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16. Abstract

The study examines the effect that increased trade with Mexico, as a result of the passage of NAFTA, will have on the Texas highway network. A dominant portion of overland trade between the U.S. and Mexico travels through Texas. Exports to and imports from Mexico are expected to increase significantly over the next two decades. The study finds a strong positive relationship between dollar-valued trade flows and border truck crossings. Thus, increased trade will translate into a need for an improvement of highway infrastructure in Texas, particularly in the border areas. Through the adoption of NAFTA, and due to existing cost advantages, Mexican manufacturing will offer improved productivity at a lower cost, which will result in a significant increase in northbound trade, and hence truck traffic, which will pass through the Texas highway network.

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THE IMPACT OF A U.S.-MEXICO FREE TRADE AGREEMENT ON THE TEXAS HIGHWAY NETWORK

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IMPLEMENTATION STATEMENT

This report is part of a small but growing body of knowledge resulting from the heightened interest in the expansion of trade and transportation in the border area of Texas and Mexico. The information herein adds to the understanding of the complex dynamics of increasing international trade and the transportation system needed to support it. For transportation agencies charged with providing the infrastructure and facilities at the border crossings, the findings help define some empirical relationships between expected growth in trade and the demands upon the border crossings. Facility usage and impacts on the network infrastructure are less obvious as the distance from the border increases. Transportation agencies must evaluate carefully the role of a particular facility or corridor in making transportation investment decisions designed to support expanded international trade. The information provided in this report is part of the body of knowledge that is needed to improve decision-making and budgetary allocations for expenditures (capital, rehabilitation, and maintenance) on the state highway system in support of the expected future trade with Mexico.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Texas Department of Transportation or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation.

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SUMMARY

There is a positive relationship between U.S. exports to Mexico and that country's GDP, i.e., U.S. exports increase when Mexican GDP rises. A similar relationship exists between U.S. imports from Mexico and U.S. GDP. However, the U.S. benefits relatively more than Mexico from an increase in the other country's GDP. Texas-based exports to Mexico rise by $248 million for every one percent increase in Mexican GDP. In determining a relationship between dollar-valued trade flows and truck traffic on the Texas highway system, we found that population growth and increasing levels of urbanization did have a positive effect on levels of truck traffic throughout the state. We could not, however, find a discernible relationship between U.S.-Mexico trade flows and truck traffic in any year and on any highway segment in Texas. This is not surprising considering that Texas-based trade with Mexico, in relation to the size of the U.S. and Texas economies, is very small.

We did find very strong relationships between dollar-valued trade flows and border truck crossings at 5 of the 6 major inland ports in Texas. Variations in U.S. exports to and from Mexico explained most of the variation in border truck crossing at El Paso, Del Rio, Eagle Pass, Laredo, and Brownsville. Most of U.S.-Mexico trade is and will for the next several years consist of capital goods for the Mexican manufacturing industry, and intermediate goods bound for the Maquiladora affiliates of U.S.-based firms. Because of the cost advantages, increasing productivity, and infusion of modern manufacturing technology, it is very likely that northbound trade flows over the next two decades will increase as a share of U.S.-Mexico trade. Since Mexico is divided along a north-south axis by its mountainous terrain, east-west rail/highway links are much less developed in Mexico than north-south links. Thus, it is very likely that northbound truck traffic will come through Laredo and El Paso and travel along I-10, hence using it as an east-west corridor for destinations in four border states, the east and west coasts of the U.S., and most importantly, for east-west intra-industry shipments in Mexico itself.

1.0 EXECUTIVE SUMMARY

1.1. THE STATISTICAL RELATIONSHIP BETWEEN INTERNATIONAL TRADE AND TRUCK TRAFFIC ON TEXAS HIGHWAYS: 1986-1992

We first estimated a set of elasticities with respect to the growth of U.S. and Mexican Gross Domestic Product (GDP), trade flows between the two countries, and economic activity in Texas. As of 1992, these relationships were positive, strongly statistically significant, and more beneficial to the United States, at least in numeric terms.[1] The asymmetry of the latter relationship lies in the relative sizes of the two countries' economies: for now, because the U.S. is so much bigger, U.S. GDP growth, relative to Mexican GDP growth, creates much larger southbound trade flows--i.e., U.S. Exports To Mexico, or USXTM--than northbound trade flows--i.e., U.S. Imports From Mexico, or USMFM. This is an important element of our findings, and we employ it later in our discussion of one possible "near-future" scenario of the effects of international trade on truck traffic and the Texas highway network.

We then attempted to estimate the statistical relationship, if any, that existed between dollar-valued, U.S.-Mexico <u>and</u> Texas-Mexico trade flows and "downstream" truck traffic on major segments of the Texas highway system. We used a data set provided by TxDOT that included 331 count and classification sites across the state from 1986 to 1992. We controlled for population growth, levels of urbanization, and regional economic effects in the counties in which the count and classification sites were located.

As expected, population growth and increasing levels of urbanization did have statistically significant and positive effects on levels of truck traffic throughout the state. Not surprisingly--given that Texas's major population centers lie north and east of border MSAs--we also found that the greater the distance a count and classification station was

[1] Details of this analysis are available from the authors.

from the Texas segment of the U.S.-Mexico border, the higher was the level of truck traffic.

We could not, however, find a discernable relationship between U.S.-Mexico trade flows and truck traffic in any year and on any highway segment in Texas, including those segments (e.g., I-35, U.S.59, and U.S.281) moving directly north out of the inland ports in the Middle and Lower Rio Grande Valley.

This finding conflicts with the expectations of a broad cross-section of observers. However, it is not surprising when we consider that Texas-based trade as a percent of total U.S. trade with Mexico, in relation to the size of the U.S. and Texas economies, is very small. We stress, however, that this finding is preliminary in the sense that as U.S.-Mexico trade increases, statistically discernable relationships may emerge between dollar-valued trade flows and higher levels of truck traffic on Texas roads further upstream from Texas border crossings.

We next examined the relationship between dollar-valued export and import flows between Mexico and Texas and the frequency of truck crossings at ports of entry along the Texas segment of the U.S.-Mexico border between 1986 and 1992. We found very strong and statistically significant relationships between dollar-valued trade flows and border truck crossings at five of the six major inland ports in Texas. There were aspects of these findings that were policy-relevant.

In **El Paso**, variations in U.S. exports to Mexico (USXTM) and U.S. imports from Mexico (USMFM) alone explained slightly over 80 percent of variations in cross-border truck traffic. In this case, as USXTM rose by 1 percent, truck crossings decreased by 2.53 percent; as USMFM increased by 1 percent, truck crossings increased by 7.31 percent. **Presidio** truck crossings were not statistically related to U.S.-Mexico trade flows. At **Del Rio**, variations in dollar-valued trade flows explained over 91 percent of the variation in border truck crossings. Here, a 1 percent increase in USXTM led to a .4

percent increase in trans-border truck traffic, and as USMFM increased by 1 percent, truck crossings increased by 1.3 percent. At **Eagle Pass**, 95 percent of the variation in border truck traffic was explained by dollar-valued trade flows. Truck crossing elasticities for 1 percent changes in USXTM and USMFM were .07 and .66., respectively. At **Laredo**, over 91 percent of the variation in truck border crossings was explained by variations in U.S.-Mexico trade. In this case, 1 percent increases in USXTM resulted in 1.25 percent decreases in trans-border truck crossings, while 1 percent increases in USMFM resulted in 4.6 percent increases in truck crossings on the Laredo bridges. Finally, at **Brownsville**, about 65 percent of border truck crossings were explained by variations in dollar-valued trade flows. As USXTM increased by 1 percent, truck crossings increased by .49 percent; as USMFM increased by 1 percent, truck crossings decreased by .33 percent.

1.2 IMPLICATIONS FOR MONITORING OF FUTURE TRADE-RELATED DEVELOPMENTS IN TRUCK TRAFFIC

Because these relationships varied by the direction of trade and across the three busiest international ports--El Paso, Laredo, and Brownsville--we believe that a modal split was occurring up through 1992 in cross-border trade-related traffic. As southbound trade (exports to Mexico) through El Paso increased by 1 percent, two-and-a-half times more than that 1 percent increase in trade (2.53 percent) moved by some mode of transport other than truck. As northbound trade (imports from Mexico) through El Paso increased by 1 percent, more than seven times as much of that 1 percent increase in trade (7.31 percent) was carried by truck than by other modes. At Laredo, as southbound trade increased by 1 percent, 25 percent more (1.25 percent) of that 1 percent increase in trade is being carried by some mode of transport other than truck. At the same time, as northbound trade increased by 1 percent, more than four-and-a-half times (4.6 percent) as much of that 1 percent increase in trade was carried by truck than by other modes. At Brownsville, the situation was reversed, and the magnitudes of the relationships were much smaller than at Laredo and El Paso.

The implication is that (1) if the volume of trade flowing through Laredo is significantly higher than at both Brownsville and El Paso combined (and it is); (2) then as we continue to monitor the effect of international trade on Texas highway truck traffic, we should focus our attention on northbound trade moving through Laredo, and to a somewhat lesser extent on El Paso.

1.3 A NEAR-FUTURE SCENARIO: THE EFFECT OF INTERNATIONAL TRADE FLOWS ON TRUCK TRAFFIC AND THE TEXAS HIGHWAY NETWORK

Mexican shippers and manufacturers will be able to invest in and own 100 percent of the equity in U.S.-based trucking concerns in 1998. This will encourage investment in U.S.-based shipping as well as logistics-related firms, and encourage Mexican firms with operations on both sides of the border to use the Texas highway system as an intra-Mexican, intra-industry transportation link as well as an international transportation link. This is the second important implication from our statistical findings.

We know that U.S. imports from Mexico (i.e., northbound trade) now constitute a much smaller share of overall U.S.-Mexican trade than U.S. exports to Mexico. We also found that economic conditions in the two countries mean that U.S. GDP growth relative to Mexican GDP growth creates much larger southbound trade than northbound trade, but this southbound flow contains the seeds of a northbound turnaround. Most of U.S.-Mexico trade is and will for the next several years be composed of capital goods for Mexican manufacturing industry, and intermediate goods being moved between U.S.-based firms and their maquiladora affiliates. Because Mexico has begun from a less-developed position, as it imports technologically advanced capital goods from the U.S. and other nations, its rate of productivity growth will be much higher than that of the U.S. The combination of lower labor costs (which are likely to persist over the long-term), higher rates of productivity growth, and the infusion of the most advanced manufacturing technology from the developed world means that Mexican producers of manufactured consumer goods will have a distinct cost advantage over their American counterparts for an indefinite period of time. Northbound trade flows over the next two decades are therefore likely to increase as a share of total U.S.-Mexico trade, and may come to dominate those flows in the early twenty-first century. Already, through the first six months of 1994, USXTM rose 16 percent over 1993's total, to stand at $24.5 billion, while USMFM rose 21 percent over the same period in 1993, to stand at $23.4 billion. Clearly the trade surplus the U.S. has enjoyed over Mexico is narrowing.

Whether increases in northbound flows will be as truck-dependent as they appear to have been for the 1986-1992 period is open to question. In this context, however, it is important to consider a transportation scenario that may develop after December 1995 and evolve into a mid- to long-term pattern.

East-west freight movements in Mexico are difficult to conduct because mountain ranges divide the country along a north-south axis. Consequently, east-west highway and rail links in Mexico are much less developed than north-south links. If future increases in northbound trade rely more heavily on truck transport than other modes--as our findings suggest--it is likely that this increase in northbound Mexican truck traffic will come through Laredo and El Paso, and that U.S. Interstate 10 will be an east-west corridor for destinations in the four U.S. border states, the West and East Coasts of the United States, and most importantly, for east-to-west intra-industry shipments in Mexico itself.

After December 1995, we might expect to see increased numbers of Mexican trucks moving up Interstate 35 from Monterrey through Laredo to San Antonio, and from Chihuahua City and Juarez to El Paso, at which both streams of traffic intersect Interstate 10. At those points, they will then be able to move east or west, carrying finished manufactured goods bound for American markets, and intermediate goods in various stages of processing bound for destinations in Mexico, e.g., Monterrey and the maquiladora complexes along the Rio Bravo, or to Tijuana and the Mexican ports along the Pacific Coast.

The strong statistical relationship between international trade flows and truck crossings along the Texas-Mexico border thus has important policy implications for the Texas Department of Transportation (TxDOT), and indicates the direction in which future research and monitoring of NAFTA's impacts on the Texas highway system should proceed.

1.4 COSTS OF INTERNATIONAL TRADE-RELATED HIGHWAY TRAFFIC ON TEXAS HIGHWAYS--FINDINGS

The Highway Performance Monitoring System, (HPMS), was used to make estimates of the impacts on the Texas highway network for several scenarios of increases in truck traffic. The estimates show the total estimated highway needs over the next 20 years for current conditions, and increases in truck traffic of 10, 25, and 50 percent. The results show that for an increase of 10 percent trucks, needs increase about $66 million, with most of that needed for added capacity in urban areas. For an increase of 25 percent trucks, about $250 million in additional expenditures is required, with the bulk needed for additional pavement related needs. For an increase of 50 percent trucks, about $782 million is required, with needs spread between increased capacity and improved pavement needs.

2.0 STUDY PROBLEM STATEMENT

The North American Free Trade Agreement (NAFTA, 1991) is intended to eliminate existing tariff barriers that restrict trade between Canada, Mexico, and the United States. NAFTA deals with aspects of economic relations among the three member countries that are connected with trade but which go well beyond the exchange of merchandise, and particularly into the transportation arena. A broad cross-section of public and private sector decision-makers and policy analysts believe that NAFTA will increase overall economic activity in Texas, and traffic on Texas highways. This seems reasonable based on an analysis of the NAFTA transportation provisions.

NAFTA provides a timetable for the gradual phase-out of mutual restrictions on the provision of transportation services among NAFTA countries. These transportation references cover a diverse range of topics, but those relating to foreign investment, bus and truck administration and ancillary services, and rail services are the most germane for this report.

The elimination of land transportation barriers and the establishment of compatible technical and safety standards are two of the key objectives of NAFTA. When the agreement goes into effect, the United States will amend its existing moratorium on the issuance of truck and bus operating authority by allowing full access for Mexican charter and tour bus operators to its cross-border market. Mexico will grant equivalent rights to U.S. and Canadian operators. The motor carrier provisions of NAFTA will be phased in over a 10 year period.

Three years after the signing of the agreement (December 1995), Mexico will permit U.S. and Canadian truckers to make cross-border deliveries to, and pick up cargo in, Mexican border states. In turn, the United States will allow Mexican truckers to perform the same services in U.S. border states. Moreover, Mexico will allow U.S. and Canadian firms to own up to 49 percent of its bus and truck companies that provide international service, while the United States and Canada will permit Mexican companies to distribute international cargo as well. The United States will maintain its moratorium on the issuance of motor carrier operating authority for the transport of domestic cargo and passenger service.

Six years after the agreement goes into effect, the United States will provide cross-border access to Mexican trucking firms to its entire territory, and Mexico will provide the same treatment to U.S. and Canadian trucking firms. A year later, Mexico will allow U.S. and Canadian companies to own up to 51 percent of Mexican trucking and bus companies providing international services. In 10 years, U.S. and Canadian ownership will be able to rise to 100 percent.

Several of these provisions have provoked concern. As currently written, the pact does not allow U.S. firms to invest in Mexican domestic trucking operations. Moreover, Mexican firms have non-controlling investment rights in U.S. international trucking operations today, and will be able to own a controlling interest in those companies in three years. U.S. carriers, on the other hand, will not have 100 percent investment rights in Mexican international carriers until 10 years after the agreement goes into effect. Many U.S. motor carriers, and especially the American Trucking Association, believe these provisions to be glaring inequities. Other perceived inequities include the fact that Mexico has provisionally reserved the right to exclude investment in trucking terminals (NAFTA, 1991). There is no such restriction on Mexican investment in U.S. trucking terminals and warehouses.

Many controversial issues, such as truck sizes and weights, are not directly addressed by NAFTA, but rather are left to a working group that has up to six years to recommend technical and safety standards. This working group has only recently begun its deliberations. Mexican carriers have complained that U.S. size-and-weight restrictions limit their access to the U.S. market, while U.S. truckers bemoan Mexico's ban on 53-foot trailers, which are rapidly becoming the standard for many U.S. truckload operators.

Mexican truckers contend that allowing longer trailers will either make them less competitive or force them to change their fleet composition (*Traffic World*, 1992). U.S. rail carriers also are adamantly opposed to allowing longer trailers and an increase in weight limits (*Journal of Commerce*, 1993). Mexico's current weight limits—currently rarely enforced—can vary up to 171,000 pounds. The typical 18-wheel motor vehicle configuration has a Mexican weight limit of 91,500 pounds, compared to 80,000 for its U.S. counterpart (*Ley de Vias Generales de Comunicacion*, 1980). More recent investigations have found that Mexican trucks often weigh up to 200,000 pounds and more (Harrison and McCullough, 1994).

There is no doubt that if NAFTA begets more--and more damaging, in terms of pavement life--truck and bus traffic on Texas highways, there will be:

(1) more traffic congestion on both sides of the border, and
(2) larger highway maintenance, rehabilitation, and construction expenditures on the border and throughout the State.

This study, therefore, is an attempt to determine the impacts of NAFTA and expanded U.S.-Mexico trade on the Texas highway infrastructure. It asks three questions:

(1) What has been, and what will be, the effect of expanded international trade and NAFTA on the Texas economy?
(2) What is the relationship, if any, between international trade flows, economic activity, and volumes of truck traffic at both the border and throughout the State's highway system?
(3) What will be the costs of pavement damage stemming from trade-related truck traffic?

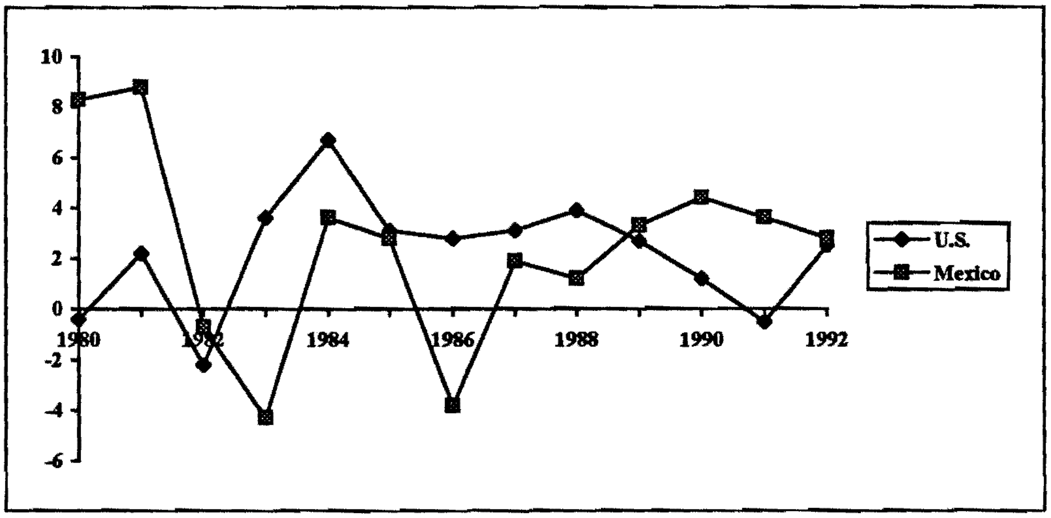
3.0 IMPACT OF FREE TRADE ON THE TEXAS ECONOMY

3.1. THE LINK BETWEEN THE U.S. AND MEXICAN ECONOMIES

Perhaps the most important factor that shapes the relationship between the U.S. and Mexican economies is their relative sizes. With a population of 260 million people, the 1992 GDP of the U.S. is approximately $6 trillion. With a population of about 86 million, Mexico's GDP of $300 billion is less than 5 percent of U.S. GDP. Additionally, Mexico is still relatively poor. For example, per capita GDP in Mexico is only 10 percent of the U.S. level, roughly $3,500 in Mexico compared with $23,000 for the U.S.

How interconnected are the U.S. and Mexican economies? The two economies followed similar growth patterns from 1969 to 1976. After 1976, however, the economies moved in different directions. The Mexican economy continued to grow while the U.S. economy's growth rate fell. We conducted a regression analysis of the relationship between Mexican and U.S. GDP growth rates and failed to demonstrate a statistically significant interdependence. Figure 3.1, below, charts the growth percentage rates of growth in the U.S. and Mexican GDP after 1980.

FIGURE 3.1 U.S. AND MEXICAN REAL GDP GROWTH RATES (PERCENT)

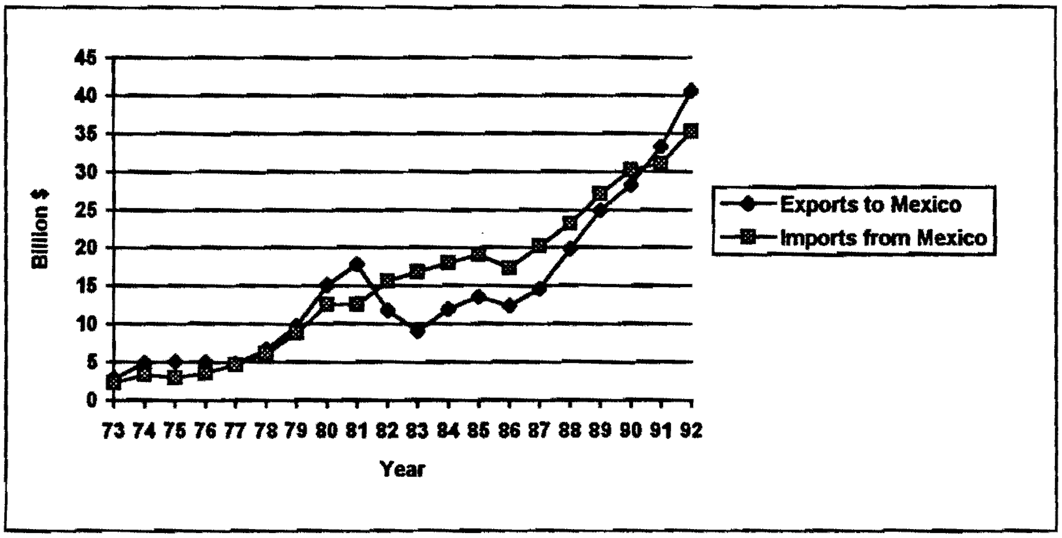


(Source: OECD, 1995)

A further analysis revealed, however, that trade flows between the two countries are linked through the mechanism of their respective GDP growth rates. Mexico is currently the United States' third largest trading partner. Between 1986 and 1992, U.S. exports to Mexico grew at an annual rate of 22 percent while imports grew by 13 percent (Lustig et al, 1992). By 1992, the U.S. exported $40.6 billion to Mexico while importing $35.2 billion, creating a net trade surplus of $5.4 billion with Mexico. Currently, over 75 percent of Mexico's total trade is with the U.S. The United States is Mexico's top merchandise export purchaser and top merchandise import supplier (GAO, September 1992). Nevertheless, in 1992 total trade with Mexico accounted for less than seven percent of total U.S. trade.

Figure 3.2 (below) shows U.S. and Mexican trade over the last three decades. U.S. exports to Mexico and U.S. imports from Mexico are shown, in nominal (i.e., current) U.S. dollars from 1973-1992. U.S. imports from Mexico grew steadily over the entire period. U.S. exports to Mexico followed a similar growth pattern up to the economic crises of the 1980's. Once trade restrictions were relaxed, the growth rate of U.S. exports to Mexico resumed to their previous level, and by 1991, the U.S. again ran a trade surplus with Mexico. On the supply side, U.S. exports to Mexico have been driven in part by the trade liberalization policies that have occurred in Mexico over the last decade.[2] On the demand side, U.S. exports to Mexico are also a function of economic growth in Mexico, i.e., a growing Mexican economy creates demand for U.S. goods.

FIGURE 3.2 U.S.-MEXICO TRADE (REAL $), 1973-1992



(SOURCE: U.S Statistical Abstracts, Annual)

We examined this relationship further by regressing U.S. exports to Mexico on Mexican real GDP. These results show that a 1 percent increase in Mexican real GDP creates a 3.2 increase in U.S. exports to Mexico. At current GDP and trade levels, this means that a $1 billion increase in Mexican real GDP increases U.S. exports to Mexico by $540 million.[3]

This relationship is symmetrical with respect to U.S. GDP and Mexican imports. Again, regression results indicate that a 1 percent increase in U.S. GDP increases U.S. imports from Mexico by 1.9 percent. A $1 billion increase in U.S. GDP increases U.S.

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[2] The extent to which a liberal trade policy promotes economic growth and the subsequent structural effects is an issue that will be examined more below.

[3] Regression results available from authors.

imports from Mexico by $11 million.[4] Although an increasing GDP in both countries increases exports (imports), the U.S. benefits relatively more from trade than Mexico.

This simple analysis ignores a host of variables that are essential determinants of economic performance and growth. Importantly, however, bilateral trade flows are structurally linked to real economic performance, an important finding for this analysis. If economic growth drives trade flows between the two economies, then trade should be linked to other variables, particularly transportation variables stimulated by growing bilateral trade, e.g., truck and other modes of traffic.

3.2 THE LINK BETWEEN THE TEXAS AND MEXICO ECONOMIES

3.2.1 Forecasting NAFTA Impacts

Much has been written about the likely impact of NAFTA on the U.S., but relatively little on what Texas can expect from it. We look first at the current structure of the Texas economy and some general considerations about NAFTA impacts, and then summarize the two leading existing forecasts of NAFTA impacts by industry and region. We then examine the results of the LBJ School/Center for Transportation Research (CTR) forecast prepared for this report.

3.2.2 The Current Statewide Economic Picture

The oil bust of the 1980s has led to a wave of economic diversification in Texas. Services now account for the lion's share of both gross state product (GSP) and employment. The Texas Comptroller of Public Accounts (1993) projects that sectors such

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[4] This relationship can also be shown for total U.S. imports. For example, regression results show that a 1 percent increase in U.S. GDP will increase total U.S. imports by 1.4%. Thus, we see that U.S. imports from Mexico are more sensitive to changes in U.S. GDP than total U.S. imports.

as services, construction, and manufacturing will fuel the growth of Texas employment for the next 35 years. In services, growth is anticipated in a number of areas, including business services, health, hotels, professional and legal services, and to a lesser extent government, transportation, communications and public utilities (TCPU), finance, insurance and real estate (FIRE), and wholesale and retail trade.

The Comptroller's Office also expects growth in some high technology manufacturing areas such as computers, industrial machinery, and electronics. Other manufacturing industries expected to grow include stone, clay, and glass products, fabricated metals, instruments, food processing, printing and publishing, and rubber and plastic products. Textiles and apparel, transportation equipment, and petroleum refining are expected to lose jobs over the next 35 years. Overall, Texas is expected to grow at rates above the national average, but below the rates it experienced in the 1960's and 1970's.

In this context, two sectors of the Texas economy are likely to be heavily affected by NAFTA: manufacturing and agriculture. Manufacturing accounts for 16 percent of GSP. Overall, NAFTA should lead to more Texas manufacturing exports, output, and jobs. But there will be winners and losers <u>within</u> manufacturing. In general, increases in Mexican per capita income should help U.S. and Texas manufacturing as the Mexican population becomes able to afford more consumer products. Since Mexican wages are much lower, Mexican manufacturers employing even relatively high-skilled workers will have a production cost advantage. However, U.S. and Texas-based firms possess an undisputed, and probably uncatchable, superiority over Mexico in skilled labor- and capital-intensive high technology manufacturing <u>and</u> service industries, especially in computer systems and software design. In the short- to medium-run (3-7 years), then, it may be difficult for Mexico to gain a comparative advantage in many industries, even with cheaper labor. In the longer-term, (7-12 years), however, current trade flow magnitudes and composition may turn around. Provisions for the protection of intellectual property rights should invite more U.S. technology into Mexico over time. In addition, Mexico is now importing relatively advanced manufacturing technology, and rates of manufacturing productivity growth are in many cases reported to be much higher than in the U.S. This combination of lower wages, which are likely to persist well into the next century, and high productivity growth will likely mean that northbound trade between the U.S. and Mexico will increase as a share of overall trade. This has important implications for transportation, as we shall see in Section 4, below.

There will also be winners and losers in Texas agriculture. Agriculture, in contrast with manufacturing, accounts for only about 2 percent of Texas's GSP, but a much larger portion of U.S. livestock and feed grain production.[5] Since Mexico is the U.S.'s fourth-largest agricultural export market, and Mexico is the second largest exporter of food to the U.S., agricultural industries in Texas already exporting to Mexico stand to gain from more open trade, while industries facing competition from Mexican imports stand to lose. Dairy, live cattle, animal fats, seeds, meats, and grain sorghum are leading products from Texas that are exported to Mexico. Vegetables, fruits, coffee, feeder/stocker cattle, malt beverages, and sugar are the major Mexican agricultural exports to the U.S. and Texas. Because agricultural specialties vary throughout Texas--for example, the Plains accounted for 60 percent of 1989 Texas cash grain production, while melon production is found predominantly in the Border Region--Texas producers of citrus fruits and certain vegetables stand to lose, while sorghum producers stand to gain from more trade with Mexico.

3.2.3 Summaries of Existing Forecasts

The three most widely quoted studies of the impact of NAFTA on Texas were prepared by the Texas Comptroller of Public Accounts and Perryman Consultants, Inc. These will be referred to as Comptroller and Perryman, respectively. The third, which was previously mentioned, was the LBJ School/CTR Free Trade Impact Model.

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[5]For example, Texas 1992 beef cattle and sorghum production represented an estimated 15.7 percent and 23.66 percent of total U.S. production, respectively (Texas Department of Agriculture, 1993).

The Texas Comptroller of Public Accounts Forecast (1991 and 1994)

The Texas Comptroller Forecast predicted an increase in the dollar value of Texas exports with Mexico and the creation of additional jobs directly connected to Mexican export trade between 1990-2000 due to NAFTA. According to the report, the increase in export trade will have a positive effect on the the GSP during the period.

The 1991 report predicted the direct value of goods and services exported to Mexico (in 1990 dollars) to increase from $16.8 billion in 1990 to $23.7 billion in 1995, an annual increase of 7.1%. Between 1995-2000 the annual growth rate will decline to 4.3% as the Mexican economy becomes more self-sufficient, resulting in $29.2 billion exports to Mexico in the year 2000. These figures represent a boost of 13% resulting from NAFTA when compared to the Comptroller estimates without NAFTA. The 1994 report revised these earlier estimates. By 1992, the 1994 report stated, most of the 1990 to 1995 growth in Texas' exports to Mexico projected in the 1991 report had already occured. The updated forecasts predict lower annual growth rates for Texas' exports to Mexico. Between 1995-2005, the revised annual growth rate projected is 3.5% compared to the 1991 report's estimate of 4.3% for 1995 to 2000.

In addition to the increase in Texas exports to Mexico, the 1991 report predicts an increase in employment resulting from NAFTA. By 1995, 65,000 jobs will be created in industries directly connected to Mexican export trade. After the initial increase in jobs, an additional 48,000 jobs will be created by 2000. The 1994 report revised the previous employment estimates. Between 1990 and 1992, 42,000 jobs were actually created due to the double-digit growth of exports with Mexico during this time period. The 1994 report forecasts an additional 19,000 jobs from the effect of trade over the previous estimate of 65,000 by 1995.

According to the 1991 report, the effect of NAFTA on Texas' industries will vary. The industries that are expected to benefit include: electronics, industrial machinery and computers, transportation equipment, and fabricated metals. Within the service sector, legal assistance, insurance, and business consulting have already shown and will continue to show gains from Mexican trade. There is also an expected negative impact on certain industries in Texas. Industries that will suffer include: agricultural, apparel and textiles, primary metals, and various manufacturing industries, especially those that have low wages. The actual growth in exports to Mexico, shown in the 1994 report, show Texas industries with the most growth include: electronics, transportation equipment, industrial machinery, primary metals, retail trade, insurance, lumber and wood products, fisheries, printing and publishing, and oil and gas field services.

According to the 1991 report, the effect of increased trade with Mexico and increased employment levels in Texas will translate to gains in the GSP. In 1990, exports to Mexico supported about $15 billion or 4.1% of the GSP. By 1995 this was predicted to increase to $22 billion or 5.3% of the GSP and by 2000, in the maturing Mexican market, increase to $28 billion or 5.7% of the GSP. The initial results, in the 1994 report, show that in 1992 the gain in GSP was $19.3 as a result of increased trade. The revised figure for the 1995 GSP contribution has risen to $23.6 billion or 5.1% to the Texas economy.

The Perryman Forecast (1993)

In the Perryman forecast, both employment and output in the service-producing sector of the Texas economy--which includes transportation, communications, and public utilities (TCPU); finance, insurance, and real estate (FIRE); wholesale and retail trade; and services--are projected to grow faster than any other set of industries through the year 2000. However, only between 7 and 11 percent of statewide growth from 1992 to 2000 in service-producing industries will be due to NAFTA.

Intuitively, we expect that regions in Texas that are home to industries expected to prosper under NAFTA will also do well. This is generally supported by the Perryman study. It allocates the results of its statewide estimates across 28 metropolitan areas around the state, and has a separate estimate for rural activity. Most of the increased economic activity attributable to NAFTA, not surprisingly, is found in the Dallas and Houston metropolitan areas. The Texas Border Region is also projected to do well.

Perhaps the most interesting aspect of the Perryman study from a transportation standpoint is his contention that if Mexican trade continues to liberalize, NAFTA will have little marginal impact in Texas. In the very short run, at least, it may therefore be unrealistic to expect a northbound flood of goods manufactured with cheap labor even as tariff and non-tariff barriers are lifted. Moreover, since services are communications-intensive but not transportation-intensive industries, and services are expected to be the chief beneficiaries of NAFTA-related economic activity, much of the growth in Texas economic activity attributable to NAFTA will not tend to generate much new heavy truck traffic on Texas highways. This is important when we assess the plausibility of our findings on the statistical relationship between trade, the Texas economy, and truck traffic. It also bears on the plausiblity of near-future scenarios of trade-related truck traffic impacts on Texas highways.

The LBJ School/CTR Free Trade Impact Model (1992)

Researchers at the LBJ School of Public Affairs and Center for Transportation Research (both at the University of Texas at Austin) have produced a series of studies of NAFTA impacts on the Texas economy. These modeling exercises look at how Texas's exports to Mexico stand to increase on a detailed sector-by-sector and regional basis. Some limitations of the conservative baseline exercise reported here include the following:

(1) the model only addresses the goods-producing sectors (agriculture, mining, and manufacturing);

(2) it focuses exclusively on direct spending and employment effects;

(3) it ignores the effects Texas investment in Mexico may have on the Texas economy (which would likely increase the employment and income effects); and

(4) it does not factor Canada, Texas' second largest trading partner, into the analysis.

The first three of these caveats imply that the LBJ School/CTR Model understates the effects of NAFTA on Texas. Clearly, because distribution services, producer services, selected professional services, and retail and wholesale activities account for around 70 percent of Texas' GSP, those segments of the economy that are tightly linked to goods-producing industries will also enjoy significant economic benefits from NAFTA above and beyond the modeled forecasts. Finally, the model does not factor in the effects that increased Texas imports of Mexican goods may have in competing with domestic production and displacing local economic activity. Overall, then, this analysis implies that the ratio of employment created by NAFTA to employment lost or displaced is approximately six-to-one. The conclusion that NAFTA will have a positive effect on the Texas economy remains unaltered.

Sectoral Impacts of NAFTA on Texas

The LBJ School/CTR Model shows that the sectors that will gain the most from liberalized trade with Mexico include aircraft and parts, electrical components and accessories, communications equipment, auto parts, and non-ferrous drawing and rolling (Table 3.1). The model forecasts a 36.5 percent increase in overall Texas trade with Mexico between 1994 and 2003, most of which is driven by an average of 4.7 percent growth in Mexican GDP. Since many recent Texas exports to Mexico consist of capital goods for which Mexico has been starved for many years, some economists argue--including the authors of this report--that we can expect to see export growth coming down as a certain level of saturation is felt in Mexico for basic production equipment. This is consistent with the modeled results.

Table 3-1: NAFTA IMPACT ON EXPORTS AND EMPLOYMENT IN TEXAS: The Big Winners Over the Period 1994-2003

Sector	Total Export Growth (000s)	New Jobs
Aircraft & Parts	$581,769	12,800
Elec. Components, Accessories	$455,149	10,000
Communications Eqpt.	$396,993	8,700
Motor Vehicles & Eqpt	$375,800	8,300
Non-Fer. Rolling/Drawing	$296,401	6,500
Audio-Video Equipment	$238,522	5,200
Misc. Elec. Mach. & Supplies	$229,969	5,100
Agriculture—Crops	$218,432	4,800
Misc. Furniture	$191,410	4,200
Construction Equipment	$189,784	4,200
Railroad Equipment	$188,352	4,100
Lighting & Wiring Eqpt	$177,968	3,900
Misc. Mfg., Tobacco, Scrap, etc.	$175,631	3,900
Refrig./Laundry/etc. Eqpt	$174,144	3,800
Electrical Indust. Eqpt	$128,313	2,800
Computer & Office Equipment	$122,852	2,700
Primary Non-Ferrous Refining	$120,668	2,700
GRAND TOTALS:	**$8,264,852**	**182,000**

Preliminary results of the LBJ School of Public Affairs Model of NAFTA Impacts, February 1993.

Assumes Mexican GDP grows gradually by 3% to 6% over the period.

As the results show, the 36.5 percent anticipated growth in exports translates into approximately $8.3 billion of direct increased spending (in 1991 dollars) over the period and into 182,000 new jobs between 1994 and 2003. To place this into perspective, this level of employment creation is equivalent to approximately 2.6 percent of Texas' current workforce. While this may seem small, it is difficult to identify other policy innovations that can compete with NAFTA in terms of creating employment in Texas in the 1990s.

The industries identified as gaining the most under NAFTA under the LBJ School/CTR Model closely match the predictions of most NAFTA studies, including the Comptroller and Perryman studies discussed earlier. This is hardly surprising. In light of factor endowments in Texas and Mexico, the theory of comparative advantage anticipates that Texas's advantages lie in the production of high value-added goods that depend on a relatively highly educated and skilled workforce, that are closely linked to research and development efforts, and that are influenced by modern production and inventory practices.

NAFTA Impacts on Texas Regions

The economic effects of NAFTA will not be uniform across all regions of the United States, nor will they be uniform across regions of Texas. Differences in goods and services produced and patterns of distribution and export destination will determine NAFTA's differential regional impact. More dynamic competitive advantages stem from the strength of the manufacturing base of the local economy and its ability to adapt to modern technologies in logistics, operations management, and marketing. Significantly enough, many of the relevant technological developments play directly into the hands of small- and medium-sized manufacturers as opposed to large corporations.

By using Texas regional gross sales as a lever, it is possible to break statewide economic forecasts down to a regional level. The level of regional analysis we chose is based on the State of Texas Uniform State Services Region Plan and balances the desire for sectoral detail with the desire to maximize regional specificity. Purely as a matter of convenience, results of the model are denominated in terms of employment gains over the period 1994-2003. A crude approximation of the direct spending equivalents of these employment impacts can be calculated by multiplying jobs gained by $46,000.

The summary of forecasted regional impacts (Table 3.2) suggests that by far the greatest proportion of benefits will accrue to the Greater Dallas-Fort Worth Metroplex. With approximately 20 percent of the state's population, the Metroplex is projected to gain over 40 percent of the economic benefits. This is consistent with the forecasts reviewed earlier. The economic base of the Metroplex possesses a scale, scope, and profile that squarely matches the kinds of economic activity widely expected to be stimulated by NAFTA. A casual glance at the current shares of gross sales in the detailed sectoral breakdowns shows that the Greater Dallas-Fort Worth Metroplex dominates those goods-producing sectors of the Texas economy that produce the kinds of high value-added and relatively capital-intensive commodities that Mexico has been demanding, and will most likely continue to demand well into the future.

TABLE 3-2: IMPACTS OF NAFTA ON REGIONAL EMPLOYMENT OVER THE PERIOD 1994-2003

REGION	DIRECT JOBS CREATED	% OF TOTAL TX JOBS GAINED
High Plains	2,400	1.4%
Northwest Texas	900	0.5%
Greater DFW Metroplex	75,600	41.4%
Upper East Texas	9,600	5.3%
Southeast Texas	4,800	2.7%
Gulf Coast	38,600	21.3%
Central Texas	12,300	6.8%
South Texas	14,000	7.7%
West Texas	1,300	0.7%
Upper Rio Grande	2,800	1.5%
Unallocated	*19,500*	*10.8%*
TOTALS:	**182,000**	**100.00%**

The Gulf Coast region, centered around Houston and Harris County, is expected to account for over 20 percent of the direct economic benefits of NAFTA stimulus to exports, a proportion roughly in line with that area's share of the state's population. These figures ignore the significant recent boost in natural gas exports to Mexico. To the extent that these trends continue—and there are a number of reasons for expecting them to do so—the goods-producing sectors of the Greater Houston area should reap greater benefits from NAFTA than the LBJ School/CTR model suggests.

The border area as a whole comes in third according to these projections despite the fact that it accounts for over 25 percent of the state's population. This ranking also obscures the fact that a good portion of these benefits accrue to San Antonio. While San

Antonio's manufacturing base is not a strong one, it is congruent enough with the consensus of NAFTA winners to pull South Texas far ahead of the Upper Rio Grande border region surrounding El Paso. The fragile manufacturing base in this latter region of Texas is heavily concentrated in the kinds of labor-intensive, late product-cycle, standard production technology industries that are most likely to become employment generators for Mexico under NAFTA. With only 1.5 percent of Texas employment gains accruing to this area and with a mere eight industries (at the 3-digit SIC level) accounting for 73 percent of the jobs projected to be created under NAFTA, the Upper Rio Grande will need to rely heavily on its service sector (especially distribution and professional services) and on its economic links with Ciudad Juárez on the other side of the border to maximize the benefits of NAFTA.

The High Plains and Upper East Texas account for only a small proportion of expected NAFTA impacts on the state. The benefits they are projected to gain under NAFTA are dominated by a small number of industries, meat products (High Plains) and the rolling and drawing of non-ferrous metals, chiefly aluminum and copper (Upper East Texas). In both cases, these are probably sources of strength with much potential for future development.

The high technology sectors of Central Texas are not significant enough to promise that region more than approximately 7 percent of Texas' employment gains under NAFTA. The fact, however, that Central Texas lies on some of the primary transportation arteries may lend it an additional boost that the LBJ/CTR model cannot capture. Other parts of Texas are expected to enjoy modest gains that are more or less in proportion with their contribution to Texas' population and current manufacturing base. It is important to note in closing that the largest portion of the 10.8 percent of unallocated employment projected to be generated probably ought to be attributed to the smaller regions. Among these, the El Paso area stands to gain the greatest share.

Significantly, the general kinds of economic activity that the LBJ School/CTR Model and other forecasts identify as being especially favored under NAFTA tend to be those activities that have already taken--or are in a good position to take--advantage of the near-revolutionary changes that have been occurring in modern manufacturing over the past decade. These changes include the widespread diffusion of just-in-time (JIT) production, delivery, and inventory systems; total quality management techniques; concurrent engineering; and other features of flexible production generally drawn from Japanese experience.

All these innovations rely heavily on dependable transportation, telecommunications, informatics, and educational infrastructure. The important point here is that Mexico lags far behind Texas and the United States in its ability to guarantee reliable infrastructure, and will continue to lag behind for many years to come. As a corollary to this, we can expect the benefits of NAFTA to Texas to unfold more slowly over time, and with greater frictional adjustments, than many people acknowledge.

From a transportation perspective, this means that NAFTA impacts on the Texas highway system may not be particularly acute, and may not be visible until after the agreement goes into effect in December 1995. At that time, however, because Mexican surface transportation infrastructure is inadequate, Mexican firms (shippers as well as manufacturers) may begin to use U.S. surface transportation infrastructure much more intensively for international ***as well as intra-national*** shipments, particularly the state highway systems of the four U.S.-Mexico Border States that will become available to them at that time. We will discuss this issue further in Section 4.

4.0 LINKAGES BETWEEN INTERNATIONAL TRADE AND TRUCK TRAFFIC ON TEXAS HIGHWAYS

4.1 EXISTING FORECASTS–METHODS AND FINDINGS

The following sections discuss the perspectives offered by existing studies on how NAFTA will effect truck traffic on Texas' highways.

4.1.1 Shiner-Moseley Study

The Shiner-Mosely Study (1993) was commissioned by cities/counties in the mid and lower Rio Grand Valley. Interested parties in this study included: Laredo, Brownsville, McAllen, Mission, Edinburg, and Del Rio. The cities/counties were concerned that NAFTA would unleash a drastic increase in truck traffic on their infrastructure. The goal of the study was to determine if this concern was valid and to present the findings to TxDOT in order to ask for money for improvements on the transportation infrastructure.

Trade traveling through Texas accounted for 80 percent of the total overland trade between the U.S. and Mexico, of which 74 percent was carried by truck. Trade between the U.S. and Mexico doubled between 1983-1993 (increased 250 percent), to $74 billion per year and Shiner-Moseley said it would double again by the turn of the century, and once again by 2020 AD. They expected that passage of NAFTA would provide a further boost to the growth in trade between the two countries.

They estimated that trade with Mexico directly generates about 644 million truck kilometers (400 million truck miles) traveled on Texas highways. Seventy-five percent of the truck kilometers (483 million kilometers or 300 million miles) is accounted for by the flow of goods between Mexico and states other than Texas. The projected cost of necessary improvements in the publicly-funded transportation infrastructure in Texas over the next decade was $3.25 billion. Improvements in the highway system would cost $2 billion, border crossings, bridges, and processing would cost $300 million, public transit would cost $618 million, and commercial and general aviation would cost $333 million.

4.1.2 FHWA/6015 Study

The FHWA/6015 study stated that U. S.-Mexico trade flow was heavily concentrated at seven ports of entry: El Paso, Laredo, Brownsville, Calexico, Nogales, Otay Mesa, and Hidalgo. The busiest port of entry for trucks was El Paso, and the busiest port of entry in terms of value of trade volume for rail traffic is Laredo (p. 5). The study concluded that out of a total two-way U. S.-Mexico land trade value of $61.8 billion in 1992, the South Texas "gateway" accounted for $33.7 billion, and the West Texas "gateway" accounted for $12.8 billion, for a total of $46.5 billion or 75 percent of the total U. S.-Mexico land trade value. With ratification of NAFTA, U. S. exports to Mexico are projected to increase between 65 percent and 70 percent by 2000. Mexican exports to the U. S. through the South Texas ports of entry are projected to increase by 120 percent; exports through the West Texas-New Mexico ports of entry should increase by 110 percent.

Arterials leading to and from border crossing sites will be hard pressed to handle significantly greater amounts of cross-border traffic. These arterials connect border crossings to the main interstate and interregional transportation system in the U. S. They are badly in need of repair and upgrading (p. 7). The facilities immediately at the border crossings (bridges, tunnels, and facilities housing Federal inspection agencies) are adequate and will remain so for the foreseeable future, even with the anticipated increase in trade. GSA is completing a $364.5 million Southwest Border Capital Improvement Program that will enable southern border crossing facilities to accommodate 8.4 million trucks annually, well in excess of the 2.3 million trucks that entered the U. S. from Mexico in 1992 (p. 7).

4.1.3 GAO Study

The GAO study (1991) was instigated due to the concern for the adequacy of the infrastrucure along the U.S.-Mexican border once NAFTA was implemented. The study focused on current and projected levels of trade and the effect this would have on the border infrastructure. The findings were used to estimate the cost of improving border infrastructure in order to meet future trade levels between U.S.-Mexico.

The study identified 24 border crossings between Texas and Mexico. Laredo and El Paso were among the five largest ports of entry on the U.S.-Mexican border. The study stated that existing border highway infrastructure in Texas was inadequate to meet current traffic needs, let alone any significant increases in truck traffic due to the adoption of NAFTA.

The study estimated costs for Texas border area highway improvements under five different scenarios (see table below):

i. Costs if traffic stayed at 1990 levels;

ii. Costs if traffic increases with a 10 percent increase in U.S.-Mexico trade;

iii. Costs if traffic increases with a 25 percent increase in U.S.-Mexico trade;

iv. Costs if traffic increases with a 50 percent increase in U.S.-Mexico trade;

v. Costs if traffic increases with a 100 percent increase in U.S.-Mexico trade.

TABLE 4-1: ESTIMATED COSTS FOR TEXAS BORDER AREA HIGHWAY IMPROVEMENTS THROUGH 2000 (in millions of U.S. Dollars)

Area	1990 Costs	Resulting costs from: 10% trade increase	25% trade increase	50% trade increase	100% trade increase
El Paso	513	517	522	527	538
Del Rio	9	9	9	9	9
Laredo	127	127	129	133	135
Rio Grande Valley	94	95	96	97	101
U.S. 281	106	107	108	110	113
Trunk System	1,180	1,192	1,207	1,224	1,256
Total	**$2,028**	**$2,047**	**$2,071**	**$2,100**	**$2,153**

Source: U.S.- Mexico Trade-Survey of U.S. Border Infrastructure Needs. pp. 35. GAO/NSIAD-92-56. November 1991

The GAO study finds that a substantial amount of money needs to be invested in border-area highway improvements. With the adoption of NAFTA, trade between the U.S. and Mexico will definitely increase, making some of the scenarios from the above table, a strong reality. The explosion in truck traffic associated with this burgeoning trade will have a significant impact on Texas highways in general, and border area roadways in particular. Therefore, the GAO study concludes that between $2 and 2.1 billion needs to be spent for border area infrastructure improvements.

4.2 TTI ESTIMATES OF FREE TRADE IMPACTS ON TRUCK TRAFFIC

4.2.1 Data and Hypotheses

The studies we examined in the preceding sections all share one critical shortcoming: in none of them did the analysts attempt to empirically estimate, prior to the full implementation of NAFTA, the existing impact of expanded trade with Mexico since 1986 (the year trade liberalization was begun) on the Texas highway system. None of them used or attempted to relate actual data on international trade, statewide and local economic activity, and truck traffic. Our research effort focused on this task.

We gathered data on annual average daily traffic data (AADT) from the Texas Department of Transportation's Texas Traffic Maps for the years 1986-1992. For each year, the maps show the AADT for individual counting stations along all the main highways in Texas. The maps show the highway along which each counting station lies as well as the county in which each counting station resides.

For this study, we traced highways across the state both horizontally and vertically[6]. Thus, all major urban areas were represented as well as a representative cross-section of rural areas. There were 331 observations (i.e., counting stations) used for each year. Because we had maps for several years, we were able to follow each observation over time, thus utilizing the panel nature of the data[7], i.e., that it contained both cross-sectional data and time-series data.

Because this study is concerned principally with truck traffic, we estimated truck traffic from total traffic data. Fortunately, we had two years of truck traffic volume maps (1990 and 1992). We were thus able to estimate an average ratio of truck traffic to total traffic for each observation. This was done by calculating the ratio of truck traffic in 1992 to total traffic in 1992 for each observation. The same ratio was calculated for truck traffic in 1990 to total traffic in 1990. Based on discussions with TxDOT District

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[6] It was generally not the case that a single highway was followed across (either vertically or horizontally) the entire state. More generally, a highway was followed as far vertically or horizontally as possible. If a highway ended, we picked up along the highway that most directly followed the path out of the state. If a highway merged into another highway, we then followed the new highway along the desired route.

[7] The counting stations were generally located at the same point along a given highway across the years. If there was a change, the next counting station closest to the original point was used.

Engineers for border area and the state, we then made the assumption that this ratio held constant for the other years, i.e., 1986, 1987, 1988, 1989, and 1991. Thus,

$$\textit{Percent of Truck Traffic}_{ijt} = \frac{\textit{Truck Traffic at Counting Station}_{ijt}}{\textit{Total Traffic at Counting Station}_{ijt}}$$

where i = station 1, . . ., 331

j = county

t = 1990, 1992

We then multiplied total traffic at each counting station by the percent of truck traffic at each counting station for those years in which only data for total traffic was available. The resulting number, an estimate of Annual Average Daily Truck Traffic (AADTT) at each count station for 1986 through 1992, was used as the **dependent variable** in our estimates of the impact of U.S.-Mexico trade on truck traffic along the Texas highway system.

We then performed a series of multiple regression analyses, regressing a set of independent variables that controlled for several well-known determinants of **AADTT** in order to isolate the effect of annual U.S.-Mexican trade flows, measured in dollar terms, on **AADTT** at the 331 counting stations throughout the Texas highway network.

First, because we knew the county in which each counting station was located, we were able to group our data into specific regions and areas. This allowed us to examine the effects of expanded international trade on **AADTT** in any region or area of the state. The **REGION** variable indicated the region of Texas in which each county's counting station(s) was located. We categorized the counties in which counting stations were located according to the ten-region configuration of the Uniform State Services Regional Plan (see Figure B-1). These regions consisted of the:

High Plains (including Lubbock and Amarillo),
Northwest Texas (including Abilene, Stephenville, and Wichita Falls),
Metroplex (the Dallas-Ft. Worth area),
Upper East Texas (including Longview, Marshall, Texarkana, and Tyler),
Southeast Texas (including Beaumont, Port Arthur, and Nacogdoches),
Gulf Coast (including Houston and Galveston),
South Texas (including San Antonio, Corpus Christi, and the Texas-Mexico border cities of Brownsville, Laredo, Eagle Pass, and Del Rio),
Central Texas (including Austin, Temple-Belton-Killeen, and Waco),
West Texas (including San Angelo and Odessa-Midland), and the
Upper Rio Grande (including the border cities of Presidio and El Paso).

Figure B-1 shows a map of this regionalization scheme. **REGION** controlled for the "fixed effects" of truck traffic generation from the combined economies of the counties in each region. Clearly, given the different magnitudes of economic activity resulting from the different types of economies in each region, these fixed effects on traffic generation were different for each region. Other things equal, the more urbanized a given region was--i.e., those with large cities such as San Antonio, Dallas-Ft. Worth, and Houston (in the **SOUTH TEXAS, METROPLEX** and **GULF COAST** regions) with their more diversified economic structures and larger firms with greater tendencies to participate in interregional and international trade--the more truck traffic we expected to see.

We also controlled for county **POPULATION** levels. Clearly, county population levels are one of the most important determinants of AADTT at any given count/classification site on the Texas highway network. We obtained population estimates for each county in the sample for 1986-1989 and 1991-1992 from the Texas State Data Center at Texas A&M University's Department of Rural Sociology, and for 1990 from the Bureau of the Census. We expected this variable to be positively correlated with **AADTT** and to account for more variation in it than any other control variable used in the study.

Finally, we used the dollar value of U.S. exports to and from Mexico--**USXTM** and **USMFM**, respectively, to estimate the impact of increasing levels of United States-Mexican trade on Texas highway **AADTT.** These statistics were taken from the *Direction of Trade Statistics Yearbook 1992* and the U.S. Department of Commerce. Figures were converted into constant 1987 dollars using implicit price deflators for U.S. imports and exports. Our hypothesis was that after controlling for the fixed effects of regional economic structure, and population levels, *we would see that a one percent increase in either one or both of these variables would yield a measurable, to-be-determined percentage increase* in **AADTT** at any given count station across the state.

4.2.2 Description of Highways

North/South Highways

SH54, U.S.90, U.S.67

This highway is located in the central part of the Upper Rio Grande region. The sample observations taken from this highway begin in upper Culberson County and end in Presidio County at the Rio Grande River. Cites of note along the sample include Van Horn and Marfa. This sample highway runs approximately 322 kilometers (200 miles).

SH118

This highway is located in the eastern section of the Upper Rio Grande region. It begins in northern Jeff Davis County and extends through Brewster County, ending at Big Bend National Park. Cities of note include Fort Davis and Alpine. This sample highway runs approximately 282 kilometers (175 miles).

SH285, SH385

This highway is located along the western edge of the West Texas Region. It begins in northern Reeves County and extends through Brewster to Big Bend National Park. This sample highway runs approximately 322 kilometers (200 miles).

SH214, SH385

The highway is located in the western part of the High Plains region and extends down through central West Texas. It begins in Bailey County at the city of Muleshoe and ends in the middle of Pecos County for this sample. Cites of note include Muleshoe, Odessa, Crane, Plains, Seminole, and Andrews. This sample highway runs approximately 386 kilometers (240 miles).

U.S.87

This highway is located in three regions. It runs through the central High Plains from the tip of the panhandle in Dallum County, through the eastern part of West Texas, and along the eastern part of South Texas to the coast at Victoria County. Cites of note include Dumas, Amarillo, Lubbock, San Angelo, San Antonio, and Victoria. This sample highway runs approximately 1006 kilometers (625 miles).

U.S.83

This highway is located in four regions. It begins in the eastern part of the High Plains at the top of the panhandle near the City of Perryton in Ochiltree County, through the western part of Northwest Texas, through the eastern part of West Texas, and runs through the central part of South Texas of which for the last approximately 241 kilometers (150 miles), it runs along the Texas/Mexico border where it ends in Cameron County near Brownsville. Cites of note include Childress, Abilene, Uvalde, and Laredo. This sample highway runs approximately 1126 kilometers (700 miles).

U.S.281

This highway is located in four regions. It begins in Northwest Texas in Wichita County near the City of Wichita Falls. The highway runs through the western edge of the Metroplex and Central Texas regions. It continues through the eastern section of South Texas ending in Hidalgo County at the Texas/Mexico border, near Edinburg. This sample highway runs approximately 805 kilometers (500 miles).

I-35

This highway is located in three regions. This highway begins in the central part of the Metroplex Region in Cooke County near Gainsville. It proceeds centrally through Central and South Texas Regions. Cities of note include Denton, Dallas, Fort Worth, Waco, Austin, San Antonio, and ends in Webb County at Laredo. This sample highway runs approximately 684 kilometers (425 miles).

I-45

This highway is located in three regions. The highway begins in the southeastern part of the Metroplex region in Ellis County near Waxahachie. It continues through the eastern part of Central Texas and the northeastern part of Southeast Texas. The highway sample ends in Montgomery County at north of Houston. Cities of note include Waxahachie, Corsicana, Huntsville, and Conroe. This sample highway runs approximately 322 kilometers (200 miles).

U.S.69

This highway begins in the northern part of the Metroplex region in Grayson County near Sherman. The highway runs along the western part of Upper East Texas and through the central counties of Southeast Texas. It ends in Hardin County, north of Beaumont. Cities of note include Sherman, Tyler, and Lufkin. This sample highway runs approximately 402 kilometers (250 miles).

East/West Highways

I-40

This highway is located in the central High Plains region in the Texas Panhandle. It begins in Deaf Smith County, runs through Amarillo, and ends in Wheeler County. This sample highway runs approximately 241 kilometers (150 miles).

U.S.60

This highway is also located in the central High Plains region in the Texas Panhandle. The highway, at the west end, begins in Parmer County in the City of Farwell and runs diagonally up to Amarillo then to Lipscomb County. This sample highway runs approximately 306 kilometers (190 miles).

SH114

This highway is located in three regions. The highway begins in the western edge of the High Plains region in Cochran County. It runs through the central part of the Northwest Texas and Metroplex regions. The highway ends in the Metroplex region outside of the Dallas/Ft. Worth Metroplex. Cities of note along the highway include Lubbock and the outskirts of the Dallas/Ft. Worth Metroplex. The sample highway runs approximately 483 kilometers (300 miles).

U.S.180/U.S.80

This highway is located in four regions. The highway begins along the north-western corner of the west Texas region in Gaines County. The highway proceeds to run through the central Northwest Texas region and through the lower Metroplex region. The highway ends in central Upper East Texas in Harrison County. Cities of note include Seminole, Palo Pinto, Weatherford, the Dallas/Ft Worth Metroplex and Longview. The sample highway runs approximately 821 kilometers (510 miles).

I-10

This highway runs across five regions. It begins in El Paso County in the City of El Paso in the Upper Rio Grande region. It runs through the southern part of the West Texas region, then through the northeast section of the South Texas region, and is followed by the central part of the Gulf Coast region. The highway ends in the southern tip of Southeast Texas in Orange County in the City of Orange. Cities of note along the highway include El Paso, San Antonio, the Houston Metroplex, and Orange. This sample highway runs approximately 1158 kilometers (720 miles).

I-20

This highway is located in four regions. It begins in Reeves County along the border between Jeff Davis County and Reeves County at the western edge of the West Texas region. It proceed to run through the lower part of the Northwest Texas region and then into the central counties of the Metroplex region. The highway runs through central Upper East Texas before ending in Harrison County at the Texas border. Cities of note along the highway include Odessa, Midland, Abilene, Weatherford, and the Dallas/Ft. Worth Metroplex. This sample highway runs approximately 877 kilometers (545 miles).

U.S.67/I-30

This highway is located in four regions. It begins in the middle of Pecos County in the West Texas region approximately 32 kilometers (20 miles) east of Ft. Stockton. The highway runs through the central West Texas region into the southern section of the Northwest region. The highway then enters the southeastern corner of the Metroplex region where it runs diagonally to the Upper East Texas region. The highway ends in the Upper East Texas region in the City of Texarkana in Bowie County. Cities of note include San Angelo, Cleburne, the Dallas/Ft. Worth Metroplex, and Texarkana. This sample highway runs approximately 805 kilometers (500 miles).

U.S.79

This highway is located in two regions. The highway begins in the middle of Williamson County about 32 kilometers (20 miles) north of Austin. The highway runs through the middle of the Central Texas region into the southern part of Upper East Texas region. The highway ends in Panola County. Cities of note along the highway include Palestine and Carthage. The sample highway runs approximately 354 kilometers (20 miles).

U.S.90/U.S.90A

This highway is located in three regions. The highway begins in the City of Del Rio in Val Verde County which is in the South Texas region. The highway runs through the central part of this region and then enters the southern counties of the Central Texas region. The highway continues through the central section of the Gulf Coast region, ending in the lower Southeast Texas region at the City of Orange in Orange County. Cities of note include Del Rio, San Antonio, the Houston Metroplex, and Orange. The sample highway runs approximately 628 kilometers (390 miles).

U.S.59

This highway is located in four regions. The highway begins in the South Texas region in Laredo in Webb County. It runs centrally through South Texas into the central Gulf Coast region. The highway then heads north into the central section of the Southeast Texas region. The highway then runs into the eastern part of the Upper East Texas region ending in Bowie County near Texarkana. Cities of note include Laredo, the Houston Metroplex, Lufkin, Carthage, and Jefferson. This sample highway runs approximately 805 kilometers (500 miles).

4.2.3 Regression Model Specifications

Model 1 examines the effects of U.S.-Mexican trade and the population, regional, and urbanization effects on annual average daily truck traffic (AADTT). The dependent variable, $\mathbf{MAADTT_{jt}}$, is the weighted Mean of Annual Average Daily Truck Traffic, where the weights are the percentages of the trucks recorded by each count and classification site in a given county j for year t. We specified the regression equation as follows:

$$\ln MAADTT_{jt} = \beta_0 + \beta_1 \ln CPOP_{jt} + \beta_2 \ln USXTM_t + \beta_3 \ln USMFM_t + \beta_4 \ln D\text{Region}_h + u_{it}$$

where:

$\ln MAADTT_{jt}$ = the natural log of $MAADTT_{jt}$;

$LnCPOP_{jt}$ = the natural log of the population of county j in year t (t = 1986, ... ,1992);

$LnUSXTM_t$ = the natural log of U.S. exports to Mexico in year t

(t = 1986, . . . , 1992);

$LnUSMFM_t$ = the natural log of U.S. imports from Mexico in year t

(t = 1986, . . . , 1992);

$DRegion_h$ = dummy variable for region h=1,.., m-1; and

Model 2 incorporates other variables that might capture the hypothesized effects of international trade on truck traffic in the Texas highway network. First, we hypothesize that $\mathbf{MAADTT_{jt}}$ falls (rises) the further (nearer) a given county is from the Texas-Mexico border. Second, we examine the effect on $MAADTT_{jt}$ of truck crossings at six specific sites along the Texas-Mexican border. The six border crossings we examined are, from west to east, El Paso (1), Presidio (2), Del Rio (3),Eagle Pass (4), Laredo (5), and Brownsville (6). The regression equation for Model 2 is, therefore, defined as:

$$\ln MAADTT_{jt} = \beta_0 + \beta_1 \ln CPOP_{jt} + \beta_2 \ln AMTBX_h + \beta_3 \ln ATBX_t (1\text{-}6) + u_{it}$$

where:

$lnAMTBX_h$ = the approximate kilometers (miles) to the nearest border crossing for region h=1,...,10.;

$LnATBX_t\ (1\text{-}6)$ = the annual truck border crossings in year t (=1986-92) at each of the six border crossings.

Other variable specifications are the same as in Model 1.

Model 3 examines the effect of international trade on average annual daily truck traffic by highway. The dependent variable in this case is $\mathbf{MAADTT_{jtk}}$ in county **j**, year **t**, highway **k** (=1,..,20) on each of 20 separate highways/combinations of highways we identified as routes leading out of the border zone and/or across Texas and into other states. Again, by following each highway/route over the years 1986 to 1992, we take advantage of the panel nature of the data set. Since introducing all 20 highways into the regression model made it possible to estimate, we used 19 (n-1) highways with Hwy 20 as the referent group. The highways/routes were:

Hwy1 = I-10.	Hwy11 = U.S.87.
Hwy2 = I-20.	Hwy12 = U.S.90.
Hwy3 = I-35.	Hwy13 = SH114.
Hwy4 = I-40.	Hwy14 = I-10
Hwy5 = I-45.	Hwy15 = SH118
Hwy6 = U.S.59.	Hwy16 = U.S.281
Hwy7 = U.S.60.	Hwy17 = U.S.67 to I-30
Hwy8 = U.S.69.	Hwy18 = U.S.180 to U.S.80
Hwy9 = U.S.79.	Hwy19 = SH214 to SH385
Hwy10 = U.S.83.	Hwy20 = SH54 to U.S.90 to U.S.67

We ran a regression analysis for each individual highway and specified each equation as follows:

$$\ln MAADTT(1\text{-}20)_{jt} = \beta_0 + \beta_1 \ln CPOP_{jt} + \beta_2 \ln USXTM_t + \beta_3 \ln USMFM_t + u_{it}$$

where the variables are as specified before.

<u>Model 4</u> is similar to Model 2 and examines the effect of truck crossings at the Texas-Mexico border on **MAADTT$_{jtk}$** in county **j** and year **t**, <u>by highway **k** (=1,..,20)</u>. The regression is specified as:

$$\ln MAADTT(1\text{-}20)_{jt} = \beta_0 + \beta_1 \ln CPOP_{jt} + \beta_2 \ln AMTBX_h + \beta_3 \ln ATBX_t(1\text{-}6) + u_{it}$$

where the variables are specified as before.

Model 5 examines the effect of international trade on the number of truck border crossings at the six Texas-Mexico border crossings specified earlier. Here, the dependent variable is $\mathbf{ATBX_{jt}}$, the annual number of truck border crossings **j** (= 1, . . ., 6) in year **t** (= 1986-92). The regression equation is specified as:

$$\ln ATBX_t(1\text{-}6) = \beta_0 + \beta_1 \ln USXTMt + \beta_2 \ln USMFM_t + u_{it}$$

where the variables are specified as before.

4.2.4 Regression Results

Tables 4-2 through 4-6 show the regression results for each of the five models specified above, respectively. All variables are shown in natural logarithms, so regression parameter estimates can be viewed as elasticities, i.e., a one percent change in the independent variable causes an x-percent change in the dependent variable. Parameter estimates are shown in bold with the accompanying t-statistics in regular type[8].

As discussed earlier, Model 1 examines the effects of international trade, county population, and the economic effects of region and level of urbanization on mean annual values of daily truck traffic at count sites across the Texas highway network. The key coefficients, i.e., those on U.S. exports to Mexico (USXTM) and U.S. imports from Mexico (USMFM) are both statistically insignificant. That is, when we controlled for the effects of county population and the economic effects of region and level of urbanization on mean annual values of daily truck traffic in counties across the Texas highway network, there was no statistically significant relationship between dollar-valued measures of international trade and truck traffic. (See Table 4-2)

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[8] Complete regression results available from authors.

We also assumed that truck traffic varied by region. To capture this, we defined dummy variables for the ten regions defined above. The dummy variables for the ten-region scheme are statistically significant and positive for the Dallas-Fort Worth Metroplex, Upper East Texas (containing Longview, Marshall, and Texarkana), South East Texas (containing Beaumont-Port Arthur and Orange), the Gulf Coast region (containing Houston and Galveston) and Central Texas (containing Waco, Austin, and Temple-Belton-Killeen). Given that these are the major population centers of the state, this finding was not surprising.

However, neither the dummy variable for South Texas (containing San Antonio, Corpus Christi, and the international ports of entry of Brownsville, Laredo, Eagle Pass, and Del Rio) nor the dummy for the Upper Rio Grande region (containing El Paso and Presidio) were statistically significant. This is surprising, given the anecdotal evidence about levels of truck traffic generated by international trade in these Texas-Mexico border regions. Nevertheless, it is consistent with our finding that international trade has had no effect--up through 1992--on levels of truck traffic "downstream" from border areas.

We also assumed that truck traffic at a given site in a given county depended on the degree of urbanization of that county. We examined this using dummy variables for metropolitan counties and non-metropolitan counties varying from metropolitan level 1 (highest level of urbanization) to non-metropolitan level 9 (lowest level of urbanization). The county urbanization variables are all positive and statistically significant. As we expected, the magnitudes of the parameter estimates generally decrease from higher levels of urbanization (metropolitan areas) to lower levels of urbanization (rural areas). This means, not surprisingly, that higher levels of urbanization generate greater volumes of truck traffic.

TABLE 4-2: MODEL 1 - REGRESSION RESULTS

$\ln MAADTT_{jt} = \beta_0 + \beta_1 \ln CPOP_{jt} + \beta_2 \ln USXTM_t + \beta_3 \ln USMFM_t + \beta_4 \ln D\text{Region}_h + u_{it}$

Variable	Parameter Estimate	T-Statistic
Intercept	**4.552**	2.107
LnCPOP (County population)	**.162**	3.519
LnUSXTM (U.S. exports from Mexico)	**-.061**	-.090
LnUSMFM (U.S. imports from Mexico)	**.044**	.034
High Plains	**.003**	.029
Northwest Texas	**-.078**	-.732
Metroplex	**.288**	2.186
Upper East Texas	**.760**	5.869
Southeast Texas	**.857**	5.805
Gulf Coast	**.991**	6.703
South Texas	**.029**	.289
Central Texas	**.841**	7.106
Upper Rio Grande	**-.084**	-.498
Metropolitan Counties	**1.079**	5.496

Table 4-3 shows the regression results for regression Model 2. This equation examines the "downstream" effects on annual daily truck traffic on the Texas highway network of border truck crossings (ATBX) and approximate kilometers (miles) to border crossings (AMTBX). The parameter estimate on AMTBX is positive and significant, indicating that the further a county was from the Texas-Mexico border, the higher the traffic volume. This is intuitively satisfactory given that the further one moves away from the Texas-Mexico border, the closer one is to the major population centers of Texas.

TABLE 4-3: MODEL 2 - REGRESSION RESULTS

$\ln MAADTT_{it} = \beta_0 + \beta_1 \ln CPOP_{it} + \beta_2 \ln AMTBX_h + \beta_3 \ln ATBX_t(1\text{-}6) + u_{it}$

Variable	Parameter Estimate	T-Statistic
Intercept	**-12.311**	-.091
LnCPOP (County Population)	**.436**	20.529
LnAMTBX	**.314**	6.112
LnATBX1 (El Paso)	**-.184**	-.129
LnATBX2 (Presidio)	**.258**	.085
LnATBX3 (Del Rio)	**-.785**	-.118
LnATBX4 (Eagle Pass)	**-.351**	-.420
LnATBX5 (Laredo)	**.682**	.133
LnATBX6 (Brownsville)	**1.348**	.122

ATBX--the annual number of truck border crossings at six Texas-Mexico border crossings--is an alternative specification of our attempt to relate international trade to truck traffic. That is, we use the volume of truck border crossings as a proxy for U.S.-Mexican trade. This specification seems reasonable since a large portion of goods traded between Mexico and the U.S. occurs through Texas, and the vast bulk of that is carried by truck. As with the explicit trade variables in Model 1, however, none of the regression coefficients are significant. This indicated that truck traffic at none of the border crossing points had a signficant affect on downstream truck traffic volumes.

Table 4-4 shows the regression results for Model 3. Model 3 attempts to capture the effect of trade (USXTM and USMFM) on annual daily truck traffic by highway. Again, however, the effect of trade on truck traffic is elusive, or perhaps better said, illusory. *Neither of the trade variable parameter estimates were statistically significant on any of the 19 highway/routes we examined.*

TABLE 4-4: MODEL 3 - REGRESSION RESULTS

$\ln MAADTT(1\text{-}20)_{it} = \beta_0 + \beta_1 \ln CPOP_{it} + \beta_2 \ln USXTM_t + \beta_3 \ln USMFM_t + u_{it}$

Highway	Intercept Parameter Estimate T-Statistic	LnCPOP Parameter Estimate T-Statistic	LnUSXTM Parameter Estimate T-Statistic	LnUSMFM Parameter Estimate T-Statistic
LnHWY1	**7.407**	**.072**	**.501**	**-.542**
(I-10)	1.422	1.709	.299	-.169
LnHWY2	**4.047**	**.112**	**-.734**	**1.67**
(I-20)	1.907	4.523	-1.094	1.290
LnHWY3	**5.274**	**.251**	**.357**	**-.297**
(I-35)	1.274	4.988	.271	-.118
LnHWY4	**8.016**	**.015**	**.266**	**-.216**
(I-40)	7.598	1.648	.786	-.333
LnHWY5	**7.608**	**.047**	**-.066**	**.234**
(I-45)	9.382	4.545	-.254	.471
LnHWY6	**3.019**	**.337**	**-.208**	**.516**
(U.S. 59)	.729	6.407	-.157	.204
LnHWY7	**2.444**	**.379**	**-.453**	**.568**
(U.S. 60)	.554	9.468	-.321	.209
LnHWY8	**3.627**	**.236**	**-.453**	**.653**
(U.S. 69)	1.031	4.539	-.405	.304
LnHWY9	**4.467**	**.257**	**-.221**	**.169**
(U.S. 79)	2.127	7.467	-.331	.133
LnHWY10	**5.079**	**.286**	**.019**	**-.519**
(U.S. 83)	1.135	8.663	.013	-.189
LnHWY11	**5.191**	**.207**	**.128**	**-.303**
(U.S. 87)	1.080	4.989	.083	-.103
LnHWY12	**2.795**	**.290**	**-.652**	**.811**
(U.S. 90)	.771	6.729	-.562	.365

LnHWY13 **(SH114)**	**8.934** 1.410	**.151** 2.909	**1.246** .609	**-2.567** -.656
LnHWY14 **(I-10)**	**3.348** .826	**-.083** -.1.274	**-.359** -.277	**.738** .298
LnHWY15 **(SH118)**	**3.149** .558	**.305** 4.970	**-.097** -.054	**.263** .076
LnHWY16 **(U.S. 281)**	**-1.146** -.148	**.712** 9.125	**-.347** -.140	**.544** .114
LnHWY17 **(U.S 67 to I-30)**	**3.265** .719	**.187** 3.949	**-.766** -.527	**.949** .341
LnHWY18 **(U.S. 180 to U.S. 80)**	**-.346** -.078	**.149** 7.862	**-1.236** -.867	**1.859** .680
LnHWY19 **(SH214 to SH385)**	**-8.368** -1.345	**1.593** 6.050	**-.799** -.427	**.187** .052
LnHWY20 **(SH54 to U.S. 90 to U.S.67)**	**4.964** 1.498	**-.594** -7.189	**-1.255** -1.191	**2.452** 1.214

Table 4-5 shows the regression results for Model 4. Again, we examined "border effects"--truck crossings at the six Texas-Mexico border ports of entry (ATBX) and the distance of a given county's count and classification sites from those ports of entry (AMTBX)--but in this case we examined the effects by highway. As was the case in Model 2, we found positive and significant relationships for the coefficient of AMTBX. In this instance, we also found some negative relationships--indicating an increased amount of truck traffic on some highways closer to the Texas-Mexico border--although these were not statistically significant. Again, as in Model 2, we did not find any consistently significant relationships between truck traffic counts on any highway and the truck border crossing variable (ATBX).

TABLE 4-5: MODEL 4 - REGRESSION RESULTS

$\ln MAADTT(1\text{-}20)_{jt} = b_0 + b_1 \ln \mathit{CPOP}_{jt} + b_2 \ln \mathit{AMTBX}_h + b_3 \ln \mathit{ATBX}_t(1\text{-}6) + u_{it}$

	Intercept	LnCPOP (County Population)	LnAMTBX	LnATBX1 (El Paso)	LnATBX2 (Presidio)	LnATBX3 (Del Rio)	LnATBX4 (Eagle Pass)	LnATBX5 (Laredo)	LnATBX6 (Brownsville)
Highway	**Parameter** T-Stat	**Parameter** T-Stat	**Parameter** T-Stat	**Parameter** T-Stat	**Parameter** T-Stat	**Parameter** T-Stat	**Parameter** T-Stat	**Parameter** T-Stat	**Parameter** T-Stat
LnHWY1 **(I-10)**	**-3.635** -.012	**.009** .228	**.438** 3.712	**-.190** -.061	**.075** .011	**-.035** -.002	**.026** .014	**.244** .022	**.664** .027
LnHWY2 **(I-20)**	**101.214** .822	**.0888** 3.328	**.126** 2.70	**1.089** .838	**-2.072** -.755	**4.354** .723	**-.178** -.235	**-3.142** -.675	**-7.633** -.759
LnHWY3 **(I-35)**	**66.983** .309	**.143** 2.889	**.501** 5.203	**.648** .283	**-1.562** -.323	**3.378** .318	**.123** .092	**-2.444** -.298	**-5.117** -.289
LnHWY4 **(I-40)**	* *	* *	* *	* *	* *	* *	* *	* *	* *
LnHWY5 **(I-45)**	**86.854** 2.339	**.061** 7.147	**-.302** -5.249	**.869** 2.216	**-1.715** -2.073	**3.759** 2.068	**.238** 1.039	**-2.892** -2.060	**-6.343** -2.092
LnHWY6 **(U.S. 59)**	**40.523** .226	**.198** 4.835	**.678** 10.618	**.418** .221	**-.916** -.229	**1.380** .205	**-.206** -.187	**-1.251** -.184	**-2.989** -.204
LnHWY7 **(U.S. 60)**	* *	* *	* *	* *	* *	* *	* *	* *	* *
LnHWY8 **(U.S. 69)**	**-218.095** -1.022	**.219** 3.665	**-.282** -.628	**-2.439** -1.084	**5.015** 1.055	**-11.185** -1.071	**-1.084** -.825	**8.703** 1.079	**18.598** 1.068
LnHWY9 **(U.S. 79)**	**-54.897** -.439	**.265** 7.497	**-.173** 1.582	**-.718** -.545	**1.343** .482	**-3.221** -.526	**-.615** -.798	**2.565** .542	**5.281** .517

LnHWY10 **(U.S. 83)**	**-33.822** -.126	**.294** 8.028	**.069** .558	**-.512** -.181	**.756** .127	**-2.165** -.165	**-.512** -.310	**1.645** .162	**3.556** .162
LnHWY11 **(U.S. 87)**	**4.847** .020	**.228** 6.432	**.779** 7.592	**.022** .009	**-.073** -.014	**.249** .021	**-.030** -.020	**-.191** -.021	**-.324** -.016
LnHWY12 **(U.S. 90)**	**38.408** .180	**.231** 4.486	**.234** 2.112	**.363** .161	**-.572** -.12	**1.163** .111	**-1.119** -.852	**-.722** -.089	**-2.155** -.124
LnHWY13 **(SH114)**	**-171.452** -.476	**.122** 2.410	**2.177** 3.267	**-1.925** -.506	**3.433** .427	**-7.533** -.427	**.204** .090	**5.603** .411	**13.274** .451
LnHWY14 **(I-10)**	* *	* *	* *	* *	* *	* *	* *	* *	* *
LnHWY15 **(SH118)**	**75.013** .354	**.155** 3.78	**-1.104** -12.386	**.702** .315	**-1.375** -.292	**3.106** .3	**.183** .141	**-2.356** -.294	**-5.293** -.306
LnHWY16 **(U.S. 281)**	**-43.136** -.132	**.36** 5.522	**1.605** 10.424	**-.397** -.115	**.804** .110	**-2.053** -.128	**-.455** -.226	**1.631** .132	**3.289** .123
LnHWY17 **(U.S 67 to I-30)**	**-242.606** -.897	**.224** 3.474	**-.135** -.864	**-2.782** -.974	**5.379** .892	**-12.785** -.965	**-1.943** -.165	**10.076** .985	**21.205** .96
LnHWY18 **(U.S. 180 to U.S. 80)**	**-120.546** -.446	**.399** 6.798	**-.132** -.970	**-1.358** -.476	**2.861** .475	**-6.930** -.524	**-2.295** -1.378	**5.684** .557	**11.339** .514
LnHWY19 **(SH214 to SH385)**	**-105.949** -.257	**1.365** .441	**.183** .080	**-1.131** -.261	**2.567** .278	**-5.782** -.284	**-.789** -.293	**4.230** .269	**8.397** .247
LnHWY20 **(SH54 to U.S. 90 to U.S.67)**	* *	* *	* *	* *	* *	* *	* *	* *	* *

*** Indicates models which were not full rank**

Table 4-6 shows the regression results from Model 5. Again, we attempted to capture the effects of international trade on truck traffic. In this case, however, we used truck border crossings (ATBX) at the six international ports of entry specified above (El Paso, Presidio, Del Rio, Eagle Pass, Laredo, and Brownsville), as the dependent variable, and analyzed the relationship of border crossings by truck to our two dollar-valued international trade variables (USXTM and USMFM). Consistent with our expectations and with most anecdotal accounts, we did find statistically significant relationships between our two principal measures of international trade, USXTM and USMFM, and annual counts of truck crossings at the major ports of entry. We describe these relationships moving from west (El Paso) to east (Brownsville).

TABLE 4-6: MODEL 5 - REGRESSION RESULTS

$\ln ATBX_t(1\text{-}6) = \beta_0 + \beta_1 \ln USXTMt + \beta_2 \ln USMFM_t + u_{it}$

Border Crossing	Intercept Parameter Estimate T-Statistic	LnUSXTM Parameter Estimate T-Statistic	LnUSMFM Parameter Estimate T-Statistic
LnATBX1	**-3.583**	**-2.531**	**7.316**
(El Paso)	-8.884	-20.512	30.935
LnATBX2	**8.984**	**-.034**	**-.015**
(Presidio)	27.192	-.338	.078
LnATBX3	**4.376**	**.426**	**1.303**
(Del Rio)	21.194	6.739	10.756
LnATBX4	**8.057**	**.075**	**.663**
(Eagle Pass)	135.175	4.108	18.985
LnATBX5	**1.246**	**-1.253**	**4.612**
(Laredo)	5.785	-19.014	36.519
LnATBX6	**11.645**	**.499**	**-.337**
(Brownsville)	78.861	11.054	-3.892

At **El Paso**, variations in USXTM and USMFM by themselves explained slightly over 80 percent of variations in cross-border truck traffic. In this case, as USXTM increased by 1 percent, truck crossings decreased by 2.53 percent; as USMFM increased by 1 percent, truck crossings increased by 7.31 percent. Both of these findings were significant at the .0001 level. That is, based on classical statistical theory, there was only one chance in ten thousand that this relationship was random.

Presidio truck crossings were not statistically related to U.S.-Mexico trade flows. At **Del Rio**, variations in dollar-valued trade flows explained over 91 percent of the variation in cross-border truck crossings. Here, a 1 percent increase in USXTM led to a .4 percent increase in trans-border truck traffic, and as USMFM increased by 1 percent, truck crossings also increased by 1.3 percent. These findings were also significant at the .0001 level.

Similarly, at **Eagle Pass**, 95 percent of the variation in cross-border truck traffic was explained by dollar-valued trade flows. Truck crossing elasticities for 1 percent changes in USXTM and USMFM were both positive, at .07 and .66, respectively. This is, as USXTM and USMFM increased, so did truck traffic. These findings were also significant at the .0001 level.

At **Laredo**, over 91 percent of the variation in truck border crossings was explained by variations in U.S.-Mexico trade. In this case, 1 percent increases in USXTM resulted in 1.25 percent decreases in trans-border truck crossings, while 1 percent increases in USMFM resulted in 4.6 percent increases in truck crossings on the Laredo bridges. These findings were also significant at the .0001 level.

Finally, at **Brownsville**, about 65 percent of border truck crossings are explained by variations in dollar-valued trade flows. As USXTM increases by 1 percent, truck crossings increase by .49 percent; as USMFM increases by 1 percent, truck crossings decrease by .33 percent. These findings were also significant at the .0001 level.

4.2.5 Interpreting the Regression Results

At El Paso and Laredo, then, USXTM is negatively related to border truck crossings, while USMFM is positively related. In both of these cases, moreover, the magnitude of the positive relationship between U.S. imports from Mexico and border truck crossings is much higher than the negative relationship between U.S. exports to Mexico and border truck crossings. In Brownsville, on the other hand, the situation is reversed: USXTM are positively related to truck crossings, while USMFM are negatively related.

These are important findings in three ways. First, as of 1992, we cannot detect an effect of increased trade with Mexico on downstream truck traffic flows on the Texas highway network, i.e., those further away from the Texas-Mexico border zone. At some point in the near future--presumably some time after December of 1995, when Mexican trucks will be allowed to use U.S.-Texas highways for point-to-point deliveries in the four U.S. states along the Mexican border--this effect may be observable. Using the most recent data, however, it is currently not observable.

Second, there is a clear and very strong statistical relationship between international trade flows and truck crossings along the Texas-Mexico border. While this is not surprising, it provides robust statistical evidence for a relationship that up to this point had been based only on the suppositions of knowledgeable observers in the field.

Third--and this is perhaps most important--the direction of these relationships varies by the type of trade and by the border crossing for the three busiest international ports of entry--El Paso, Laredo, and Brownsville. The best available evidence indicates that in El Paso and Laredo, as exports to Mexico increased, truck traffic across the bridges decreased. It was only as imports from Mexico increased that cross-border truck traffic increased. In Brownsville, the situation was reversed: as exports to Mexico increased, so did cross-border truck traffic; as imports from Mexico increased, however, cross-border truck traffic decreased.

These findings suggest that a modal split was occurring in cross-border trade-related traffic. As southbound trade (exports to Mexico) moving through El Paso increases by 1 percent, apparently more than two-and-a-half times as much of that 1 percent increase in trade (2.53 percent) is moved by some mode of transport other than truck. At the same time, as northbound trade (imports from Mexico) moving through El Paso increases by 1 percent, more than seven times as much of that 1 percent increase in trade (7.31 percent) was carried by truck than by other modes.

At Laredo, the situation was the same as at El Paso, although the magnitudes of the relationships were smaller. As southbound trade increases by 1 percent, 25 percent more of that 1 percent increase (1.25 percent) in trade was being carried by some mode of transport other than truck. At the same time, as northbound trade increases by 1 percent, more than four-and-a-half times as much of that 1 percent increase in trade (4.6 percent) was being carried by truck than by other modes. At Brownsville, the situation was reversed, and the magnitudes of the relationships were much smaller than at both Laredo and El Paso.

Policy implications from these findings are:

(1) if the volume of trade flowing through Laredo is significantly higher than at both Brownsville and El Paso combined (and it is),

(2) then they suggest that if in the near future we again attempt to discern a significant positive effect of international trade on Texas highway truck traffic, we should focus our attention on northbound trade moving through Laredo, and to a somewhat

lesser extent on El Paso.[9]

And there is another important implication. We know, from the findings presented in Section 3.0 above, that U.S. imports from Mexico (i.e., northbound trade) now constitute a much smaller share of overall U.S.-Mexican trade than U.S. exports to Mexico. We also found that for the 1986-1992 period, at least, economic conditions in the two countries dictate that U.S. GDP growth relative to Mexican GDP growth created larger southbound trade than northbound trade.

But this southbound flow contains the seeds of a northbound turnaround. Current data on the composition of southbound trade, and our forecast of NAFTA effects on the Texas economy, both indicate that most of this trade is, and will for the next several years be composed of capital goods for Mexican manufacturing industry, and intermediate goods being traded between U.S.-based firms and their maquiladora affiliates. Economic theory, and the experience of the Newly Industrialized Countries (NICs) of East Asia over the last three decades tell us something about how we might expect this situation to evolve over the next two or three decades. Because it starts from a less-developed position, as Mexico imports technologically advanced capital goods from the U.S., its rate of productivity growth will be much higher than that of the U.S. We see this already in the maquiladora industries, where industry-wide growth of output per labor hour has been reported to be as much as eight percent annually. This is as much as four times higher than is common in U.S. manufacturing today.

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[9]Trade volumes moving through Brownsville and El Paso will undoubtedly continue to grow, but Laredo's share of the overall trade volume is not likely to change radically in the coming decade, given that it is geographically closer (and better linked) to Mexico's principal population and economic centers-of-gravity than are Brownsville and El Paso. Although the elasticity coefficient of northbound trade on border truck crossings in El Paso is greater than Laredo (7.31 versus 4.6), El Paso's share of trade is smaller. Therefore, the focus is on Laredo.

The combination of lower labor costs (which are likely to persist over the long-term), higher rates of productivity growth, and the infusion of the most advanced manufacturing technology means that Mexican producers of consumer goods will have a distinct cost advantage over their American counterparts for an indefinite period of time. Northbound trade flows over the next two decades are, therefore, likely to increase as a share of total U.S.-Mexico trade.

Whether increases in northbound flows will be as truck-dependent as they appear to have been for the 1986-1992 period is open to question. Other circumstances may intervene, including intermodal development in the U.S. and Mexican railroad industries. In this context, however, it is important to consider a transportation scenario that may develop after December 1995 and evolve into a mid- to long-term pattern.

East-west freight movements in Mexico are difficult to carry out because mountains divide the country roughly in two parts along a north-south axis. Consequently, east-west highway and rail links in Mexico are much less developed than north-south links. If the current situation prevails, and future increases in northbound trade are more heavily reliant on truck transport than other modes--as our findings suggest--it is likely that an increasing share of northbound Mexican truck traffic will come through Laredo and El Paso and use U.S. Interstate 10 as an east-to-west corridor for destinations in the four U.S. border states, the West and East Coasts of the United States, and most importantly, for east-to-west intra-industry shipments in Mexico itself.

After December 1995, then, we might expect to see increased numbers of Mexican trucks moving up Interstate 35 from Monterrey through Laredo to San Antonio, and from Chihuahua City and Juarez to El Paso, at which points both streams of traffic intersect with Interstate 10. They will then be able to move east or west, carrying finished manufactured goods bound for American markets, and intermediate goods in various stages of processing bound for destinations in Mexico, e.g., Monterrey and the maquiladora complexes along the Rio Bravo, Rio Grande, or to Tijuana and the Mexican ports along the Pacific Coast.

5.0 IMPACT ON TEXAS HIGHWAY NETWORK

5.1 DESCRIPTION OF HPMS

The Highway Performance Monitoring System (HPMS) is a computerized informational system developed by the Federal Highway Administration (FHWA). The HPMS analysis package was developed to meet requirements to make periodic estimates of the present condition of U.S. highways and future highway needs. FHWA presents comprehensive analysis of the status and needs of the nation's highway system to the U.S. Congress every two years. These reports, required by the U.S. Code, Title 23, Section 307, were first prepared in 1968 and have continued to the present. HPMS was designed to make those required condition and needs estimates. FHWA has also made available to the states the HPMS analysis package for use at the state level.

The input data for HPMS consists of inventory and condition data for a sample of highway sections selected to represent the highway system in the state. Each state collects and reports data to FHWA annually. All public roads are sampled except for the local functional class. The sample data consist of specific geometric and alignment items, physical condition data, and operational performance data (Federal Highway Administration, 1987). Work by TTI in Study 480 (Memmott, 1986), resulted in a substantial increase in the sample size in Texas, making it possible to make some needs estimates at the district level.

HPMS uses the data collected by the states in a series of computer programs that can provide an analysis of the current condition of the highway system as well as the needs in the future. Different levels of investment can also be analyzed and the impacts on the future condition can be simulated (Federal Highway Administration, 1986). There are four major models in the analysis process: the needs model, the composite index model, the investment performance model, and impact assessment model. In addition, two other models can be used within each funding period. These are the multiple deficiency model and the deferred cost model. The most important of these models are briefly described below.

The needs model simulates the improvements necessary to keep the physical and operational conditions of the highway system from falling below prescribed minimum criteria during the analysis period. The model goes through several steps, including: identifying individual highway section deficiencies which occur during the analysis period, determining the appropriate improvement to correct the deficiency, estimating the cost of improvement, and modifying the section record to reflect performance in the analysis year, with or without the improvement. Deficiencies are identified from a number of categories, including: peak hour operating speed or v/c ratio, lane width, shoulder width, pavement condition, horizontal or vertical alignment, and surface type. Improvements are made to design standards and can be constrained by widening restrictions, such as the maximum number of lanes.

The investment performance model provides a method to select improvements when there are not enough funds for all identified deficiencies to be corrected. Potential improvements are ranked using a cost-effectiveness index or one of the composite indexes. Improvements are selected from the top of the priority list downward until the funds are exhausted. The condition of the highway system at the end of the analysis period can then be compared to the condition if all deficiencies had been corrected, in order to identify the impacts of a less than fully funded highway investment program.

The impact assessment model converts existing and future highway physical and operating conditions into user costs. The estimated vehicle performance measures include: average overall travel speed, vehicle operating costs, fuel consumption, emissions, and accidents. Each of these measures are calculated based upon relationships and tables within the program, developed by FHWA or in conjunction with consulting contracts. The costs are calculated for seven vehicle types, with the exception of accident costs, given the physical and operational conditions for each highway segment.

A recent GAO study concluded that HPMS was adequate for making needs estimates at the national level, and provides a valuable tool for making an assessment of both the current condition of the highway system and the future needs over time (U.S. General Accounting Office, 1987).

5.2 IMPACT OF INCREASED TRUCK TRAFFIC ON TEXAS HIGHWAYS

The HPMS data set and analytical package were used to make estimates of the impact of increased truck traffic on the Texas highway network. An HPMS data set was created corresponding to the Texas highways most affected by NAFTA, as shown in the figure of Texas highways. This NAFTA impact highway network consists of 11,764 kilometers (7,307 miles) of highways, with 9,506 kilometers (5,904 miles) in rural areas, and 1,968 kilometers (1,403 miles) in urban areas. The 1992 HPMS data set was used for the analysis, the latest data available for the study. The expansion factors for the HPMS sample sections were recalculated to correspond to that network. It was not possible to maintain the sample estimates by district and each individual urban area. The sample is not valid for that level of estimation on this subset of Texas highways.

The impacts of increased truck traffic on Texas highways were simulated by increasing the percent trucks and total traffic volume in the HPMS data set for several scenarios. These scenarios correspond to increases in truck traffic on the NAFTA impact highway network by 10 percent, 25 percent, 50 percent, 75 percent, and 100 percent. The percent trucks was increased uniformly on all highway sections in the network. Since HPMS uses a sample, it was not possible to segregate the impacts within the network. Also, it was not possible to simulate the impact of heavier truck weights on the highway network; HPMS does not have an input data item corresponding to truck weight. There are also some categories of highway related impacts not estimated by HPMS, including bridge rehabilitation and replacement, intersection improvements, new interchanges, and bypasses around impacted towns. For those reasons, readers should view the impacts given below as conservative estimates. The combined impacts would be higher.

Table 5.1 presents the results of the analysis. The table shows the total estimated highway needs over the next 20 years for current conditions, and increases in truck traffic of 10, 25, and 50 percent. The analyses were run with four periods of five years for each period, with no budget constraint.[10]

The top section of the table shows the increase in vehicle kilometers traveled on the impact network over time and resultant increases in truck traffic. A significant increase in traffic volume is projected for the highway network. Daily vehicle kilometers traveled (DVKT) is projected to increase from 183 million DVKT to 282 million DVKT in 20 years, an increase of about 54 percent. With a 50 percent increase in trucks, the truck traffic would increase to about 295 DVKT, adding to the congestion and pavement needs of the network. The next sections in the table show the investment needs by period and category. The first period shows a much higher expenditure than subsequent periods because of the large backlog of deficiencies currently needing improvements on the network. The investment needs by category separates needs by rural/urban and by project type. The added capacity category includes reconstruct to freeway, reconstruct with more lanes, and major widening. The pavement category includes pavement reconstruction and resurfacing, and geometric improvements, such as lane widening, shoulder improvements, and alignment improvements. It should also be noted that when a capacity improvement is simulated in HPMS, pavement rehabilitation is also included.

The first scenario, a 10 percent increase in truck traffic, results in an increase in investment needs of about $66 million. All of that, plus $3 million used previously for pavements, would be needed for additional added capacity. Nearly all of that additional expenditure would be required in the first period in urban areas.

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[10] The complete summary output for each of these scenarios, along with increases of 75 percent and 100 percent are available from the authors.

The second scenario, a 25 percent increase in truck traffic, results in an increase in investment needs of about $250 million. Most of that increase, $187 million, would be required for additional pavement related needs. The additional needs would also be spread over both rural and urban areas, with about $76 million needed for rural areas.

The third scenario, a 50 percent increase in truck traffic, results in a dramatic increase in needs to about $782 million. Most of the needs are for capacity related improvements, $587 million, and $204 million for pavement related improvements.

For informational purposes, the 75 percent increase in truck traffic gives an increase in investment needs of $1,468 million, and the 100 percent increase in truck traffic gives an increase of $1,900 million.

TABLE 5.1 IMPACT OF INCREASED TRUCK TRAFFIC ON THE TEXAS HIGHWAY NETWORK

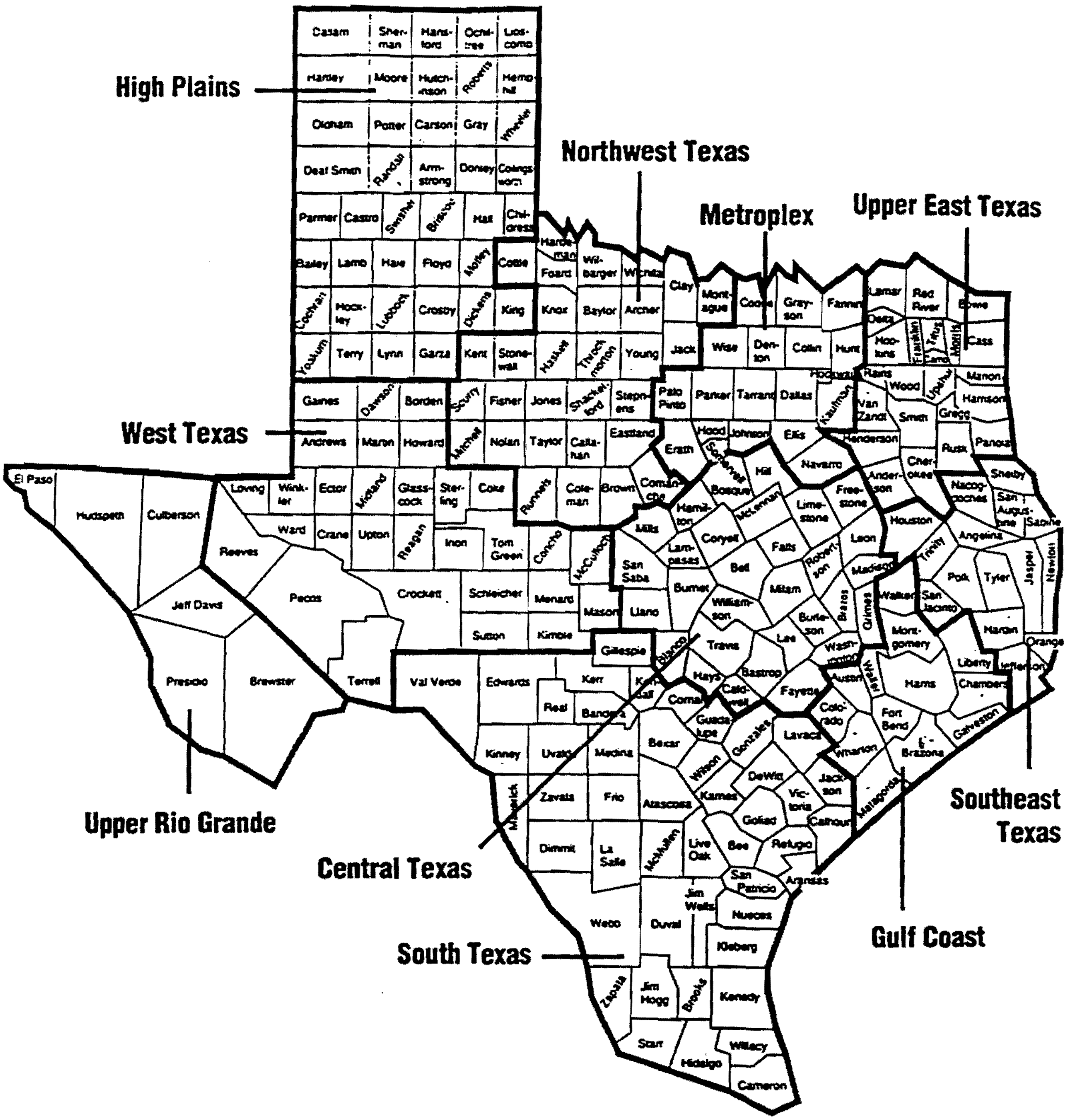
		Percent Increase in Trucks:		
	Current Conditions	10%	25%	50%
Daily Vehicle Kilometers (Miles)Traveled: (Millions)				
1992	184 (114)	184 (114)	184 (114)	184 (114)
1997	204 (127)	204 (127)	208 (129)	214 (133)
2002	227 (141)	230 (143)	232 (144)	238 (148)
2007	253 (157)	254 (158)	258 (160)	264 (164)
2012	282 (175)	283 (176)	288 (179)	295 (183)
Investment Needs (Million $)				
1993-1997	5,457	5,505	5,581	6,061
1998-2002	854	860	929	1,017
2003-2007	1,188	1,183	1,258	1,270
2008-2012	1,193	1,210	1,174	1,126
Total	$ 8,692	$ 8,758	$ 8,942	$ 8,474
Investment Needs by Category (Million $)				
Rural				
Added Capacity	986	987	1,028	1,222
Pavement	1,143	1,152	1,177	1,195
Total	2,129	2,139	2,205	2,414
Urban				
Added Capacity	5,248	5,316	5,269	5,590
Pavement	1,315	1,303	1,468	1,467
Total	6,563	6,619	6,737	7,057
Combined				
Added Capacity	6,234	6,303	6,297	6,812
Pavement	2,458	2,455	2,645	2,662
Total	8,692	8,758	8,942	9,474

APPENDIX A:

MAPS

FIGURE A.1:

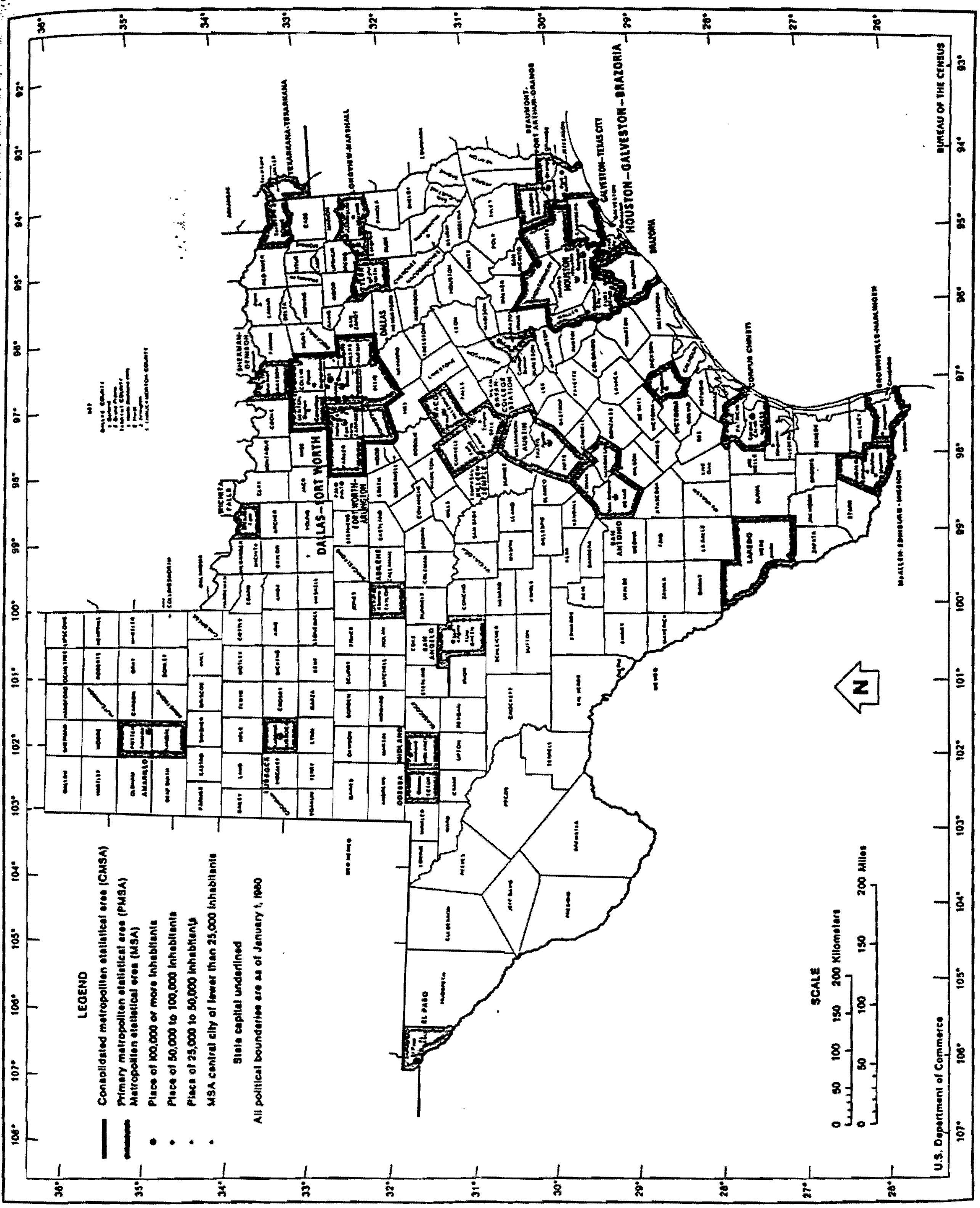
Uniform State Services Region Plan—10 Region Configuration



SOURCE: Texas Comptroller of Public Accounts

FIGURE A.2:

TEXAS - Consolidated Metropolitan Statistical Areas, Primary Metropolitan Statistical Areas, Metropolitan Statistical Areas, Counties, and Selected Places



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