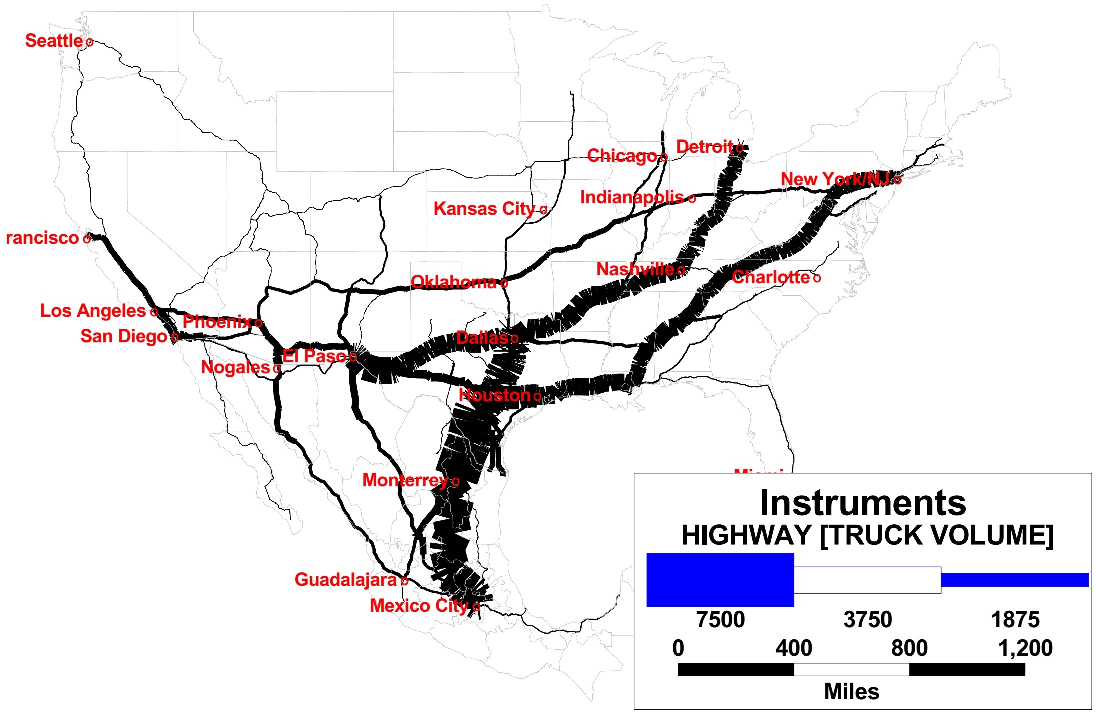


Figure 114. Instruments (Southbound).

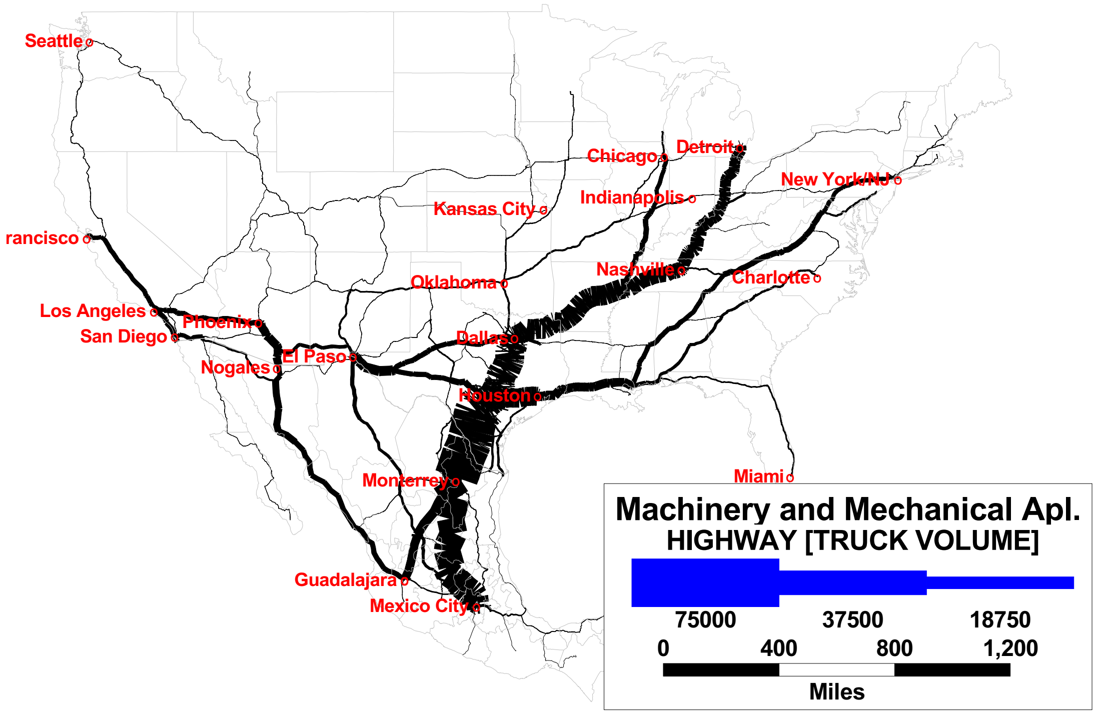


Figure 115. Machinery And Mechanical Appliances (Southbound).

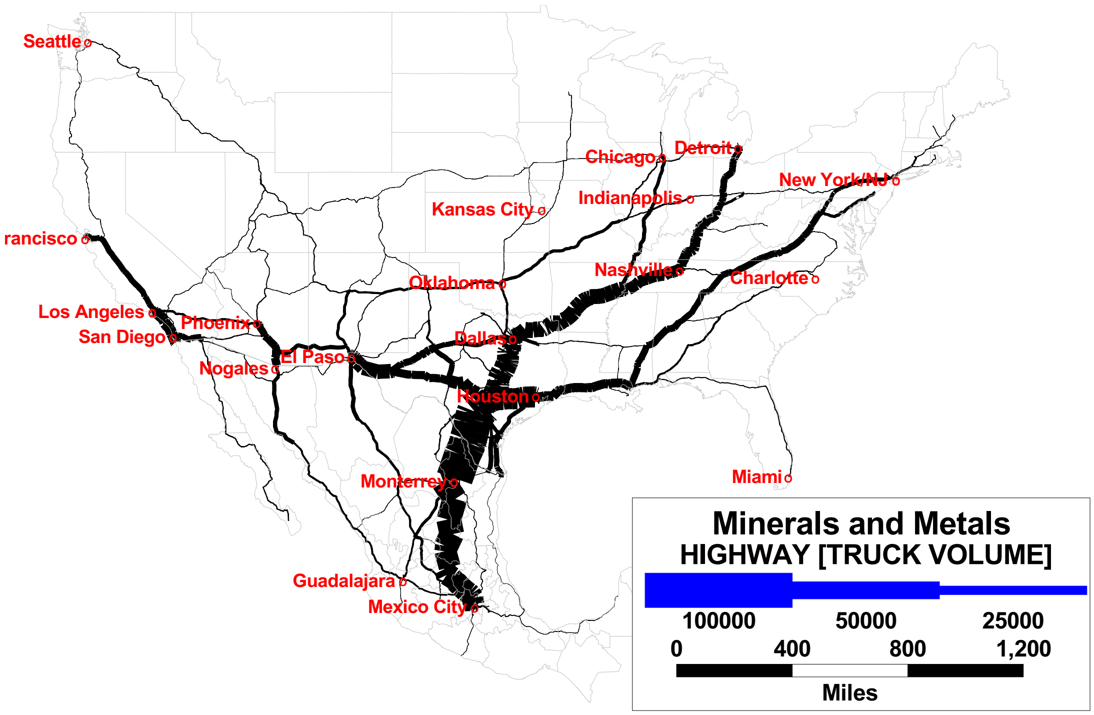


Figure 116. Minerals And Metals (Southbound).

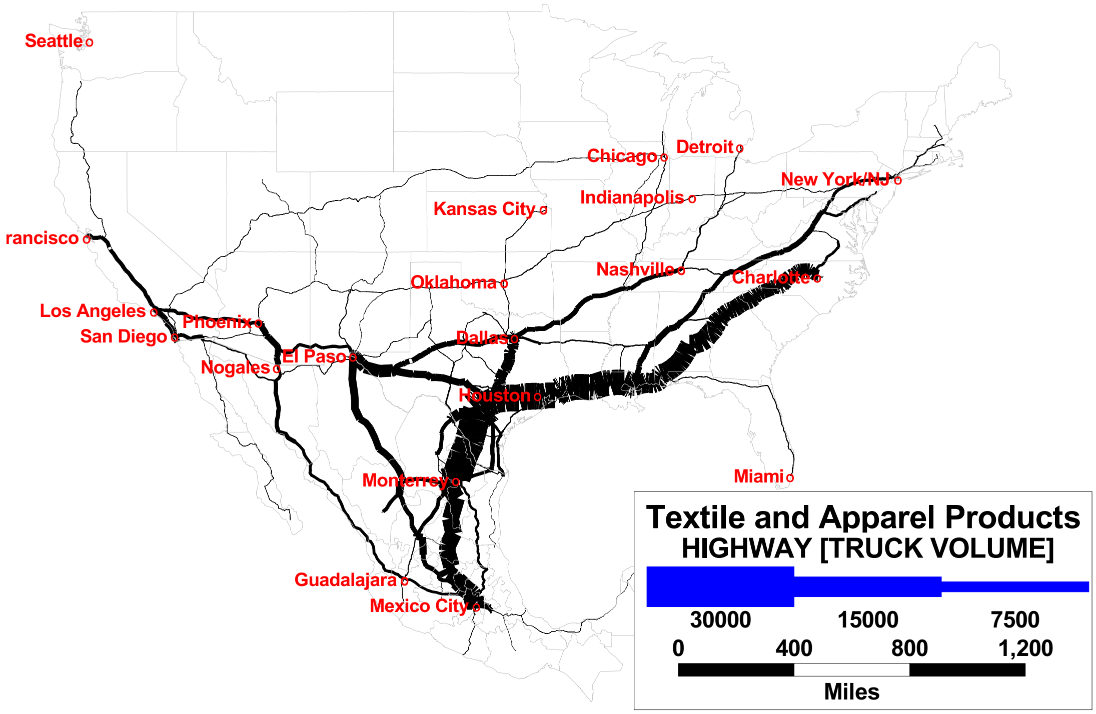


Figure 117. Textile And Apparel Products (Southbound).

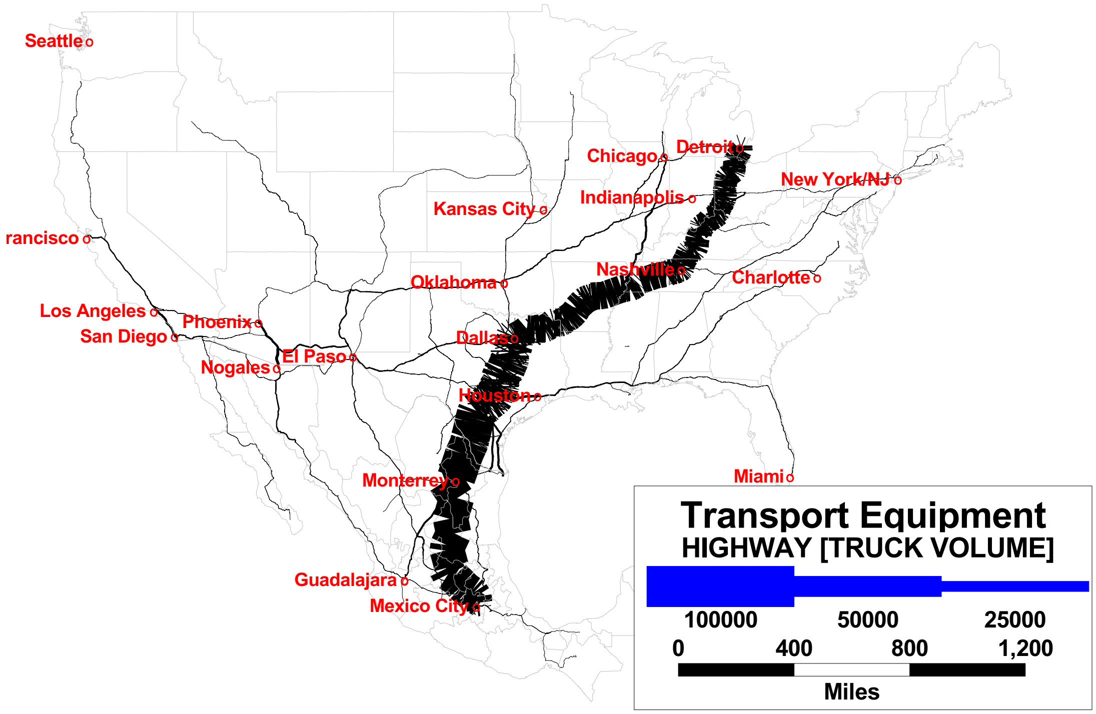


Figure 118. Transport Equipment (Southbound).

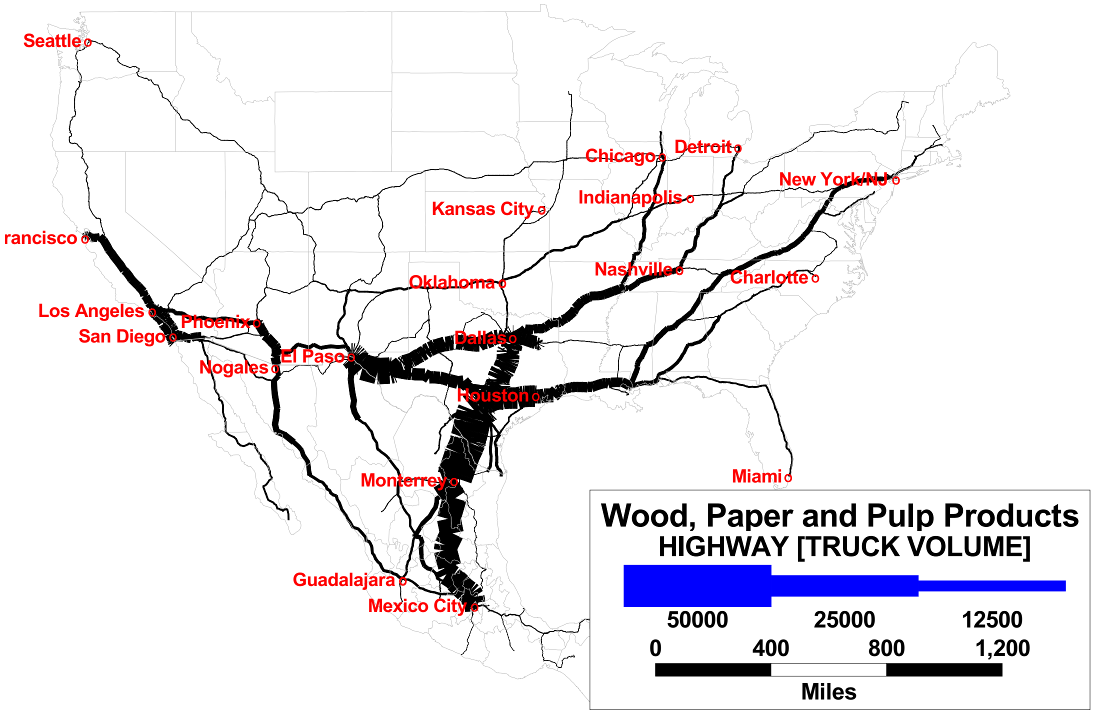


Figure 119. Wood, Paper, And Pulp Products (Southbound).

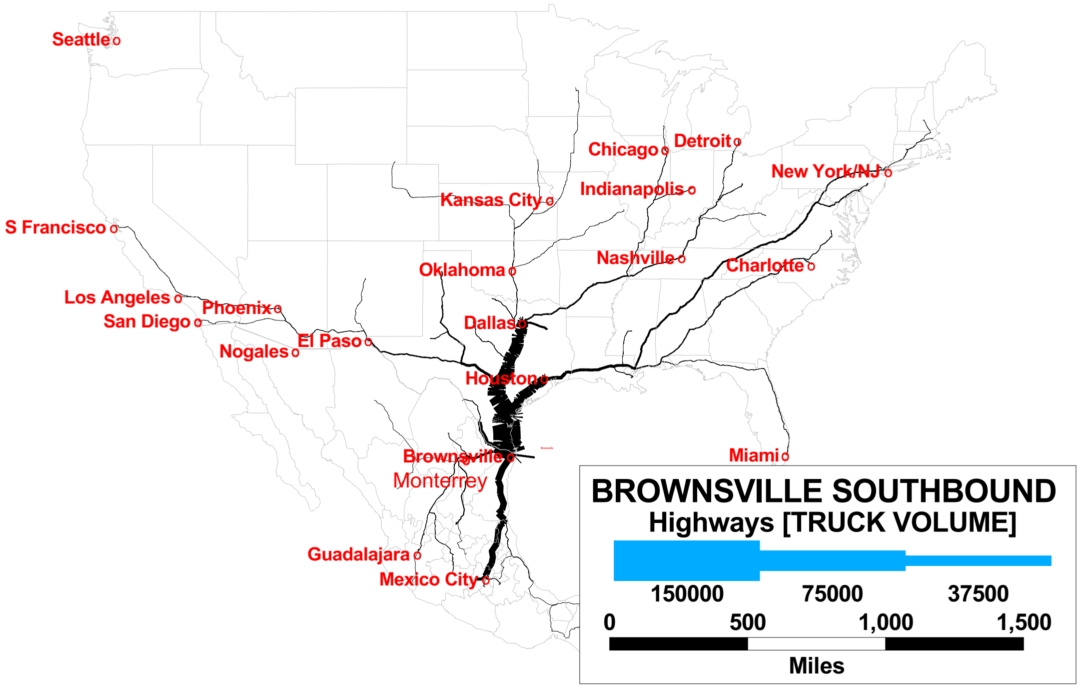


Figure 120. Brownsville (Southbound).

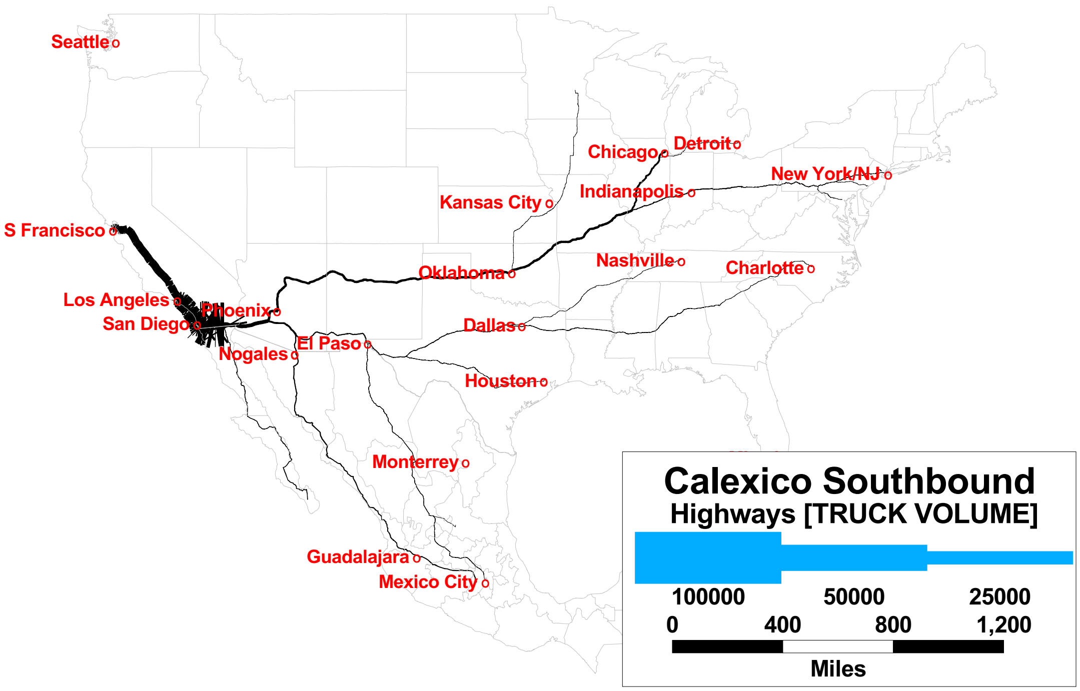


Figure 121. Calexico (Southbound).

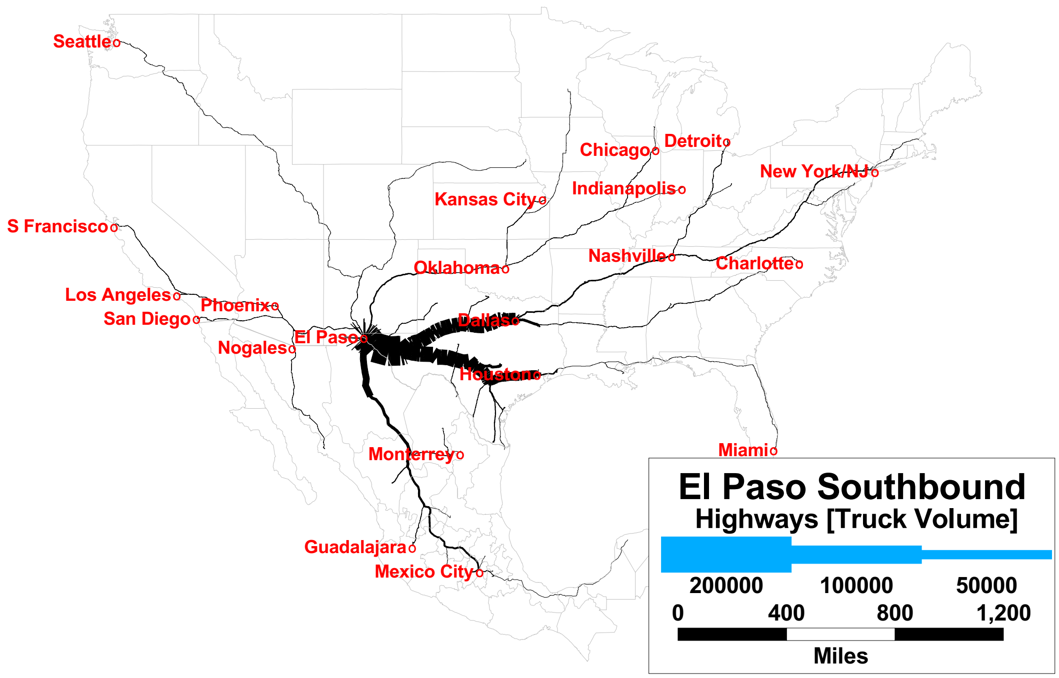


Figure 122. El Paso (Southbound).

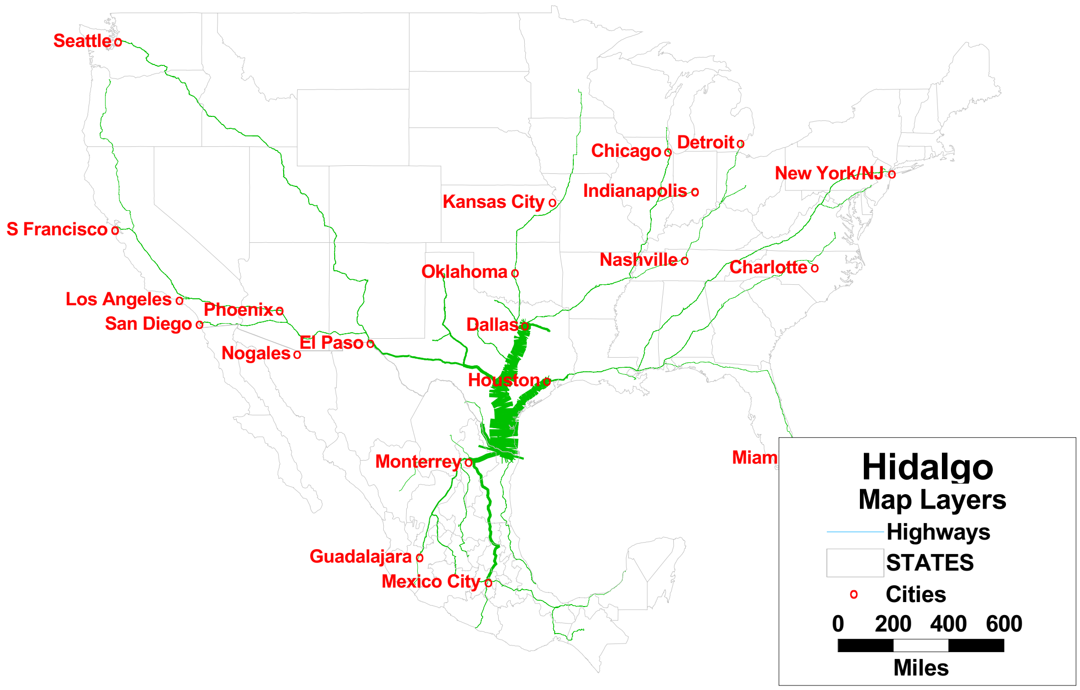


Figure 123. Hidalgo (Southbound).

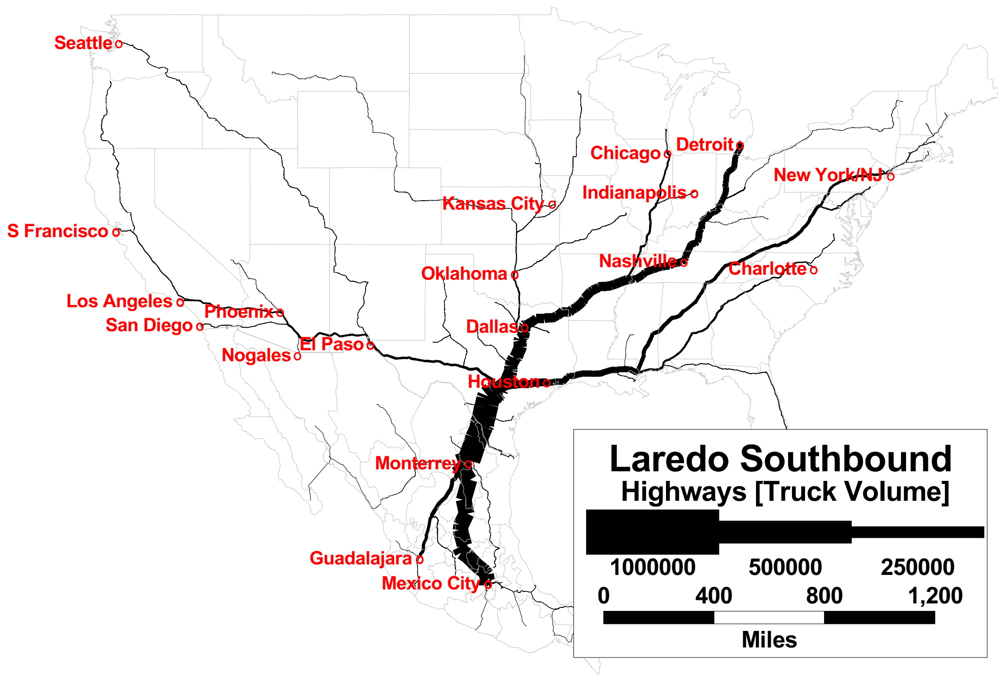


Figure 124. Laredo (Southbound).

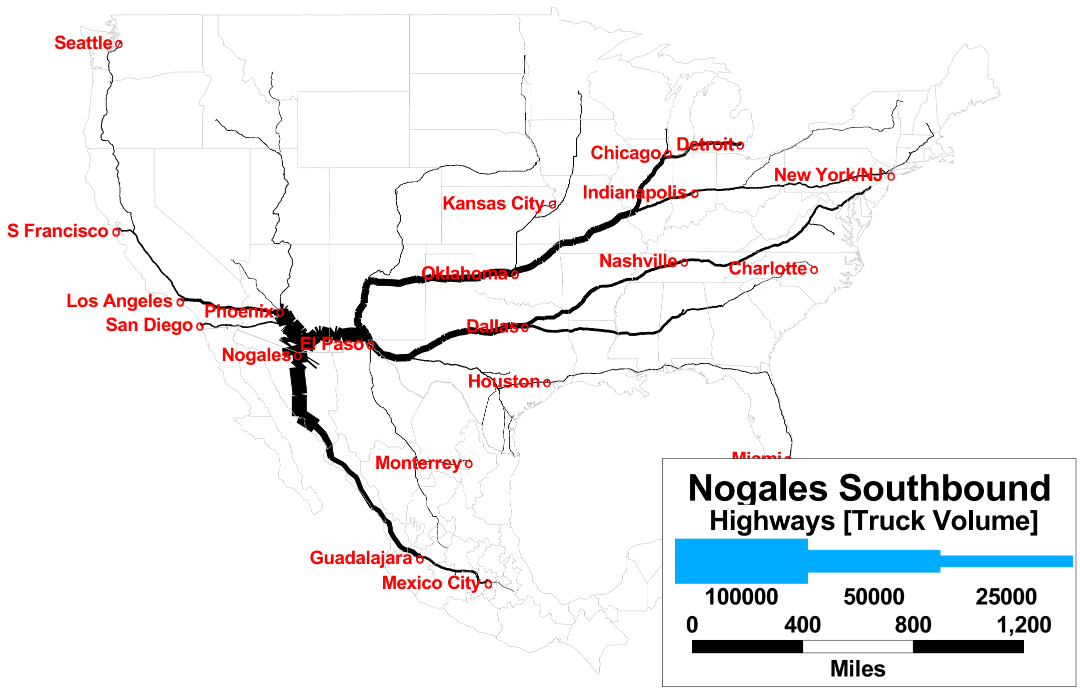


Figure 125. Nogales (Southbound).

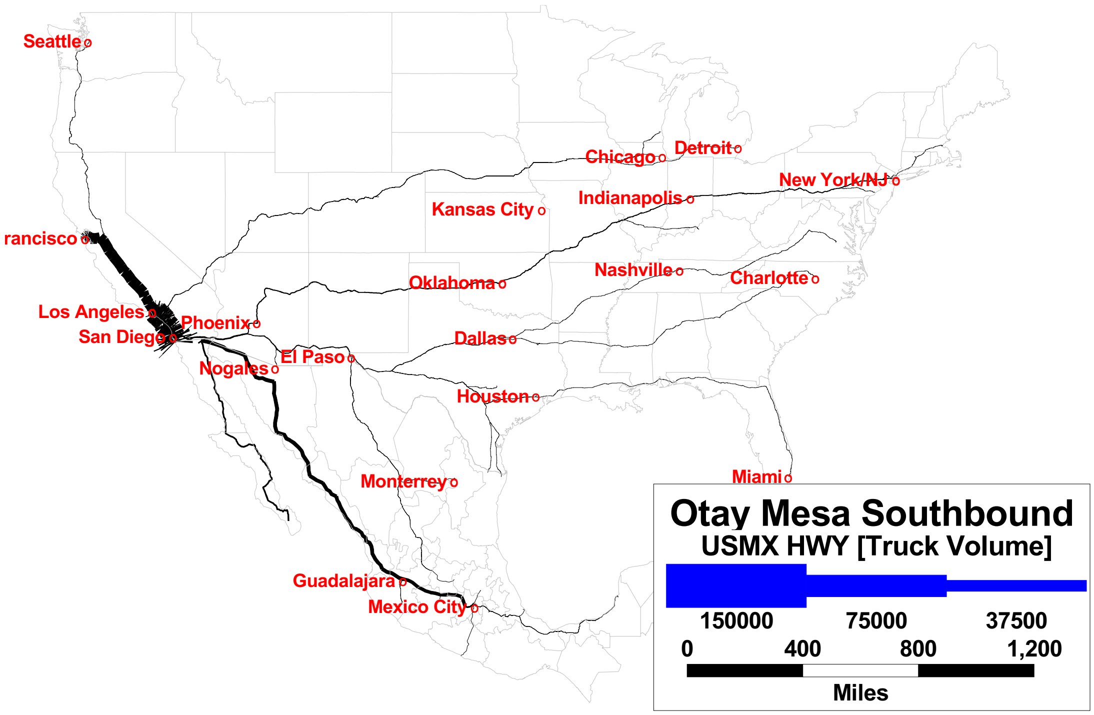


Figure 126. Otay Mesa-San Ysidro (Southbound).

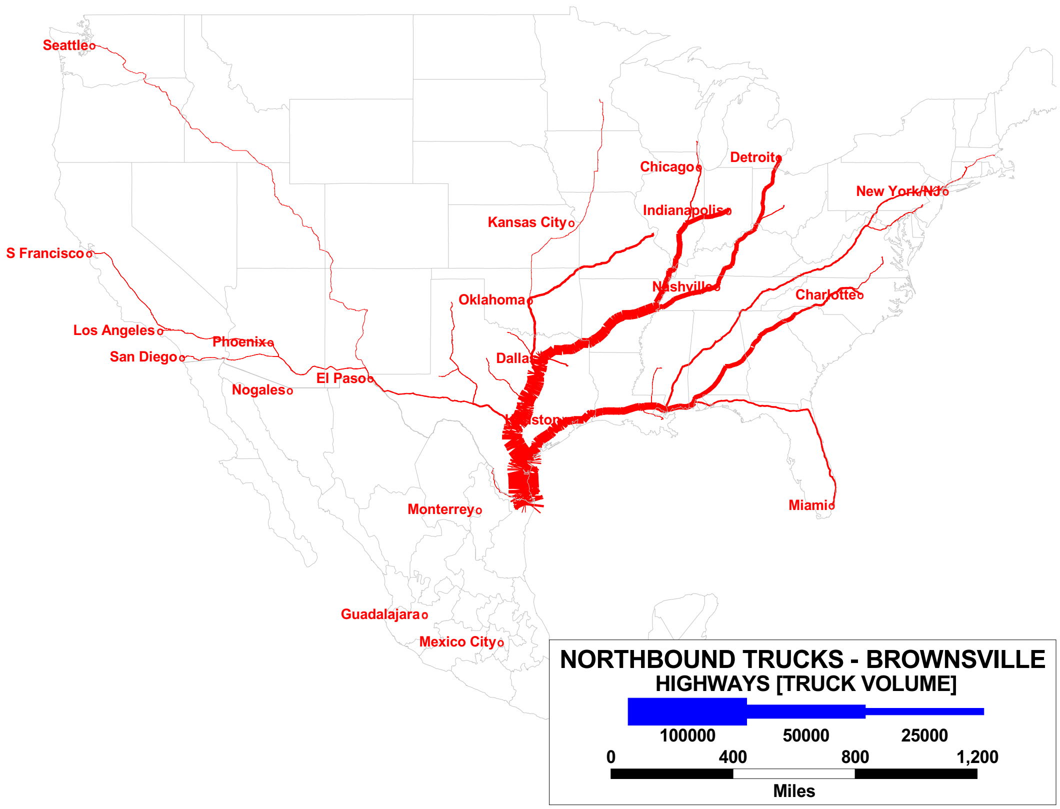


Figure 127. Brownsville (Northbound).

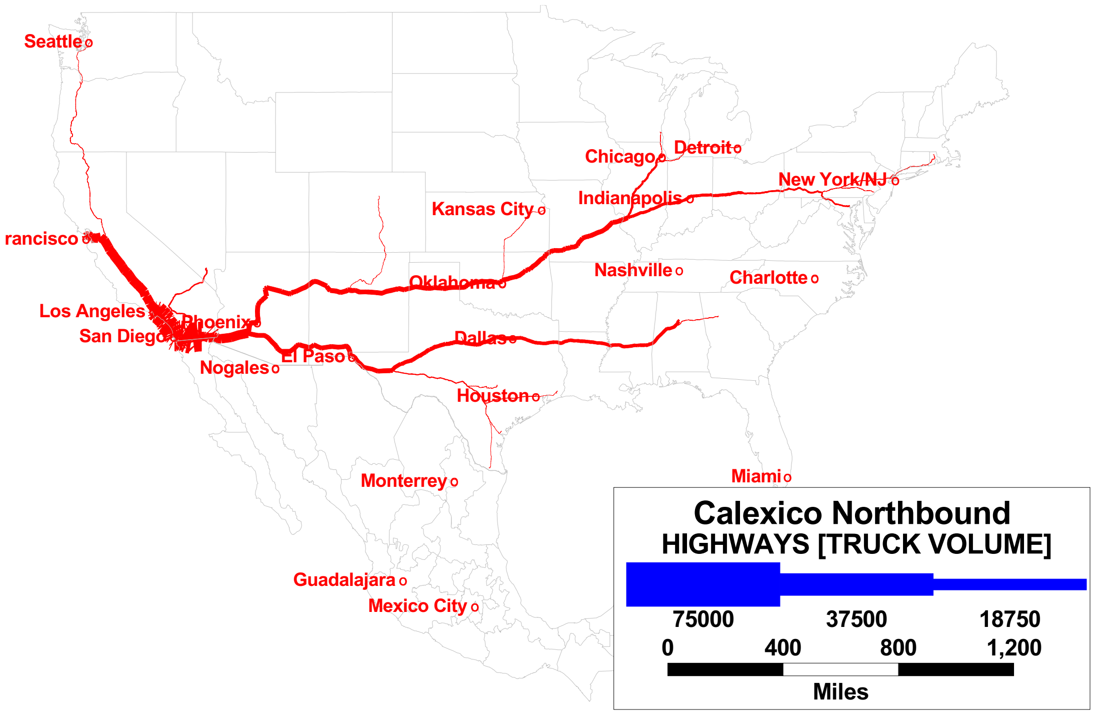


Figure 128. Calexico (Northbound).

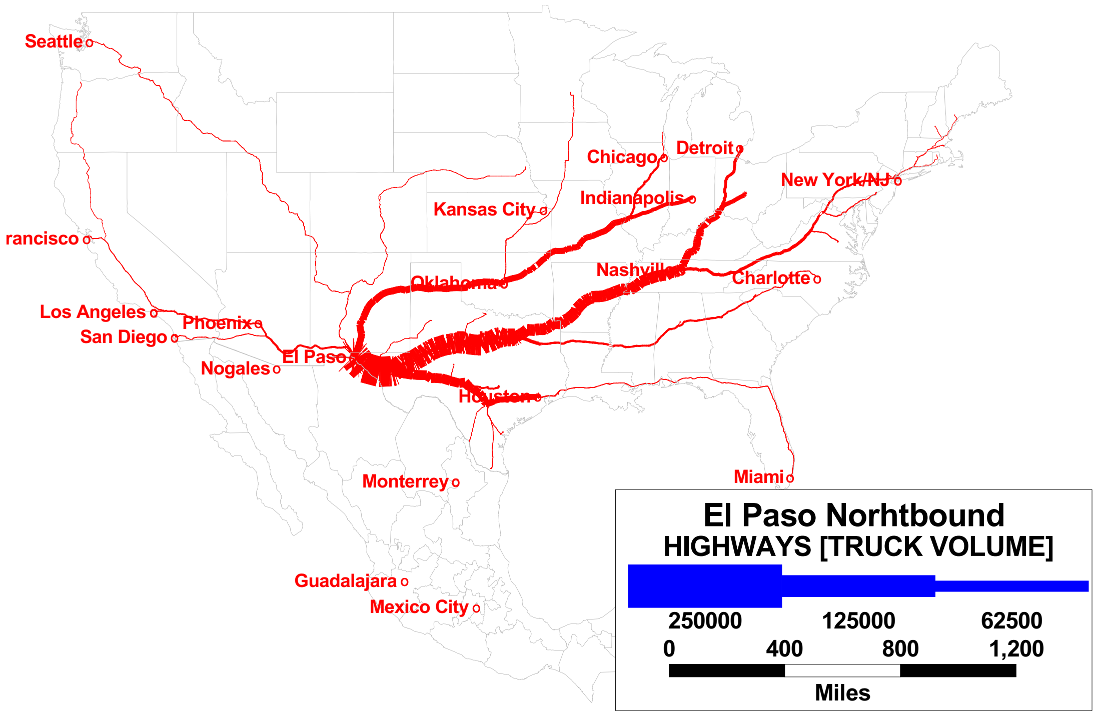


Figure 129. El Paso (Northbound).

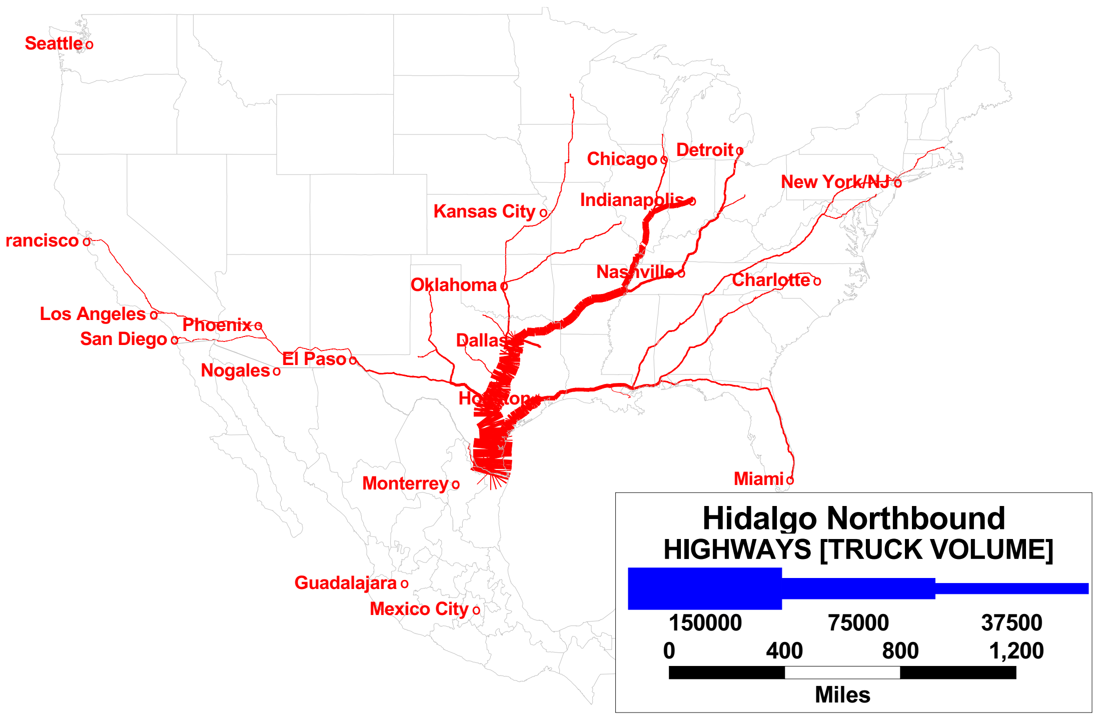


Figure 130. Hidalgo (Northbound).

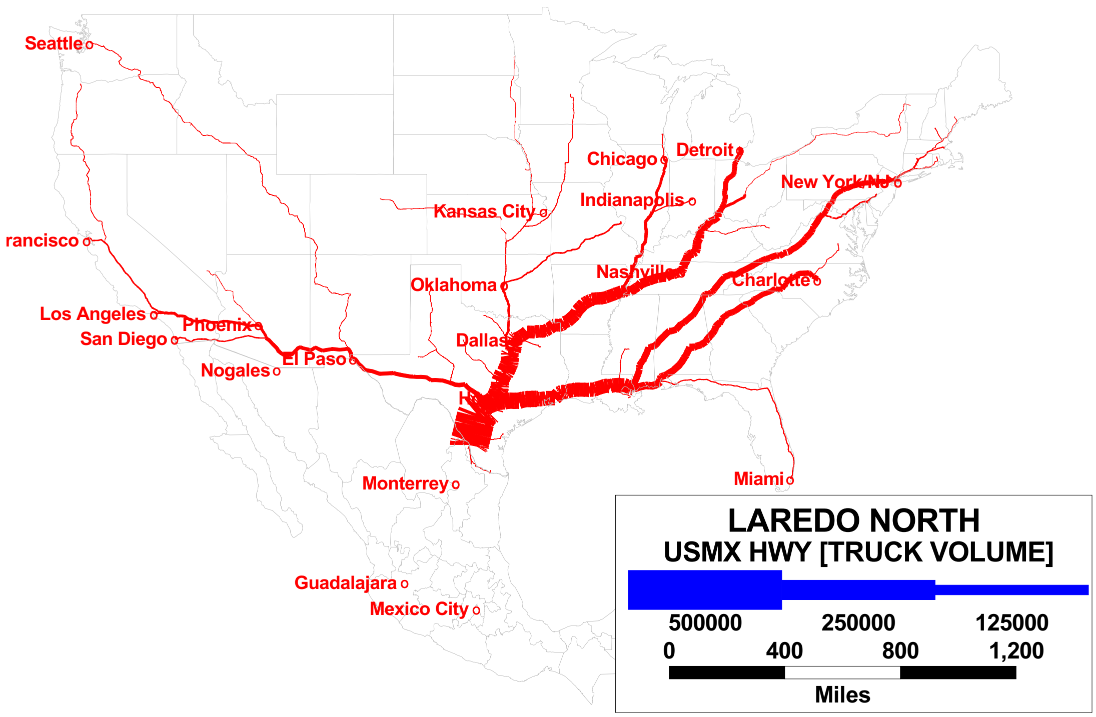


Figure 131. Laredo (Northbound).

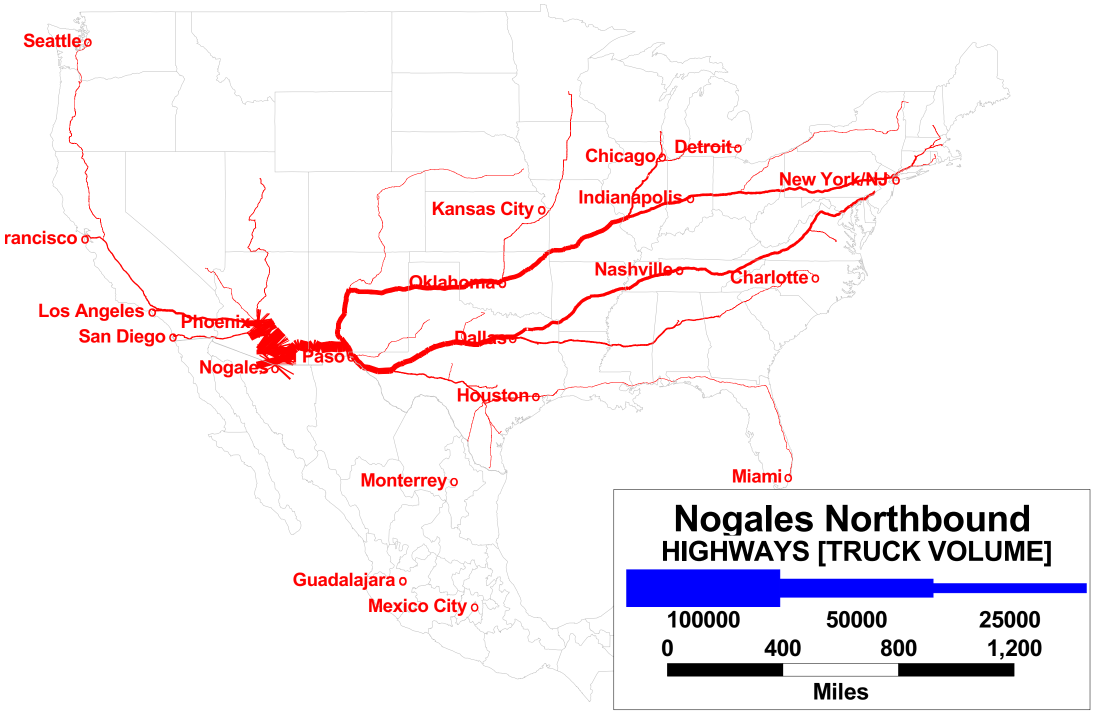


Figure 132. Nogales (Northbound).

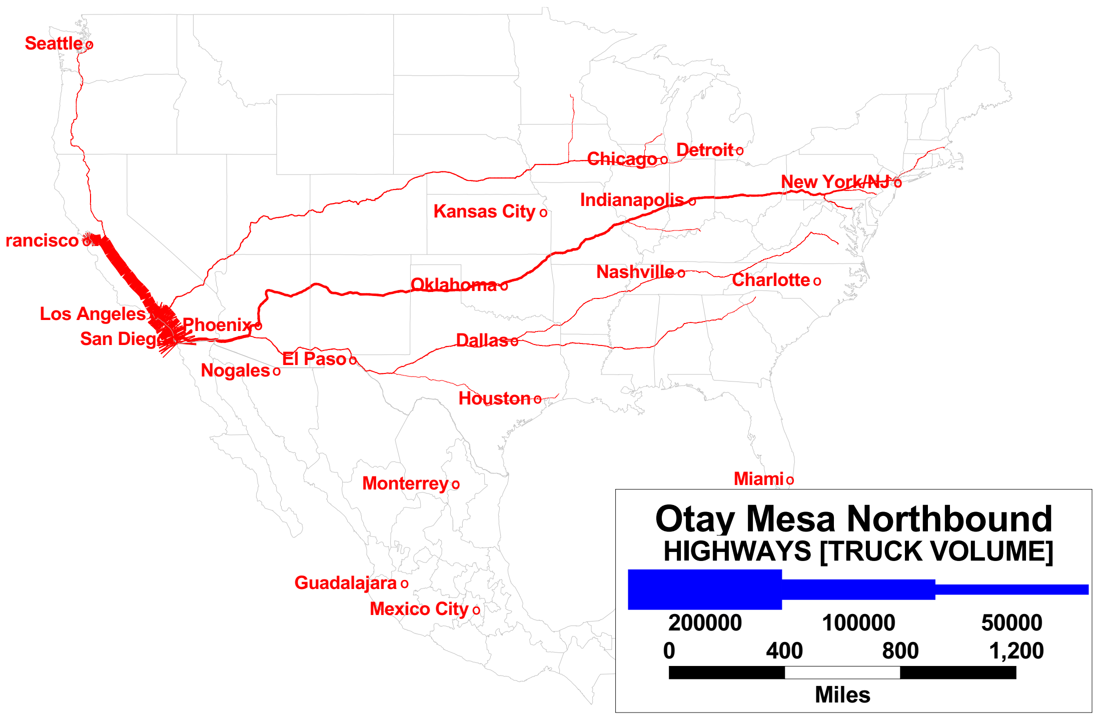


Figure 133. Otay Mesa-San Ysidro (Northbound).

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