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1999

TRUCK TRADE CORRIDORS BETWEEN THE U.S. AND MEXICO

by

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THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE IN ENGINEERING

The University of Texas at Austin

May 1999

TRUCK TRADE CORRIDORS BETWEEN THE U.S. AND MEXICO

Approved by
Supervising Committee:

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Hani S. Mahmassani

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Rob Harrison

To my family, my father

Acknowledgements

I would like to acknowledge the support and assistance of Rob Harrison sharing his knowledge and guiding my research efforts, and Hani Mahmassani for his assistance with the revision of this thesis. I would like to thank Professor John McCray from the University of Texas at San Antonio for his insights into understanding the particularities of NAFTA trade. Finally, I would like to thank Ing. Juan Carlos Espinosa (La Empresa S.A.- Mexico) for providing Mexican trade data.

My deepest gratitude goes to my family and friends for their support.

Austin, May 1999

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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 stimulated a range of research at both federal and state level. At the federal level, a recent study, the Binational Border Transportation Planning and Programming Study (Ref 1), analyses transportation issues at the U.S.-Mexico border. At the state level, significant research has been undertaken especially in the four southern border states.

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. In terms of methodologies to apply in NAFTA transportation planning, two studies were undertaken at the Center for Transportation Research (CTR) at the University of Texas at Austin; the first study focused on methodologies to forecast the effects of NAFTA on the demand for freight transportation at the Texas-Mexico border (Ref 2); the second study used available data to forecast modal split among U.S. and Mexican regions (Ref 3). 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 3).

Border crossings and especially corridors to those crossings are likely to remain an area of interest in the near future, because they critically impact 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 study 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 elements to analyze the impact of NAFTA trucks on the infrastructure. This study can be seen as a continuation in the efforts to provide data and methodologies that can be applied in NAFTA transportation planning (Ref 2 and Ref 4).

ORGANIZATION OF THE STUDY

Chapter 1 introduces the background, objectives and structure of this study. In Chapter 2 the highlights of US-Mexico trade are presented, placing the transportation problem into the larger picture of binational 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; Chapter 7 presents an analysis of the main corridors of NAFTA truck trade. Chapter 8 introduces elements that are useful to analyze impact of NAFTA related truck traffic on the highway infrastructure, specifically on pavements.. This study finishes with conclusions and recommendations. The flow chart in Figure 1 presents the relations among the chapters

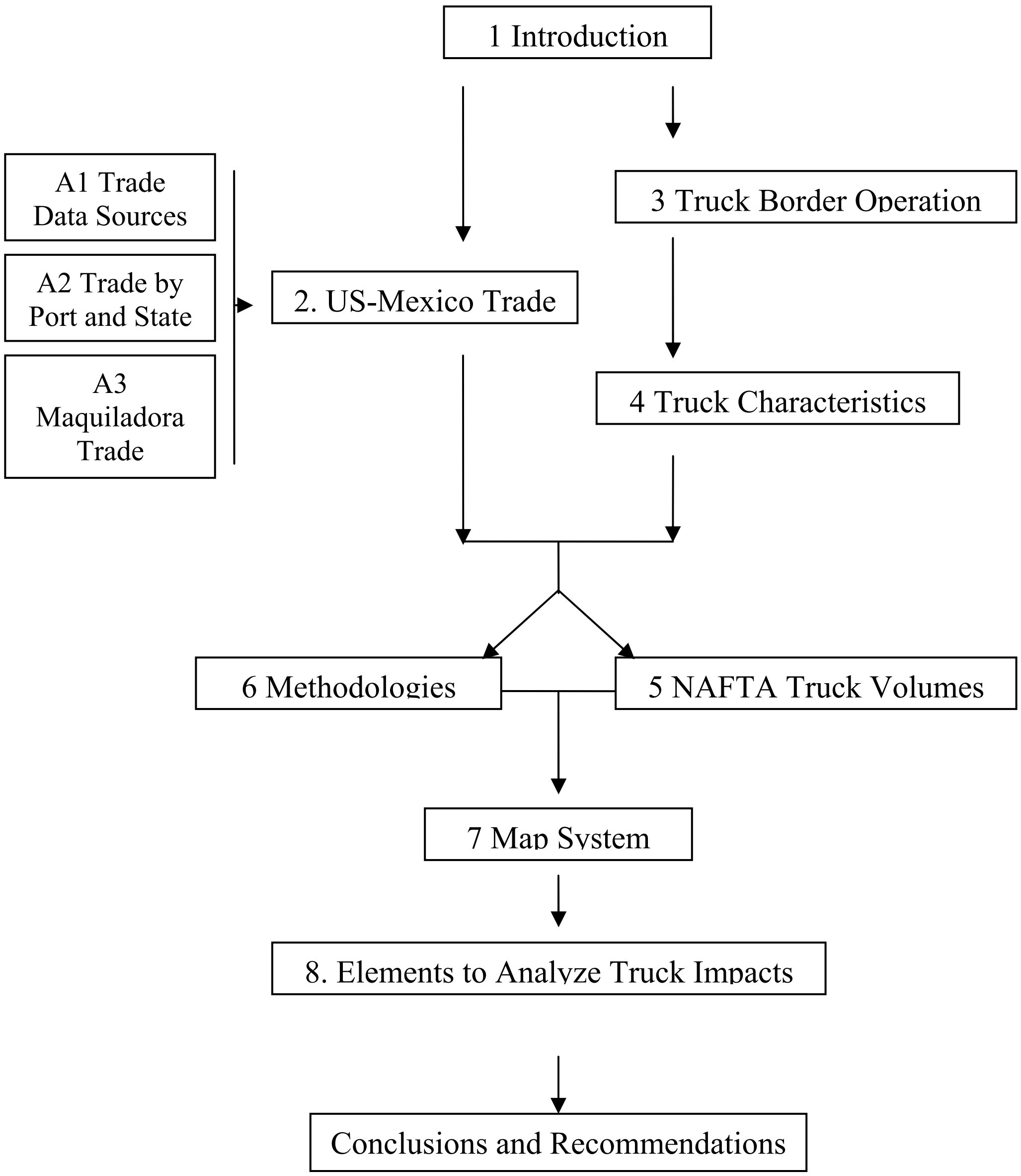


Figure 1. Organization of the Study

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 the 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, 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 with the publication of the Transportation Surface Freight Data (TSFD), beginning in April 1993.

The Bureau of Transportation Statistics (BTS) publishes these data monthly and they are based on declarations filed at U.S. Customs and processed by the Census Bureau.

Though these data sets introduce important improvements over previous data, still the data available to study transportation aspects of U.S.-Mexico trade presents 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 (Ref 5).

An important share of the shortcomings of the data stems from the data collection design. U.S.-Mexico trade data sets available to the public are collected by Mexico or U.S. custom 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 and 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, however, 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 onwards. (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 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). So 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 when analyzing 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 and 12) , produced at The University of Texas at Austin and focusing 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 (2 or 10 digits) or using SITC classification; employment data is published using SIC classification; commodity density is available using STCC data. Unfortunately these systems are not fully compatible, making 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 identification 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 Transborder Surface Freight Database (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 DISTRIC	*					
	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 DISTRIC	*					
	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: (1) surface modal split and commodity classification, (2) surface modal split by port of entry/exit. The other data sources are valuable to complement and verify TSFD. For example, data regarding maquiladora trade are only available from Mexican sources.

Though U.S. trade data are fragmented across several data sources, they substantially match when they are compared with each other 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. When comparing U.S. and Mexico data, disagreements may occur, largely to the different ways the value of the goods are appraised at customs (Ref 1) and also to inaccuracies inherent to the trade data sets.

This section has described characteristics of the data sources available to the transportation planner when examining the U.S.-Mexico trade. While these data are incomplete and need careful treatment when developing 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 to the current situation where Mexico is now one of the leading trading partners with the United States.

MEXICAN ECONOMY, TRADE POLICIES AND U.S.-MEXICO TRADE

The evolution of the U.S.-Mexico trade in the last two decades has been impressive. In 1980 total trade amounted to 28 billion dollars. Ten years later, in 1990, total trade reached 58 billion dollars by 1997; (latest available data) the number reached 159 billion dollars. Total trade over the past 17 years has grown at an average annual rate of 10.7%. The rate of growth accelerated during the nineties. Between 1991 and 1997, imports grew 18.4% and exports at 13.6% per year (Ref 8), which enabled Mexico to replace Japan and become 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 post war Mexican economic policy. The aim of this economic policy was to estimate the growth of the manufacturing sector but at the cost of loss of competitiveness. This policy continued until 1976 when the first economic crisis was created by a deficit of Mexican foreign reserves. In 1981, a fall in the price of oil combined with the scarcity of international credit caused the Mexican economy to collapse (Ref2).

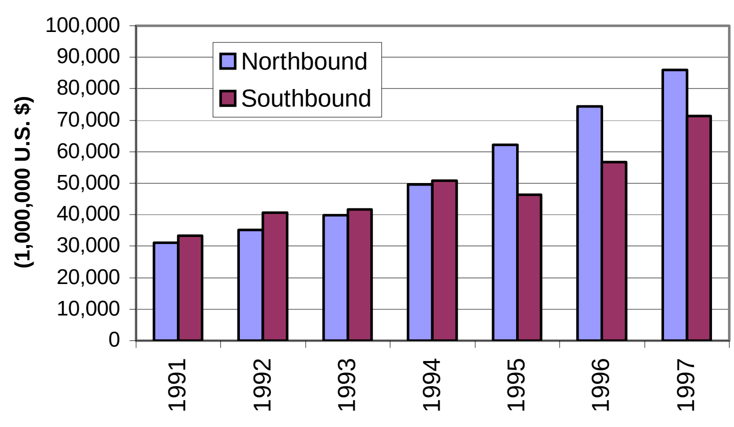


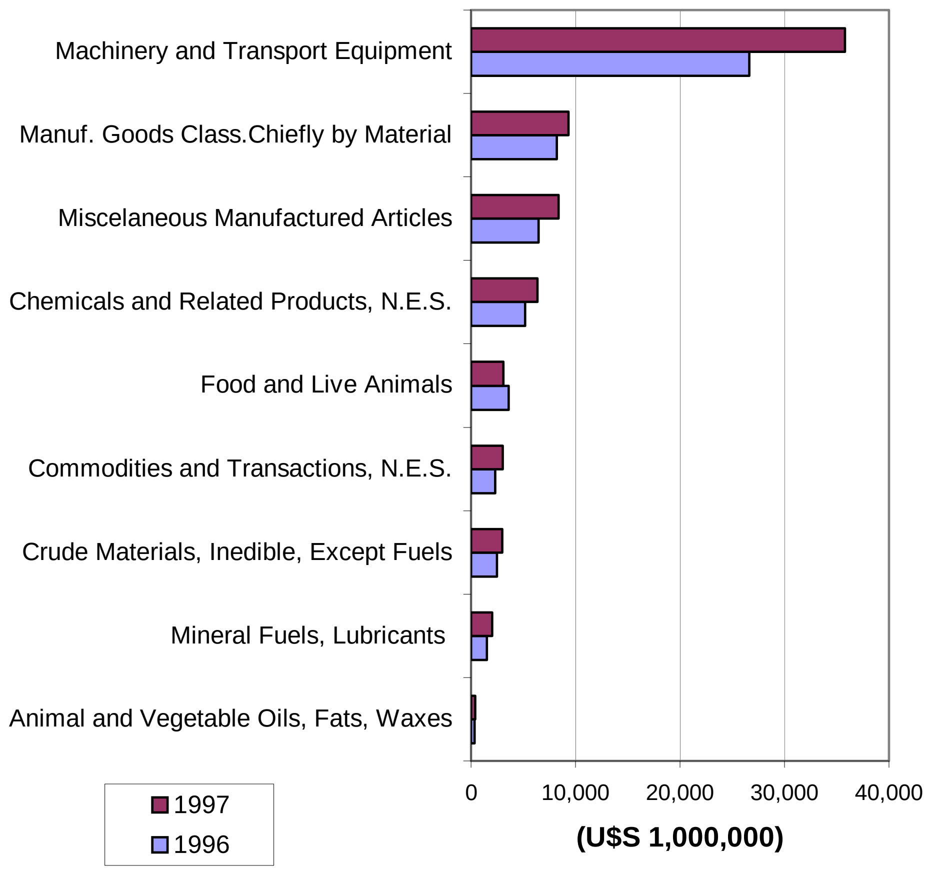
Figure 1 U.S. Trade with Mexico

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 1981-83 and again in December 1994. Devaluation was undertaken as part of the corrective measures by the Mexican government, which further affected the terms of trade. As 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 1.

U.S.-MEXICO TRADE BY COMMODITY

Not only have the trade volumes changed substantially but also so have the commodities traded. In the early 1980's, 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% of total southbound trade by value (1997), up from 46.9% in 1996.

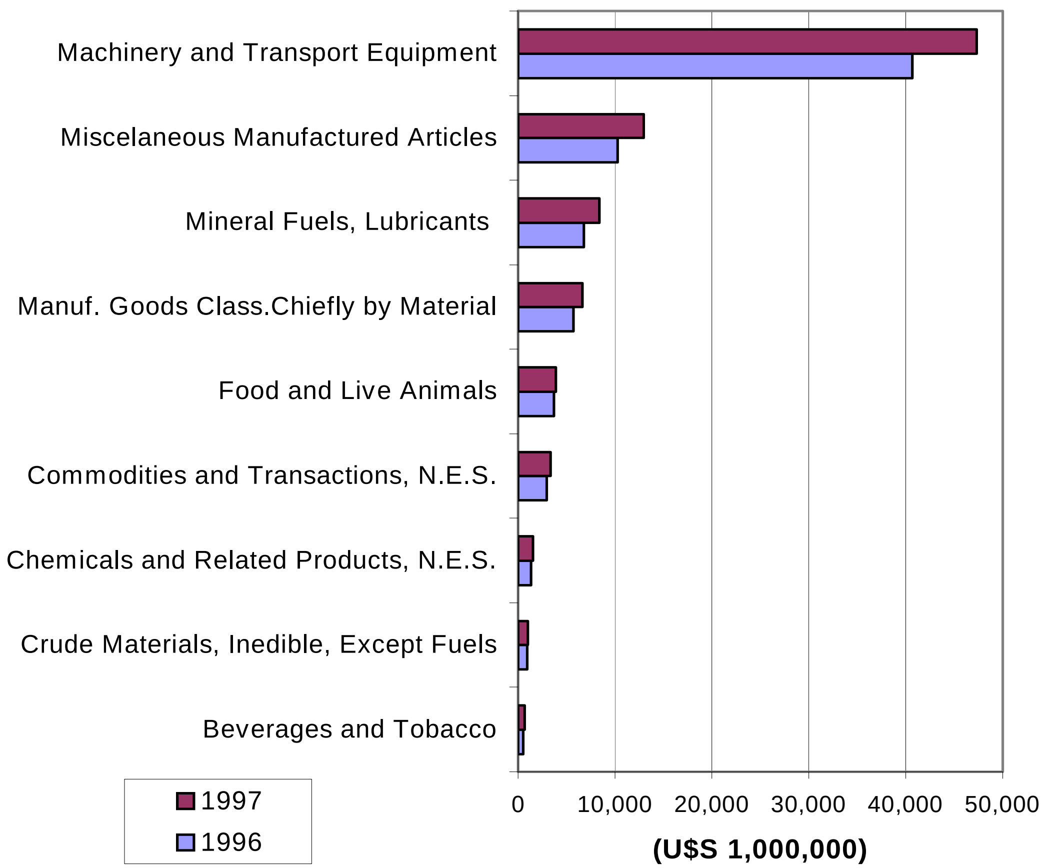


Source: Bureau of Census

Figure 2 Total Southbound Trade

For northbound trade, the share of machinery and transport equipment is even higher, 55.1% in 1997. It is important to note that this corresponds to value traded; if weight is used, 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 3 Total Northbound Trade



Source: Bureau of Census

TRANSPORTATION MODES

Regarding trade by value, both southbound and northbound trades are dominated by surface transportation modes (90% southbound and 85% 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% of southbound trade value and 3% of northbound trade. Southbound sea movements (6% by value) are mainly comprised of agricultural products, minerals, metals, plastics, and chemicals listed in order of importance. Northbound sea movements are more important (12%) due primarily to the U.S. import 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% of southbound trade and 76% of northbound trade cross 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, 17% of northbound trade against a 9% for southbound trade, due to the shipment of assembled items like automobiles from Mexican plants.

Other modes comprise pipelines, mail, 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 does 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 U.S.-Mexico surface trade by value. Electrical machinery alone provides for 36.8% (northbound) and 28.7% (southbound) of 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% (northbound) and 51.8% (southbound) of the trade.

Table 6. Commodity Shares by Truck Trade

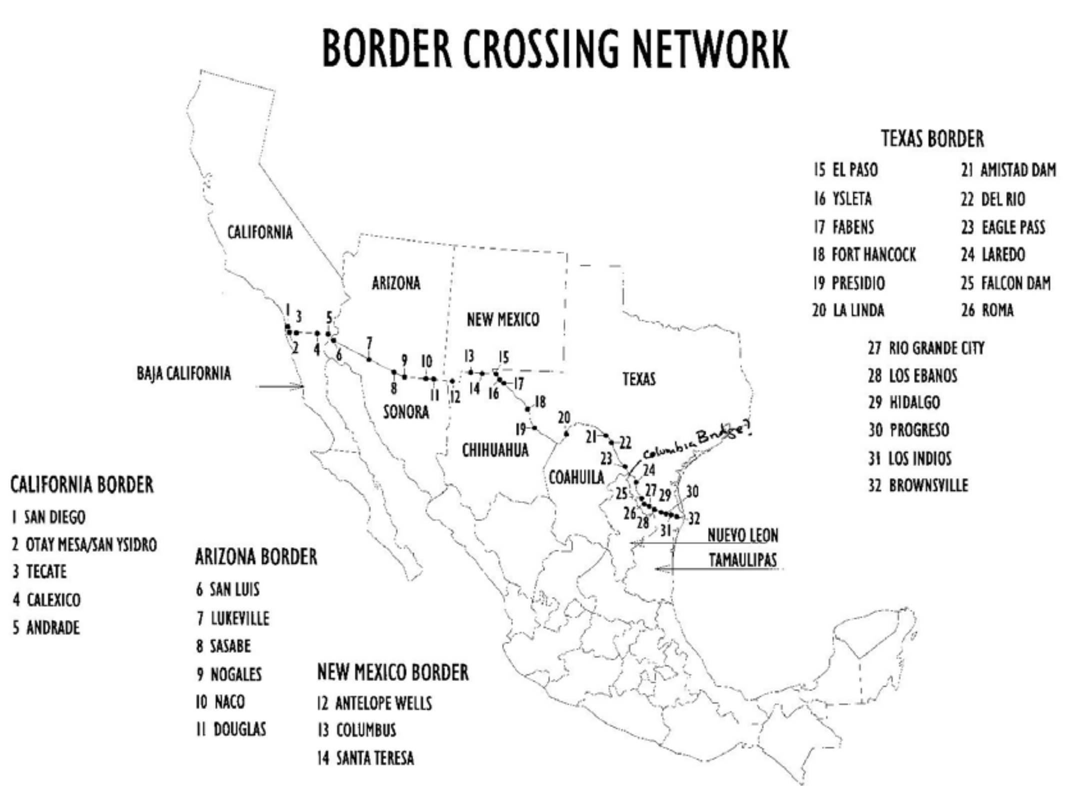
DESCRIPTION	NORTHBOUND		SOUTHBOUND	
	TRUCK	% TRUCK	TRUCK	% TRUCK
Agricultural Products	2,893	6.0%	1,252	2.8%
Food Products	872	1.8%	882	2.0%
Minerals and Metals	3,322	6.9%	4,914	11.1%
Chemicals Plastics	1,509	3.1%	6,246	14.2%
Wood Paper/Pulp	2,540	5.3%	2,597	5.9%
Textiles/Apparel	4,801	9.9%	3,053	6.9%
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 account for 90% of the total U.S.-Mexico surface trade in 1997 are shown in Figure 5. Five of these ports are located on the Texas-Mexico border and comprise Laredo, El Paso, Brownsville, Hidalgo, and Eagle Pass.



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

Figure 4 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 trade crossed through Laredo. Laredo is also the fastest growing port, and during the period 1995-1997 trade grew 74.7%.

El Paso is the second largest port by trade value with 23.1% of all surface trade, but it is one of the slower growing ports (from 1995 to1997 trade grew 13%).

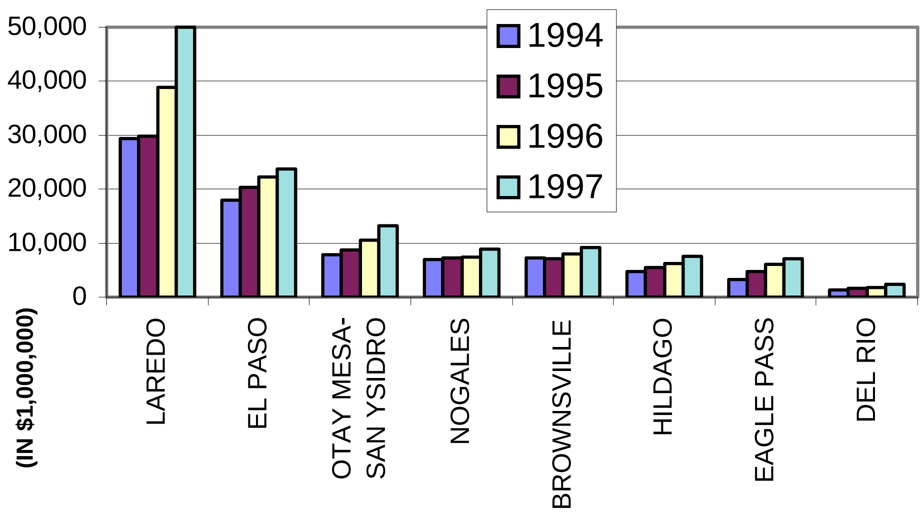


Figure 5 Total Surface Trade by Ports

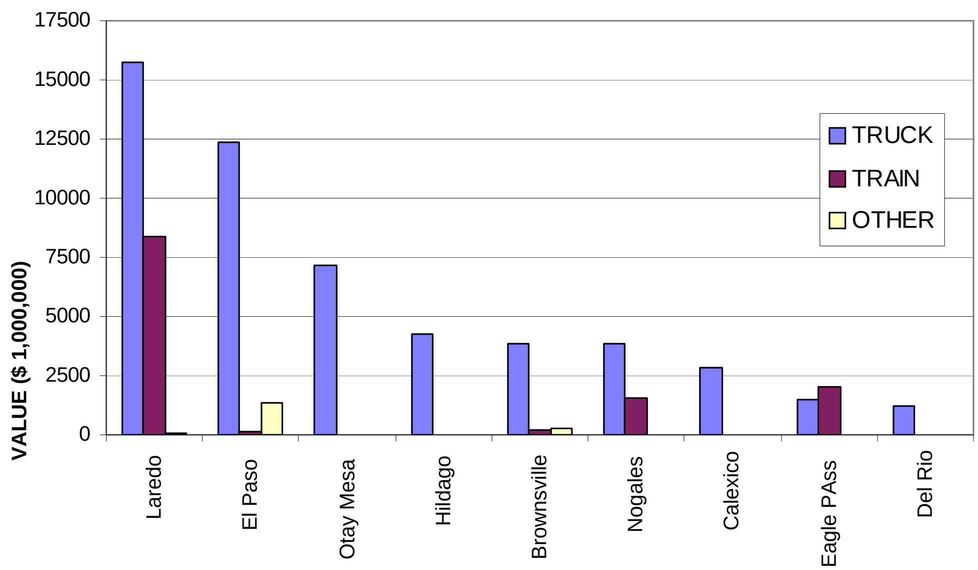


Figure 6 Mode Split by Port (1997 Northbound Movements)

Mode Split by Port

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

Three ports have an important share of railroad traffic as illustrated in Figure 6 and Figure 7; Laredo, Nogales, and Eagle Pass. 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 only have marginal importance in the ports of El Paso and Brownsville.

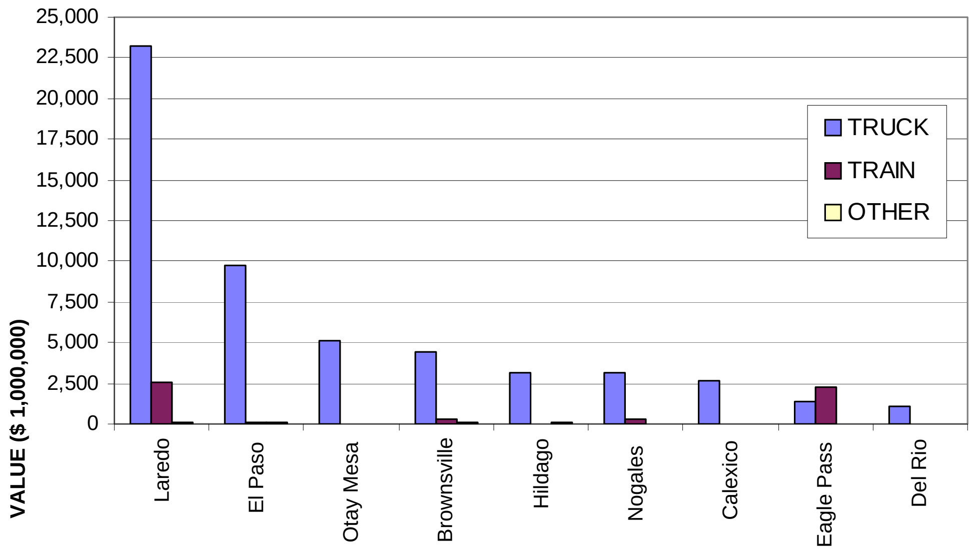


Figure 7 Mode Split by Port (1997 Southbound Movements)

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 Standard International Trade Classification (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 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 strong influence on the commodities traded, e.g., electrical products and machinery has a strong influence on maquiladora ports. There are two aspects related to maquiladora trade that should be kept in mind; first 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% and 19% of the total truck trade respectively (Figure 8). Northbound trade is also more important than southbound trade in California and several non-border states.

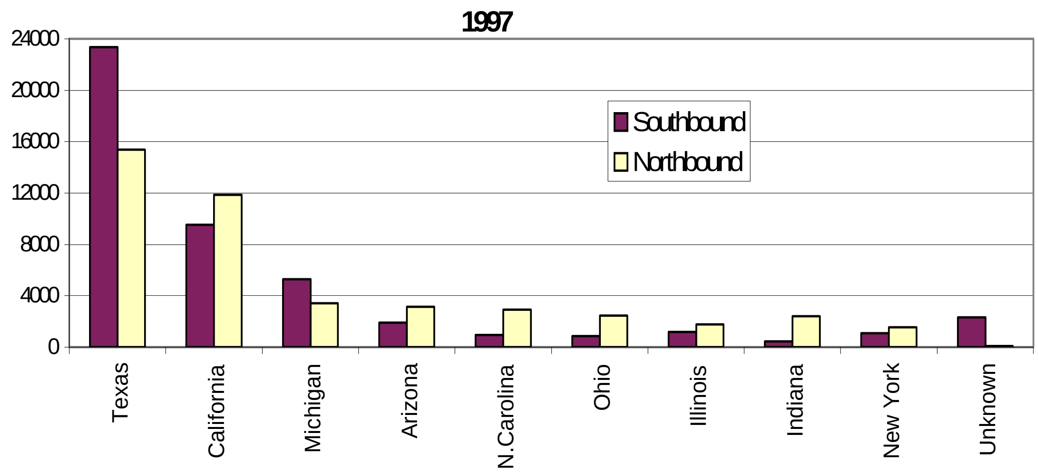


Figure 8 Trade by State (1997)

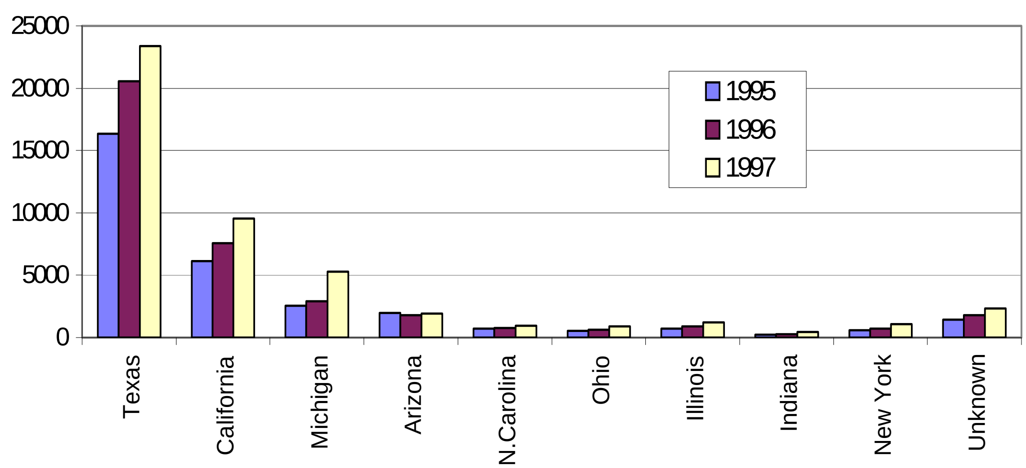


Figure 9 Southbound Trade by State (1995-1997)

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

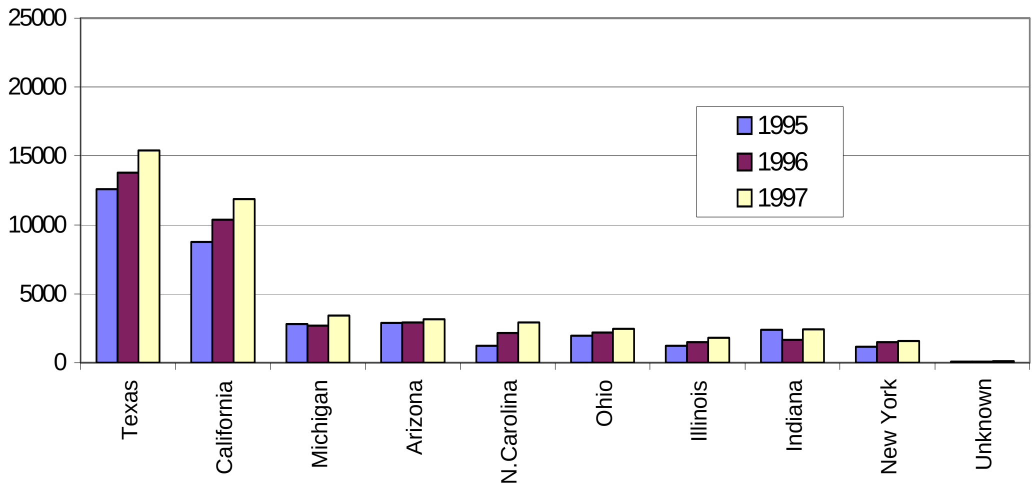


Figure 10 Northbound Trade by State (1995-1997)

COMMODITIES BY STATE

There is a clear commodity specialization by states. States with important industrial concentration related to a commodity are important in that commodity trade, indicating that specialized industrial concentrations are the centers of goods productions or consumption. For example, Michigan, where important auto-makers and heavy industries are located, has an important participation in transportation equipment and industrial machinery; North Carolina shows important imports of industrial machinery and textile products. .But the same centers are not always the centers of attraction/production for the same commodity groups. The important 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 commodity distribution of the six more important states by value. All states show some unbalance per commodity group between imports and exports, but some states show serious inbalances in certain commodities. Arizona with agricultural products and Ohio with electrical products are examples of this situation.

SUMMARY

Trade between 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 to study trade features but they 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, where maquiladoras have a key participation, 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 since they have important influence in the estimation of truck volumes and impacts on highway infrastructure due to 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 be expected 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 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, both 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 has 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) and this is the current status quo (as of August 1998).

BORDER CROSSING

Mexican trucks are generally only allowed to haul from Mexico to within the border commercial zone. The border commercial zone includes the municipality of the border city and the adjacent areas within a specific mileage that depends on the population size of the base municipality (ranges from 3 to 20 miles) as shown in Table 7. To operate in this border zone, the U.S. Department of Transportation Office of Motor Carriers issues a certificate when the carrier complies with U.S. equipment safety standards, 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 (Ref 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 the description of the stages of truck border crossing, the focus of this study is put on the movement of the transportation equipment and cargo but other steps have to be completed. Additionally, there is an exchange of information and documentation that is necessary 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 Shipper's 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 Mexico customs by a local drayage company.
6. After Mexican customs is cleared, the truck proceeds to the Mexican carrier's yard (on the Mexico 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 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 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: U.S. carrier, brokers, customs, drayage company, Mexican carrier, and warehouses. This system has often been criticized as highly inefficient and costly. An ideally seamless operation will not require to stop truck movements at the border and hand over trailers, which in turn would decrease travel time and cost.

One example of this inefficiency is presented in "Bordering the Future" (Ref 20). Based on interviews with truckers, the report describes the steps to carry computer parts from Chicago to Monterrey. While the time to transport the shipment from Chicago to Laredo takes 26 hours, and to Laredo to Monterrey 12hours, the crossing of the border (around 30 miles) consumes 35 hours. As described before many binational entities or organizations are involved in the crossing. This time is required to prepare and submit the paperwork for customs, verify the cargo and prepare documents each time that 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 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% of the workers who work in transportation services in the state of the 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, maquiladora's trucks or a drayage company cross 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, having only tractor changes.

For intermodal shipments, two different situations may take place with the handling of Containers or trailers. Usually trailers (TOFC) are unloaded at the intermodal yard on the U.S. side, they are 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 Transborder Surface Freight Database (TSFD), because these shipments are registered as truck shipments rather than intermodal shipments. Containers (COFC) in general cross the border on train. 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 uses Laredo as 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, though 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 due to 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 the Mexican trucks on the U.S. side 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%, while the rate for Mexican trucks reaches 63 percent (data collected in Arizona in 1994). Most of the problems were related to equipment (structural cracks, lights, brakes, steering, etc.), driver (age, licenses, drug use, language problems), and cargo (mislabeled, misweighted, unsecured, and 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 (Ref4)

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 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 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 body injuries is automatically treated as both criminal and civil matter, which may involve detention or impoundment of the vehicle (Ref 21). This situation hinders seamless transportation since a truck that crosses the border needs double coverage for only one truck.

TRUCK SIZE AND WEIGHT

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

Two situations are possible with a shipment that weighs out:

1. The shipment is consolidated at the border. Therefore the truck operates with two different truckloads: one in Mexico (heavier) and another in 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.

Regarding truck size, truck lengths regulations are in general 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. Mexico and U.S. Truck Size and Weight Limits (Ref 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 need to be studied with a binational perspective. Motor carrier regulations, truck size and weight, insurance and customs operations on both sides of the border are the most important elements that constrain truck operations. These characteristics complicate and 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 to the border, and WIM sites located at Laredo and El Paso bridges. Truck characteristics will be used in Chapter 5 to estimate NAFTA trucks and in Chapter 8 that gives elements to analyze the impact of NAFTA on infrastructure.

Previous Research

Using specifically installed weigh in motion systems (WIM), truck axle loads, truck classification, and truck counts were obtained and studied 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 the Texas Department of Transportation (TxDOT) and The University of Texas at Austin's Center for Transportation Research (CTR) made it possible to collect data at a variety of WIM stations. A database was created utilizing information from nonborder WIM sites provided by TPP and 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	IH20	NOLAN	IH20 WEST OF SWEETWATER
LW507	IH45	WALKER	IH45 SOUTH OF HUNTSVILLE
LW509	IH30	HUNT	IH30 EAST OF GREENVILLE
LW510	IH10	EL PASO	IH10 NORTH OF EL PASO
LW512	IH37	LIVE OAK	IH37 NORTH OF THREE RIVERS
LW513	IH35	BELL	IH35 SOUTH OF SALADO
LW515	U.S.281	HIDALGO	U.S.281 NORTH OF EDINBURG
LW516	IH35	BEXAR	IH35 SOUTH OF LOOP1604
LW517	U.S.83	HIDALGO	U.S.83 WEST OF FM1426

TPP Stations

In Figure 11 , the locations of the stations have been plotted on a map of Texas. There are three stations located close to the border and therefore likely to capture the influence of NAFTA truck traffic. These stations are LW510, LW516 and LW517.

Station LW510 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 LW517 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 with 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 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 IH 20, IH 30, and IH 35), they also carry even heavier amounts of domestic trade to varying degrees according to the station location. For example between San Antonio and Laredo more than 90% of the combination trucks are expected to be NAFTA trade related, however between San Antonio and Austin the percentage of NAFTA trucks is not higher than 40% (according to result of Chapter 5 and HPMS data provided by TxDOT). The further away from the border the less percentage of NAFTA trucks in the truck traffic is expected to be found, especially after big urban areas (e.g. San Antonio, Austin, Dallas, Houston). Therefore, this study assumes that they 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.

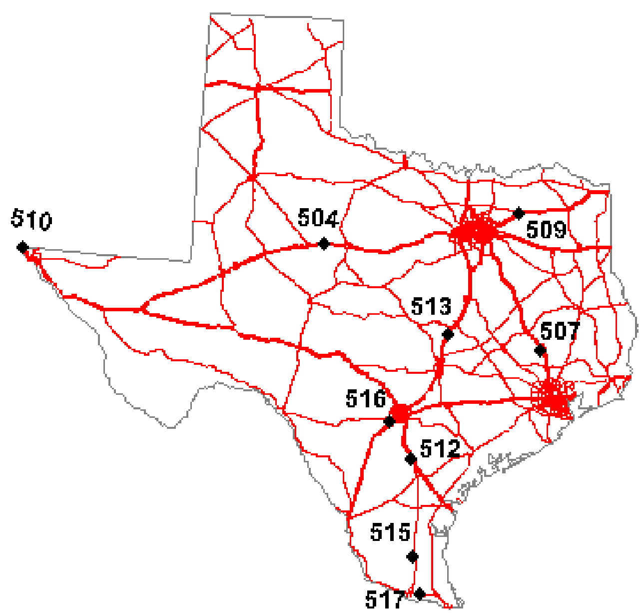


Figure 11 WIM station locations

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 done throughout the day (24 hours) on selected weekdays. The number of collection days varies from 2 to 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 days was September 13th at station 512 and the other was October 23 at station 516. There are records for all the hours throughout 24 hours of the day on both days and stations, besides the total number of trucks is about the half of the average; however, the average weight per truck and standard deviation is still consistent with the rest of the data. This was the only inconsistency found in the data and is shown in Table 12.

Table 11 WIM Station Location and Days of Data Collection

STATION	HIGHWAY	YEAR	MONTH	DAY		RECORDS	Av. WEIGHT	StDev
LW504	IH 20	95	Feb	Monday	13	2854	57,911	17,581
			Feb	Tuesday	14	3645	58,188	17,295
LW507	IH 45	95	Feb	Wednesday	1	3937	54,874	17,821
			Feb	Thursday	2	4116	54,646	17,804
			May	Wednesday	17	4068	56,934	18,659
			May	Thursday	18	4221	56,567	18,244
LW509	IH 30	95	Jun	Wednesday	14	5065	56,241	17,921
			Jun	Thursday	15	3701	55,909	18,067
LW510	IH 10	95	Mar	Monday	20	2691	54,052	16,980
			Mar	Tuesday	21	3546	55,210	16,786
			Apr	Tuesday	18	3296	54,649	17,034
			Apr	Wednesday	19	4157	55,778	16,525
			Sep	Tuesday	19	3359	56,476	17,655
			Sep	Wednesday	20	4250	58,554	17,142
			Dec	Tuesday	12	4045	57,509	17,238
			Dec	Wednesday	13	4701	58,668	16,949
LW512	IH 37	95	Apr	Tuesday	18	2329	54,854	20,017
			Apr	Wednesday	19	2045	54,119	20,072
			Sep	Tuesday	12	1601	50,175	18,875
			Sep	Wednesday	13	**832**	51,754	19,158
			Dec	Tuesday	12	2155	52,933	19,274
			Dec	Wednesday	13	1887	53,798	18,770
LW513	IH 35	95	Feb	Tuesday	21	4425	54,485	17,430
			Feb	Wednesday	22	4603	54,367	17,393
			Jun	Wednesday	21	4591	53,075	17,091
			Jun	Thursday	22	4767	52,357	17,045
			Jul	Monday	10	3781	51,494	16,965
			Jul	Tuesday	11	4412	51,573	17,252
			Dec	Wednesday	13	4851	52,435	16,456
			Dec	Thursday	14	4903	52,158	16,635
LW515	US 281	95	Feb	Monday	27	1365	52,705	18,783
			Feb	Tuesday	28	1615	54,176	18,845
			May	Wednesday	17	1550	52,927	19,801
			May	Thursday	18	1463	51,953	19,588
			Jul	Monday	17	918	49,352	17,406
			Jul	Tuesday	18	1023	50,473	18,142
LW516	IH 35	95	May	Monday	22	2295	56,494	19,224
			May	Tuesday	23	2258	56,412	19,230
			Oct	Monday	23	**854**	59,857	18,482
			Oct	Tuesday	24	2398	55,585	18,208
			Oct	Wednesday	25	2567	55,934	17,770
			Oct	Thursday	26	2658	55,922	17,959
LW517	US 83	95	Feb	Monday	27	1570	48,736	19,275
			Feb	Tuesday	28	1558	48,599	19,237
			May	Monday	22	1481	47,686	19,604
			May	Tuesday	23	1693	49,564	20,829
			Jul	Monday	10	1141	47,487	19,486
			Jul	Tuesday	11	1178	46,856	19,730
			Dec	Monday	11	1620	46,694	19,293
			Dec	Tuesday	12	1751	47,474	20,038

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 Day of Data Collection

STATION	HIGHWAY	YEAR	MONTH	DAY		RECORDS	Av. WEIGHT	StDev
LW504	IH 20	95	Feb	Monday	13	2854	57,911	17,581
LW504	IH 20	95	Feb	Tuesday	14	3645	58,188	17,295
LW507	IH 45	95	Feb	Wednesday	1	3937	54,874	17,821
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LW507	IH 45	95	May	Wednesday	17	4068	56,934	18,659
LW507	IH 45	95	May	Thursday	18	4221	56,567	18,244
LW509	IH 30	95	Jun	Wednesday	14	5065	56,241	17,921
LW509	IH 30	95	Jun	Thursday	15	3701	55,909	18,067
LW510	IH 10	95	Mar	Monday	20	2691	54,052	16,980
LW510	IH 10	95	Mar	Tuesday	21	3546	55,210	16,786
LW510	IH 10	95	Apr	Tuesday	18	3296	54,649	17,034
LW510	IH 10	95	Apr	Wednesday	19	4157	55,778	16,525
LW510	IH 10	95	Sep	Tuesday	19	3359	56,476	17,655
LW510	IH 10	95	Sep	Wednesday	20	4250	58,554	17,142
LW510	IH 10	95	Dec	Tuesday	12	4045	57,509	17,238
LW510	IH 10	95	Dec	Wednesday	13	4701	58,668	16,949
LW512	IH 37	95	Apr	Tuesday	18	2329	54,854	20,017
LW512	IH 37	95	Apr	Wednesday	19	2045	54,119	20,072
LW512	IH 37	95	Sep	Tuesday	12	1601	50,175	18,875
LW512	IH 37	95	Sep	Wednesday	13	**832**	51,754	19,158
LW512	IH 37	95	Dec	Tuesday	12	2155	52,933	19,274
LW512	IH 37	95	Dec	Wednesday	13	1887	53,798	18,770
LW513	IH 35	95	Feb	Tuesday	21	4425	54,485	17,430
LW513	IH 35	95	Feb	Wednesday	22	4603	54,367	17,393
LW513	IH 35	95	Jun	Wednesday	21	4591	53,075	17,091
LW513	IH 35	95	Jun	Thursday	22	4767	52,357	17,045
LW513	IH 35	95	Jul	Monday	10	3781	51,494	16,965
LW513	IH 35	95	Jul	Tuesday	11	4412	51,573	17,252
LW513	IH 35	95	Dec	Wednesday	13	4851	52,435	16,456
LW513	IH 35	95	Dec	Thursday	14	4903	52,158	16,635
LW515	US 281	95	Feb	Monday	27	1365	52,705	18,783
LW515	US 281	95	Feb	Tuesday	28	1615	54,176	18,845
LW515	US 281	95	May	Wednesday	17	1550	52,927	19,801
LW515	US 281	95	May	Thursday	18	1463	51,953	19,588
LW515	US 281	95	Jul	Monday	17	918	49,352	17,406
LW515	US 281	95	Jul	Tuesday	18	1023	50,473	18,142
LW516	IH 35	95	May	Monday	22	2295	56,494	19,224
LW516	IH 35	95	May	Tuesday	23	2258	56,412	19,230
LW516	IH 35	95	Oct	Monday	23	**854**	59,857	18,482
LW516	IH 35	95	Oct	Tuesday	24	2398	55,585	18,208
LW516	IH 35	95	Oct	Wednesday	25	2567	55,934	17,770
LW516	IH 35	95	Oct	Thursday	26	2658	55,922	17,959
LW517	US 83	95	Feb	Monday	27	1570	48,736	19,275
LW517	US 83	95	Feb	Tuesday	28	1558	48,599	19,237
LW517	US 83	95	May	Monday	22	1481	47,686	19,604
LW517	US 83	95	May	Tuesday	23	1693	49,564	20,829
LW517	US 83	95	Jul	Monday	10	1141	47,487	19,486
LW517	US 83	95	Jul	Tuesday	11	1178	46,856	19,730
LW517	US 83	95	Dec	Monday	11	1620	46,694	19,293
LW517	US 83	95	Dec	Tuesday	12	1751	47,474	20,038

Table 13 Vehicle Type coding chart

	1st Character	*2nd Character*	*3rd Character*	*4th Character*	*5th 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

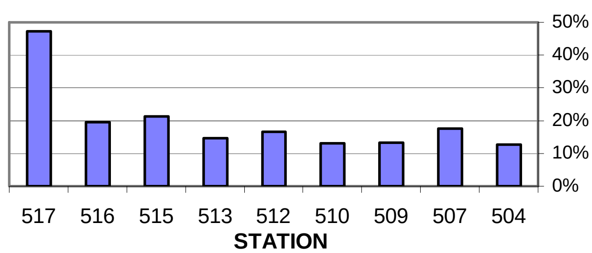


Figure 12 Vehicle Type 220000

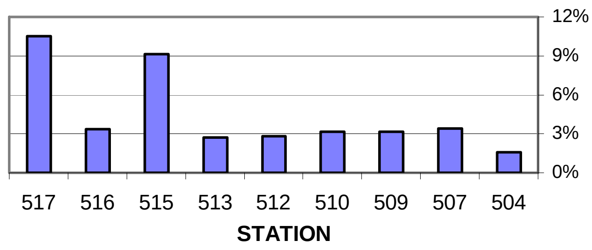


Figure 13 Vehicle Type 230000

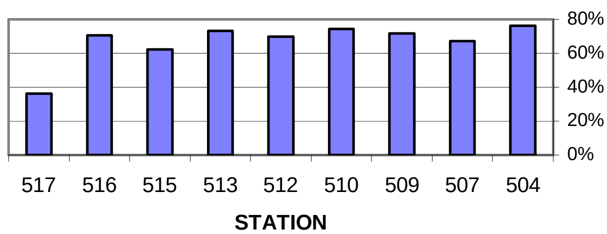


Figure 14 Vehicle Type 332000

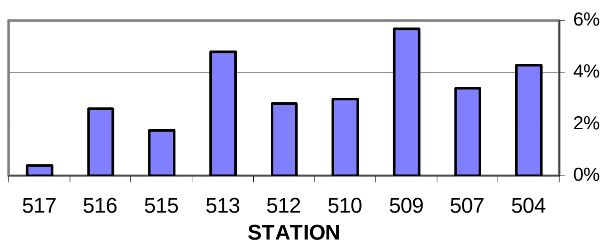


Figure 15 Vehicle Type 521200

The percentage of these trucks found at the stations is shown in Figure 12 to Figure 15, where it is seen that these four truck types total more than 95% 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 combination and 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. 332000 trucks account in some cases for 88% (*) of the total weight moved on the highway, for example at station 504. In Tables 14 to 22 there are detailed classifications of the nine stations with truck type count, 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% of the combination trucks account for almost 70% (*) of the total weight. Total weight is used as an indicator of pavement damage by truck type though in order to analyze exactly pavement damage it is necessary to 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. At border zones, these tend to be operated within border commercial zones and generally comprise less than 2% of the truck traffic but they also tend to be heavily overloaded unless U.S. enforcement personnel are in the area.

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

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 commodity carried. Three possible situations occur when calculating 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 under 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 vs. frequency were plotted for vehicle type 3320000, the truck type with the highest representation on highways and therefore the largest number of records. Nine histograms, with the weight distribution for vehicle type 332000 are shown in Figure 16 to Figure 24. 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 road (a certain percentage over the weight limit) determines the highest weight value. Extreme values may be caused by:

- Misclassification that leads to include a smaller vehicle in a bigger category or vice versa
- Overweighed 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% of the records in all the stations analyzed.

Table 14. Statistical parameters of weight 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 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 limit weight 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.

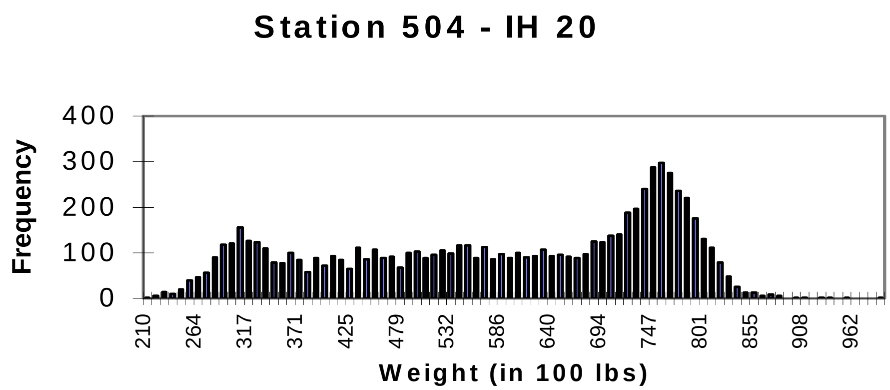


Figure 16 Weight Histogram (Truck 332000) Station 504

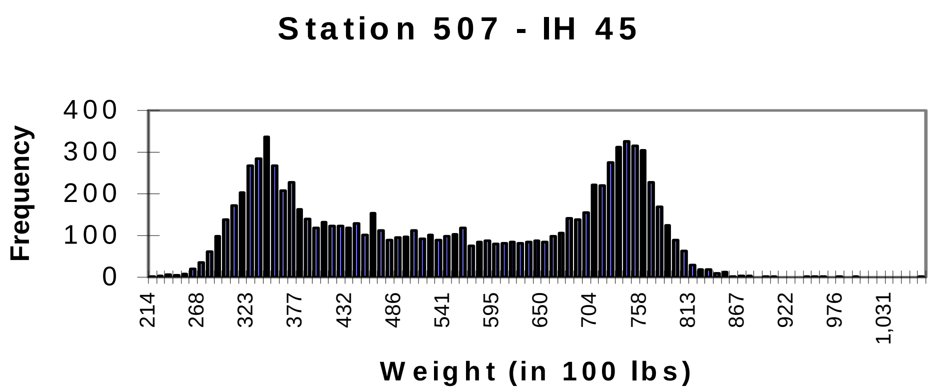


Figure 17 Weight Histogram (Truck 332000) Station 507

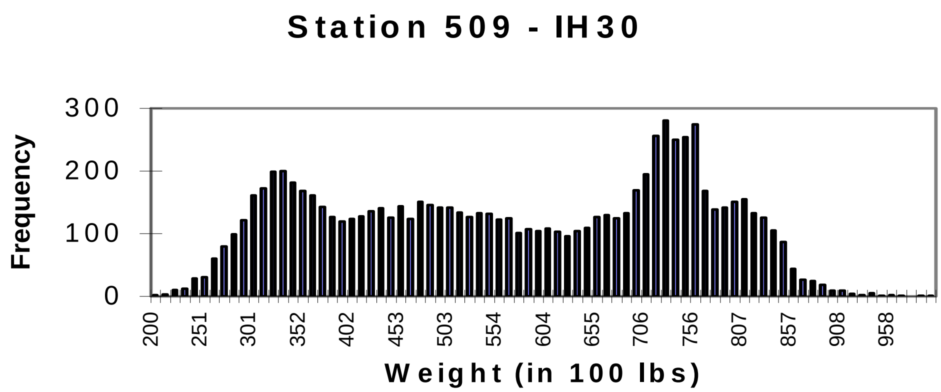


Figure 18 Weight Histogram (Truck 332000) Station 509

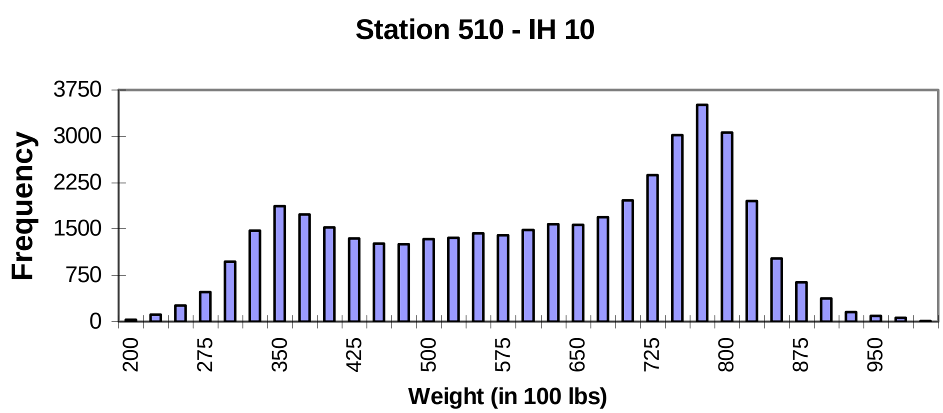


Figure 19 Weight Histogram (Truck 332000) Station 510

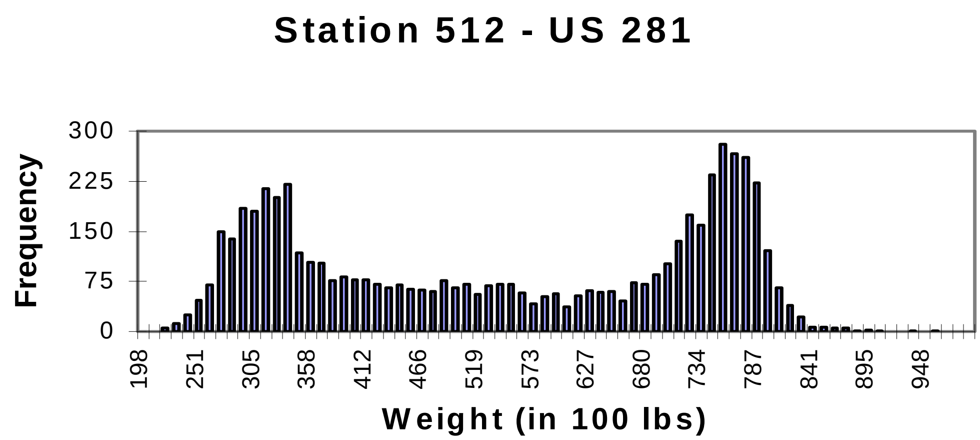


Figure 20 Weight Histogram (Truck 332000) Station 512

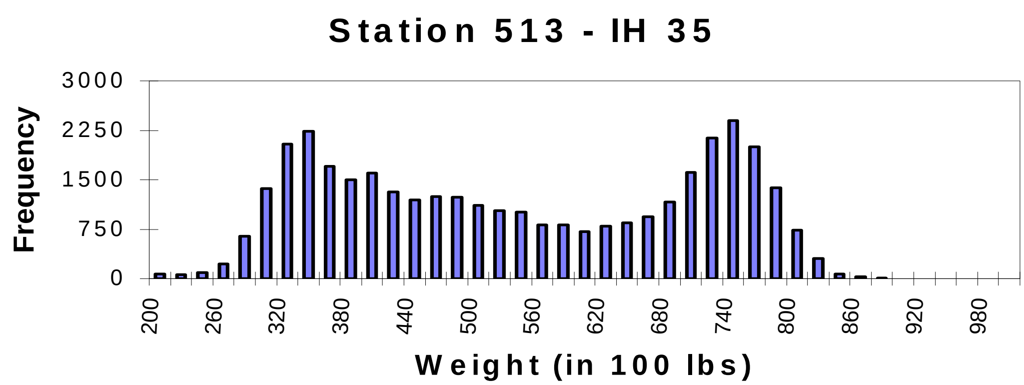


Figure 21 Weight Histogram (Truck 332000) Station 513

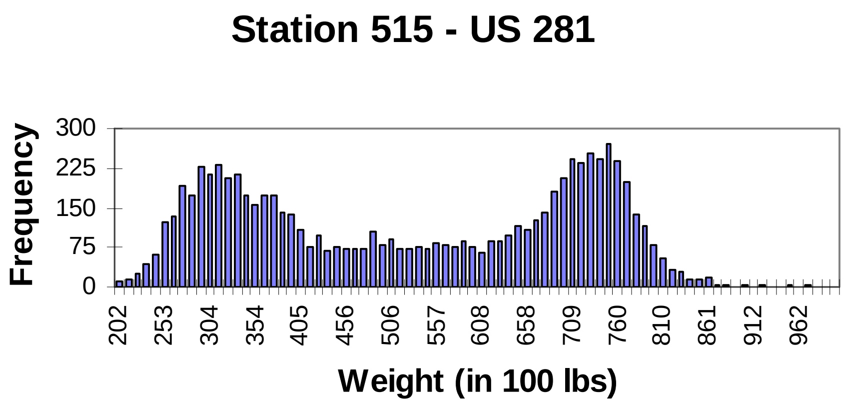


Figure 22 Weight Histogram (Truck 332000) Station 515

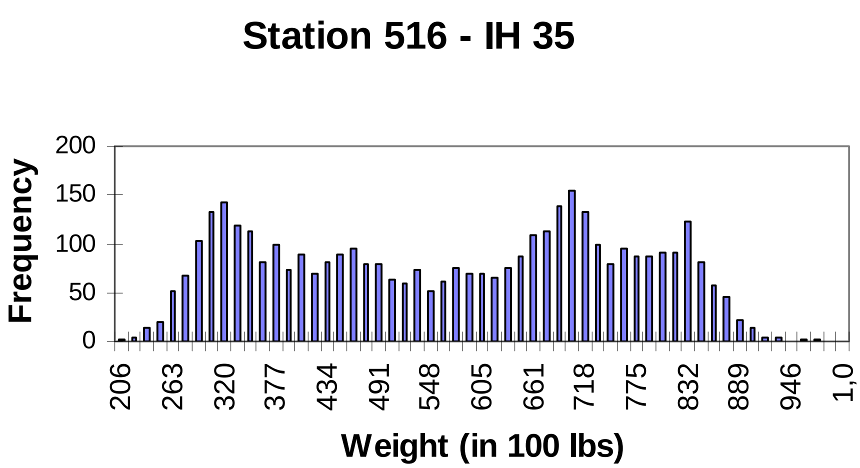


Figure 23 Weight Histogram (Truck 332000) Station 516

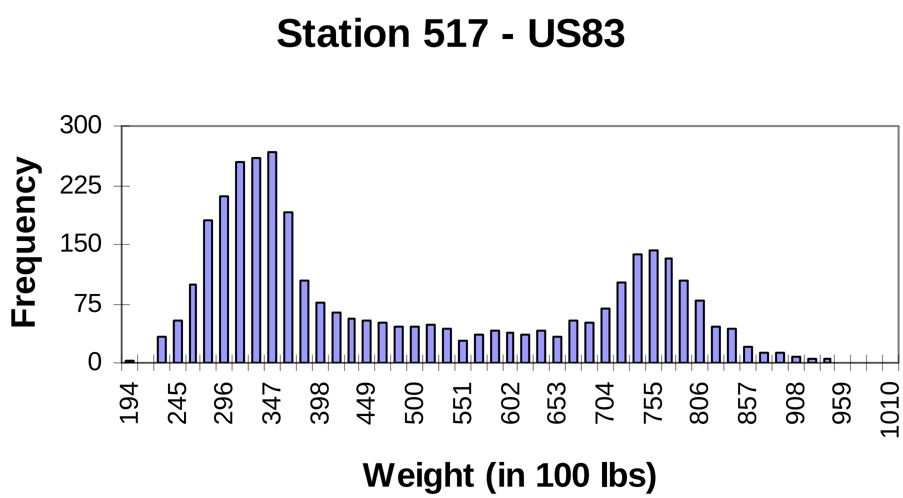


Figure 24 Weight Histogram (Truck 332000) Station 517

TRUCK WEIGHT CLASSIFICATION

Table 15 shows the limits 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% of the maximum load (80,000 lb.). Overloaded trucks were those with gross weights higher than 80,000 lb., the U.S. truck-load limit on U.S. interstate highways.

Table 15. Weight Limits for Truck Categories (lbs.)

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. Comparing these results to those of the Laredo study, only 10.0% of the northbound trucks were overloaded (Ref13), a figure that is clearly above the average of Texas highways in this data set (4.3%).

Station 516, located south of San Antonio on IH 35, shows the highest percentage of overloaded trucks (9.4%), as shown in Table 16. Knowing that Station 516 lies on the main corridor to Laredo, this value is very close to the 10.0% 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%) is significantly higher than 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% of the 333000 are overloaded in Laredo (Ref 18), suggesting that NAFTA trucks of these type are considerably more overloaded than other types (see Table 17) .

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

Table 17. 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%	

Type 521200 and 322000

Type 521200 is also included because it is important on highways carrying LTL loads and 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% as against less than 1% 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 the type 2S2 (322000). These are two axle tractors pulling the regular two-axle trailer, normally configured as 332000 operating only across the border because of the lower toll than for 332000 trucks. On Texas highways 322000 trucks are not frequently seen and rarely overloaded at any of the stations, comprising less than 1%.

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%), 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.

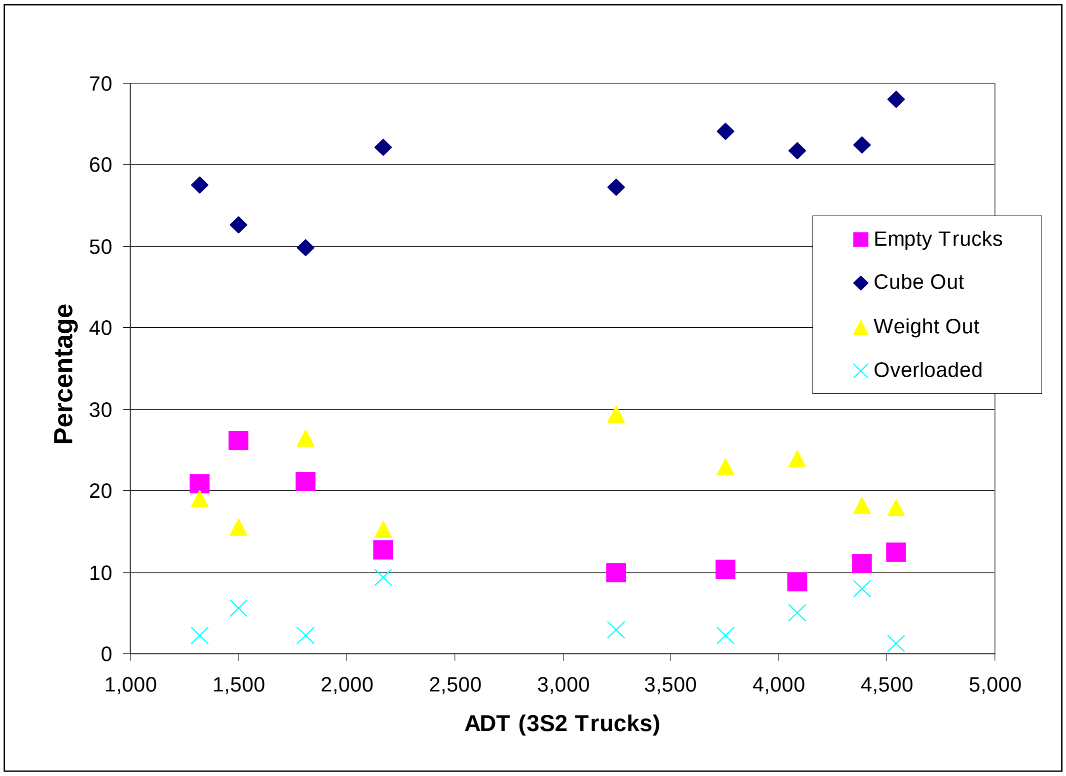


Figure 25 ADT effect on Empty, Cube Out, Weight Out and Overld. Truck %

Station 515 registers a lower number of empty trucks. Since this station is located on the corridor that connects the Hidalgo port with Texas, the number of empty trucks may be lower due to the consolidation of loads that occurs in the warehouses close to the ports of entry. This implies that volume of NAFTA trucks close to the border and bridges may be different than 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 percentage of empty trucks around 21%. This value is higher than the average of 14.8%.The lowest percentage of empty trucks is found on IH 45 with only 8.8%.

Another explanation is related with to the truck ADT. As shown in Figure 25, 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 also the possibilities to quickly pick up another cargo.

Figure 25 shows the relationship between average 3S2 truck ADT per station and the percentage of empty trucks, using all records of the station; Figure 26 shows the relationship between daily 3S2 trucks ADT and 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.

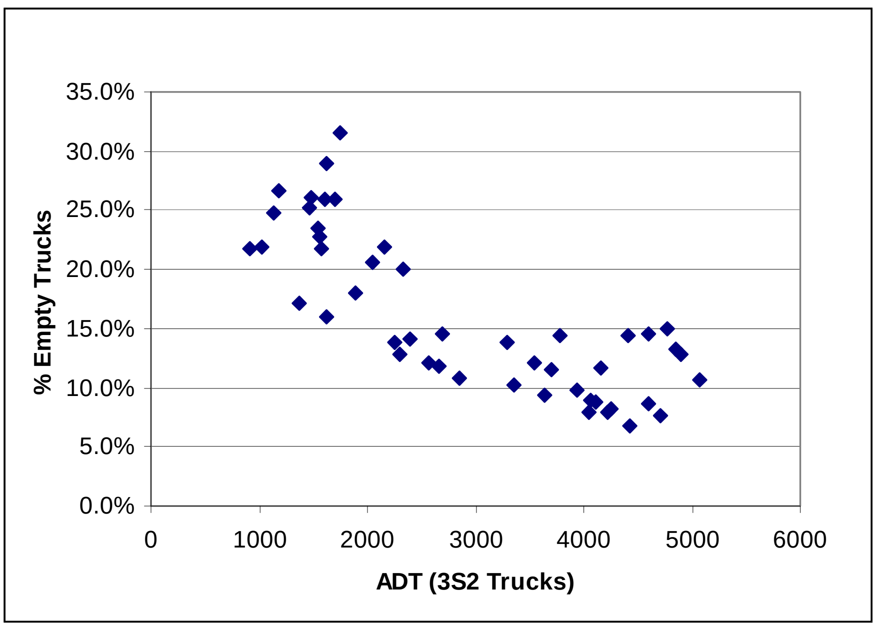


Figure 26 ADT Effect on Percentage of Empty Trucks

Cube out and Weight out Percentages

IH 35 has a higher average percentage of cube out vehicles than the average and IH 20 has a higher 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 25.

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

For heavy commodities, the 333000 type is more often used (52% cube out and 32.4% 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 respectively.

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 truck loads, a higher percentage of overloaded trucks head southbound than northbound. 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 values higher southbound, especially in the case of 3S3 (Ref 24).

As a general pattern, it is interesting to notice that northbound-northeast movements in rural stations have a higher percentage of empty 3S2 trucks than southbound-southwest movements (with the exception of Station 510 that carries more east-west traffic). These north-south highways are very important NAFTA corridors, especially: IH 20, IH 35, and US 281. This suggests that it is easier for southbound trucks to pick a cargo than for northbound trucks, therefore some trucks have to return north empty. Commodity type, maquiladora operation, consolidation at the border and import/export value at port level may have some influence in this occurrence. 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 to the West (36%) than going East (19%), 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	OVER LOADED	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	U.S.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	U.S.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 encompasses or samples 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 truck 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 with 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 (3) they have important seasonal variations where spring is the peak season.

Table 20. Direction of Travel Effect on Truck Weight Classification (3S3)

Station	Highway	Direction	EMPTIES	CUBE OUT	WEIGH OUT	OVER LOADED	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

Figure 27, Figure 28, and Figure 29 show the effect of direction of travel and 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 was plotted with the number of trucks versus the time of the day. For the two stations along the border, the influence of customs work hours is clearly defined as shown in Table 25 and Figure 30 to Figure 35.

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 station 513 and 515 (see Figure 36, Figure 37, and Figure 38)

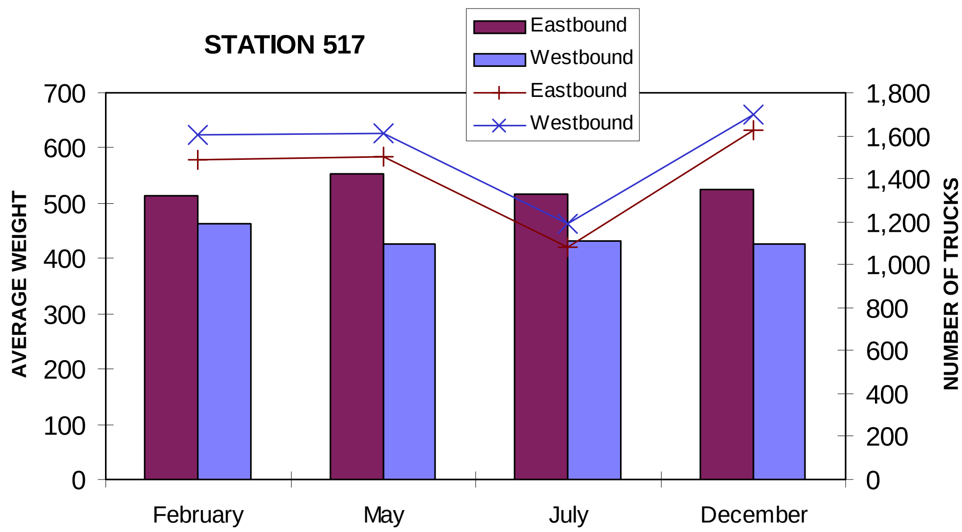


Figure 27 Month and Direction Effects on Station 517

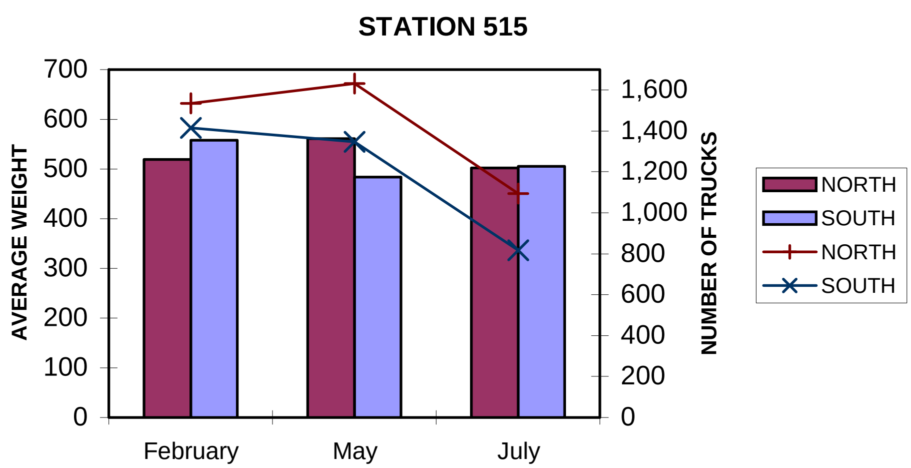


Figure 28 Month and Direction Effects on Station 517

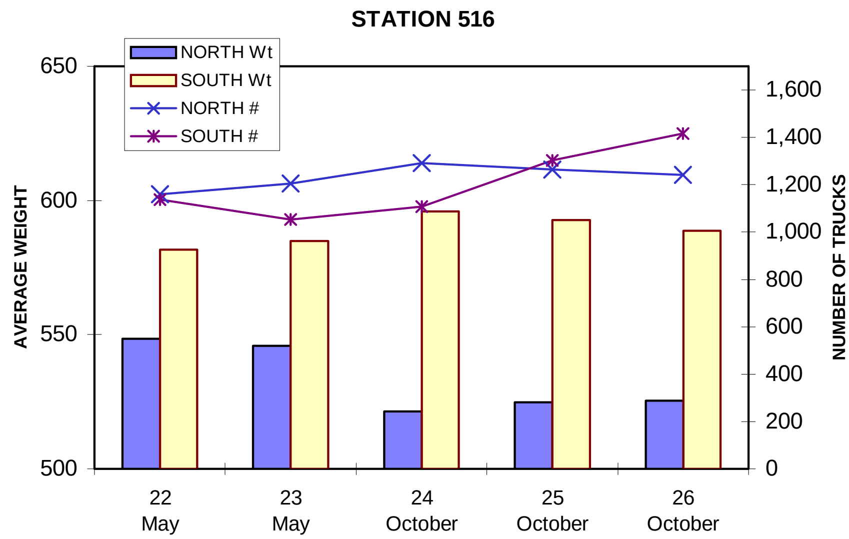


Figure 29 Month and Direction Effects on Station 516

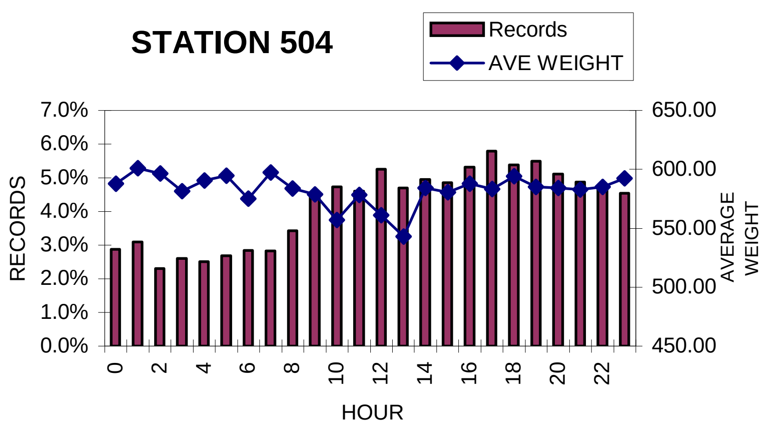


Figure 30 Hour Effect, Truck Type 332000 Station 504

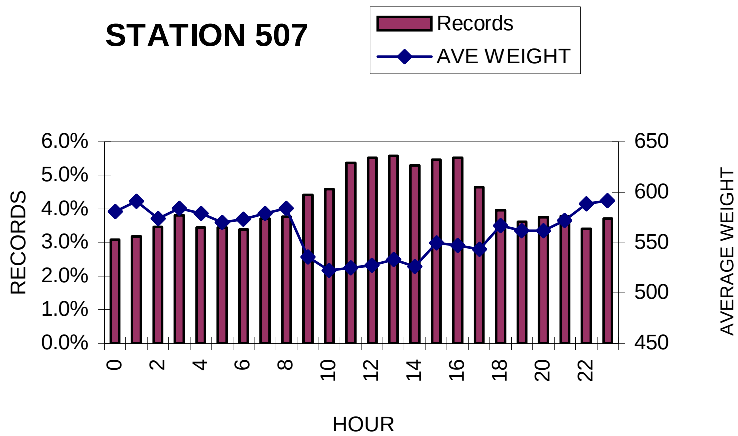


Figure 31 Hour Effect, Truck Type 332000 Station 507

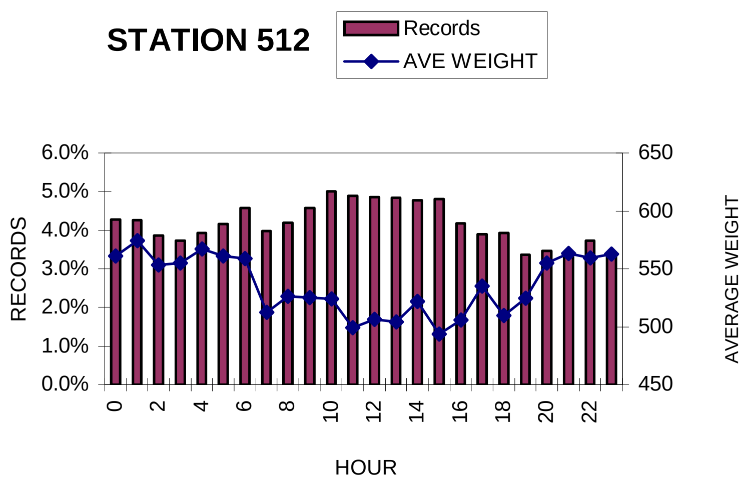


Figure 32 Hour Effect, Truck Type 332000 Station 512

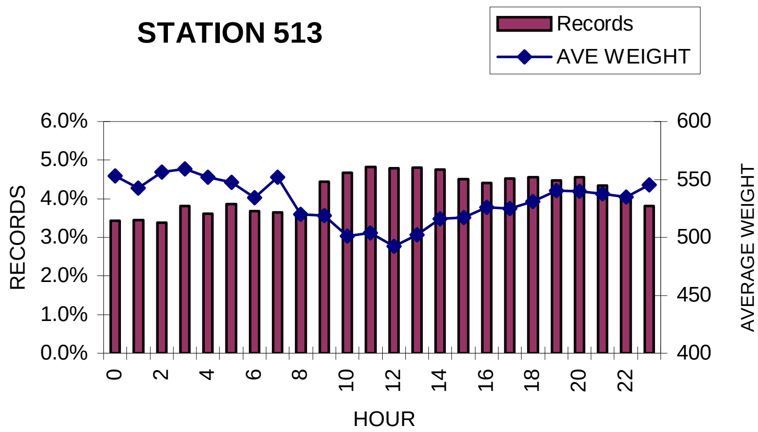


Figure 33 Hour Effect, Truck Type 332000 Station 513

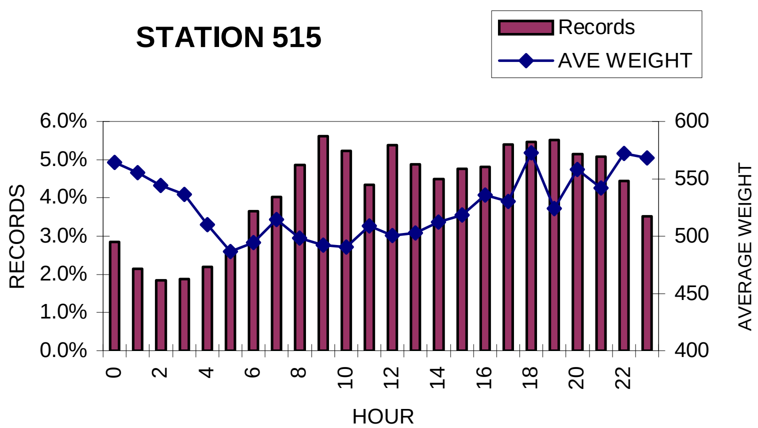


Figure 34 Hour Effect, Truck Type 332000 Station 515

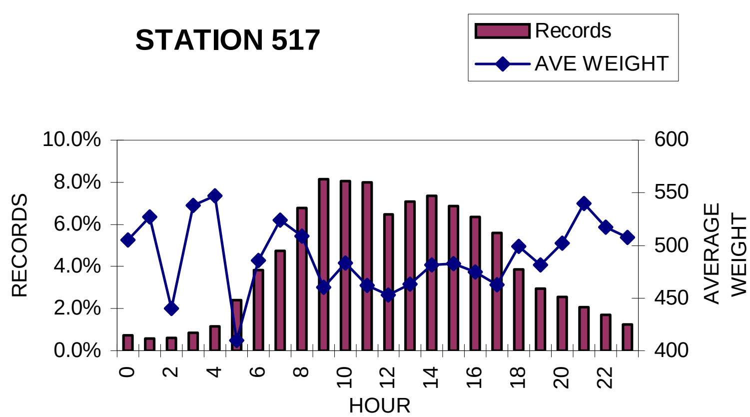


Figure 35 Hour Effect, Truck Type 332000 Station 517

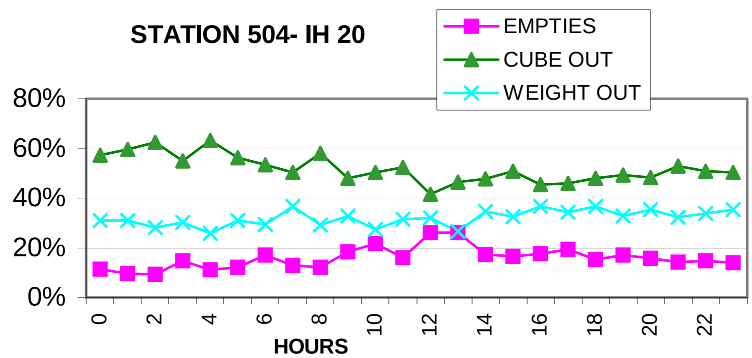


Figure 36 Hour Effect and Truck Weight Station 504

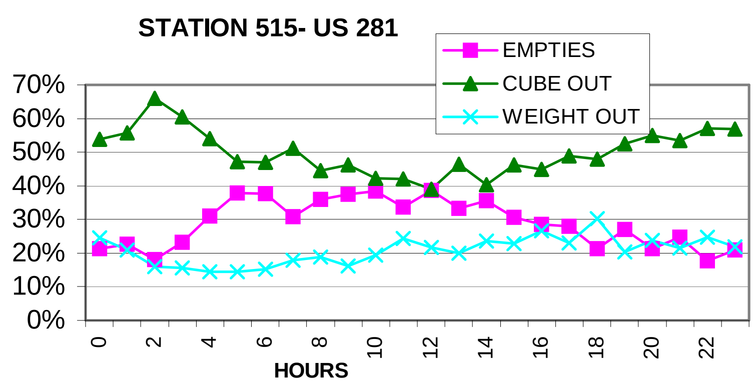


Figure 37 Hour Effect and Truck Weight Station 515

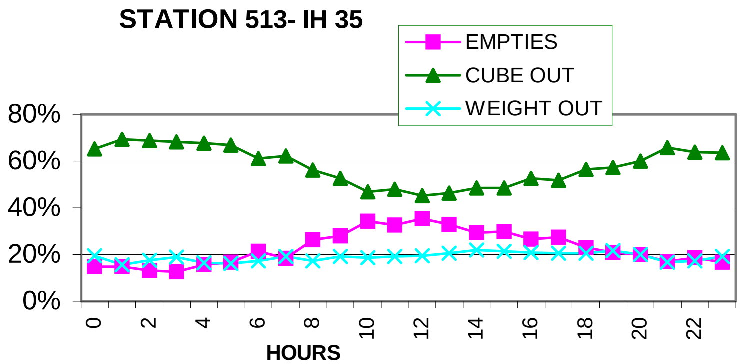


Figure 38 Hour Effect and Truck Weight Station 513

ANALYSIS OF AXLE LOAD OVERWEIGHT

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. Though the presence of this truck type is very small in the total truck composition, over 65% of the 3S3 trucks were overweight. .

The second highest 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 ESAL's.

Table 21 represents the percentage of overloaded axles found during the summer of 1996 (Ref 24). The load limit for tandem axle in Texas is 34 kip, and the limit for tridem axle is 42 kip (using the bridge formula). It is important to note that the northbound and southbound directions in El Paso have almost equal percentages of overloaded trucks. At Laredo, WIM was 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 shows 0% of overloaded trucks and the southbound shows 18% of overloaded trucks. Figure 39 and Figure 40 show the different axle load distribution for both directions. Southbound trade tends to be heavier than northbound due to 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. To take advantage of this situation, carriers may load trucks over 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 since 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 US 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. Though there are large numbers of overloaded axles on Texas highways (around 8% for 3S2 and 12% for 3S3), the percentage is considerably lower than for the trucks at the border stations. Overall, 3S3 trucks have a higher percentage of overloads than 3S2 trucks. Axle load weight distributions for trucks 3S2 and 3S3 are in Figure 39 to Figure 46.

Table 22 Percentage of Overloaded Axles

Station Location	Truck Type 332000	
	Tractor Tandem	Trailer Tandem
Nine Stations [1]	8.6%	7.9%
LW516 IH35	12.3%	9.7%
LW516 IH35 Northbound	3.2%	1.5%
LW516 IH35 Southbound	20.9%	20.6%

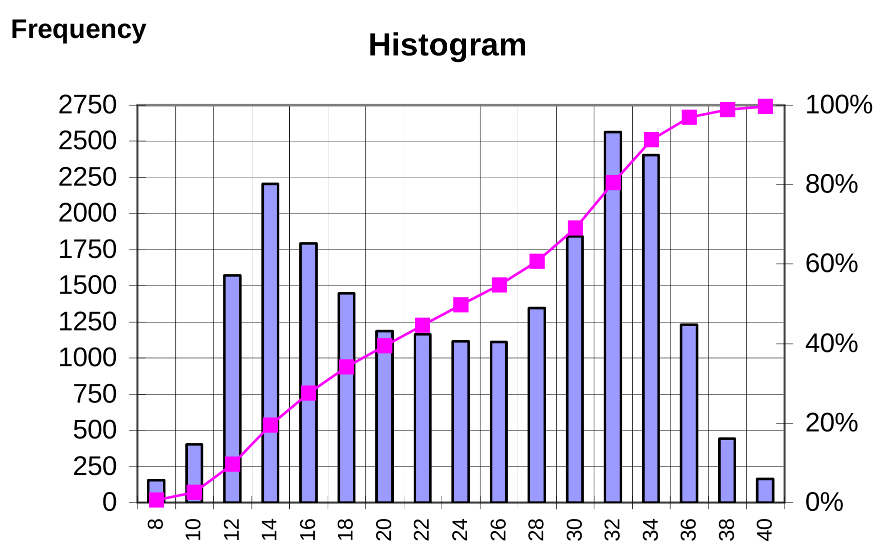


Figure 39 All Stations Vehicle Type 3S2 - Tractor Tandem Axle

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

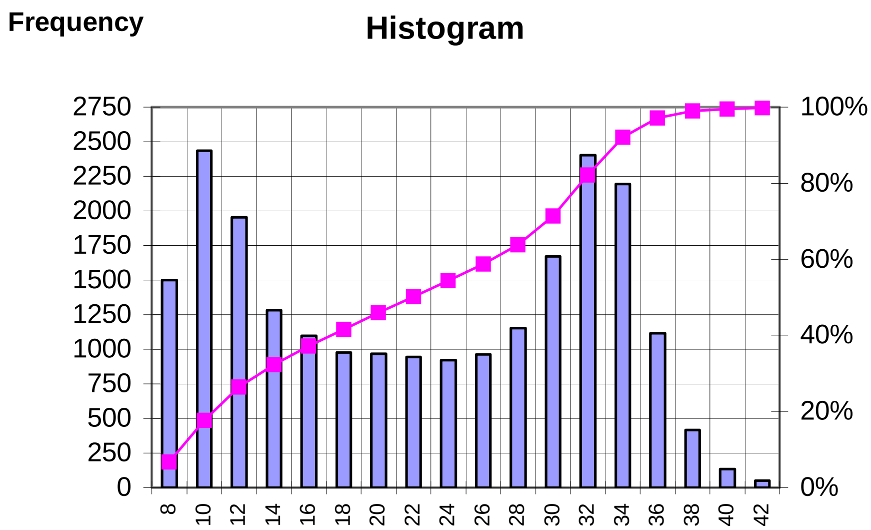


Figure 40 All Stations Vehicle Type 3S2 - Trailer Tandem Axle

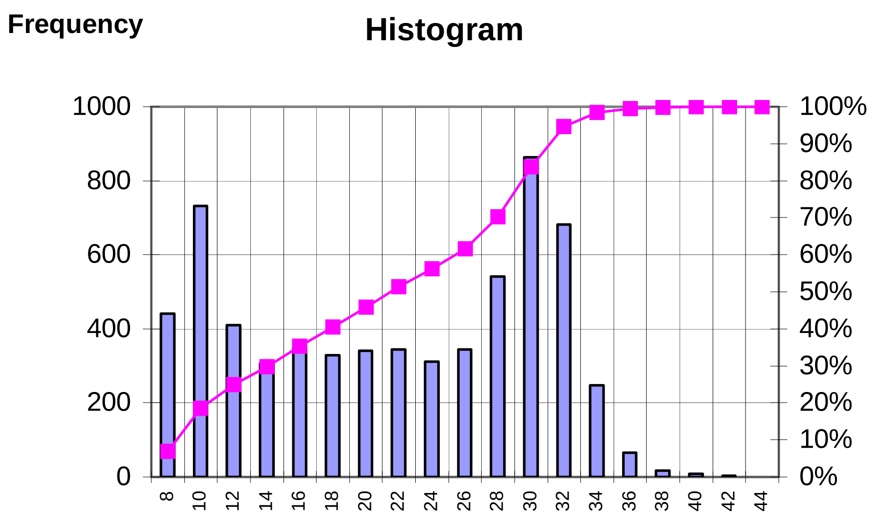


Figure 41 Station 516 Northbound Vehicle Type 3S2 - Trailer Tandem Axle

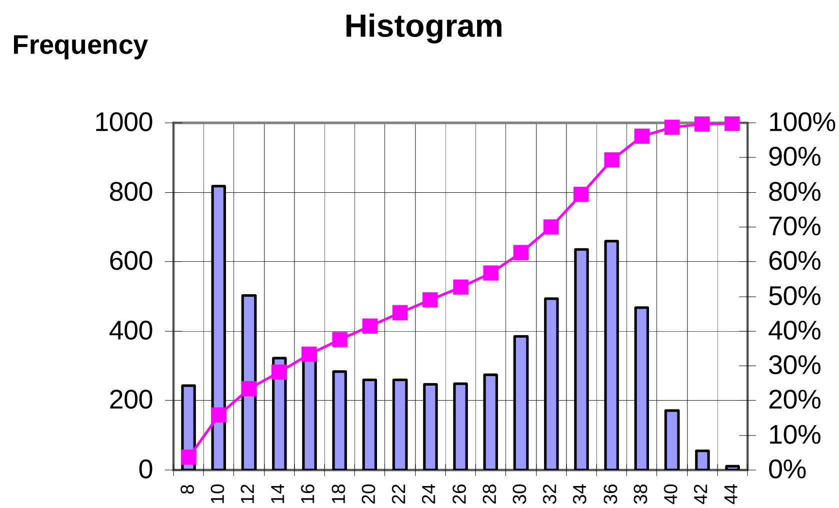


Figure 42 Station 516 Southbound Vehicle Type 3S2 - Trailer Tandem Axle

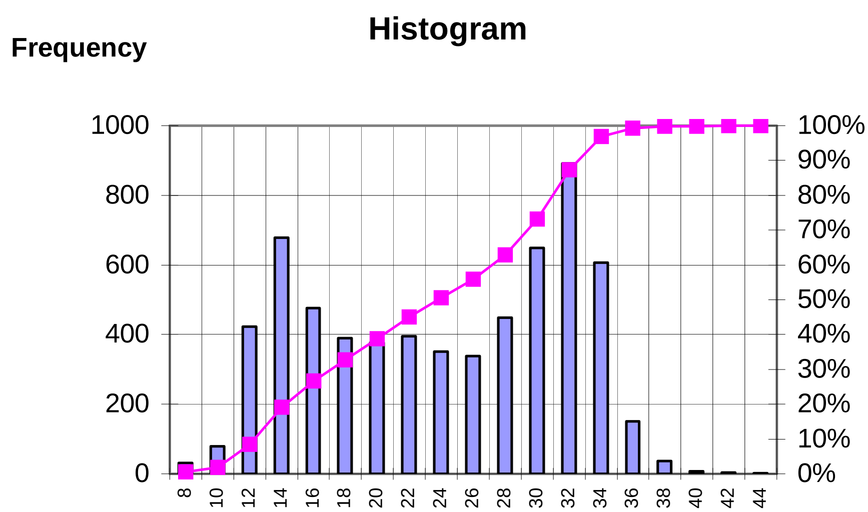


Figure 43 Station 516 Northbound Vehicle Type 3S2 - Tractor Tandem Axle

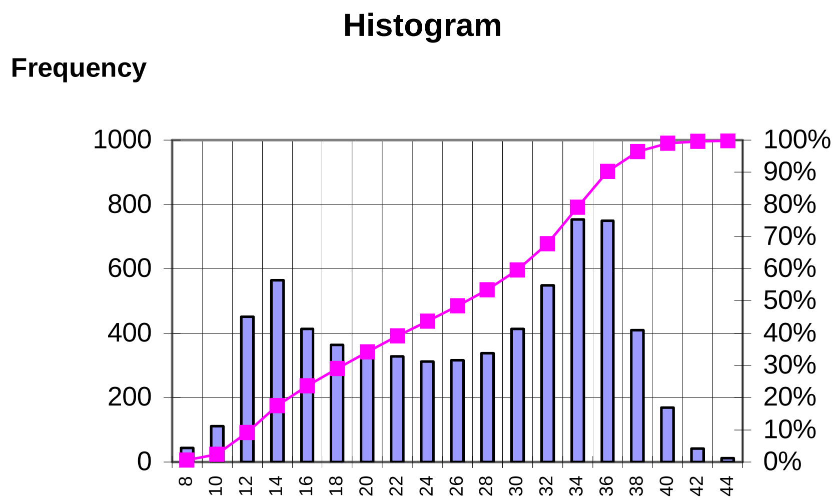


Figure 44 Station 516 Southbound Vehicle Type 3S2 - Tractor Tandem Axle

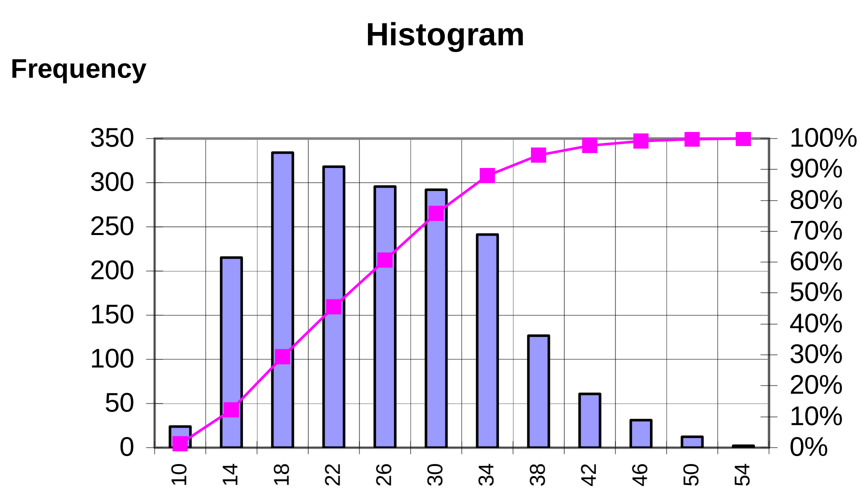


Figure 45 All Stations Vehicle Type 3S3 - Trailer Tridem Axle

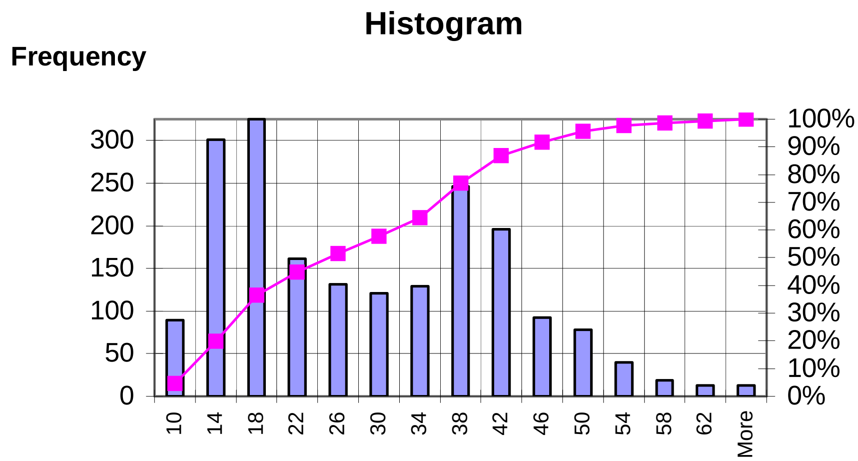


Figure 46 All Stations Vehicle Type 3S3 - Tractor Tandem Axle

SUMMARY

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

3S2 trucks dominate truck volumes on both border and nonborder highways. If loads are analyzed, their share is even more significant, as it is the only truck type with 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 is that in the border zone, truckloads are much heavier than on the interior highways of Texas.

Percentages of weigh out and cube 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 (monthly), 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, where rail may affect truck operation as shown by the higher percentage of empty northbound trucks. Other notable findings pertains to the incidence of overloaded axles and its relation to the direction of travel on IH 35, south of San Antonio. Southbound 332000 trucks (3S2) have a significant percentage of overloaded truck while northbound 332000 trucks have 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 impacting both U.S. trade corridors and Texas highways, yet trade data related to trucking does 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 as 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 the U.S.-Mexico surface trade on both U.S. and Mexico highway systems.

The objective of this chapter is to study different ways to estimate the number of NAFTA trucks in nonborder zones. First an analysis of passing and non-passing flows, the definition of NAFTA trucks and a description of the border system is presented. Second, methods to estimate NAFTA truck numbers are presented. 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.

PASSING AND NON PASSING 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 is often concentrated in certain corridors or ports, while the major benefits are concentrated where employment and economic activity is created.

Analyzing the state of Texas, an important share of trade uses Texas infrastructure without significantly contributing to its economy (passing trade); on the other hand trade originating or destined in Texas contributes more to the economy, employment or local consumer needs (non-passing trade).

Analyzing only a specific border region (an area of few miles around a border city), most trade can be classified as passing trade. The greater the population of the border city and its industrial activity, the more non-passing trade value could be expected. However, at border regions, even passing 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 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 related to imports or exports data.

THE BORDER SYSTEM

The border region as described in Chapter 3 and Chapter 4 present special characteristics. Moreover, though 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 47 presents a schematic description of the border region system. It can be considered as 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, consumed or just be passing cargo. Local population, 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.

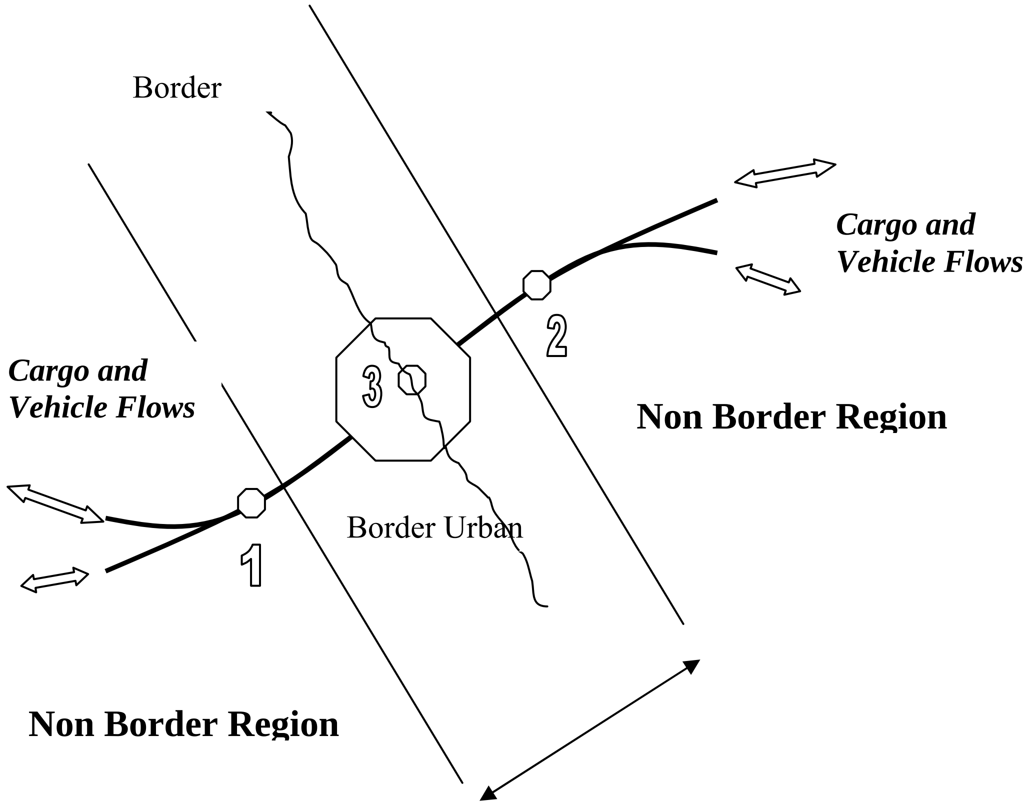
At the border system endpoints (points 1 and 2 in Figure 47) an equilibrium of trucks, trailers and train cars (empties or loaded) can be established over a certain period of time. That is, the total number of vehicles coming in must be equal to those coming out assuming that no vehicles are consumed or fabricated in the border region.

Cargo equilibrium is not possible because of the possible 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, low population and maquiladora activity; on the other hand El Paso contains important maquiladora operations, factories and an important population. With enough data about activities in the border zone, an analysis of input-output matrix flows could be accomplished, but even when equilibrium (of vehicles or cargo) can be established, the shares of NAFTA and non NAFTA movements are undetermined as well as the share of NAFTA passing and non-passing trade.

At the border crossing point (point 3 in Figure 47) the movement of cargo, truck 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 of Figure 47) due to drayage and other factors, as discussed in the next section. A methodology to estimate 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 using 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 and origin and destination surveys at border crossings and system endpoints, which 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 border city population and industrial activity is small compared to importance of international trade. Commodity type is certainly an element that also influences the share of passing and non-passing trade.



BORDER REGION

- Drayage
- Warehouses
- Maquiladoras
- Customs
- Population Consumption
- Local Factories

Figure 47 The Border Region System

DIFFERENCES BETWEEN BORDER AND NON BORDER 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 impact 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 impact 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 bi-national interlining of trucking companies at the border, the short drayage haul and the considerable time spent to cross a few miles.

As will be shown next, drayage has an important 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 natural inbalances 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 (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, specially rail, create inbalances in the number of trailers and containers.

The percentage of empty trucks at border crossings is calculated using the ratio of total number of loaded trucks to number of trucks crossing. Loaded trucks have to clear their load 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 (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, therefore 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 % 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% (for truck type 332000).

Significant differences appear among ports of entry. Del Rio and Hidalgo have lower percentages of empty trucks (27 and 33% respectively). Two other important ports, Laredo and Brownsville, show a high proportion of empty trucks (over 50%). 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% empty trucks. There are no data regarding loaded trucks in El Paso, the second largest port in terms of value trade.

Why are there differences between 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 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 mostly single-unit trucks. However, the number of single-unit trucks appears to be too high to be related to only 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, US-Mexican 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
Hldago	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 97
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 97
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	US77 Nbound	US77 Sbound	FM255	
BRIDGE	GATEWAY N	GATEWAY S.	B&M RR	
SINGLE UNIT TRUCKS				
TWO 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	1253

STATION NUMBER	MT140	MT141	MT160	TOTAL
HIGHWAY	US77 Nbound	US77 Sbound	FM255	
BRIDGE	GATEWAY N	GATEWAY S.	B&M RR	
SINGLE UNIT TRUCKS				
TWO 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	*IH35*	*IH35 A*	*FM255*	
BRIDGE	*JUAREZ-LINCOLN*	*CONVENT ST*	*COLOMBIA*	
SINGLE UNIT TRUCKS				
TWO AXLE (NO PICKUPS)	930	87	45	1062
3 AXLE	2434	7	150	2591
4 AXLE	1	4	0	5
TOTAL SINGLE UNIT	3365	98	195	3658
COMBINATIONS SEMI TRAILER				
3 AXLE	33	0	0	33
4 AXLE	71	25	69	165
5 AXLE	2453	397	565	3415
6 AXLE OR MORE	40	0	7	47
SUBTOTAL	2597	422	641	3660
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	2602	422	641	3665
TOTAL TRUCKS	5967	520	836	7323

STATION NUMBER	*MT420*	*MT440*	*MT480*	***TOTAL***
HIGHWAY	*IH35*	*IH35 A*	*FM255*	
BRIDGE	*JUAREZ-LINCOLN*	*CONVENT ST*	*COLOMBIA*	
SINGLE UNIT TRUCKS				
TWO 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*	
HIGHWAY	*FC*	*IH110*	*US62 N*	*US62 S*	***TOTAL***
BRIDGE	*ZARAGOSA*	*CORDOVA*	*STANTON ST.*	*SANTA FE ST.*	
SINGLE UNIT TRUCKS					
TWO AXLE (NO PICKUPS)	247	743	53	55	1098
3 AXLE	205	665	5	4	879
4 AXLE	12	4	0	0	16
TOTAL SINGLE UNIT	464	1412	58	59	1993
COMBINATIONS SEMI TRAILER					
3 AXLE	9	4	0	4	17
4 AXLE	26	24	0	0	50
5 AXLE	2095	801	0	0	2896
6 AXLE OR MORE	22	10	0	0	32
SUBTOTAL	2152	839	0	4	2995
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	2171	839	0	4	3014
TOTAL TRUCKS	2635	2251	58	63	5007

STATION NUMBER	*MT660*	*MT680*	*MT700*	*MT704*	
HIGHWAY	*FC*	*IH110*	*US62 N*	*US62 S*	***TOTAL***
BRIDGE	*ZARAGOSA*	*CORDOVA*	*STANTON ST.*	*SANTA FE ST.*	
SINGLE UNIT TRUCKS					
TWO 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	US281		SH200	US57	US277
BRIDGE	PHARR	R. GRANDE	ROMA	E PASS	DEL RIO
SINGLE UNIT TRUCKS					
TWO 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	US281		SH200	US57	US277
BRIDGE	PHARR	R. GRANDE	ROMA	E PASS	DEL RIO
SINGLE UNIT TRUCKS					
TWO 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 Class. in Main Corridors to Main Texas Trade Ports

STATION NUMBER	*M1130*	*MS74*	*BC2101*	*BC2206*	*BC2405*
HIGHWAY	*US57*	*US77*	*US281*	*IH35*	*IH10*
SINGLE UNIT TRUCKS					
TWO 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	1217	1579	2436	3311
6 AXLE OR MORE	2	17	33	19	18
SUBTOTAL	314	1458	1753	2777	3457
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	1551	1795	2870	3651
TOTAL TRUCKS	400	1941	2317	3262	4330

STATION NUMBER	*M1130*	*MS74*	*BC2101*	*BC2206*	*BC2405*
HIGHWAY	*US57*	*US77*	*US281*	*IH35*	*IH10*
SINGLE UNIT TRUCKS					
TWO 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 U.S.281 (77.5%) was the lowest found in 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% and 40%, respectively). On the main corridors to these cities, IH 35 and IH 10, the percentage of single-unit trucks is only 12 and 15%, 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 pounds, the ratio among truckloads is 1.67.

Table 30 Northbound Truck Volumes (1997)

Trucks -North '97	Brownsv.	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 a year 277				
TRADE VALUE	3,848,819,516	1,198,310,629	1,487,742,434	15,722,744,058
AVG VALUE $	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
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**
277					
Days a year 277					
TRADE VALUE	4,256,818,377	43,529,127	56,443,799	12,342,837,252	63,746,034
AVG VALUE $	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 (lbs.)					

Table 31 Southbound Truck Volumes (1997)

Trucks -South '97	**Browns.**	**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
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 a year 277				
TRADE VALUE	4,433,369,186	1,101,012,505	1,367,202,749	23,184,247,251
AVG VALUE $	42,464	42,963	34,883	41,303
PER TRUCK				

Trucks -South '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
% empty trucks					
Total	**126,171**	**4,536**	**4,314**	***178,290***	**12,165**
ADT 18W	**455**	**16**	**16**	***643***	**44**
277					
Days a year 277					
TRADE VALUE	3,151,373,025	70,322,987	66,860,140	9,717,301,656	74,063,672
AVG VALUE $	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	22.00	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 vs. the number found on rural highways. Origin destination surveys at bridges (Ref 25), indicates that the predominant origin or destination are warehouses followed by manufacturing centers.

ESTIMATING NAFTA TRUCKS

The three methodologies proposed in this study to estimate NAFTA trucks have three common steps, being step 2 and 3 the same for all three methodologies:

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

1. Number of equivalent loaded combination trucks

Three methodologies are proposed to get this number, one based on the number of trucks crossing the border, the second using commodity weights and densities and the last one 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 comprise 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 highway segment, the percentage of empty trucks depends on the 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 for northbound movements were found but for this study, the average value found for southbound and northbound movements will be used. If WIM data collected at the main rural corridor to the ports were available, a specific coefficient for each port could be applied instead of averaging.

ESTIMATING NAFTA TRUCKS USING BORDER CROSSING COUNTS

The first method uses truck counts at border crossings to estimate NAFTA trucks. Border truck traffic counts are the main input and then correction factors are applied to account for the differences between border and non-border 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 after applying 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. As a representative combination truck, the type 332000 or 3S2 was chosen 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 and 46,000 pounds for two-axle and three-axle trucks, respectively, while for eighteen wheelers the gross limit is 80,000 pounds, giving a ratio between 2.5 and 1.7.

The ratio between single-unit and combination truckloads for different commodities is shown in Figure 48 . The ratios vary between 1.7 and 2.2 (if hazmat commodities are not considered).

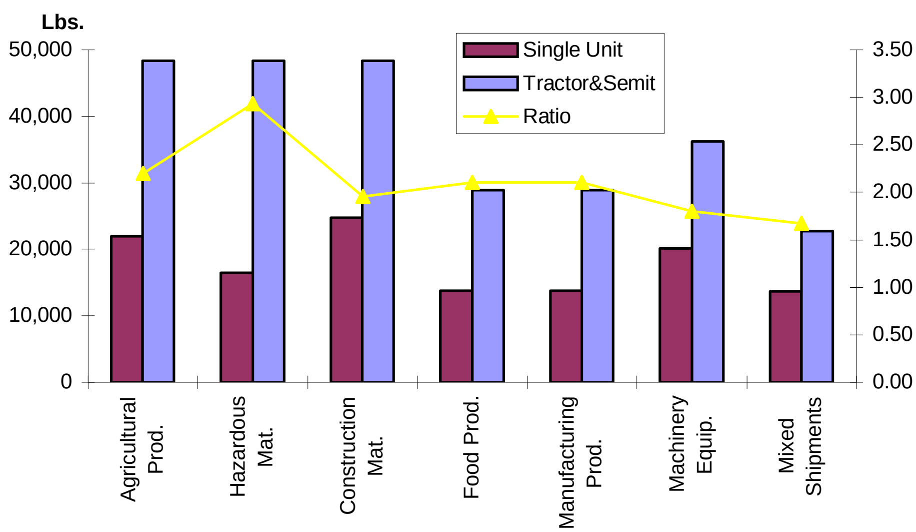
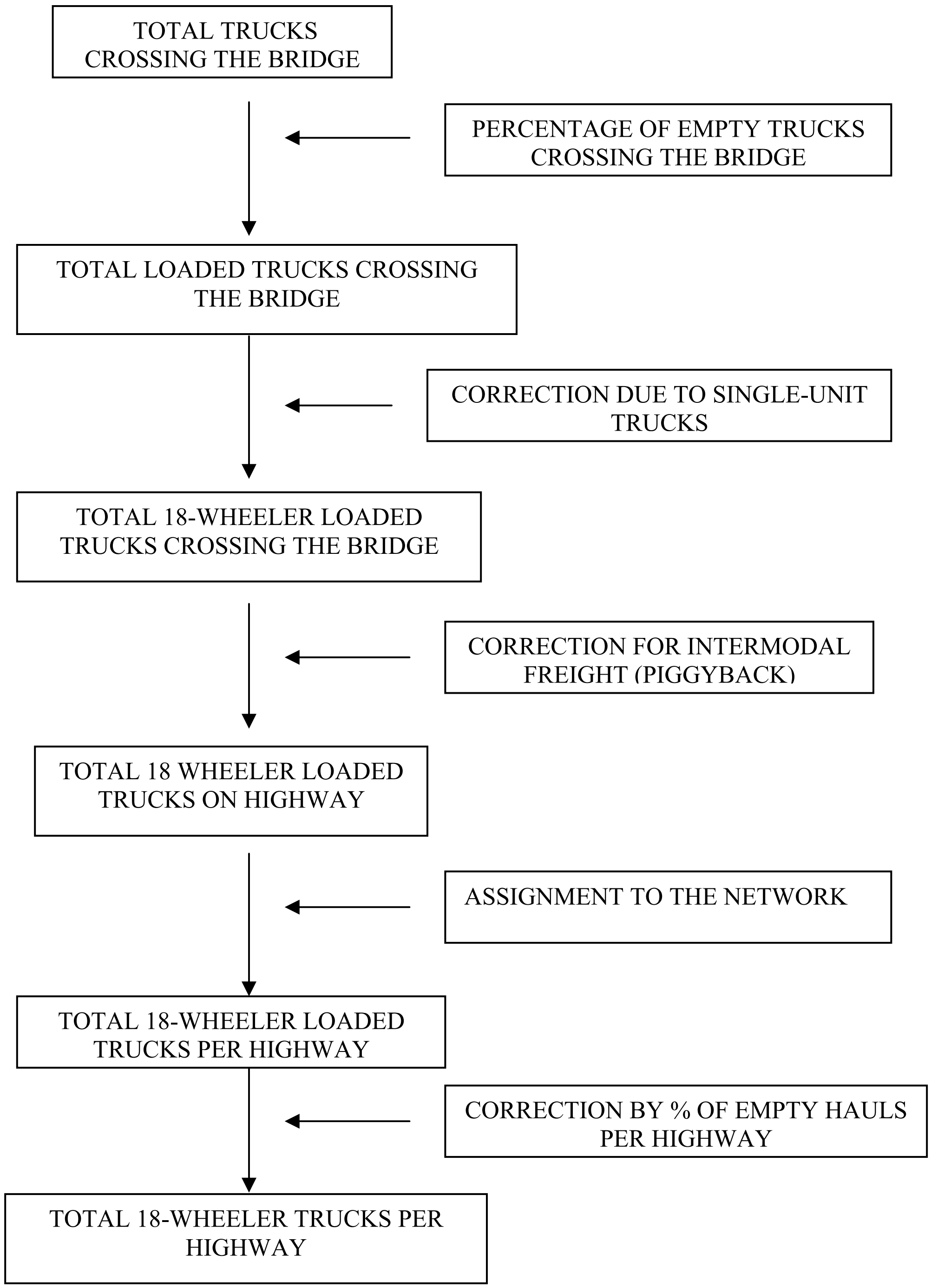


Figure 48 Truckload ratio by commodity and truck type

Figure 49. **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 non-related with warehouse, maquiladora, or intermodal trade were less than 10%. A big portion of this trade may be captured by low value shipment in the trade commodity classification, which is a very low percentage of the total trade (1.9%).

This study assumes that a percentage of single unit trucks carries local commerce. This percentage is estimated at 33% in all the ports except Laredo, where it is assumed to be 25% due to 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 compared to typical weights seen 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 dissagregation 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 to estimate the accuracy of the truck volumes obtained.

Truckload average weight may be used also in the other two methods to check for consistency.

Main Assumptions

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

- The percentage of empty trucks is similar for single-unit and combination trucks.
- Non passing trade is considered not significant, which 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 trucks are estimated (3S2 type), and
- 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 number of total trucks and loaded trucks crossing the border northbound was obtained from Ref 1 and Ref 3, respectively.

- An equivalence value of 2 was used to translate single-unit trucks into combination trucks.
- 67% the single-unit trucks were assumed to be associated with rural truckloads. In Laredo, 75% of the single-unit trucks was assumed to be related to 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
- 277 days per year were used to calculate ADT. 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% (the same value as Laredo).

3.5.2 Southbound Volumes

- The number of total trucks crossing the border northbound was obtained from (Ref 27)
- The southbound number of loaded trucks is known only for Laredo and Eagle Pass
- When the percentage of southbound empty trucks was not available, the northbound percentage of empty trucks at the border was assumed.
- An equivalence value of 2 was used to translate single-unit trucks into combination trucks.
- 67% of the single-unit trucks were assumed to be associated with rural truckloads. In Laredo, 75% of the single-unit trucks was assumed to be related to 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
- 277 days per year were used to calculate ADT. 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 per truck obtained at the WIM stations in Texas highways. Brownsville, Hidalgo, and Eagle Pass results 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 trade 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 greatly differs 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 gives an average of 7,660 trucks per day. Figure 50 and Figure 51 show the number of trucks obtained for northbound and southbound, respectively.

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

When analyzing truck volume, El Paso shows a reduction in its importance as a port based solely on truck numbers. Higher value commodities, electronic and electrical products characterize El Paso, contrary to Hidalgo and Brownsville. By comparison, low value and heavier commodities at Hidalgo and Brownsville create relatively higher number of trucks.

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

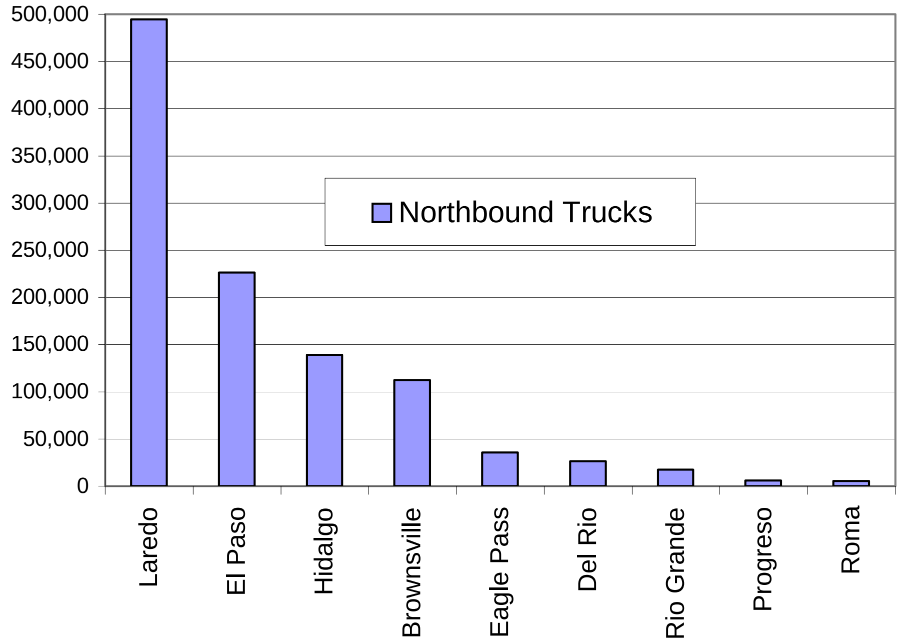


Figure 50 Total Northbound Trucks by Port (Texas)

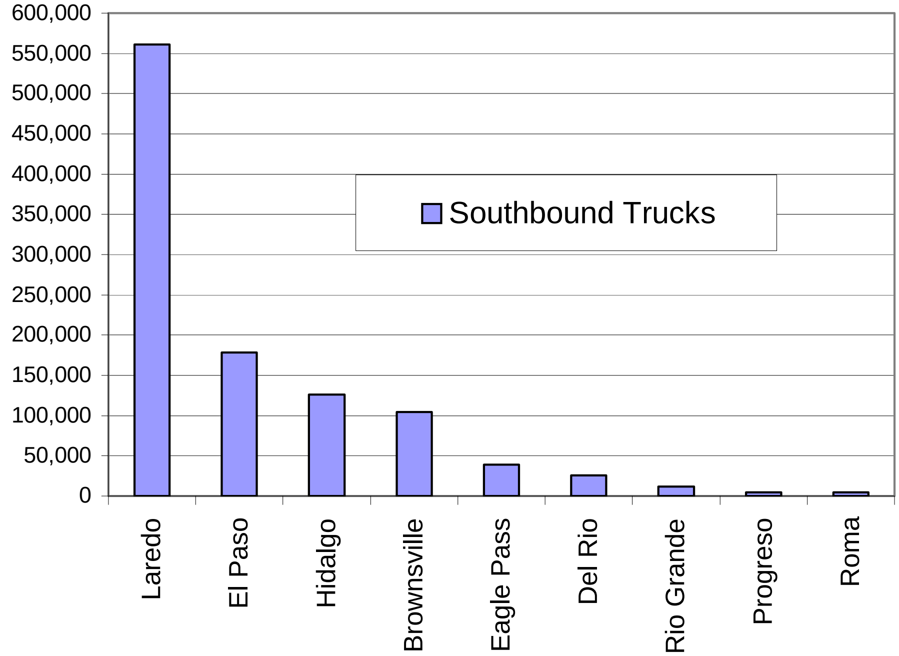


Figure 51 Total Southbound Trucks by Port (Texas)

Estimation of Truck Volumes Using Commodity Density

In transportation planning studies interested in 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.

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 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 used in this study to discriminate between the two types of loaded truck.

PROCEDURE

The first step is to separate cube out from weigh out commodities using the criterion of critical density (Figure 54). In the second step it is necessary to chose 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 a nonlinear function of the weight proportion of each commodity, the density of each commodity, the truck capacity volume, and truck maximum weight.

Using the representative density by group (di), truck volume (Vi), and the total weight per group (Wi), the number of trucks per group is calculated (Ni).

Commodity Group Density

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

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

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

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

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,

$$Wi = \sum_{J} Wij.$$

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

$$di = \frac{1}{\sum_{j} \frac{Pij}{Dij}}$$

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

The total number of trucks is the sum of Ni, which gives the total number of loaded trucks; a correction for empty trucks is necessary to obtain total number of trucks. 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 in two key assumptions: first, a truck load either cubes out or weighs out (no trucks with partial cargo). Second, a single commodity per truck is considered (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 used in the Transborder Surface Freight Database.

Densities by commodity are obtained from NHCRP 260 (Ref 28). In this report, density data are reported in pounds per cubic feet, with the same units used here after.

Some important problems appear with the application of these data. These problems include:

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

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

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

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 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 for loaded and empty trucks -the average value per truck per commodity is useful to check 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 obtained in Table 30 to total northbound truck value. Texas ports in Table 30 account for 70% of total northbound truck value.

The average value per truck in Texas ports in Table 30 is $36,650. The calculated number of trucks was 15% higher than the calculated number of loaded trucks using densities. This difference accounts for the percentage of empty trucks on the highways. Thus the number of loaded trucks predicted from both methodologies was 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 54, consistency of the results can be verified analyzing the truckload value per truck. This is useful when some historic data is available that enables 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 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, it is possible to obtain truckload commodity group values and weights. These values are specifically obtained for northbound movements during 1997.

Southbound truckload commodity group values are obtained using commodity northbound values. The number of trucks obtained is corrected using the average southbound truckload value ($40,870) from Table 31 and applied to the total southbound truck trade. Results for southbound and northbound movements are shown in Table 36. 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 Figure 52 and Figure 53. Inbound trade, electrical products and machinery, as well as low value and heavy weight 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.

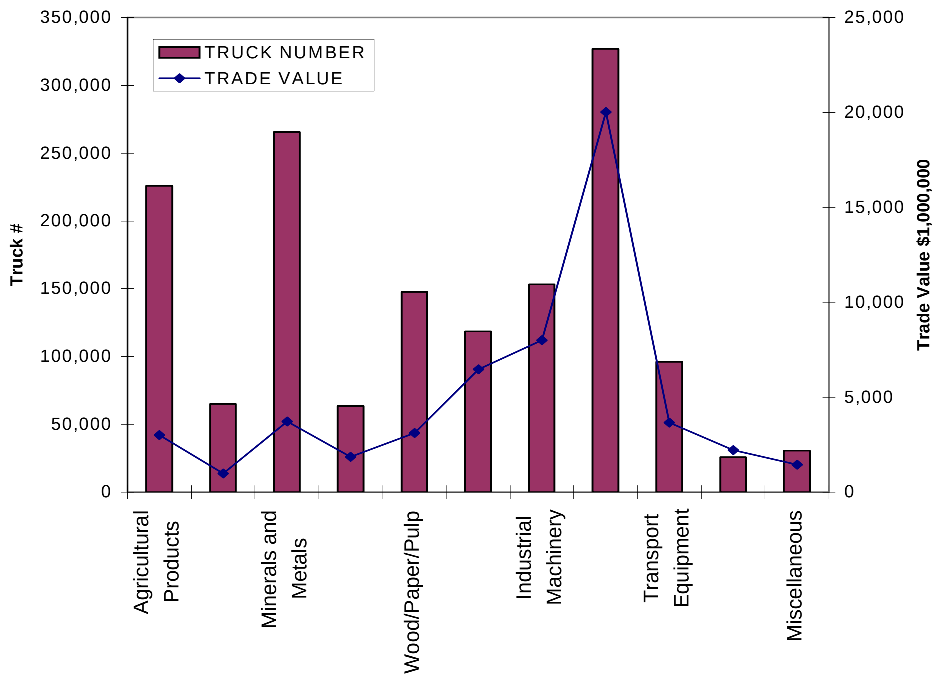


Figure 52 Commodity value and Truck Volume (Northbound 1997)

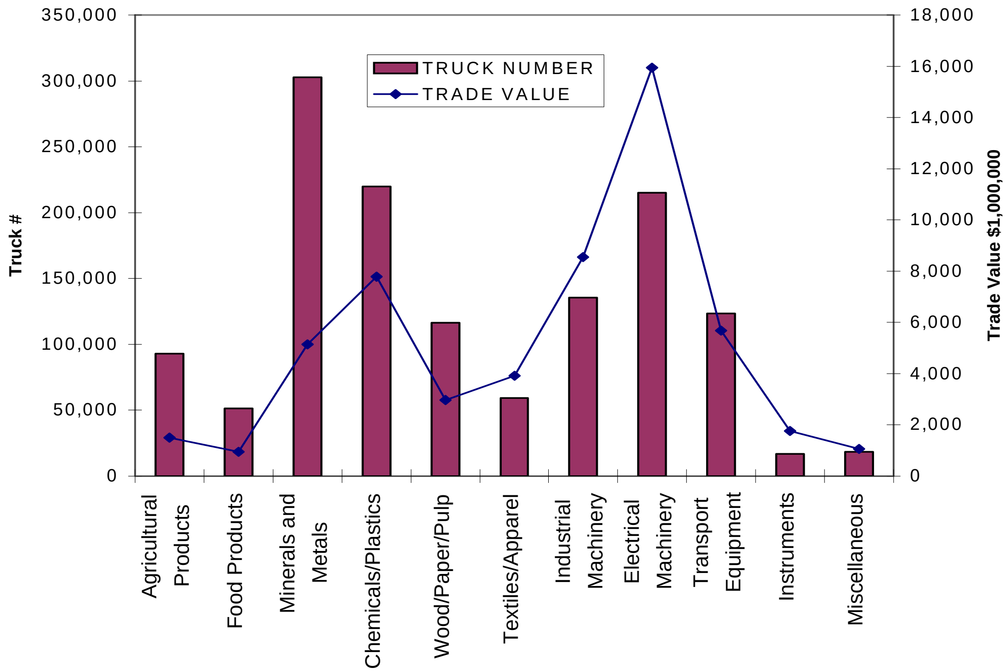


Figure 53 Commodity value and Truck Volume (Southbound 1997)

Figure 54 Truck Weight Estimation (By Commodity Group)

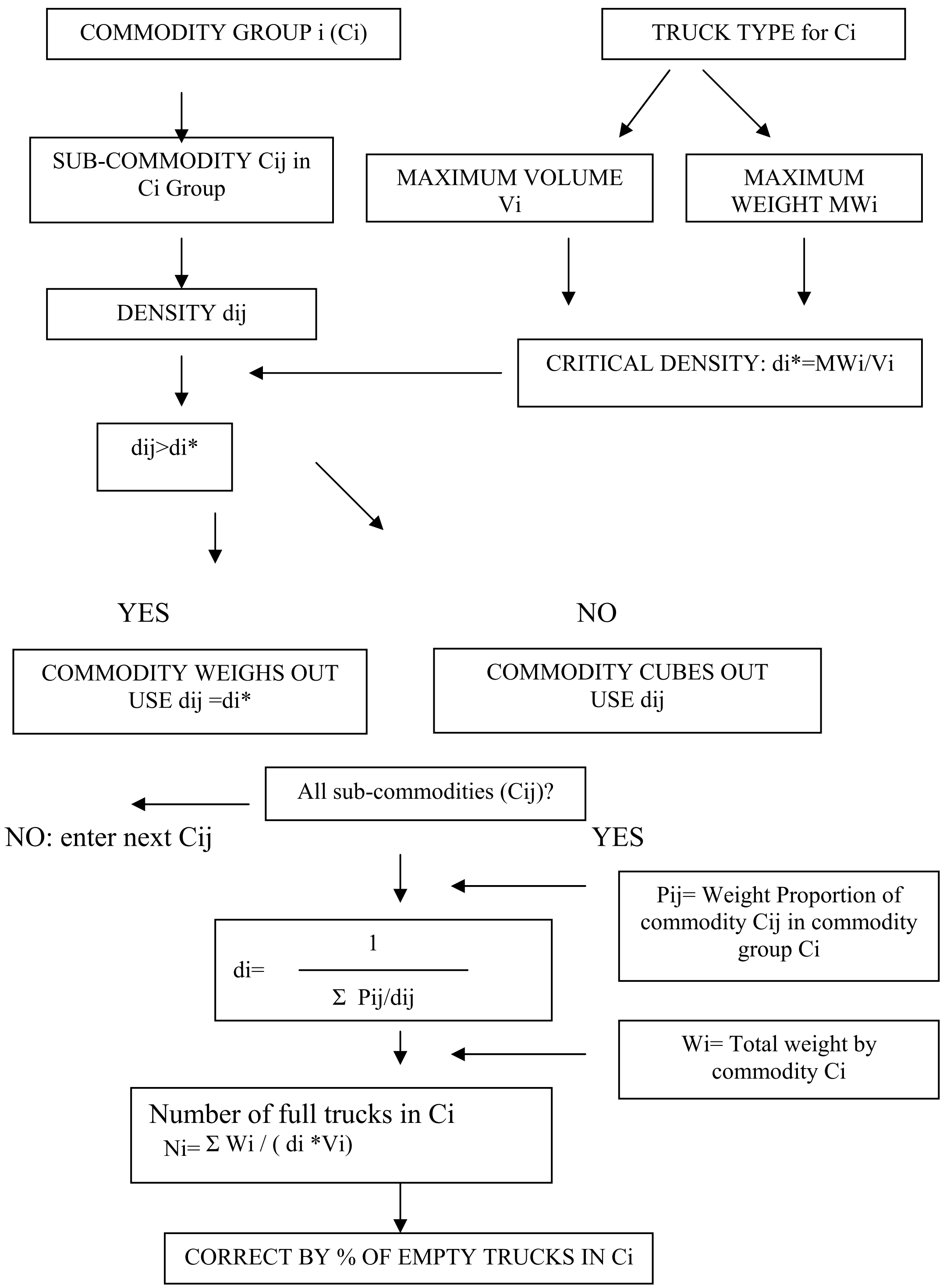


Figure 55. Consistency of Truckload Value Per Commodity

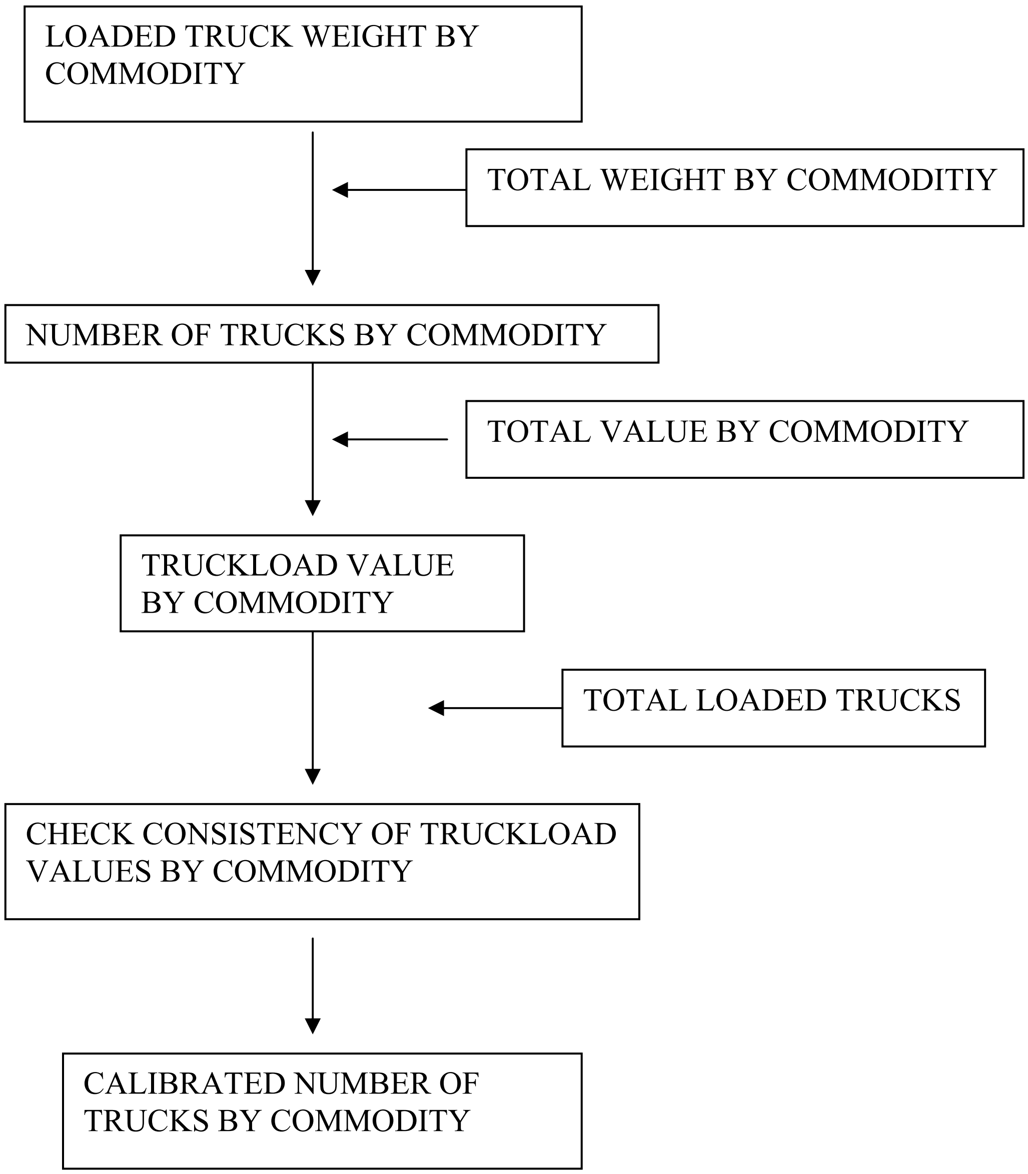


Table 34 Densities Used To Calculate Number of Loaded Trucks Northbound

CHAPTER	DENSITY lbs/ft3	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

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/ft3	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

CHAPTER	DENSITY lbs/ft3	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	3,662,662,722	38,110
Instruments	25,921	2,221,475,282	85,702
Miscellaneous	30,562	1,456,031,127	47,642

SOUTHBOUND

DESCRIPTION	TRUCKS	TRADEVALUE	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 VOLUME USING SIMULATION

The second method employed in this study to estimate 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 (for example 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 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:

$$N = \sum_i \frac{V_i}{v_i}$$

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 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 gives a better understanding of the possible outcomes that could occur.
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 is applied to northbound shipments through the port of Hidalgo during 1996, mainly because data availability, as explained in the next section.

Commodity Value Data

Trade value per commodity is 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 corresponds to the total surface northbound 1996 trade value moving through Hidalgo.

Values for 47 of the 78 two digit commodities were obtained. These forty-seven commodities account for more than 98% of the total value of northbound Hidalgo trade.

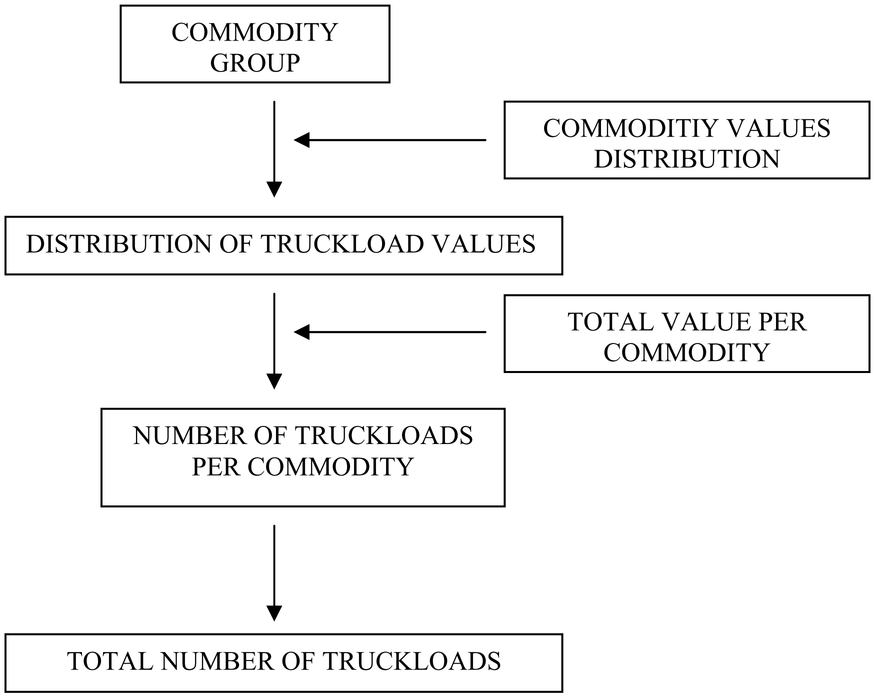


Figure 56 Simulation Process for Estimating NAFTA Truck Volumes

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 correspond to four months: March, June, September, and December. Thus it is 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 commodity classified as 2210603059 (HTS ten-digit classification with 22 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 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, since those are 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. An upper truckload limit of 56,000 lb. was used as the upper limit.
- Lower weight limit was set according 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. Though the data may not be very accurate, they serve to show the simulation methodology approach. Of course some conclusion can be drawn from the figures, but precaution should be taken, since 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 of the forty-seven commodity groups are presented in Table 37 for values in U$S and 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 digits HTS value distributions. All the commodities presented a left-skewed distribution: value<mode<mean<maximum value. For example, in Figure 57 it is possible to see the value distribution of commodity 87 (vehicle parts and accessories).

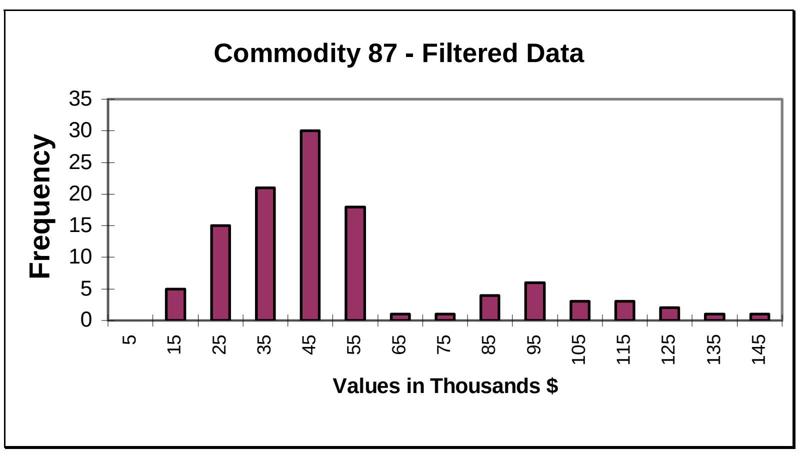


Figure 57 Distribution values in raw data

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

- Limit of values minimum and maximum. It is a bounded function; the values will neither go lower than the minimum nor higher than the maximum. Therefore, there is no possibility of negative or very extreme values (low or high).
- Few parameters that 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.
- 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

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

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

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

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

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

Figure 58 shows the distribution of commodity 87 and its final representation.

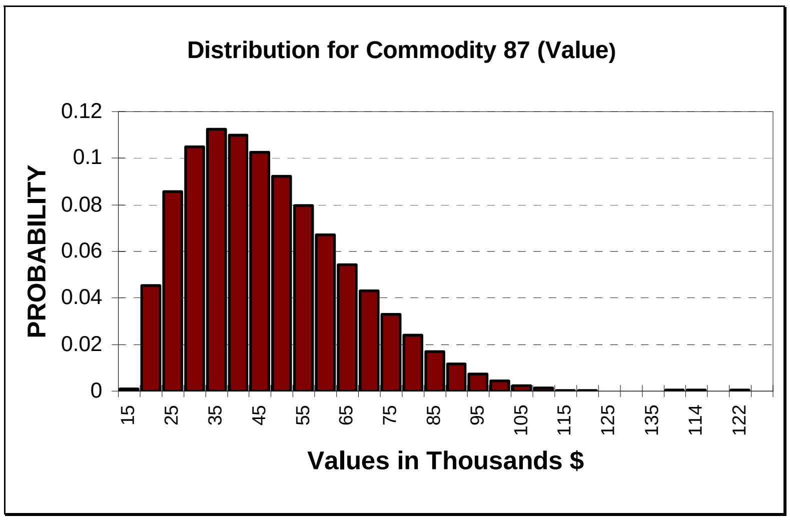


Figure 58. Simulated distribution values per commodity 87

Simulation Results

Figure 59 shows the number of northbound number trucks.

Table 39 shows the probability distribution of the total number of trucks and the nine main commodities.

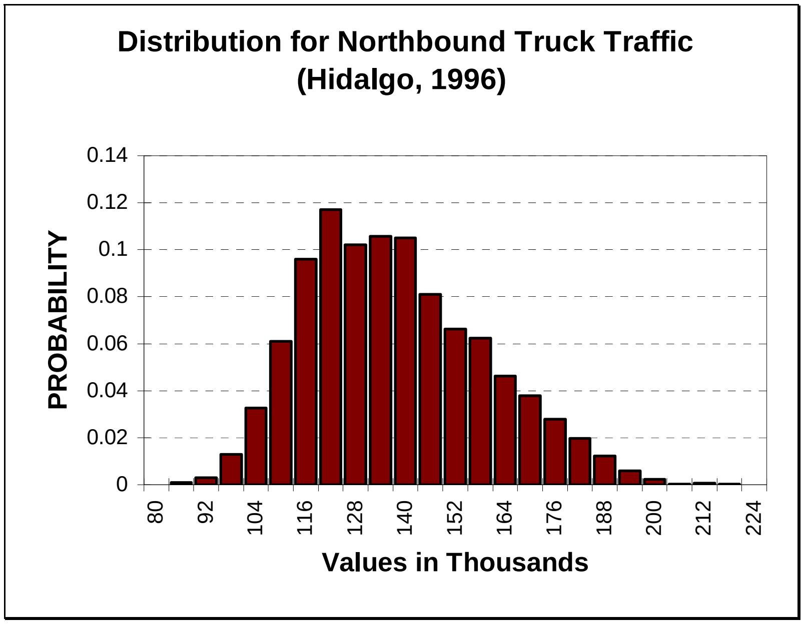


Figure 59 Simulation results total truck volume (Hidalgo Northbound 1996)

Table 37 Assumed Values for Beta Distribution In $

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 Lbs.

TSUSA	RECORDS	WT MIN	WT AV	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 60 shows commodities by value and truck trips. For the same value of trade, high-value commodities require fewer trucks than low-value commodities. Commodities like fruits (08), vegetables (07), and prepared fruits 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.

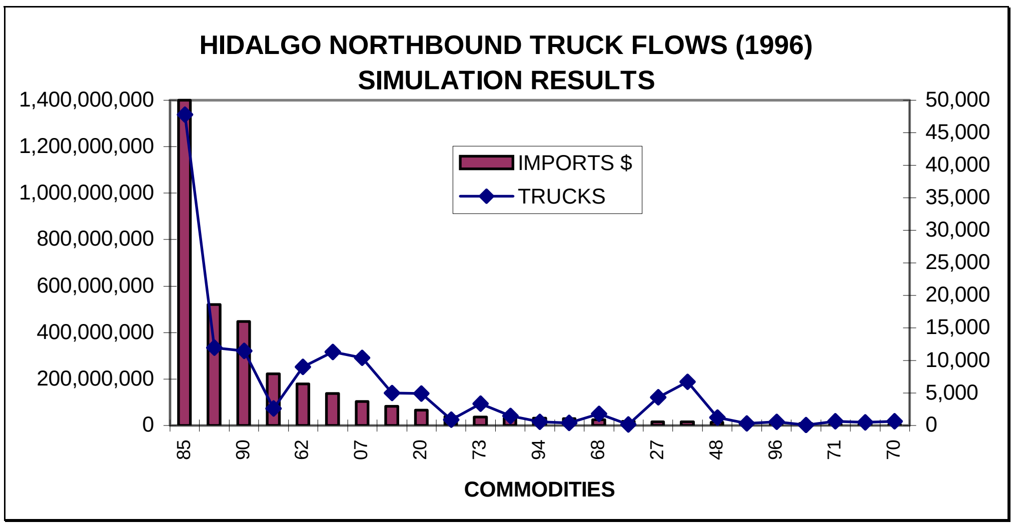


Figure 60. Truck volume and truck value per commodity

The model was calibrated with the estimated number of northbound trucks moving through Hidalgo obtained for 1996. The simulated number of trucks was 17% 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

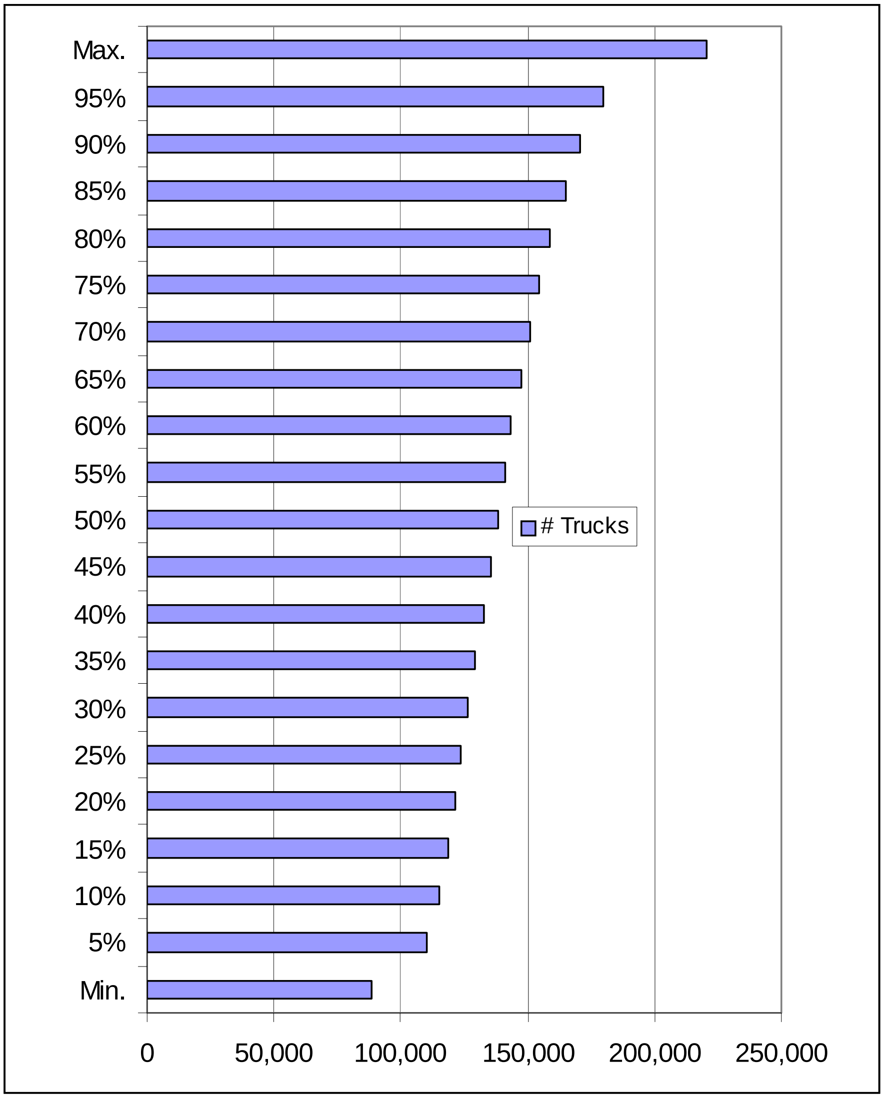


Figure 61. Distribution of Simulated Number of Trucks

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 to tackle the estimation of NAFTA truck volumes. Though 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.

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

Results show that average value per truckload per port varies significantly. El Paso, for example, shows a higher truckload value due to the high proportion of electrical products. There is not a linear relation between trade value per port and number of trucks or between trade value and average truck weight, which suggests that trade value is not enough to compare port characteristics and how trade can impact infraestructure.

Two methodologies to dissagregate NAFTA trucks by commodity are also presented. Commodity dissagregation provides more insight in the planning analysis. Key commodity groups can be identified what allows 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 data available heavily affect the quality of the results.

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

Unfortunately, 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 therefore understanding of US-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 in actual highway truck traffic flows. These steps, presented in this chapter, comprise zoning, network representation, assignment procedures, commodity grouping, and map generation. These are now described in more detail, sequenced 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 defining transportation zones strongly impacts 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, 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% of the exports and 28.5% of the imports. It is easy to see that using one zone for the whole state of Texas (hence only one origin and destination for 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 (21.4% of total exports and 17.1% of total imports). Border Mexican states also show important concentrations of trade. Higher accuracy can be obtained 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, with no effect on the configuration of long-haul corridors. Texas neighboring states have a small share in the truck trade and are, therefore considered as one zone per state. So, only Texas and California are split in the U.S.

Mexican border states are split based on their proximity to Texas and to 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 of the three Mexican nonborder states that have important 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 since 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 mostly between generally large industrial and consumption centers, which are few in number at the state level. The best example of this is the flow of transportation equipment between Mexico and U.S.. Southbound trade occurs between production centers in Michigan and Illinois and big consumption and productions centers like Mexico City and Guadalajara.

Table 56 shows the relationships between 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 big concentration of employment implies 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 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 the 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., Bureau of Census 1995 employment data were incorporated into a GIS layer using TRANSCAD software. The employment data correspond to seventy different activities at county level and employment is broken down using Standard Industrial Classification (SIC) categories.

Within the Mexican border states, maquiladora employment by "municipio" (the equivalent of a U.S. metropolitan area) is used. However, maquiladora employment classified by city and activity is not available. Therefore, 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 61 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 considerable. 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, for example, chemical employment in the Houston area, electronics in the Dallas-Austin corridor and textiles in El Paso.

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, with small influence on Texas ports of entry.

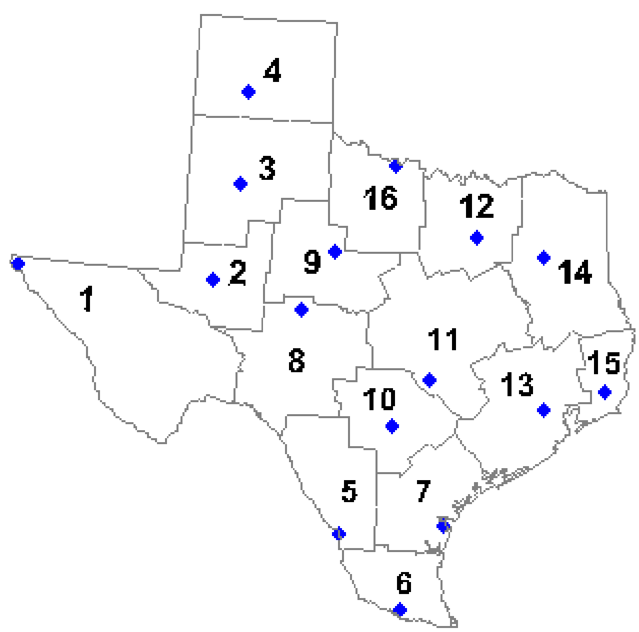


Figure 62 Texas Zones and Centroids

CITY	NUMBER
El Paso	1
Odessa	2
Lubbock	3
Amarillo	4
Laredo	5
Mcallen	6
Corpu.S. Christi	7
San Angelo	8
Abiline	9
San Antonio	10
Austin	11
Dallas	12
Houston	13
Tyler	14
Beaumont	15
Wichita	16

In Mexico, the border states are split using total maquiladora employment by city. All cities, with the exception 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
Juarez	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 production and attraction of freight movements) were used as criteria for centroid selection. When a state is split into smaller zones, important centers form 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 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.

To accurately represent 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 miles of centerline highway. The accuracy of the network is at a scale of 1:100,000 (precision of 80m). The network was 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 over 300 miles). 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).

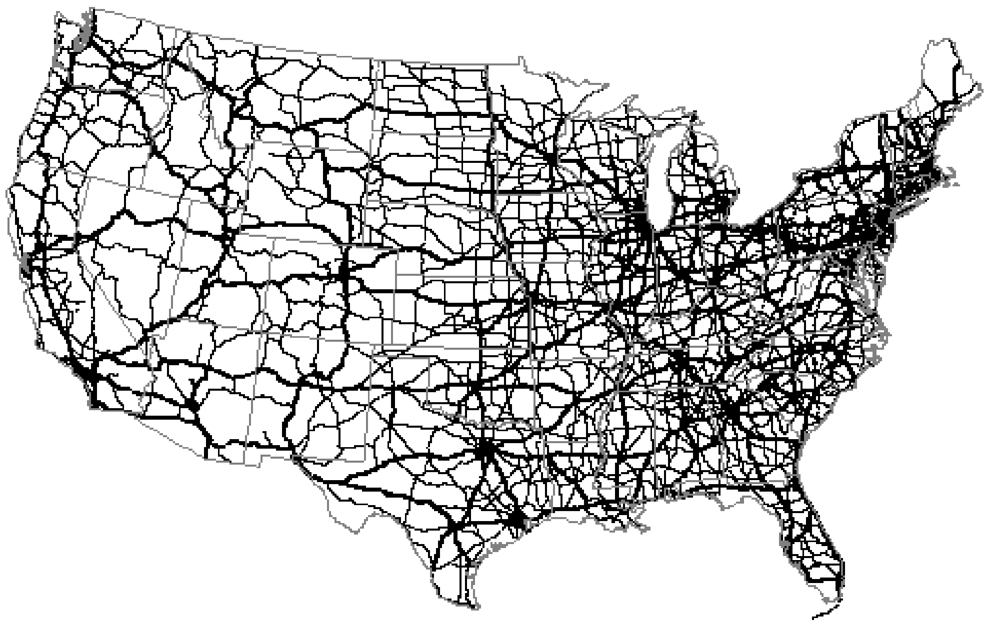


Figure 63. U.S. National Highway System (Ref 30)

Figure 62 shows the GIS layout of the NHS, with the Interstate system represented with thicker lines. Note that higher highway densities and populations are located in the east, northeast, and the midwest. In the central and west mountainous part of the country the network becomes sparser. Trade between the U.S. and Mexico is mostly concentrated within highly industrial and populated areas in Texas, California, the midwest, the east coast, and Mexican maquiladoras and Mexico's main cities.

Considering the Interstate and access-controled roads, the south-northbound corridors are reduced to five: I55-I57 corridor from Chicago to New Orleans, I35 corridor from Minnesota to Laredo, I25 from Montana to El Paso, I15 from Montana to San Diego, and I5 from Washington state to San Diego. Only I35 and I5, when they reach Texas and California, respectively, carry significant U.S.-Mexico trade. I15 and I25 run through states having low levels of trade with Mexico, while I55-I57 captures some traffic in the northern part.

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 I10, I20, and I40 and the main north-east-south west corridors parts of I30, I44, and I81.

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.

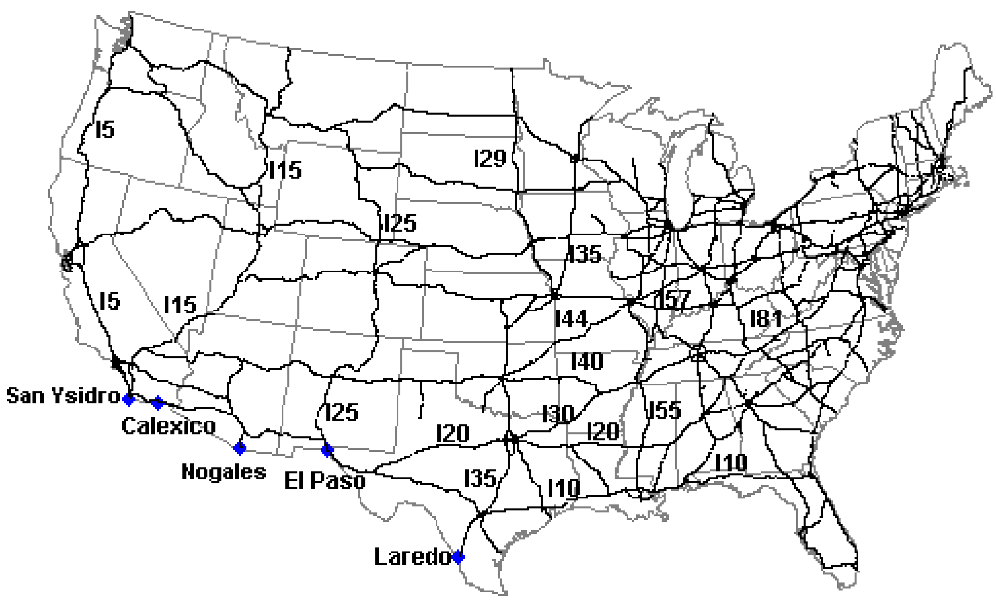


Figure 64. Main U.S. Corridors

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 64 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 using data from the 1996 Texas Truck Traffic Flow Map produced by the Texas Department of Transportation.

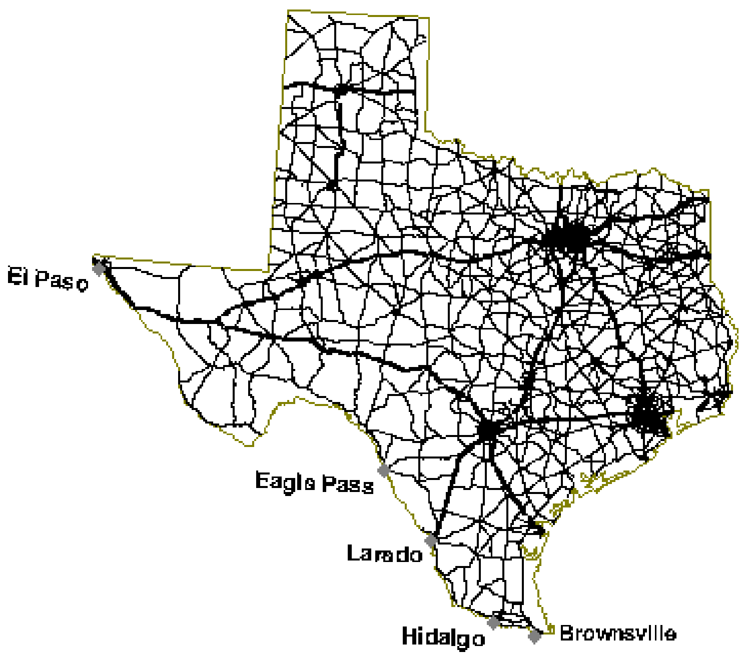


Figure 65. The Texas Highway Network

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	%
Interstate system	44,919	28
ISTEA High Priority Corridors	6,209	4
STRAHNET (Strategic Highway Network)	12,604	8
ISTEA/STRHNET Connector-Corridors	2,962	2
Other Highways	91,984	58

Table 43. NHS Urban/Rural

CLASS	Length	%
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	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 miles 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 industrial and consumption centers are located. The triangle connecting Mexico City, Guadalajara, and Monterrey contains the industrial heart of Mexico (especially nonmaquiladora). The absence of highways in the north and northwestern mountainous zone is noted, as well as in the south, as shown in Figure 67.

The Mexican highway system is strongly influenced by two factors:

Topography: Two mountain chains run along the north-south direction, hampering east-west communication, as seen in Figure 66. Mexico Topography Mapwhich depicts a topographical map of Mexico.

- this can be observed. 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 has not the same extension and 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 66. Mexico Topography Map

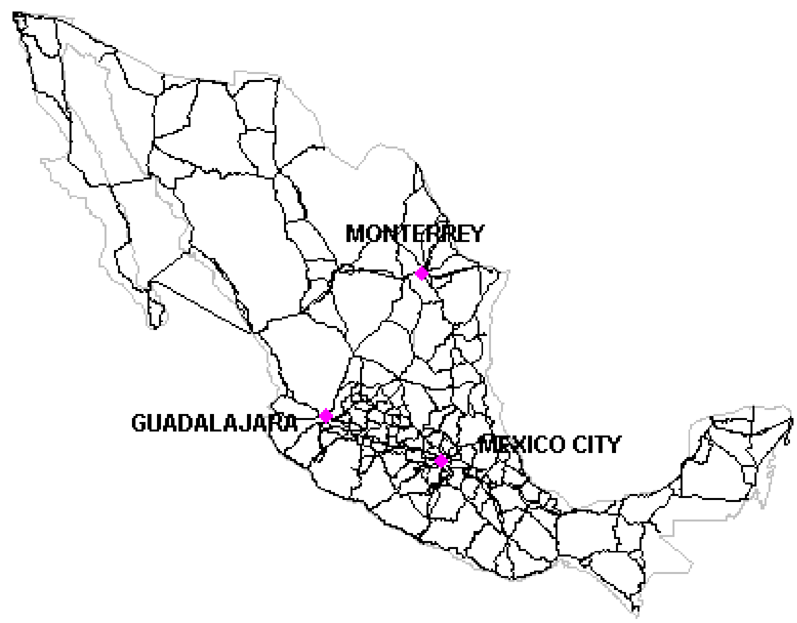


Figure 67. Mexican highways

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 location of six major freight corridors ending at the U.S. border is not surprising, since binational trade accounts for almost 80% of Mexico's international trade.

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 sea-trade.

Figure 68. Mexican Truck Freight Corridors

According to the same study, these seventeen corridors, totaling nearly 8,700 miles, move 80% of the freight ton-kilometers transported by truck in Mexico. Figure 67 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	TRUCKS/DAY	TONNAGE/DAY	FREIGHT VALUE 10^6 $/DAY
Mexico-Queretaro	212	6400	85000	164
Queretaro-Nuevo Laredo	**1058**	**3500**	**50200**	**119**
Mexico-Veracruz	446	3460	33200	90
Guadalajara-Monterrey	734	2760	43500	65
San Luis Potosi-Cd Juarez	**1348**	**2470**	**38200**	**54**
Mexico-Campeche	1447	2800	25000	47
Irapuato-Zacatecas	285	2700	24000	45
Queretaro-Guadalajara	380	1900	19900	40
Mexico-Tampico	522	2100	21000	38
Reynosa-Durango	**843**	**2000**	**32000**	**37**
Mexico-Guadalajara	624	3000	30200	33
Guadalajara-Nogales/Tijuana	**2303**	**1470**	**21000**	**29**
Mexico-Monterrey	1010	1670	19300	25
Reynosa/Matamorros-Tampico	**565**	**1070**	**12700**	**19**
Guadalajara -Tampico	806	1330	14300	16
Guadalajara-Manzanillo	306	1580	10500	12
Puebla-Oaxaca	419	2100	11600	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 Mexico highway network is far shorter than 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 truck volume through the mountainous zones. Even when mountain routes are shorter in distance through the mountains, they are not chosen owing to low geometric design characteristics, which translates into higher operation costs, lower speed, and greater safety risks (see Table 47).

Table 47. Mexican Highway Topography

CLASS	LENGTH
Hilly	13,207
Mountainous.	2,702
Flat	10,794

The urban network is very short, and most of the highways (over 80%) 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 been built over the last decade, 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 based on trucking company's behavior. Trucking companies, under the assumption of rational behavior, seek the route that minimizes their costs.

Route choice has two important aspects that impact 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 with the route chosen and the speed on the route. Speeds are not uniform; they basically 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 condition, highway functional class, and congestion. Speed, 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 in all the border crossings, and therefore have not being considered. This important aspect of border crossing could be the subject of future specific research.

Capacity constraints can be a relevant factor in urban conditions but less 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. Traffic volume data availability may considerable 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 Mexico trucking operations, where the highway system does not have the same level of quality as that in the U.S. Operational factors, such as 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 between 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 found is that urban highways have lower speed limits than rural highways.

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

- Distribution centers, trucking terminal hubs, and main industrial and consumer centers are connected by interstates,
- 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 due to 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 (Less 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 (binational perspective) because usually there is a very short haul from the border to the maquiladora.
- Interior Trade: interior trade concentrated between Mexico City, 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, the same approach used for U.S. highways is applied. 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 Mexico 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. (Ref 32,33).

COMMODITY GROUPS

The study of commodity movements among binational trade is one of the objectives of this study. Though the study of flows for each port is important, the study of commodity movements is more useful in describing regional flow patterns; it is also a significant step in accurately estimating NAFTA trucks. In the Transborder Surface Freight Database (TSFD), the origin-destination commodity data are presented as ninety-eight (98) two-digit commodity classifications (HTS). This number of commodities is too high, besides some commodities have very low participation in the trade.

For the purpose of this study, commodities are grouped into a small number of categpories 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 the U.S.-Mexico trade.

2. Characteristics of the commodity, such as type of product, volume/weight ratio, 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
- Transportation equipment
- Instruments
- Textile/Apparel products
- Chemical/Plastics/Rubber products
- Food products
- Wood products
- Mining/Metal/Stone/Ceramic/Glass products
- Agriculture products
- Miscellaneous products

Appendix 2 shows the relationship between these commodity groups and the ninety-eight two-digit HST 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, owing to 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 owing to their weight. This 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 truck carrying those commodities. Though there are no data available to account for this aspect, it is important to remember that the percentage of empty hauls may vary considerable 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, are developed, comprising

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

Southbound movements through a border port

Southbound port movement flowchart is presented in Figure 68. 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 shortest path in TRANSCAD software. Using the speeds from Table 51 and Table 52, times are calculated and the shortest time path is found.

Northbound flows through a border port

Northbound movement port flowchart is presented in Figure 69. For northbound movements, only the border port, the destination state, and value 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 flows maps is presented in Figure 68. For southbound commodity movements, the U.S. state of origin and Mexican destination state are known, as well as 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 (Laredo and Eagle Pass basically), 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, not difficult to overcome, are strongly 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 mainly from Michigan to Laredo or Eagle Pass to Mexico (see transportation equipment flow map, Chapter 7).

Capacity for highway links is assumed to be unlimited, therefore costs are equal to the free flow costs used in the shortest time path assignment. 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, however here it has been adapted to assign annual flows and to create an impedance at border crosses when the annual trade by port is exceeded.

Comparing 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, the results 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 state of origin with commodity classification. There are also no mode-split data and no commodity detail 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 early 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% of the northbound trade, and without maquiladora trade data, it may be difficult to determine the in-state, out-state, and U.S. trade proportion of the freight generation.

Another important problem is modal split, since 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 under the characteristics 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 chain in 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 have been also made and could be subject of further study in future research.

Figure 69. Southbound Flow by Port Flowchart

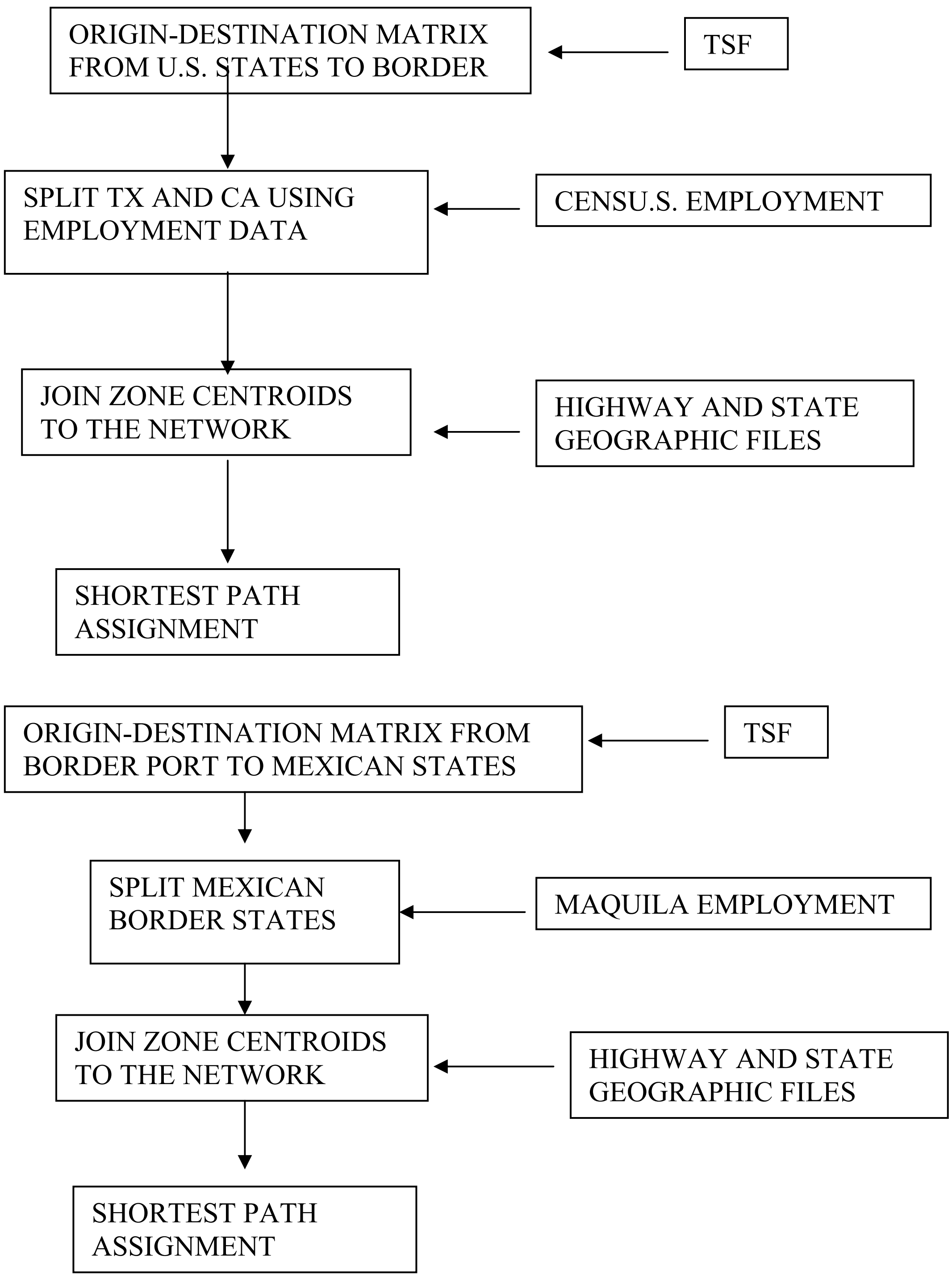


Figure 70. Northbound Flow by Port Flowchart

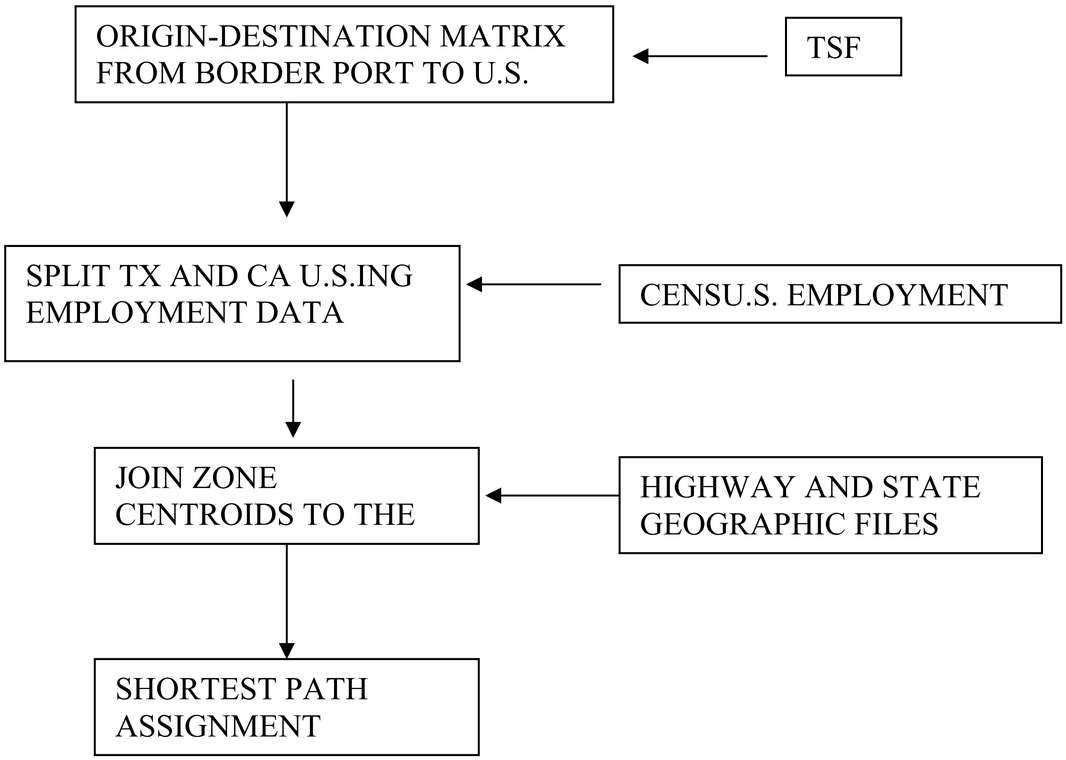
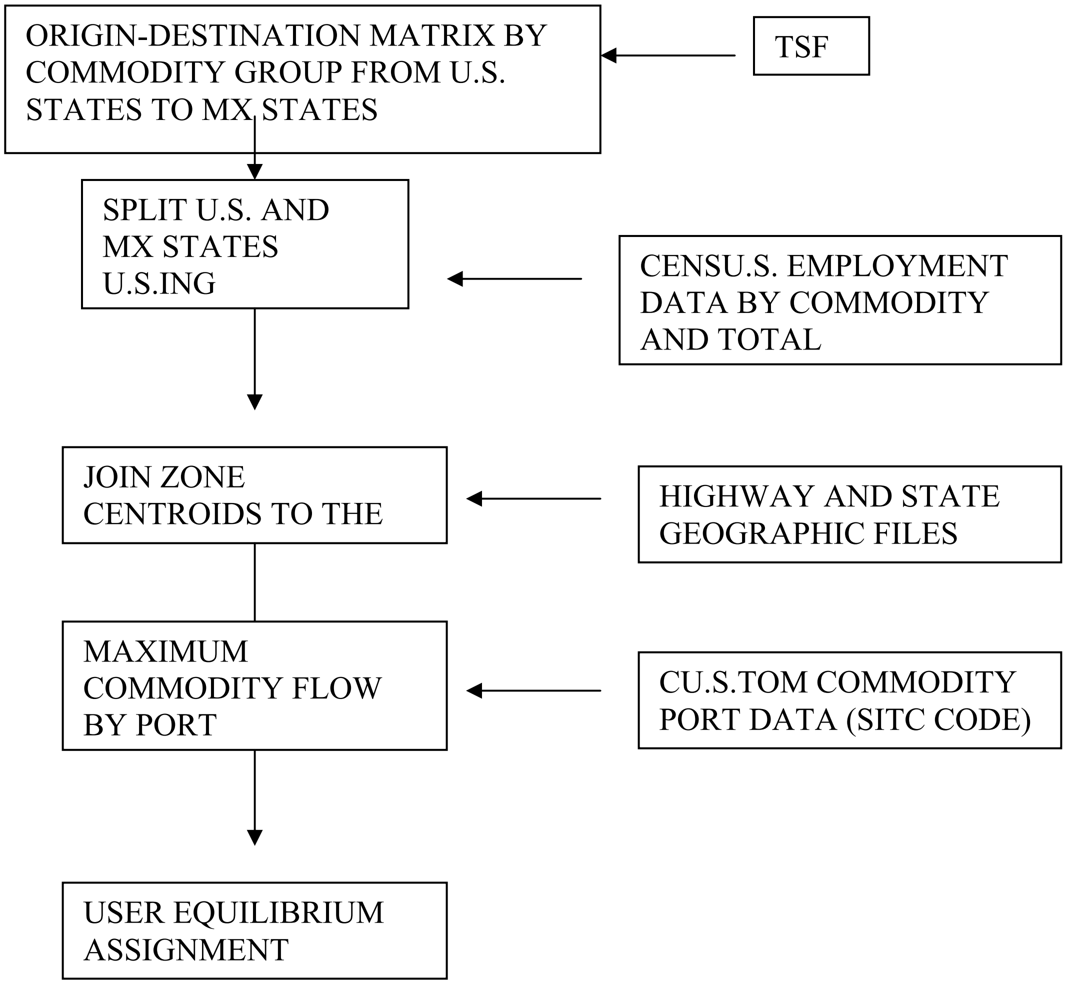


Figure 71. Southbound Commodity Flow



CHAPTER 7

PORT AND COMMODITY TRUCK MAPS

Trade databases containing origin destination details (TSFD) and NAFTA truck volumes obtained in Chapter 5 are 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 reporting annual truck volumes on the various corridors. The main corridors are identified and an estimated number of trucks for northbound and southbound movements are presented.

SEASONAL EFFECTS

The maps presented in this chapter present annual volumes of NAFTA trucks in 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 where obtained, therefore the appropriate correction factors (that 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, e.g., agricultural products or food products. Table 53 shows 1997 monthly average, standard deviation, and the 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 71; summer and spring months are where the peaks of the trade are found. April and May are the peak months while August and July show the lowest trade values.

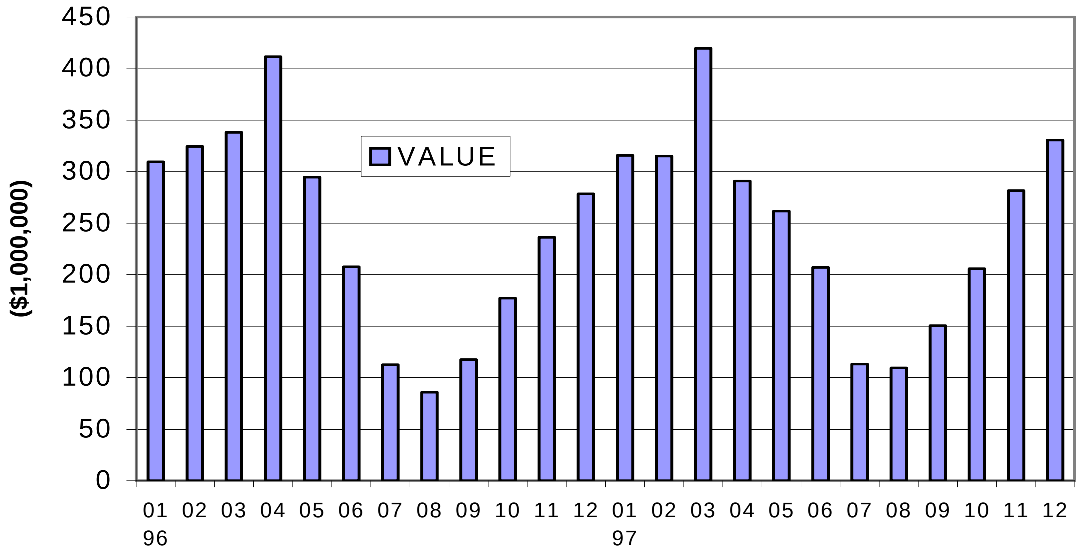


Figure 72. Northbound Agricultural Products (Seasonal Effects)

NAFTA trade continues to experience an increasing trend over time as shown in Table 54, which shows 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 as shown in Table 54.

In other cases the growth of certain commodity groups is so important that the seasonal variation is concealed; an example is found in southbound movements of agricultural products that grew 385.7% from '96 to '97, shown in Figure 73.

Agricultural products weigh out in general, therefore 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 (96-97)

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%

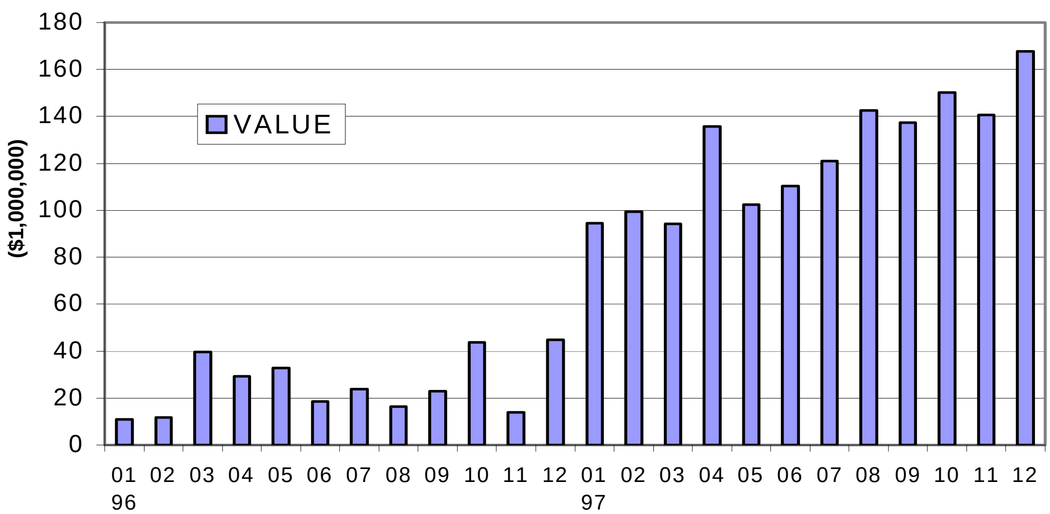


Figure 73 Southbound Agricultural Products (Seasonal Effects)

BY PORT

Significant monthly variations in truck volumes occur at certain ports, and these are related to seasonal commodity variations. Table 55 and Table 56 show the variation of northbound truck count 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 standard deviation of monthly truck count and 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) show a ratio between standard deviation of monthly truck volumes and monthly truck volume average around 0.09.

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**
Progresso	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 74. Considering the sum of both bridges the ration 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

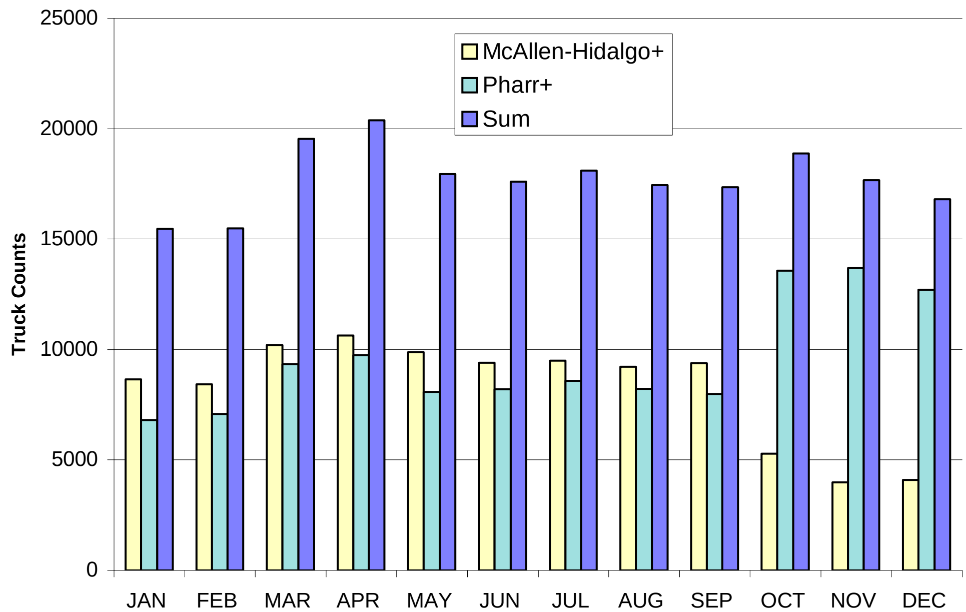


Figure 74. Truck Counts at Hidalgo Bridges

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 74). The values of Figure 74 were obtained getting the average haul by commodity after the commodity assignments. This figure provides valuable insight into modal split. Many factors influence mode choice, distance being a determinant factor, for example, transportation equipment has the longest haul and also the highest rail participation. Due to the long haul length found in NAFTA trade, it is possible to speculate that with an efficient rail service all commodities could present some diversion to rail.

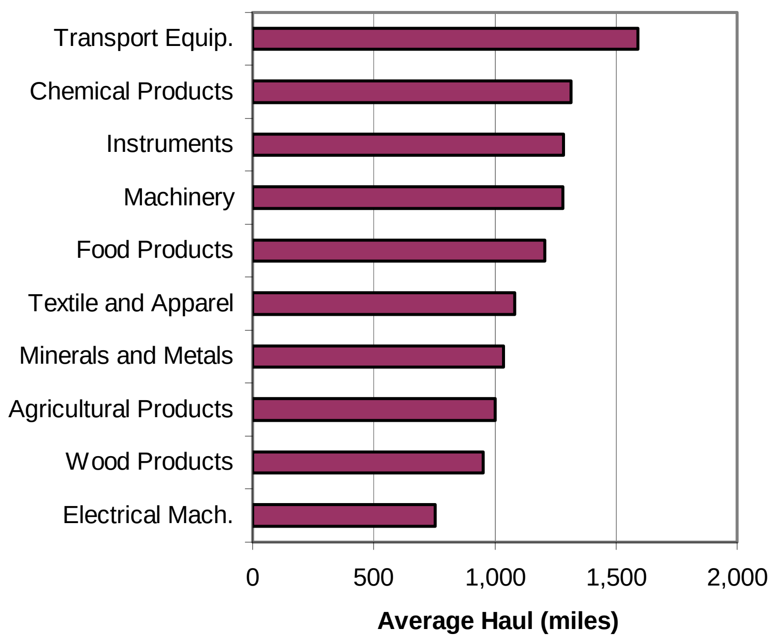


Figure 75. Average Length Haul by Commodity (Southbound 1997)

TRUCK MAPS

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

The most important corridors stem from the border to important centers in the east coast, midwest, west coast and Texas.

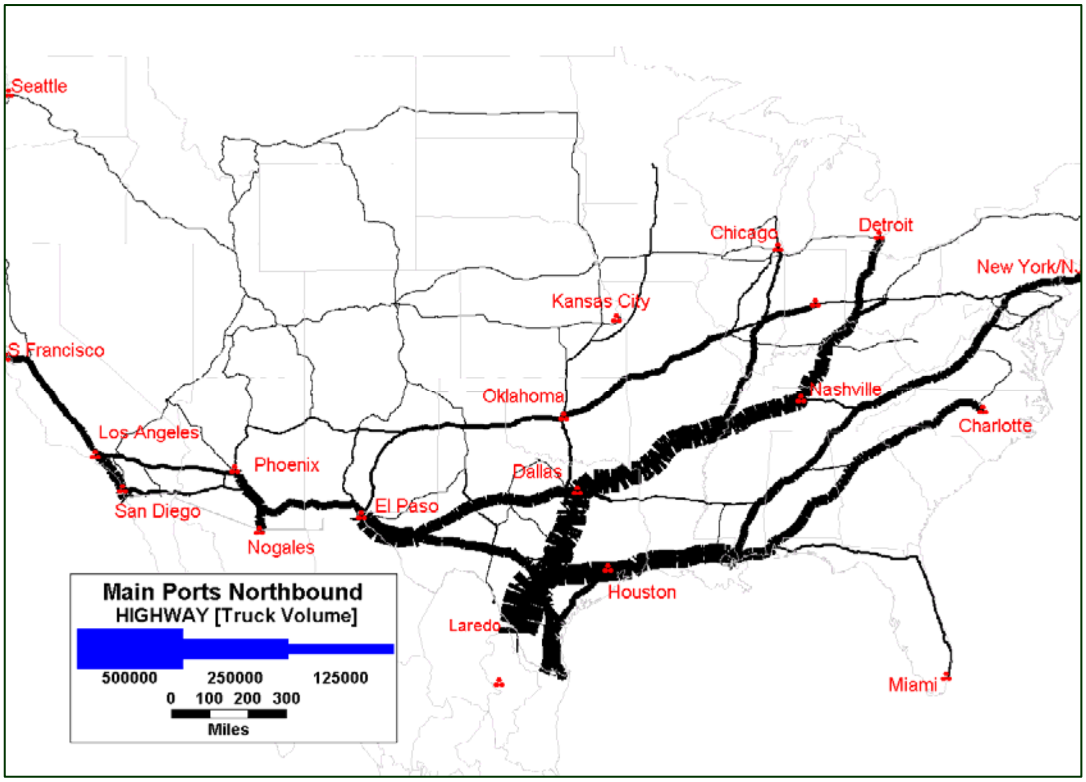
U.S.-Mexico truck trade corridors are highly concentrated; a few highways carry significant portions of the trade. As corridor length to the border increases, corridors follow a path comprised by segments of the main interstate highways.

The main corridors identified are listed here and in Table 58 the number of estimated trucks is presented.

1. IH 35 From Laredo to San Antonio-Austin-Dallas
2. IH 30-IH 40 from Dallas to the midwest and east coast through Nashville.
3. IH 10-IH 20 from El Paso to Dallas
4. IH 10 from El Paso to Houston.
5. IH5-IH8 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, respectively.
7. IH 10 from Houston to New Orleans.
8. IH59-IH81 and IH65-IH85 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-IH40 from Oklahoma to El Paso

Figures 75 and 76 show the main corridors for northbound and southbound corridors respectively.

Figure 76. Northbound Truck Corridors



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

As shown in Figure 77, in Mexico there is only one dominant corridor: Laredo-Monterrey-Mexico City. This corridor connects with U.S. infrastructure at Laredo, from where it stems to Texas cities, the east cost and the midwest. The other ports show an important maquiladora influence and their trade share with non border states is small. This is particularly true with the ports of California. In Appendix 7, maps by port and by commodity are presented.

Table 58. Main Corridor in US

HIGH WAY	FROM	TO	SOUTHBOUND TRUCK VOLUME	NORTHOBUND TRUCK VOLUME
IH 35	Laredo	San Antonio	585,649-554,097	523,120
	San Antonio	Austin	419,666-419,666	386,912
	Austin	Dallas	419,669-387,488	364,880
IH 30	Dallas	Little Rock	219,494-219,494	296,384
IH 40	Little Rock	Nashville	174,031-174,031	216,931
IH 65	Nashville	Louisville	174,031-147,508	169,913
IH 71	Louisville	Cincinnati	147,508-147,508	147,068
IH 75	Cincinnati	Detroit	121,822-121,822	91,545
IH 10	El Paso	IH20 (TX)	276,046-276,046	246,285
	IH 20	San Antonio	139,306-139,306	109,409-110,443
	San Antonio	Houston	235,077-235,077	254,876
	Houston	Beaumont	170,954-170,954	241,318
	Beaumont	IH 59 (LA)	155,079-149,178	230,657
IH 20	IH 10	Dallas	90,062- 90,969	136,376-111,117
IH 37	San Antonio	U281	156,373-156,373	172,275-
	U281	U77	68,732- 68,732	73,816
U281	IH 37	McAllen	121,494-124,494	186,631
U77	IH37	Brownsville	100,885-100,885	109,535
U77-	Corpus Christi	Houston	68,213- 68,213	75,309
U59	San Ysidro	San Diego	197,806	194,519
IH 805	San Diego	Los Angeles	114,064	131,877
IH 5	Calexico	San Diego	140,149	39,677
IH 8				

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.

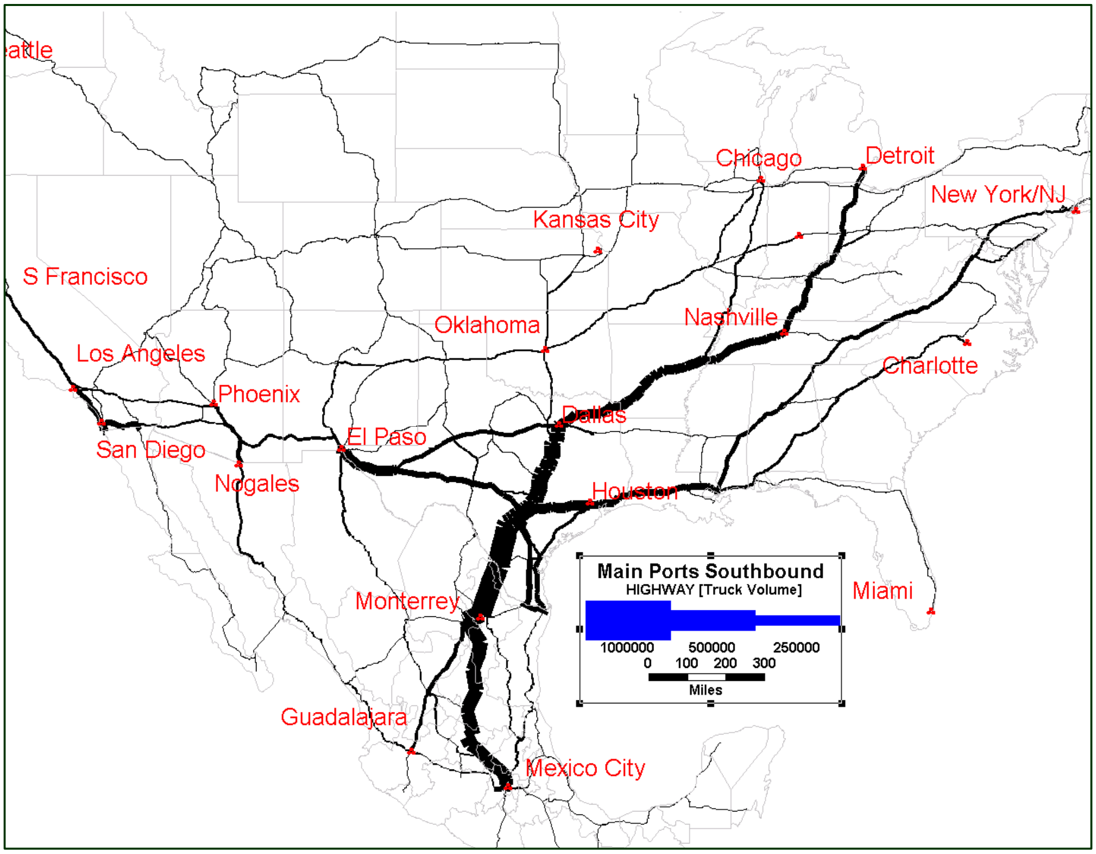


Figure 77. Southbound Truck Corridors

As shown in Appendix 7 (Figure 109 to Figure 118), commodity maps present very distinctive characteristics. Each commodity shows a different proportion of passing and non-passing 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 an important movement between the east coast and central Mexico. Commodity maps are important to understand the nature of the trade and as it is shown in Chapter 8, to analyze the impact of NAFT trade because different commodities have different impact on infrastructure and a different value/weight ratio.

SUMMARY

This chapter has identified truck corridors for southbound and northbound trade. The location of Texas, in the middle of the largest industrial 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 small amount of truck volume coming from other states; its trade is mostly with Baja California.

Laredo is the main port and has special characteristics that makes it unique in the sense that carries most of the out-of-state trade, being the preferred connection between the east coast and midwest to interior Mexico. Maquiladora trade, in different degree, characterizes the other important ports, comprising El Paso, Brownsville, Hidalgo, San Ysidro, Calexico, and Nogales.

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

CHAPTER 8

NAFTA TRUCK LOADS 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 with safety problems. Indeed, safety concerns with Mexican trucks was the reason 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 truck loads cause to Texas pavements. The Center for Transportation Research (CTR) at the University of Texas at Austin has undertaken three projects focusing on truck load-impacts along the Texas-Mexico border (Ref 18,23,24) using WIM data. This study, in Chapter 4, has a section that describes overweight truck axle loads at both border and nonborder locations. This chapter will use some of these important findings from both sources to study possible impacts on border ports based on commodity and vehicle classification.

Pavement Damage Concepts

Truck loads 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 were developed to evaluate the damage of ESAL's. 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 varies approximately following the fourth power of the change in axle load.

Overloaded Axles by Truck Type

The effect of the fourth power rule is so considerable that an axle overload of 20% will cause damage equivalent to the passage of two legal axle loads. Pavement engineers design pavement structures to endure a projected number of ESAL's. 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, it is necessary to express truck loads in ESAL's. Figure 77 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% 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.

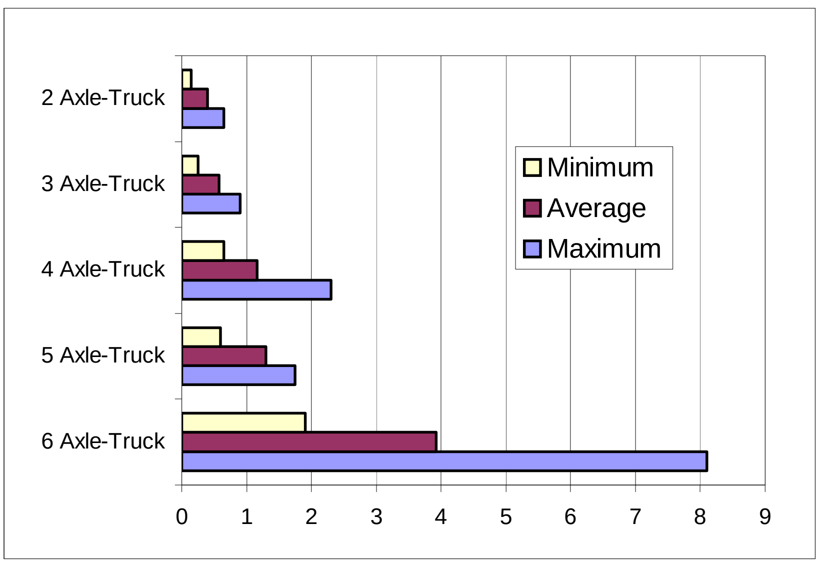


Figure 78 ESAL by Truck Type

It is important to notice the influence of load in the ESAL. In Laredo, 2% of the truck population (six-axle trucks) accounted for 9% of the total ESALs. In the same way 48% of the population (five-axle trucks) accounted for 60% of the ESALs and 21% of empty trucks accounted for only 1% of ESALs (Ref 18). Figure 78 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%), Rio Grande (58.8%), and Roma (13%). The presence of four axle trucks is low in all ports and decreasing.

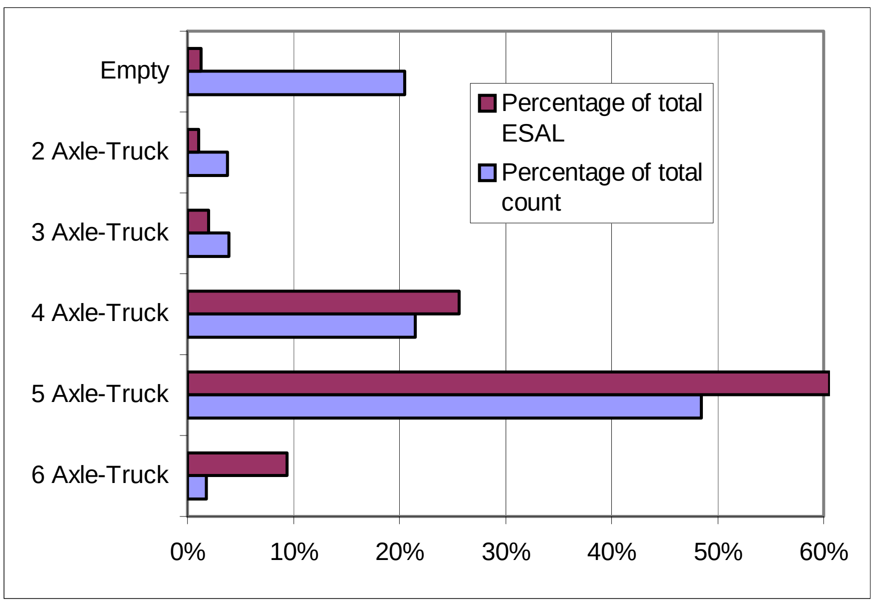


Figure 79 ESAL and Truck Count

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% 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 to all the axles, a truck that weighs 60% more will have the same damaging effect as almost 7 lighter trucks.

The following graph shows the influence of commodity type on truck weight (Figure 80). The data for Figure 80 were obtained from study of "Commodity movements on the Texas Highway System" (Ref 35). Assuming 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 showed in Figure 80. Using these values, the fourth power formula, and the value of mixed shipments as reference, the values in Table 59 were calculated. The effect of a commodity that weighs out (such as agricultural, construction and hazardous materials) is equivalent to 4.6 trucks with mixed commodities.

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 ports that handle cube out commodities. In order to classify commodities as cube out and weigh out, a list of commodity densities contained in the National Cooperative Highway Research Program Report 260 is used (Ref 28). The list is broken down using 5-digit Standard Transportation Commodity Code (STCC). Table 60 lists the classification of the commodities as cube out or weight out. Exceptions may occur and the table only provides a general picture.

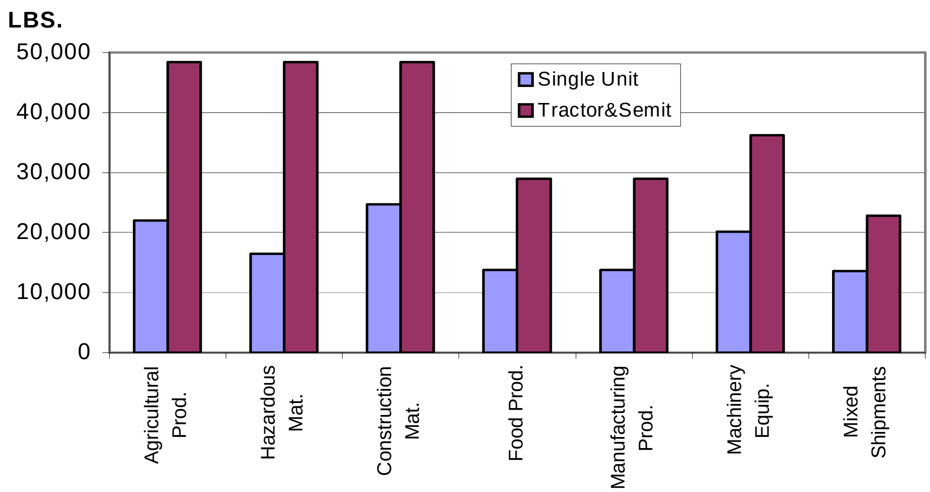


Figure 80 Truckload commodities by truck type

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 81 shows weight data by commodity group. These data correspond to 1997 northbound movements for all ports and were produced using the Transborder Surface Freight Database (TSFD). Agricultural products, as well as minerals and metals, comprise a important share of all the weight shipped by truck (49% of 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%. Weight by commodity group is not available by port; however, value by commodity group is available by port..

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 weight 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.

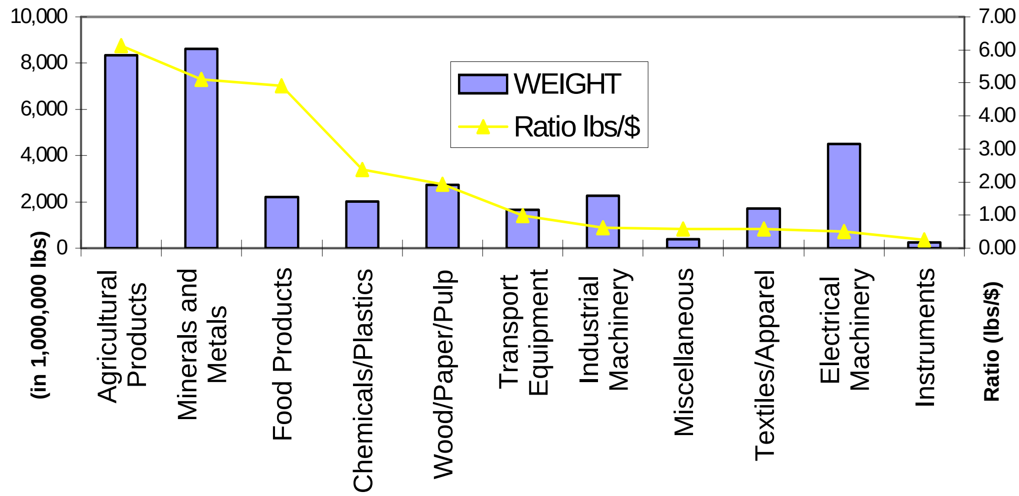


Figure 81 Northbound Commodities Weight (1997)

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 may 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 strictly restricted to transportation aspects, required a sequential analysis of trade statistics, truck border operation, truck characteristics, origins and destinations, truck corridors, and estimation of truck volumes. Available data were gathered and analyzed to estimate main U.S.-Mexico truck trade corridors, truck volumes, and to produce maps and tables.

Even before its implementation in 1993, NAFTA motivated many debates and heated discussions about its benefits and costs. These discussions were often not based on sound analysis or reliable data to back up the arguments. One objective of this study was to quantify and provide methodologies and figures that can develop 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 with few previous quantitative analyses. Data are generally scattered, and are often not suitable for transportation analysis or given in formats that make 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. Though the figures provided in some chapters might appear limited due to the accuracy of the original data or assumptions made, they help to clarify and to put in the right perspective aspects of NAFTA truck trade.

NAFTA trade between Mexico and the U.S. is expected to have high rates of growth in the next 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 that will allow Mexican truckers to circulate in the border states of the US, and in a similar fashion US drivers will be able to circulate in Mexican border states. It was scheduled to take place in December 1995 but was unilaterally postponed by the U.S. Department of Transportation. Though still delayed, there is growing evidence that it 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 that 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 the midwest, northeast and Canada regions.

As it was shown, US-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 basis to anticipate infrastructure problems and to guide 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 would be 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 important to also keep track of rail trade, railcar crossings as well as their origins and destinations. This study provides insights by explaining data analysis issues, analyzing trends, and providing methodologies to estimate truck volumes and corridors. Customs collaboration with TxDOT would give access to valuable commodity and origin-destination data and substantially improve our understanding of trade flows.

As a better understanding of NAFTA is reached and more data are available, further work may include the integration of other modes (rail and sea) in the analysis as well as other countries, especially Canada. 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," Bureau of Transportation Statistics (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

This 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 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 Bureau of the Census using the AES. Approximately 42% 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. Costums' automated commercial system. About 97% 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 % of the 14.4 million entries during 1995 (U.S. Customs, Customs Automated Broker Interface, (Ref 58).

Value Reported

The f.a.s. (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. Bureau of Census 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 (HTU.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 having a value less 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% of exports and imports to Mexico.

District of Exportation and Importation

For exports using surface mode transportation (rail, truck, pipeline, or other), 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 where the merchandise is loaded on the vessel or aircraft that takes the merchandise 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.

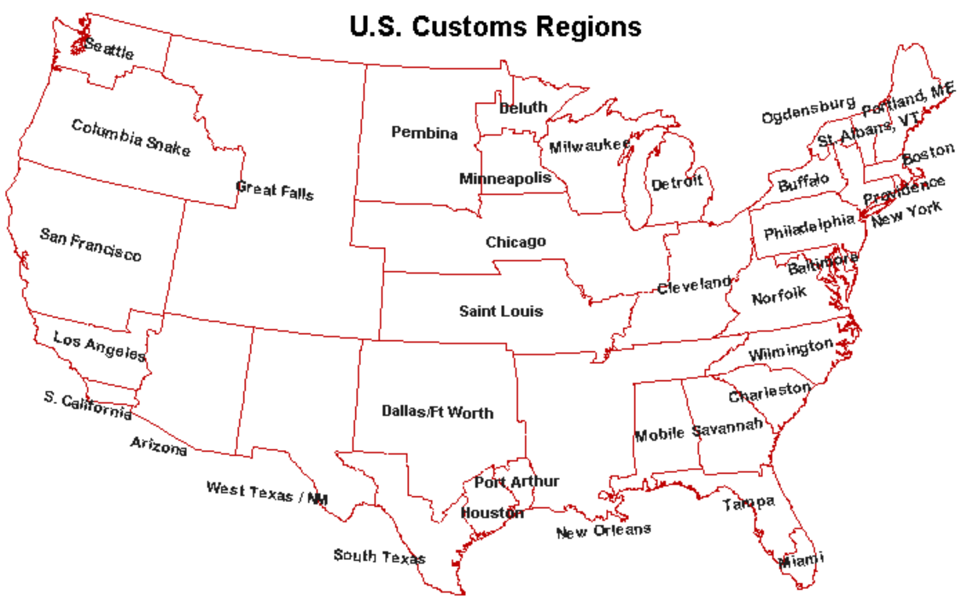


Figure 82 U.S. customs districts.

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 82) 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. Every district is identified with two digits (e.g., 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, Progresso, Rio Grande City, 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., 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 is the ultimate destination as 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 attributed to the country of shipment (resulting 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. Total weight exported or imported by all modes is not available.

To summarize, 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 data as the import and export data except for two important differences:

- The data set contains four digit custom port data. This means that data can be broken down at district and port level, e.g., we can know total shipped through Laredo district (as in Commerce Data) as well as through Brownsville, Hidalgo, Laredo, etc.
- Commodity data are provided with five-digit Standard International Trade Classification (SITC). This classification code has been adopted by the United Nations and is fully described in "Standard International Trade Classification, Revision 3." (Ref

54). Though 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 HTSU.S.A classification into SITC; however, 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 (HTSUSA), 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 is:

- 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 Bureau of Transportation Statistics (BTS) has been publishing the Transborder Surface Freight Data (TSFD) since April 1993. The data are published monthly, usually with a delay of five to six months. The Mexico-U.S. data are contained in six monthly files available for free from BTS via Internet or CD-ROM.

Although the TSFD is published by BTS, the provider of the data is the Department of Commerce through the Bureau of Census. 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 automated broker interface system (ABI).

"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: Increase in commodity detail and geographic detail
- April 1995: The shipping weight for Mexican imports was added
- January 1996: Shipping weight for transhipments through water was added
- January 1997: Transshipments through a third country were removed. Also some additional inland port were identified.

FILE DETAIL

For U.S. exports to Mexico it is possible to obtain:

- Exports to Mexico with U.S. state of origin and commodity detail: Transportation mode, 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: transportation mode, 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, 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 (fileD11).

Note:

- In the case of U.S. imports, there is no information regarding Mexican state of origin.
- File 3B and 5B have as 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 (either truck or mail), other. Aircraft and vessels moving under their own power but not carrying cargo are included in "other," as well as electricity, pedestrian carrying freight, and unknown. For imports foreign trade zones are also included.

- Commodity code: two digit Harmonized Tariff Schedule of the United States Annotated (HTSUSA) 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
  - National Transportation Analysis Region (NTAR) of the exporter address
- Mexican state of destination (only for U.S. exports): state in which the ultimate consignee is located in Mexico.
- Destination of U.S. imports: the U.S. state of destination is taken from the importer's address.
- District and port of entry: customs port where the entry documentation was filed with Customs and the duties 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): cost of freight and insurance from the origin in Mexico to the U.S. border.
- Container code (only for import data): containerized and non-containerized shipments for truck and rail can be disaggregated.
- Shipping weight (only for U.S. imports): 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 purchasing. 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. This trade is a very important component of the U.S.-Mexico trade and has very special characteristics (as discussed in another appendix). For some border ports, maquiladora trade accounts for more than 90% of the total trade. U.S. customs does not publish any 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. 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 overrepresentation of Mexico City because many companies are headquartered there.

The information available for imports and exports for1995 includes:

- 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 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

For Laredo, transport equipment through the port is very important with 36% 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, as will be illustrated later in a later chapter, typify this port. It is important to note that the percentage of Maquiladora trade is very small.

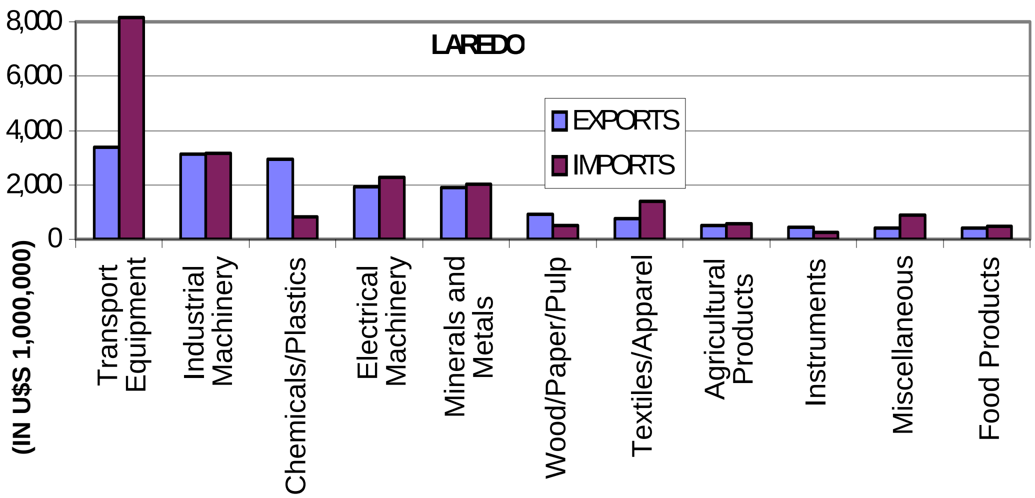


Figure 83 Commodity Groups (Laredo 1996)

Port of El Paso

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

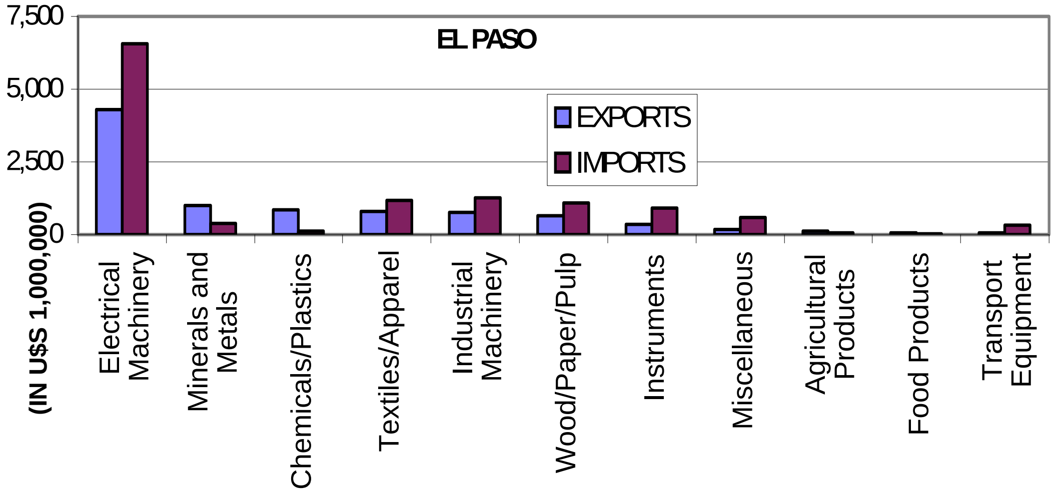


Figure 84 Commodity Groups (El Paso 1996)

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 that accounts for almost 41% of the total trade.

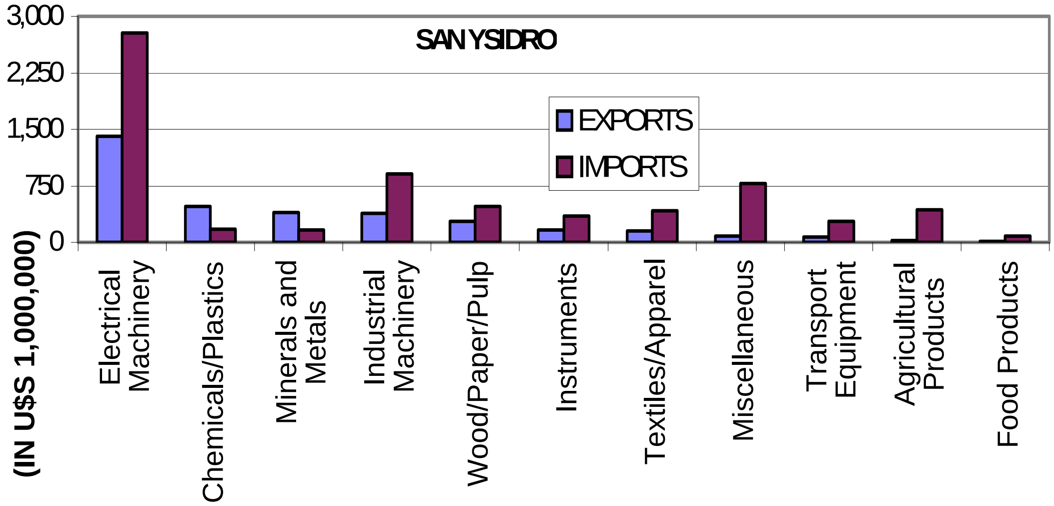


Figure 85 Commodity Groups (San Ysidro 1996)

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% of the trade. Chemicals/plastics and minerals/metals are also important.

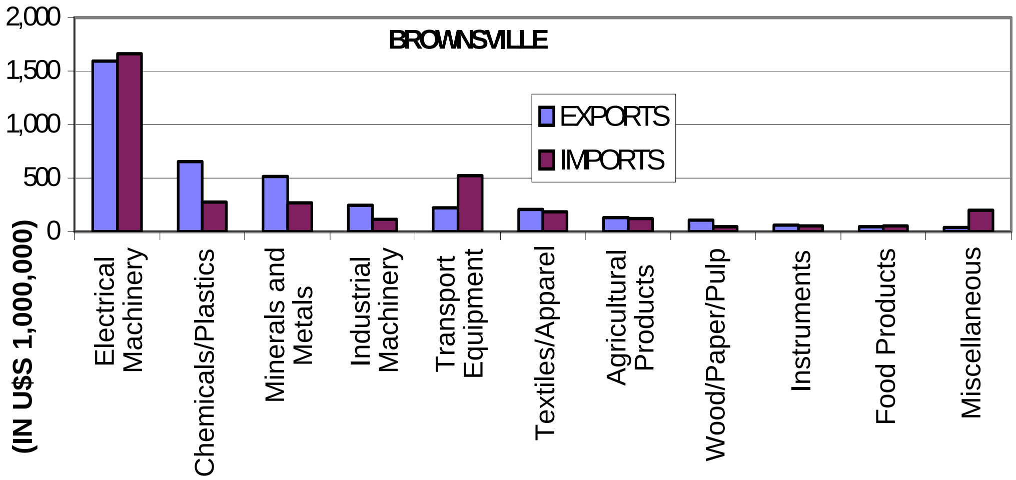


Figure 86 Commodity Groups (Brownsville 1996)

Port of Nogales

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

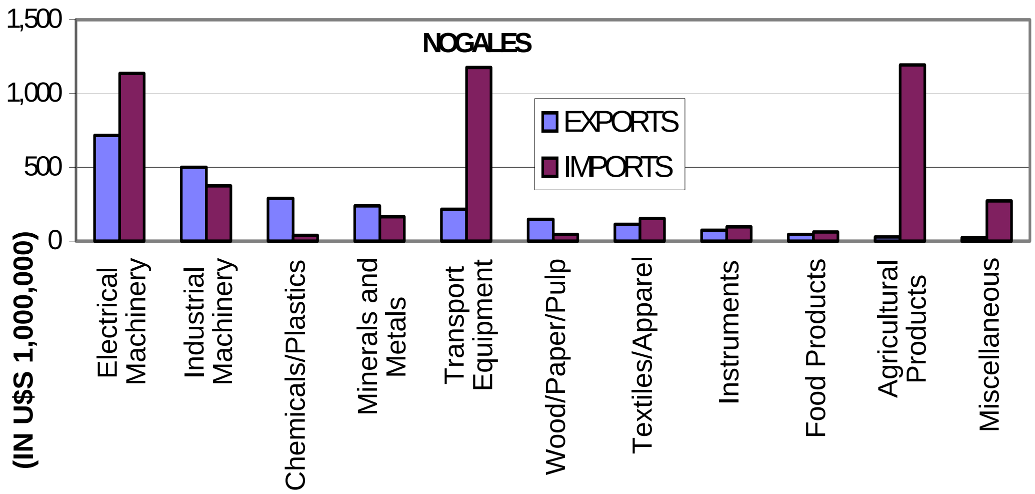


Figure 87 Commodity Groups (Nogales 1996)

Port of Hidalgo

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 important unbalances between northbound and southbound trade in agricultural products, instruments, and transport equipment.

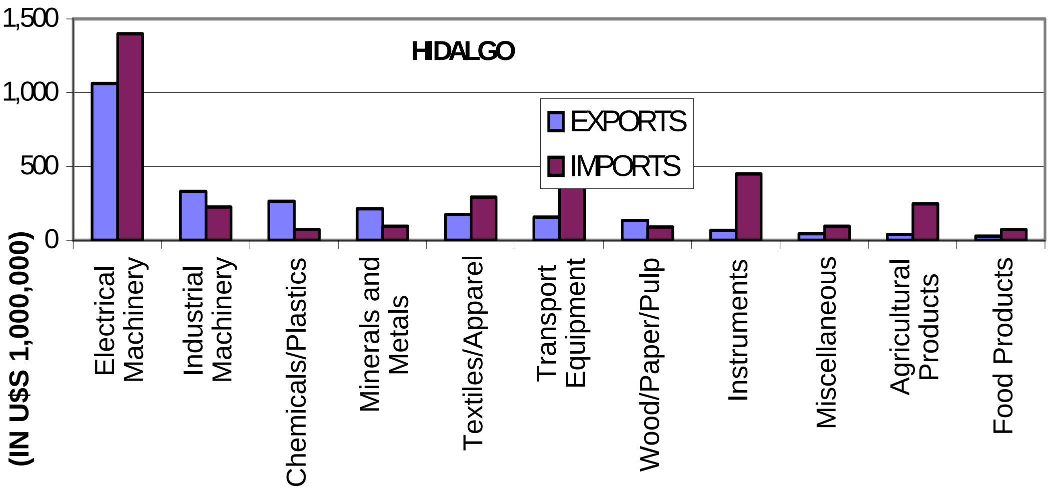


Figure 88 Commodity Groups (Hidalgo 1996)

Port of Eagle Pass

Eagle Pass is the only port where railroad has the highest share of trade.

Trade at Eagle Pass present many points in common with Laredo. Like 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 considerable smaller than in Laredo as well as the number of truck crossing.

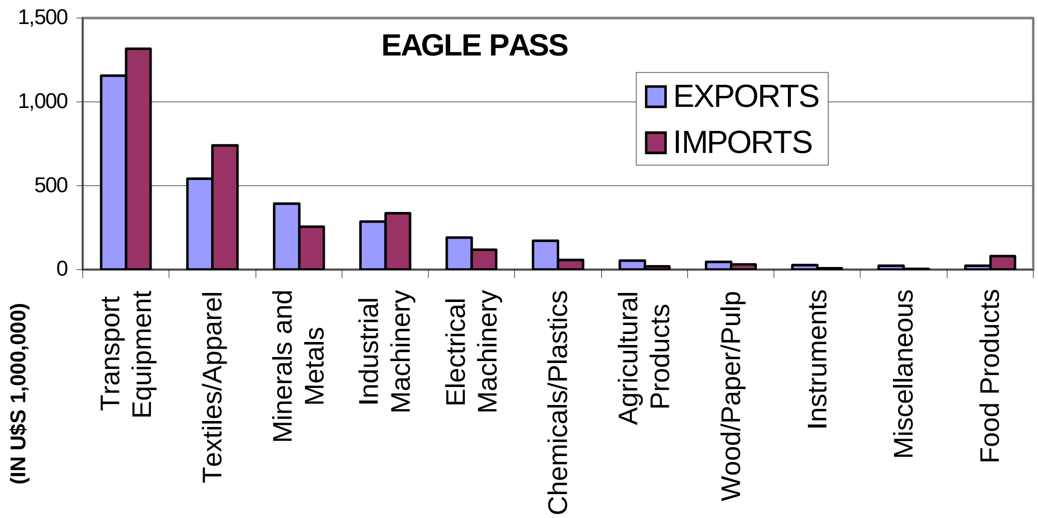


Figure 89 Commodity Groups (Eagle Pass 1996)

Texas

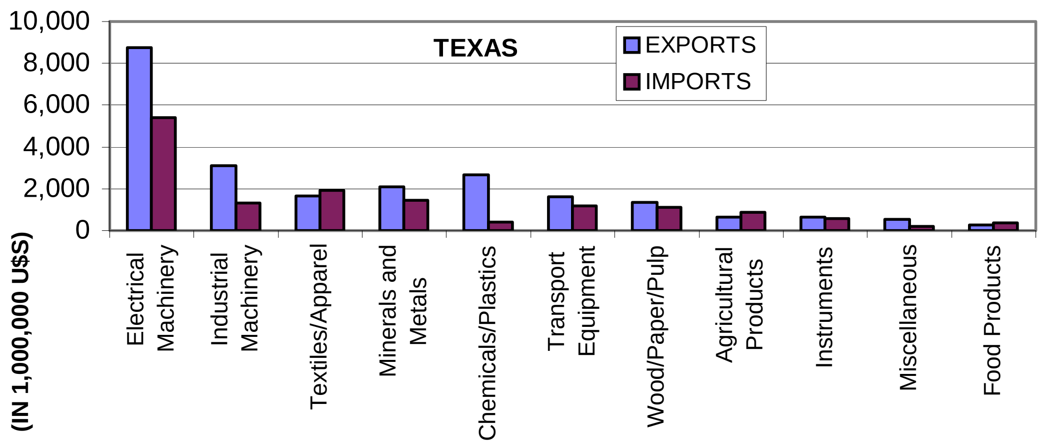


Figure 90 Commodity Groups (Texas 1997)

California

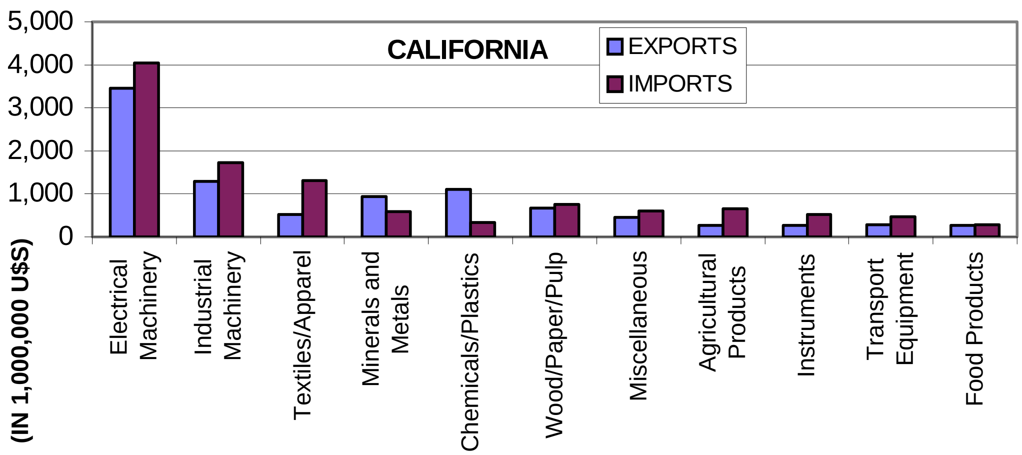


Figure 91 Commodity Groups (California 1997)

Michigan

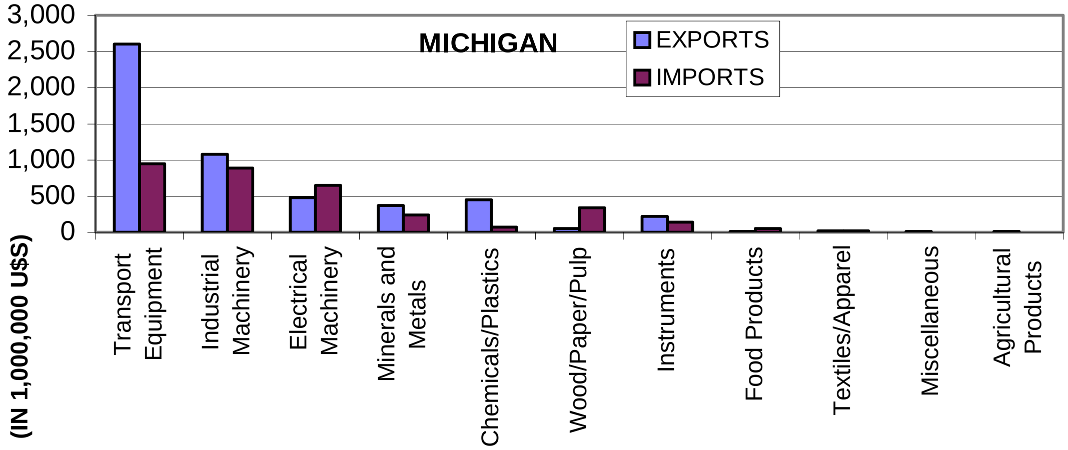


Figure 92 Commodity Groups (Michigan 1997)

Arizona

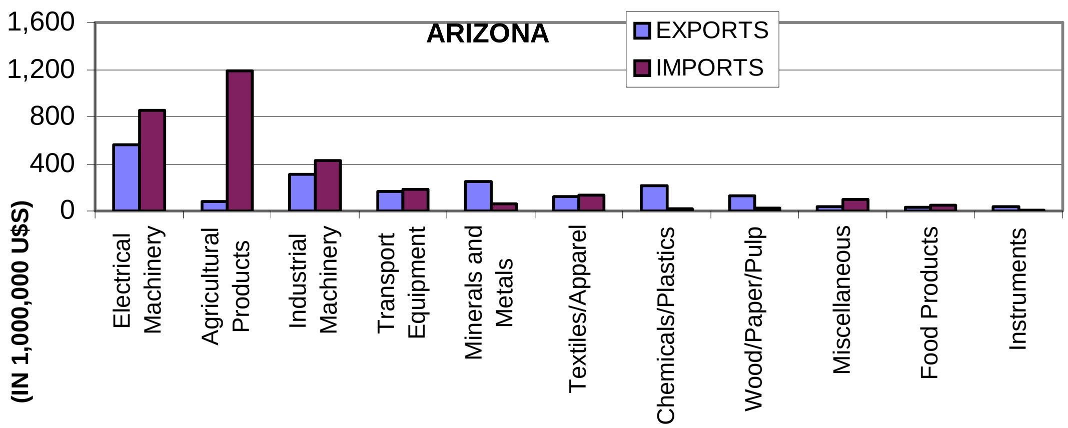


Figure 93 Commodity Groups (Arizona 1997)

North Carolina

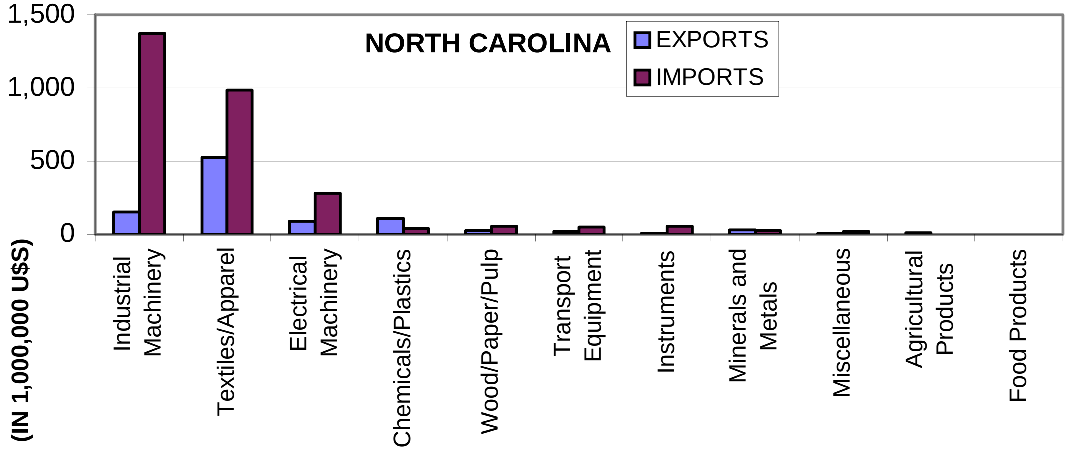


Figure 94 Commodity Groups (North Carolina 1997)

Ohio

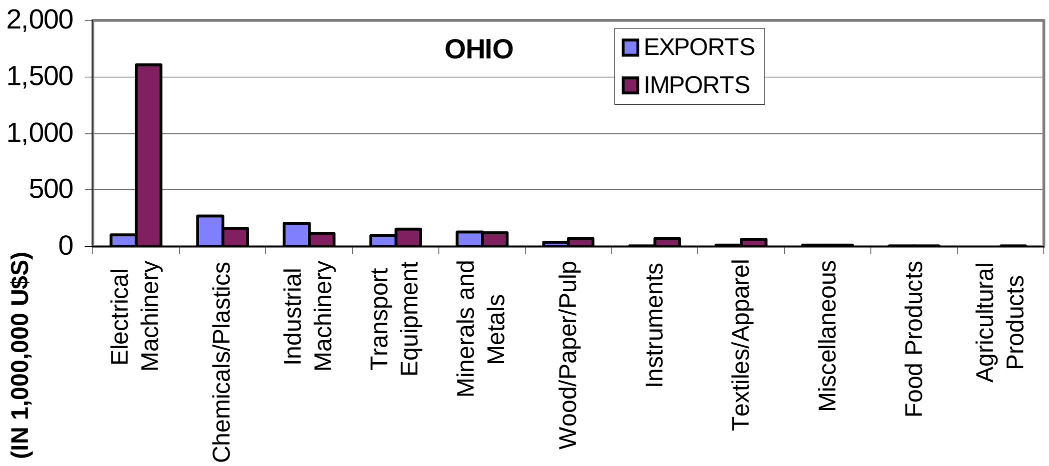


Figure 95 Commodity Groups (Ohio 1997)

APPENDIX 3

MAQUILADORA INDUSTRY

Introduction

An important aspect of the 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 (Ref 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 the North American Free Trade Agreement (NAFTA) in December 1993. In 1994, only 20% of the maquiladora output could be sold in Mexico, today the limit is set at 75% 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.

Besides the important tax reduction, the competitive edges of the maquiladora industry offers lower labor wages found in Mexico with the proximity to the U.S. market. Labor intensive manufacturing and assembly operations found in maquiladoras substantially reduce cost. The proximity to the U.S. market translates into lower transportation cost and travel time than in Asian maquiladoras.

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

History of 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 of places like Taiwan, South Korea, and Singapore paled 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, maquiladora industry has followed the same ups and downs of the Mexican economy. Maquila industry has experienced important growth and change in the last sixteen years. The evolution of total employment (Figure 96) shows four different periods. From 1980 to 1983, there was a slow annual growth of 3.1%. 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 1983-1989 was 21.1%. During the next five years, 1989-1994, there was a slowdown in growth, with the average annual growth being 6.8%. From 1994 to the present there has been an important growth of 15.1%. 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 last statistics show maquila employment reaching one million. Today the maquiladora industry is not only a very important source of employment, but also has replaced oil exports and tourism as Mexico's main source of foreign currency.

Data employment presented in Figure 96 to Figure 100 was obtained from the Mexican agency in charge of official statistics, INEGI (Ref 49).

Characteristics of Maquiladora Trade

International trade movements are usually 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 the goods are mostly shipped back northbound.

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 (twin plant).
3. A substantial part of the manufacturing process has to be finished in a U.S. industrial plant.

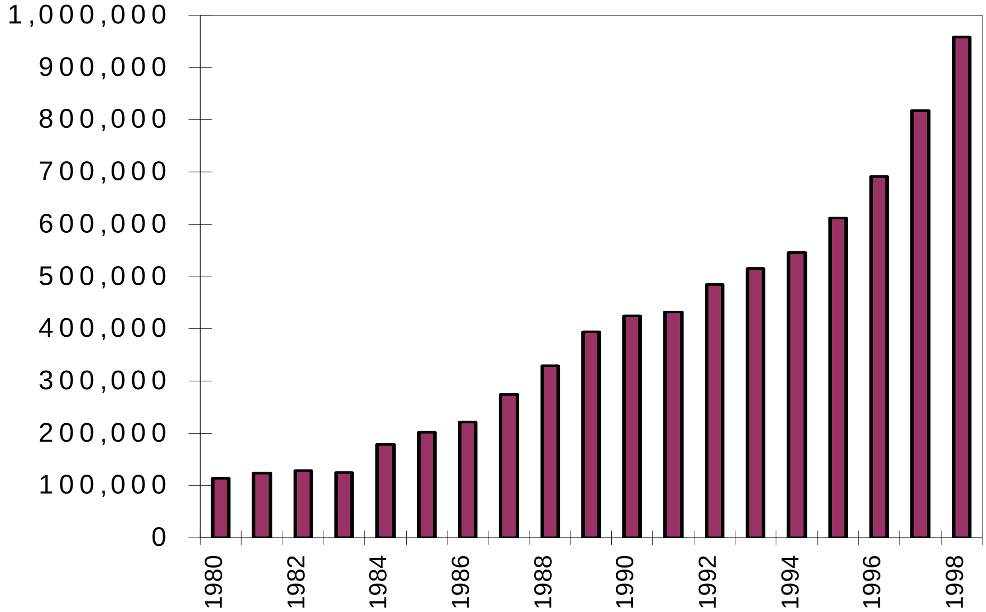


Figure 96 Total Maquiladora Employment (1980-1998)

This type of operation obscures the study of U.S.-Mexico trade. This is aggravated by the absence of Mexico origin- 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 Reference 8. These data correspond to 1992 and encompass only the border city area (origins or destinations outside the border city are not specified).

Most maquiladoras acquire the gross of their supplies from U.S. sources, with less than 2% purchased locally (Ref 40). According to a survey of 128 maquiladora factories adjacent to Laredo, Eagle Pass, and Del Rio, these plants purchase (Ref 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 say in Monterrey maquiladoras buy 20% of locally made supplies against 5% at the border) (Refs 1,5).

Location of Maquilas

In the beginning most maquiladoras were located in the San Diego-Tijuana area, and later due to a shortage of labor force 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 nineties. Figure 97 shows a trend toward more nonborder maquiladora employment. Maquiladoras located in the interior have grown faster than border state maquiladoras. During 1980 to 1998 (2,756%). Coahuila and Baja California (1068% and 936%) have grown also over the Mexican national average (741%). At the present time (1998), the percentage of nonborder employment reached almost 20%. 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% 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.

Though Mexican transportation infrastructure has substantially improved in the last 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)

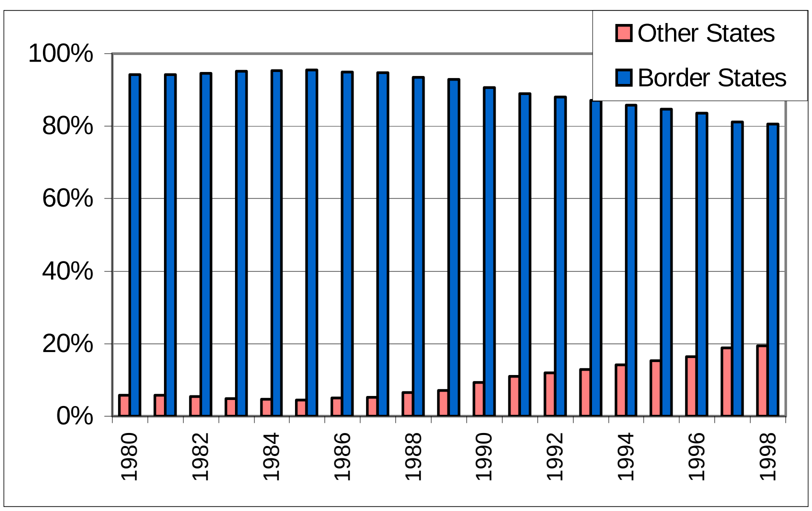
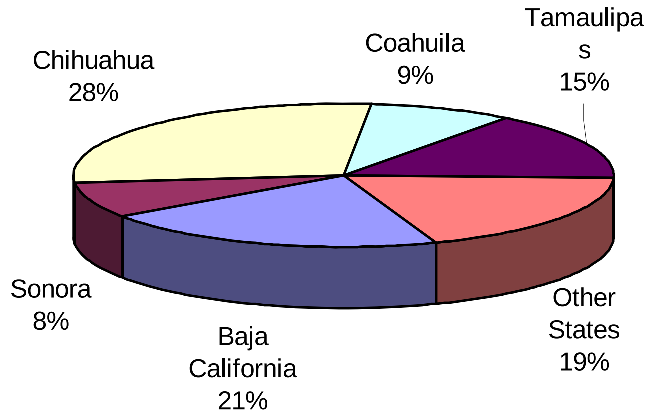


Figure 97 Maquiladora Border and Nonborder Employment

The most important concentration of maquilas is found in Chihuahua. In 1997, Chihuahua had 28.3% of the total maquila employment, this value is down from a peak of 44% in 1986 (Figure 98). Baja California follows with 21.1%.

Figure 98 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% of the total. Tijuana, San Diego's neighbor city follows with 15%. Matamoros (Brownsville) and Reynosa (Hidalgo) follow with 6% and 5%. Nuevo Laredo, Laredo's Neighbor City, only accounts for 2% of the Maquila employment.

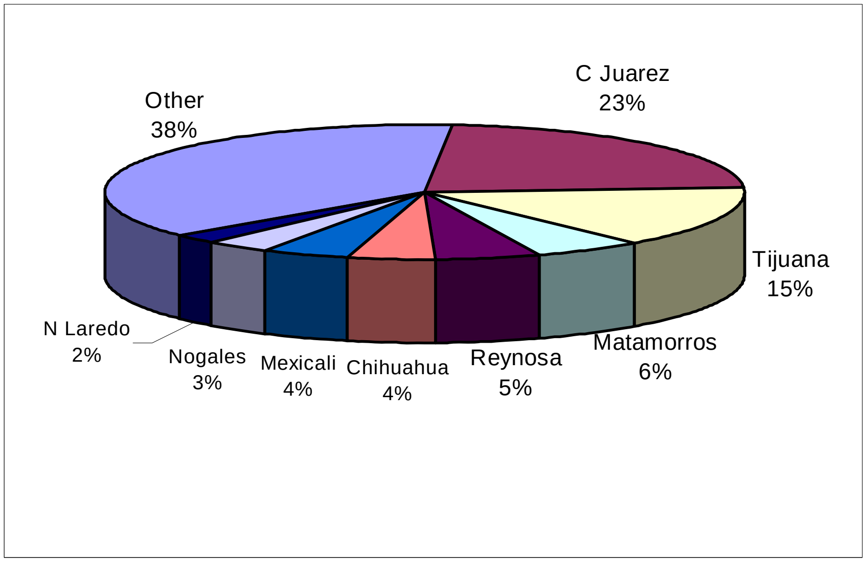


Figure 99 Maquiladora Employment by Municipio (1997)

Maquiladora Employment by Industry

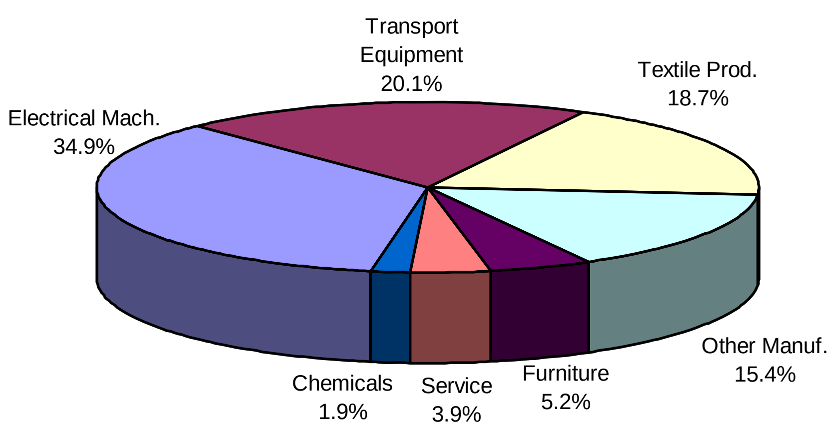


Figure 100 Maquiladora Employment by Industry (1997)

Electrical machinery is the more important group and also the commodity group that accounts for the highest trade value. Manufacturing employment is predominant. Electrical machinery, transportation equipment, and textile production have 73.7% of the total employment. Service employment only accounts for 3.9% of the maquiladora employment. (Figure 100)

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 border region rank among the last 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 industry account for half of the manufacturing employment in the border region and around 50% of the Texas employment in the sector.

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

According to projections of the Texas Comptroller of Public Accounts (Ref 45), there will be a shift in the labor force employment in the next 20 years. With the consolidation of NAFTA, employment in the Texas border region will go from manufactured nondurable goods (foodand apparel) to the production of manufactured durable goods such as televisions and automobiles. Most of the new production will be related with the production of parts for maquiladoras on the other side of the border. Actual employment in textiles or 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 the U.S.-Mexico trade will be at their smallest level. 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. Which may increase purchases in Mexico and consumption of more local supplies, decreasing the movement of raw materials and components from the U.S.

Some maquiladoras are pressuring their Asian supplier to switch to North American based alternatives (Ref 48). This will reduce the imports of non-NAFTA products that now enjoy some duty drawback provisions and that would end in 2001. If the supply change 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 interior Canada or U.S. This will certainly increase maquiladora trade between Mexico and 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 depending 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 with the U.S. system.
- Proximity to suppliers and consumers: products oriented only to the U.S. or Canadian market would tend to locate 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 decide 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 (Secretaria de Comercio y Finanzas) collects the data. La Empresa, a Mexican consulting firm that participated in the U.S.-Mexico binational study, provided this data to The University of Texas at Austin. The data presented in these points correspond to 1995. Data presented in Figure 101 to Figure 108 are based on this data set.

Commodities

Figure 101 and Figure 102 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 the highest proportion of maquiladora trade. Apparel products are also important.

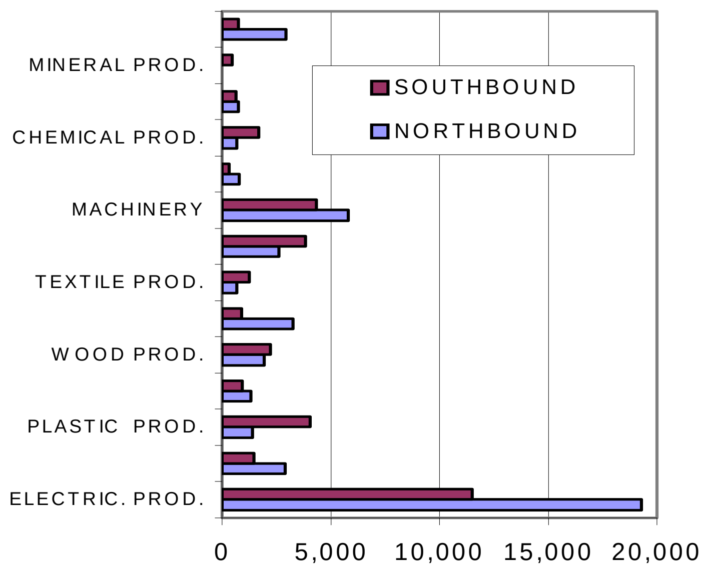


Figure 101 Trade in Millions by Commodity (Highway, 1995)

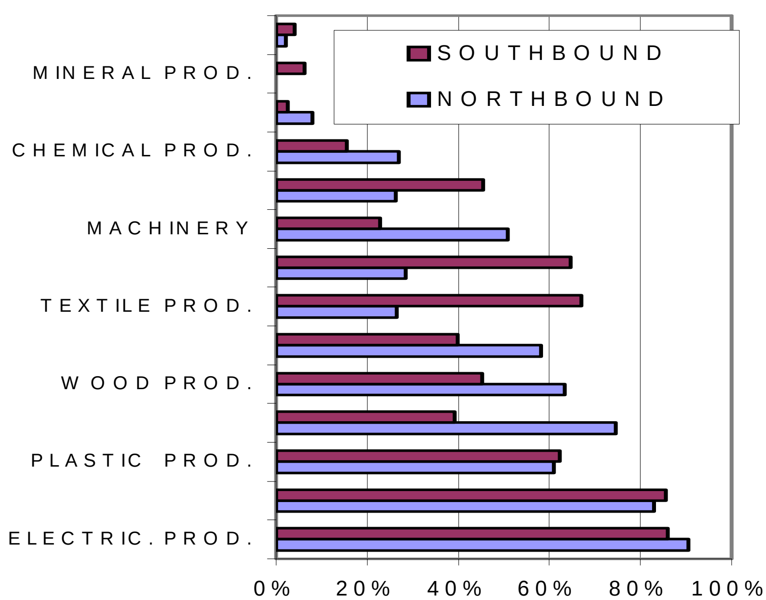


Figure 102 Maquiladora Share by Commodity (Highway, 1995)

The share 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 northbound maquiladora share. In general, commodities where assembly operations may take place show a higher northbound maquiladora share. On the other hand, commodities where assembly or manufacturing are 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 103 and Figure 104 display data relating port trade volume and percentage 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 trade is mapped. Most of the trade that goes through Laredo is nonborder state. The other ports, headed by El Paso in Texas and San Ysidro/San Diego in California, present an important maquiladora influence. This fact will translate to high trade with border states (where more than 80% of the maquiladora employment is located).

Nogales is the only port that shows an important difference in southbound and northbound maquiladora share. This is explained by the important flow of northbound agricultural products that reduce the northbound maquiladora share.

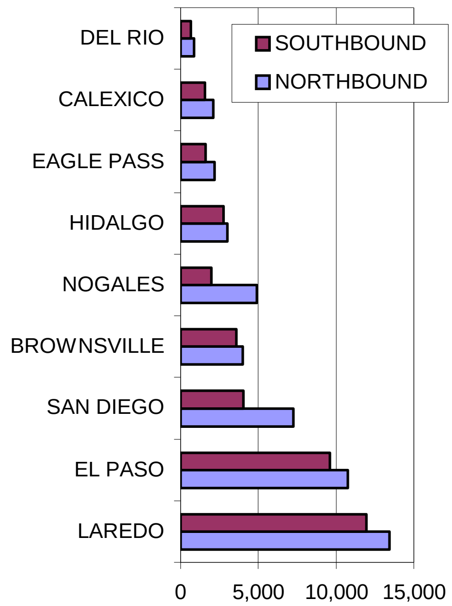


Figure 103 Trade by Port (Highway, 1995)

Figure 105 and Figure 106 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 that concentrate the biggest industrial and consumption centers in Mexico), show very low maquiladora participation. Nuevo Leon's maquiladora participation is neutralized by an important industrial concentration in n 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

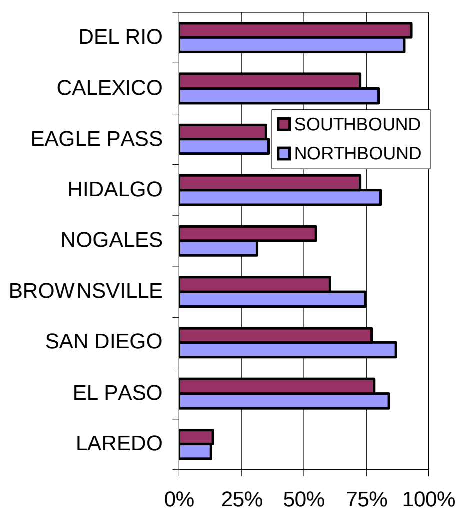


Figure 104 Maquiladora Share by Port (Highway, 1995)

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 Leon(*)		X	
Jalisco			X
Federal District			X
Mexico State			X

(*) Border States

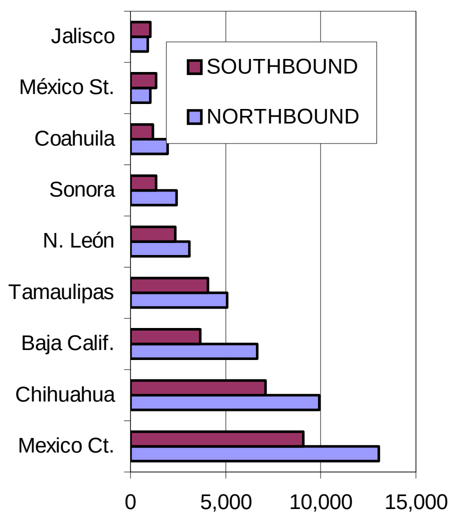


Figure 105 Trade by Mexican State (Highway, 1995)

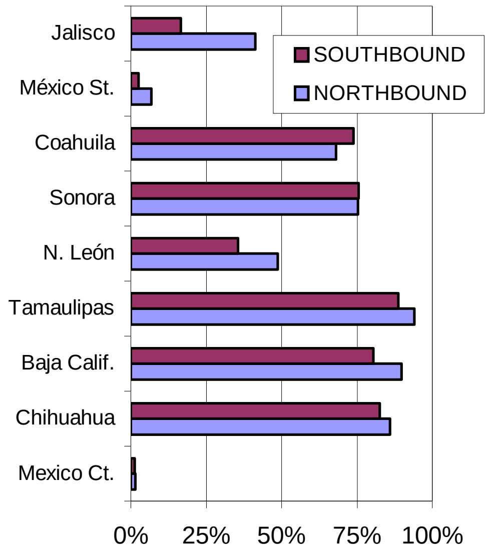


Figure 106 Maquiladora Share by Mexican State (Highway, 1995)

Maquiladora and Railroad Trade

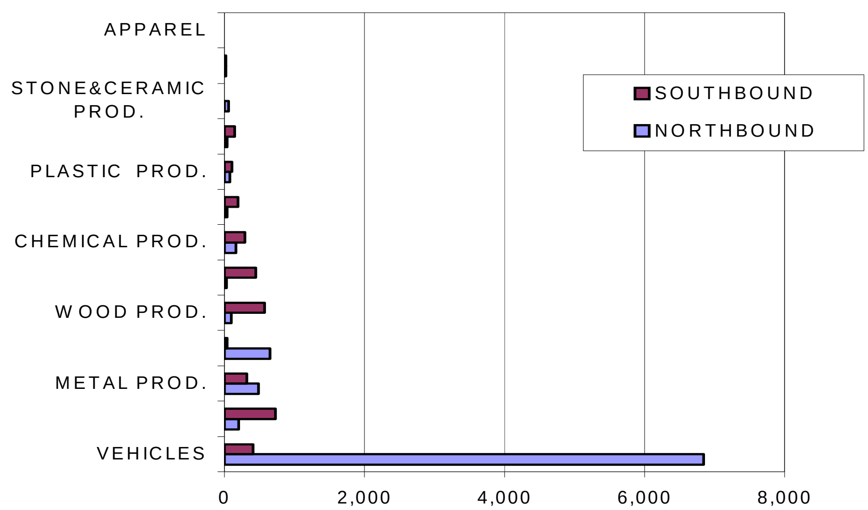


Figure 107 Commodity Trade (Railroad, 1995)

Maquiladora trade moves mostly by highway. The participation of the railroad is not important as shown in Figure 107 and Figure 108. This may change if maquiladoras begin to massively locate in the interior of Mexico and with improvements in railroad performance at both sides of the border.

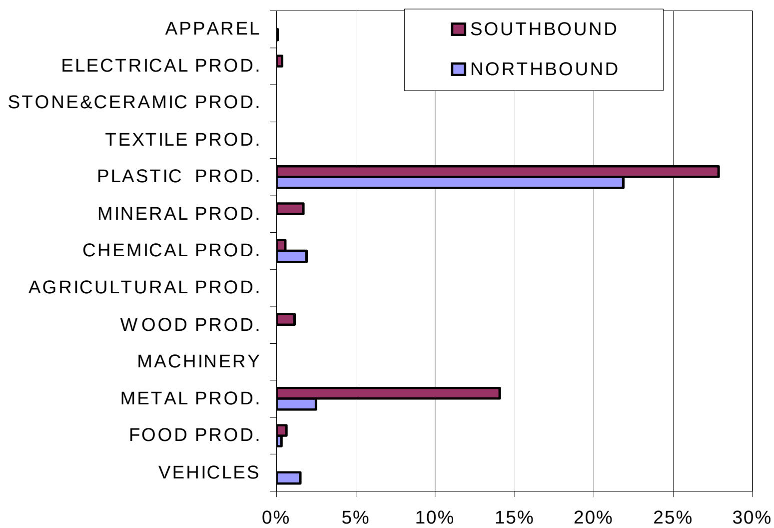


Figure 108 Commodity share (Railroad, 1995)

APPENDIX 4

COMMODITY GROUPS BY 2 DIGIT CHAPTER HTS

COMMODITY GROUP	CHAPTER	CHAPTER DESCRIPTION
Agricultural Products	01	LIVE ANIMALS
	02	MEAT AND EDIBLE MEAT OFFAL
	03	FISH AND CRU.S.TACEANS, MOLLU.S.CS 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 CITRU.S. FRUIT OR MELONS
	09	COFFEE, TEA, MATE AND SPICES
	10	CEREALS
Chemicals/Plastics	28	INORGANIC CHEMICALS; ORGANIC OR INORGANIC COMPOUNDS OF PRECIOU.S. 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

COMMODITY GROUP	CHAPTER	CHAPTER DESCRIPTION
	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
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 INDU.S.TRY; MALT; STARCHES; INULIN; WHEAT GLUTEN
Food Products	12	OIL SEEDS AND OLEAGINOU.S. FRUITS; MISCELLANEOU.S. GRAINS; SEEDS AND FRUIT; INDU.S.TRIAL 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

COMMODITY GROUP	CHAPTER	CHAPTER DESCRIPTION
	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 CRU.S.TACEANS, MOLLU.S.CS 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	MISCELLANEOU.S. EDIBLE PREPARATIONS
	22	BEVERAGES, SPIRITS AND VINEGAR
	23	RESIDUES AND WASTE FROM THE FOOD INDU.S.TRIES; 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 APPARATU.S.; PARTS AND ACCESSORIES THEREOF
	91	CLOCKS AND WATCHES AND PARTS THEREOF
	92	MU.S.ICAL 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; BITUMINOU.S. 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
Minerals and Metals	82	TOOLS, IMPLEMENTS, CUTLERY, SPOONS AND FORKS, OF BASE METAL; PARTS THEREOF OF BASE METAL
	83	MISCELLANEOU.S. ARTICLES OF BASE METAL
Miscellaneous	00	UNKNOWN
	24	TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES
	41	RAW HIDES AND SKINS (OTHER THAN FURSKINS) AND LEATHER
	42	ARTICLES OF LEATHER; SADDLERY AND HARNESS; TRAVEL GOODS, HANDBAGS AND SIMILAR CONTAINERS; ARTICLES OF ANIMAL GUT (OTHER THAN SILKWORM GUT)
	43	FURSKINS AND ARTIFICIAL FUR; MANUFACTURES THEREOF
	71	NATURAL OR CULTURED PEARLS, PRECIOU.S. OR SEMIPRECIOU.S. STONES, PRECIOU.S. METALS; METALS CLAD WITH PRECIOU.S. METAL, AND ARTICLES THEREOF; IMITATION JEWELRY; COIN
	95	TOYS, GAMES AND SPORTS EQUIPMENT; PARTS AND ACCESSORIES THEREOF

COMMODITY GROUP	CHAPTER	CHAPTER DESCRIPTION
	96	MISCELLANEOU.S. 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 ADJU.S.TMENT ACT, AS NEEDED
Textiles/Apparel	50	SILK
	51	WOOL, FINE OR COARSE ANIMAL HAIR; HORSEHAIR YARN AND WOVEN FABRIC
	52	COTTON
	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 INDU.S.TRIAL U.S.E
	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

COMMODITY GROUP	CHAPTER	CHAPTER DESCRIPTION
	63	OTHER MADE-UP TEXTILE ARTICLES; NEEDLE CRAFT 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 FIBROU.S. CELLULOSIC MATERIAL; WASTE AND SCRAP OF PAPER OR PAPERBOARD

	48	PAPER AND PAPERBOARD; ARTICLES OF PAPER PULP, OF PAPER OR OF PAPERBOARD
	49	PRINTED BOOKS, NEWSPAPERS, PICTURES AND OTHER PRODUCTS OF THE PRINTING INDU.S.TRY; MANU.S.CRIPTS, TYPESCRIPTS AND PLANS
	94	FURNITURE; BEDDING, MATTRESS SUPPORTS, CU.S.HIONS 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 plastics 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 and other 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 homefurnishings 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, 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 FIGUERES

Table 65 Station 504 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 66 Station 507 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	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 67 Station 509 Vehicle Classification and Weight

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

Table 68 Station 510 Vehicle Classification and Weight

Veh. Type	Count	Max. Weight	Min Weight	Ave. Weight	St. Dev. Wt.	Weight %
190200	152	250	168	207	23	0.1%
190300	769	657	124	356	62	0.9%
220000	10,984	438	46	118	61	4.3%
230000	1,969	701	63	258	105	1.7%
240000	4	568	280	420	122	0.0%
321000	30	533	109	239	89	0.0%
322000	2,270	715	88	231	109	1.7%
323000	158	468	132	231	59	0.1%
331000	121	718	123	369	131	0.1%
332000	42,443	1,431	106	598	178	83.2%
333000	261	1,109	282	614	180	0.5%
421000	591	571	80	255	106	0.5%
422000	199	201	106	172	19	0.1%
423000	22	801	268	608	152	0.0%
431000	108	754	109	462	153	0.2%
432000	1	173	173	173		0.0%
521200	2,103	993	205	638	129	4.4%
522100	61	811	377	662	96	0.1%
531200	350	1,006	213	598	132	0.7%
532100	33	848	329	632	136	0.1%
532400	9	1,815	996	1,496	228	0.0%
533300	2	1,365	1,219	1,292	103	0.0%
542300	5	1,546	767	1,221	314	0.0%
543200	2	1,008	908	958	71	0.0%
632100	521	945	208	653	129	1.1%
721230	1	608	608	608		0.0%
731220	1	679	679	679		0.0%
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	227	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	532	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	532100	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 %
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 72 Station 516 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	1	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 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	1	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
		SOUTH	19%	52%	20%	9%	54
		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 332000

Station	Highway	Direction	EMPTIES	CUBE OUT	WEIGH OUT	OVERLOADED	COUNT
LW504	IH 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	10.0%	57.2%	29.4%	2.9%	6499
LW507	IH 45	2	9.3%	63.8%	23.9%	2.7%	8053
LW507		5	8.4%	59.9%	24.1%	7.4%	8289
LW509	IH 30	6	11.0%	62.5%	18.2%	8.0%	8766
LW510	IH 10	3	13.2%	68.4%	17.6%	0.5%	6237
LW510		4	12.6%	67.7%	18.9%	0.5%	7453
LW510		9	9.1%	60.4%	26.8%	3.5%	7609
LW510		12	7.8%	61.3%	26.8%	3.7%	8746
LW512	IH 37	4	20.3%	45.0%	31.3%	3.2%	4374
LW512		9	24.5%	54.0%	19.8%	1.2%	2433
LW512		12	20.1%	52.4%	24.9%	2.1%	4042
LW513		2	7.7%	66.5%	22.9%	2.6%	9028
LW513	IH 35	6	14.8%	66.6%	17.7%	0.5%	9358
LW513		7	14.4%	68.2%	15.9%	1.2%	8193
LW513		12	13.0%	71.0%	15.2%	0.5%	9754
LW515	US 281	2	16.5%	62.0%	17.8%	3.3%	2980
LW515		5	24.3%	49.6%	23.8%	1.9%	3013
LW515		7	21.8%	63.2%	13.5%	1.4%	1941
LW516	IH 35	5	13.4%	61.2%	13.9%	11.3%	4553
LW516		10	12.3%	62.8%	16.0%	8.4%	8477
LW517	US 83	2	22.3%	56.6%	16.2%	4.8%	3128
LW517		5	26.0%	50.5%	16.4%	6.9%	3174
LW517		7	25.7%	54.4%	13.3%	6.5%	2319
LW517		12	30.3%	49.5%	15.8%	4.4%	3371

TRUCK TYPE 333000

Station	Highway	Month	EMPTIES	CUBE OUT	WEIGH OUT	OVERLOADED	COUNT
LW504	IH 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 (Station 504 And 507)

TRUCK TYPE 332000

STATION	HIGHWAY	COUNTY	HOUR	EMPTIES	CUBE OUT	WEIGHT 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%	28.2%	149
			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 (Station 509 And 510)

TRUCK TYPE 332000

STATION	HIGHWAY	COUNTY	HOUR	EMPTIES	CUBE OUT	WEIGHT 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%	53.3%	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%	1159
			8	22.6%	56.7%	20.6%	1391
			9	23.2%	55.6%	21.0%	1727
			10	23.0%	54.8%	22.0%	1823
			11	20.6%	55.0%	24.2%	1853
			12	21.0%	55.5%	23.3%	1745
			13	20.5%	53.4%	25.9%	1728
			14	17.6%	55.4%	26.4%	1844
			15	20.3%	54.0%	25.5%	1712
			16	20.1%	54.0%	25.3%	1562
			17	17.2%	55.1%	27.3%	1467
			18	12.9%	59.9%	26.6%	1415
			19	12.9%	60.0%	26.8%	1294
			20	12.0%	59.7%	28.1%	1189
			21	11.2%	61.5%	27.0%	1187
			22	11.1%	59.0%	29.5%	1012
			23	12.1%	55.6%	31.9%	953

Table 78 **Hour Effect on Truck Weight and Volume (Station 512 And 513)**

TRUCK TYPE 332000

STATION	HIGHWAY	COUNTY	HOUR	EMPTIES	CUBE OUT	WEIGHT 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%	1247
			1	14.7%	69.2%	15.5%	1248
			2	13.1%	68.8%	17.6%	1226
			3	12.7%	68.1%	18.8%	1390
			4	15.6%	67.6%	16.5%	1313
			5	16.7%	66.9%	16.1%	1404
			6	21.3%	61.1%	17.4%	1336
			7	18.3%	62.3%	19.2%	1326
			8	26.3%	56.1%	17.3%	1318
			9	28.0%	52.5%	19.0%	1617
			10	34.2%	47.0%	18.8%	1695
			11	32.5%	47.9%	19.3%	1755
			12	35.2%	45.3%	19.4%	1737
			13	33.0%	46.4%	20.5%	1756
			14	29.3%	48.4%	22.0%	1726
			15	29.8%	48.5%	21.5%	1644
			16	26.5%	52.6%	20.9%	1606
			17	27.4%	51.7%	20.7%	1646
			18	23.0%	56.4%	20.4%	1655
			19	20.9%	57.2%	21.7%	1628
			20	19.9%	59.9%	19.9%	1654
			21	17.0%	65.6%	16.8%	1572
			22	18.5%	63.7%	17.2%	1451
			23	16.7%	63.6%	19.3%	1383

Table 79 Hour Effect on Truck Weight and Volume (Station 515 and 516)

TRUCK TYPE 332000

STATION	HIGHWAY	COUNTY	HOUR	EMPTIES	CUBE OUT	WEIGHT OUT	ALL
LW515	US281	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	WEIGHT OUT	ALL
LW517	US83	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%	848
			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

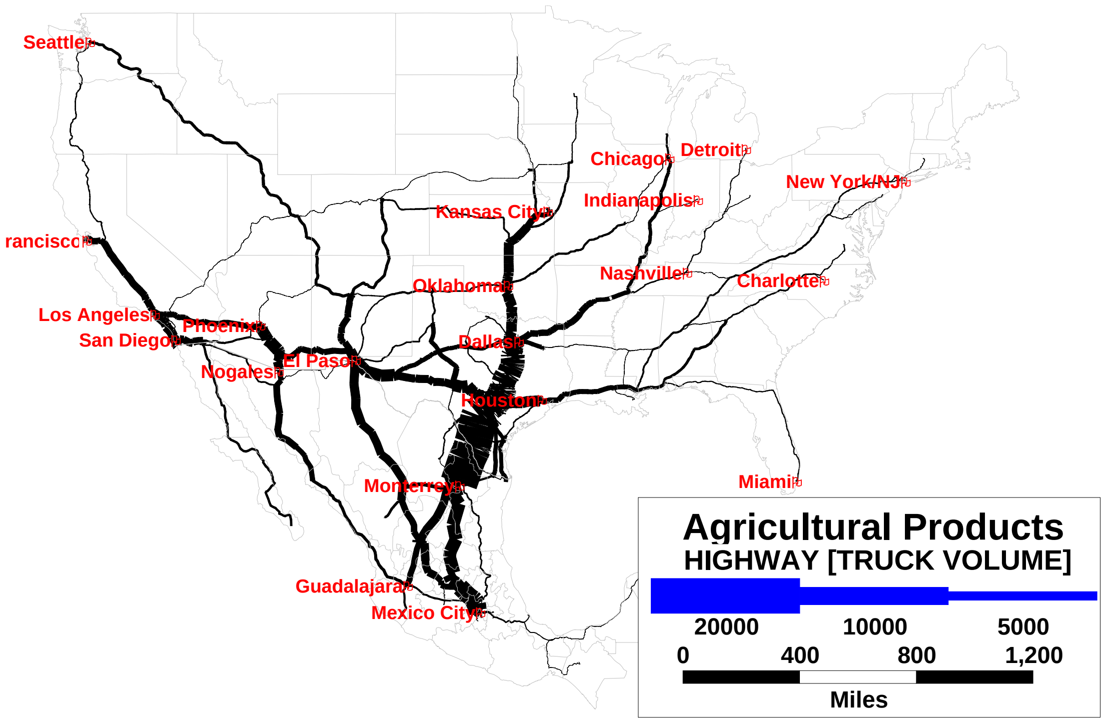


Figure 109 Agricultural Products (Southbound)

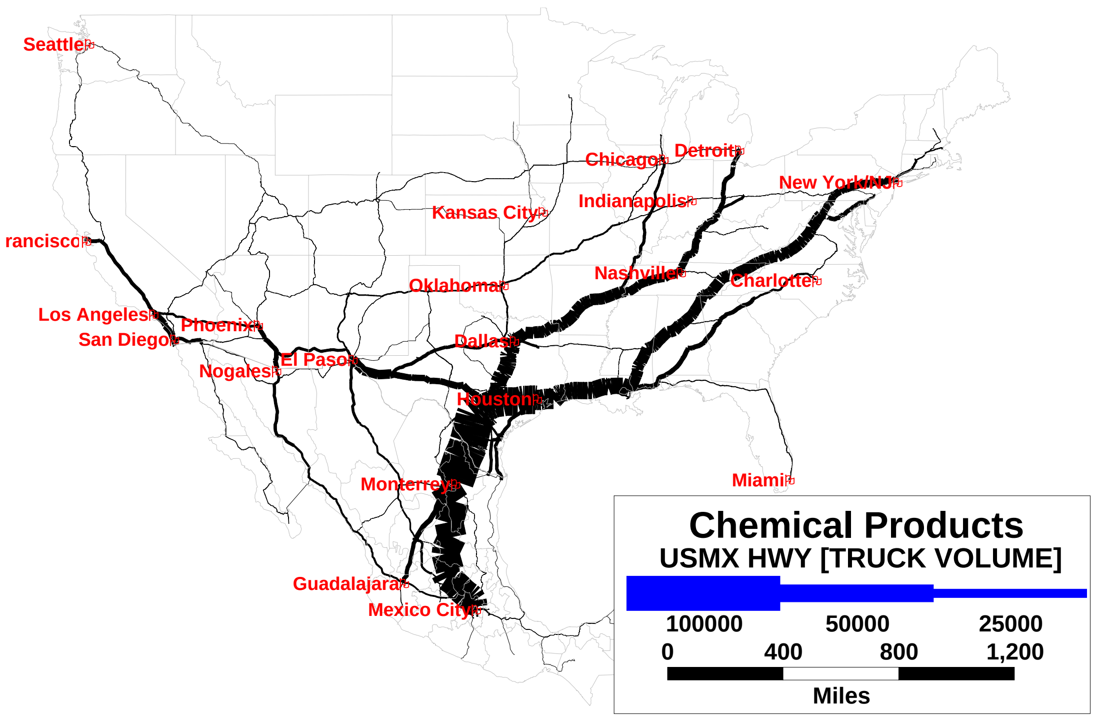


Figure 110 Chemical Products (Southbound)

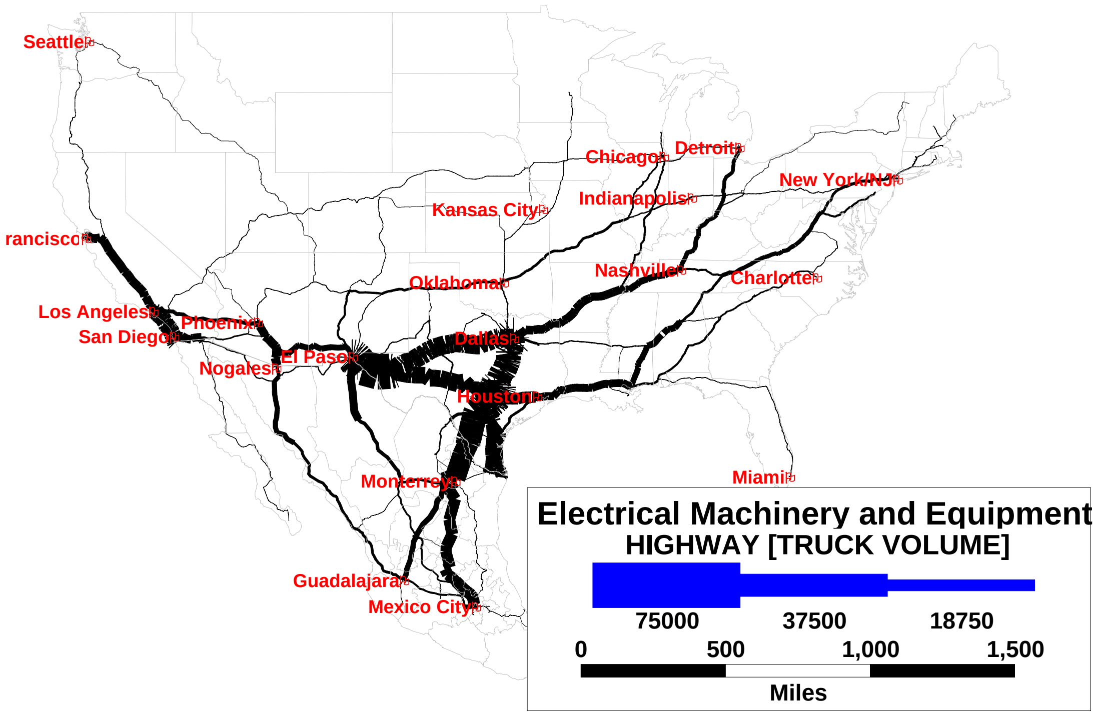


Figure 111 Electrical Products (Southbound)

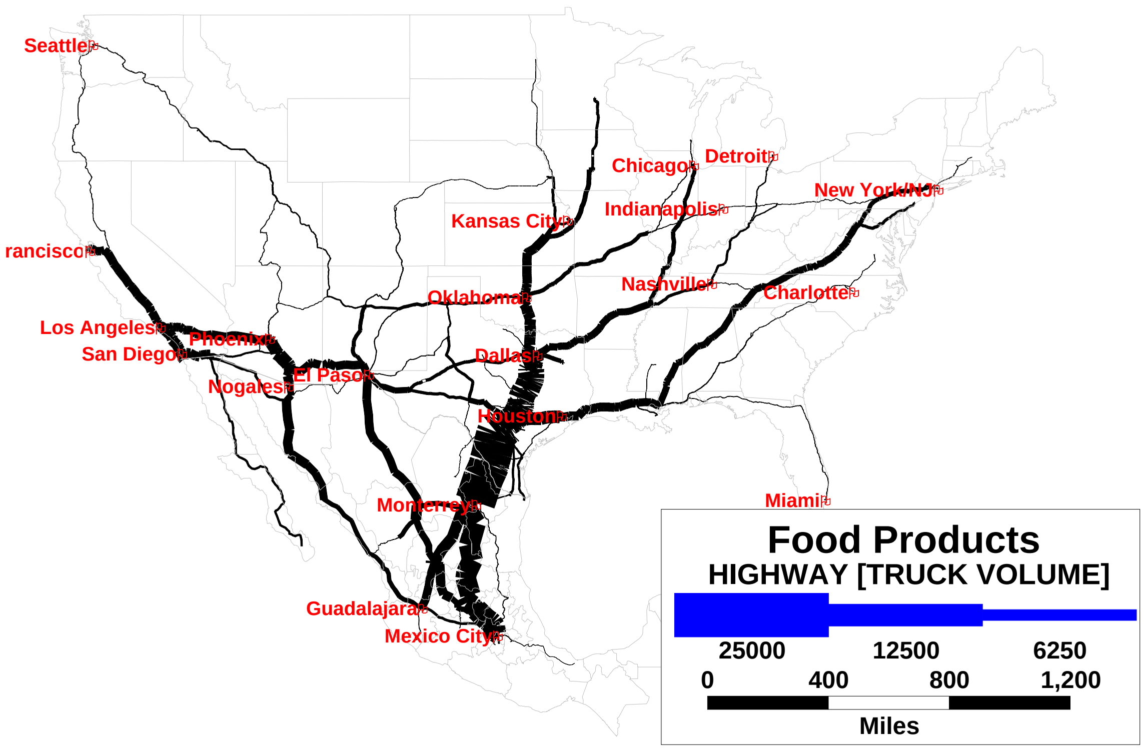


Figure 112 Food Products (Southbound)

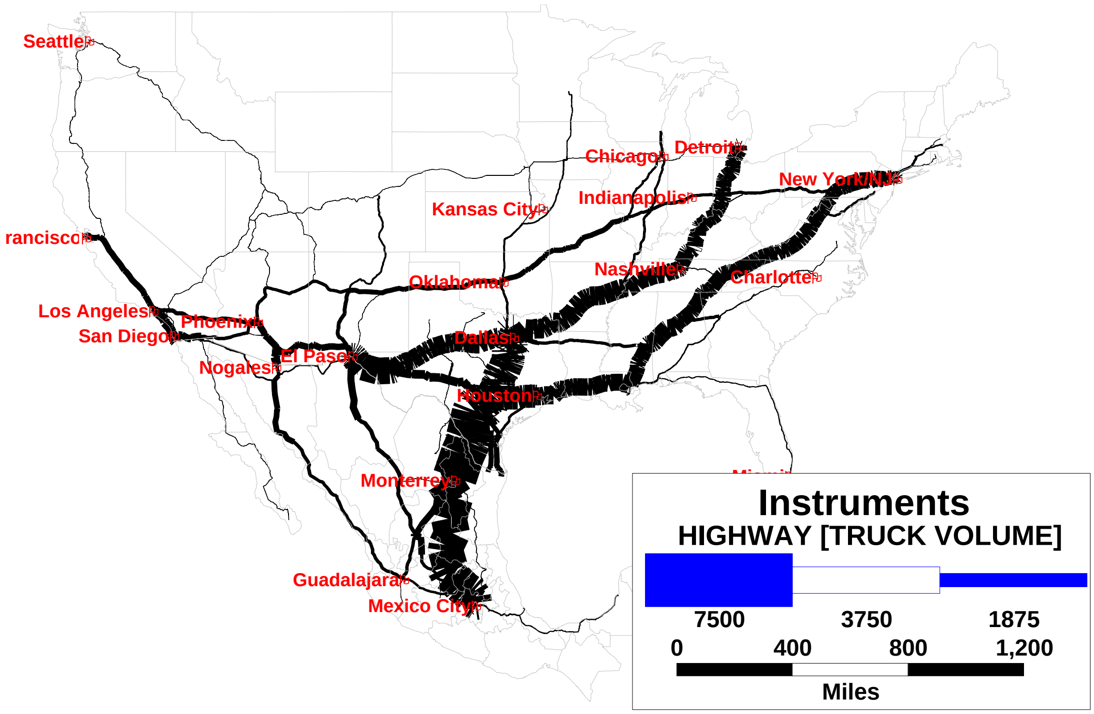


Figure 113 Instruments (Southbound)

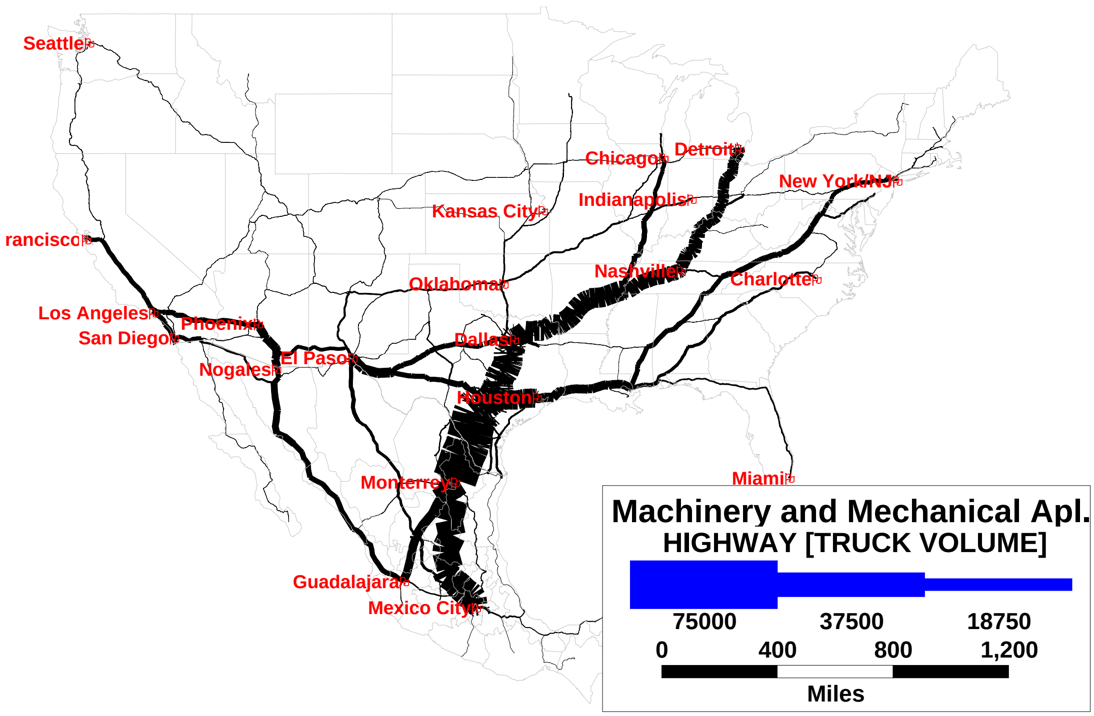


Figure 114 Machinery and Mechanical Appliances (Southbound)

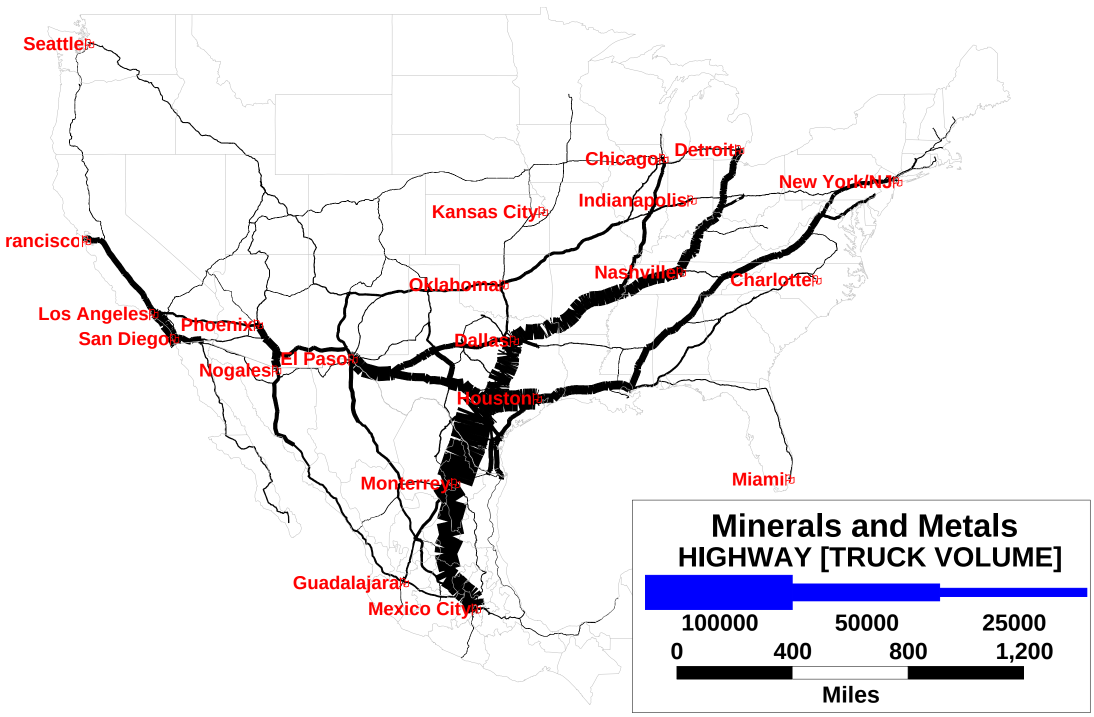


Figure 115 Minerals and Metals (Southbound)

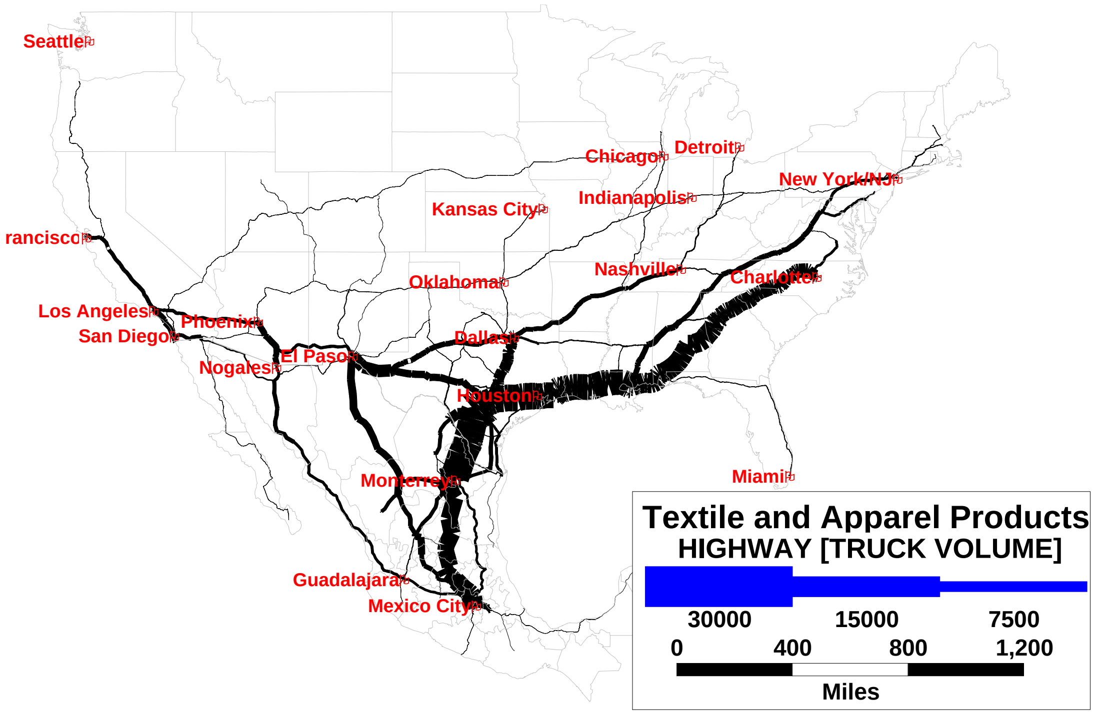


Figure 116 Textile and Apparel Products (Southbound)

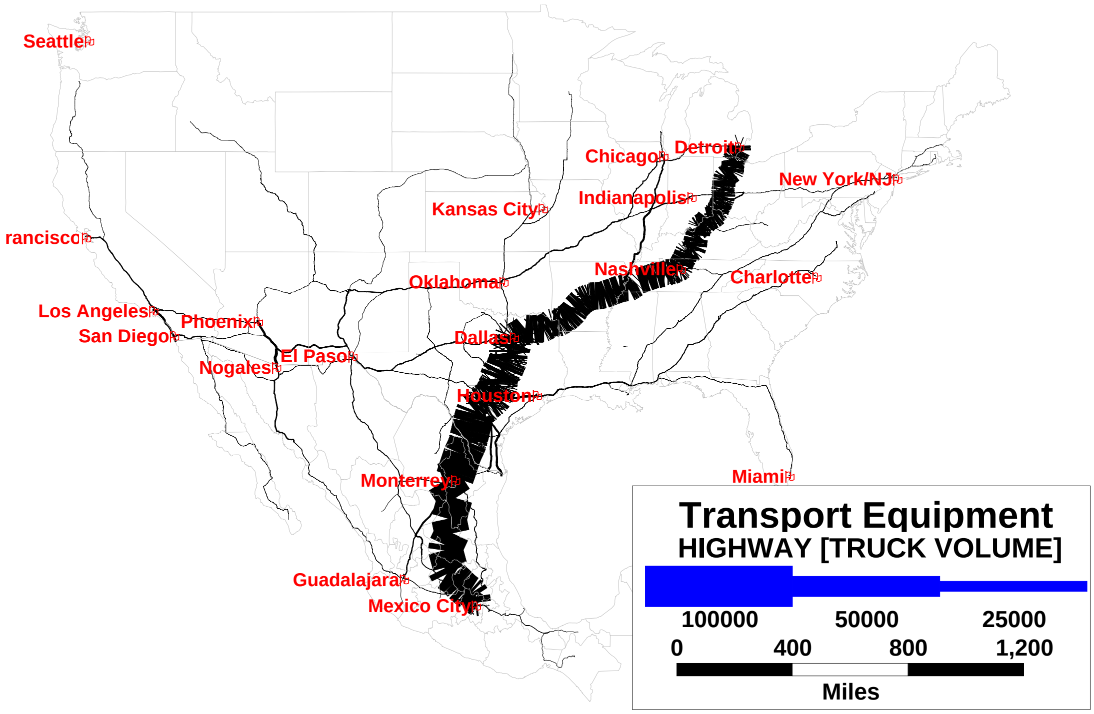


Figure 117. Transport Equipment (Southbound)

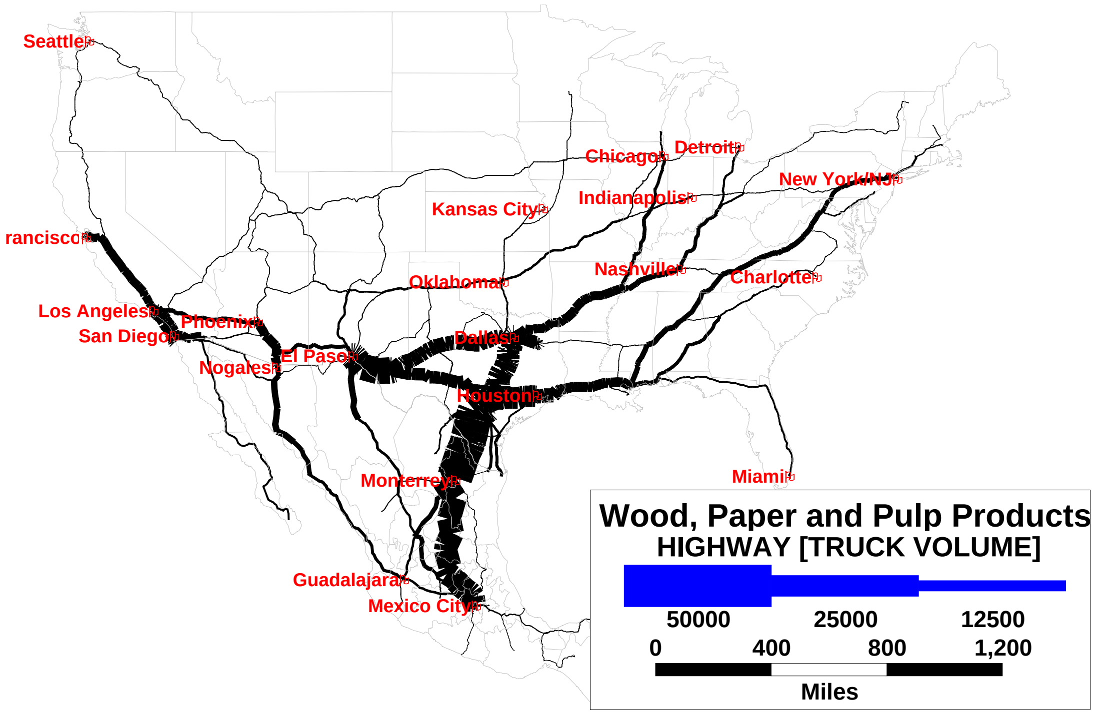


Figure 118 Wood, Paper and Pulp Products (Southbound)

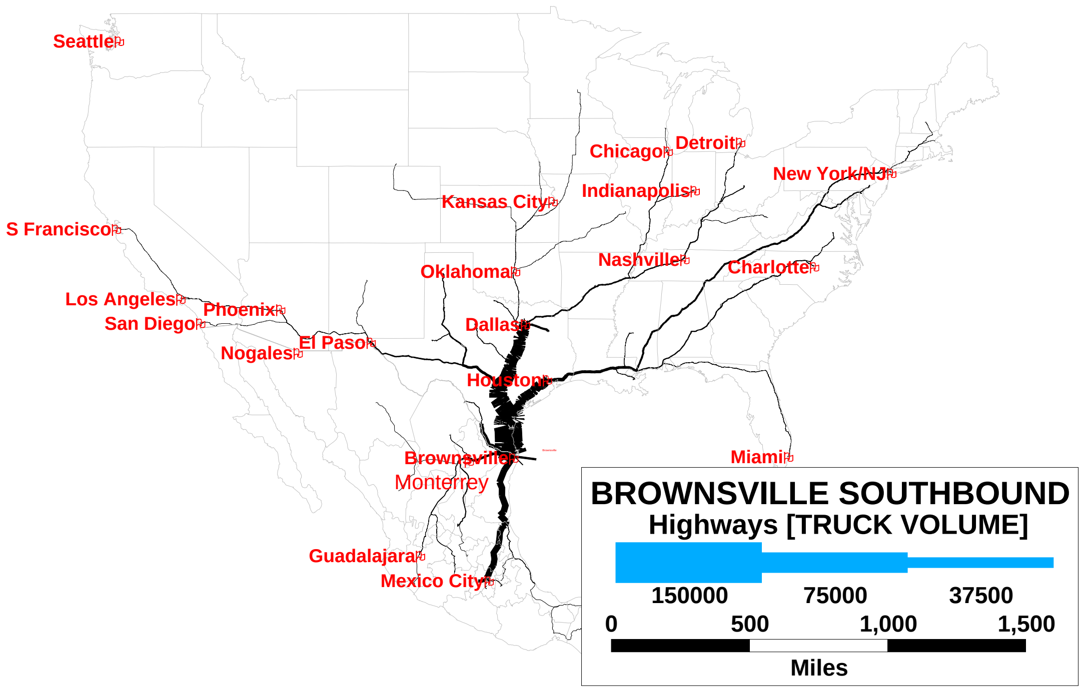


Figure 119Brownsville (Southbound)

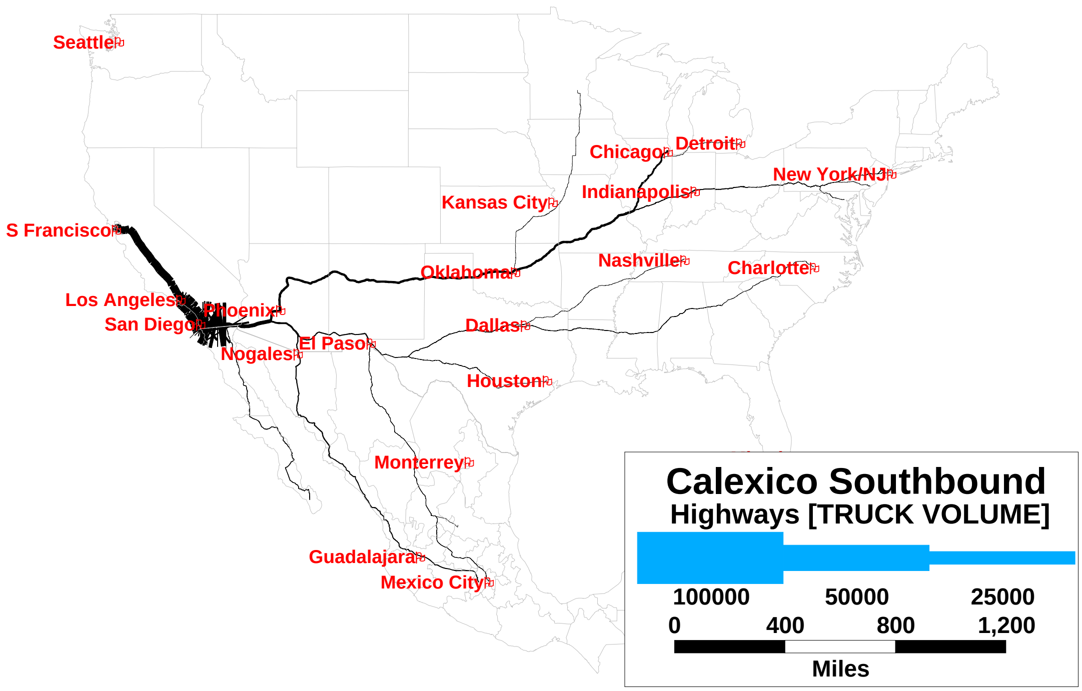


Figure 120 Calexico (Southbound)

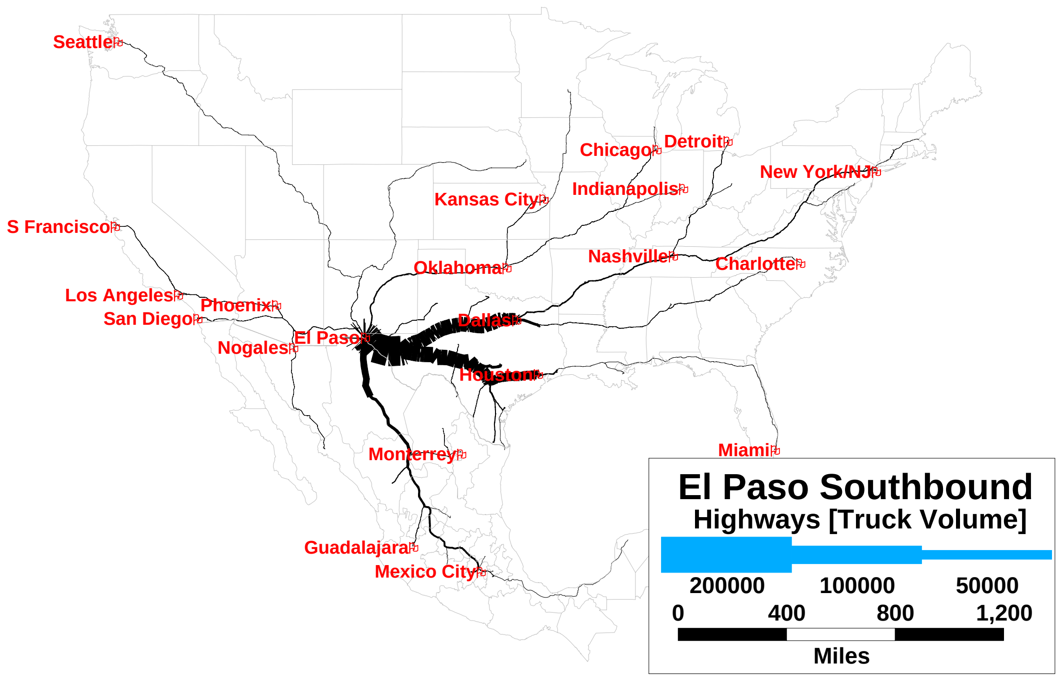


Figure 121 El Paso (Southbound)

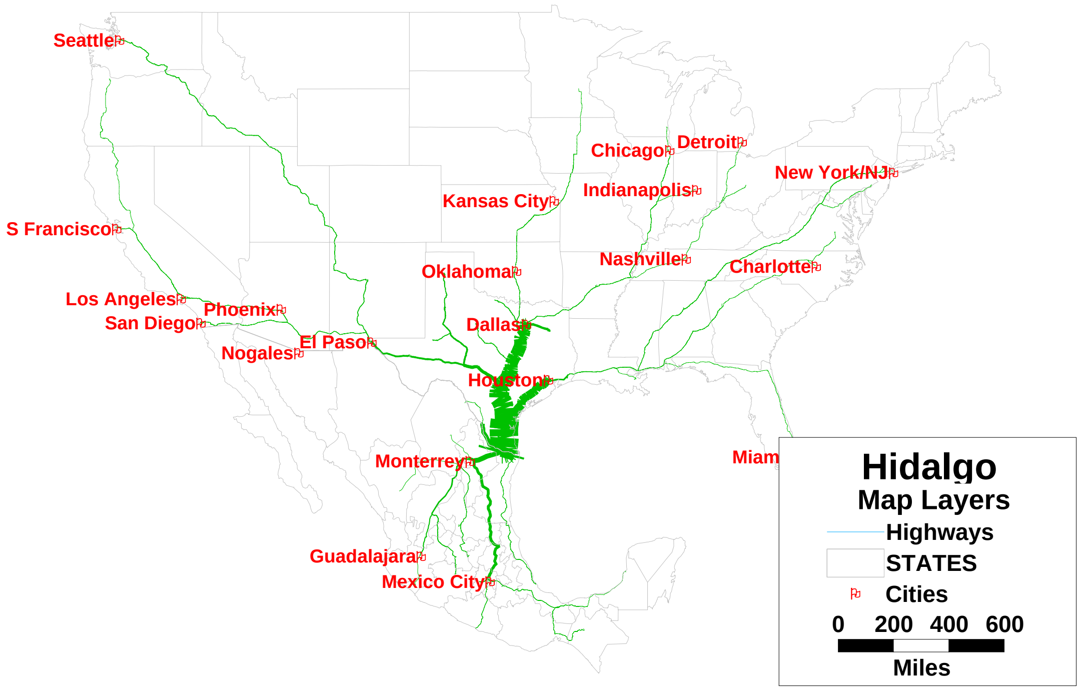


Figure 122 Hidalgo (Southbound)

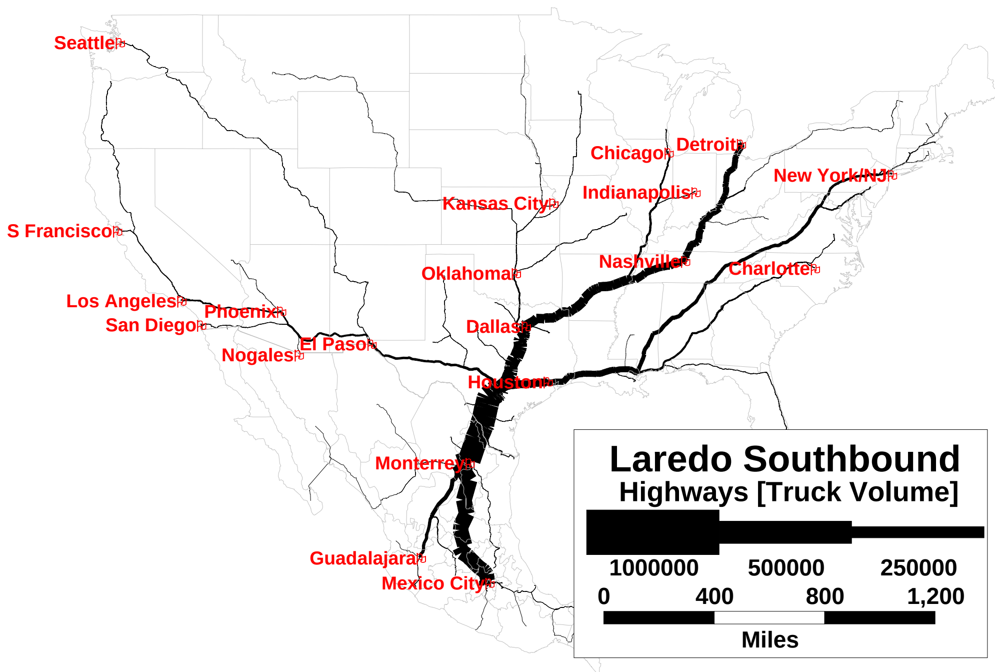


Figure 123 Laredo (Southbound)

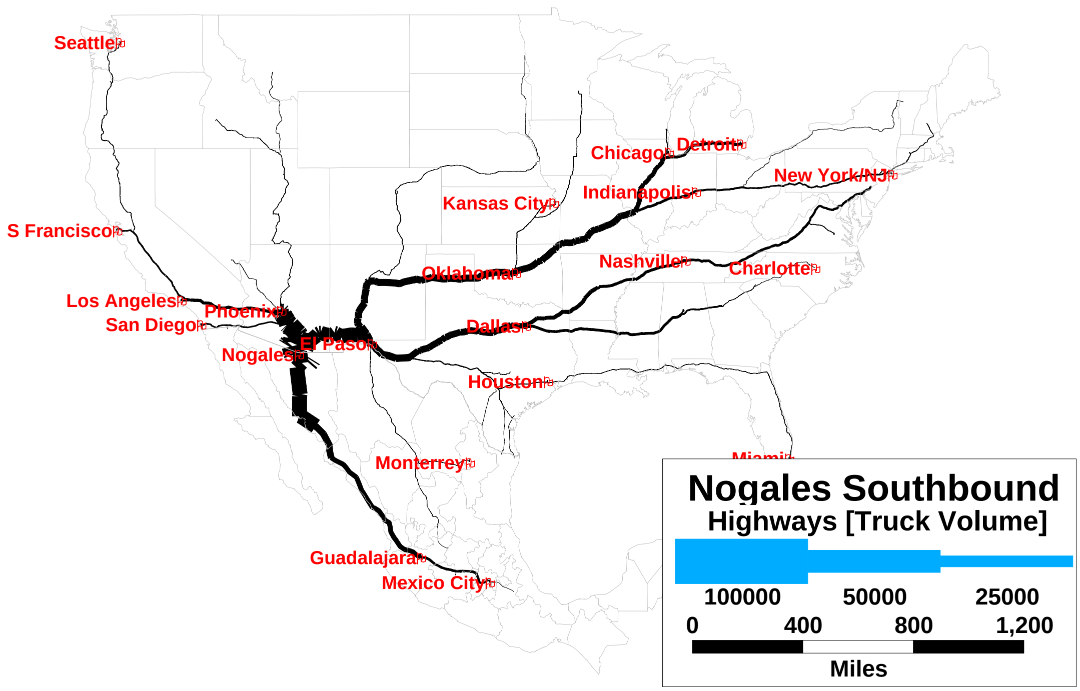


Figure 124 Nogales (Southbound)

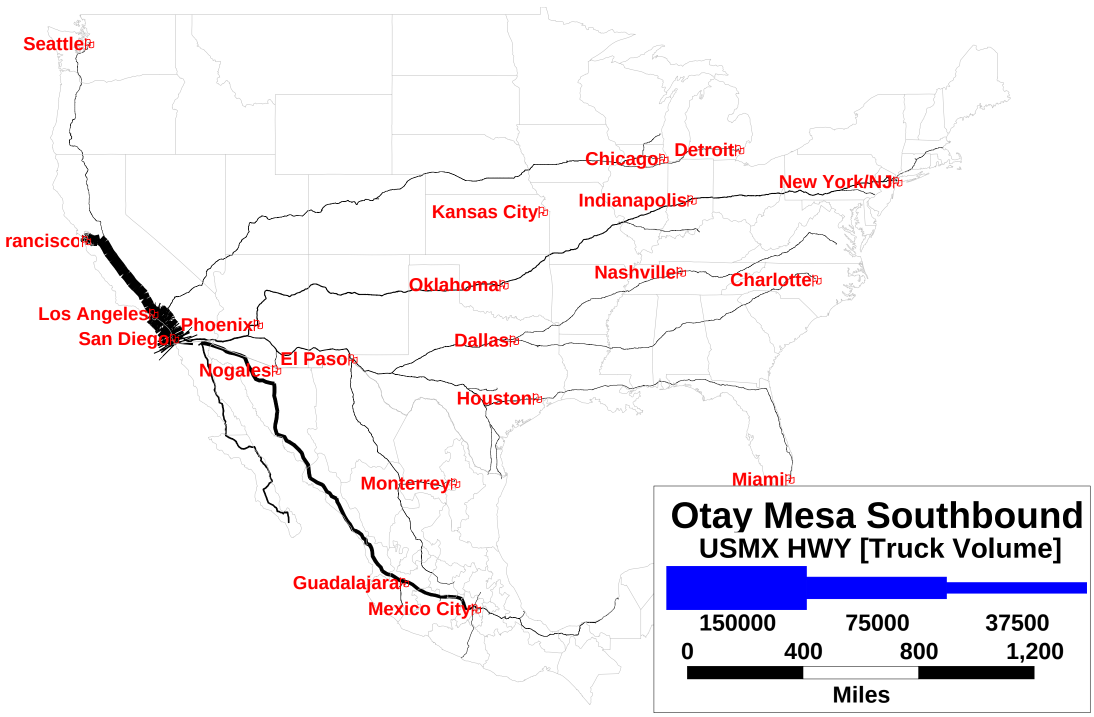


Figure 125 Otay Mesa-San Ysidro (Southbound)

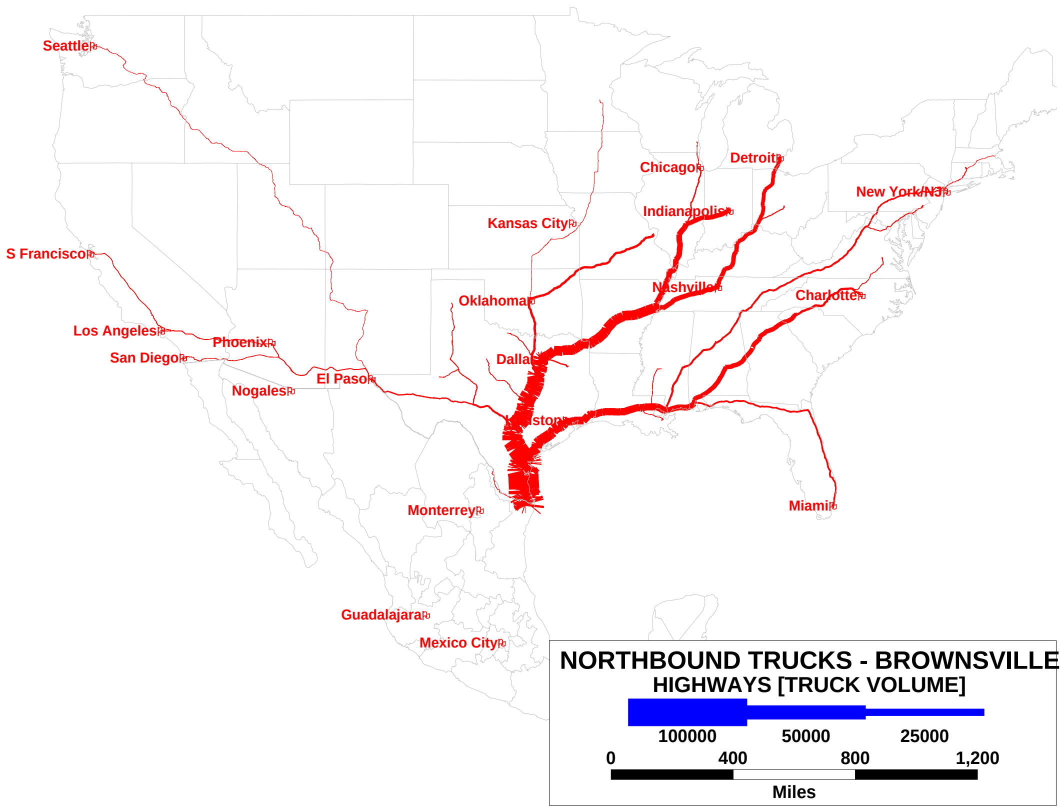


Figure 126 Brownsville (Northbound)

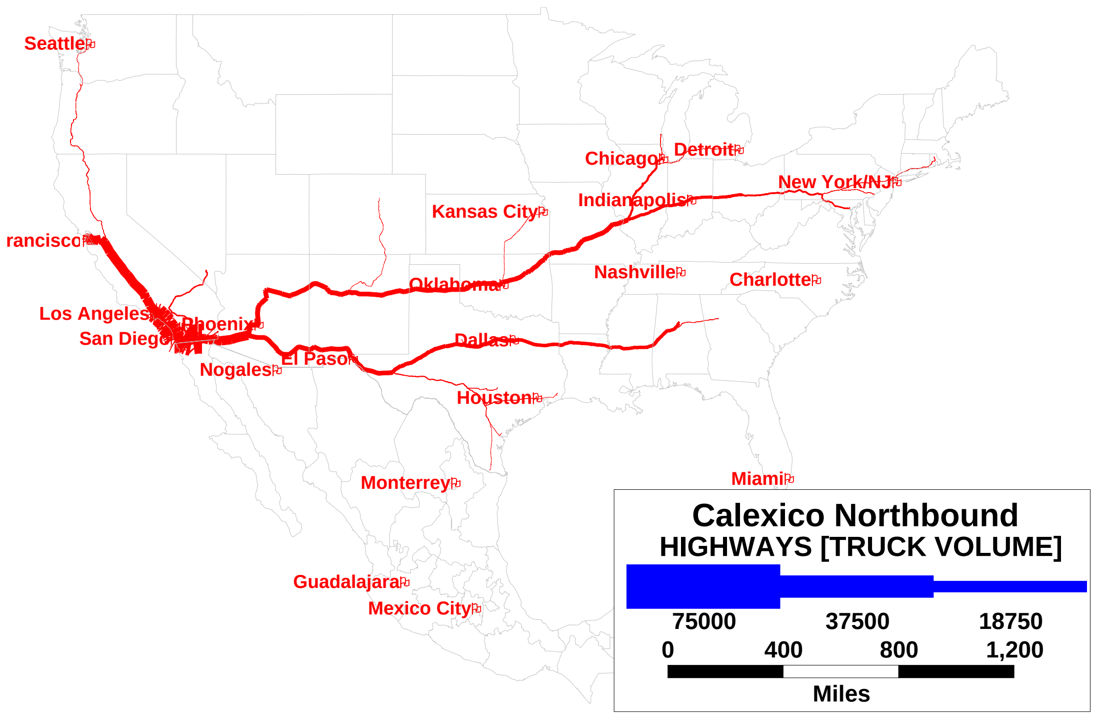


Figure 127 Calexico (Northbound)

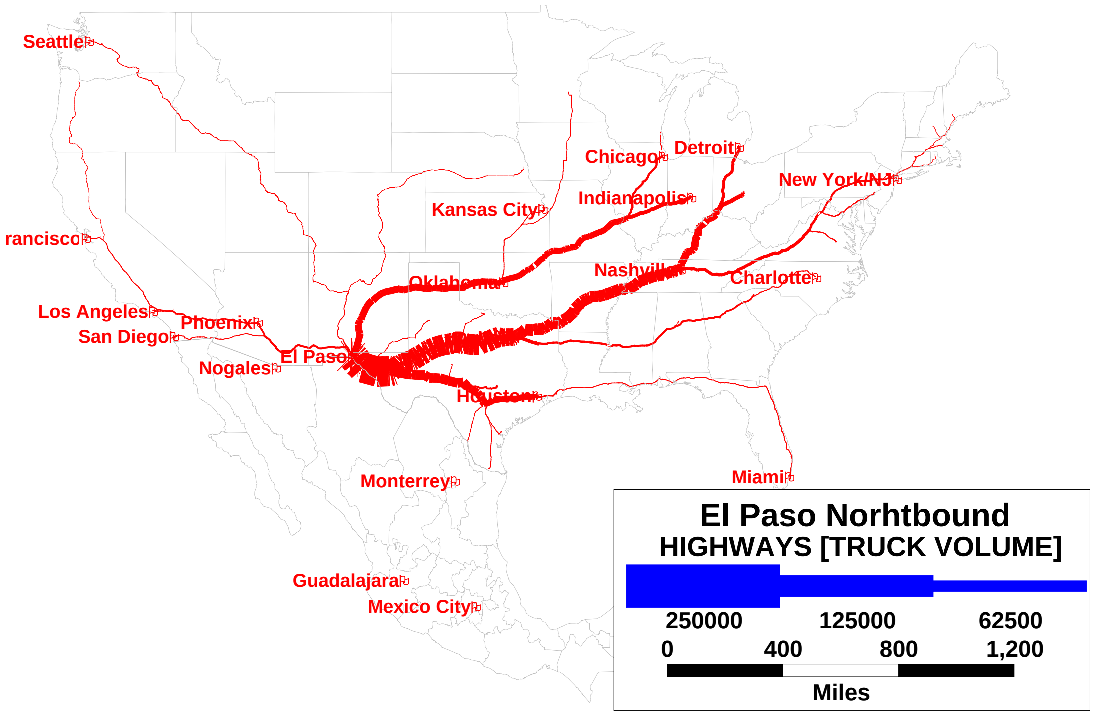


Figure 128 El Paso (Northbound)

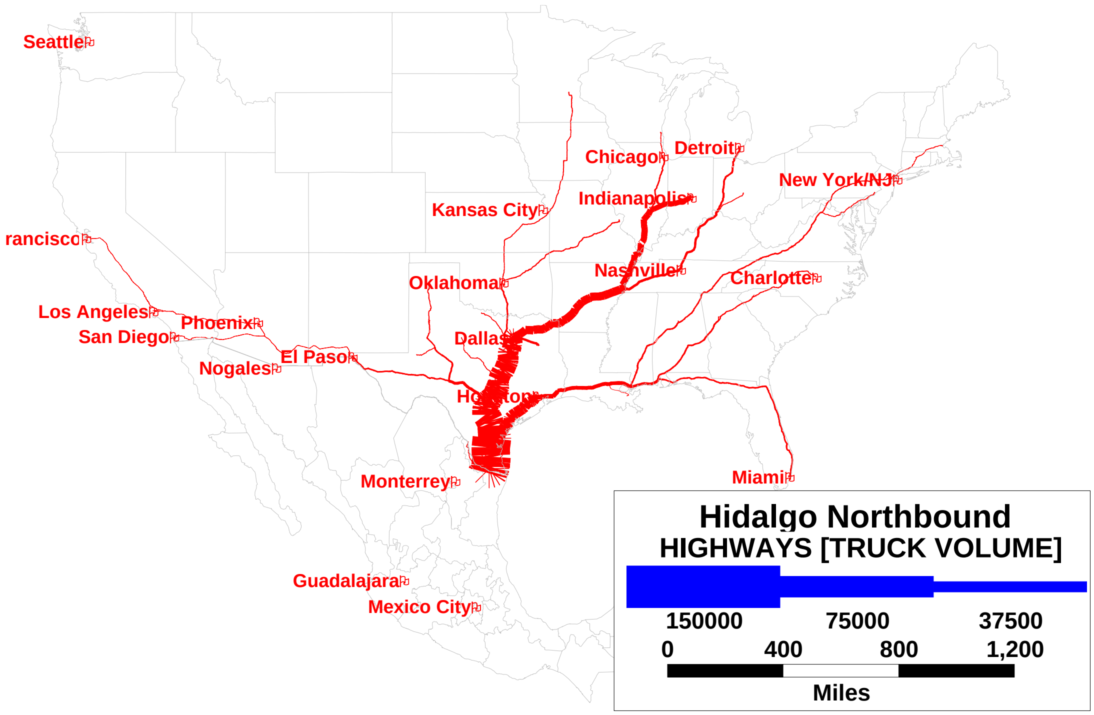


Figure 129 Hidalgo (Northbound)

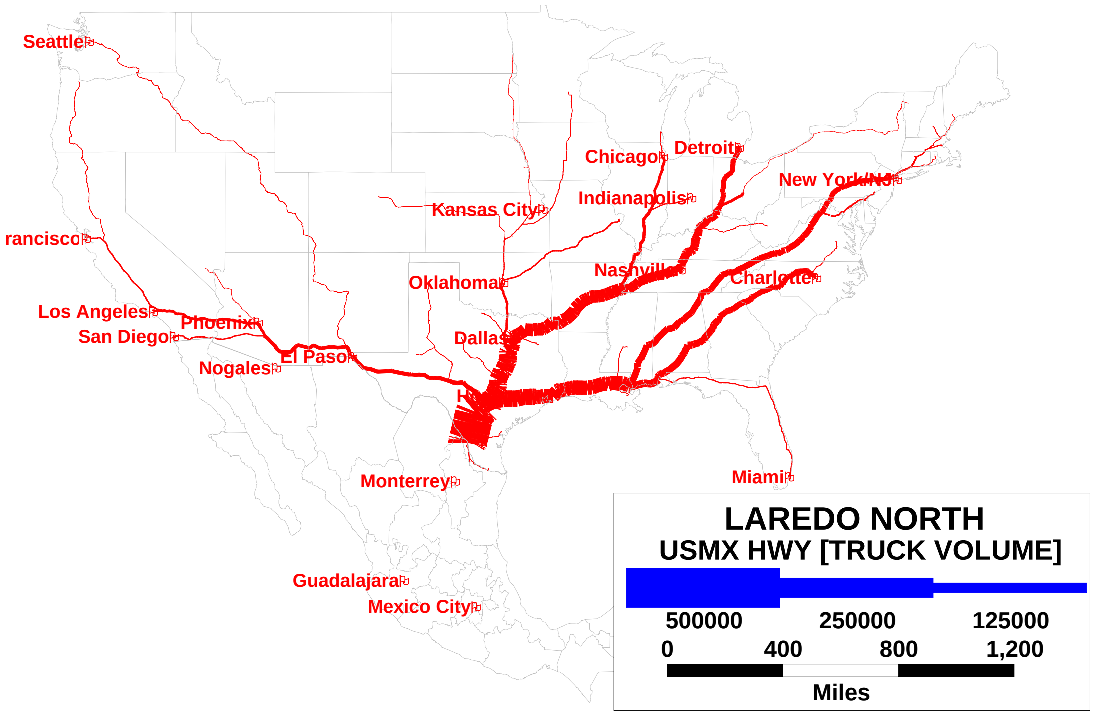


Figure 130 Laredo (Northbound)

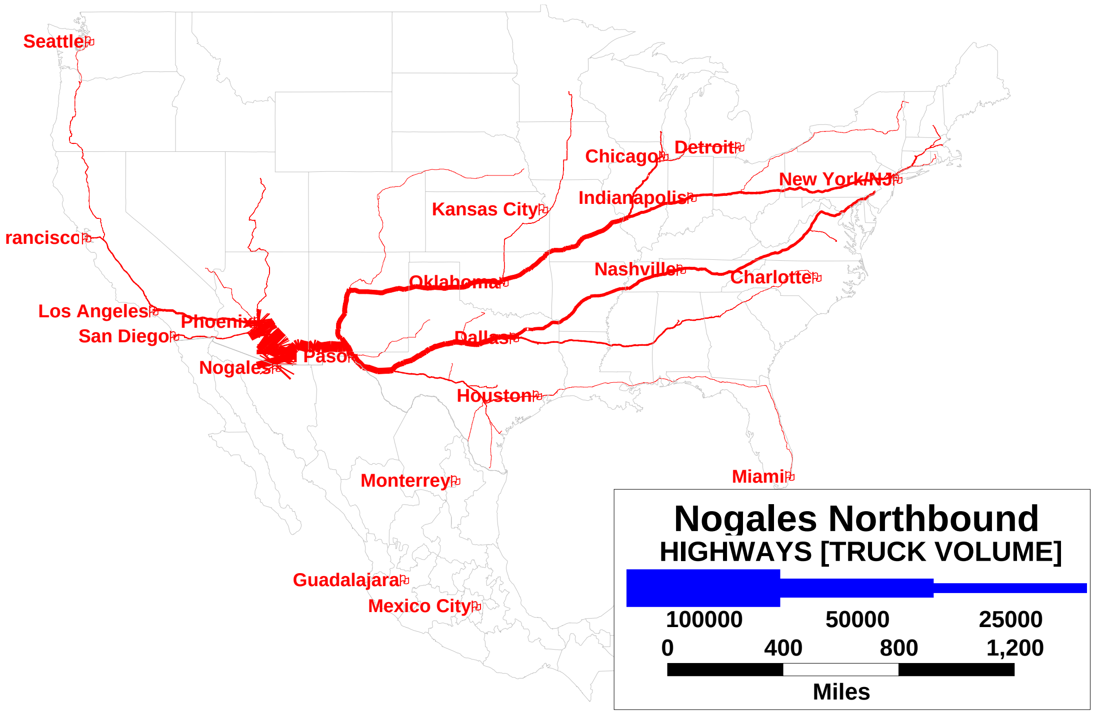


Figure 131 Nogales (Northbound)

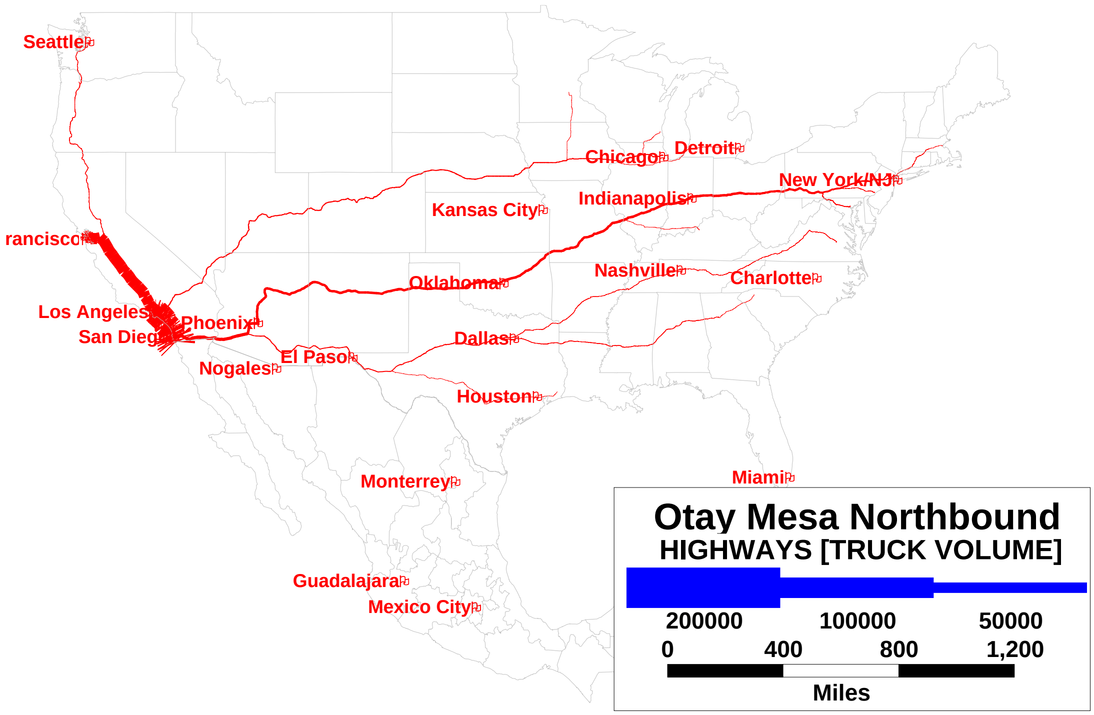


Figure 132 Otay Mesa-San Ysidro (Northbound)

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This thesis was typed by the author