BORDER PARK, CROSS, AND RIDE

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DISCLAIMER AND ACKNOWLEDGMENTS

This research was performed by the Center for International Intelligent Transportation Research, a part of the Texas A&M Transportation Institute. The contents of this report reflect the views of the author, who is responsible for the facts and the accuracy of the data presented herein.

CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

Prior to fiscal year (FY) 2019, as part of a project funded by the United States Department of Transportation (USDOT) Tier 1 University Transportation Center (UTC), the author of this report developed parking models, conducted a survey to understand the intelligent transportation system (ITS) needs for parking, and established the level of service (LOS) criteria for parking. This previous work showed that *search time* is the most important factor in defining the LOS for parking. The UTC member university requested that the author, through the Texas A&M Transportation Institute (TTI), conduct a study that continued building on these findings. That study has gained support from the City of El Paso International Bridges Department, whose mission is to provide cross-border mobility and parking services to residents of El Paso. The department is responsible for international bridges whose annual traffic volumes are around 3.7 million passenger vehicles and 4.3 million pedestrians. The department also manages over 1,700 on-street parking meters citywide, which makes them the focal point of the study. The author's parking experience and the available data led the author to conduct a separate study sponsored by the Center for International Intelligent Transportation Research, with more focus on people who park their vehicles before crossing the border.

In the El Paso–Ciudad Juarez region, one alternative mode of border crossing is to park the car, walk across the border, and take a ride on the other side (park, cross, and ride). This mode is expected to be more frequent based on technological developments such as greater use of smart mobile applications and market penetration of automated vehicles. People who prefer this mode of border crossing are expected to use technologies to find an available parking spot, be informed about the border crossing times, and reserve and catch their ride on the other side of the border. This border crossing method is expected to save time for some individuals, which will also lead to a reduction in the number of passenger vehicles on the bridges.

1.2 OBJECTIVE

Since the park, cross, and ride behavior is currently not very widely used, no research has been performed to evaluate the cost and the benefits. The goal of this project was to be the first study that evaluated the behavior by developing a cost-benefit analysis. For the analysis, different scenarios were introduced, and the outcomes of each scenario selection were calculated based on the costs and time savings/losses. The time values were then converted to monetary values using the "value of time" (*1*) concept defined by USDOT and added to the overall cost of the alternative.

1.3 OUTLINE OF REPORT

The remaining chapters of this report include the following:

- **Chapter 2—Literature Review**: This chapter summarizes the reviewed literature and focuses on ITS technology use in the parking industry (present and future).

- **Chapter 3—Data**: This chapter presents the study area and the different types of data processed and used in the analysis.
- **Chapter4—Scenarios and Cost-Benefit Analysis**: This chapter first introduces the different border crossing scenarios, followed by the cost-benefit analysis and the results of the study.
- **Chapter 5—Conclusions**: This chapter summarizes the study and conclusions drawn from the study.

CHAPTER 2. LITERATURE REVIEW

This chapter summarizes and documents the relevant literature related to parking, with a focus on border crossings and ITS implementation.

2.1 MOBILE APPLICATIONS FOR PARKING

The process of searching and paying for parking has been simplified by innovation in ITS and smartphone applications, which has been done mainly to improve the functionality of the parking lots and reduce traffic caused by people looking for a space to park their car. Many applications on the market help users locate, navigate, and pay for parking with smart devices.

Many visitors in big cities and major airports utilize these smartphone applications to help locate empty parking spaces, reserve their spot, and make payments for parking. With the help of mobile technologies, drivers know exactly where they are going to park before they arrive. Consequently, this approach reduces the time they spend actually looking for a spot. Moreover, drivers can choose their desired spot and follow the in-app GPS system, which offers the fastest route to that location by avoiding congested areas. Users can filter lots by type, such as open lots or garage spaces, or by price to see which are cheaper (or more expensive). Everyday users can notify others of price changes and the rules and regulations in the area, such as time restrictions.

The majority of the parking apps have an option when selecting parking spaces to pay for them directly through the app itself. The app's built-in timer notifies drivers when their spot is close to expiration so they can avoid tickets and have the choice to add additional time without going to a meter or pay station. Similarly, many apps partner with organizations, event locations, and stadiums so customers can save time by reserving a spot and paying directly through the app. This process relieves some of the stress that drivers face when having to fight for space at an event that attracts many people at the same time.

Some mobile apps give drivers additional discounts up to 50 percent off for using and paying through their device and allow drivers to refer friends and family in exchange for free parking. This benefit encourages even more customers to download these apps and eventually evolves the way people search and pay for parking. It can be concluded that more people are expected to use mobile applications for parking in the near future.

2.2 CITY PARKING SERVICES

According to the Federal Highway Administration Tolling and Pricing Program, performance-based parking pricing helps to reduce parking search time (*2*). ITS technologies enable the implementation of performance-based parking pricing. San Francisco, Los Angeles, and Seattle are some good examples of cities that adjust parking prices based on the occupancy.

SFPark is the parking monitoring and pricing program that San Francisco has been using since 2011 (*3*). The system covers 6,000 stalls across seven districts in the city. Every parking stall in the SFPark system has a sensor that monitors the real-time occupancy. Parking meters are programmed to charge variable prices according to the time of the day. Based on observed occupancy rates, San Francisco adjusts the parking prices every month. Rates are either reduced by no more than 50 cents per hour or increased by up to 25 cents per hour.

The LA Express Park program was designed as a component of the Los Angeles Congestion Reduction Demonstration to help reduce traffic congestion in Los Angeles (*4*). This program was launched in 2012 and followed a concept similar to SFPark. Not only does the program allow users to monitor parking availability in real time, it also increases the availability of limited parking spaces through performance pricing.

The Seattle Department of Transportation (SDOT) has been using a similar system since 2010 (*5*). However, SDOT collects and analyzes the data annually. Its program, in which the occupancy and rates are evaluated over three time periods (morning, afternoon, and evening), administers 12,000 on-street parking stalls. The target range of the parking occupancy is between 70 and 85 percent. If the parking occupancy is below target, parking prices in that area are decreased by $0.50. If the occupancy is above target, SDOT increases the rate by $0.50 for the following year.

Another approach is to vary prices in real time based on the real-time parking congestion level. The District of Columbia is proposing a pilot program for on-street commercial vehicle parking; however, it has not been tested yet (*6*). Although promising, performance-based pricing has not been implemented on any university campus.

2.3 AUTONOMOUS VEHICLES

Autonomous vehicles (AVs) will sooner or later join the transportation system in the United States. It is expected that autonomous and non-autonomous vehicles will share the country's roadways for a number of years, until AVs reach 100 percent market penetration. However, fully realizing the benefits expected from the arrival of AVs will also require the development of roadway and parking infrastructure that can adequately accommodate them as they gradually integrate into the transportation system.

Instead of AVs replacing privately owned non-autonomous vehicles on a one-to-one basis, many argue that this mode lends itself to shared use or mobility-on-demand services. More dramatic changes are expected if AVs are shared rather than privately owned. Modeling studies have demonstrated that parking demand could be reduced by up to about 90 percent in scenarios where all AVs are shared (*7, 8*). It is also expected that with more AVs in the shared mobility market, the prices for carpooling reduce to such a level that the people who cross the border will embrace this option as an attractive alternative. In other words, more people will prefer to use a park, cross, and ride option in the future since the last step will be more affordable than today.

2.4 CITY OF EL PASO PARKING

El Paso is a growing city experiencing significant downtown growth. This development causes some constraints in terms of available parking in some regions. The city conducted a comprehensive parking study to assess existing parking conditions (*9*). It was found that in the downtown area, there are 11,686 available parking spots—2,271 of them are on the street, and the rest are off-street spaces. The 3,055 parking spaces in the downtown area are managed by the

City of El Paso International Bridges Department. The study's concluding recommendations to focus on, listed from highest to lowest in terms or importance, were the following:

1. Utilization of technology.
2. Enforcement.
3. Parking data management.
4. Marketing plan.
5. Parking rate structure.
6. Parking division.
7. Special event parking management.
8. Parking wayfinding program.
9. Downtown stakeholders.
10. Development of a shared parking policy.
11. Curb management.
12. Plan for the future.

An online parking survey was conducted among El Paso downtown parking users that comprised more than 1,500 participants. Over half of participants considered themselves visitors or not employees within the downtown corridor. Forty-nine percent of the survey participants declared that they park on the street; 35 percent of participants were employees who park in garages. Unfortunately, no question asked participants about their final destination after they park or whether they cross the border, but one question asking about the main factors for parking showed that participants wanted to park close to their destination at an affordable cost. Moreover, more than 80 percent of participants walked more than two blocks. This information contributed to narrowing the study to focus on public parking within two blocks from the port of entry (POE).

CHAPTER 3. STUDY AREA

El Paso, which is the primary urbanized area along the Texas-Mexico border, was selected as the study area. The El Paso–Ciudad Juarez region has more than 2 million residents, which induces significant cross-border passenger travel. In its *Texas-Mexico International Bridges and Border Crossing* report, the Texas Department of Transportation (TxDOT) listed 10 border crossings within the El Paso region (*10*) from west to east:

1. BNSF Railroad Rail Bridge.
2. Paso del Norte (PDN) Bridge.
3. Union Pacific Railroad Rail Bridge.
4. Stanton Bridge.
5. Bridge of the Americas (BOTA).
6. Ysleta-Zaragoza Bridge.
7. Tornillo-Guadalupe International Bridge.
8. Fort Hancock–El Porvenir Bridge.
9. Presidio Bridge.
10. South Orient Rail Bridge.

Seven of the above-mentioned international bridges allow pedestrian crossings, and four of them are located in an urbanized setting for both sides of the border (PDN Bridge, Stanton Bridge, BOTA, and Ysleta-Zaragoza Bridge). Among those crossings, PDN Bridge has the most pedestrian crossings. Figure 1 and Figure 2 demonstrate the north and southbound pedestrian traffic with respect to years for different international bridges. Both of the figures indicate that, for all the reported years, PDN had more than twice the number of pedestrian crossings as the next most-used international bridge. The data in these figures were gathered from a publicly available source (*11*) that was developed by the International Bridges Steering Committee in order to help commuters and commercial drivers manage travel routes and departure times.

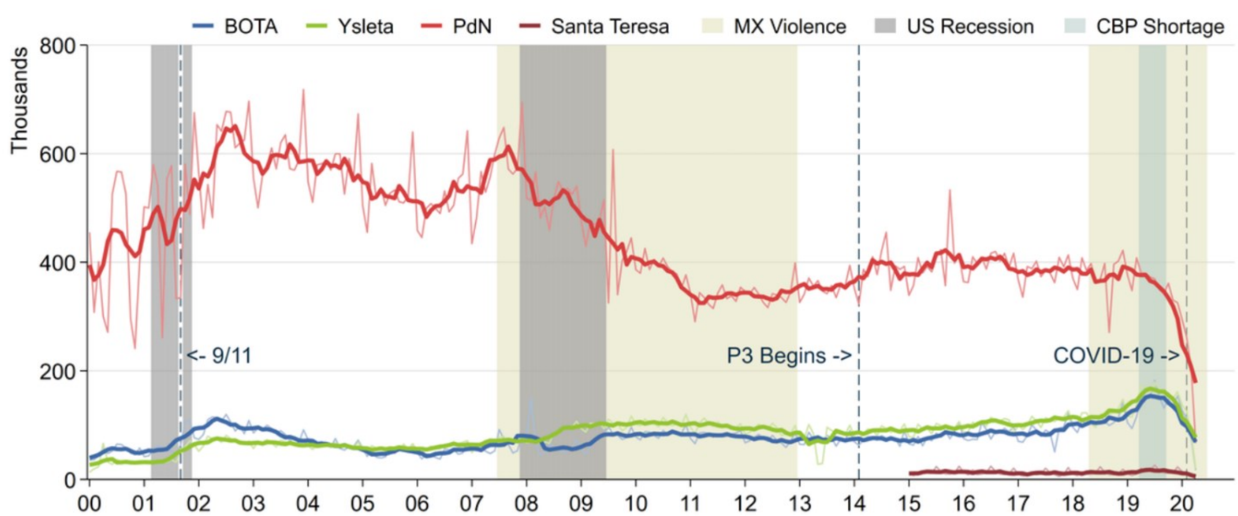

Figure 1. Northbound Pedestrian Traffic.

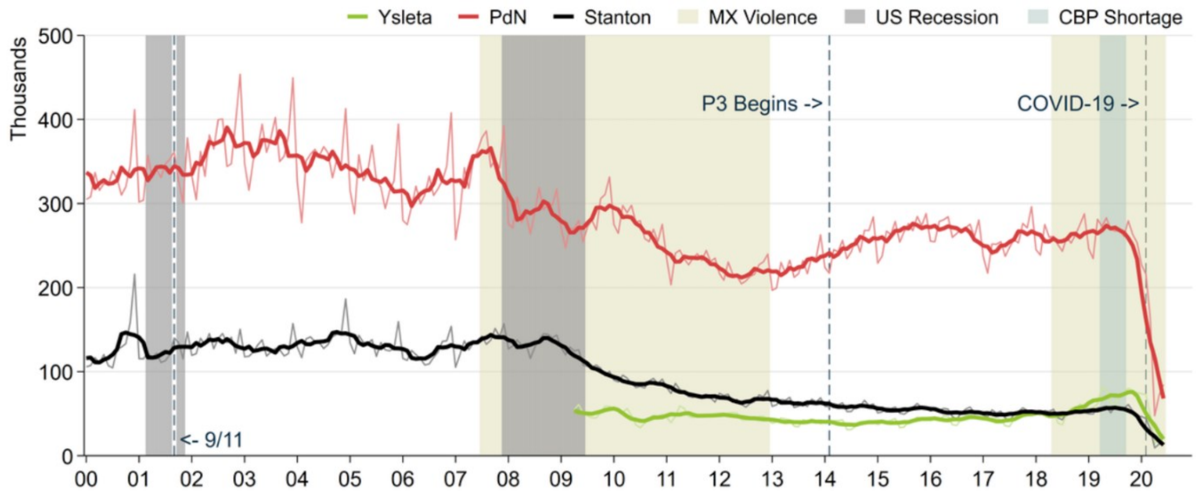

Figure 2. Southbound Pedestrian Traffic.

As the figures demonstrate, certain events affected the number of border crossings, and the largest effect has been the COVID-19 pandemic. In order to limit further spread of the virus, the United States reached agreement with Mexico to limit all nonessential travel across borders. The measures were implemented on March 21, 2020, and were originally in place for 30 days; they have been reevaluated several times since then, and the measures extended. To illustrate the effects on border mobility, in April of 2020, the PDN Bridge had 114,351 total pedestrian crossings, whereas for the same month in the previous year, the number of pedestrian crossings was 653,146. In other words, based on the numbers from the PDN Bridge, it can be concluded that pedestrian crossings decreased by more than 80 percent from the previous year. This study developed its scenarios and documented the findings based on numbers that considered the average border mobility and crossing patterns. Therefore, for the analysis, the data after border restrictions due to COVID-19 were not used.

The PDN Bridge is located at 1000 S. El Paso Street on the U.S. side and on Avenida Benito Juarez on the Mexican side. PDN is dedicated to northbound passenger vehicles and other noncommercial traffic, as well as bidirectional pedestrian traffic. The bridge links downtown El Paso with central Ciudad Juarez, which makes it an attractive POE for pedestrian travelers crossing the border (see Figure 3).

Figure 3. Location of the Paso del Norte Bridge.

The U.S. side of the bridge is owned and managed by the City of El Paso and operates 24 hours a day, 7 days a week. Among three modes of passenger transport that can be used at the PDN Bridge, pedestrians are the most dominant mode. According to the International Bridges Steering Committee (*11*), there were 7,522,108 pedestrian crossings over PDN in 2019. During the same period, 3,753,491 passenger vehicles used the bridge, which only allows northbound traffic. For the methodology development, the returning commuters who used the PDN Bridge to enter the United States were all assumed to prefer the nearby Stanton Bridge (0.3 miles away) to go back to Ciudad Juarez. At PDN, all pedestrian and vehicular crossings are tolled. Southbound toll costs are as follows:

- Standard passenger vehicles: $3.50.
- Pedestrians: $0.50.

Northbound prices are quite different from southbound prices and are as follows:

- Standard passenger vehicles: $1.50.
- Pedestrians: $0.30.

This study focused on commuter parking, and the closest public parking facilities on each side of the border were considered to be in use (see Figure 4). The availability of the parking was not taken into account, and commuters were assumed to find a parking spot each time they searched for parking. The closest public parking facility on the U.S. side is a 5-minute walk to the entry of the bridge. On the other hand, the closest public parking facility on the Mexico side is a 4-minute walk to the entry to the international bridge.

Both parking facilities allow commuters to park their cars for more than 8 hours. For the methodology development, daily commuters having their offices in different countries from where their homes are located were considered in the case study. In the various scenarios, these commuters were expected to park their cars in a public parking facility and pick them up at least 8 hours later. Therefore, parking prices that encompass more than 8 hours were used for the study (see Table 1).

Table 1. Parking Facilities.

Location	***Walking Time to PDN***	***Parking Price***
Juarez	4 min	70 pesos
El Paso	5 min	$5.0

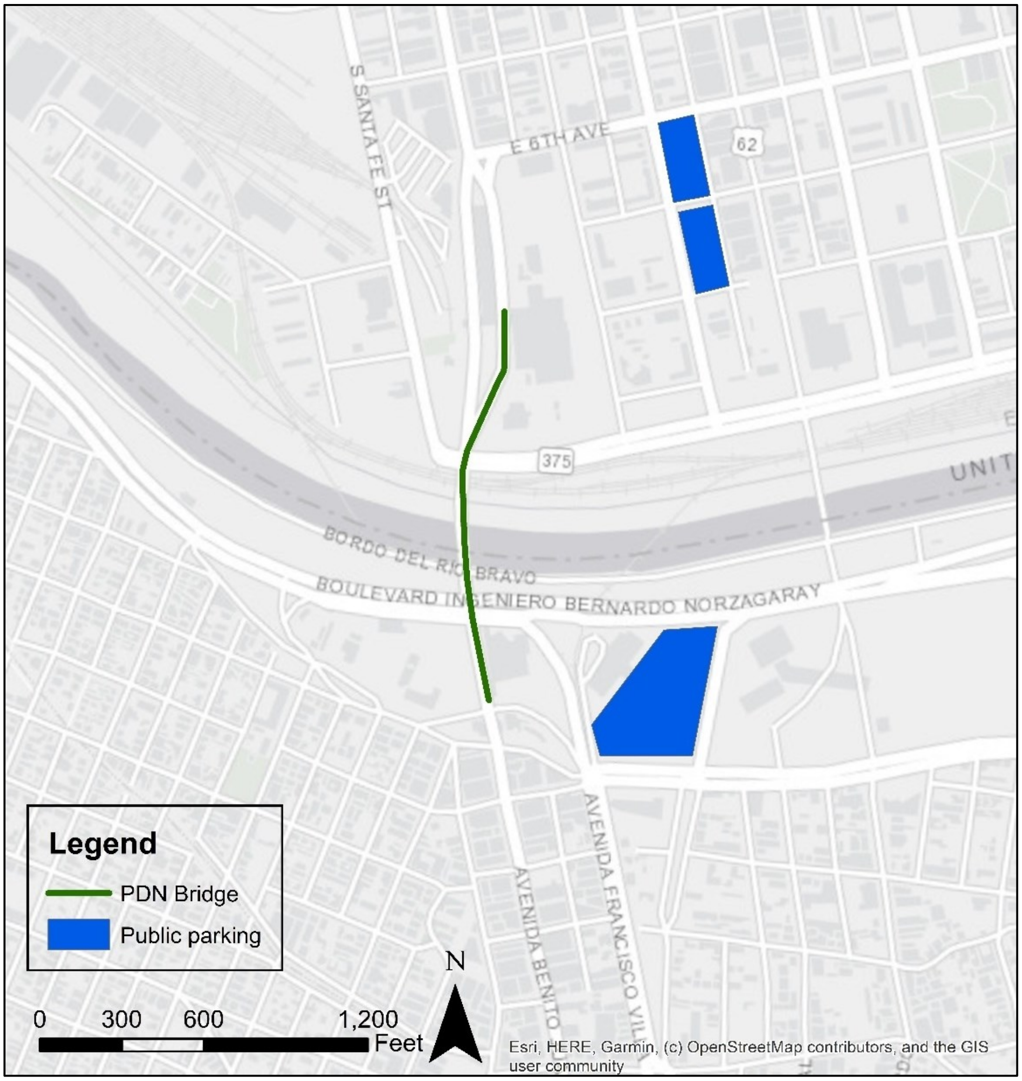

Figure 4. Study Area.

CHAPTER 4. SCENARIOS AND COST-BENEFIT ANALYSIS

4.1 BORDER CROSSING SCENARIOS

Two scenarios with two alternative modes for border crossing were developed, and the alternatives were compared based on the individual levels of commuters who cross the border daily. In the first scenario, a commuter living in Mexico and working in the United States with two alternative ways of border crossings was explored. He/she could park his/her car close to the border (public parking), cross the border by walking, and then get a ride from a ridesharing company, which was defined as Alternative 1 (park, cross, and ride). The second alternative was that he/she could cross the border using his/her passenger vehicle and go directly to work (Alternative 2; see Figure 5).

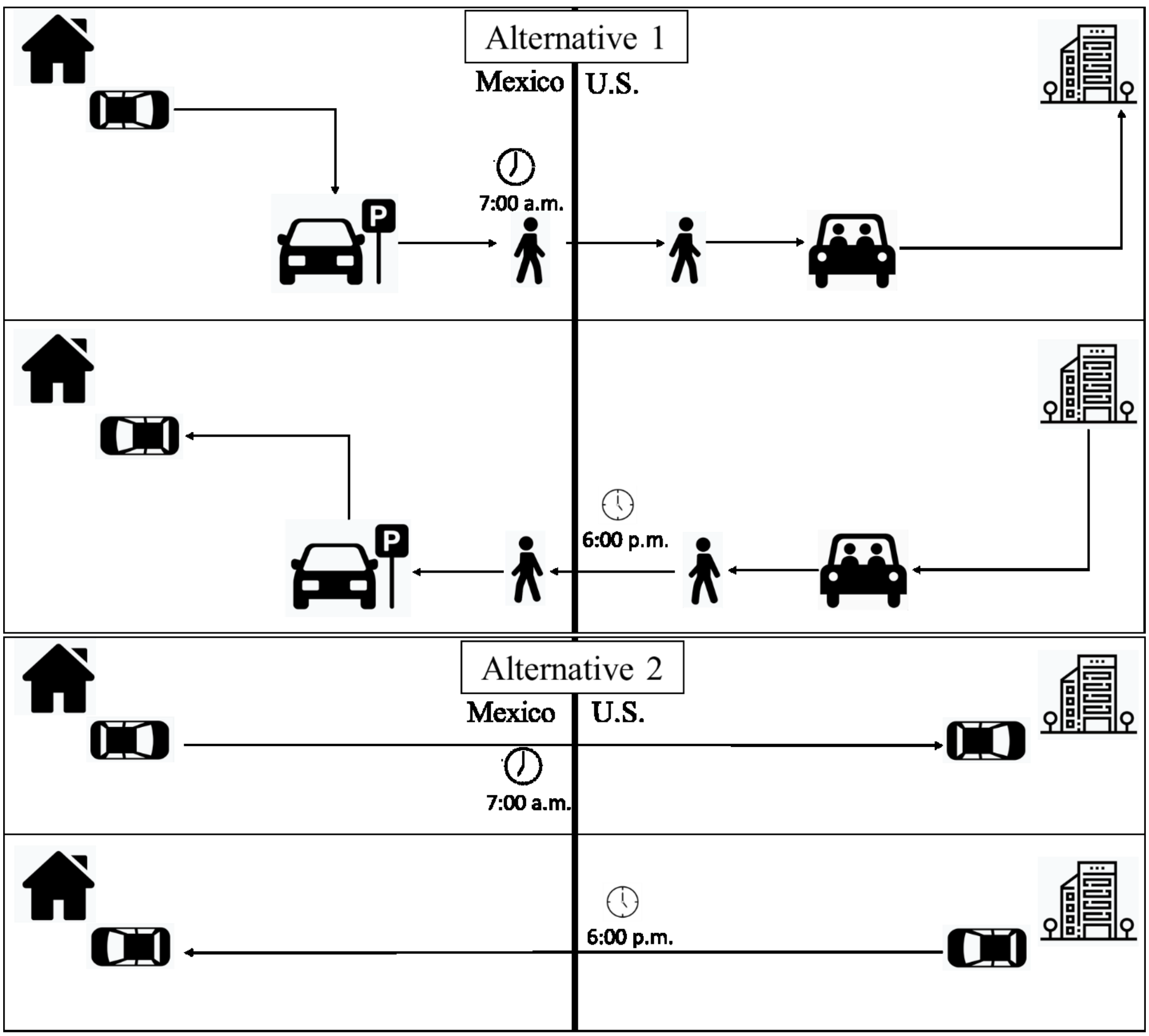

Figure 5. Alternatives for Scenario 1.

In the second scenario, a commuter living in the United States who crosses the border daily to work in Mexico was explored. Similar to the first scenario, he/she had two alternative modes of access. The first one was to park the car close to the border, cross the border as a pedestrian, and get a ride in Mexico (park, cross, and ride). Alternatively, he/she could take his/her car across the border (see Figure 6). The average time spent on the alternatives of scenarios was figured to convert the value of time of the commuter and then added to the cost of the trip for each alternative.

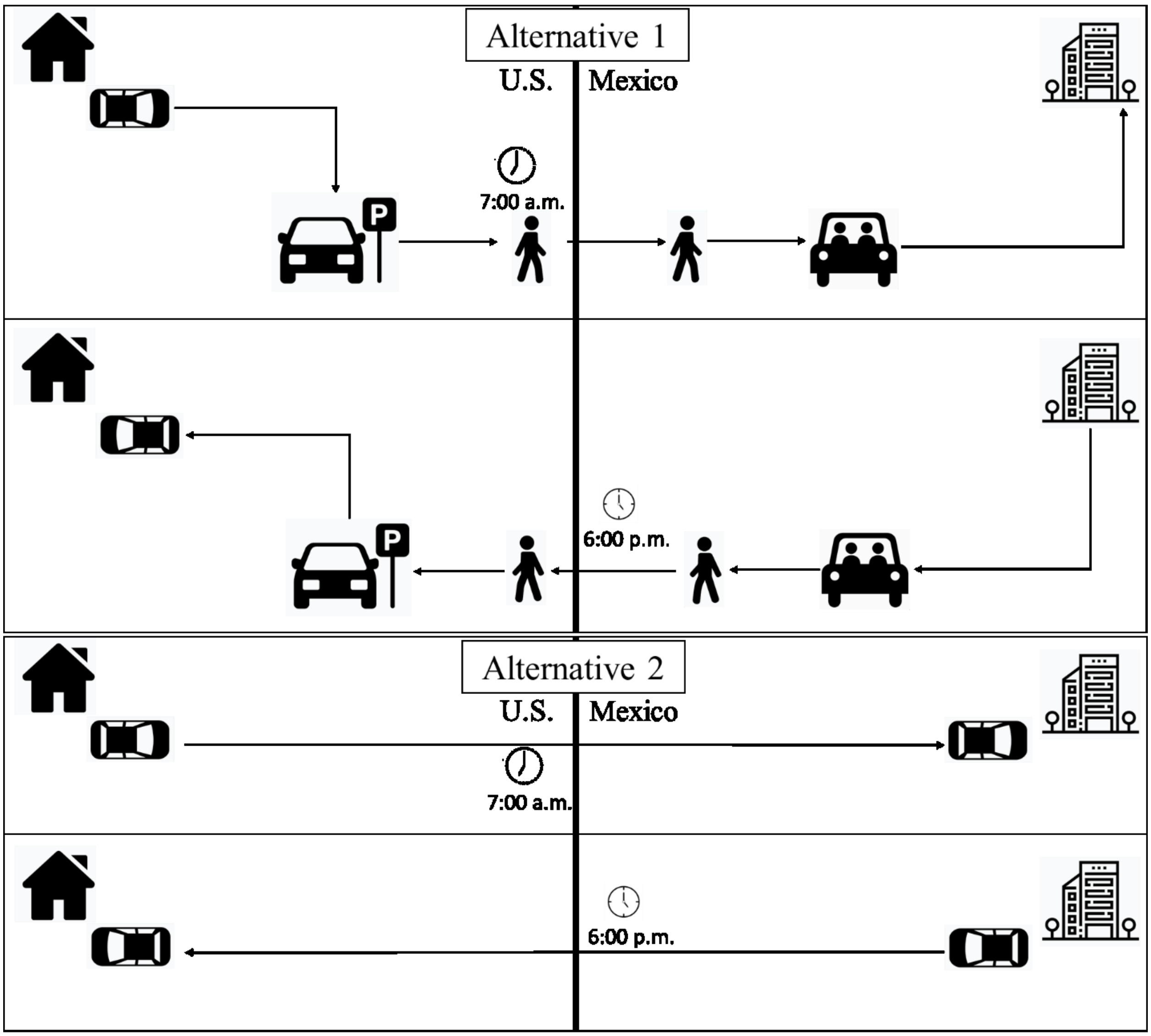

Figure 6. Alternatives for Scenario 2.

4.2 METHODOLOGY

Based on which alternative a commuter picks to cross the border, he/she may save some overall travel time (OTT). The OTT of a commuter is defined in this report as adding the average travel time from the origin (where he/she lives) to the final destination, where he/she works, to the average travel time to finish the round trip. The trip concludes when the commuter arrives back to his/her house. Since the time spent from the house to the border is the same for both alternatives, for comparison purposes, the time from the house to the border was not taken into account.

One of the key elements of the study is converting the OTT to a monetary value and adding it to other expenses, including the price of gas and the price of taking a ride. USDOT publishes the value of time (VoT) of travelers to guide the analyst in evaluating the benefits of transportation infrastructure improvements. For local personal travel, the average VoT is estimated at 50 percent of the hourly median household income (*1*). The U.S. Census Bureau publishes the median household income every year for each county. The latest median household income for El Paso County was published as $44,957 (*12*). This value can be converted to the VoT in minutes by using USDOT's equation:

$$VoT_m = \frac{(0.5)*(I_{mh})}{(2080)(60)} \tag{1}$$

where,

- VoT_m is the VoT of a local personal traveler in $/min,
- 0.5 is the coefficient used to convert the median household income to the personal travel,
- I_{mh} is the median household income in $/year, and
- 2,080 is the hours in a year that USDOT assumes an average traveler works.

For this reason, to convert the median household income per year to per hour, 2,080 hours were used. The equation has 60 in the denominator to convert the per hour value to per minute.

The calculations start by identifying the alternatives and calculating the time spent for an average trip (OTT). Table 2 demonstrates all significant parameters that create differences among alternatives. The parameters were listed under cost-related and time-related groups. Cost-related parameters are the parameters that have a direct economic effect on the calculations; on the other hand, time-related parameters indirectly affect the results by means of VoT of the commuter who crosses the border. Excluding gas use, all the parameters are calculated based on the location of the individual. The expenses calculated by gas use are based on gas prices in the United States. Because the data were taken from different sources, it is necessary to explain how certain parameters were determined:

- *Public parking price* is the daily parking price of the closest public parking facility and assumes the commuter will park his/her car for more than 8 hours.
- *Pay for crossing* is the amount that commuters must pay based on the selected alternative.
- *Ridership* is the price that the commuter must pay if he/she takes the ridesharing service for a 5-mile trip.
- *Mileage expenses* are the estimation of the total expense of using a personal vehicle. Texas' maximum mileage reimbursement rate is used.
- *Walk between parking and POE* is the walking time from the closest public parking to the port of entry (PDN).

- *Pedestrian border crossing* is the average time for border waiting, crossing, and reaching the point where the commuter can take a ride on the other side of the border. The U.S. Customs and Border Protection online dashboard was used to find the average border wait times (*13*) for pedestrian crossings.
- *Wait for a ride* is the average waiting time for an available ride.
- *Vehicle border crossing* is the average time it takes for a passenger vehicle to cross the border. The Border Crossing Information System developed by TTI (*14*) was used to find the average crossing times.

Table 2. Cost- and Time-Related Parameters.

Scenario	*Alternative*	*Cost-Related*	*Time-Related*
1	1	Public parking price Pay for crossing Ridership	Walk between parking and POE Pedestrian border crossing Wait for a ride
1	2	Pay for crossing Mileage expenses	Vehicle border crossing
2	1	Public parking price Pay for crossing Ridership	Walk between parking and POE Pedestrian border crossing Wait for a ride
2	2	Pay for crossing Mileage expenses	Vehicle border crossing

4.3 COST-BENEFIT ANALYSIS FOR SCENARIOS

The VoT for El Paso was found to be $0.18 by using the U.S. Census median household income and Equation (1). In other words, commuters save $0.18 if they can save 1 minute in their OTT. Table 3 lists all other input parameters for the comparison methodology. These numbers are the average numbers and do not fully represent border crossing patterns. For example, some daily users prefer to use other international bridges to cross back based on the current crossing times or the prices to cross. Each scenario with its alternatives is listed with the findings of the cost- and time-related parameters based on the existing or average values found. Specifically, the time-related parameters are the average values found from the publicly available resources introduced in the methodology. While calculating the daily input parameters for each alternative, a round trip was considered. In other words, a commuter needs to start and end his/her trip at his/her home.

Table 3. Daily Input Parameters.

Scenario	*Alternative*	*Cost-Related*		*Time-Related*	
1	1	Public parking price	70 pesos	Walk between parking and POE	8 min
		Pay for crossing	16 pesos	Pedestrian border crossing	32 min
		Ridership	437 pesos	Wait for a ride	3 min
1	2	Pay for crossing	110 pesos	Vehicle border crossing	61 min
		Mileage expenses	127 pesos		
2	1	Public parking price	$5.0	Walk between parking and POE	10 min
		Pay for crossing	$0.8	Pedestrian border crossing	57 min
		Ridership	$7.6	Wait for a ride	5 min
2	2	Pay for crossing	$5.0	Vehicle border crossing	59 min
		Mileage expenses	$5.8		

Based on the daily input parameters, the average daily cost of a commuter was calculated for each alternative. As demonstrated in Figure 7, park, cross, and ride alternatives allow commuters to save daily. This savings is more if the commuter lives in El Paso and works in Ciudad Juarez.

Figure 7. Average Daily Commuter Costs.

The difference between alternatives in the first scenario was found to be $1.21/day. Assuming that an average worker goes to his/her work 260 days a year, the consumer experiences a total savings of $313 annually if he/she picks the park, cross, and ride alternative to cross the border. Meanwhile, the second scenario reflects a $5.59 difference per day between the two scenarios, with an overall $1,452 annual savings for a commuter who prefers the second alternative.

Ridership is the main expense of the park, cross, and ride alternatives (see Table 3). The values are calculated based on three different locations from the border, all of which are 5 miles from the border. Thus, anybody who works closer to the border will save more since he/she pays less for ridership. Conversely, one who works farther from the border will save less or may not save at all. Another point is that, as explained in Section 2.4, it is expected that more use of mobility-on-demand and ridesharing services with AVs will increase, mainly because the driver costs will be removed, and the ridership will be cheaper. In conclusion, the active use of AVs and cheaper ridership will be more likely to increase the attractiveness of the park, cross, and ride alternative.

CHAPTER 5. CONCLUSIONS

One mode of crossing the border is to park a personal car close to the POE, cross the border, and take a ride on the other side (park, cross, and ride). This mode is expected to become more frequent because of technological developments, such as more use of smart mobile applications and AVs. Further, this mode for border crossings is expected to save some time for individuals, which may lead to a reduction in the number of passenger vehicles on the bridges and increase overall mobility. The goal of this project was to compare alternative modes by developing a cost analysis that included the time-related parameters. For the analysis, two alternatives for two scenarios were introduced. The outcomes of each alternative analysis were calculated based on overall expenses and time savings/losses. The time values were then converted to monetary values using the VoT concept defined by USDOT.

El Paso, which is the primary urbanized area along the Texas-Mexico border, was selected as the study area. The El Paso–Ciudad Juarez region has more than 2 million residents, which induces significant cross-border passenger travel. This study focused on the PDN Bridge, which has the highest number of pedestrian crossings.

In the first scenario, two alternatives for a commuter living in Ciudad Juarez and working in El Paso were explored. He/she could park his/her car close to the POE in public parking, cross the border by walking across the bridge, and then take a ride by a private carsharing company, which was defined as the first alternative. The second alternative was that he/she could cross the border in his/her passenger vehicle and go directly to work. The second scenario had the same alternatives, except in that case, the commuter lived in El Paso and worked in Ciudad Juarez. The data for cost- and time-related parameters were gathered from publicly available resources, and the daily expenses for each alternative were calculated. The daily differences between alternatives were then converted to annual savings for comparison purposes.

The results showed that the park, cross, and ride alternative allows commuters to save $1.21 and $5.59 per day for the first and the second scenarios, respectively. These numbers result in an annual savings of $313 for the first scenario and $1,452 for the second. Moreover, savings values would change if the commuters were involved in a Fast Pass program that allowed them to cross faster and cheaper. When considering the convenience of having a personal vehicle, savings from the park, cross, and ride alternative may be arguable. The main contributor to the overall cost of the park, cross, and ride alternative was found to be ridership expenses. However, with AV technology, which offers a future of cheaper prices for carsharing and mobility-on-demand services, the savings will increase, and it is more likely that this alternative will attract more international bridge users.

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