ANALYSIS OF THE ARIZONA-CENTRAL MEXICO INTERNATIONAL TRADE AND TRANSPORTATION CORRIDOR AT THE SUPPLY CHAIN LEVEL[1]

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Introduction

Cross-border trade between the United States and Mexico has grown more than four times since the implementation of the North American Free Trade Agreement. In recent years, trade patterns at the Arizona-Mexico border have been changing and the Arizona Department of Transportation (ADOT)is conducting a Binational Freight Study. The study´s unique approach is to analyze cross-border trade from the point of origin in one country to the point of destination in the neighboring country at the supply chain and corridor levels. The results of the study will provide valuable insights to ADOT and Mexican federal and state transportation planning agencies to improve cross-border supply chain movement and increase Arizona's economic development attracting freight-dependent businesses.

This paper presents the methodology that was used to identify truck freight flows at the supply chain level onthe corridor than runs from Phoenix Arizona to Central Mexico along the Pacific Coast and to develop freight forecasts. The approach required assembling multiple data sources from the U.S. and Mexico to first identify key commodities and specific supply chains in the region, then to define origin-destination patterns, andfinally, to develop three forecast scenarios.

Methodology

The methodology that was usedto identify binational truck flows at the commodity or supply chain level included the following steps:

Step 1. Identify Arizona-Mexico Cross border truck flows

Step 2. Select key commodities that represent the largest proportion of cross-border flows

Step 3. Identify origin and destination points in each country

Step 4. Assign flows to the Pacific Corridor

Step 5. Develop commodity flow forecasts

Step 1. Identify Arizona-Mexico Cross border truck flows

The following data sources were analyzed to identify key supply chains and volumes:

Datamyne 2016 Border Crossing Commodity Flow Data

The U.S.-Mexico Datamyne dataset was purchased for this project. The dataset includes characteristics of individual shipments for imports and exports across the border. Information on the shipper/consignee names and addresses is provided by this database, although these are not always accurate, as the geographic information not always represent the true origin or destination. Datamyne captures the 6-digit Harmonized System (HS) commodity classification for each shipment and includes value, weight, and location where the shipment crossed the border. Fields for transportation equipment type and service (e.g., TL versus LTL for trucking) are also provided by this database.

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U.S. Census Information Analysis

The U.S. Census provides U.S./Mexico trade data at the border crossing district level. Detailed commodities were collapsed into broad commodity categories (2-digit HS code) for ease of interpretation. The limitation of the Census information is that provides information by commodity value and not by weight, and does not provide transportation mode or border crossing detail (only border crossing district, that may include more than one border crossing.

2013 Transearch Database

ADOT provided the 2013 Transearch database that includes 4-digit standard transportation commodity code (STCC) type commodity flows that are handledby Arizona's transportation system, which includes freight moved from, to, within and through Arizona. Binational trade from, to, and through Arizona is included; and associated truck and rail based top commodities by weight and value. The Transearch database has a limitation that it only provides the first or the last node on Arizona's roadway system for commodity flows.

Step 2. Select key commodities that represent the largest proportion of cross-border flows

The Datamyne database was used as control totals for truck-based freight flows by commodity at the Arizona border crossings, as it provides the greatest level of detail. All three databases provided similar results in identifying key supply chains that cross through the Arizona/Mexico border. The following table presents the top ten commodities by weight crossing the Arizona/Mexico border by truck.

Table1Top 10 Truck Commodities Crossing the Arizona/Mexico Border

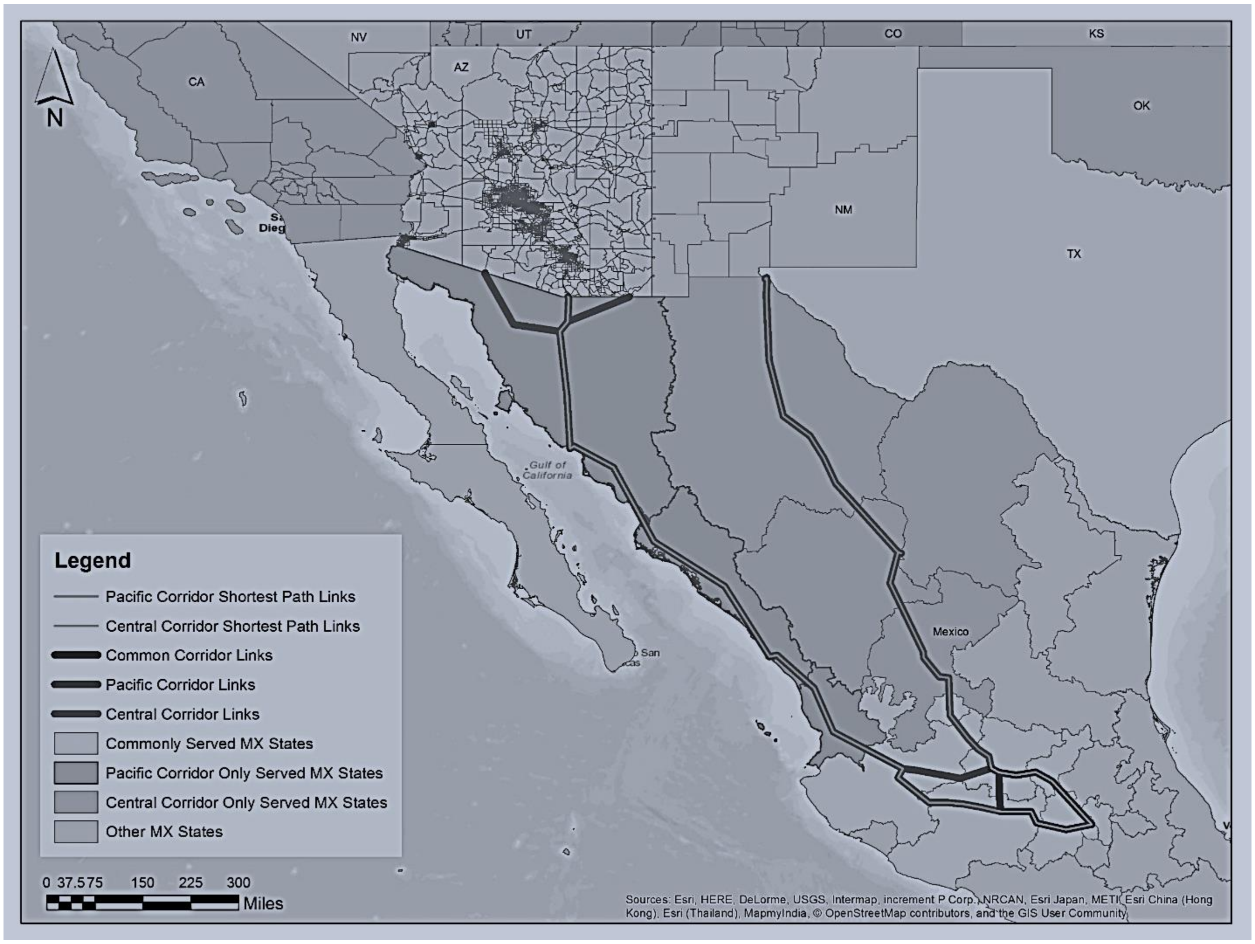
Commodity	Datamyne 2016 Data (in Thousands of Metric Tons)		
	Export	**Import**	**Total**
1. Fruits and Vegetables	264	2,940	3,204
2. Electric Machinery and Equipment	135	208	343
3. Plastics	178	68	245
4. Paper	137	101	238
5. Vehicles and Parts	38	41	79
6. Wood and Articles of Wood	26	51	77
7. Sugars	1	64	64
8. Meat	47	9	56
9. Copper and Ores, Slag and Ash	52	0	52
10. Beer	1	24	25
Total	**878**	**3,505**	**4,383**

Source: Datamyne 2016 Border Crossing Flow Data

Step 3. Identify origin and destination points in each country

In order to develop origin-destination flows, the first task was to develop a binational zoning structure. The zones in the U.S. and Mexico used in the study are based on the Federal Highway Administration (FHWA) HEPGIS application's border crossing commodity flow data ([i]). The HEPGIS application uses the FHWA's Freight Analysis Framework Version 4 (FAF4) ([ii])zones to represent the study zones in the U.S., and the Mexican states to represent the study zones in Mexico. The zone structure in Mexico was the aggregation of states into three large zone groups: the Pacific Corridor only states, states in the north-central part of the countrythat serve the Texas/Mexico border in El Paso/Ciudad Juarez (Central Corridor) and zones that could be served by both the Central and Pacific Corridors (Figure 1).

Figure 1. Map of Study Zones for Commodity Flow Analysis of Pacific Corridor.



In the HEPGIS application, flows from/to Mexico are disaggregated from country level to state level in Mexico. However, the data do not always identify the zone as a Mexico state; for some freight flows, the data designate zone as "Mexico—Unknown." Freight flow data are available at the border crossing level. Within the U.S., the data use the same zone structure and commodity types (i.e., the 2-digit Standard Classification of Transported Goods or SCTG2) as FAF4. The information is provided by weight and value. The origin-destination flows were extracted by commodity, for the top ten commodities identified in the previous step creating a truck-based freight flow database for the Central and Pacific Corridors.

A second verification of the origin-destination flows in Mexico was performed analyzing Mexico's Ministry of Communications and Transport (SCT) surveys that are documented by the Mexican Transportation Institute (IMT)([iii]). The results of this analysis confirmed initial findings from the HEPGIS dataset.

Step 4. Assign flows to the Pacific Corridor

The FHWA HEPGIS data showed some differences from the Datamyne data on the Pacific Corridor, specifically in that they contained origin-destination details for flows. To take advantage of this information and still be accurate, the FHWA HEPGIS data commodity totals for the top 10 truck-based commodities by weight on the Pacific Corridor were adjusted to match the commodity totals in the Datamyne data.

The FHWA HEPGIS origin-destination information suffered from an issue which was that the data did not always identify the zone as a Mexico state; for some freight flows, the data designated the zone as "Mexico—Unknown." This issue was identified to be of greatest concern for fruit and vegetable imports from Mexico. In order to identify the origin of these flows from Mexico, interviews with stakeholders and statistical data from the Mexican National Geography and Statistics Institute (Instituto Nacional de Geografía y Estadística or INEGI) ([iv]) were used.

For truck traffic assessment on the Pacific Corridor, the Study developed and used a static network assignment method, the steps of which are as follows:

1. Identify a centroid city for each Mexico study zone.
2. Obtain directions from Nogales to the centroid city for Mexico State using Google maps or similar map direction services and identify node locations where the directions force an exit from the Pacific Corridor. Repeat this for all centroid cities. Multiple centroid cities may have the same node location. The centroid city is connected to the node location on the Pacific Corridor using a dummy link connector.
3. Using the node locations, divide the Pacific Corridor in Mexico into segments.
4. For the Mexico side, develop an all-or-nothing type static unit flow assignment matrix with columns of segments and rows of centroid cities in Mexico.
5. Use the tonnage flows from/to study zones in Mexico in the processed FHWA HEPGIS data as weights to compute total assigned flow on the segments of the Pacific Corridor in Mexico.
    a. The segmentation of the U.S. side of the Pacific Corridor was predetermined as the three segments: for the Nogales–Tucson segment, all flows in the processed FHWA HEPGIS data to the United States were assigned,
    b. For the Tucson–Casa Grande segment, the flows stopping at/starting from Tucson or destinations using I-10 east of Tucson were subtracted out. It was assumed that I-10 east of Tucson was used for all destinations except the western US states of Arizona, California, Idaho, Nevada, Oregon, and Washington, and
    c. For the Casa Grande–Phoenix segment, the flows going to/coming from San Diego through I-8 were also subtracted out. In other words, this segment carried flows to/from all of the western US states except Tucson and San Diego.

Step 5. Develop commodity flow forecasts

Truck freight flow forecastsfor the top 10 supply chains in the Pacific Corridorwere developed for years 2020, 2025, and 2030. Producing forecasts beyond 2030 did not seem realistic, particularly given the uncertainty in the U.S.-Mexico trade relationship in the future.

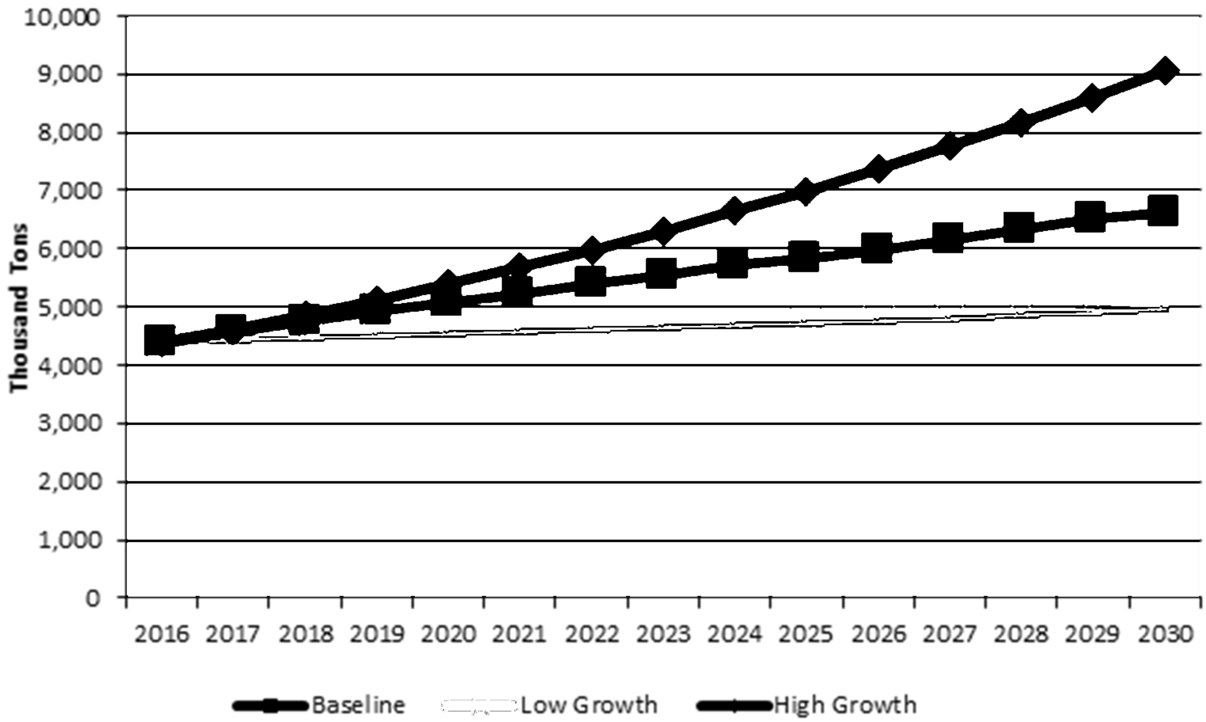
Self-projecting time series and cause-and-effect models were analyzed. Because historic data on the dependent variables was limited to only four years, that is, from 2016 to 2020, self-projecting models were discarded, and two specific statistical causal methods were assessed. The Ordinary Least Squares (OLS), which is the most common method used to capture the explanatory level of a set of variables for the target variable was the first alternative. The second model that was analyzedwas the Generalized Linear Models (GLM), which is a more flexible method in terms of assumptions to find linear relations among different variables. After several models runs and based on the model-fitting indicators, OLS time series models were selected.

The set of data used to build these models included 15 years of data for the independent variables that could explain each top 10-freight truck commodity flows in the Pacific Corridor. This level of disaggregation allowed forecasting of each commodity trade value based on independent variables with a statistical confidence level of 95 percent, as well as construction of the best casual forecast model for each top commodity. Specifically, the selected OLS linear regression model estimated the changes in the commodity trade value in the Pacific Corridor due to changes in population, gross domestic product (GDP), and per capita GDP in Mexico and the U.S. Due to information availability constraints, the parameter estimations used commodity trade value data as the dependent variables (instead of commodity trade weight data).

The next step of the forecasting methodology was to identify any planned changes in the top 10 supply chains that could have a significant impact in the forecast, such as new or expansion of existing manufacturing plants, changes in the fruits and vegetables regulations, etc. Interviews with shippers and manufacturers, as well as review of other sources of information did not provide solid information that would modifythe expected trade flows. The coefficients from the OLS exercise were applied to the base year tonnage from Datamyne to obtain future flows. This assumes that the value to weight ratio will remain constant during the forecast period. Based on the analysis of historical information, the product mix in each supply chain was not expected to change in the future; therefore, using a constant commodity value to weight ratio is a valid assumption.

The following figure shows the projected growth in weight for the base year's top 10 truck-based trade commodities on the Pacific Corridor and the low and high growth scenarios.

Figure 2. Top 10 Truck-Based Trade Commodities on the Pacific Corridor in 2016–2030.



Source: Datamyne 2016 commodity flow data for the Nogales border crossing, Federal Highway Administration HEPGIS 2015 commodity flow data for the Nogales border crossing, and TTI's forecasting and analysis

Freight Forecast outcomes

Table 2 shows the projected growth in weight for the base year's top 10 truck-based trade commodities (by weight) on the Pacific Corridor, but only for the forecast year of 2030 under all future scenarios. Total trade estimations between 2016 and 2030 grow by 51 percent, or an annual growth rate of 3.0 percent, compared to 106.7 percent (annual growth rate of 5.3 percent) for the high-growth truck trade scenario, and 13.4 percent (0.9 percent annual growth rate) for the low-growth truck trade scenario.

US exports of the top 10 commodities in the corridor are estimated to grow by 79 percent between 2016 and 2030 in the baseline scenario, equivalent to 4.2 percent annually. In the high-growth scenario, the expected growth of US exports between 2016 and 2030 is 210.4 percent, or an annualized rate of 8.4 percent. The low-growth truck trade scenario is estimated to grow only 3.9 percent in the 2016–2030 period, or an annualized rate of 0.3 percent.

US truck trade imports are expected to grow 44 percent in the 2016–2030 period under the baseline scenario, or an annualized rate of 2.6 percent. In the high-growth truck trade scenario, the expected growth in the same time period is estimated at 80.7 (4.3 percent annually), while the expected growth is 15.8 percent in the low-growth truck trade scenario, or an annualized rate of 1.1 percent.

Table**2All Future Scenario Weight Distributions for Import and Export Flows by Commodity of Top 10 Truck-Based Trade Commodities (by Weight) on Pacific Corridor, 2030**

Weight	**Export**				**Import**				**Total**			
Truck Flow in Metric Tons 000	**2016**	**2030 Baseline**	**2030 High Growth**	**2030 Low Growth**	**2016**	**2030 Baseline**	**2030 High Growth**	**2030 Low Growth**	**2016**	**2030 Baseline**	**2030 High Growth**	**2030 Low Growth**
Fruits and Vegetables	264	601	1,098	281	2,940	4,133	4,870	3,474	3,204	4,734	5,968	3,755
Electric Machinery and Equipment	135	194	196	192	208	284	652	89	343	478	848	281
Plastics	178	273	338	217	68	122	188	74	245	395	526	291
Paper	137	187	375	75	101	141	169	117	238	328	544	192
Vehicles and Parts	38	76	156	30	41	89	116	66	79	165	272	96
Wood and Articles of Wood	26	40	55	28	51	68	95	47	77	108	150	75
Sugars	1	2	2	2	64	142	163	122	64	144	165	124
Meat	47	87	104	72	9	19	24	14	56	105	128	86
Copper and Ores, Slag and Ash	52	118	400	14	0			0	52	118	400	14
Beer	1	2	2	2	24	56	56	56	25	58	58	58
TOTAL	**878**	**1,579**	**2,726**	**912**	**3,505**	**5,054**	**6,334**	**4,060**	**4,383**	**6,633**	**9,060**	**4,972**

Sources: Datamyne 2016 Commodity Flow Data for the Nogales Border Crossing; FHWA HEPGIS 2015 Commodity Flow Data for the Nogales Border Crossing; Study Team Forecasting and Analysis.

Key Findings

The analysis was conducted for the top 10 commodities or supply chains since they represent more than three-quarters of the total trade in the corridor. The network assignment methodology estimated the usage of Pacific Corridor highways by the top commodities by weight in the base year 2015/16 and forecast years 2020, 2025 and 2030. The weight of commodities is an indicator of public highway system impacts of binational trade.

The potential cargo diversion from the Central Corridor to the Pacific Corridor, showed that there only a few commodities that could be diverted. However, due to supply chain and logistics operations, such as consolidation at the El Paso/Ciudad Juarez or in the Mexico City metropolitan region, potential diversion to the Pacific Corridor was deemed negligible.

These findings can be used by ADOT, SCT and other Mexican federal and state agencies, to outline improvement strategies focused upon the efficiency and competitiveness of the multimodal transportation system that support key supply chains served by the Pacific Corridor.

Fruits and vegetables tonnage is almost three times larger than the other nine supply chains combined, and it is expected to grow at a very fast pace, therefore special attention should be paced to improve the efficient move of these commodities.

Understanding and responding to the evolving needs and trends of these supply chains and the multimodal transportation system that supports them can improve supply chain efficiencies and lead to job growth and continued economic prosperity for Mexico and the U.S.

References

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