EXPLORATION OF CROSS-BORDER TRIP CHARACTERISTICS USING CROWDSOURCED DATA

by

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CHAPTER 1: INTRODUCTION

The U.S.-Mexico border uniquely merges two different languages, cultures, and economies. Consequently, the border has always been high in traffic demand. In fact, it is the busiest border in the world, with 26 major land ports of entry (LPOEs) along its length (Bureau of Transportation Statistics, 2020). An estimated $1.5 billion in exports flows through the border every day (Miroff, 2018). More than 6 million jobs in the United States are supported by bilateral trade with Mexico, and approximately 80 percent of U.S. bilateral trade crosses through the southbound (SB) land border every day (Figueroa et al., 2012). Residents from either side can conduct cross-border trips any time if qualified to cross the border. Reasons for trips to the neighboring country range from work or educational purposes to shopping, obtaining medical attention, or socializing.

Among the LPOEs along the U.S.-Mexico border, El Paso del Norte region (comprised of El Paso, Texas, Ciudad Juárez, Chihuahua, and Las Cruces, New Mexico), is one of the busiest. The El Paso and Ciudad Juárez regions have long functioned together as one metropolitan center divided by a border wall but united by international LPOEs. El Paso is currently the sixth largest city in Texas, while Juárez is the largest city in the Mexican state of Chihuahua. The combined population of El Paso County and Juárez is greater than 2.3 million (Instituto Nacional de Estadistica, Geografia e Informatica [INEGI], 2020a; U.S. Census Bureau, 2020). Thousands of residents travel frequently between El Paso and Ciudad Juárez by crossing the international border and using the LPOEs that connect the two cities. Jon Barela, the executive director of The Borderplex Alliance, an organization that promotes the development between El Paso, Ciudad Juárez, and Las Cruces emphasizes that cross-border travel is the lifeblood for the regional economy (KFOX14, 2020).

Nonetheless, 2020 was a year of change due to the extreme restrictions applied to slow the spread of Coronavirus Disease 19 (COVID-19). The World Health Organization (WHO) declared COVID-19 a pandemic on March 11, 2020, based on its rapid spread throughout the world. As a consequence, the United States and Mexican governments agreed to apply temporary restrictions on March 21, 2020, at land borders to northbound (NB) trips (PDNUno, 2020a), which led to a reduction in trips to El Paso from Juárez of approximately 50 percent (Bureau of Transportation Statistics, 2020). With respect to SB trips, the state of Chihuahua initiated sanitary filters at international borders on March 31, 2020, in order to control the entry flow from El Paso to Juárez (Instituto Nacional de Migración, 2020). Such filters, which occurred during the initial stage of the pandemic, were implemented on a random sample of travelers who were asked if they had any COVID-19 symptoms; those travelers who did were sent back to the United States. Subsequently, El Paso and Juárez were temporarily split as cross-border restrictions were applied to reduce the spread of COVID-19 (the restrictions remain in place during the development of this report—i.e., as of October 2021—but are expected to be lifted on November 8, 2021, for travelers who are fully vaccinated; Carrillo, 2021). Such restrictions have enormously affected travel volume and the economy of businesses on both sides of the border, though to what degree remains to be discovered given that limited studies exploring the impact on the border region, especially within the El Paso–Ciudad Juárez border literature, have been conducted (Gurbuz et al., 2020).

Regardless of the ongoing pandemic, understanding trip patterns and demand is the first step toward solving transportation issues such as congestion, air quality, or traffic safety. However, acquiring rich, accurate, and continuous travel information is not an easy task. This difficulty is particularly the case for binational metropolitan areas like El Paso and Juárez, where international cross-border trips can represent a significant portion of daily trips but are often underrepresented in travel demand or behavior analysis. Acquiring trip information in this environment is challenging not only because of time and budget limitations but also because of the international jurisdictions involved. Data that depict activity related to the origin-destination (OD) of international trips are also limited, with few existing sources. OD data have been limited to surveys that have been compiled in a schedule and did not cover most international trips. However, location-based crowdsourced databases have the potential to provide valuable assistance to cities and agencies in need of alternative data sources. As noted by Lee and Sener (2020), "Advancements in technologies and the proliferation of smartphones have created new data sources that can help eliminate limitations related to small sample size and infrequent updates due to limited resources."

In light of these recent developments, this project aimed to explore cross-border trip characteristics using crowdsourced data, with a primary focus on INRIX data (INRIX, n.d.). Utilizing location-based services through mobile phones and connected vehicles, INRIX data provide detailed trip information on a continuous time and space spectrum. This project was based on three months of INRIX data purchased by the Center for International Intelligent Transportation Research (CIITR) that explored cross-border trips (i.e., trips that used one of the border crossings in either direction across the U.S.-Mexico border). Specifically, the data included trips from five of the six LPOEs in the region providing connection between El Paso and Juárez. Among these LPOEs, four are located in the immediate area of El Paso and directly connect the border of Juárez and El Paso, including Paso del Norte (PdN), Stanton, Bridge of the Americas, and Ysleta-Zaragoza. The Santa Teresa LPOE, on the other hand, is located 15 miles (mi) away from downtown El Paso and connects Santa Teresa, New Mexico, and Ascensión, Chihuahua. Cross-border data related to the LPOE at Tornillo were not acquired, and therefore Tornillo LPOE was not considered in this study. In addition, the data corresponded to the period of January 20, 2020, to April 19, 2020, to allow researchers to identify the degree and patterns of trips that took place just before and after the declaration of the COVID-19 pandemic and the implementation of border restrictions along the U.S.-Mexico border.

The rest of this report includes four chapters:

- Chapter 2 positions the study within the context by introducing the cross-border travel characteristics as well as the impact of COVID-19 on border travel, particularly focusing on the connection between El Paso and Juárez.
- Chapter 3 describes the methodological details of the research study, including a description of the study area, the data used (both primary and secondary data sources), and the analysis conducted.
- Chapter 4 provides the results of the analysis conducted, including a descriptive statistics-based analysis examining the travel patterns of cross-border trips for the study area during the corresponding study period.
- Chapter 5 concludes the report with a summary and final remarks.

CHAPTER 2:
THE STUDY IN CONTEXT

THE TWO BORDER REGIONS: CONNECTING EL PASO AND JUÁREZ

According to the most current census, El Paso and Juárez have a population of 839,238 and 1,512,450, respectively (INEGI, 2020a; U.S. Census Bureau, 2020). As noted earlier, El Paso County and Ciudad Juárez congregate into a single metropolitan city (with a population over 2.3 million), and thousands of residents commute frequently from one side to the other by crossing the international border. The international border serves as the second busiest border region for vehicles and pedestrians among the borders between the United States and Mexico. According to U.S. Customs and Border Protection, in 2019, more than 26 million people crossed the border from Juárez to El Paso—over 18.7 million people in personal vehicles and 7.6 million pedestrians (Bureau of Transportation Statistics, 2020). Of the international commuters, 60.3 percent corresponded to individuals whose country of residence was Mexico, while 39.7 percent corresponded to commuters who resided in the United States (Olmedo et al., 2020).

Figure 1 provides the operational characteristics of each LPOE considered in this study: PdN (also known as Santa Fe), Stanton (also known as the Good Neighborhood), Bridge of the Americas (BOTA), Zaragoza (also known as Ysleta), and Santa Teresa (see PDNUno [2021]). There are three types of lanes at the noncommercial LPOEs: Ready lanes, Secure Electronic Network for Travelers Rapid Inspection (SENTRI) lanes, and standard lanes. Travelers who own a radio frequency identification (RFID) travel document use Ready lanes, while preapproved low-risk travelers use SENTRI lanes with expedited clearance. Other travelers (i.e., travelers who do not qualify to use Ready or SENTRI lanes) use standard lanes. At the commercial LPOEs, a commercial clearance program called the Free and Secure Trade (FAST) program is used for known low-risk shipments entering the United States from Canada and Mexico. The FAST program allows expedited processing for commercial trucking companies that have completed background checks and fulfilled certain eligibility requirements. Thus, while commercial vehicles participating in the FAST program can use dedicated FAST lanes, commercial vehicles not participating in the FAST program use the standard lanes. Standard lanes are always available at any LPOE; however, Ready, SENTRI, and FAST lanes may or may not be present. Figure 1 shows the presence of these lanes in the column labeled “Dedicated Lanes.” Finally, the Ready, SENTRI, and FAST lanes only serve vehicles traveling in the NB direction. Stanton LPOE only serves passenger vehicles in the SB direction; however, there is a SENTRI lane in the NB direction that serves preapproved cross-border passenger vehicles.

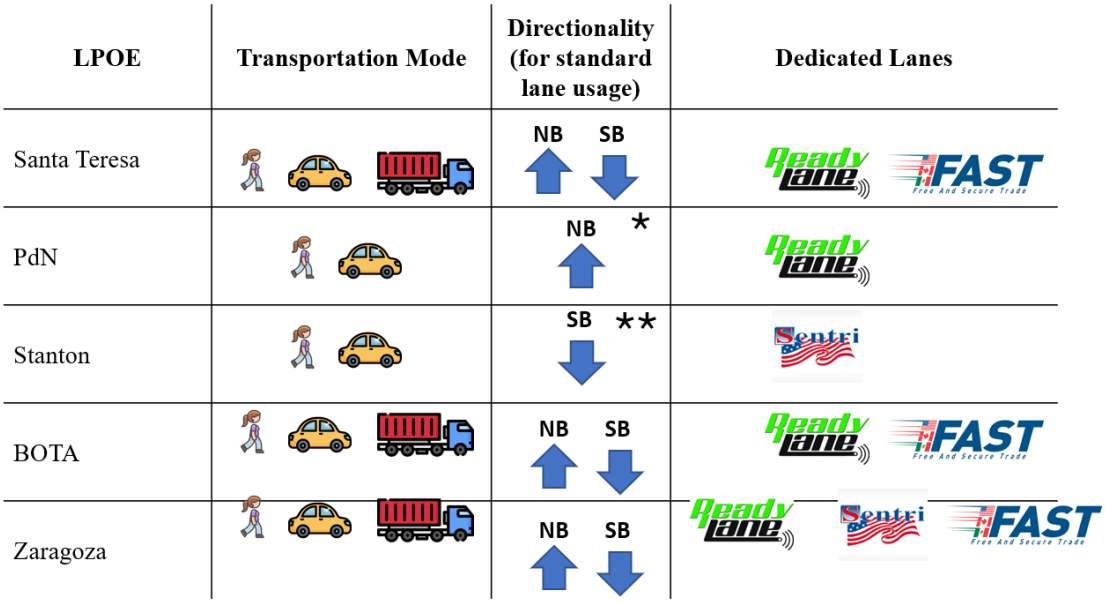

Figure 1. Operations of El Paso del Norte Region LPOEs Considered in this Study.

Of the six LPOEs located in the El Paso del Norte region, four are located within the El Paso city limits: BOTA, PdN, Stanton, and Zaragoza. Each LPOE has NB and SB traffic except for the LPOEs at downtown El Paso—PdN and Stanton. These two LPOEs complement each other because the PdN LPOE supports NB traffic, while Stanton supports both NB and SB traffic. The NB traffic at Stanton LPOE is comprised of passenger vehicles with a SENTRI designation, as described above (PDNUno, 2020b). Although the City of El Paso International Bridges Department owns and operates three of these bridges (PdN, Stanton, and Zaragoza) (City of El Paso, 2020), BOTA is owned by the United States and is under the jurisdiction, custody, and control of the General Services Administration (GSA) (Texas Department of Transportation, 2019). Each bridge varies in traffic volume demand, but for a long time, BOTA has remained the most popular for international commuters (PDNUno, 2020c). The PdN bridge connects downtown areas of both cities and has the highest pedestrian traffic among the international bridges in the region. Zaragoza has increased its traffic demand because it connects the east sides of Ciudad Juárez and El Paso, areas that have grown significantly during the last decade. Last, Santa Teresa's traffic demand is much lower since it is both the smallest LPOE and the farthest from downtown El Paso and Juárez.

Residents conduct cross-border trips often for many different purposes. Trip purposes range from work, education, shopping, obtaining medical attention, and visiting family members or friends. Another important trip purpose corresponds to freight traffic: thousands of trips every day are responsible for the flow of materials and goods that ship from or to the United States. Shopping trips by Mexican nationals to the United States (i.e., El Paso) account for 40.5 percent of trips, which makes it the most common purpose among the previously categorized. Social trips represent 25.4 percent of trips, followed by work activities (20 percent) and education-related trips (5.5 percent). On the other hand, the most common trip purpose to Juárez by U.S. residents is social (55.7 percent); shopping is the second most common purpose (14.9 percent),

followed by work activities (9 percent), health trips (8.1 percent), and last, eating or drinking trips (4.7 percent) (Olmedo et al., 2020).

IMPACT OF COVID-19 ON CROSS-BORDER TRAVEL

When COVID-19 was declared a pandemic in March 2020, more than 118,000 confirmed cases existed in 114 countries, and more than 4,000 people had lost their lives (WHO, 2020). Several countries decided to close their borders to slow the spread of COVID-19, whereas other countries chose to keep their borders open, regardless of the pandemic. Most governments across the world encouraged residents to stay home to flatten the curve of COVID-19. Such practices influenced the way people circulated daily and therefore had a huge impact on the world's behavior, including travel behavior and patterns.

El Paso and Ciudad Juárez residents had to adapt to COVID-19-related restrictions at the LPOEs, which were applied especially to NB trips. Traffic demand, foreign trade, and shopping trips were significantly reduced after the border restrictions, especially during the first month when El Paso County applied a stay-at-home order to its residents. Several alterations occurred in the region immediately upon declaration of the pandemic. First, the United States and Mexico reached a binational agreement that became effective on March 21, 2020 (U.S. Customs and Border Protection, 2020). This agreement prevented Mexican citizens from traveling to the United States by land unless the travel was deemed essential. Nonessential travel included tourism, travelers seeking to purchase supplies that could be found where they resided, and visitation to family or friends. Although the Mexican government agreed to deny entry into the United States to Mexican citizens via land borders, Mexico applied no restrictions at the land border to U.S. citizens/residents besides the sanitary filters applied during the initial weeks of the pandemic. Second, El Paso applied a mandatory lockdown, and nonessential businesses remained closed while the stay-at-home order was in force. Third, nonessential businesses closed in Mexico, which directly impacted the import and export traffic to and from the United States. These alterations affected international travel, and virtually no recreational trips occurred once the border restrictions were implemented.

Traffic Reduction

Traffic congestion declined enormously after the COVID-19 outbreak was declared a pandemic. According to research conducted in British Columbia, Canada, out-of-home activities decreased by more than 50 percent during COVID-19. Even though most retail stores were closed, shopping remained the most frequent activity since people needed to buy groceries. Work-related travels were the second most common activity. Work travel even increased for some occupations, such as health, government associations, services, and sales (Fatmi, 2020).

Traffic in both El Paso and Juárez was significantly reduced during the initial pandemic period, and as a consequence, the traffic demand at the international borders fell by more than 50 percent (Bureau of Transportation Statistics, 2020). Considering the restrictions applied by the U.S. government to Mexican nationals and the mandatory lockdowns that El Paso County applied to its residents, a reduction in international trips was to be expected. During January and February of 2020, approximately 2 million people crossed the border at El Paso each month. A

dip of 50 percent occurred in March when the restrictions went into effect, with approximately 1 million commuters passing through the El Paso border. April registered the lowest volume in the year 2020, with fewer than 400,000 commuters crossing the bridge in the NB direction (Bureau of Transportation Statistics, 2020).

Foreign Trade

The U.S.-Mexico border is a strong economic tie for both countries. Due to Mexico's proximity to the United States, extensive bilateral trade exists, which has been supported by the North American Free Trade Agreement (NAFTA) and its replacement, the United States–Mexico–Canada Agreement (USMCA). In 2019, Mexico was the largest goods trader with the United States, with $614.5 billion in total trade (import and export). Its international trade supports 6 million jobs in the United States, which means that one in 24 workers depends on international trade. U.S. exports to Mexico in 2019 totaled $256.6 billion, while the imports from Mexico in the same year were equivalent to $358 billion. Moreover, the United States is Mexico's most important target for export goods, with 80 percent designated for the United States (Villareal, 2021).

International trade was deeply affected by the onset of COVID-19. The Mexican government was forced to close nonessential businesses, including manufacturing plants. The aforementioned plants remained closed for a period of two months, from March 31 to June 1 of 2020. Such closures caused a reduction in production and directly reduced the volume that Mexico exported to the United States by 40.7 percent during April 2020 (INEGI, 2020b). U.S. exports to Mexico in 2020 fell to $211.4 billion, while the imports decreased to $325.2 billion (Embamex, 2021), which corresponds to a 12 percent decrease in total bilateral trade from the total obtained in the previous year (2019).

Shopping

In general, cross-border shopping provides a gateway for Mexico's residents to spend their money. Cross-border shopping offers several benefits that incentivize commuters: lower tax rates, lower costs, and greater ease of finding goods. The average amount that a Mexican resident spends while shopping in El Paso is $150. Of the cross-border shopping trips, four out of five are to retail stores, while the remaining one corresponds to purchasing a service. According to a 24-week study conducted by the City of El Paso International Bridges Department, Mexican residents spent $226.7 million in the United States from October 2019 to March 2020, which was almost twice the expenditures of U.S. residents in Mexico (Olmedo et al., 2020).

Mexican nationals stopped being able to cross-border shop when the restrictions were implemented at the border, and many retail businesses were affected by the lack of Mexican shoppers. Although Mexican shoppers can still purchase American products from online stores, such stores do not support El Paso's economy because online sales usually accrue to other states/cities.

According to Tom Fullerton, an economist from the University of Texas at El Paso (UTEP), the economy in El Paso will barely return to normal in the coming months even if the restrictions at the land border are lifted (Resendiz, 2020). In the short term, retail businesses will benefit

during the first 90 days of the border opening to all commuters. However, in the long term, past economic pandemic ruptures have shown that around five years will be required to completely heal. Fullerton noted that Mexican shoppers represent a $135 million boost to the retail economy of El Paso, and their absence will be felt as long as the border restrictions remain enforced. Due to reduced sales volume in 2020, several retail businesses in El Paso have closed, and this closure rate will increase if the border restrictions to Mexican nationals continue. Examples of hardships for local business owners abound. One shoe store in downtown El Paso went from having 10 customers per hour to around one or two (Resendiz, 2020).

CHAPTER 3: METHODOLOGY

STUDY AREA

This study included four study sites (PdN/Stanton, BOTA, Zaragoza, and Santa Teresa) that correspond to a particular LPOE between El Paso and Juárez, as shown in Figure 2. The PdN and Stanton LPOEs were merged and treated as one LPOE because of their close proximity to one another and because they complement each other in serving passenger vehicles in the NB and SB directions. As noted earlier, cross-border data related to the LPOE at Tornillo were not acquired, and therefore Tornillo LPOE was not considered in this study.

BOTA and PdN are conveniently located for commuters since these LPOEs are close to the downtown areas of both regions. Zaragoza is farther away from downtown El Paso and connects Juárez to the east side of El Paso, while Santa Teresa connects Juárez to Doña Ana County, New Mexico. BOTA and Santa Teresa do not charge any fee to commuters crossing from either side of the border, whereas PdN, Stanton, and Zaragoza charge a fee. Santa Teresa has considerably lower demand due to its location outside the limits of Juárez, which makes most commuters prefer to cross through any of the others LPOEs.

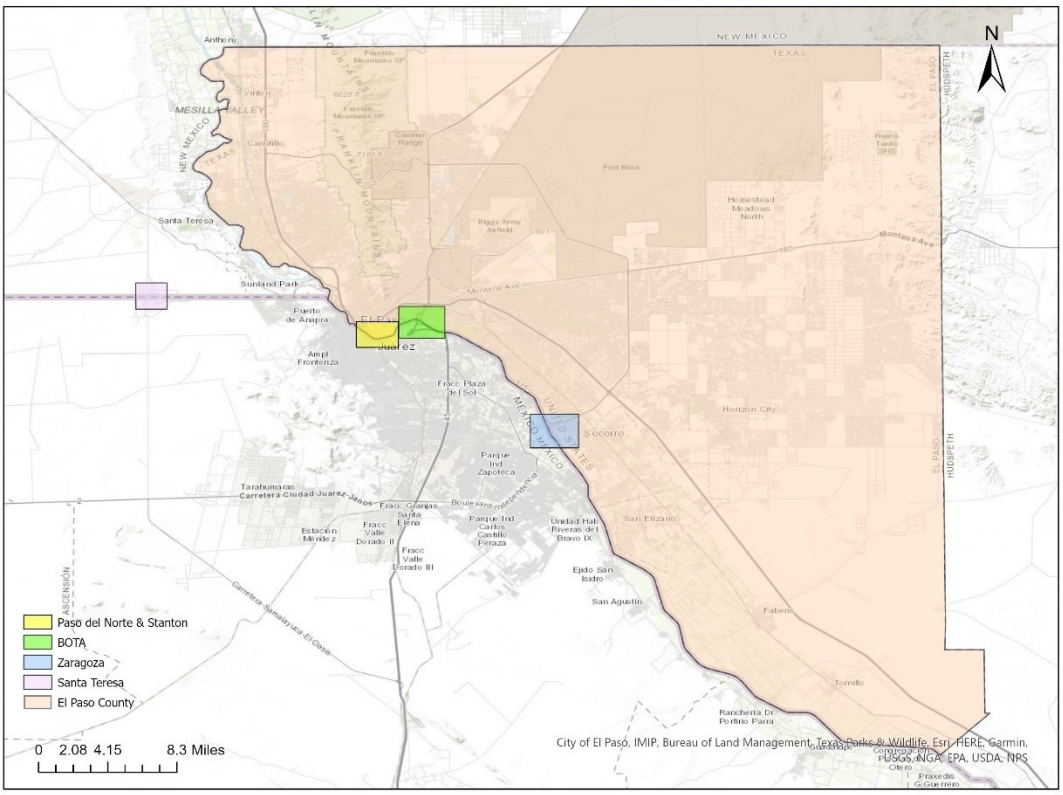

Figure 2. Study Area.

PRIMARY DATA

The primary data used in this study were obtained from INRIX, which collects anonymized, real-time traffic data from various sources, such as mobile devices, road sensors, cars equipped with a global positioning system (GPS), cameras, and the like. INRIX data facilitate extracting OD travel data and include trip information on all devices that entered a requested area at a specified time regardless of whether the device started or ended the trip in the selected area. In this case, the collection of trips corresponded to individuals crossing to El Paso from Juárez or vice versa for a three-month period beginning January 20, 2020, and ending April 19, 2020. Four datasets, each from a particular LPOE—BOTA, PdN/Stanton, Zaragoza, and Santa Teresa—were considered for this analysis.

Data Characteristics

INRIX collects many attributes for every trip registered, and these attributes are shown in Table 1. The data were provided in two datasets: (a) *trips* and (b) *trajectories*. The trips dataset covers every trip by focusing on the locations of the origins and destinations of the trips with exact timestamps. On the other hand, the trajectories dataset keeps records of all trips' route information (trajectory) by reporting the segments that the trip crosses.

Table 1. Attributes of INRIX Trip Datasets.

Attribute	Description
Trip ID	Trip's unique identifier.
Device ID	Device's unique identifier. Set to the trip ID for restricted data providers.
Provider ID	Provider's unique identifier.
Mode	Mode of travel (0 = walk, 1 = vehicle, 2 = unknown).
StartDate	Trip's start date and time in UTC ISO-8601 format. For example: "2014-04-01T08:33:35.000Z."
StartWDay	Trip's start weekday in local time, where 1 = Mon., 2 = Tues., 3 = Wed., 4 = Thurs., 5 = Fri., 6 = Sat., 7 = Sun.
EndDate	Trip's end date and time in UTC ISO-8601 format. For example: "2014-04-01T08:33:35.000Z."
EndWDay	Trip's end weekday in local time, where 1 = Mon., 2 = Tues., 3 = Wed., 4 = Thurs., 5 = Fri., 6 = Sat., 7 = Sun.
StartLocLat	Latitude of the centroid of the trip's start quadkey in decimal degrees.
StartLocLon	Longitude of the centroid of the trip's start quadkey in decimal degrees.
EndLocLat	Latitude of the centroid of the trip's end quadkey in decimal degrees.
EndLocLon	Longitude of the centroid of the trip's end quadkey in decimal degrees.
GeospatialType	Trip's geospatial intersection with the requested zones (EE, EI, IE, II).
ProviderType	Numeral representing the provider type (consumer, fleet, mobile).
VehicleWeightClass	Numeral representing the vehicle weight class.
OriginZoneName	Origin zone of the trip if the trip started in a zone.
DestinationZoneName	Destination zone of the trip if the trip started in a zone.
EndpointType	Indicates if the trip starts and ends in a detected stop: blank = unknown (prior to 2017), −1 = unknown, 0 = trip does not start or end at stop, 1 = trip starts at stop, 2 = trip ends at stop, 3 = trip starts and ends at stop.
TripMeanSpeedKph	Mean speed of the trip, in kph.
TripMaxSpeedKph	Max. speed of the trip, in kph.
MovementType	Moving trip = 1, nonmoving trip = 0.
OriginCensusBlockGroup	Census block group of origin (United States only).
DestinationCensusBlockGroup	Census block group of destination (United States only).
StartTimezone	Time zone of the trip's start coordinate.
EndTimezone	Time zone of the trip's end coordinate.
WaypointFreqSeconds	Waypoint frequency of the trip in seconds.
StartQuadkey	Level 18 quadkey corresponding to the trip's start coordinate at a resolution of ~300 m.
EndQuadkey	Level 18 quadkey corresponding to the trip's end coordinate at a resolution of ~300 m.

Data Processing and Cleaning

Cross-border travelers often make more than one trip within the same day. However, although trajectory information is provided for each trip, such trip-chaining information was not readily available in the INRIX datasets. To identify such potential trip-chaining information from the INRIX datasets, trips need to be linked by the same device ID and date. In the datasets, each trip detected is designated by a unique trip ID, meaning that no matter how many trips are detected, no trip ID will be duplicated. In cases when mobile providers have restricted the device ID of their users, INRIX sets the same value of trip ID to the device ID. Consequently, the trip pattern of individuals who have the device ID restricted are untraceable since INRIX provides a unique device ID to each of these trips. Conversely, individuals can be traced when the device ID is not restricted. To detect duplicate device IDs, researchers compared the value in the device ID attribute for every column and segregated the information for every trip whose device ID was registered more than once. A CSV file was automatically created, and the trips were sorted by device ID, date, and time, which facilitated the processing task.

After the data were preprocessed and cleaned, two different datasets were created for every LPOE—a full INRIX sample dataset (or "full dataset" in the rest of the report) and a traceable INRIX sample dataset (or "traceable dataset" in the rest of the report) because some trips were not traceable due to restrictions from the mobile providers. Although most trips could not be traced, the full dataset provided the most complete results on the cross-border trip patterns because the origin and destination coordinates of all trips in raw data could be extracted. However, the trip-chaining information was not extractable in this dataset.

The raw full dataset corresponded to the data with no filters—in other words, all trips registered from January 20 to April 19, 2020. Table 2 presents the origin and destination of all detected trips for both datasets: the full dataset and traceable dataset. Table 2 exhibits the trips that took place in El Paso County and within the boundaries of El Paso City, as well as trips to Juárez and out-of-town trips (trips from outside the boundaries of El Paso and Juárez). The full dataset demonstrated that most trips started or ended within the boundaries of El Paso County and Ciudad Juárez (90 percent), while only 10 percent of the trips started or ended outside the border boundaries. Therefore, most trips were classified as local trips. On the other hand, the traceable dataset produced a variation in the ODs of trips. First, trips within El Paso County decreased to 51 percent, while only 41 percent remained in El Paso City. Trips in Juárez and out-of-town trips increased to 35 percent and 14 percent, respectively. Although most of trips still classified as local trips (86 percent), out-of-town trips increased by 4 percent compared to the full dataset.

Table 2. Trip OD Location for INRIX Full and Traceable Datasets.

INRIX sample dataset	Area	Origin	Origin %	Destination	Destination %
Full dataset	El Paso County	3,315,982	77%	3,309,602	77%
	El Paso City	2,877,734	67%	2,867,673	66%
	Ciudad Juárez Municipality	596,331	14%	642,264	15%
	Other	410,960	10%	370,296	9%
	Total Trips	4,319,005	100%	4,319,005	100%
Traceable dataset	El Paso County	210,706	51%	215,099	52%
	El Paso City	168,142	41%	170,734	41%
	Ciudad Juárez Municipality	146,305	35%	147,989	36%
	Other	56,704	14%	50,634	12%
	Total Trips	413,212	100%	413,212	100%

The traceable sample dataset corresponds to approximately 10 percent of the full data. A traceable trip provides the different locations an individual travels during a day, which makes it easier to determine the travel patterns. Therefore, the traceable dataset facilitates encountering the travel path of individuals by linking the ODs of trips traveled during a desirable time range. Nonetheless, a limitation found with this dataset is that most traceable trips correspond to commercial traffic, which is not helpful when trying to detect the path of regular international commuters who cross in personal vehicles.

Figure 3 presents three trip examples from the traceable dataset; for ease in presentation, the ODs of each trip example were connected by a link. The first example demonstrates an SB trip that started within El Paso County at US 54 and Loop 375. The commuter crossed to Juárez through BOTA LPOE and ended the trip at an industrial park in Juárez named Municipio Libre. The second example demonstrates an NB trip that started in Juárez in an industrial park named Villas de Salvarcar. The commuter crossed through Zaragoza LPOE and ended the trip on the east side of El Paso, specifically at Zaragoza Avenue and Tierra Este Road. The third example demonstrates an NB trip that crossed to the United States through Santa Teresa LPOE from Juárez. The trip started outside the boundaries of Juárez, crossed to Doña Ana County in New Mexico through Santa Teresa LPOE, and went back to an industrial park in Juárez named INTERMEX sur. A common characteristic of these examples is that each trip either started or ended at an industrial park in Juárez; in other words, these sample trips correspond to commercial vehicles.

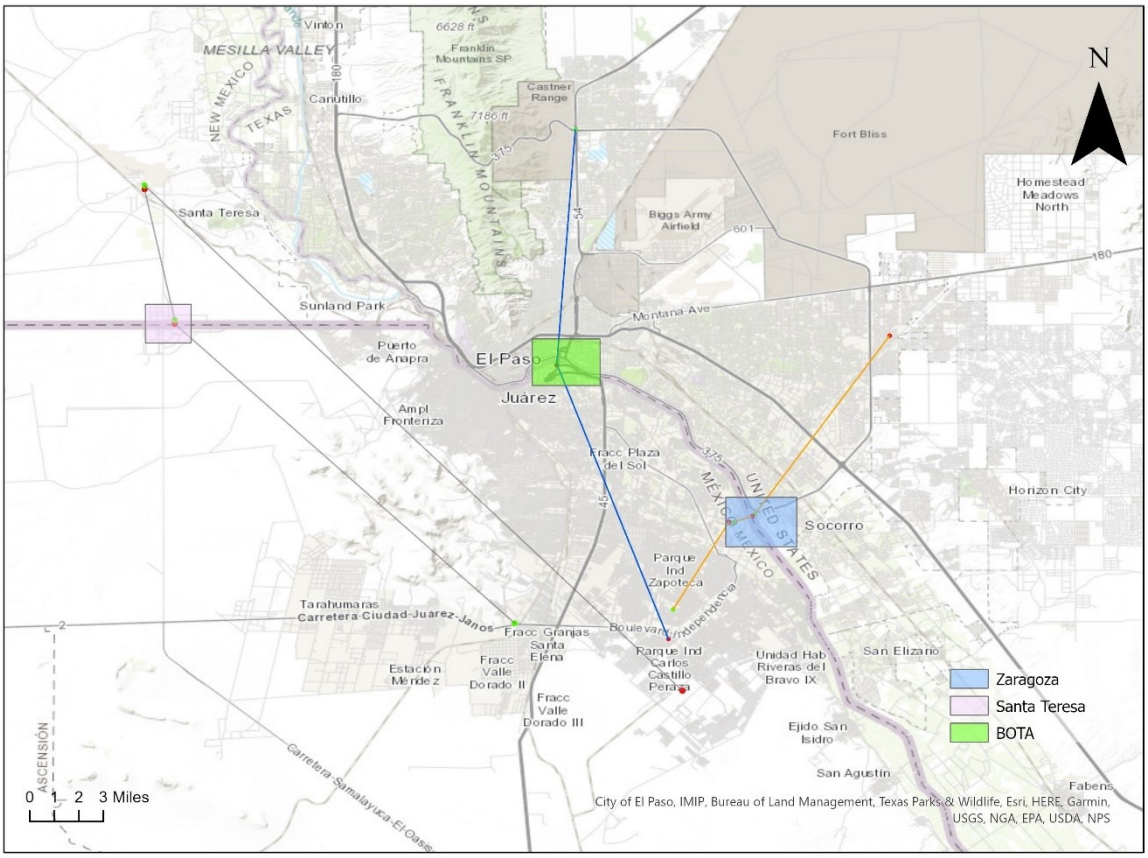

Figure 3. Traceable Trip Examples.

In addition to processing the data to identify potential trip-chaining information, the research team cleaned the data to identify any potential duplicate values that existed in the sample data received. Extensive data cleaning was conducted to prepare the data for analysis. The following primary steps were undertaken (using geographic information system [GIS] tools):

- Mapping the trips data: As shown in Table 1, the INRIX trips dataset has the latitude and longitude of each trip's origin and destination. Using this information, the research team developed two different maps showing the ODs of each trip.
- Detecting NB trips: The ODs were filtered with an origin located in Mexico and destination located in the United States. Those trips were joined, and the ones with the same unique trip ID were kept and labeled as the *NB trips*.
- Detecting the correct LPOE using trajectory data: Although the data were provided through four separate files, one for each LPOE in the study area, and each trip should have been recorded in just one of these datasets, some trips were captured in more than one LPOE dataset because INRIX provided the trip data (in each dataset) based on rectangular boundaries created for each LPOE of the study area. However, some of these boundaries were quite large, whereas the distance between the LPOEs was relatively short. This anomaly eventually resulted in the duplication of trips, which were then detected and removed by the research team. To achieve this result, the research team used the trajectory dataset. As explained above, the trajectory dataset provides each trip's route by giving the timestamp of the vehicles crossing for different segments. Since every road has a unique segment ID, international border crossings have their own IDs. Those IDs

were used in the trajectory dataset to check for the trips crossing the international crossings and then were linked to the corresponding LPOE.

- Removing the duplicates: After detecting the correct LPOE, the research team removed the duplicates from the NB trips dataset and finalized the corrected NB trips.
- Repeating the steps for the SB trips: To find the corrected SB trips, the research team followed the steps defined above by focusing on the trips that originated in the U.S. and ended in Mexico.

As a result of this cleaning process, the number of trips decreased drastically for both NB and SB trips (see Table 3). For the full data sample, the final clean dataset had around 50,000 trips entering the United States and over 86,000 trips leaving the country. The corresponding values for the clean traceable dataset were much lower than expected. Nonetheless, in the cleaned traceable dataset, the commercial vehicle trips remained the same as the full dataset—indicating that all commercial trips in the corresponding full dataset were traceable.

Table 3. Number of Trips in the INRIX Final Clean Datasets.

INRIX sample dataset	Direction of trip	LPOE	Total
Full dataset	NB	BOTA	13,203
		PdN/Stanton	13,466
		Zaragoza	22,332
		Santa Teresa	1,010
		Total	50,011
	SB	BOTA	33,569
		PdN/Stanton	13,596
		Zaragoza	34,434
		Santa Teresa	4,789
		Total	86,388
Traceable dataset	NB	BOTA	1,212
		PdN/Stanton	643
		Zaragoza	2,673
		Santa Teresa	302
		Total	4,830
	SB	BOTA	2,204
		PdN/Stanton	499
		Zaragoza	4,611
		Santa Teresa	1,604
		Total	8,738

SECONDARY DATA

Several secondary data sources were also compiled and merged with the INRIX trip data to provide a more detailed perspective on trip patterns. These data sources were mainly developed to be used in a follow-up study of the current research as well as to serve as resources in other future studies. These additional data sources included:

- SafeGraph.
- Central appraisal districts.
- OnTheMap.
- Topologically Integrated Geographic Encoding and Referencing (TIGER)/Line files and shapefiles.
- State departments of transportation.
- INEGI.

SafeGraph

SafeGraph (n.d.) provides trip data from cell phone records and contains aggregated, anonymized, high-frequency geolocation data collected across mobile devices that have opted in to location-sharing services. These data have been used in different research studies to measure trip patterns based on points of interest (POIs). The use of the dataset has increased to measure various effects of the COVID-19 pandemic thanks to the company policy that allows free use of data for research purposes. In this study, the *core places* and *patterns* datasets were used. While the former provides general information for every POI, including location name, address, category, brand, and more (Table 4), the latter provides information on hourly visitors based on the locations of all POIs in a selected region (Table 5).

SafeGraph data account for individuals who have a cell phone with location services turned on. The sampling rate is calculated for each region based on the active users of data resources. The El Paso County sampling rate was reported as 16.3 percent (Google Colab, 2021). Although a good source of information, the data have limitations due to sampling biases, similar to various other crowdsourced data sources (see Lee and Sener [2020]). For example, the data may not adequately represent trips taken by specific population groups, such as senior adults and small children, given the low percentage of smart device ownership among these groups. One other limitation with the SafeGraph data is related to the accuracy of the GPS location data. Businesses sharing the same building or located in close proximity to each other could be mislabeled. In addition, although SafeGraph is continually trying to define new POIs in its database, it currently does not contain all POIs. Therefore, linking INRIX destinations may also mislabel the trip's destination.

Table 4. Attributes of SafeGraph Core Places Dataset.

Attribute	Description
safegraph_placekey_id	Unique ID tied to the POI.
parent_safegraph_placekey_id	If place is encompassed by a large place (e.g., mall, airport), this lists the placekey of the parent place.
location_name	Name of the place.
safegraph_brand_ids	Unique ID that represents the brand.
brands	If the POI is an instance of a larger brand, this will contain that brand name.
store_id	Unique ID associated with the store as provided and maintained by the store/brand itself.
top_category	Label associated with the first digits of the POI's North American Industry Classification System (NAICS) category.
sub_category	Label associated with all six digits of the POI's NAICS category.
naics_code	NAICS code of the place describing the business.
latitude	Latitude coordinate of the POI.
longitude	Longitude coordinate of the POI.
street_address	Street address of the POI.
city	City of the POI.
region	State of the POI.
postal_code	Postal code of the POI.
iso_county_code	Two-letter ISO 3166-1 alpha 2 country code.
phone_number	Phone number of the POI.
open_hours	String with days as keys and opening and closing times (in the POI's local time) as values.
category_tags	For POI with naics_code starting 722 (food services and drinking places), this provides extra descriptive tags indicating higher-resolution category information.
opened_on	Year and month this POI opened.
closed_on	Year and month this POI closed.
tracking_closed_since	Year and month SafeGraph started tracking of the close of the POI.

Table 5. Attributes of SafeGraph Patterns Dataset.

Attribute	Description
safegraph_placekey_id	Unique ID tied to the POI.
location_name	Name of the place.
street_address	Street address of the POI.
city	City of the POI.
region	State of the POI.
postal_code	Postal code of the POI.
safegraph_brand_ids	Unique ID that represents the brand.
brands	If the POI is an instance of a larger brand, this will contain that brand name.
date_range_start	Start time for measurement period (local time).
date_range_end	End time of measurement period (local time).
raw_visit_counts	Number of visits to this POI during the date range.
raw_visitor_counts	Number of unique visitors to this POI during the date range.
visits_by_day	Number of visits to the POI each day (local time).
poi_cbg	Census block group the POI is located within.
visitor_home_cbgs	Number of visitors to the POI from each census block group based on the visitor's home location.
visitor_daytime_cbgs	Number of visitors to the POI from each census block group based on primary daytime location between 9 a.m. and 5 p.m.
visitor_country_of_origin	Number of visitors to the POI from each country based on the visitor's home country code.
distance_from_home	Median distance from home traveled by visitors (in meters).
median_dwell	Median minimum dwell time in minutes.
bucketed_dwell_times	The distribution of visit dwell times based on prespecified buckets.
related_same_day_brand	Other brands that the visitor to this POI visited on the same day as the visit to this POI.
related_same_month_brand	Other brands that the visitor to this POI visited in the same month as the visit to this POI.
popularity_by_hour	Number of visits in each hour over the course of the date range in local time.
popularity_by_day	Number of visits in total on each day of the week over the course of the date range (in local time).
device_type	Number of visitors to the POI that are using Android or iOS.

Central Appraisal Districts

The research team gathered cadastral data from the central appraisal districts of El Paso County, Doña Ana County, and Otero County. Cadastral data are generally structured in two datasets: appraisal data and geographic data. Appraisal data contain real property value, land use, development status, and acreage. Geographic data contain information that identifies real property location. The research team used GIS tools to join these two datasets. The resulting dataset allowed the research team to characterize parcels where cross-border trips start and end on the U.S. side of the border. Table 6 provides the attributes of El Paso County, Doña Ana County, and Otero County cadastral datasets.

Table 6. Attributes of Central Appraisal District Datasets.

Attribute	Description
El Paso County Cadastral Data	
PROP_ID	Unique identifier for the real property parcel.
PROP_VAL_Y	Year of the dataset.
Market_Val	Market value of the real property expressed in U.S. dollars (USD).
Land_Use	Land use of the real property—agricultural, commercial, industrial, residential, or utilities.
Dev_Status	Status of the parcel development—vacant or developed.
Doña Ana County Cadastral Data	
ACCOUNTNUM	Unique identifier for the real property taxpayer.
PARELNUM	Unique identifier for the real property parcel.
TOTALACRES	Area of the real property parcel expressed in U.S. acres.
TOTALVALUE	Market value of the real property expressed in USD.
Land_Use_T	Land use of the real property if developed (i.e., church, commercial, industrial, residential, retail, or school) or "vacant" if undeveloped.
PROP_VAL_Y	Year of the dataset.
Otero County Cadastral Data	
ACCOUNT_NU	Unique identifier for the real property taxpayer.
TOTAL_VALU	Market value of the real property expressed in USD.
Land_Use	Land use of each developed real property—agricultural, church, commercial, industrial, residential, or school.
Total_Acre	Area of the real property parcel expressed in U.S. acres.
PROP_VAL_Y	Year of the dataset.
Dev_Status	Status of the parcel development—vacant or developed.

OnTheMap

OnTheMap is a tool developed by the U.S. Census Bureau to access historical employment data values per NAICS sector, earnings, age, ethnicity, and educational level. The research team collected employment geographic databases from 2002 to 2018 for El Paso County, Doña Ana County, and Otero County. Table 7 provides the attributes of the three county employment datasets.

Table 7. Attributes of OnTheMap Datasets.

Attribute	Description
C000	Total number of jobs.
CA01	Number of jobs for workers aged 29 or younger.
CA02	Number of jobs for workers aged 30 to 54.
CA03	Number of jobs for workers aged 55 or older.
CE01	Number of jobs with earnings $1250/month or less.
CE02	Number of jobs with earnings $1251/month to $3333/month.
CE03	Number of jobs with earnings greater than $3333/month.
CNS01	Number of jobs in NAICS Sector 11 (Agriculture, Forestry, Fishing, and Hunting).
CNS02	Number of jobs in NAICS Sector 21 (Mining, Quarrying, and Oil and Gas Extraction).
CNS03	Number of jobs in NAICS Sector 22 (Utilities).
CNS04	Number of jobs in NAICS Sector 23 (Construction).
CNS05	Number of jobs in NAICS Sector 31–33 (Manufacturing).
CNS06	Number of jobs in NAICS Sector 42 (Wholesale Trade).
CNS07	Number of jobs in NAICS Sector 44–45 (Retail Trade).
CNS08	Number of jobs in NAICS Sector 48–49 (Transportation and Warehousing).
CNS09	Number of jobs in NAICS Sector 51 (Information).
CNS10	Number of jobs in NAICS Sector 52 (Finance and Insurance).
CNS11	Number of jobs in NAICS Sector 53 (Real Estate and Rental and Leasing).
CNS12	Number of jobs in NAICS Sector 54 (Professional, Scientific, and Technical Services).
CNS13	Number of jobs in NAICS Sector 55 (Management of Companies and Enterprises).
CNS14	Number of jobs in NAICS Sector 56 (Administrative and Support and Waste Management and Remediation Services).
CNS15	Number of jobs in NAICS Sector 61 (Educational Services).
CNS16	Number of jobs in NAICS Sector 62 (Health Care and Social Assistance).
CNS17	Number of jobs in NAICS Sector 71 (Arts, Entertainment, and Recreation).
CNS18	Number of jobs in NAICS Sector 72 (Accommodation and Food Services).
CNS19	Number of jobs in NAICS Sector 81 (Other Services [except Public Administration]).
CNS20	Number of jobs in NAICS Sector 92 (Public Administration).
CR01	Number of jobs for workers with Race: White, alone.
CR02	Number of jobs for workers with Race: Black or African American alone.
CR03	Number of jobs for workers with Race: American Indian or Alaska Native alone.
CR04	Number of jobs for workers with Race: Asian alone.
CR05	Number of jobs for workers with Race: Native Hawaiian or Other Pacific Islander alone.
CR07	Number of jobs for workers with Race: Two or More Race Groups.
CT01	Number of jobs for workers with Ethnicity: Not Hispanic or Latino.
CT02	Number of jobs for workers with Ethnicity: Hispanic or Latino.
CD01	Number of jobs for workers with Educational Attainment: Less than high school.
CD02	Number of jobs for workers with Educational Attainment: High school or equivalent, no college.
CD03	Number of jobs for workers with Educational Attainment: Some college or associate's degree.
CD04	Number of jobs for workers with Educational Attainment: Bachelor's degree or advanced degree.

TIGER/Line Files and Shapefiles

TIGER/Line files and shapefiles provide a set of geographic and cartographic datasets to extract information from the U.S. Census Bureau. Specifically, the research team collected two geographic datasets that define the geographical limits of El Paso County, Doña Ana County, and Otero County, along with the urban areas within those counties. The research team used these datasets to extract relevant information from the U.S. Census Bureau for the counties subjected to analysis and the urban areas located in these counties. The datasets only have one attribute, called "NAME," which provides the name of each county or urban area.

State Departments of Transportation

State departments of transportation have geodatabases of their transportation assets on their websites available for public access. In this case, the research team obtained the roadway networks of El Paso County, Doña Ana County, and Otero County. These datasets can be used to define the roadways used by cross-border commuters and measure accessibility of certain areas of interest. The datasets only have one attribute, called "FULLNAME," which provides the name of each roadway.

INEGI

INEGI provides statistical, geographic, and economic information for Mexico. It is the Mexican equivalent of the U.S. Census Bureau. The research team gathered the following four datasets from INEGI:

- Chihuahua Cadastral—This dataset provides the land use for each block in Juárez and the traffic analysis zone (TAZ) where the blocks are located. The attributes of this dataset are "AMBITO" and "CVE_AGEB." AMBITO provides the land use of the block (i.e., rural or urban). CVE_AGEB provides the unique identifier of the TAZ where the block is located. The research team used this dataset to characterize blocks where cross-border trips started and ended.
- Juárez Transportation Network—This dataset covers the roadway network of Juárez. The research team used this dataset to define the roadways used by cross-border commuters and measure accessibility of certain areas of interest. Four attributes exist in this dataset—"Nombre," "Carriles," "Administra," and "Circula." Nombre provides the name of the roadway. Carriles provides the number of lanes on the roadway. Administra provides the name of the administrative body who owns the roadway. Finally, Circula provides the directionality of the roadway.
- Juárez Industrial Areas—This dataset provides the location of industrial areas in Juárez. The research team used this dataset to identify the industrial areas that are the main generators and attractors of cross-border trips. This dataset has one attribute, "Name," which provides the name of each industrial area.
- Directorio Estadístico Nacional de Unidades Economicas—This dataset provides information about the location and nature of the businesses in Juárez. The research team used this dataset to identify business activities that are the main generators and attractors of cross-border trips. This dataset consists of three attributes, named "nombre_estab," "nombre_act," and "per_ocu." Nombre_estab provides the name of the business.

Nombre_act provides the name of the economic activity of the business. Finally, per_ocu provides the number of employees of the business.

DATA ANALYSIS

The data were analyzed through an exploratory approach, including an extensive descriptive exploration of patterns in trips crossing the border, with a focus on vehicle type, trip time (month, day of week, and time of day), trip distance, and trip purpose. For the latter, several polygons were developed by the researchers at the most popular POIs across El Paso and Juárez, such as shopping centers, educational institutes, hospitals, and more. Shopping center polygons were developed based on shopping centers with high client volume. The polygons for educational institutes included colleges, universities, and public schools in El Paso. The public schools point shapefile was obtained on GIS servers (through ArcGIS REST Services Directory [2021]), including public schools from the entire country, and was then segregated by public schools within El Paso. Polygons from all hospitals within El Paso were created. Trips were segregated by location and assigned a trip purpose from the destination.

INRIX considers a trip ended when the vehicle stops for more than a certain amount of time. As noted by Montero and Ros-Roca (2020), INRIX end-of-trip identification uses common established rules (10 minutes of inactivity or motion within a 100 m radius). In the context of cross-border travel, this is problematic because cross-border trips tend to be unstable in terms of crossing time. Although some trips may take minutes, other trips may take more than two hours. Therefore, many cross-border trips are labeled as ended while crossing the border.

Both univariate and bivariate analyses were conducted. The analyses were conducted for each LPOE using both full and traceable datasets to examine the similarities or differences in distributions. Both NB and SB trips were examined. In addition, given that the INRIX data were obtained for a three-month period covering before and after border restrictions, the analysis also included a high-level examination of the border restrictions' effects (due to the pandemic) on these cross-border trip patterns (see Gurbuz et al. [2021a] and Gurbuz et al. [2021b] for detailed analyses of the impact of the pandemic on cross-border trips).

CHAPTER 4: RESULTS

Several descriptive statistics were computed using the final cleaned sample of the INRIX datasets (as described in Chapter 3) to examine the cross-border trip patterns of each LPOE of the study area (i.e., BOTA, PdN/Stanton, Zaragoza, and Santa Teresa). The analysis provided insights into the strengths and weaknesses of the sample data. In this chapter, the results are presented and discussed based on the cleaned version of the full INRIX sample dataset. For further insights and comparison purposes, additional tables are provided in Appendix A using the cleaned version of the full dataset and in Appendix B using the cleaned version of the traceable dataset.

TOTAL NUMBER OF CROSS-BORDER TRIPS

Table 8 presents the total number of trips crossing the border at the LPOEs in both directions (i.e., NB and SB). Although the raw full dataset included more than 4 million trips from January 20 to April 19, 2020, the numbers were much lower once the data were cleaned, and duplicate trips were removed from the individual LPOE datasets. The final clean full dataset captured 50,011 NB trips and 86,388 SB trips. The clean full dataset analysis results indicated Zaragoza as the busiest LPOE according to the data for both NB and SB directions. For NB trips, PdN ranked as the second busiest LPOE, followed by BOTA in third. It was the other way around for SB trips, with BOTA ranking the second busiest, followed by PdN in third. Clearly, the considerable traffic demands of LPOEs are not supported by Santa Teresa's facility since it is the smallest LPOE among all located in the area and was the least busy LPOE for both directions.

Table 8. Number of NB and SB Cross-Border Trips in the INRIX Sample Data.

Direction of trip	LPOE	Total	Weekdays	Weekends
NB	BOTA	13,203	8,309	5,164
	PdN/Stanton	13,466	8,465	5,001
	Zaragoza	22,332	13,145	9,187
	Santa Teresa	1,010	677	333
	Total	50,011	30,326	19,685
SB	BOTA	33,569	19,176	14,393
	PdN/Stanton	13,596	7,441	6,155
	Zaragoza	34,434	20,185	14,249
	Santa Teresa	4,789	2,849	1,940
	Total	86,388	49,844	36,825

CROSS-BORDER TRIPS BY VEHICLE TYPE

INRIX collects the type of vehicle for every trip and sets a number from 1 to 3 to recognize the vehicle type based on the weight of the vehicle. Type 1 corresponds to vehicles lighter than 14,000 lb—in other words, passenger vehicles or light-duty trucks. Type 2 is for vehicles heavier

than 14,000 lb and lighter than 26,000 lb, which corresponds to medium-duty trucks. Last, Type 3 refers to heavy-duty trucks heavier than 26,000 lb.

Table 9 shows a relationship between the LPOE and the type of vehicle crossing per day of the week. Although most of the traffic crossing the border corresponds to passenger vehicles, a representative volume of border crossings corresponds to freight traffic. Thousands of trips every day are responsible for the flow of materials and goods that ship from or to the United States. While BOTA, Zaragoza, and Santa Teresa have commercial traffic, PdN/Stanton has no operations for commercial vehicles.

Table 9. Cross-Border Trips by Vehicle Type and Day of the Week for NB Trips.

Day of the week	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
Monday	1,897	83	3	2,028	—	—
Tuesday	1,954	93	8	2,195	—	—
Wednesday	1,813	82	12	2,139	—	—
Thursday	1,965	123	6	2,103	—	—
Friday	1,828	92	9	2,034	—	—
Saturday	1,614	35	0	1,620	—	—
Sunday	1,550	36	0	1,347	—	—
Total	**12,621**	**544**	**38**	**13,466**	**—**	**—**
Day of the week	**Zaragoza**			**Santa Teresa**		
	Type 1	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
Monday	2,935	227	152	105	77	0
Tuesday	2,898	238	179	104	60	6
Wednesday	2,880	244	157	137	39	3
Thursday	2,840	213	182	110	34	2
Friday	2,782	229	173	90	53	2
Saturday	3,043	156	88	89	5	0
Sunday	2,681	35	0	93	1	0
Total	**20,059**	**1,342**	**931**	**728**	**269**	**13**

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

As shown in Table 9, the demand of any LPOE varied based on the day of the week. Thousands of cross-border commuters resided in Juárez but traveled daily across the border to El Paso to work, adhering to a traditional work schedule of Monday to Friday. In addition, students usually crossed the border during the week. Potentially due to the reduction of travel for these workers and students on the weekend, the number of cross-border trips was significantly lower, especially on Sundays (and, on most occasions, Saturdays). The most crowded day of the week varied across LPOEs, while Sunday was the least crowded day for all LPOEs.

Unsurprisingly, passenger vehicle was the most common vehicle type crossing the border. Passenger vehicle trips remained constant through weekdays, whereas trips diminished during weekends. Zaragoza and PdN/Stanton registered the highest volume of passenger vehicles for the

NB trips. Similarly, commercial traffic was constant during weekdays but dropped significantly on weekends. Commercial vehicles are limited to crossing the border during an LPOE's work schedule, which explains the high reduction in the number of trips, especially on Sundays.

Southbound trips showed similar results. More trips took place on weekdays than on weekends, as shown in Table 10. In contrast to the NB trips, SB trips increased on Fridays and Saturdays, while Sunday was the day with the lowest trips. Nonetheless, more trips were registered during weekdays than weekends.

Table 10. Cross-Border Trips by Vehicle Type and Day of the Week for SB Trips.

Day of the week	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
Monday	4,701	123	17	1,774	—	—
Tuesday	4,830	144	29	1,910	—	—
Wednesday	4,478	121	37	1,817	—	—
Thursday	4,548	130	18	1,940	—	—
Friday	5,248	135	23	2,443	—	—
Saturday	5,619	78	6	2,526	—	—
Sunday	3,222	62	—	1,186	—	—
Total	**32,646**	**793**	**130**	**13,596**	**—**	**—**
Day of the week	**Zaragoza**			**Santa Teresa**		
	Type 1	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
Monday	4,257	329	335	464	303	32
Tuesday	4,206	352	406	364	279	25
Wednesday	4,227	367	431	373	267	32
Thursday	4,518	326	431	430	252	28
Friday	4,983	350	379	685	260	25
Saturday	4,973	199	128	535	42	0
Sunday	3,169	68	0	372	21	0
Total	**30,333**	**1,991**	**2,110**	**3,223**	**1,424**	**142**

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

CROSS-BORDER TRIPS BY MONTH

As indicated by the LPOE data, each LPOE carries a high volume of traffic monthly. The first month of data captured the greatest combined number of trips of all LPOEs, with over 20,000 trips. Out of the three INRIX data months, no notable change occurred in trips during the first two months. However, a reduction of over 50 percent occurred in most LPOEs during the last month of data, from March 20 to April 19, 2020, when the international restrictions went into effect (Figure 4). During the initial two months of data, and with trips of all the LPOEs combined, more than 19,000 trips were registered, while in the last month, a little over 9,000 trips were detected.

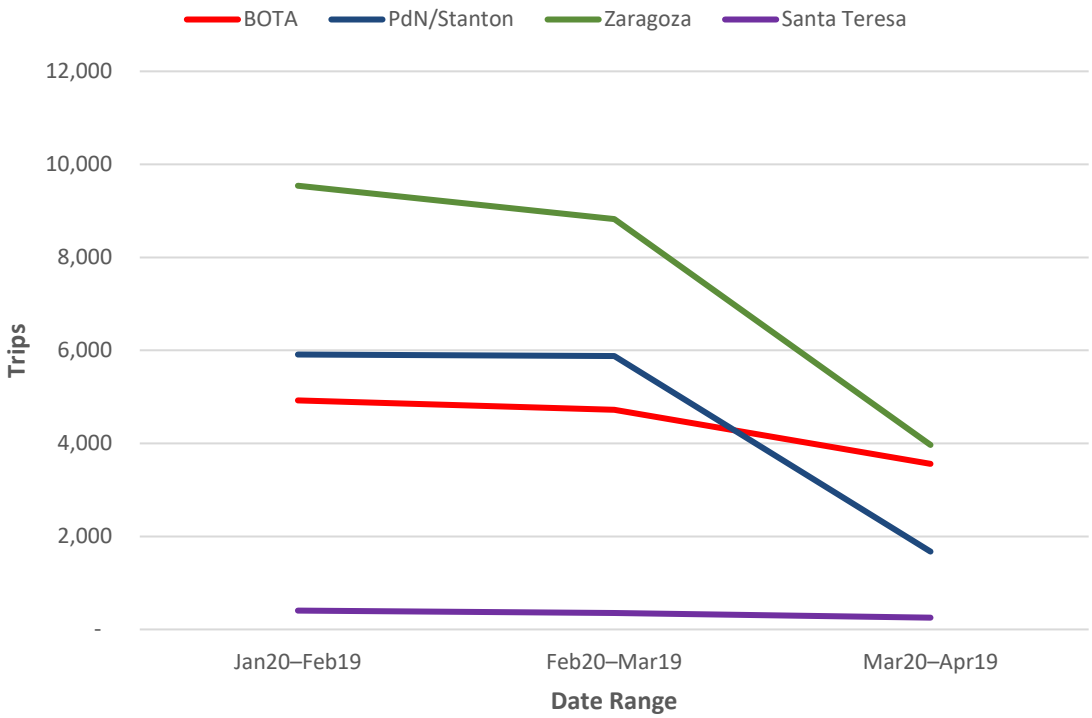

Figure 4. Cross-Border Trips by Month for NB Trips.

The reduction occurred due to people from El Paso and Juárez taking action to prevent COVID-19 by isolating at home and avoiding crowded areas. Governments from both countries applied restrictions to slow the spread of COVID-19 by temporarily closing recreational areas. In addition, El Paso County applied a mandatory curfew on March 24 that allowed residents to conduct only essential travel—such as to grocery stores or medical offices—and nonessential businesses remained closed during the curfew. Juárez did not apply a mandatory curfew but encouraged people to stay home, and nonessential businesses were not able to operate. Nonessential businesses remained closed in Juárez for a period of two months, which discouraged any recreational trips. The closure of nonessential businesses in both cities and the curfew applied in El Paso resulted in a clear reduction in the number of international trips.

Figure 5 demonstrates the SB trip reduction, similar to NB trips, once the border restrictions went into effect. No recreational trips to El Paso were undertaken by Mexican residents, and trips to Juárez diminished as a consequence. Southbound trip volume was reduced by more than 50 percent at some LPOEs—especially at BOTA, which went from registering 14,460 trips in the first month to 4,413 in the last month, indicating a trip reduction of 70 percent.

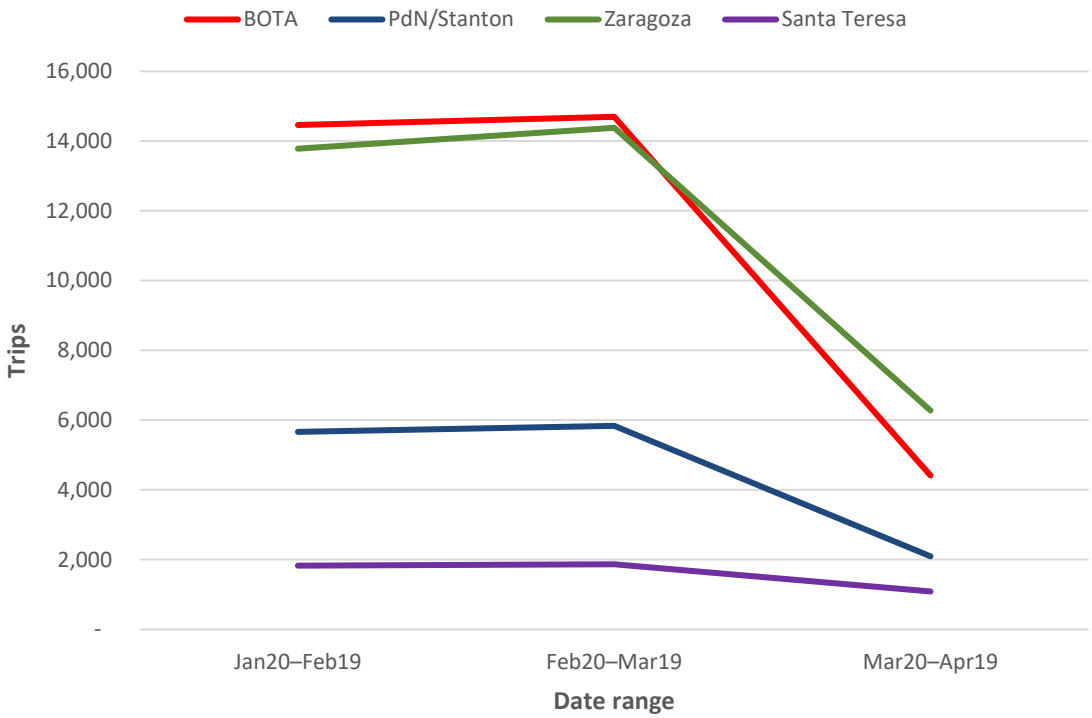

Figure 5. Cross-Border Trips by Month for SB Trips.

CROSS-BORDER COMMERCIAL TRIPS BY MONTH

Figure 6 presents the monthly data for both NB and SB cross-border commercial trips (see the appendices for additional tables showing the cross-border trip distribution by vehicle type by month). The results demonstrate that although a reduction in commercial trips occurred once the land border restrictions were applied, commercial trips did not diminish as much as cross-border trips by personal vehicles.

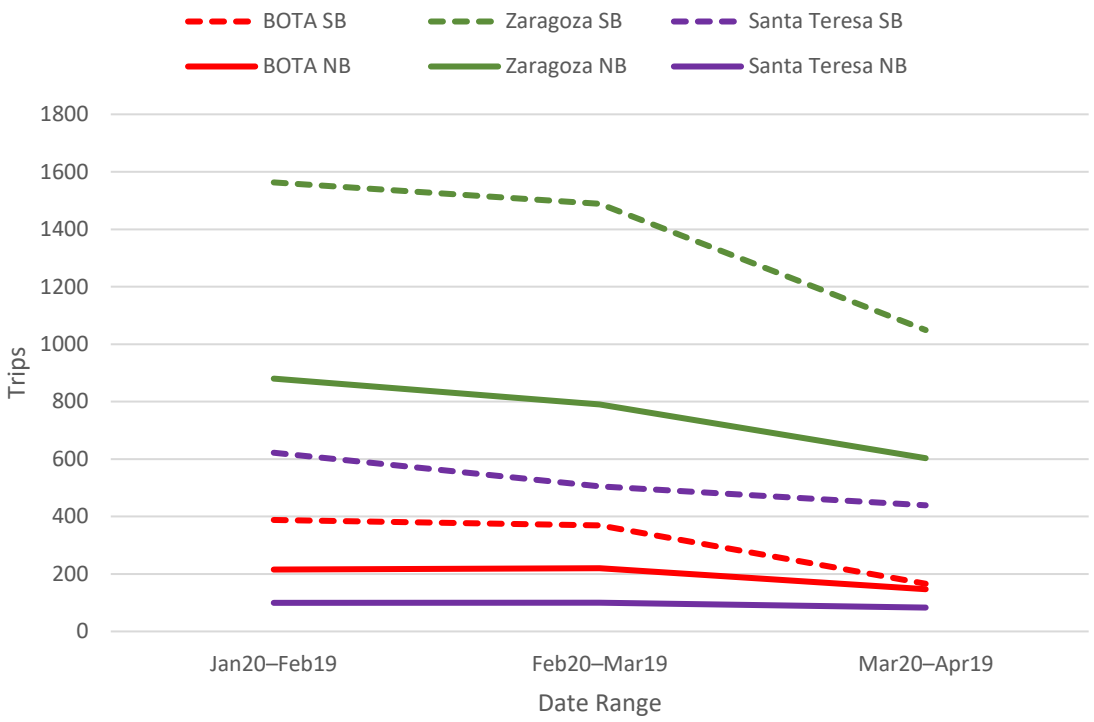

Figure 6. Cross-Border Commercial Trips by Month for NB and SB Trips.

CROSS-BORDER TRIPS BY TIME OF DAY

Three of the four selected LPOEs between El Paso and Juárez operate 24/7 for passenger vehicles and pedestrians, which leads to cross-border trips at any time of the day. Santa Teresa is the only LPOE that operates under a schedule for passenger vehicles and pedestrians: 6:00 a.m. to midnight every day of the week. Regarding commercial traffic, all LPOEs that have operating lanes for commercial traffic work under a schedule, and therefore commercial traffic is limited to following the work schedule of the LPOE. BOTA is open to commercial traffic Monday through Friday from 6:00 a.m. to 2:00 p.m. On the other hand, Zaragoza is open to commercial traffic Monday through Friday from 6:00 a.m. to midnight and Saturdays from 8:00 a.m. to 4:00 p.m. Finally, Santa Teresa is open to commercial traffic Monday through Friday from 6:00 AM to 8:00 PM.

All LPOEs shared a similar trip demand curve by time in the NB direction, illustrating that all cross-border trips occurred during the same peak and nonpeak periods during the day (Figure 7). While Santa Teresa shared the same distribution, the demand compared to the other LPOEs was lower. Night and afternoon periods were the peak times of the day of the NB dataset, while the morning was the least busy time.

Southbound trips showed consistent results in terms of how peak times were distributed through the day (Figure 8). The peak time occurred during the afternoon and remained constant for the rest of the day, while the nonpeak time occurred in the morning up to 10:00 a.m., which is when the demand started increasing.

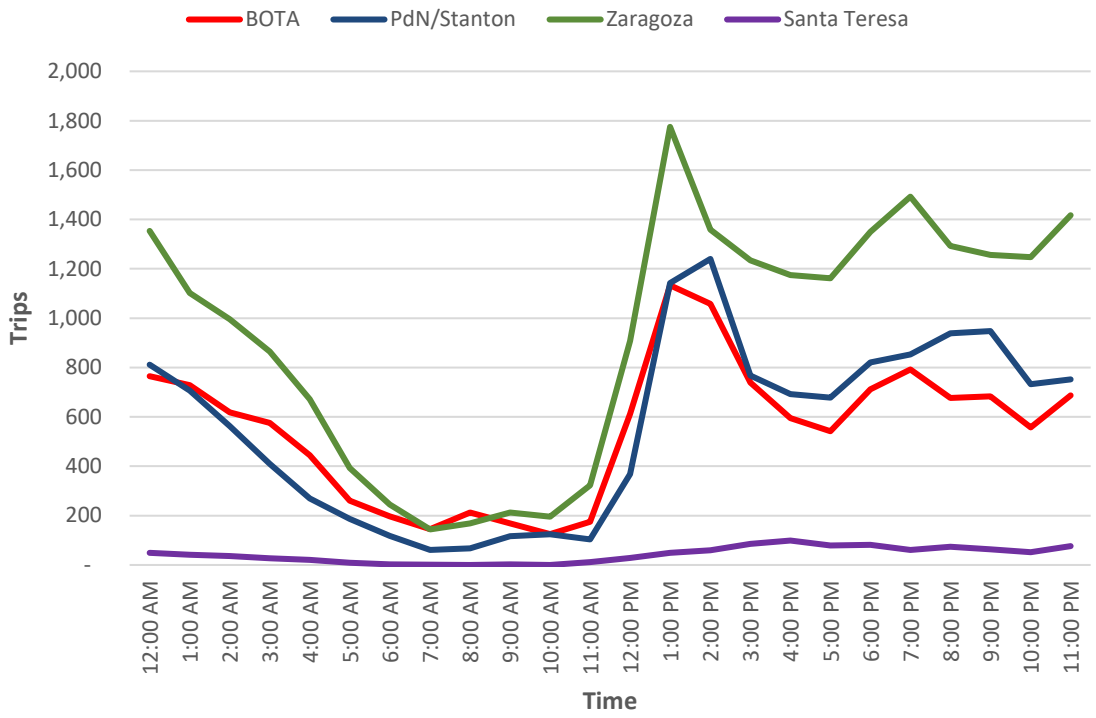

Figure 7. Cross-Border Trips by Time of Day for NB Trips.

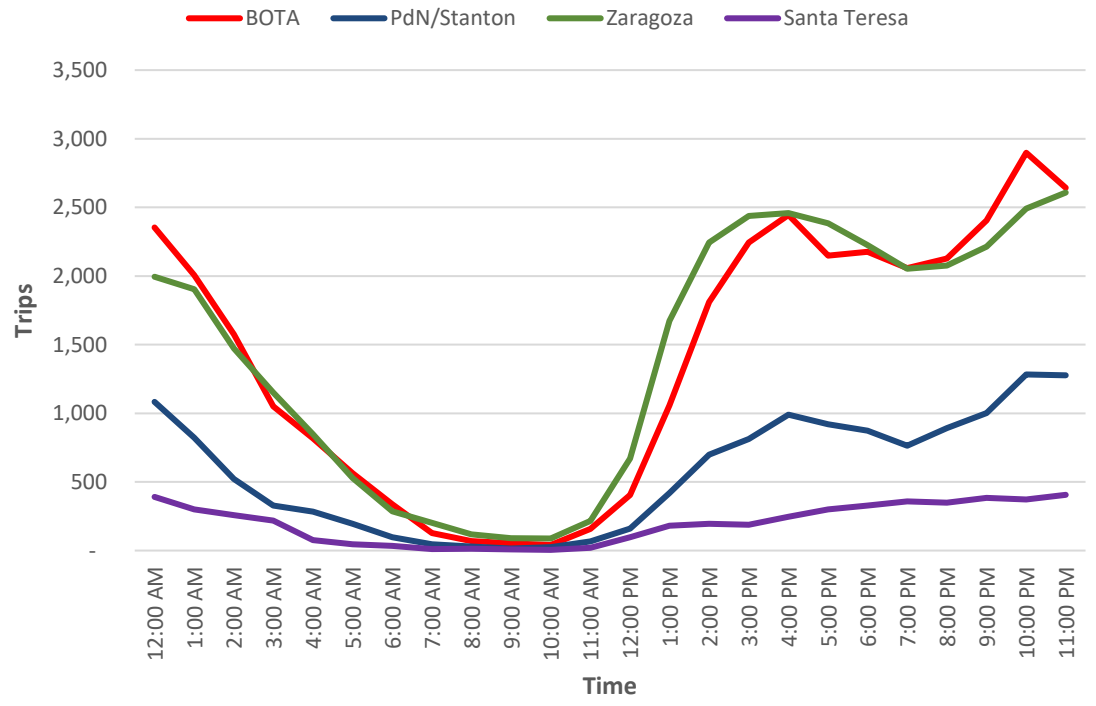

Figure 8. Cross-Border Trips by Time of Day for SB Trips.

CROSS-BORDER TRIPS BY TRIP DISTANCE

Knowing the length of trips is especially helpful in determining local trips that take place in the El Paso–Ciudad Juárez region. The size of the region is relatively small, and commuters do not often drive a distance greater than 25 mi to get to their destination. However, the trip distance might be affected by the end-of-trip limitation. INRIX registers the end of a trip when the device stops for more than a certain amount of time—more specifically, 10 minutes of inactivity within a 100 m (0.062 mi) radius, according to Montero and Ros-Roca (2020).

Based on the trips detected in the NB dataset, 0–10 mi was the most frequent distance traveled by those who crossed the border through either Zaragoza or PdN. On the other hand, 11–20 mi was the most frequent distance traveled by travelers crossing through BOTA and Santa Teresa (Figure 9). In addition, an increase in trips occurred when the distance was greater than 91 mi, which could be attributed to commercial traffic or to commuters making out-of-town trips.

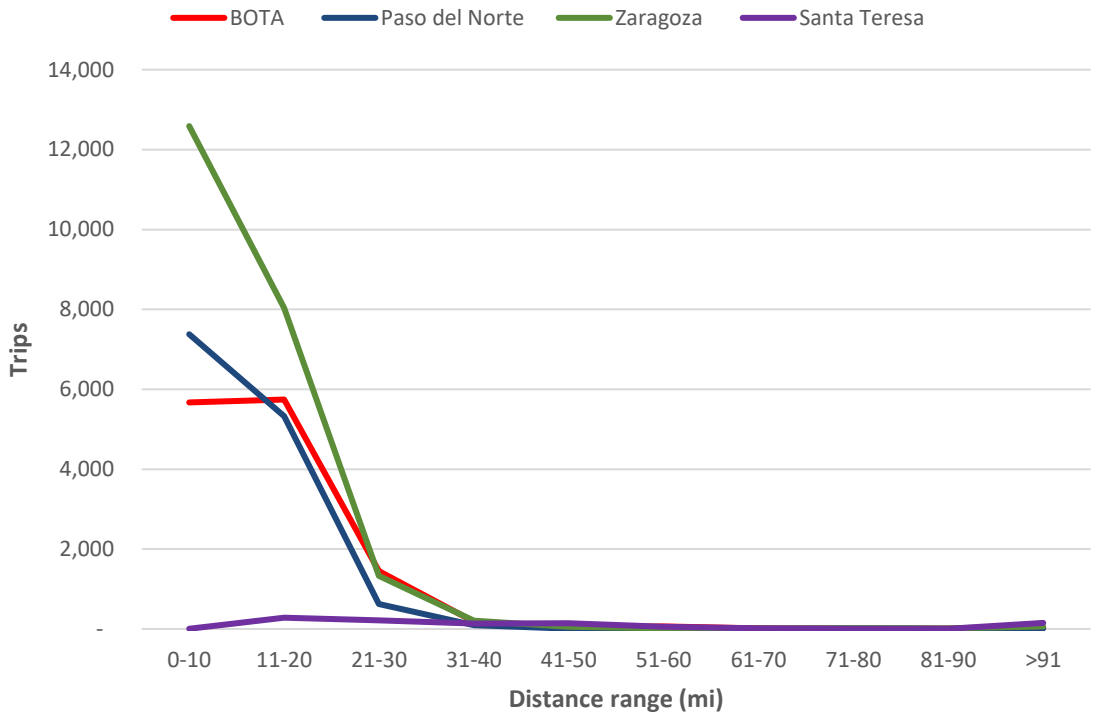

Figure 9. Cross-Border Trips by Trip Distance for NB Trips.

The SB trips displayed a different curve on the distance graph. The trip distance distribution curve started with a peak, dropped to a constant, and peaked again for distances greater than 81 mi (Figure 10). The 0–10 mi range was the most frequent distance range for commuters crossing to Juárez through Zaragoza, while the 11–20 mi distance range was the most frequent range for BOTA and PdN commuters. The 21–30 mi was the most frequent distance range among commuters crossing through Santa Teresa. The appendices provide additional tables presenting the cross-border trip distribution by trip distance at various scales and by vehicle type (for both NB and SB data).

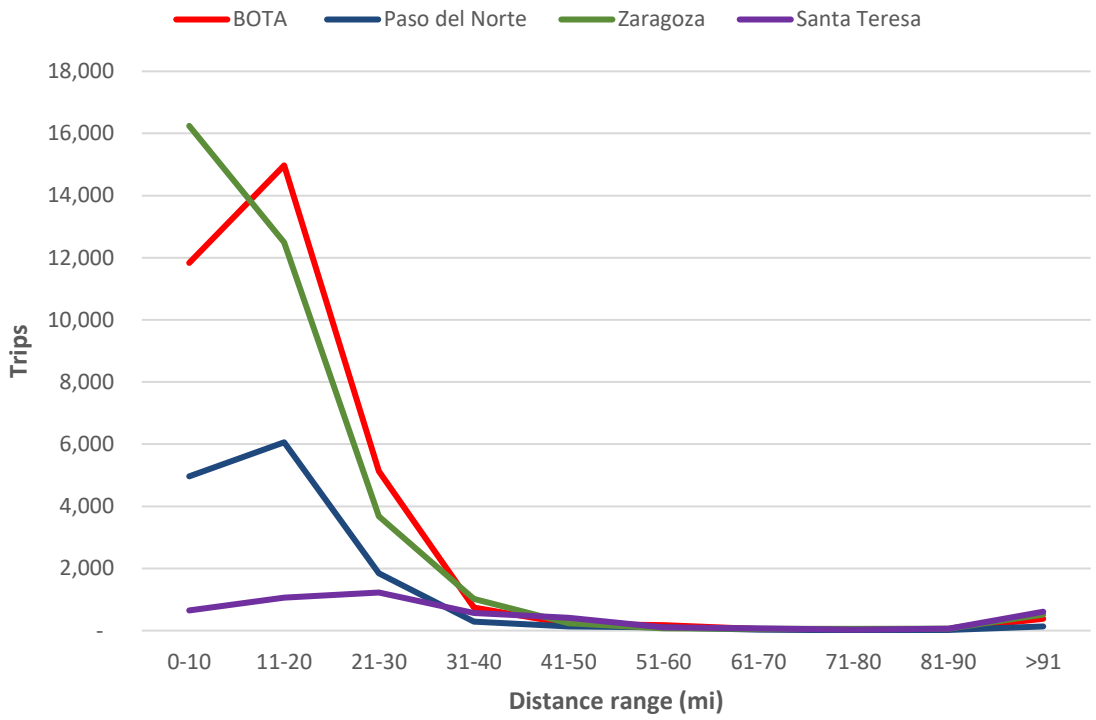

Figure 10. Cross-Border Trips by Trip Distance for SB Trips.

CROSS-BORDER TRIPS BY TRIP PURPOSE

Trips to El Paso

People conduct cross-border trips for many reasons, and such purposes may be obtained by extracting the destination coordinates, as briefly discussed earlier. To analyze cross-border trip purposes to El Paso, only NB trips were taken into consideration as trips destined for the U.S. side. Trip purposes were classified into three categories: shopping, which included malls and grocery stores; educational, which included UTEP, all El Paso Community College (EPCC) campuses, and public schools; and medical, which corresponded with all hospitals in El Paso.

Figure 11 presents the cross-border trips from Juárez to El Paso by each of the three trip purposes across all months of data for the clean full dataset. Considering all LPOEs combined, shopping generated the most trips among the three purpose categories, with 4,229 during the three months of data. Although grocery stores and mall trips are within the same category, trips were segregated to analyze the trip characteristics. The biggest shopping centers in El Paso registered more cross-border trips during weekends than weekdays, while grocery stores and small shopping centers had lower cross-border trip volume on weekends. During the initial two months of data when there were no COVID-19 restrictions, more than 2,700 trips were made to malls in El Paso—in other words, a monthly average of greater than 1,300 cross-border shopping trips. Trips to grocery stores during the same period totaled a monthly average of 443. During the last month of the data, 282 trips to grocery stores were registered. Basset Place Mall was the most visited mall in El Paso for cross-border trips, while the second most visited mall was Cielo

Vista Mall. The second most popular reason for cross-border trips was for education purposes, with 1,566 trips. Among the educational institutions, UTEP registered the highest volume, with 1,064 trips, followed by EPCC and public schools with 264 and 238 trips, respectively. As expected, educational trips were mostly during weekdays and decreased significantly on weekends. Last, 276 cross-border trips to hospitals were made from January to April; medical trips were steady on weekdays and dropped during the weekend.

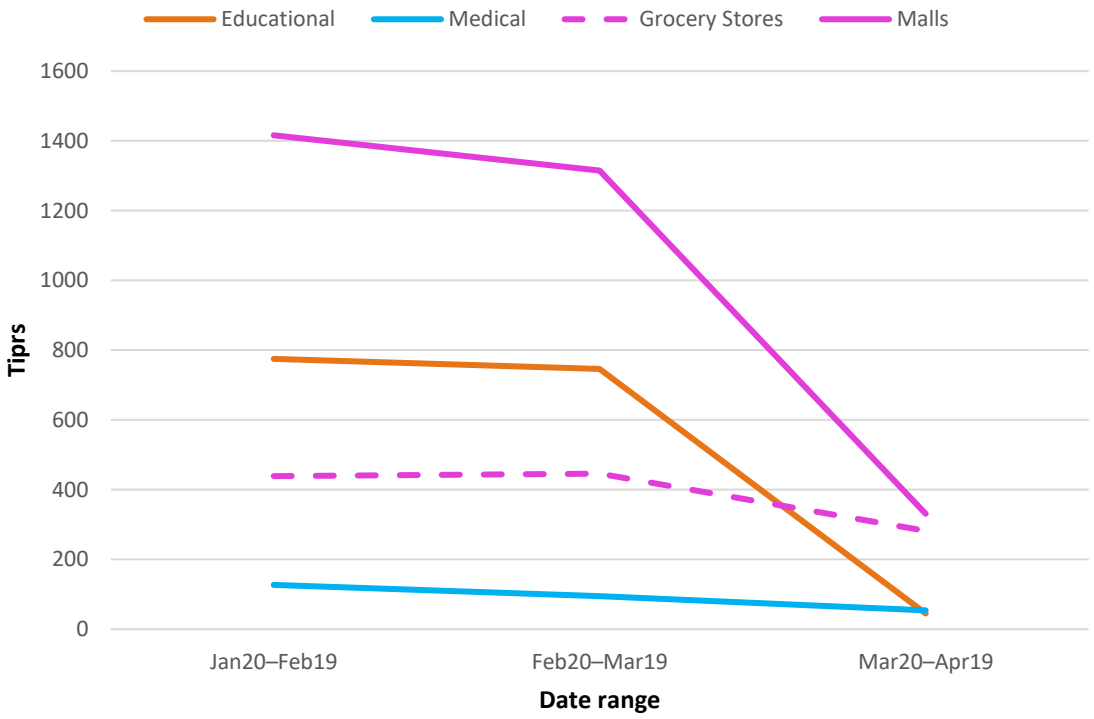

Figure 11. Cross-Border Trips to El Paso by Trip Purpose by Month.

As discussed previously, COVID-19 impacted border traffic drastically since only essential travel was allowed and nonessential businesses could not operate during the first curfew applied by El Paso County. Thus, a huge reduction in travel occurred in the last month of data for all trip purposes. Retail businesses were the facilities most greatly impacted by COVID-19-related restrictions since businesses were not allowed to operate for a period. During the first two months, 3,616 trips were taken for shopping purposes, whereas only 613 trips were registered during the last month. After COVID-19 restrictions were implemented, grocery stores remained the highest visited destination for international commuters; nonetheless, the volume decreased. On the other hand, cross-border trips to malls were drastically impacted once border restrictions were enforced, with only 331 cross-border trips to malls detected. Meanwhile, malls with no essential businesses received almost no trips because all stores were closed. During the first two months of data, 346 cross-border trips embarked to Cielo Vista Mall, while cross-border trips to the same location dropped to two in the last month. This falloff signified a huge reduction in trips, especially since Cielo Vista is the mall in El Paso that previously generated one of the highest volumes of cross-border trips. Educational trips registered 1,521 trips during the first two months of data but fell in the last month to 45 due to the closure of schools. Trips to hospitals

also diminished, but not as much as trips in the other categories. In the first two months of data, there were 222 trips to hospitals; 54 trips to hospitals were detected in the last month.

Trips to Juárez

Although most of the trips from El Paso to Juárez relate to social purposes, many commuters cross the border for other purposes, such as trips to grocery stores, hospitals, or malls. To analyze cross-border trip purposes to Juárez, SB trips were only considered if their destination was on the Mexico side.

Figure 12 presents the cross-border trips from El Paso to Juárez by each of the three trip purposes across all months of data for the full dataset. In regard to the three categories previously stated, hospital-related trips registered the highest volume from El Paso to Juárez; 1,804 trips were detected during the three months of data. Trips to hospitals in Juárez were constant from Monday to Saturday but diminished on Sundays, while Saturdays had the most cross-border trips to hospitals in Juárez. In addition, there were 1,309 trips to malls over the three months, with a peak increase on Fridays and Saturdays. Finally, there were 1,093 trips to grocery stores in Juárez. Grocery store trips from El Paso did not vary daily, and no weekday received a significantly lower volume than the rest of the days, but Saturday had the highest volume.

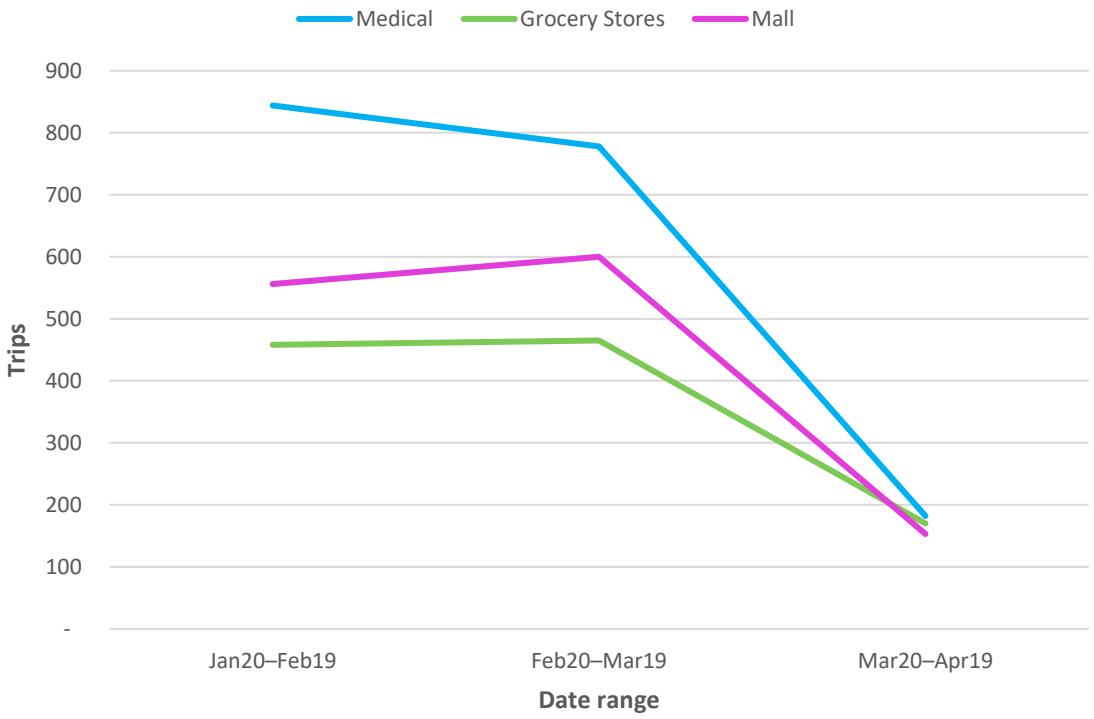

Figure 12. Cross-Border Trips to Juárez by Trip Purpose by Month.

Similar to what transpired in El Paso, even though no border restrictions for commuters crossing to Juárez from El Paso existed, COVID-19 affected Juárez. Due to the closure of nonessential businesses in Juárez, travel decreased significantly in the last month of data. Nonetheless, trips to Juárez did not drop as much as did trips to El Paso.

During the first two months, on average, 811 medical trips per month were detected, while in the last month, trips dropped to 182. Visitation to malls went from 578 trips on average per month to 153. Last, grocery stores went from having an average 462 monthly trips from commuters during the first two months to 170 trips during the last data month. In comparison to the trip reduction for malls in El Paso, malls in Juárez did not have a huge reduction since many malls in Juárez have a grocery store—an essential business—and thus could remain open.

The appendices provide additional tables that present both NB (to El Paso) and SB (to Juárez) cross-border trip distribution by trip purpose across all months and days of the week (for both the full and traceable datasets).

CHAPTER 5: CONCLUSION

The El Paso–Ciudad Juárez border has been widely studied over the years; however, research on cross-border trips (e.g., to predict cross-border travel demand or examine destination choices by cross-border commuters) has been limited. To conduct cross-border research, CIITR acquired three months of INRIX data for four study sites (PdN/Stanton, BOTA, Zaragoza, and Santa Teresa) that correspond to particular LPOEs between El Paso and Juárez. The main objective of this study was to explore the cross-border trip characteristics using the crowdsourced data while exploring the data's potential limitations for future studies. Secondary data sources were also compiled and integrated to expand the potential capabilities of the data moving forward. In addition to investigating overall cross-border trip characteristics, the researchers examined the reduction COVID-19 caused in international travel by segregating the data by months since the data depicted the reduction in trips once the restrictions went into effect.

Upon completion of data cleaning and processing, the researchers conducted an exploratory analysis of cross-border trips, including both NB (i.e., from Juárez to El Paso) and SB trips (i.e., from El Paso to Juárez). Two datasets were created from the raw data because some trips were fully traceable, and therefore a travel path could be examined in detail. While the full dataset provided more complete results on cross-border travel, the traceable dataset produced detailed traffic patterns commuters follow while conducting cross-border trips. However, the traceable dataset was comprised, for the most part, of vehicles heavier than 14,000 lb—in other words, commercial vehicles. The exploratory analysis included an overall examination of various trip characteristics over the course of the three-month time period (from January 20 to April 19, 2020) and used the final clean datasets. Given the time period, the analysis also highlighted the severe impact of a pandemic declaration on cross-border travel.

The findings revealed various patterns of cross-border travel. For instance, Zaragoza was the LPOE with the highest cross-border trip volume in both the NB and SB directions, while Santa Teresa was the LPOE with the lowest volume of trips. Cross-border trip volume in any direction was higher on weekdays than on the weekend, with passenger vehicles being the most common vehicle type that crossed the border. The peak of cross-border trips occurred during the afternoons, whereas mornings were off-peak times for both NB and SB trips. Based on the end-of-trip limitation, most binational trips ranged from 0 to 20 mi, which is reasonable since El Paso–Ciudad Juárez is a growing metropolitan center. Finally, shopping was the most common cross-border trip purpose for NB trips, while trips to hospitals were most common for SB trips.

The INRIX analysis results showed that trips to El Paso diminished significantly during the last month of data, from March 20 to April 19, 2020, after COVID-19 had already been declared a pandemic. The onset of the COVID-19 pandemic generated massive changes in the El Paso–Ciudad Juárez border, as it did worldwide. The international borders at El Paso were deeply affected due to the land border restrictions applied to nonessential NB trips to Mexican nationals. The closure of LPOEs caused a disruption for many Juárez residents to a lifestyle that previously included frequent trips to El Paso. Among the vehicle types, passenger vehicles were the most affected, probably due to border restrictions, the fact that several businesses were not able to

operate, and the closure of recreational areas. Commercial vehicles were also affected during the first month after the pandemic declaration. However, the reduction was not as extreme as it was with passenger vehicles, probably because trips made by commercial vehicles were considered essential travel. The reduction in commercial traffic can be attributed to the closure of manufacturing plants in Mexico since only essential manufacturing plants could operate at the time, thereby reducing the export volume to the United States from Mexico. In addition, results showed a drastic impact on retail stores. COVID-19 not only reduced trips due to the border closure, it also affected the local economy because retail stores were not able to operate during the initial phase of the pandemic. Although the retail store closures did not last long, many retail stores are still seeing a reduction in sales due to the absence of Mexican customers, whose expenditures provide a strong boost to the local economy.

The INRIX data provide valuable insights into cross-border travel, especially given that such data are hard to obtain due to limited resources and jurisdictional matters (such as the potential of violating the law of either country if the research does not comply with permissions). The data provide several attributes for every trip detected that can be used to segregate trips to examine cross-border trip characteristics. The analysis results also reveal the data's potential value to detect detailed travel pattern information of commercial traffic since most of the commercial vehicles were able to be traced. Similar to other data sources, the data will be of great use when merged with other data sources to validate the data or explore additional trip characteristics. For instance, the OD information provided by INRIX can be used to detect POIs of travelers that can be obtained from other crowdsourced data sources like SafeGraph data. However, the data are not without limitations. The analysis helped identify various limitations that need to be taken into consideration—limitations related to either the data themselves or the way the data were acquired. For instance, travel patterns from most passenger vehicle trips were not possible to extract due to mobile restrictions. The end-of-trip data limitation is crucial, especially for international LPOEs where people might wait for a long period of time to cross to the other side of the border. To eliminate this issue, extensive data cleaning was needed, which led to a huge reduction in trip data volume in the final dataset. This loss is particularly problematic since it makes trips appear to be less in demand than they really are. In addition, the data cleaning process was complicated and time consuming because many trips were duplicated in datasets of different LPOEs. When acquiring INRIX data, it is important to select a boundary that covers an area that is no larger than the POI (in the current study LPOEs); otherwise, the data will contain considerable data noise.

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APPENDIX A

This appendix provides supplementary tables that present the descriptive analysis of the INRIX sample data for both NB and SB trips using a cleaned version of the *full* dataset.

Table 11. Cross-Border Trips by Month and Vehicle Type for NB Trips.

Data Range	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
Jan20–Feb19	4,709	206	9	5,911	—	—
Feb20–Mar19	4,499	211	9	5,881	—	—
Mar20–Apr19	3,413	127	20	1,674	—	—
Data Range	**Zaragoza**			**Santa Teresa**		
	Type 1	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
Jan20–Feb19	8,660	544	336	306	94	5
Feb20–Mar19	8,035	473	317	252	95	5
Mar20–Apr19	3,364	325	278	170	80	3

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

Table 12. Cross-Border Trips by Month and Vehicle Type for SB Trips.

Data Range	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
Jan20–Feb19	14,072	345	43	5,664	—	—
Feb20–Mar19	14,327	320	49	5,836	—	—
Mar20–Apr19	4,247	128	38	2,096	—	—
Data Range	**Zaragoza**			**Santa Teresa**		
	Type 1	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
Jan20–Feb19	12,215	834	729	1,211	569	53
Feb20–Mar19	12,892	748	741	1,363	462	43
Mar20–Apr19	5,226	409	640	649	393	46

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

Table 13. Cross-Border Trips by Distance for NB Trips.

Distance (mi)	BOTA	PdN/ Stanton	Zaragoza	Santa Teresa
0–10	5,667	7,377	12,588	5
11–20	5,743	5,326	8,030	282
21–30	1,445	622	1,331	213
31–40	180	93	207	134
41–50	39	9	56	145
51–60	62	10	16	58
61–70	17	5	7	14
71–80	9	6	19	7
81–90	9	2	13	5
>91	32	16	65	147

Table 14. Cross-Border Trips by Distance for SB Trips.

Distance (mi)	BOTA	PdN/ Stanton	Zaragoza	Santa Teresa
0–10	11,838	4,968	16,244	653
11–20	14,972	6,060	12,495	1,061
21–30	5,128	1,848	3,679	1,225
31–40	739	286	1,024	569
41–50	219	130	235	409
51–60	178	104	68	103
61–70	51	35	56	76
71–80	20	12	56	30
81–90	42	16	63	58
>91	382	137	514	605

Table 15. Cross-Border Trips by Distance and Vehicle Type for NB Trips.

Distance (mi)	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
0–10	5,373	281	13	7,377	—	—
11–20	5,630	102	11	5,326	—	—
21–30	1,378	65	2	622	—	—
31–40	151	27	2	93	—	—
41–50	29	7	3	9	—	—
51–60	10	47	5	10	—	—
61–70	6	9	2	5	—	—
71–80	7	2	0	6	—	—
81–90	8	1	0	2	—	—
>91	29	3	0	16	—	—
Total	**12,621**	**544**	**38**	**13,466**	**—**	**—**
Distance (mi)	**Zaragoza**			**Santa Teresa**		
	Type 1	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
0–10	10,850	892	846	5	0	0
11–20	7,558	410	62	212	69	1
21–30	1,287	29	15	186	26	1
31–40	199	5	3	81	47	6
41–50	56	0	0	43	99	3
51–60	16	0	0	41	17	0
61–70	4	1	2	10	3	1
71–80	18	1	0	6	0	1
81–90	11	1	1	5	0	0
>91	60	3	2	139	8	0
Total	**20,059**	**1,342**	**931**	**728**	**269**	**13**

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

Table 16. Cross-Border Trips by Distance and Vehicle Type for SB Trips.

Distance (mi)	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
0–10	11,469	357	12	4,968	—	—
11–20	14,725	208	39	6,060	—	—
21–30	4,980	122	26	1,848	—	—
31–40	651	43	45	286	—	—
41–50	178	39	2	130	—	—
51–60	168	8	2	104	—	—
61–70	48	3	0	35	—	—
71–80	19	1	0	12	—	—
81–90	40	1	1	16	—	—
>91	368	11	3	137	—	—
Total	**32,646**	**793**	**130**	**13,596**	**—**	**—**
Distance (mi)	**Zaragoza**			**Santa Teresa**		
	Type 1	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
0–10	14,238	600	1,406	449	192	12
11–20	10,957	1,117	421	958	67	36
21–30	3,451	125	103	535	654	36
31–40	816	74	134	304	234	31
41–50	186	30	19	193	190	26
51–60	63	2	3	91	11	1
61–70	51	2	3	60	16	0
71–80	48	3	5	29	1	0
81–90	56	7	0	40	18	0
>91	467	31	16	564	41	0
Total	**30,333**	**1,991**	**2,110**	**3,223**	**1,424**	**142**

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

Table 17. Cross-Border Trips to El Paso by Trip Purpose on Weekdays for NB Trips.

POI		Monday	Tuesday	Wednesday	Thursday
Educational	UTEP	224	231	228	232
	EPCC	61	36	75	45
	Public Schools	40	44	44	45
Shopping	Basset Place	74	101	67	71
	Cielo Vista	43	36	42	43
	The Fountains	34	32	39	32
	Las Palmas	25	23	19	20
	Sunland Park Mall	22	25	29	24
	The Outlet Shoppes	11	9	10	8
	West Town	30	26	32	45
	Downtown El Paso	138	144	149	126
	El Paseo (east side)	31	23	19	29
	Grocery Stores	131	187	183	188
Medical	Hospitals	41	47	46	48
Sun Metro Stations	Downtown	6	9	5	7
	East Side	3	2	5	5
	Mission Valley	3	5	1	4
	West Side	0	0	2	1
	Northeast	1	0	0	1

Table 18. Cross-Border Trips to El Paso by Trip Purpose on Weekends for NB Trips.

POI		Friday	Saturday	Sunday
Educational	UTEP	118	17	14
	EPCC	38	9	0
	Public Schools	41	14	10
Shopping	Basset Place	74	72	50
	Cielo Vista	42	84	58
	The Fountains	39	52	49
	Las Palmas	24	34	34
	Sunland Park Mall	27	59	18
	The Outlet Shoppes	15	23	24
	West Town	47	34	37
	Downtown El Paso	142	160	132
	El Paseo (east side)	24	50	27
	Grocery Stores	146	158	174
Medical	Hospitals	40	28	26
Sun Metro Stations	Downtown	2	6	1
	East Side	4	1	3
	Mission Valley	3	1	4
	West Side	3	0	0
	Northeast	0	0	1

Table 19. Cross-Border Trips to El Paso by Trip Purpose and Month for NB Trips.

POI		Jan20–Feb19	Feb20–Mar19	Mar20–Apr19
Educational	UTEP	535	508	21
	EPCC	148	115	1
	Public Schools	92	123	23
Shopping	Basset Place	237	217	55
	Cielo Vista	175	171	2
	The Fountains	126	138	13
	Las Palmas	76	84	19
	Sunland Park Mall	101	87	16
	The Outlet Shoppes	57	39	4
	West Town	108	91	52
	Downtown El Paso	442	416	133
	El Paseo (east side)	94	72	37
	Grocery Stores	439	446	282
Medical	Hospitals	127	95	54
Sun Metro Stations	Downtown	10	19	7
	East Side	9	10	4
	Mission Valley	11	7	3
	West Side	4	2	0
	Northeast	0	0	3

Table 20. Cross-Border Trips to Juárez by Trip Purpose on Weekdays for SB Trips.

POI	Monday	Tuesday	Wednesday	Thursday
Hospitals	286	285	262	246
Grocery Stores	153	142	130	145
Mall	171	171	173	173

Table 21. Cross-Border Trips to Juárez by Trip Purpose on Weekends for SB Trips.

POI	Friday	Saturday	Sunday
Hospitals	282	323	120
Grocery Stores	157	218	148
Mall	219	273	129

Table 22. Cross-Border Trips to Juárez by Trip Purpose and Month for SB Trips.

POI	Jan20–Feb19	Feb20–Mar19	Mar20–Apr19
Medical	844	778	182
Grocery Stores	458	465	170
Mall	556	600	153

Table 23. Cross-Border Trips to El Paso by Trip Purpose and Vehicle Type for NB Trips.

POI		Type 1	Type 2	Type 3
Educational	UTEP	1,028	36	0
	EPCC	264	0	0
	Public Schools	233	5	0
Shopping	Basset Place	506	3	0
	Cielo Vista	342	6	0
	The Fountains	274	3	0
	Las Palmas	179	0	0
	Sunland Park Mall	204	0	0
	The Outlet Shoppes	100	0	0
	West Town	250	1	0
	Downtown El Paso	957	34	0
	El Paseo (east side)	203	0	0
	Walmart	1,151	16	0
Medical	Hospitals	274	2	0
Sun Metro Stations	Downtown	36	0	0
	East Side	20	3	0
	Mission Valley	20	1	0
	West Side	6	0	0
	North East	3	0	0

Table 24. Cross-Border Trips to Juárez by Trip Purpose and Vehicle Type for SB Trips.

POI	Type 1	Type 2	Type 3
Hospitals	1,781	19	4
Grocery Stores	1,079	9	2
Mall	1,296	11	1

APPENDIX B

This appendix provides supplementary tables presenting the descriptive analysis of the INRIX sample data for both NB and SB trips using a cleaned version of the *traceable* dataset.

Table 25. Number of NB and SB Cross-Border Trips in the INRIX Traceable Dataset.

Direction of trip	LPOE	Total	Weekday	Weekends
NB	BOTA	1,212	830	382
	PdN/Stanton	643	414	229
	Zaragoza	2,673	1,855	818
	Santa Teresa	302	230	72
	Total	4,830	3,329	1,501
SB	BOTA	2,204	1,328	696
	PdN/Stanton	499	288	211
	Zaragoza	4,611	3,326	1,285
	Santa Teresa	1,604	1,242	362
	Total	8,738	6,184	2,554

Table 26. Cross-Border Trips by Vehicle Type and Day of the Week for NB Trips in the INRIX Traceable Dataset.

Day of the week	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
Monday	102	83	3	120	—	—
Tuesday	116	93	8	98	—	—
Wednesday	97	82	12	93	—	—
Thursday	105	123	6	103	—	—
Friday	90	92	9	117	—	—
Saturday	67	35	0	68	—	—
Sunday	53	36	0	44	—	—
Total	**630**	**544**	**38**	**643**	**—**	**—**
Day of the week	**Zaragoza**			**Santa Teresa**		
	Type 1	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
Monday	58	227	152	1	77	0
Tuesday	84	238	179	1	60	6
Wednesday	61	244	157	2	39	3
Thursday	60	213	182	5	34	2
Friday	55	229	173	4	53	2
Saturday	54	156	88	1	5	0
Sunday	28	35	0	6	1	0
Total	**400**	**1,342**	**931**	**20**	**269**	**13**

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

Table 27. Cross-Border Trips by Vehicle Type and Day of the Week for SB Trips in the INRIX Traceable Dataset.

Day of the week	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
Monday	162	123	17	64	—	—
Tuesday	192	144	29	72	—	—
Wednesday	174	121	37	70	—	—
Thursday	181	130	18	82	—	—
Friday	171	135	23	95	—	—
Saturday	146	78	6	71	—	—
Sunday	75	62	0	45	—	—
Total	**1,101**	**793**	**130**	**499**	**—**	**—**
Day of the week	**Zaragoza**			**Santa Teresa**		
	Type 1	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
Monday	85	329	335	12	303	32
Tuesday	76	352	406	3	279	25
Wednesday	91	367	431	1	267	32
Thursday	97	326	431	8	252	28
Friday	72	350	379	6	260	25
Saturday	60	199	128	6	42	0
Sunday	29	68	0	2	21	0
Total	**510**	**1,991**	**2,110**	**38**	**1,424**	**142**

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

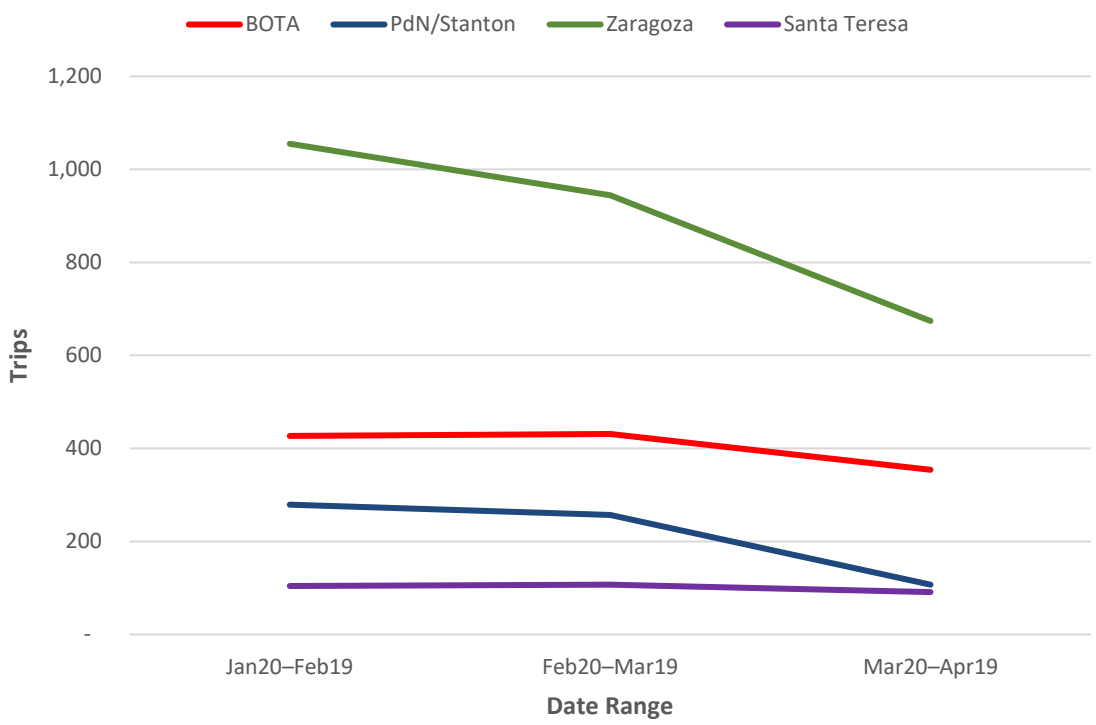

Figure 13. Cross-Border Trips by Month for NB Trips in the INRIX Traceable Dataset.

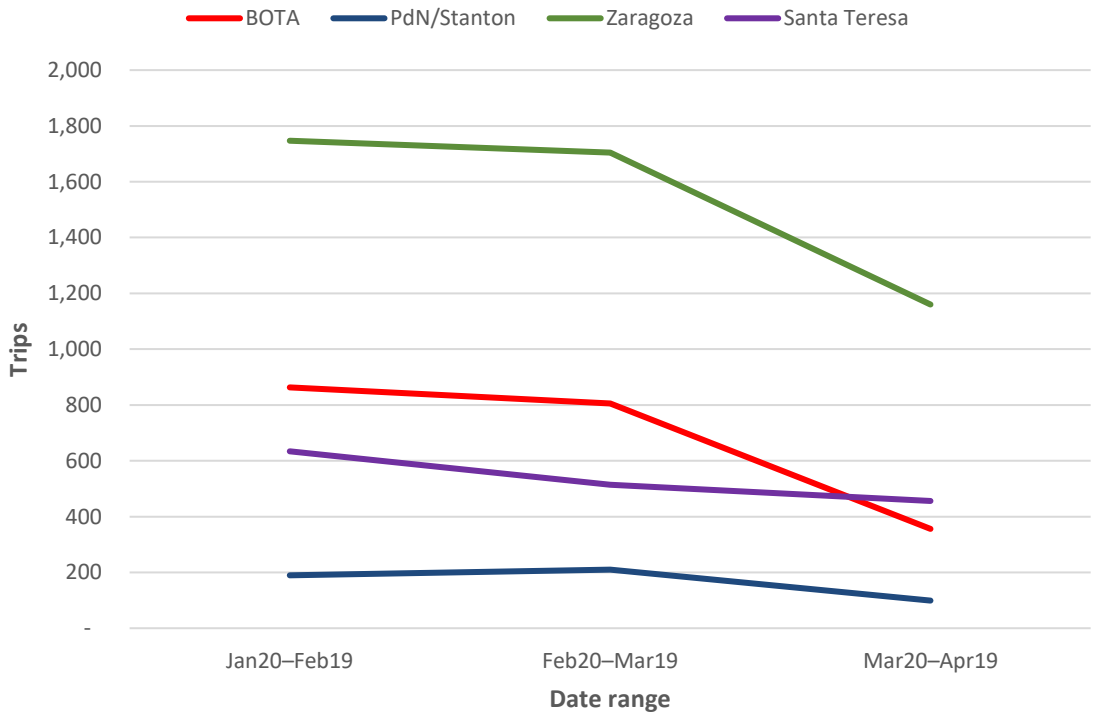

Figure 14. Cross-Border Trips by Month for SB Trips in the INRIX Traceable Dataset.

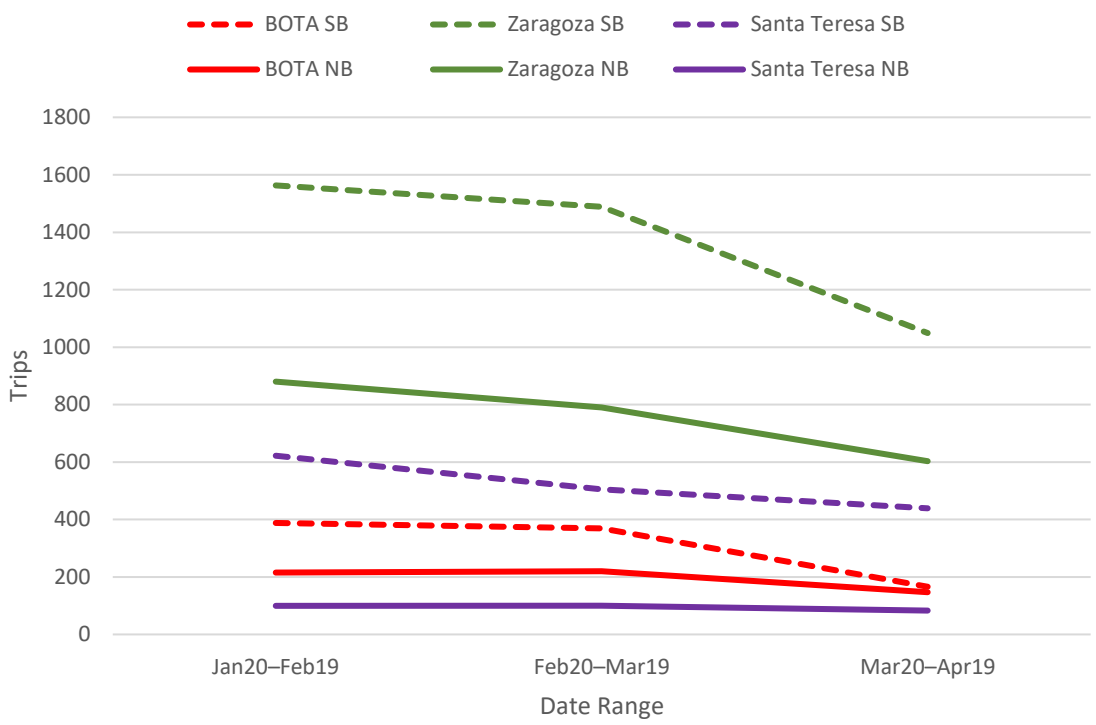

Figure 15. Cross-Border Commercial Trips by Month for NB and SB Trips in the INRIX Traceable Dataset.

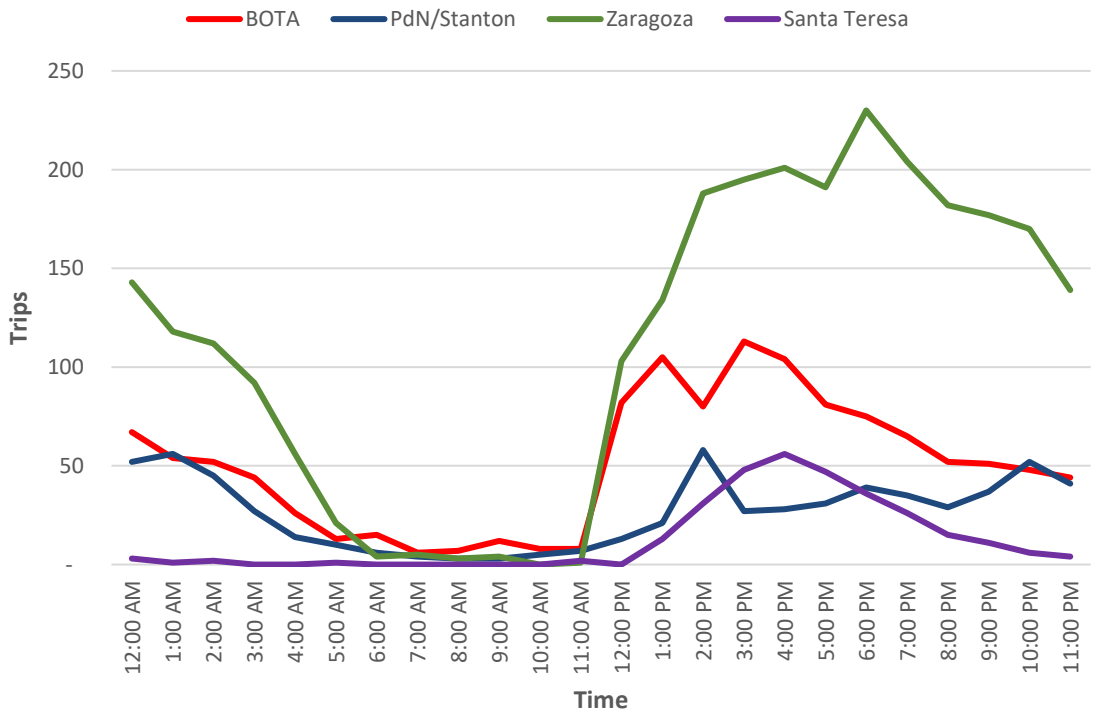

Figure 16. Cross-Border Trips by Time of Day for NB Trips in the INRIX Traceable Dataset.

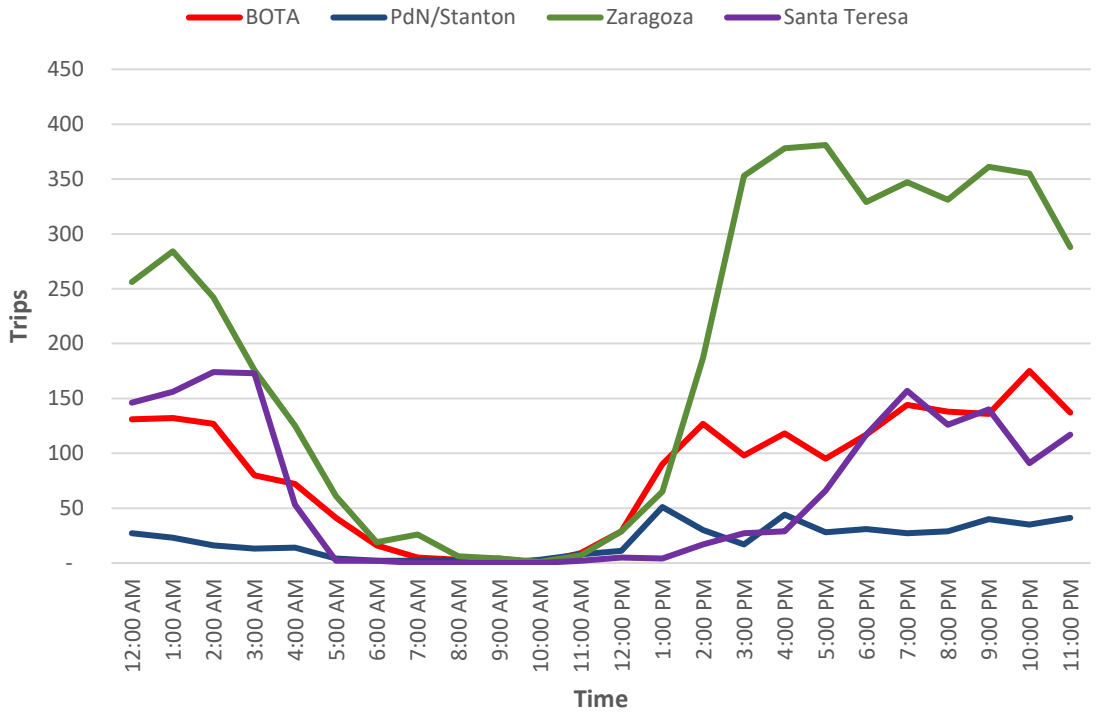

Figure 17. Cross-Border Trips by Time of Day for SB Trips in the INRIX Traceable Dataset.

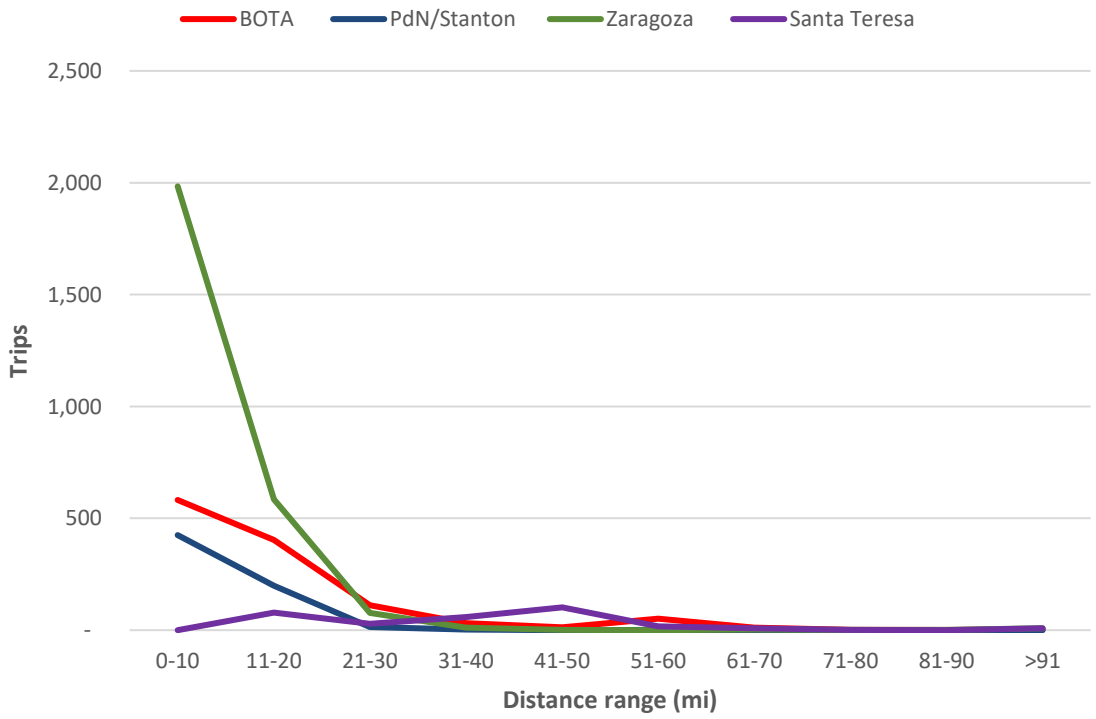

Figure 18. Cross-Border Trips by Trip Distance for NB Trips in the INRIX Traceable Dataset.

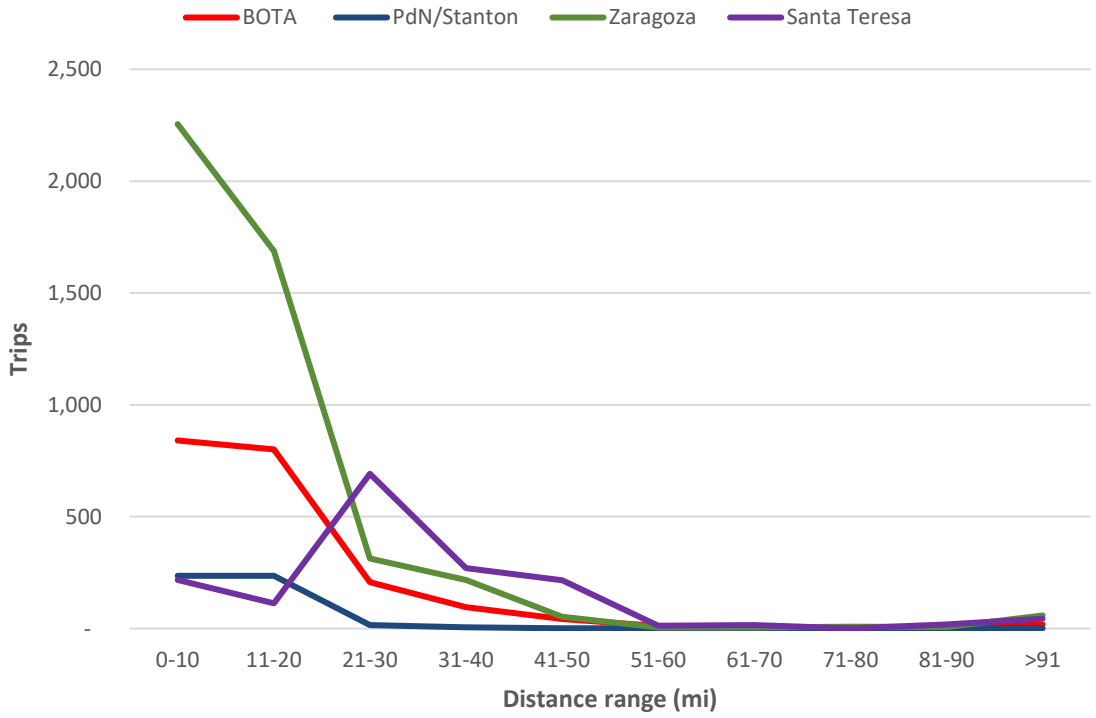

Figure 19. Cross-Border Trips by Trip Distance for SB Trips in the INRIX Traceable Dataset.

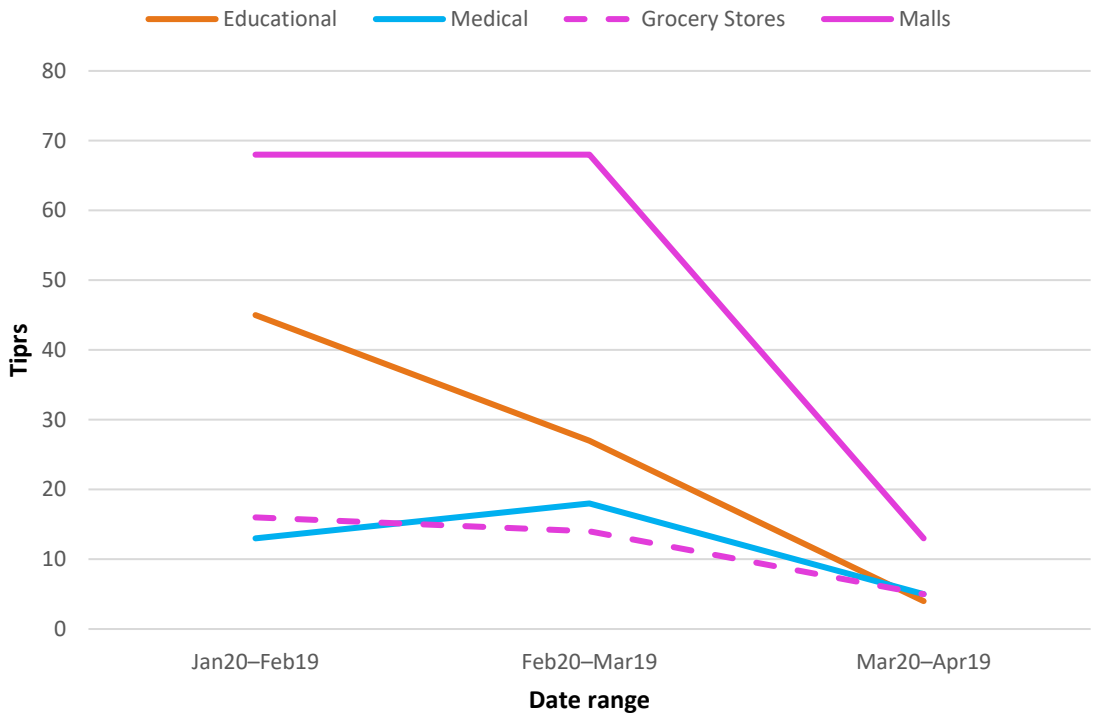

Figure 20. Cross-Border Trips to El Paso by Trip Purpose by Month in the INRIX Traceable Dataset.

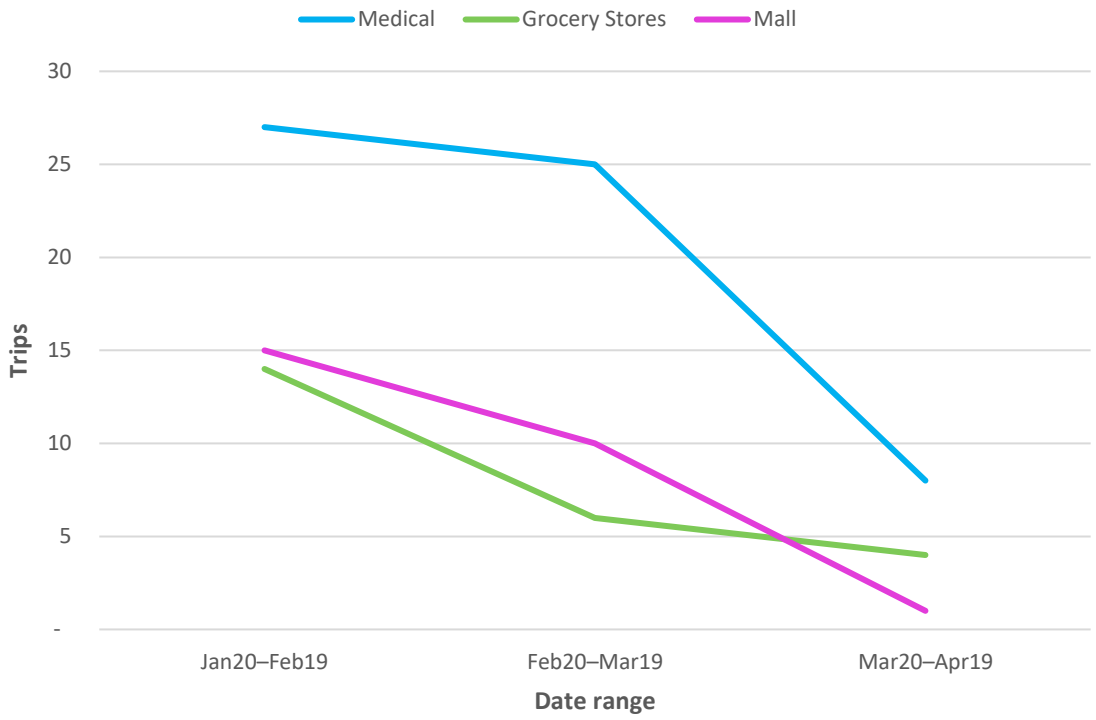

Figure 21. Cross-Border Trips to Juárez by Trip Purpose by Month in the INRIX Traceable Dataset.

Table 28. Cross-Border Trips by Month and Vehicle Type for NB Trips in the INRIX Traceable Dataset.

Data Range	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
Jan20–Feb19	212	206	9	279	—	—
Feb20–Mar19	211	211	9	257	—	—
Mar20–Apr19	207	127	20	107	—	—
Data Range	Zaragoza			Santa Teresa		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
Jan20–Feb19	175	544	336	5	94	5
Feb20–Mar19	154	473	317	7	95	5
Mar20–Apr19	71	325	278	8	80	3

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

Table 29. Cross-Border Trips by Month and Vehicle Type for SB Trips in the INRIX Traceable Dataset.

Data Range	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
Jan20–Feb19	475	345	43	190	—	—
Feb20–Mar19	436	320	49	210	—	—
Mar20–Apr19	190	128	38	99	—	—
Data Range	Zaragoza			Santa Teresa		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
Jan20–Feb19	184	834	729	12	569	53
Feb20–Mar19	215	748	741	9	462	43
Mar20–Apr19	111	409	640	17	393	46

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

Table 30. Cross-Border Trips by Distance for NB Trips in the INRIX Traceable Dataset.

Distance (mi)	BOTA	PdN/ Stanton	Zaragoza	Santa Teresa
0–10	582	425	1984	0
11–20	404	199	585	78
21–30	112	14	77	29
31–40	32	3	12	58
41–50	13	0	1	102
51–60	52	2	0	17
61–70	11	0	3	8
71–80	2	0	1	1
81–90	1	0	2	0
>91	3	0	8	9

Table 31. Cross-Border Trips by Distance for SB Trips in the INRIX Traceable Dataset.

Distance (mi)	BOTA	PdN/ Stanton	Zaragoza	Santa Teresa
0–10	841	236	2,255	218
11–20	801	236	1,688	113
21–30	208	15	313	692
31–40	96	6	217	271
41–50	43	2	53	216
51–60	11	1	5	13
61–70	3	0	5	16
71–80	1	1	9	1
81–90	2	0	7	19
>91	18	2	59	45

Table 32. Cross-Border Trips by Distance and Vehicle Type for NB Trips in the INRIX Traceable Dataset.

Distance (mi)	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
0–10	288	281	13	425	—	—
11–20	291	102	11	199	—	—
21–30	45	65	2	14	—	—
31–40	3	27	2	3	—	—
41–50	3	7	3	0	—	—
51–60	0	47	5	2	—	—
61–70	0	9	2	0	—	—
71–80	0	2	0	0	—	—
81–90	0	1	0	0	—	—
>91	0	3	0	0	—	—
Total	**630**	**544**	**38**	**643**	**—**	**—**
Distance (mi)	**Zaragoza**			**Santa Teresa**		
	Type 1	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
0–10	246	892	846	0	0	0
11–20	113	410	62	8	69	1
21–30	33	29	15	2	26	1
31–40	4	5	3	5	47	6
41–50	1	0	0	0	99	3
51–60	0	0	0	0	17	0
61–70	0	1	2	4	3	1
71–80	0	1	0	0	0	1
81–90	0	1	1	0	0	0
>91	3	3	2	1	8	0
Total	**400**	**1,342**	**931**	**20**	**269**	**13**

***** PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

Table 33. Cross-Border Trips by Distance and Vehicle Type for SB Trips in the INRIX Traceable Dataset.

Distance (mi)	BOTA			PdN/Stanton		
	Type 1	Type 2	Type 3	Type 1	Type 2*	Type 3*
0–10	472	357	12	236	—	—
11–20	554	208	39	236	—	—
21–30	60	122	26	15	—	—
31–40	8	43	45	6	—	—
41–50	2	39	2	2	—	—
51–60	1	8	2	1	—	—
61–70	0	3	0	0	—	—
71–80	0	1	0	1	—	—
81–90	0	1	1	0	—	—
>91	4	11	3	2	—	—
Total	**1,101**	**793**	**130**	**499**	**—**	**—**
Distance (mi)	**Zaragoza**			**Santa Teresa**		
	Type 1	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
0–10	249	600	1,406	14	192	12
11–20	150	1,117	421	10	67	36
21–30	85	125	103	2	654	36
31–40	9	74	134	6	234	31
41–50	4	30	19	0	190	26
51–60	0	2	3	1	11	1
61–70	0	2	3	0	16	0
71–80	1	3	5	0	1	0
81–90	0	7	0	1	18	0
>91	12	31	16	4	41	0
Total	**510**	**1,991**	**2,110**	**38**	**1,424**	**142**

* PdN/Stanton has no operations for commercial vehicles (as defined by Type 2 and 3).

Table 34. Cross-Border Trips to El Paso by Trip Purpose on Weekdays for NB Trips in the INRIX Traceable Dataset.

POI		Monday	Tuesday	Wednesday	Thursday
Educational	UTEP	14	14	14	9
	EPCC	0	0	1	0
	Public Schools	1	2	5	1
Shopping	Basset Place	3	3	5	3
	Cielo Vista	3	1	2	0
	The Fountains	6	1	1	0
	Las Palmas	1	1	0	2
	Sunland Park Mall	1	1	2	2
	The Outlet Shoppes	0	0	0	0
	West Town	2	0	1	1
	Downtown El Paso	8	10	11	7
	El Paseo (east side)	2	0	1	1
	Grocery Stores	3	9	4	8
Medical	Hospitals	5	10	7	7
Sun Metro Stations	Downtown	0	0	0	0
	East Side	0	0	0	1
	Mission Valley	0	1	0	0
	West Side	0	0	0	0
	Northeast	0	0	0	0

Table 35. Cross-Border Trips to El Paso by Trip Purpose on Weekends for NB Trips in the INRIX Traceable Dataset.

POI		Friday	Saturday	Sunday
Educational	UTEP	6	1	2
	EPCC	0	3	0
	Public Schools	1	1	1
Shopping	Basset Place	4	1	0
	Cielo Vista	3	3	1
	The Fountains	1	5	4
	Las Palmas	0	0	0
	Sunland Park Mall	2	3	3
	The Outlet Shoppes	0	0	1
	West Town	2	1	1
	Downtown El Paso	18	4	8
	El Paseo (east side)	0	2	0
	Grocery Stores	5	4	2
Medical	Hospitals	5	1	1
Sun Metro Stations	Downtown	0	0	0
	East Side	1	0	1
	Mission Valley	0	0	0
	West Side	0	0	0
	Northeast	0	0	0

Table 36. Cross-Border Trips to El Paso by Trip Purpose and Month for NB Trips in the INRIX Traceable Dataset.

POI		Jan20–Feb19	Feb20–Mar19	Mar20–Apr19
Educational	UTEP	38	18	4
	EPCC	2	2	0
	Public Schools	5	7	0
Shopping	Basset Place	4	11	4
	Cielo Vista	6	7	0
	The Fountains	9	8	1
	Las Palmas	2	2	0
	Sunland Park Mall	5	7	2
	The Outlet Shoppes	0	1	0
	West Town	5	2	1
	Downtown El Paso	35	26	5
	El Paseo (east side)	2	4	0
	Grocery Stores	16	14	5
Medical	Hospitals	13	18	5
Sun Metro Stations	Downtown	0	0	0
	East Side	3	0	0
	Mission Valley	1	0	0
	West Side	0	0	0
	Northeast	0	0	0

Table 37. Cross-Border Trips to Juárez by Trip Purpose on Weekdays for SB Trips in the INRIX Traceable Dataset.

POI	Monday	Tuesday	Wednesday	Thursday
Hospitals	9	7	14	7
Grocery Stores	3	3	3	7
Mall	2	6	1	4

Table 38. Cross-Border Trips to Juárez by Trip Purpose on Weekends for SB Trips in the INRIX Traceable Dataset.

POI	Friday	Saturday	Sunday
Hospitals	12	9	2
Grocery Stores	4	2	2
Mall	7	3	3

Table 39. Cross-Border Trips to Juárez by Trip Purpose and Month for SB Trips in the INRIX Traceable Dataset.

POI	Jan20–Feb19	Feb20–Mar19	Mar20–Apr19
Medical	27	25	8
Grocery Stores	14	6	4
Mall	15	10	1

Table 40. Cross-Border Trips to El Paso by Trip Purpose and Vehicle Type for NB Trips in the INRIX Traceable Dataset.

POI		Type 1	Type 2	Type 3
Educational	UTEP	24	36	0
	EPCC	4	0	0
	Public Schools	7	5	0
Shopping	Basset Place	16	3	0
	Cielo Vista	7	6	0
	The Fountains	15	3	0
	Las Palmas	4	0	0
	Sunland Park Mall	14	0	0
	The Outlet Shoppes	1	0	0
	West Town	7	1	0
	Downtown El Paso	32	34	0
	El Paseo (east side)	6	0	0
	Walmart	19	16	0
Medical	Hospitals	34	2	0
Sun Metro Stations	Downtown	0	0	0
	East Side	0	3	0
	Mission Valley	0	1	0
	West Side	0	0	0
	Northeast	0	0	0

Table 41. Cross-Border Trips to Juárez by Trip Purpose and Vehicle Type for SB Trips in the INRIX Traceable Dataset.

POI	Type 1	Type 2	Type 3
Hospitals	37	19	4
Grocery Stores	13	9	2
Mall	14	11	1