Transportation Policy Brief #5

Intra-Industry Trade: Transportation Needs of Growing Texas Industries


texaswideopenforbusiness.com


cnet.com

Project Directors:

Michael Bomba, Ph.D., Adjunct Associate Professor
Lyndon B. Johnson School of Public Affairs
The University of Texas at Austin &
Associate Research Professor
Center for Logistics Education and Research
University of North Texas

Leigh B. Boske, Ph.D., Professor,
Lyndon B. Johnson School of Public Affairs,
The University of Texas at Austin

Robert Harrison, Deputy Director,
Center for Transportation Research,
The University of Texas at Austin

CENTER FOR LOGISTICS EDUCATION & RESEARCH
UNT

LBJ LYNDON B. JOHNSON SCHOOL OF PUBLIC AFFAIRS
THE UNIVERSITY OF TEXAS AT AUSTIN

CTR THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

Transportation Policy Brief #5

Intra-Industry Trade: Transportation Needs of Growing Texas Industries

CALLIE FLYNN
SARAH KLINE
AVERY SAXE

September 2015

Project Directors:

Michael Bomba, Ph.D., Adjunct Associate Professor
Lyndon B. Johnson School of Public Affairs
The University of Texas at Austin &
Associate Research Professor
Center for Logistics Education and Research
University of North Texas

Leigh B. Boske, Ph.D., Professor
Lyndon B. Johnson School of Public Affairs
The University of Texas at Austin

Robert Harrison, Deputy Director
Center for Transportation Research (CTR)
The University of Texas at Austin

POLICY RESEARCH PROJECT PARTICIPANTS

Students

- Samuel Biscaro, B.B.A. (Business Administration), B.S. (Political Science), University of Hawaii
- Martha Bohrt, B.B.A. (Marketing), University of North Texas
- Tracy Del Bianco, B.A. (Political Science), Boston University
- Robert E. Dolan, B.A. (Political Science), The University of Notre Dame
- Maia P. Draper, B.A. (Comparative Literature, Psychology), Stanford University
- Callie Flynn, B.S. (Economics), B.A. (Sociology), University of Nebraska-Lincoln
- Beatrice Halbach, B.A (Economics, Asian Studies), The University of Texas at Austin
- Jennifer Huffman, B.A. (Psychology), B.A. (Spanish), Texas Lutheran University
- Sarah Kline, B.S. (Economics), B.A. (Political Science, French), Texas Christian University
- Max H. Krupp, B.B.A. (Finance), The University of Texas at Austin
- Dylan Roberts, B.A. (Political Science), The University of Tennessee, Knoxville, M.A. (International Studies), Florida International University
- Avery Saxe, B.A. (International Studies, German), Butler University
- Maria Monica Villarreal, B.A. (Government, Latin American Studies), The University of Texas at Austin
- Victoria Wilson, B.A. (Philosophy, German), Colgate University

Project Directors

- Michael Bomba, Ph.D., Adjunct Associate Professor, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin;
Associate Research Professor, Center for Logistics Education and Research at the University of North Texas
- Leigh B. Boske, Ph.D., Professor, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin
- Robert Harrison, Deputy Director, Center for Transportation Research (CTR), The University of Texas at Austin

FOREWORD

The Lyndon B. Johnson School of Public Affairs at The University of Texas at Austin has established interdisciplinary research on policy problems as the core of its educational program. A major part of this program is the nine-month policy research project (PRP), in the course of which two or more faculty members from different disciplines direct the research of 10 to 20 graduate students of diverse backgrounds on a policy issue of concern to a government or nonprofit agency.

During the 2014–2015 academic year, the Texas Department of Transportation (TxDOT) supported a policy research project on manufacturing trends in Texas and Mexico, addressing six key policy issues. The project was a collaboration of the Center for Transportation Research (CTR) and the Lyndon B. Johnson School of Public Affairs at The University of Texas at Austin, and the Center for Economic Development and Research at the University of North Texas.

The research team interacted with TxDOT officials throughout the course of the academic year. Overall direction and guidance was provided by Mr. Marc Williams, Director of Planning for TxDOT. Mr. Williams participated in an October 10, 2014, workshop to determine the scope of the study. As a consequence, the following policy issues were selected for study:

1. Texas Manufacturing Competitiveness;
2. Reshoring in Texas;
3. Nearshoring in Mexico;
4. Inland Ports and Logistics Hubs;
5. Intra-Industry Trade; and
6. Implications of the Trans-Pacific Partnership on Transportation in Texas.

The findings of each policy issue are presented within the context of separate transportation policy briefs. This particular policy brief, "Intra-Industry Trade," was researched and written by Callie Flynn, Sarah Kline, and Avery Saxe.

ACKNOWLEDGEMENTS

This policy research project would not have been possible without the generous contributions of numerous individuals and organizations. For Policy Brief #5, we are especially grateful to:

- David Marquez, Executive Director, Bexar County
- Terry Pohlen, Associate Professor of Marketing and Logistics, University of North Texas

We are also very grateful and acknowledge the following TxDOT officials, transportation, and border trade experts for participating in weekly class presentations or scheduled interviews:

- Marc Williams, Director of Planning, Texas Department of Transportation (TxDOT)
- Caroline Mays, Manager – Freight Transportation Planning Branch, TxDOT
- Elisa Arias, Principal Regional Planner, San Diego Association of Governments
- Christina Casgar, Goods Movement Policy Manager, San Diego Association of Governments
- Jorge Garces, Director, International Relations Office, TxDOT
- Juan Villa, Program Manager, Texas A&M Transportation Institute
- Sarah Overmyer, Assistant Transportation Researcher, Texas A&M Transportation Institute
- Travis Black, Border Specialist, Federal Highway Administration (FHWA)
- Jay Bond, Legislative Liaison, State Legislative Affairs Division, TxDOT
- Ariana García Reyna, Esq., Director, Committee for Industrial Development of Nuevo Laredo
- Joseph Mendiola, Business Development Specialist, Laredo Development Foundation
- Daniel B. Hastings III, Vice-President, Daniel B. Hastings, Inc.
- Fatima P. Perez, Exports Manager, Daniel B. Hastings, Inc.
- Lic. René Gonzaléz de La Hoya, Director of Promotion - Industry, Trade, and Services, Secretary of Economic Development – Nuevo Laredo
- Gonzalo Prida, Executive Vice-President, Association of Laredo Forwarding Agents
- Mario Maldonado, Bridge Manager, Laredo International Bridge Systems
- Mike Garza, U.S. Customs & Border Protection Officer, U.S. Customs & Border Protection - Free and Secure Trade Office

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This policy paper describes the changing nature of international trade and its impact on the Texas economy and Texas's transportation infrastructure. It focuses on automobile manufacturing, which is a growing Texas industry that relies heavily on intra-industry trade (IIT) during the manufacturing process to maintain its competitive advantage.

IIT represents the trading of goods between two countries within the same industry. Horizontal IIT is the simultaneous export and import of goods classified in the same sector and at the same stage of production. Vertical IIT is the simultaneous export and import of goods classified in the same sector but at different stages of production, representing a global value chain (GVC). Firms use GVCs to optimize production processes and firm competitiveness by adding value to the good at different stages of production in various locations. As a result, a good may cross the border more than once.

IIT exists because of preferences, economies of scale, and political economy. IIT allows manufacturers to produce goods in a collaborative manner across borders while specializing in different aspects of the production process, which results in a cost advantage for both nations. As countries continue to eliminate barriers to trade and companies continue to formalize GVC networks, IIT will increase, leading to cost reductions and economic gains for participating industries.

The automobile industry is a prime example of an IIT relationship between the United States and Mexico. Since 2008, the Texas-Mexico Automotive SuperCluster (TMASC) has supported industry coordination and expansion between Texas and Mexico. TMASC supports a network of suppliers at different stages of production and increasingly, suppliers are relocating to Texas and Mexico. Most final assembly plants use just-in-time processes, requiring extensive cross-border supply chain coordination.

In 2014, the automobile industry cited rail congestion as a significant problem in Texas-Mexico trade. Other sources indicate reliable border crossing wait times would benefit the automobile industry, but the extent remains unknown. Finally, Texas's growing finished vehicle imports from Mexico will continue to affect rail efficiency. Because most finished vehicles travel by rail, a widening trade gap means that Mexico is increasingly sending full railcars north with no return shipments south.

The growth of IIT and the spread of production using GVCs present both transportation planning challenges and economic opportunities for Texas. Transportation policies that attract IIT-heavy industries, such as the automobile, electronics, and aviation industries, can foster the development of advanced manufacturing in Texas. To support the needs of these manufacturers, the Texas Department of Transportation (TxDOT) should consider the following:

- Making strategic investments in transportation infrastructure to further encourage industries like the automobile industry to expand within corridors along the Texas-Mexico border;
- Increasing capacity for freight along major manufacturing corridors like IH-35, including truck-only toll lanes; and
- Consolidating rail flows at smaller-scale logistics hubs to promote last-mile efficiency.

INTERNATIONAL TRADE

The United States is the largest trading nation in the world. In 2013 alone, the U.S. exported and imported $2.3 trillion worth of goods and services.[1] The U.S.'s top three export partners were Canada, Mexico, and China (respectively), which collectively represented 41 percent of total U.S. exports in 2013. The U.S.'s top three import partners were China, Canada, and Mexico (respectively), representing 46.4 percent of total U.S. imports in 2013.[2] Yet, many of these goods traded across borders (particularly with Canada and Mexico) are not necessarily final products. In fact, 56 percent of global trade between nations was at the intermediate level of production in 2006.[3] It is not just final products like computers, clothing, and automobiles that are traded, but also subcomponents of goods like semiconductors, textiles, and chassis.

To facilitate greater trade, countries may choose to integrate economically, which helps to eliminate trade discrimination. Economic integration between two nations occurs on a continuum from free trade area on the most limited scale, to a customs union, to a common market, to an economic union, and finally complete economic integration.[4] To achieve greater economic integration in North America, Canada, the United States, and Mexico created the North American Free Trade Agreement (NAFTA), which celebrated its 20th anniversary in 2014. NAFTA facilitated trade in the region, but stopped short of a more intertwined relationship.

The State of Texas shares a 1,241-mile boundary with Mexico.[5] Texas and Mexico not only share geographic, historic, and cultural ties, but also significant economic and trade ties. In 2013, Texas was the largest goods exporting state in the United States, with a significant portion of those goods headed to Mexico. During 2013, Texas exported $279.5 billion worth of goods globally, representing 18.2 percent of Texas's GDP; $100.9 billion worth of goods, 36 percent of total exported goods, were exported to Mexico. Texas also exported $26.1 billion worth of goods to Canada, followed by $10.9 billion worth of goods to Brazil and $10.8 billion worth of goods to China. Overall, 60 percent of goods exported from Texas go to 20 countries with which the United States has Free Trade Agreements. The majority of goods exported from Texas come from nine major metropolitan areas in Texas (see Table 1): Houston, the Woodlands, Sugar Land; Dallas, Fort Worth, Arlington; San Antonio, New Braunfels; El Paso; Austin, Round Rock; Beaumont, Port Arthur; Laredo; McAllen, Edinburg, Mission; and Brownsville, Harlingen.[6]

---

[1] Office of the U.S. Trade Representative, "Benefits of Trade."
[2] U.S. Census Bureau, "Top Trading Partners – December 2013."
[3] Miroudot, Lanz, and Ragoussis, "Trade in Intermediate Goods and Services," 5.
[4] Balassa, *The Theory of Economic Integration*, 1-2.
[5] Beaver, "U.S. International Borders: Brief Facts," 2.
[6] Ibid.

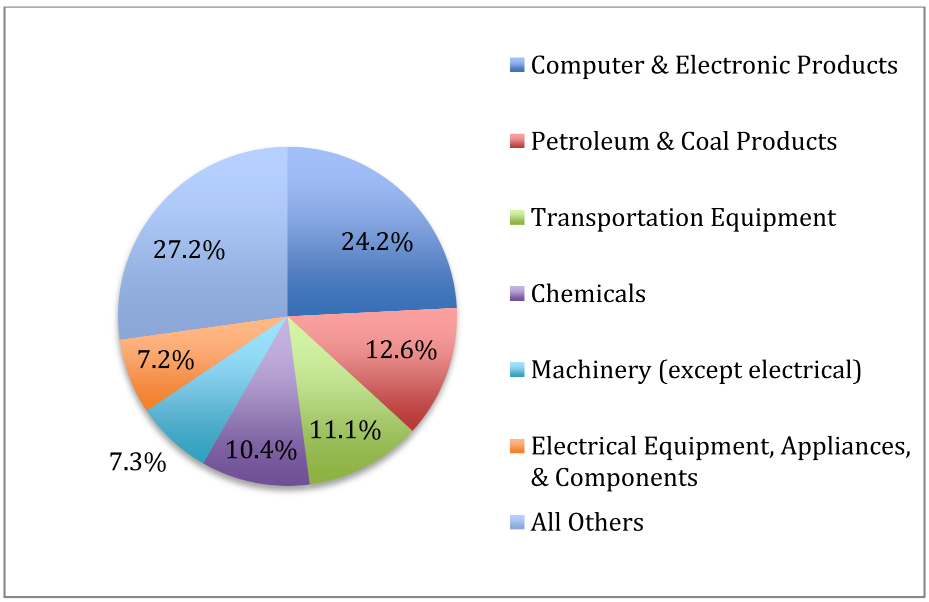
Table 1. Value of Exports by Texas Metropolitan Areas in 2013

Texas Metropolitan Area	Goods Exported (2013)
Houston, the Woodlands, Sugar Land	$115.0 billion
Dallas, Fort Worth, Arlington	$27.6 billion
San Antonio, New Braunfels	$19.3 billion
El Paso	$14.4 billion
Austin, Round Rock	$8.9 billion
Beaumont, Port Arthur	$8.2 billion
Laredo	$5.6 billion
McAllen, Edinburg, Mission	$5.3 billion
Brownsville, Harlingen	$4.6 billion

Source: Office of the U.S. Trade Representative, "United States."

If the Texas and Mexico economies were combined, they would represent the sixth largest economy in the world,[7] and these economies are only strengthened by the interplay between the two. In 2014, Texas's exports to Mexico totaled approximately $103 billion (see Figure 1) and its imports were approximately $90 billion (see Figure 2).[8]

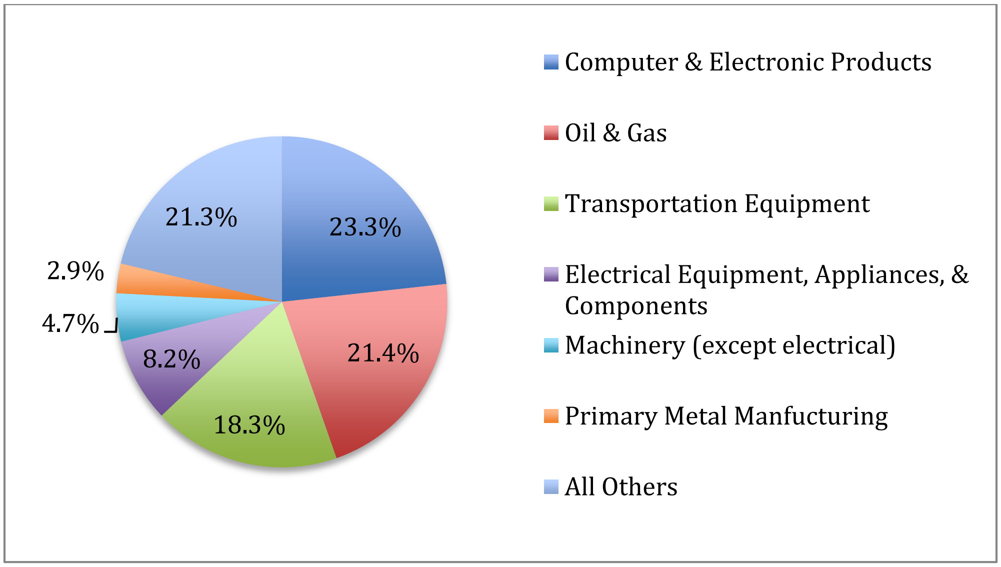
Figure 1. Texas Exports to Mexico by Type, 2014



Source: U.S. International Trade Administration, "Product Profiles of U.S. Merchandise Trade."

[7] Gresham, "Mexico as a Growing Market and Powerhouse."
[8] U.S. International Trade Administration, "Import Product Profile from a Selected Market."

Figure 2. Texas Imports from Mexico by Type, 2014



Source: U.S. International Trade Administration, "Product Profiles of U.S. Merchandise Trade"

Generally, it is estimated that there were 1.1 million export-related jobs in Texas in 2013. During that same year, 26.1 percent of Texas's manufacturing jobs were supported by the export activities. In 2013, the five largest manufacturing industries in Texas related to exports were petroleum and coal, electronics, chemicals, machinery, and transportation equipment. These five industries represented 81 percent of Texas's global manufacturing exports of $260.8 billion during 2013.[9]

TYPES OF TRADE

Trade is the exchange of goods and services between two entities, whether individuals, firms, or countries. The exchange of goods and services can take two distinct forms: inter-industry trade and IIT. Inter-industry trade represents the trade of goods and services in different industries. An example of inter-industry trade is Country A exporting textiles to Country B and importing wheat from Country B. In contrast, IIT represents the trade of goods and services in the same industry. An example of IIT is Country A exporting hard drives to Country B, while Country B imports semiconductors from Country A.

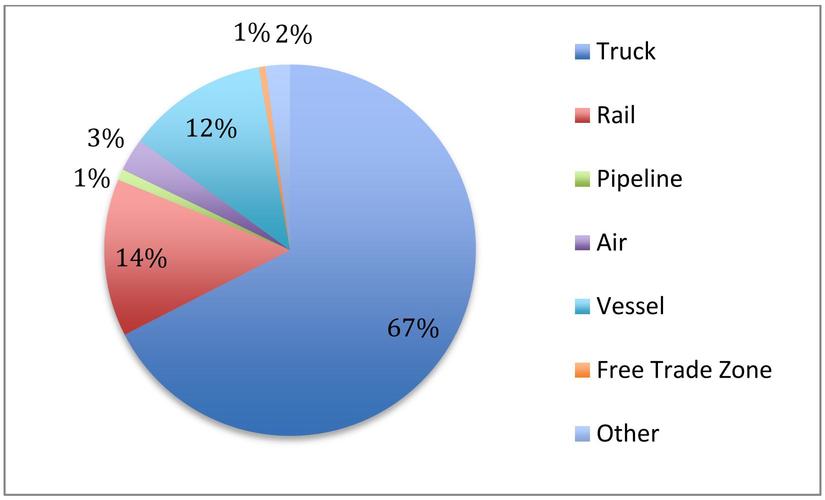
Inter-industry trade has typically been the focus of economic models, wherein comparative advantage and labor and capital abundance determines the types and volumes of trade. Yet, starting in the 1960s, economists began to recognize IIT and its potential to change the production of goods as well as the supply chain.[10]

[9] Office of the U.S. Trade Representative, "United States."
[10] Krugman, "The Rise of Intra Industry Trade."

TRADE AND TRANSPORTATION

It is commonly accepted that trade is positive for an economy. For producers, trade creates a larger market and allows them access to raw materials they may not be able to acquire domestically; for consumers, trade creates more options (or even availability) at lower costs. But the practice of international trade is not solely a business transaction and an economic policy. For trade to occur, there are significant logistical concerns that firms must address. One such concern is how to get a traded good from one country to another. For trade between the United States and Mexico in 2014 (January–November), surface modes of transportation (truck, rail, and pipeline) conveyed 82.2 percent of all traded goods (see Figure 3). Additionally, surface mode transportation in 2014 (January–November) saw an 8.2 percent increase from 2013 in the indexed value of goods being transported.[11]

Figure 3. U.S.-Mexico Trade Value by Mode of Transportation, January–November 2014



Source: U.S. Department of Transportation, "North American TransBorder Freight Data: Indexed Data."

INTRA-INDUSTRY TRADE

There are two types of IIT: horizontal IIT and vertical IIT. Horizontal IIT is the simultaneous export and import of goods classified in the same sector and at the same stage of production. An example of horizontal IIT is Country A exporting cheddar cheese to Country B and importing parmesan cheese from Country B. Vertical IIT is the simultaneous export and import of goods classified in the same sector but at different stages of production. An example of vertical IIT is Country A exporting airplane propellers to Country B and importing airplanes from Country B.

[11] Ibid.

Economists often cite three reasons for the occurrence of IIT. The first reason is preferences. Not all goods are the same. Consumers can differentiate goods by various methods, such as price, quality, and brand. IIT provides both a demand and supply of goods in a specific market. Preferences are specifically important in horizontal IIT. As the world becomes more globalized and there is a greater movement of populations, individuals prefer a variety of goods and services from around the world, not just from their current location.

The next reason is economies of scale. Economics defines economies of scale as a "situation in which output can be doubled for less than a doubling of cost."[12] Economies of scale occur as a result of the size, output, or scale of production. IIT allows companies or factories to specialize in certain goods, thereby decreasing costs and creating economies of scale.

The third reason is political economy. In traditional models of trade like the Ricardian model, the existence of an industry depends on comparative advantage. As a result of the opening of a country to trade, industries may shrink or disappear if the industry is unable to compete. Therefore, firms and workers have an incentive to block trade agreements that may result in a decline in their industry. However, IIT mitigates this fear of lost jobs and production. Industries are not destroyed by IIT, but instead they become more specialized. IIT allows countries and businesses to expand their markets and become a part of the global supply chain, while also maintaining their industrial sector.

MEASURING INTRA-INDUSTRY TRADE

The main index used to estimate the amount of IIT is the Grubel-Lloyd Index, which is calculated using the equation in Figure 4. This index is calculated by subtracting the absolute value of exports minus imports over exports plus imports from 1. A value of zero represents pure (unidirectional) inter-industry trade, while a value of one represents pure IIT.[13] There are various other indices used to measure IIT, but unfortunately, there are neither exact data nor indices for IIT due to the difficulty of counting, collecting, and categorizing trade data.

Figure 4. Grubel-Lloyd Index

$$1-\frac{|X-I|}{X+I}$$

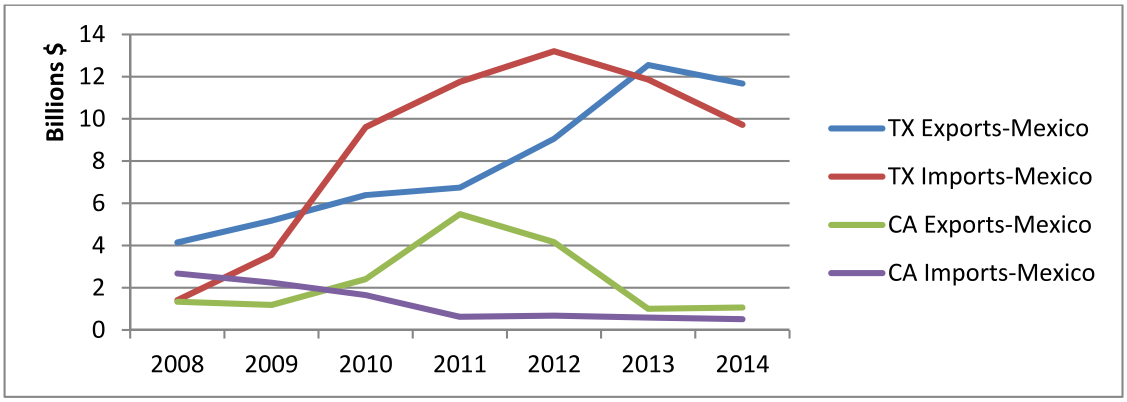
X=Exports
I=Imports

To facilitate collection, analysis, and publication, various standards of classification for data are employed. The U.S. Economic Classification Policy Committee, Statistics Canada, and the

[12] Pindyck and Rubinfeld, *Microeconomics,* 255-256.
[13] Grubel and Lloyd, "The Empirical Measurement of Intra-Industry Trade," 496.

Instituto Nacional de Estadística y Geografía of Mexico developed the North American Industry Classification System (NAICS).[14] Using trade data with NAICS classifications, the Grubel-Lloyd Index can be calculated for various countries and states. The following figure and tables are examples of a graphical representation of trade in the NAICS category 3341, computer equipment (see Figure 5), as well as calculated Grubel-Lloyd indices for NAICS category, 334 computer and electronic products (see Tables 2 and 3).

Figure 5. Value of NAICS Category 3341 Computer Equipment in Billions, by Year from 2008 to 2014 (January–November)



Source: U.S. Census Bureau, "State Imports and Exports by NAICS Commodities: 2008-2014."

Table 2. Grubel-Lloyd Index for NAICS Category 334 Computer and Electronic Products for Texas-Mexico and California-Mexico, January–November 2014

Product	TX-Mexico	CA-Mexico
3341 Computer Equipment	0.9086	0.6518
3342 Communications Equipment	0.9997	0.4647
3343 Audio and Video Equipment	0.5324	0.2834
3344 Semiconductors and Other Electronic Components	0.2564	0.8565
3345 Navigational/Measuring/Medical/Control Instrument	0.9026	0.7171
3346 Magnetic and Optical Media	0.2255	0.7666

Source: U.S. Census Bureau, "State Imports and Exports by NAICS Commodities: 2008-2014."
Note: A value of 0 = pure inter-industry trade while a value of 1 = pure IIT.

[14] U.S. Census Bureau, "North American Industry Classification System (NAICS)."

Table 3. Grubel-Lloyd Index for NAICS Category 334, Computer and Electronic Products, for Texas-Mexico, Texas-Canada, and Texas-China, January–November 2014

Product	TX-Mexico	TX-Canada	TX-China
3341 Computer Equipment	0.9086	0.1117	0.2190
3342 Communications Equipment	0.9997	0.2966	0.4576
3343 Audio & Video Equipment	0.5324	0.0335	0.1183
3344 Semiconductors & Other Electronic Components	0.2564	0.4746	0.7015
3345 Navigational/Measuring/Medical/Control Instrument	0.9026	0.4567	0.6720
3346 Magnetic & Optical Media	0.2255	0.1602	0.8309

Source: U.S. Census Bureau, "State Imports and Exports by NAICS Commodities: 2008-2014."
Note: A value of 0 = pure inter-industry trade while a value of 1 = pure IIT.

For example, there was a high degree of IIT of NAICS category 3341, computer equipment, between Texas and Mexico in January–November 2014, whereas there was a high degree of inter-industry trade of this equipment between Texas and Canada in the same time period. Therefore, depending on the trading partners (at the U.S. state and country level) and the industry, the characterization of trade as IIT or inter-industry trade will vary.

In addition, for NAICS category 3342, communications equipment, in January–November 2014, Texas-Mexico trade represented almost pure IIT while California-Mexico trade in this same industry represented neither pure IIT nor pure IIT. Yet, Texas trade in this industry will not always represent IIT. When trading with Canada, Texas trade in this industry represented inter-industry trade in January–November 2014; and when trading with China, Texas trade in this industry was neither pure IIT nor inter-industry trade in this time period. As such, one should not assume that trade in a specific industry will be the same across countries and states. All in all, IIT characterized Texas-Mexico trade in January–November 2014 in NAICS category 3341 (computer equipment), category 3342 (communication equipment), and category 3345 (navigational, measuring, medical, and control instruments). Additional Grubel-Lloyd Indices for industries are provided in Appendix 2.

INTRA-INDUSTRY TRADE AND GLOBAL SUPPLY CHAINS

Vertical IIT represents the global supply chain in action. It also represents the GVC in action. Though distinct concepts (supply chains focus on cost and efficiency while value chains focus on added value in the eyes of consumers), both represent the flow of goods and services at various stages of production from the supplier to the consumer.[15] A good then may cross the border more than once. Border delays, security issues, transportation congestion and costs, and infrastructure constraints all limit the effectiveness and profitability of a global supply chain.[16] If the existing barriers were reduced or eliminated, these changes would increase world GDP by 5 percent and total trade volume by 15

[15] Feller, Shunk, and Callarmah, "Value Chains Versus Supply Chains," 1-2.
[16] U.S. Chamber of Commerce, "Steps to a 21st Century U.S.-Mexico Border," 5.

percent.[17] Even with the current limitations, fragmentation and segmentation of the global supply chain continues. However, global supply chains are actually regional and not global. Rather than a good moving around the world for different stages of production, the good moves around the region for different stages of production.[18] Yet, how do these chains work?

There are five main forms of governance for GVCs: markets, modular, relational, captive, and hierarchical. The **markets** type occurs as a result of continued market interactions and linkages between business and firms, with a low cost for switching a good bought from one firm to a competitor. The **modular** type occurs when a firm makes a product to the specifications of the client. The **relational** type is similar to the modular type, but it depends on the reputation, proximity, and ties between the firms. Substituting one product with another may be easy or complex, depending upon situational issues. The **captive** type of GVCs occurs when a large firm significantly monitors and controls the smaller firms, creating thicker and less easily broken linkages. This arrangement is frequently found in the automobile industry, where the manufacturer has deep influence over the activities of the suppliers. Finally, the **hierarchical** type is defined by vertical integration and managerial control in the firms.[19]

Currently, there is a push for better information regarding global supply chains. Though global supply chains are a business advancement, they could be improved if information was shared among firms and steps were taken to minimize the environmental effects of the global supply chain.

GLOBAL SUPPLY CHAINS AND TEXAS INDUSTRIES

The global supply chain model and IIT have become critical to growing Texas's advanced manufacturing, including automobile, aerospace and aviation, and electronics. Although supply chain requirements and structures vary among these industries, all three rely on IIT to operate in Texas. IIT allows companies to balance production costs and requirements with transportation needs, quality control, risk management, and responsiveness to customer demand.

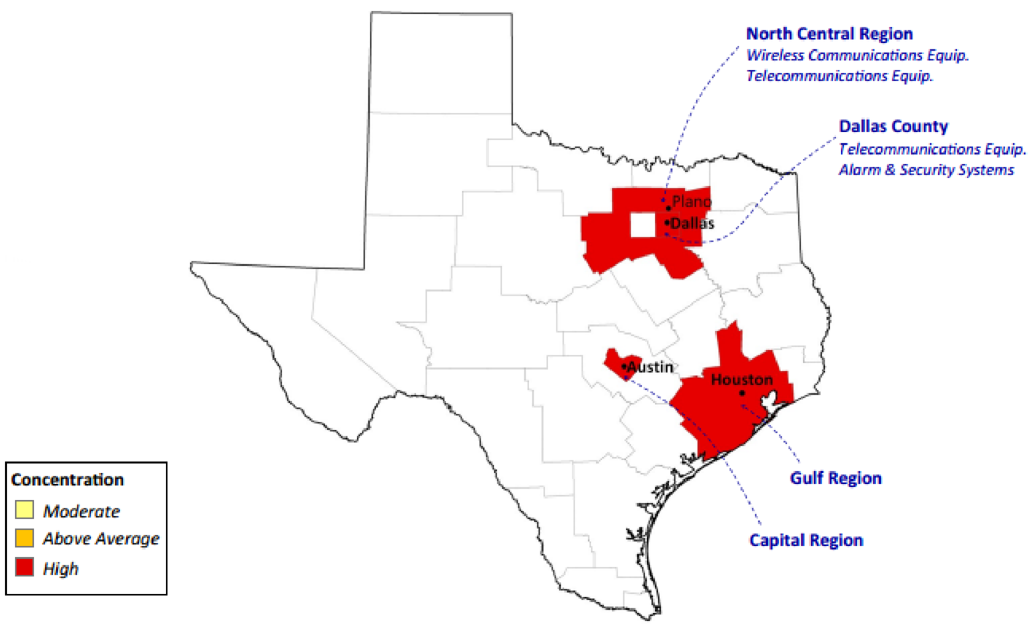
Electronic and high tech manufacturing represent a rapidly growing sector of the Texas economy. As of 2012, these industries were responsible for 285,000 Texas jobs.[20] Employment projections by the Texas Workforce Commission predict there will be 21 percent job growth in these industries by 2022.[21] This sector's growth is reinforced by Texas's current economic development policy of recruiting more electronic industry companies to the state. A 2015 report by the Governor's Office of Economic Development

[17] World Economic Forum, *Enabling Trade: Valuing Growth Opportunities*, 4.
[18] Baldwin, "Global Supply Chains," 20.
[19] Gereffi, Humphrey, and Sturgeon, "The Governance of Global Value Chains," 83-84.
[20] Texas Workforce Commission, "Tracer Future Job Growth by Occupations."
[21] Ibid.

boasts that there were 15 major high tech relocations to Texas in 2014, including the first phase of the Apple Americas Operation Center and a new HID Global headquarters and manufacturing facility.[22] Many of these companies were actively recruited using financial incentives from the Texas Enterprise Fund,[23] demonstrating the state's investment in expanding advanced manufacturing.

Electronics manufacturing in Texas involves a number of sub-industries that include communications device manufacturing, computer manufacturing, computer systems design, electrical equipment and instrument manufacturing, and device repair and maintenance (see Figure 6).

Figure 6. Communications Equipment Manufacturing in Texas



Source: Texas Wide Open for Business, "Texas Electronics Industry."

These sub-industries take advantage of a global supply chain model due to the varying skill requirements and cost drivers associated with producing different components of a single device. For example, companies such as Samsung[24] and Flextronics[25] currently produce cell phones and telecommunications devices in the Dallas/ Fort Worth area. Dallas locations import technical components manufactured in China and plastic cases and basic exterior components made in countries such as Mexico. The Dallas plants assemble components into the final devices on-demand (i.e., as domestic customers place orders). After the sale, customers can also return any defective products to the company's tech support centers in the area, promoting customer satisfaction. Using this global supply chain, electronics

[22] Texas Wide Open for Business, "Big Stories from Texas 2014."
[23] Texas Wide Open for Business, "Texas Electronics Industry."
[24] Samsung, "Samsung Electronics America."
[25] Flextronics, "Global Locations."

companies take advantage of low-skilled, low-cost labor for simple parts (cell phone exterior), high skilled but relatively cheap labor from China for electronic assembly, and a strategic location close to the product's U.S. market for quick fulfillment of customer orders and the repair of malfunctioning devices.[26]

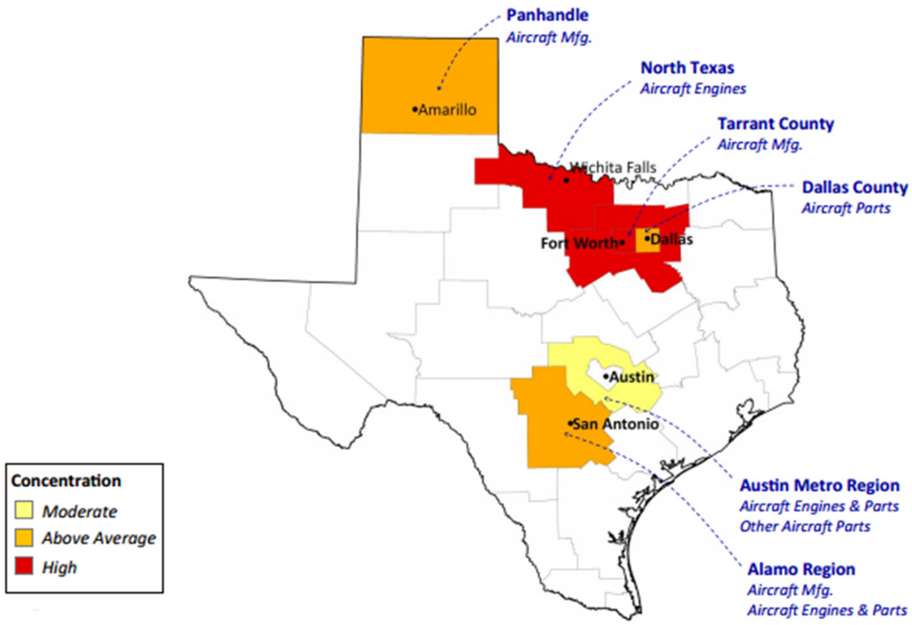
Another key economic sector, aerospace and aviation manufacturing, currently employs almost 52,000 Texans at 176 firms (see Figure 7).[27] Although a recent study released by the governor's office reports minimal job growth in this industry between 2009 and 2014, the state's economic development policy includes plans to recruit aerospace investment to Texas.[28] For example, the Office of Aviation, Aerospace, and Defense within the Governor's Office of Economic Development recently distributed $15 million through the Spaceport Trust Fund (funded by the Texas Enterprise Fund), including $2.3 million to recruit SpaceX to build a new spaceport in Brownsville and $13 million to the Cameron County Spaceport Development Corporation to support the development of spaceport infrastructure. The SpaceX spaceport is expected to bring 300 new jobs to the area.[29]

Due to the complexity and high cost of production, aerospace and aviation manufacturing firms rely on IIT to stay competitive. Each individual aircraft can include thousands to millions of component parts that must be precisely manufactured to ensure the quality and on-time delivery of the final product. With these requirements, an IIT supply chain model allows aerospace manufacturers to utilize skilled U.S. labor for high-tech and major components, tier one manufacturing, and assembly, while still paying competitive prices for tier two, sub-component parts.[30] For example, the Boeing 747-8 consists of approximately six million component parts manufactured by 550 suppliers in 30 countries.[31] IIT also supports airline profitability under its demand-driven manufacturing process. While traditional supply chains create potential for delays if problems occur in any one stage of production, the disaggregated, cross-border supply chain also allows the industry greater flexibility to ensure they deliver products on schedule.[32]

---

[26] Pohlen interview.
[27] Texas Wide Open for Business, "The Texas Aerospace & Aviation Industry."
[28] Ibid.
[29] Texas Wide Open for Business, "Gov. Perry Helps Break Ground."
[30] Pohlen interview.
[31] Mayer, "Supply Chain Metrics."
[32] Becks, "Addressing Supply Chain Challenges."

Figure 7. Texas Aerospace Product and Parts Manufacturing



Source: Texas Wide Open for Business, "The Texas Aerospace & Aviation Industry."

Finally, automobile manufacturing is a rapidly growing and heavily promoted Texas industry that uses the IIT model. The automobile industry also includes the sub-industries of auto parts, auto body, and final vehicle assembly. The Texas Workforce Commission expects that auto manufacturing jobs will grow by 17 percent from 2012 to 2022, from approximately 20,000 jobs in 2012 to 23,500 jobs in 2022. As is discussed in the following case study, the Texas auto manufacturing industry relies on complex supply chains that extend from Dallas to Central Mexico to produce trucks and heavy machinery at competitive prices.

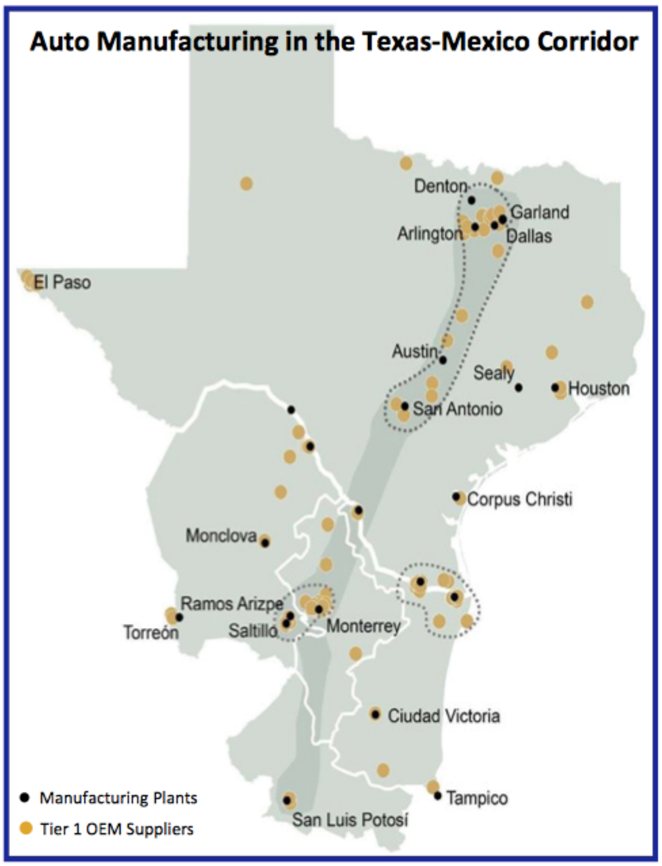
TEXAS-MEXICO AUTOMOBILE TRADE: AN INTRA-INDUSTRY TRADE CASE STUDY

Texas's auto industry is a truly GVC, increasingly interconnected with Mexico and shipping vehicles worldwide. The auto manufacturing supply chain consists of firms at multiple production levels. First, tier three producers supply raw materials (such as steel and plastic resins) to tier two firms. Next, tier two firms manufacture specialized inputs for tier one firms, such as die casts or stamped parts. Finally, tier one firms manufacture functional car components—such as steering systems and air conditioning units—that are supplied to final car manufacturers such as Toyota.[33] Increasingly, firms at all levels of production are re-locating to Mexico, and to a lesser extent, Texas. Relocating close to the strong North America car sales market mitigates transportation risks and controls wages, offering firms competitive advantages.

[33] ProMexico, "The Auto Parts Industry."

Since 2008, TMASC has supported bi-national industry coordination and expansion between Texas and Mexico. The TMASC is comprised of manufacturers in Texas, Tamaulipas, Nuevo León, Coahuila, and San Luís Potosí (see Figure 8). Currently, 27 auto manufacturing and assembly plants and 230 original equipment manufacturers (OEMs) operate within the TMASC region. Texas's two largest passenger vehicle assembly plants are General Motors (GM) in Arlington and Toyota in San Antonio. GM produces sport utility vehicles and Toyota produces a full-size and a mid-size pickup truck model.[34] Texas is also home to many heavy-duty truck manufacturers, including Peterbilt Motors, construction equipment manufacturers (such as Caterpillar), and military vehicle manufacturers. Most manufacturers locate along the NAFTA highway but purposefully maintain distance from other suppliers to reduce competition for skilled labor.[35] As shown by Table 4, approximately 175 manufacturers operate in Mexican states on or near the border with Texas, employing more than 120,000 Mexican workers.

Figure 8. Texas-Mexico Automotive SuperCluster Suppliers



Source: Texas Economic Development Corporation, "The Texas Automotive Manufacturing Industry."

---

[34] Ibid.
[35] Bexar County, Texas, "Competitive Advantage."

Table 4. Texas-Mexico Automotive SuperCluster Suppliers by State[36]

State	Number of Suppliers, 2012	Employment, 2012	% Of TMASC Employment
Coahuila	58	44,013	33%
Texas	55	13,694	10%
Tamaulipas	52	44,632	33%
Nuevo León	46	26,003	19%
San Luís Potosí	19	5,889	4%
Total	**230**	**134,241**	**100%**

Source: TIP Strategies, Inc., "The Texas-Mexico Automotive Supercluster."

TMASC firms consist of both first-tier suppliers that produce complete auto modules (such as an entire passenger seat or car door) and second-tier (and beyond) suppliers, which provide first-tier suppliers with components such as batteries, glass panes, and screws. In the past decade, many first-tier suppliers have relocated to Texas to be near the final assembly plants, and second-tier suppliers have relocated to Mexico.

The TMASC region attracts companies seeking competitive advantages in labor and market proximity. Many manufacturers locate operations in Mexico for inexpensive, skilled labor and fast cargo shipments to and from Texas. Building final assembly plants in either Mexico or Texas mitigates logistical risks and ensures vehicles are quickly available for sale in the North American market, an important customer base. To leverage both Mexico's and Texas's unique advantages, TMASC companies support cross-border trading, often at multiple stages of vehicle assembly.

For example, second-tier suppliers may ship components from Mexico across the border to first-tier suppliers in manufacturing hubs, such as Dallas and San Antonio, a clear example of vertical IIT. Given the large number of components on a finished vehicle, the magnitude of shipments back and forth across the border is significant. To the extent possible, the next section attempts to quantify and categorize the volume of auto IIT between Texas and Mexico.

INDUSTRY DATA AND INTRA-INDUSTRY TRADE

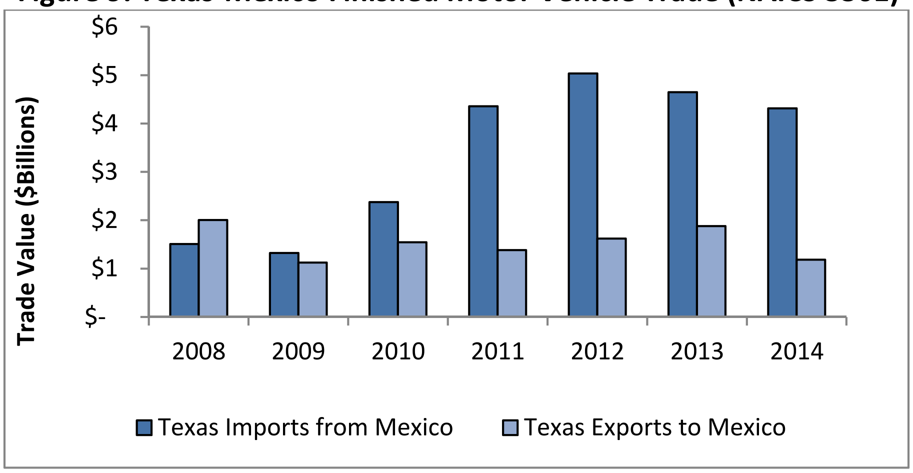
In 2014, Mexico was the world's fourth-largest vehicle exporter, doubling its automobile exports from 2009 to 2014.[37] During 2014, the country produced 3.2 million vehicles and exported 2.6 million automobiles (82 percent), primarily to the U.S. market.[38] Production in Mexico's automobile industry is expected to grow to almost five million units in 2018.[39] Still, the United States remains the world's second largest vehicle producer behind China,

[36] TIP Strategies, Inc., "The Texas-Mexico Automotive Supercluster: Vehicle Manufacturing Overview and Prospects."
[37] U.S. International Trade Administration, "Automotive Meetings Webinar."
[38] Althaus, "Mexico Sets Auto Production Record, Aims for More."
[39] Wallenius Wilhelmsen Logistics, "Automotive Industry Faces Port Capacity Strains in Mexico."

which manufactured more than 11 million vehicles in 2013, a seven percent increase from 2012.[40] The trade data shows two industry developments important to Texas. First, Texas has significantly increased imports of Mexican-made automobiles since 2008. Second, motor vehicle parts traded between Texas and Mexico has intensified, with Texas manufacturers increasingly importing parts from Mexican plants.

The Grubel-Lloyd Index for finished motor vehicle shipments (NAICS 3361) between Texas and Mexico is 0.45, indicating moderate horizontal ITT. In 2008, Texas exported more automobiles to Mexico, but thereafter, Texas became a net importer of vehicles from Mexico (see Figure 9). The disparity in trade patterns has grown significantly since 2011. In 2014, Texas still exported a significant number of cars to Mexico—$1.2 billion's worth—but Mexico exported $4.3 billion in finished vehicles to Texas.

Figure 9. Texas-Mexico Finished Motor Vehicle Trade (NAICS 3361)



Source: U.S. Census Bureau, "State Imports and Exports by NAICS Commodities: 2008-2014."

Numbers supporting high levels of ITT in automobile parts are the most compelling. From January to November 2014, the Grubel-Lloyd Index for motor vehicle parts (NAICS 3363) was 0.81—an exceptionally high value, approaching the pure ITT index value of one. A 2014 National Auto Parts Industry report found that 56 percent—about $36 billion—of Mexican automobile part imports come from the United States. The same report also found that 90 percent of Mexican automobile part exports go to the United States, accounting for $56.5 billion of trade in 2014.[41]

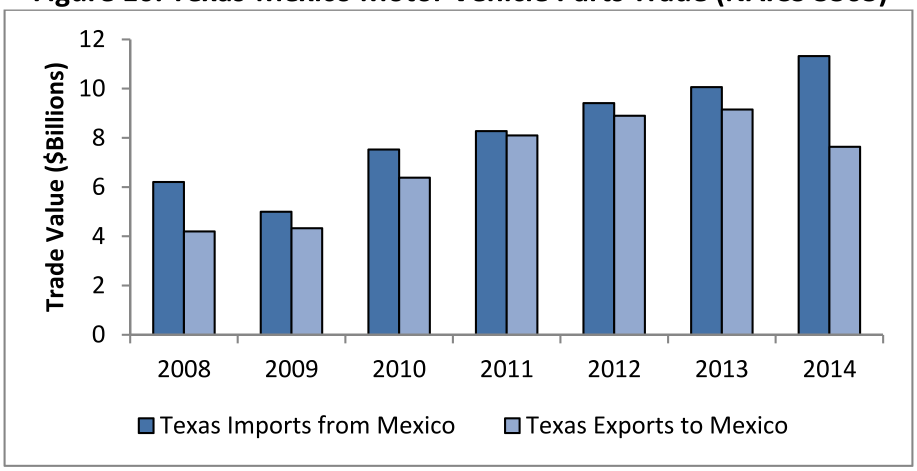
The Texas-Mexico automobile parts trade accounted for over $19 billion of traded goods in 2014.[42] Texas automobile part manufacturers—which produce everything from car seats to microcontrollers to engines—employ nearly half of Texas's automobile industry

[40] International Organization of Motor Vehicle Manufacturers, "2013 Production Statistics."
[41] U.S. International Trade Administration, "Automotive Meetings Webinar."
[42] U.S. Census Bureau, "State Imports and Exports by NAICS Commodities: 2008-2014."

workforce. The average plant is small, employing 60 workers.[43] Manufacturers supply parts to U.S.-based assembly plants (GM, Toyota, and Ford) and to vehicle assembly plants in Mexico, which manufacture cars for GM, Kia, BMW, Nissan, and Mercedes.

Figure 10 shows that Texas's motor vehicle part exports to Mexico more than doubled between 2008 and 2013. From 2009 to 2013, Texas imports from and its exports to Mexico increased. However, 2014 trade data show a 13 percent increase in Mexican auto part imports alongside a 17 percent *decrease* in auto part exports to Mexico. This trade decrease may stem from Mexico's rising auto parts production capacity, with Texas companies shifting (offshoring) more parts production to Mexico, Texas companies simply producing fewer exports, or a combination of these phenomena. Future data will provide a better understanding of the direction of this trend. Overall, however, it is clear that auto parts production will remain a multi-billion-dollar industry for both Texas and Mexico in the coming years.

Figure 10. Texas-Mexico Motor Vehicle Parts Trade (NAICS 3363)



Source: U.S. Census Bureau, "State Imports and Exports by NAICS Commodities: 2008-2014."

High levels of ITT reflect the trading of goods back and forth across the Texas-Mexico border, which consequently impacts traffic patterns. Neither Texas nor Mexico simply ships parts or completed vehicles one-way across the border. Today, a finished car has likely traveled in pieces across the border multiple times. For example, Texas manufacturers may ship an electrical component to Mexico, where technicians integrate that piece into a chassis (a car's basic frame). This chassis then travels back to an American car assembly plant. Just one car element—the electrical component—crosses the border twice in this oversimplified scenario. Multiplied across thousands of car parts—not to mention completed vehicles—border crossing efficiency could significantly influence the profitability of the automobile industry. Shipping processes are explored further in the next section.

[43] Texas Economic Development Corporation, "The Texas Automotive Manufacturing Industry."

AUTO INDUSTRY SHIPPING: THE IMPORTANCE OF RAIL

The auto industry's fragmented supply chain relies on efficient and timely transportation to be successful. Most factories employ just-in-time production systems, where delayed imports can shut down production and belated exports represent undesirable inventory. Transportation systems also determine when new cars arrive to markets, impacting sales. Texas's transportation infrastructure thus affects current industry profitability and impacts future firm relocation to (and from) Texas.

Many auto industry shipments travel via rail, moving by truck for only short distances to and from rail stations. In 2012, 70 percent of completed vehicles in North America shipped by rail.[44] In 2013, Mexico sent 1.7 million vehicles by rail to the United States (and eventually Canada). By 2018, the amount of finished cars shipped via rail is projected to grow to 2.8 million.[45] As northbound shipments grow, the rail industry faces two pressing issues: (1) having enough capacity to meet demand, and (2) sending full railcars north with no return shipments south. TTX, the largest U.S. railroad car provider, stated in 2012 that the automobile industry was hundreds of railcars short on a daily basis.[46] Part of this issue stems from growing Mexican car exports unaccompanied by increases in U.S. car exports.[47] When railroads have to cover roundtrip costs with one-way revenues, shortages occur.

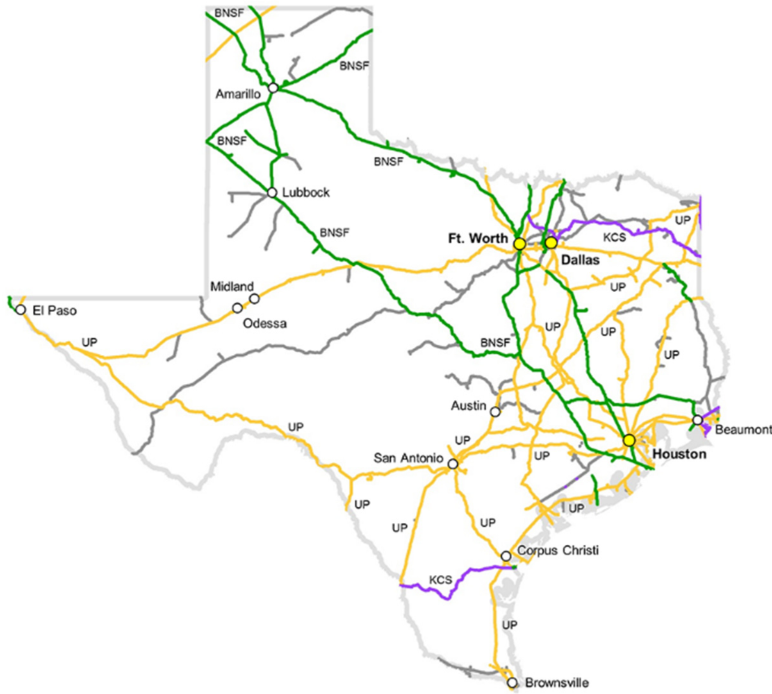
Like finished vehicles, many automobile parts and components are transported short distances by trucks before being shipped longer distances on railcars. XPO Logistics—formerly Pacer International—a freight transportation provider that uses Ferromex and Union Pacific networks, relies on Tier One automotive suppliers as a significant customer base. XPO's intermodal services are used by all major automakers for shipments back and forth across the Mexican border.[48] Indeed, as Ferromex Chief Executive Officer Rogelio Velez stated, "rail access is one of the 'musts' for the auto industry."[49] Thus, having the infrastructure to connect railroads to manufacturing plants is vital to Texas suppliers and manufacturers.

Because Texas is home to five of the seven locations for U.S.-Mexico rail crossings, its rail systems must be ready for increasing automobile industry shipments. Texas's five rail crossings with Mexico are in Brownsville, Laredo, Eagle Pass, Presidio, and El Paso. Every location has a single-track bridges except El Paso, with two rail bridges.[50] Figure 11 offers a visual representation of Texas railways. While it is clear that rail demand is increasing, little is known about the economic costs of congestion and shipment delays. In 2014, the automobile industry cited rail congestion as a significant problem in Texas-Mexico trade. Other sources indicated reliable border crossing wait times would benefit the auto

[44] Nelson and Sellers, "North American Rail Industry: Automotive Sector."
[45] Wallenius Wilhelmsen Logistics, "Automotive Industry Faces Port Capacity Strains in Mexico."
[46] Nelson and Sellers, "North American Rail Industry: Automotive Sector."
[47] Case, "Mexico Auto Boom Means Ford Fusions Ride Rails to U.S."
[48] Douglas, "In Mexico, Rail Is on a Roll."
[49] Case, "Mexico Auto Boom Means Ford Fusions Ride Rails to U.S."
[50] Texas Department of Transportation, "Rail Plan."

industry, but the extent to which improvements could benefit the industry remains unknown.

Figure 11. Texas Railways



Source: American Association of Railroads, "Texas Railways."

One certainty is an industry desire to improve current conditions. The Association of American Railroads supports the Automotive Industry Logistics Steering Committee (AILSC), a consortium of American OEMs whose goal is to "improve the final delivery process of finished vehicles." AILSC includes every major automaker, including Chrysler, Ford, GM, Honda, KIA, Nissan, and Toyota.[51] One of AILSC's goals includes more communication with all parties involved in logistics. Other key initiatives include encouraging flexibility in railcar design and improving railcar cycle time.

Beyond improving rail infrastructure, the automobile industry is also looking to expand all transportation options as output increases in the coming years. In 2013, after a series of freezing weather conditions significantly diminished rail capacity (due to operational constraints), automakers turned to trucking as a necessary transportation solution. Amidst this rail shortage, automakers found trucking could be cost competitive at 500-700 miles, longer than the previous standard of 200-300 miles. Hauling finished vehicles by truck does cost more, but faster lead times can counteract higher costs.[52] At the 2014 Finished Vehicle Logistics Conference, one leader even suggested relay teams for trucking vehicles across the country, changing drivers every 300-600 miles.[53] Leaders also mentioned the

[51] Association of American Railroads, "Rail Transportation of Finished Vehicles."
[52] Ludwig, "What's keeping US outbound executives awake in the middle of the night?"
[53] Ibid.

idea of consolidating rail flows at hubs where trucks could take over for these "relay" transportations.

In addition to trucking, automakers also seek to increase short-sea shipping options from Mexico to America. Mexico's port of Veracruz currently oversees 80 percent of Mexican OEM's automotive part exports and suffers from overcrowding.[54] Strategic investment in ports could increase capacity and improve efficiency, resulting in more profitable supply chains.

Overall, auto industry success and expansion depends, in part, on how transportation supports its development. Manufacturers at every level would benefit from increased transport options, including rail, short-sea shipping (ports), and direct trucking (roads).[55] Increasingly, automakers depend on truck and rail to ensure just-in-time production operates seamlessly. Cross-sector collaboration that supports sharing data on vehicle distribution and logistics would also increase transportation efficiency and spur economic development.

MITIGATING IIT IMPACT THROUGH LOGISTICS CONSOLIDATION

Although the growth of Texas's IIT industries has had a positive impact on the Texas economy, the IIT production model also creates major burdens on the state's already congested transportation network. Research such as a 2009 report by the Organisation for Economic Cooperation and Development shows that the global supply chain model and IIT have already increased freight transportation globally.[56] In Texas, the auto and electronics industries rely increasingly on the IH-35 corridor to move component and final goods multiple times across the US-Mexico border. Projected industry growth will likely result in heavier traffic and greater highway infrastructure deterioration than past manufacturing activities that relied on traditional supply chains.

Despite the challenges, growing trends in logistics management provide insights into reducing the burden of IIT on state infrastructure. Due to the increasing complexity of just-in-time supply chains, companies need greater oversight and coordination of the manufacturing process. Consequently, major manufacturers are beginning to hire third party logistics (3PL) firms to manage many aspects of production. Expanding beyond traditional shipping services, many 3PLs now manage procurement, design and coordinate supply chains, and even provide value-added services such as packaging and light assembly.[57] One advantage of 3PLs is the ability to consolidate shipping activities across companies and sectors of the economy by combining less-than-truckload shipments and cross-docking loads to fully utilize truck and warehouse space. These practices reduce inventory and transportation costs for manufacturers, increasing their profit margins. As

[54] Ibid.
[55] Wallenius Wilhelmsen Logistics, "Automotive Industry Faces Port Capacity Strains in Mexico."
[56] Organisation for Economic Cooperation and Development, "Delivering the Goods."
[57] Pohlen interview.

seen in Table 5, all of the top ten logistics firms in North America, by 2014 net revenue,[58] practice one or more of these activities.

Table 5. Services of Top North American 3PLs

	Value-Added Services/ Light Manufacturing	Supply Chain Management	Partial Shipments / Cross Docking
UPS Supply Chain Logistics		X	X
J.B. Hunt			X
Excel	X	X	X
Ryder	X	X	X
Expeditors International		X	X
C.H. Robinson Worldwide	X	X	X
Ceva Logistics	X	X	X
Americold		X	X
Uti Worldwide	X	X	X
Schneider	X	X	X

Source: See Appendix 5 for data sources.

3PL shipping and warehousing consolidation are not only good for businesses, but they also have the potential to mitigate the impact of IIT industries on the transportation infrastructure. Empty or partially full trucks increase traffic on congested corridors and contribute to unnecessary pavement deterioration.[59] Reducing wasted freight space will maximize state investments in new and existing infrastructure.

More efficient consolidation of cargoes could also reduce pollution and support meeting the requirements of the Clean Air Act for non-attainment areas like Houston and Dallas-Fort Worth, which are also the centers of manufacturing growth in Texas's IIT industries. For example, a recent study by the University of California at Berkeley's Center for Future Urban Transport found that policies that increased truck loads on large, long-haul vehicles could significantly reduce overall trucking emissions, even when including potential emissions resulting from the increased pavement repair required for heavier trucks.[60]

POLICY RECOMMENDATIONS

To mitigate and plan for the transportation needs of growing IIT Industries like auto, aerospace, and electronics manufacturing, TxDOT should explore options to encourage shipment consolidation through multimodal rail transportation and larger truck loads.

[58] Statista, "Leading Logistics Companies."
[59] Sathaye, Horvath, and Madanat, "Impacts of Increased Truck Loads."
[60] Ibid.

Truck-Only Toll Lanes

Previously successful policies for achieving truck load consolidation in other states and countries have included increasing weight minimum and maximum limits on highways.[61] However, reductions in traffic and tailpipe emissions must be considered alongside potential impacts on road infrastructure. TxDOT should explore options for providing freight-specific infrastructure, including truck-only toll (TOT) lanes for long combination vehicles. This type of highway infrastructure would require a significant initial investment but could be less expensive to maintain if more trucks used roadways specifically engineered for their use and could improve safety along existing highways.

Truck-only toll lanes have been researched in recent years by states like Oregon, California, Illinois, Indiana, and Georgia and by transportation planning groups like the Texas Transportation Institute.[62] These studies show that TOT lanes have the potential to improve reliability of travel time and overall productivity for long combination vehicles.[63] However, transportation planners must evaluate projects on a case-by-case basis to ensure tolls do not exceed the value of increased productivity.[64]

Rail Improvements

As demonstrated by the auto industry case study, rail is increasingly demanded for shipments between Mexico and Texas (and the remainder of the United States). Given that truck shipments are likely to increase, consolidating rail flows at hubs where trucks could take over goods transportation would improve efficiency. Ensuring that modes of transportation align and coordinate decreases shipping time, reduces congestion, and makes Texas more attractive to companies. Additionally, collaboration and information-sharing between public and private entities can help identify where and when rail shortages are likely to occur, minimizing shipment disruptions and keeping more trucks from congested interstates.

CONCLUSIONS

This study of Texas IIT industries reveals a level of complexity in our trade relationship with Mexico that is not commonly discussed. The study also points to a growing demand for U.S.-Mexico freight transportation infrastructure to handle existing and future IIT. TxDOT should explore the feasibility of expanding all transport options to meet the needs of Texas's growing economy. During project planning, TxDOT should continue its nascent practice of consulting with logistics firms and other major Texas shippers to ensure that proposed infrastructure projects align with projected industry demand.

---

[61] Ibid.
[62] Poe, "Truck Use of Toll Roads."
[63] Parsons, Brinckerhoff, Quade & Douglas, Inc., "Truck Only Toll Facilities."
[64] Cambridge Systematics, Inc., "Truck-Only Toll (TOT) Lanes."

REFERENCES

Althaus, Dudley. "Mexico Sets Auto Production Record, Aims for More." *The Wall Street Journal*, January 8, 2015. Accessed March 1, 2015. http://www.wsj.com/articles/mexico-sets-auto-production-record-aims-for-more-1420749573.

American Association of Railroads. "Texas Railways." Accessed March 10, 2015. https://www.aar.org/Style%20Library/railroads_and_states/dist/data/img/rails/texas.png.

Association of American Railroads. "Rail Transportation of Finished Vehicles." Accessed April 6, 2015. http://www.aar.com/standards/AAR%20Damage%20Prevention%20and%20Freight%20Claim%20Conference/Main%20Session%2006-18-13/AAR%20Conf%20VEQ%20June%202013%20-%20Final.pdf.

Bacchetta, Marc, Cosimo Beverelli, Olivier Cadot, Marco Fugazza, Jean-Marie Grether, Matthias Helble, Alessandro Nicita, and Roberta Piermartini. *A Practical Guide to Trade Policy Analysis*. New York: United Nations Conference on Trade and Development, 2012.

Balassa, Bela A. *The Theory of Economic Integration*. Homewood, Ill.: R.D. Irwin, 1961.

Baldwin, Richard. "Global Supply Chains: Why They Emerged, Why They Matter, and Where They Are Going." *Global Value Chains in a Changing World*: 13-84. Geneva: WTO Publications, 2013.

Beaver, Janice Cheryl. "U.S. International Borders: Brief Facts." CRS Report for Congress. November 9, 2006. Accessed March 9, 2015. http://fas.org/sgp/crs/misc/RS21729.pdf.

Becks, Rich. "Addressing Supply Chain Challenges." Aerospace Manufacturing and Design. Last Modified August 13, 2014. http://www.onlineamd.com/amd0814-supply-chain-competencies.aspx#.VPsY9vnF97E.

Bexar County, Texas. "Competitive Advantage." Texas-Mexico Automotive SuperCluster. Accessed March 9, 2015. http://www.bexar.org/709/Texas-Mexico-Automotive-SuperCluster.

Cambridge Systematics, Inc., and CH2M HILL. "White Paper #7 Truck-Only Toll (TOT) Lanes." Oregon Department of Transportation. Last modified February 2009. http://www.oregon.gov/ODOT/TD/TP/docs/tolling/whitepaper7.pdf.

Case, Brenden. "Mexico Auto Boom Means Ford Fusions Ride Rails to U.S." Bloomberg Business, July 3, 2013. Accessed March 9, 2015. http://www.bloomberg.com/news/articles/2013-07-03/mexico-auto-boom-means-ford-fusions-ride-rails-to-u-s-.

Douglas, Merrill. “In Mexico, Rail Is on a Roll.” Inbound Logistics, January 1, 2012. Accessed March 10, 2015. http://www.inboundlogistics.com/cms/article/in-mexico-rail-is-on-a-roll/.

Feller, Andrew, Dan Shunk, and Tom Callarman. “Value Chains Versus Supply Chains.” *BP Trends*. March 2006. Accessed March 10, 2015. http://www.ceibs.edu/knowledge/papers/images/20060317/2847.pdf.

Flextronics, “Global Locations.” Accessed February 24, 2015. http://www.flextronics.com/global_locations/Pages/americas%20map.aspx#
Dallas.

Gereffi, Gary, John Humphrey, and Timothy Sturgeon. “The Governance of Global Value Chains.” *Review of International Political Economy* 12, no. 1 (2005): 78-104. Accessed March 20, 2015. http://www.fao.org/fileadmin/user_upload/fisheries/docs/GVC_Governance.pdf.

Gresham, Rebeka. “Mexico as a Growing Market and Powerhouse when Combined with Texas.” TMASC Blog. February 28, 2013. Accessed March 9, 2015. http://www.bexar.org/Blog.aspx?IID=2#item.

Grubel, H. J., and P. J. Lloyd. “The Empirical Measurement of Intra-Industry Trade.” *Economic Record* 47, no. 4 (December 1971): 494–517.

International Organization of Motor Vehicle Manufacturers. “2013 Production Statistics.” January 1, 2015. Accessed March 6, 2015. http://www.oica.net/category/production-statistics/2013-statistics/.

Krugman, Paul. “The Rise of Intra Industry Trade.” Accessed March 10, 2015. http://www.princeton.edu/~pkrugman/Intraindustry.pdf.

Ludwig, Christopher. “What’s keeping US outbound executives awake in the middle of the night?” Accessed April 6, 2015. http://www.automotivelogisticsmagazine.com/events/fvl-north-america-conference/archive/2014-conference/report.

Mayer, Abby. “Supply Chain Metrics that Matter: A Focus on Aerospace and Defense.” Supply Chain Insights, LLC. Last Modified March 18, 2014. https://www.kinaxis.com/Global/resources/papers/metrics-that-matter-aerospace-and-defense-supply-chain-insights-research.pdf.

Miroudot, S., R. Lanz, and A. Ragoussis. “Trade in Intermediate Goods and Services.” OECD Trade Policy Working Paper, no. 93 (2009). http://www.oecd.org/trade/its/44056524.pdf.

Nelson, Mike, and David Sellers. "North American Rail Industry: Automotive Sector." Accessed March 9, 2015. https://mwrailshippers.com/mars_pdfs/2012_nelson_sellers_presentation.pdf.

Office of the U.S. Trade Representative. "Benefits of Trade." Accessed March 9, 2015. https://ustr.gov/about-us/benefits-trade.

Office of the U.S. Trade Representative. "United States." Accessed March 9, 2015. https://ustr.gov/countries-regions/united-states.

Organisation for Economic Cooperation and Development. "Delivering the Goods: 21st Century Challenges to Urban Goods Transport." Accessed February 18, 2015. http://www.internationaltransportforum.org/pub/pdf/03DeliveringGoods.pdf.

Parsons, Brinckerhoff, Quade & Douglas, Inc. "Truck Only Toll Facilities: Potential for Implementation in the Atlanta Region." State Road and Tollway Authority. Last modified July 18, 2005. http://www.georgiatolls.com/assets/docs/TOT_Final_Report.pdf.

Pindyck, Robert S., and Daniel L. Rubinfeld. *Microeconomics*. 8th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2013.

Poe, Christopher. "Geometric Design and Operational Factors that Impact Truck Use of Toll Roads." Texas Transportation Institute. Last modified September 2010. http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-5377-1.pdf.

ProMexico. "The Auto Parts Industry." Accessed March 9, 2015. http://www.oesa.org/Doc-Vault/Knowledge-Center/Intl-Markets-and-Trade-Content/ProMexico-Auto-Parts.pdf.

Samsung, "Samsung Electronics America." Accessed February 24, 2015. http://www.samsung.com/us/aboutsamsung/samsung_electronics/us_divisions/.

Sathaye, Nakul, Arpad Horvath, and Samer Madanat. "Unintended Impacts of Increased Truck Loads on Pavement Supply-Chain Emissions." UC Berkely Center for Future Urban Transport. Last modified August 2009. http://www.its.berkeley.edu/publications/UCB/2009/VWP/UCB-ITS-VWP-2009-7.pdf.

Statista. "The leading logistics companies in the United States in 2014, based on North American net revenue (in million U.S. dollars)." Accessed February 18, 2015. http://www.statista.com/statistics/184538/20-leading-us-logistics-companies-by-net-revenue/.

Terry Pohlen. Interview with Avery Saxe. January 22, 2015.

Texas Department of Transportation. "Rail Plan." Accessed March 10, 2015. ftp://ftp.dot.state.tx.us/pub/txdot-info/rail/plan/ch3.pdf

Texas Economic Development Corporation. "The Texas Automotive Manufacturing Industry." Accessed March 9, 2015. https://texaswideopenforbusiness.com/ sites/default /files/01/13/15/2014_ automotive_report_final.pdf.

Texas Wide Open for Business. "Big Stories from Texas 2014." Accessed February 25, 2015. https://texaswideopenforbusiness.com/sites/default/files/02/25/15/bigstories texas.pdf.

Texas Wide Open for Business. "Gov. Perry Helps Break Ground on SpaceX Commercial Launch Facility." Last Modified September 22, 2014. https://texaswideopenforbusiness.com/news/gov-perry-helps-break-ground-spacex-commercial-launch-facility.

Texas Wide Open for Business. "Texas Electronics Industry." Accessed February 24, 2015. https://texaswideopenforbusiness.com/sites/default/files/02/24/15/texas_electro nics_report.pdf

Texas Wide Open for Business. "The Texas Aerospace & Aviation Industry." Accessed November 13, 2014. https://texaswideopenforbusiness.com/sites/default/ files/11/13/14/aerospace_report.pdf.

Texas Workforce Commission. "Tracer Future Job Growth by Occupations." Accessed January 15, 2015. http://www.tracer2.com/cgi/dataanalysis/dataType Selection.asp?tableName=notable.

Tip Strategies, Inc. "The Texas-Mexico Automotive Supercluster: Vehicle Manufacturing Overview and Prospects." Accessed 9, 2015. http://www.bexar.org/ DocumentCenter/View/1702.

U.S. Census Bureau. "North American Industry Classification System (NAICS)." Accessed March 10, 2015. http://www.census.gov/eos/www/naics/.

U.S. Census Bureau. "State Imports and Exports by NAICS Commodities: 2008-2014." Accessed February 16, 2015. https://usatrade.census.gov.

U.S. Census Bureau. "Top Trading Partners - December 2013." Accessed March 9, 2015. https://www.census.gov/foreign-trade/statistics/highlights/top/top1312yr. html#exports.

U.S. Chamber of Commerce. "Steps to a 21st Century U.S.-Mexico Border." 2010. Accessed March 9, 2015. https://www.uschamber.com/sites/default/files/legacy/reports/ 2011_us_mexico_report.pdf.

U.S. Department of Transportation. "North American TransBorder Freight Data: Indexed Data." Accessed March 10, 2015. http://transborder.bts.gov/programs/ international/transborder/index/Index_Interface.html.

U.S. International Trade Administration. "Automotive Meetings Webinar." Accessed January 8, 2015. http://www.export.gov/mexico/static/AutomotiveMeetings_webinar1_ Latest_eg_mx_079354.pdf

U.S. International Trade Administration. "Import Product Profile from a Selected Market." Accessed March 9, 2015. http://tse.export.gov/stateimports/.

U.S. International Trade Administration. "Product Profiles of U.S. Merchandise Trade with a Selected Market." Accessed February 1, 2015. http://tse.export.gov/TSE/ TSEhome.aspx.

Wallenius Wilhelmsen Logistics. "Automotive Industry Faces Port Capacity Strains in Mexico." Accessed March 9, 2015. http://www.2wglobal.com/news-and-insights/articles/features/ automotive-industry-faces-port-capacity-strains-in-mexico/#.VP2yaFpK78F.

World Economic Forum*. Enabling Trade: Valuing Growth Opportunities*. Geneva: World Economic Forum, 2013.

APPENDIX 1. NAICS 2012

Sector	Description
11	Agriculture, Forestry, Fishing and Hunting
21	Mining, Quarrying, and Oil and Gas Extraction
22	Utilities
23	Construction
31-33	Manufacturing
42	Wholesale Trade
44-45	Retail Trade
48-49	Transportation and Warehousing
51	Information
52	Finance and Insurance
53	Real Estate and Rental and Leasing
54	Professional, Scientific, and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
61	Educational Services
62	Health Care and Social Assistance
71	Arts, Entertainment, and Recreation
72	Accommodation and Food Services
81	Other Services (except Public Administration)
92	Public Administration

Source: U.S. Census Bureau, "North American Industry Classification System (NAICS)."

APPENDIX 2. GRUBEL-LLOYD INDEX, JANUARY–NOVEMBER 2014

		Mexico	Canada	China	World
333 Machinery (except electrical)					
3331 Ag & Construction Machinery	Texas	0.9775	0.7962	0.9615	0.6553
	California	0.7474	0.8601	0.5650	0.8731
	United States	0.9925	0.5231	0.6538	0.8706
3332 Industrial Machinery	Texas	0.9987	0.8996	0.4697	0.9095
	California	0.7696	0.8685	0.5930	0.9139
	United States	0.6983	0.9363	0.5198	0.8573
3333 Commercial & Service Industry Machinery	Texas	0.5541	0.7286	0.1064	0.9238
	California	0.5182	0.9513	0.5526	0.8519
	United States	0.7222	0.9398	0.3721	0.9926
3334 HVAC & Commercial Refrigeration Equipment	Texas	0.5994	0.4038	0.0751	0.7258
	California	0.7282	0.8827	0.1294	0.3997
	United States	0.5128	0.5199	0.1614	0.7593
3335 Metalworking Machinery	Texas	0.1568	0.8781	0.5349	0.9986
	California	0.0564	0.4915	0.6972	0.8138
	United States	0.1602	0.9724	0.7275	0.7255
3336 Engines, Turbines, & Power Transmission Equipment	Texas	0.2115	0.5138	0.8572	0.3603
	California	0.8615	0.6589	0.9744	0.9528
	United States	0.6622	0.3255	0.6442	0.8927
3339 Other General Purpose Machinery	Texas	0.5781	0.9453	0.5921	0.8191
	California	0.9087	0.9091	0.3858	0.9191
	United States	0.9122	0.7047	0.4634	0.9278
334 Computer & Electronic Products					
3341 Computer Equipment	Texas	0.9086	0.1117	0.1306	0.9999
	California	0.6518	0.0261	0.0515	0.4475
	United States	0.9143	0.0797	0.0626	0.6971
3342 Communications Equipment	Texas	0.9997	0.2966	0.0334	0.4566
	California	0.4647	0.2662	0.1421	0.5409
	United States	0.6908	0.5154	0.0706	0.5479
3343 Audio & Video Equipment	Texas	0.5324	0.0335	0.0160	0.6076
	California	0.2834	0.1306	0.0208	0.2798
	United States	0.3717	0.1419	0.0258	0.4270
3344 Semiconductors & Other Electronic Components	Texas	0.2564	0.4746	0.2977	0.8569
	California	0.8565	0.4166	0.1813	0.5012
	United States	0.5855	0.7166	0.4968	0.8701
3345 Navigational/Measuring/Medical/ Control Instrument	Texas	0.9026	0.4567	0.6538	0.9711
	California	0.7171	0.4912	0.8568	0.8350
	United States	0.7051	0.5510	0.8521	0.9756
3346 Magnetic & Optical Media	Texas	0.2255	0.1602	0.3649	0.8760
	California	0.7666	0.0699	0.0905	0.4216
	United States	0.7059	0.1358	0.2492	0.8444

		Mexico	Canada	China	World
335 Electrical Equipment, Appliances, & Components					
3351 Electric Lighting Equipment	Texas	0.7219	0.6199	0.0259	0.5112
	California	0.4801	0.4972	0.0151	0.2543
	United States	0.4137	0.5600	0.0206	0.3519
3352 Household Appliances and Miscellaneous Machines, Nesoi	Texas	0.5254	0.2913	0.0481	0.7136
	California	0.3244	0.3149	0.0750	0.2575
	United States	0.4407	0.3254	0.0660	0.5636
3353 Electrical Equipment	Texas	0.8864	0.5070	0.5119	0.9870
	California	0.9856	0.5670	0.1940	0.8049
	United States	0.7204	0.5629	0.3390	0.8109
3359 Electrical Equipment & Components, Nesoi	Texas	0.6524	0.4385	0.1891	0.7941
	California	0.8689	0.3000	0.1503	0.7312
	United States	0.8896	0.3601	0.2139	0.9296
336 Transportation Equipment					
3361 Motor Vehicles	Texas	0.4526	0.2878	0.5957	0.6594
	California	0.1245	0.0179	0.0527	0.1215
	United States	0.1597	0.7530	0.0185	0.5481
3362 Motor Vehicle Bodies & Trailers	Texas	0.1603	0.2848	0.5464	0.2169
	California	0.7998	0.2460	0.4171	0.9050
	United States	0.4539	0.1860	0.4756	0.3530
3363 Motor Vehicle Parts	Texas	0.8100	0.7540	0.6586	0.8258
	California	0.9609	0.6483	0.0756	0.5090
	United States	0.6352	0.8303	0.3032	0.6478
3364 Aerospace Products & Parts	Texas	0.7138	0.5729	0.3423	0.9105
	California	0.6404	0.5275	0.2274	0.3558
	United States	0.7531	0.8404	0.1230	0.5890
3365 Railroad Rolling Stock	Texas	0.1132	0.8898	0.0141	0.3899
	California	0.0112	0.2561	0.6155	0.3989
	United States	0.2811	0.4680	0.3595	0.5767
3366 Ships & Boats	Texas	0.6339	0.2591	0.2802	0.6961
	California	0.0088	0.3653	0.7758	0.5132
	United States	0.7562	0.5808	0.5045	0.5880
3369 Transportation Equipment, Nesoi	Texas	0.1701	0.0868	0.0166	0.2265
	California	0.7287	0.3633	0.0947	0.4054
	United States	0.5029	0.7954	0.0609	0.7947

Source: U.S. Census Bureau, "State Imports and Exports by NAICS Commodities: 2008-2014."

Note: Nesoi = Not Elsewhere Specified or Included.

APPENDIX 3. LIMATIONS OF THE GRUBEL-LLOYD INDEX

The Grubel-Lloyd Index is a mathematical equation to estimate the level of IIT between two countries. Though the index is helpful in determining whether or not an industry is categorized by inter-industry trade or IIT, there are limitations to the index. Therefore, one should be careful in the interpretation of the index as well as understand the constraints and potential pitfalls of the index.

..

The first limitation of the index relates to the data aggregation type. Depending on what industry level one uses (e.g., NAICS at the two-digit level versus NAICS at the five-digit level), one will get different numbers for the index. The categorization digit level impacts how the industry will be characterized for inter-industry trade and IIT.[65] For this report, the Grubel-Lloyd Index was calculated using the four-digit level of NAICS, which is a fairly conservative approach.

..

The next limitation relates to the type of IIT. The Grubel-Lloyd Index does not differentiate horizontal IIT from vertical IIT. One must use different calculations to determine the various types of IIT. Finally, the Grubel-Lloyd Index is a ratio and should not be used to compare various years. Just because the Grubel-Lloyd Index is higher in one year compared to another year does not necessarily mean that IIT has increased. Rather it means that the proportion of IIT compared to all trade has increased.

---

[65] Bacchetta et al., *A Practical Guide to Trade Policy Analysis*, 21.

APPENDIX 4. MODAL SHARES OF U.S./MEXICO TRADE FLOWS, JANUARY–NOVEMBER 2014

Mode	Value of Exports	Value of Imports
Truck	$114 billion USD	$131 billion USD
Rail	$28.9 billion USD	$20.9 billion USD
Pipeline	$3.3 billion USD	$137 million USD
Air	$6.0 billion USD	$4.5 billion USD
Vessel	$19.2 billion USD	$25.2 billion USD
Mail	$2.738 thousand USD	$360 thousand USD
Other	$6.4 billion USD	$1.3 billion USD
Free Trade Zone	--	$2.1 billion USD

Source: U.S. Department of Transportation, “North American TransBorder Freight Data.”

APPENDIX 5. DATA SOURCES FOR TABLE 5

Americold. "Business Solutions." Accessed February 18, 2015. http://www.americold.com/services/cost_reduction.aspx.

C.H. Robinson. "Logistics." Accessed February 18, 2015. http://www.chrobinson.com/en/us/Logistics/.

Ceva Logistics. "What We Offer." Accessed February 18, 2015. http://www.cevalogistics.com/en-US/whatweoffer/Pages/default.aspx.

Excel. "What We Do." Accessed February 18, 2015. http://www.exel.com/exel/exel_what_we_do.jsp.

Expediters. "Cross Dock Solutions." Accessed February 18, 2015. http://www.expeditors.com/news-media/featured-information/2011/cross-dock.asp.

IPS. "UPS Supply Chain Solutions." Accessed February 18, 2015. https://www.ups-scs.com/.

J.B. Hunt Transport, Inc. "Freight Solutions." Accessed February 18, 2015. http://www.jbhunt.com/.

Ryder. "Supply Chain Solutions by Capability." Accessed February 18, 2015. http://www.ryder.com/supply-chain/solutions-by-capability.aspx.

Schneider. "Your Deadline or Your Bottom Line." Accessed February 18, 2015. http://www.schneider.com/www1/groups/public/@marketing-public/documents/webcontent/prd_006211.pdf.

UTi Worldwide. "Managed Solutions." Accessed February 18, 2015. http://www.go2uti.com/transportation-managed-solutions.