Exploring the Characteristics of Faculty and Staff Parking on University Campuses

Center for Transportation, Environment, and Community Health
Final Report

by
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16. Abstract

This project studied the characteristics of faculty and staff parking on university campuses. This project had two parts. Part one reviewed the faculty and staff parking management at four universities: Cornell University, University of California, Davis, University of South Florida, and The University of Texas at El Paso. The spatial distributions of parking zones, types of permits and permit fees for faculty and staff were compared. Part two developed a faculty and staff annual median permit fee model called the faculty and staff base price model using campus land-use, demographics, and economic and climate data gathered from 213 universities. A faculty and staff base price model, as a linear function of the log of a city's population, average Fall temperature, in-state tuition fee, number of employees, and campus population density, has been developed using the Tobit regression technique. The model developed has been applied to four universities in a case study.

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EXECUTIVE SUMMARY

One of the main responsibilities of a university's Transportation and Parking Offices (TPOs) is to manage the parking facilities on campuses. The TPOs usually designates parking stalls into zones and limits the use of the zones to permit holders. The permits are sold in limited quantities to different types of users at different set fees. This research focuses on faculty and staff parking on university campuses.

Part one of this project reviewed and compared the management practices of faculty and staff parking management at four universities: Cornell University, University of California at Davis, University of South Florida, The University of Texas at El Paso. The spatial distributions of parking zones, types of permits and permit fees for faculty and staff were compared. The following trends have been observed:

- The geographical distributions of parking lots across the university campuses follow two patterns: rings and clusters. University campuses that are designed with a center core, have their parking lots zoned in several rings, each with a different walking distance to the campus core. For campuses that are spread out with several clusters of buildings in different areas, each cluster has its parking lots. Since the walking distances between a cluster's parking zones to the cluster center have smaller differences, fewer types of parking zones and the types of permits are used.
- Three out of the four universities are moving towards License Plate Recognition (LPR) systems for entry and exit control, and enforcement.
- Three out of the four of the universities sell faculty and staff parking permits for a zone at one fee. Only the University of South Florida offers a discount for staff members whose salaries are below $25,000/year. This salary-based permit pricing may be considered by other universities.
- For faculty and staff who occasionally drive to the campus, single-day permits via a smartphone application are being offered by two of the four universities.

The second part of this research has developed a Faculty and Staff Base Price (FSBP) model. The base price may be regarded as the median level fee of faculty and staff permits on campus. It may be used as the reference to calculate the zone-specific faculty and staff permit fees. Campus land-use, demographic, economic, and climate data collected from 213 universities across the United States were used to develop the FSBP model by the Tobit regression, and a combination of Tobit and linear regressions. It was found that the best FSBP model was a linear function of the (a) log of the city's population; (b) average Fall temperature; (c) in-state tuition fee; (d) number of employees; and (e) campus population density. The developed FSBP model was applied to a case study that compared the base prices predicted by the FSBP model against the observed permit fees at the four universities reviewed in Part 1 of this research. Overall, the fitted FSBP-1 model appeared to give a reasonably good prediction of the annual median permit fees, except when one or more of its significant variables have extremely high or low values.

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1. INTRODUCTION

1.1. Background and Motivation

The Center for Transportation, Environment and Community Health (CTECH) has funded UTEP researchers with two parking projects in the past years (Cheu et al., 2018, 2021). The first project identified the characteristics of parking on university campuses and developed the total demand and base price models for student parking for a campus. The second project explored the impacts of health benefits and carbon footprint in students' parking location choices. This project is the third in the series and it has expanded the scope of parking research on university campuses from student parking to faculty and staff parking.

University campuses are large trip generators. The trips that start or end at universities create parking demand on campus. Large universities have an enrollment of at least 10,000 students plus several thousand faculty and staff members. Most universities do not have sufficient parking spaces to cater to the parking demand. Therefore, the universities establish policies to manage their parking facilities. These policies include setting up Transportation and Parking Offices (TPOs), allocating parking areas into zones, deciding the structure (user and permit types) and levels (fees) of parking. A typical university has four main types of users: students, faculty, staff, and visitors. These users travel to the university for different purposes. Students form the largest group of users. Many studies, including the first two parking projects funded by CTECH, focused on student parking. This project turned the attention to faculty and staff parking.

At universities, faculty and staff are sometimes called employees. They travel to campus for work. However, the duties of faculty and staff are different. Staff is expected to follow fixed work schedules, usually from Monday to Friday from 8:00 a.m. to 5:00 p.m. Faculty's office hours are flexible, but they are expected to be present on campus during scheduled class times. Because faculty and staff are employees, they are treated as the same group by parking policies. For example, many universities zone certain parking facilities and sell the zone's parking permits exclusively for faculty and staff only.

1.1. Objectives

This research has two objectives:
1. To compare the management of faculty and staff parking at four CTECH university campuses and learn from their experiences.
2. To collect data from universities across the United States and develop a model to predict the annual median faculty and staff parking permit fees at universities.

1.2. Outline of Report

This report is organized as follows:
- Chapter 2 reviews the materials that contributed to the understanding of university parking, especially faculty and staff parking.
- Chapter 3 reviews the faculty and staff parking policies of the four CTECH institutions. Comparisons were made and the best practices were recommended.
- Chapter 4 describes the development of the faculty and staff parking permit fee model, including the data collection.
- Chapter 5 concludes this research, reports the outputs, outcomes, and potential impacts.

2. LITERATURE REVIEW

There are more than 300 universities in the United States with enrollments of more than 10,000 full-time equivalent students. These universities also have a relatively large number of faculty and staff compared to universities with smaller enrollments. Data collected from universities with enrollments of at least 10,000 were used in this project.

The parking demand at a university campus is generated by three major types of users: students, faculty and staff. The fourth type of user is visitors. During most of the weekdays during the Fall and Spring semesters, the number of visitors is negligible. The trip characteristics of students, faculty, and staff on campus and their parking patterns have been discussed by Gurbuz et al. (2020). Most studies on parking demand at university campuses started with student parking because students are the largest group of parking facility users. Most commuter students travel to campus when they have classes. They tend to arrive on campus a few minutes to an hour before the first class meeting of the day and leave the campus after the last class of the day. Most of the staff follow a fixed work schedule between 8:00 a.m. to 5:00 p.m. on weekdays. The arrival and departure times of faculty members on campus are harder to predict. Faculty members tend to have flexible hours outside of their scheduled class times. The different travel behavior described above suggests that the parking demand for each type of user may be analyzed independently. However, the parking demands of students, faculty, and staff are likely to interact. This is because they are forced to compete for a limited number of parking spaces either in real-time at a parking zone, or remotely once a year when they try to purchase parking permits.

Almost every university does not have adequate parking capacity to meet the demands. As a result, TPOs control the use of the limited supply of parking facilities by dividing or assigning parking facilities into zones and restrict the use of each zone to certain types of users. To mitigate parking congestion problems, the UPOs usually control the access to parking facilities by permits, and for each parking zone sell a limited quantity of parking permits to qualified members of the community. Permit fees differ for the different types of users and the zone locations. The variations in zoning and permit policies will be reviewed in Chapter 3.

Gurbuz et al. (2020) have developed a Tobit regression model that estimates the “base price” of a 12-month student parking permit on campus. The Tobit regression model is similar to the multiple linear regression model but it limits the dependent variable to an upper or lower limit (in this case a minimum permit fee of $0). They used data collected from 208 universities to calibrate and validate the model (172 for calibration and 35 for validation). The fitted model suggested that the base price of a student parking permit was dependent on the campus setting (urban or suburban), cost of living, the proportion of undergraduate students (among the total enrollment), faculty-student ratio, and proportion of students who purchased permits. The coefficients of the proportion of undergraduate students, and the proportion of students who purchased permits were negative values, which are counter-intuitive. Gurbuz has also developed a demand model, which is the proportion of students who will purchase permits, using the Beta regression technique. The demand (quantity)for faculty and staff parking permits is not part of this research and therefore this topic is not reviewed here.

3. COMPARATIVE STUDY ON THE MANAGEMENT OF FACULTY AND STAFF PARKING

In this chapter, the parking policies of Cornell University, the University of California at Davis (UCD), the University of South Florida (USF), and The University of Texas at El Paso (UTEP) were reviewed. The emphasis was placed on faculty and staff parking. The parking information on the selected campuses was mainly taken from the university websites, including the National Center for Education Statistics Common Data Sets (CDS) which are open to the public. These four universities were selected because they were partnering institutions in CTECH, and the authors were familiar with the campuses. The CTECH researchers and staff at these campuses served as resource persons to help fact-check the contents of this chapter. In addition, the four universities are located in the four regions in the country. The following sections of this chapter each review a university's campus parking policy. The last section compares parking management and draws lessons from the best practices of each campus.

3.1. Cornell University

The Cornell University campus was founded in 1865 and sits on more than 745 acres of land in Ithaca, New York. Cornell is a private research university with more than 24,027 students. Approximately 52% of all students are residents on campus. The university's population also includes 2,216 faculty and 5,214 staff.

The Department of Transportation and Delivery Services (TDS) is the unit at Cornell that manages parking within the university's Ithaca campus (Cornell, 2021). Parking lots on campus are organized into the following "tiers": central, mid, perimeter, and outer tiers, based on the proximity from the campus core (see Figures 1 and 2). Each tier is color-coded and has separate parking lots. Each parking lot is labeled with a one or two-letter code called "designated letter" (e.g., A, B, C, D, SC) which also indicates the type of permits that are allowed to park. Therefore, it can be said that at Cornell University, each parking permit is only valid at a specific parking lot or a group of several lots in the same tier and area. TDS manages the limited number of parking spaces by selling a limited number of parking permits. Faculty and staff purchase permits to park in any tier. Students can only purchase commuter permits to park in the perimeter tier or resident permits to parking in the residential areas. Faculty and staff purchase their permits annually. Students purchase their parking permits by semester. All permits must be purchased online via a TDS portal. The faculty and staff parking lots are separated from the student parking lots, although they may be in the same tier. Table 1 list the most common types of parking permits, their fees, and parking privileges on Cornell's Ithaca campus. The faculty and staff parking permits in high-demand lots (such as E, R, WE) are sold to the employees whose workplace is in the immediate vicinity. TDS calls this eligibility "work-in-zone". Cornell University is in the process of transitioning from the decal permits to using vehicle license plates as virtual permits. The TDS also offers a "daily decision" parking option for users. This option is essentially hourly or daily paid parking which is open to all users (including faculty, staff, students, and visitors). It requires users to park at designated areas (called ParkMobile zones) and pay the fees by a smartphone application called ParkMobile.

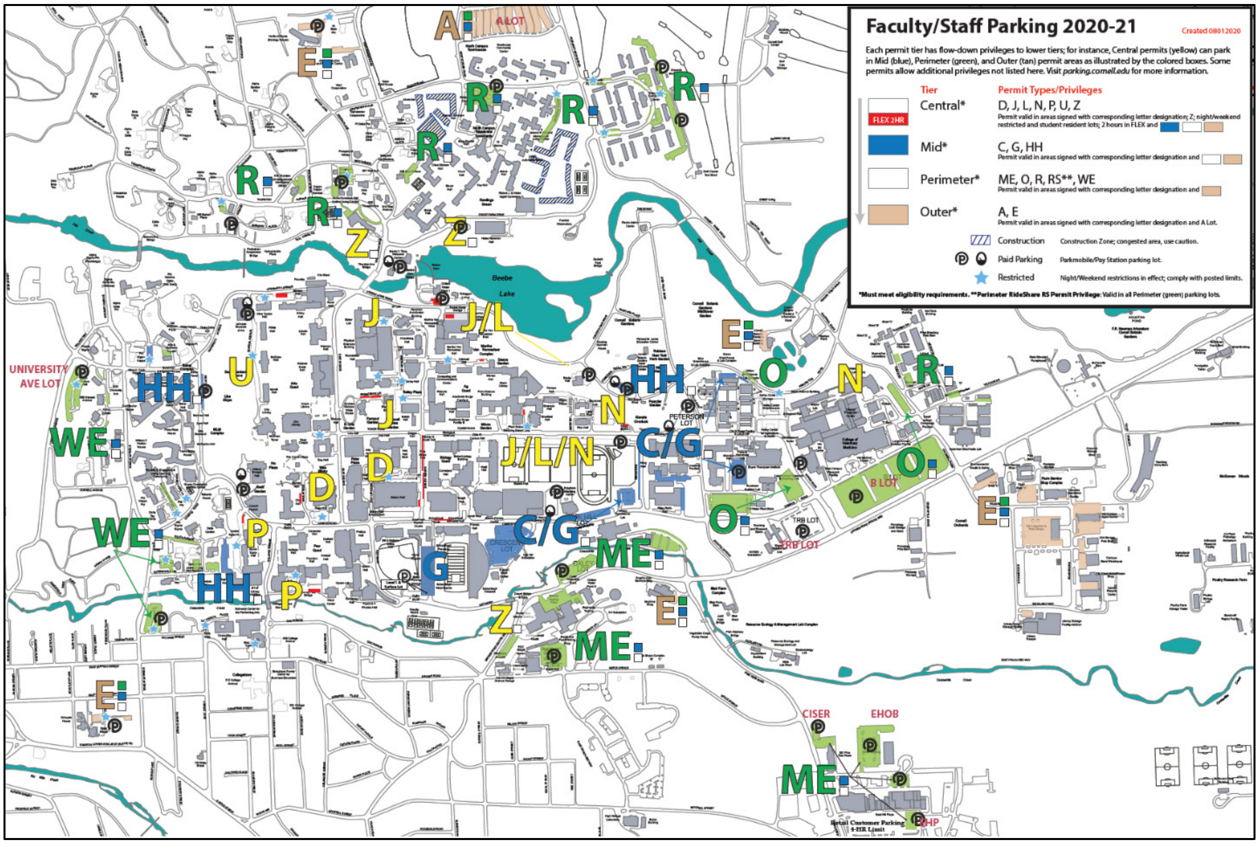

Figure 1 Map of Cornell University's central tier, mid-tier and perimeter tier parking lots (from Cornell (2021)).

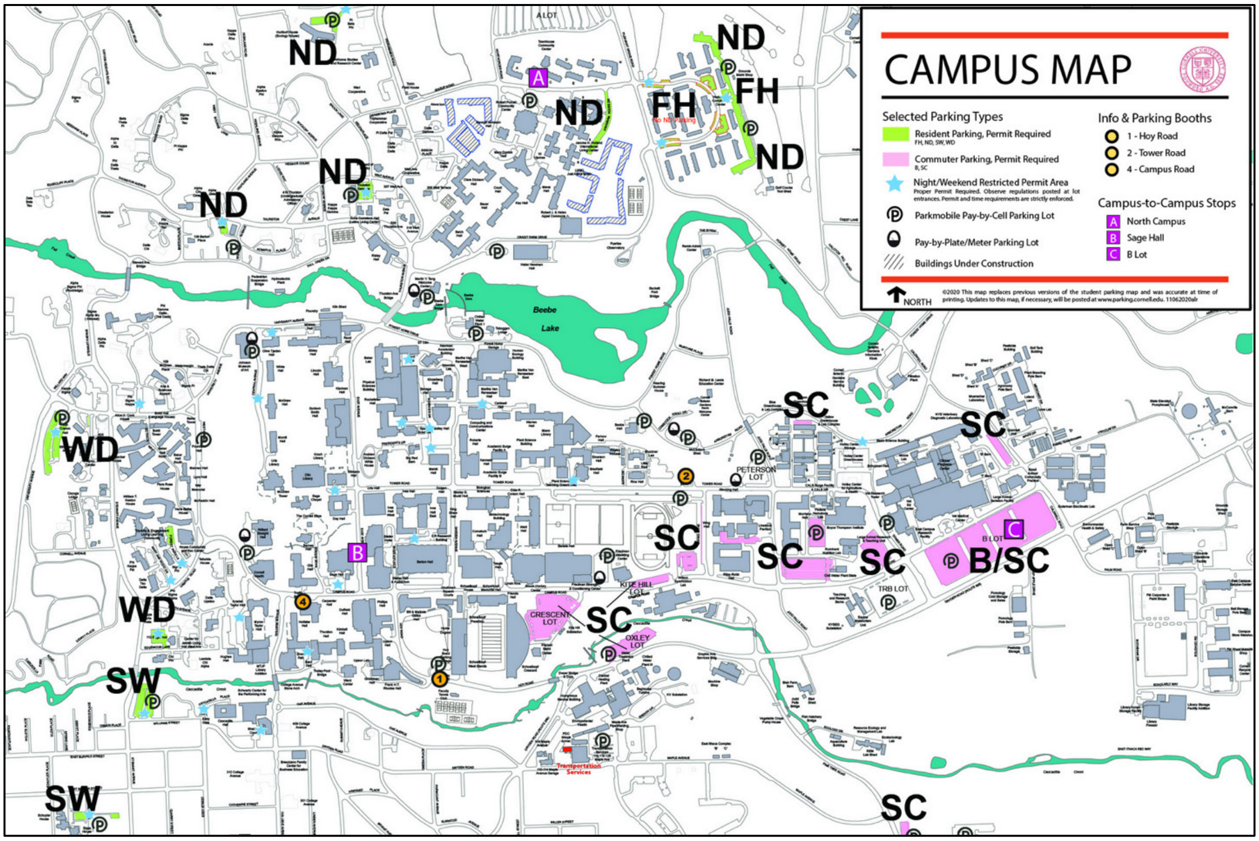

Figure 2 Map of Cornell University's outer tier parking lots (from Cornell (2021)).

Table 1 Parking permit types, users, locations and permit fees at Cornell University.

Tier	Permit type (designated letter)	For	Valid to park at	Permit fee (before tax)
Central	D, J, K, N, P, U	Faculty and staff	Designated letter lots, mid, perimeter and outer tier areas	$747/year
	Z	Faculty and staff	Designated letter lots, mid, perimeter and outer tier areas	$532/year
Mid	C, HH	Faculty and staff	Designated letter lots, perimeter and outer tier areas	$532/year
	G	Faculty and staff	Designated letter lots, perimeter and outer tier areas	$697/year
Perimeter	ME, O, R, WE	Faculty and staff	Designated letter lots and outer tier area	$333/year
	RS (ride share)	Faculty, staff and students	A, E, ME, O, R, WE	Free
	B	Student commuters	Only in B lot	$180/semester
	SC	Student commuters	Only in SC lots	$376/semester
	FH, ND, SW, WD	Student residents		$376/semester
Outer	A and E	Faculty and staff	Outer tier areas	Free

3.2. University of California at Davis

The University of California at Davis (UCD) was founded in 1905 as part of the University of California system. The UCD campus is located in the City of Davis, Yolo County, north of the San Francisco Bay area, and 15 miles west of Sacramento. Its campus spreads across 5,300 acres. The university has 38,035 students, 2,214 faculty and 6,702 staff. About 32% of students live on campus, while the rest live in the surrounding neighborhoods in the City of Davis.

Parking on the UCD campus is managed by Transportation Services. Its acronym TAPS is derived from Transportation and Parking Services (UCD, 2021). This unit handles permit sales, bicycle registrations, and street repairs. Parking lots on the UCD campus are labeled as A, C and L lots. These letters indicate the type of lots but not the locations. Lots marked with the same letter are not necessarily near each other. The A parking lots are designated for faculty and career staff only (see Figure 3), while the C and L lots are available to commuter students, faculty members, and career staff (see Figure 4). Faculty and staff with an A permit can park in any of the 16 open surface A lots or in the designated A spaces within the three parking garages. UCD faculty members and staff may purchase permits monthly or daily. The monthly permits used to be either physical hangtags or decals. The physical permits have been replaced by electronic permits which uses License Plate Recognition (LPR). The permits must be purchased from the online parking portal. The daily permits must be purchased via a smartphone application called ParkMobile.

TAPS gives users the option of paying a long-term fee (for a permit that lasts for six or more consecutive months) or a short-term fee (for a permit that will expire in five or fewer consecutive months). Table 2 displays the permit options available and their corresponding long-term and short-term monthly fees. The TAPS website does not list fee by academic quarter or by year.

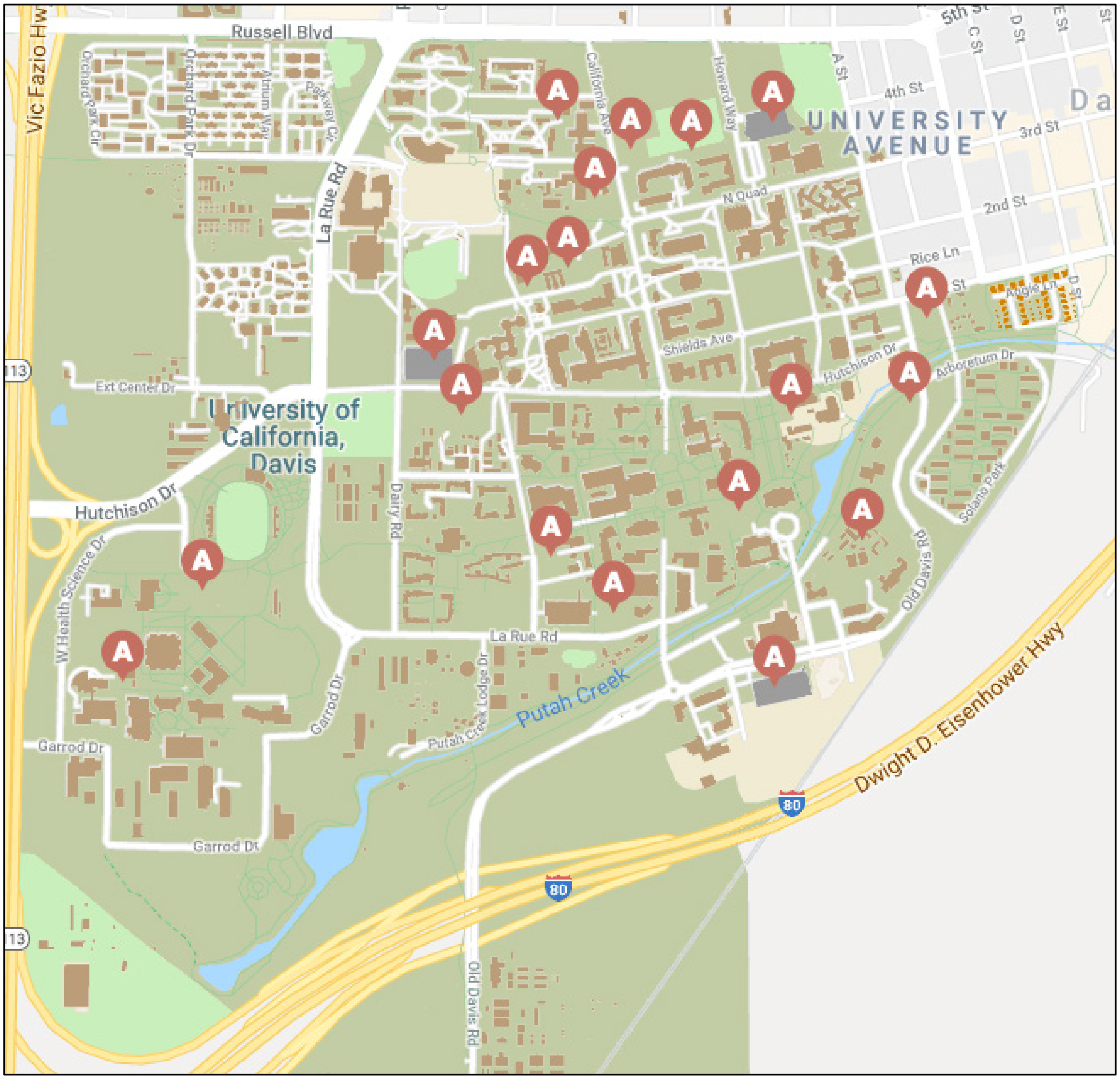

Figure 3 Map of University of California at Davis's A parking lots (from UCD (2021)).

Figure 4 Map of University of California at Davis's C and L parking lots (from UCD (2021)).

Table 2 Parking permit types, users, locations and permit fees at University of California at Davis.

Permit Type	For	Valid to park at	Long-Term Fee (before tax)	Short-Term Fee (before tax)
A	Faculty and career staff	Lots marked with A signs	$65/month	$70/month
C	Faculty, staff and students	Lots marked with C signs	$55/month	$60/month
L	Faculty, staff and students	Lots marked with L signs	$35/month	$40/month

3.3. University of South Florida

The University of South Florida (USF) is a public research university located in the City of Tampa, Florida. The university was founded in 1956 and covers a land area of 1,562 acres. USF has two other campuses located in St. Petersburg and Sarasota, Florida. The main campus in Tampa is the focus of this report. USF has a total enrollment of 44,231 students. Fifteen percent of its students live on campus. USF employs a total of 1,946 faculty and 3,811 staff.

At USF, the Parking and Transportation Services Department (PATS) is the office responsible for the management of the parking facilities, permit sales, and the USF Bull Runner Transit System (USF, 2021). There are 45 parking lots and six parking garages on USF's Tampa campus, offering more than 2000 parking spaces. Figure 5 shows the parking map of USF. Each parking lot or garage in USF is labeled with either a number or a number followed by a letter (e.g., 5E, 29A, 24, 35). Each lot or garage has areas marked for different types of parking permits. For example, parking lot 8A is only for E permits while parking lot 8C is for E and S permits. USF offers S, R, E, and GZ permits. S and R permits are for students and resident students, respectively. E permits are for employees (faculty and staff). GZ or Gold Zone permits are prime and limited parking spaces in high demand by faculty and staff. A vehicle that has a valid permit can park in any lot in any stall marked for the same type of permit. That is, a vehicle registered for an E permit can park in the spaces marked for E permits in lots 8A, 8B, 8C, and so on. Since the Fall semester of 2020, USF has implemented a electronic permit system. This new system uses vehicle license plates as virtual permits. Access and enforcement are by LPR. All USF's parking permits for faculty, staff, and students, with the exception of carpool permits, are sold online through a parking portal. Permits can be purchased by the academic year or per semester. Table 3 lists the most common types of parking permits on the USF Tampa campus and their fees before sales tax.

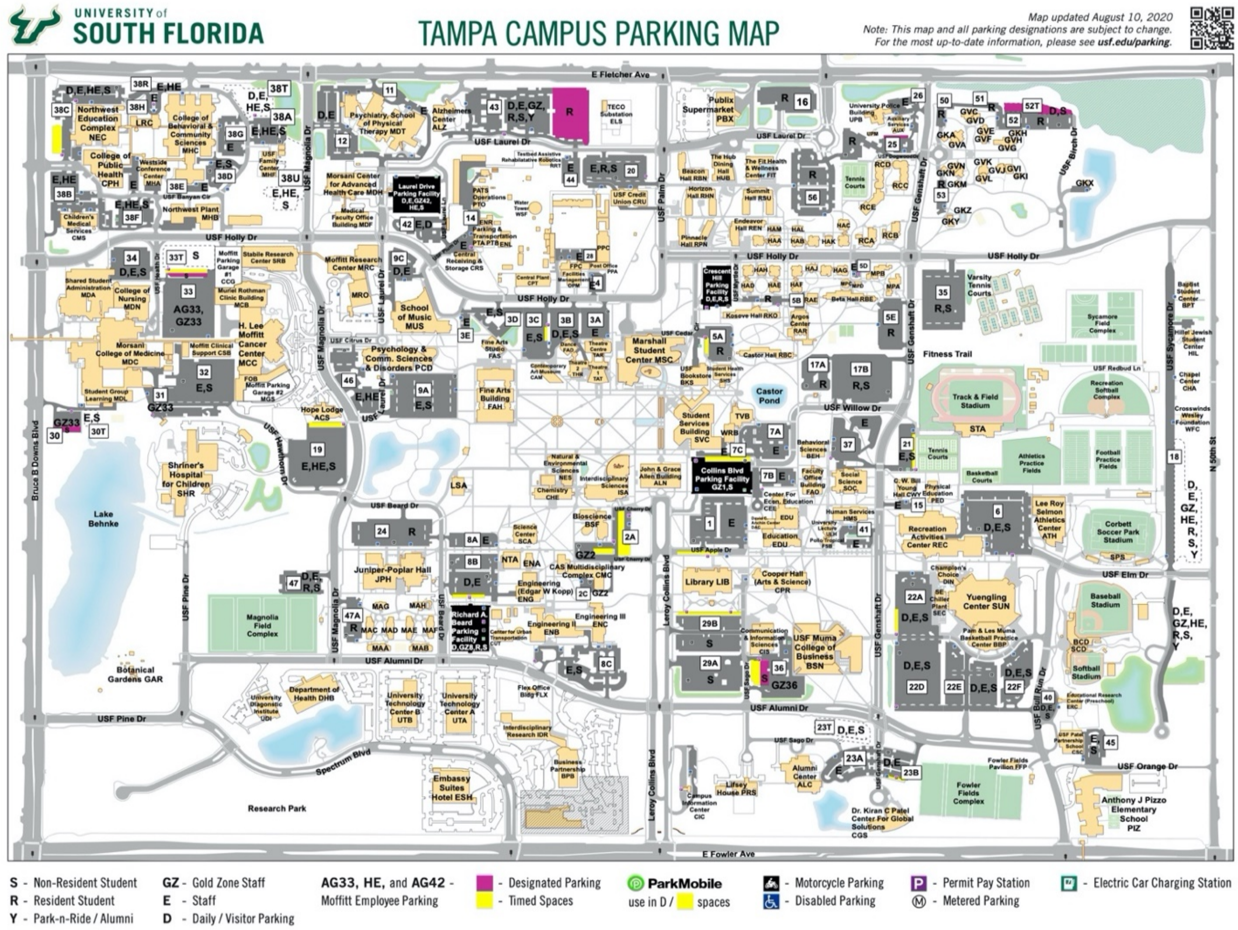

Figure 5 Map of University of South Florida's parking lots (from USF (2021)).

Table 3 Parking permit types, users, locations and permit fees at The University of South Florida.

Permit code	Permit type	For	Valid to park at	Permit fee (before tax)
GZ	Gold zone	Employees	Any area marked with GZ	$450/year
E	Employee	Employees with annual salary >$25K	Any area marked with E	$270/year or $135/semester
E	Employee	Employees with annual salary <$25K	Any area marked with E	$262/year $132/semester
S	Student	Commuting students	Any area marked with S	$183/year $91/semester
R	Resident	Resident students	Any area marked with R	$226/year $113/semester
ECP	E-carpool	Employees who carpool	Reserved stalls assigned by PATS	$230/year
SCP	S-carpool	Students who carpool	Reserved stalls assigned by PATS	$156/year
Y	Park-n-ride	Employees and students	Lots 18, 43	$59/year

3.4. The University of Texas at El Paso

The University of Texas at El Paso (UTEP) is part of The University of Texas System. Its campus is located next to downtown El Paso just minutes away from the US-Mexico border. UTEP's campus occupies just over 420 acres of mountainous land. It has an enrollment of 25,177 students. Only 4% of these students are residents on campus. UTEP employs 1,315 faculty and 1,174 full-time equivalent staff.

UTEP has a department named Parking and Transportation Services (PTS) that manages all the parking lots and garages, permit sales, and the Miner Metro campus shuttle bus service (UTEP, 2021). There are a total of 64 off-street open surface parking lots, on-street areas, and three parking garages on the UTEP campus. These facilities are usually identified by a code that starts with two letters (which represents the name of the access road) followed by a number (e.g., SC4, SB10). The two garages at the center of the campus are labeled differently by replacing the number with the letter G (which indicates Garage), i.e., SBG, SCG. Figure 5 is a map of the UTEP campus with all the parking lots and garages. UTEP's PTS controls the access and use of the parking facilities by selling parking permits. It groups the parking facilities by color. Permits of the same color are sold at the same fee. Table 4 lists the permit type, annual permit fee (sold in the Fall 2019 semester). As can be seen in Table 4, UTEP faculty and staff can purchase red, orange, brown, blue, green, and garage permits. The permits are sold annually and must be purchased via an online portal. Faculty and staff pay higher permit fees than students to park in the same lots. The permits are physical hangtags that must be displayed on the rearview mirror.

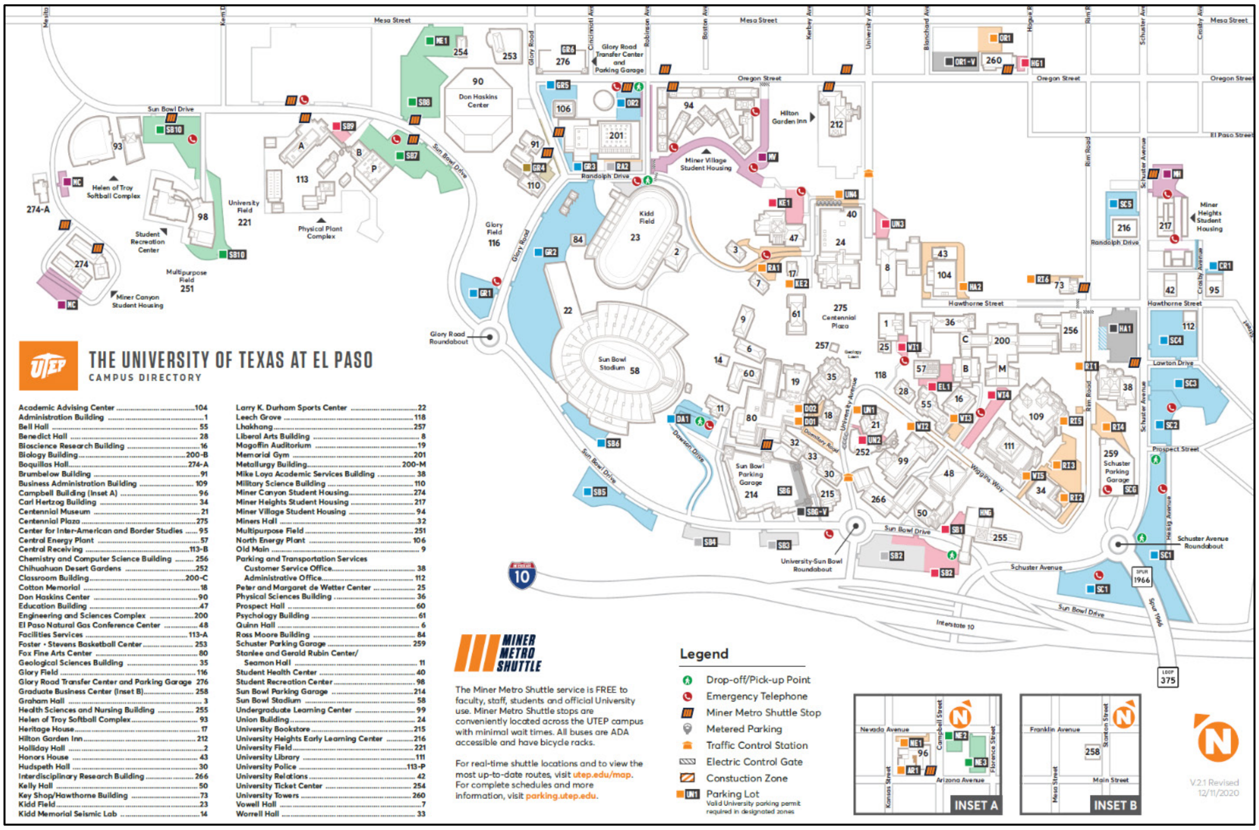

Figure 6 Map of The University of Texas at El Paso parking lots (from UTEP (2021).

Table 4 Parking permit types, users, and permit fees at The University of Texas at El Paso.

Color	Permit type	For	Permit fee (12-months, before tax)
Red	Inner-campus reserved	Faculty and staff	$600/year
Orange	Inner-campus	Faculty and staff	$525/year
Brown	GR4 reserved	Faculty and staff	$500/year
Silver	-	Students	$300/year
Blue	Perimeter	Faculty and staff Students	$400/year for Faculty and staff $225/year for students
Green	Remote	Faculty and staff Students	$300/year for Faculty and staff $50/year for students
Purple	Residents	Resident students	$150/year
Gold	SBG – Sun Bowl Garage	Faculty and staff Students	$575/year for faculty and staff $400/year
Gold	SCG – Schuster Garage	Faculty and staff Students	$575/year for faculty and staff $400/year for students
Gold	GR6 – Glory Road Garage	Students	$300/year

3.5. Comparative Evaluation

This section compares the policies and management practices of faculty and staff parking at the four campuses. Table 5 summarizes the permit fees, expressed in $ per month for ease of comparison. This table also compares the various aspects of parking management.

Table 5 Comparisons of monthly permit fees and parking management policies..

Items	Cornell	UCD	USF	UTEP
Highest permit fee ($/month)	62	70	50	50
Median permit fee ($/month)	44	55-60	30	44
Lowest permit fee ($/month)	free	35	29	25
Types of permits for faculty & staff	4	3	2	6
Cross parking in any lot of the same type	Yes	Yes	Yes	
License plate recognition	Yes	Yes	Yes	
Salary based permit fee			Yes	
Daily permit option		Yes		
Monthly permit option		Yes	Yes	
Semester permit option	Yes		Yes	
Annual permit option	Yes		Yes	Yes
Hourly payment by app.	Yes	Yes		

By comparing the campus maps, their land use, and distribution of parking lots, one can observe that the Cornell and UTEP campuses each have a core area. Parking lots are assigned in three to four rings, from central or inner campus, mid, perimeter to outer or remote. On the other hand, the Colleges at UCD and USF are spread across the campus, each with its own cluster of buildings. The parking lots follow a similar pattern which build around the clusters. There are fewer permit options to choose from since their placement is random.

Among the four universities, UCD charges the most expensive monthly parking permit fees. UCD's highest, median and lowest permit fees are higher than the three other universities. USF and UTEP have the lowest parking permit fee distributions. They offer their staff and faculty the options that equivalent to paying the $1 per workday for parking. Cornell University is the only one that offers free parking at the remote lots.

In terms of the types of permits, USF has only two options for its faculty and staff (E and GZ permits), UCD has three types of permits for its faculty and staff (A, C, and L permits) where C and L are shared with students. Cornell University has four types of parking permits. These three universities have fewer types of permits so that their faculty and staff can cross park, i.e., park in a different lot of the same permit category. UTEP divides its staff parking permits into six different types, each assigned to color with a different fee. Each parking lot has only one valid permit type. However, permit holders are not allowed to cross park. At UTEP, the perimeter and remote lots are shared between students, faculty, and staff.

Cornell, UCD, and USF have implemented the LRP system. This system uses vehicle license plates as virtual permits (for control access and enforcement). This reduces the need to distribute physical parking permits to faculty and staff. UTEP has a patrol vehicle equipped with LRP technology but still relies on physical permits and TPO staff on patrol for enforcement. Cornell and UCD both utilize the ParkMobile parking application to collect daily and hourly parking fees for visitors and those who do not wish to commit to purchasing a long-term parking permit.

USF is the only university that offers a discounted fee for employees whose annual salaries are $25,000 or lower. Although the discount is only a few dollars per year, this policy may be a good example for other universities to follow.

All four universities list the permit fees before tax. Cornell is the only university that lists the fees payable after-tax on its website. UCD lists its permit fees by month. This is because its academic calendar operates in the quarter system. UCD offers a discount off the monthly fee if a faculty or staff is committed to purchasing six months or longer. UTEP is the only university that sells permits by the academic year. Faculty and staff at USF and Cornell have options to purchase permits by semester or academic year. In any case, all these universities have monthly payroll deduction plans and pro-rated refund policies.

4. DEVELOPMENT OF FACULTY AND STAFF BASE PRICE MODELS

This chapter describes the data that were used in the development of a model that predicts the median fee of a 12-month faculty and staff parking permit. The predicted fee is referred to as the Faculty and Staff Base Price (FSBP) in $/year. The experience of Gurbuz et al. (2020) helped in the data organization and the online data collection process.

4.1. Data Collection

The data collection process started with the 310 universities used by Gurbuz et al. (2020). These 310 universities are the universities in the United States with full-time equivalent enrollment of 10,000 or more. Not every university announces their faculty and staff parking permit fees publicly on their websites. For example, some universities require a faculty or staff to log into his/her university computer account to access this information. After eliminating these universities, only 220 universities were left. For each university, the public available information about its land-use, demographics, economic and climate data were found in the Internet. These variables and their data sources are summarized in Table 6. Some of the variables were the same as Gurbuz et al. (2020) but the values were updated to the data in Academic Year 2018-19 which were published in 2019 or 2020.

The data came from five sources. They are listed in the last column of Table 6.

- University: The university websites, especially the parking websites and facts-and-figure pages, have information on the permit fees for faculty and staff, and the land area of the campus.
- Common Data Set: The Common Data Set (CDS) contains standard variables each university must report every year to the National Center for Education Statistics, under the U.S. Department of Education. Among the attributes is the type of university (public/private), campus setting (urban/suburban), number of rainy days, in-state tuition, enrollment, number of faculty, and number of staff. The CDS is available for download on each university's website.
- The U.S. Censor Bureau: The U.S. Censor Bureau (Census, 2021) has the latest estimate of the city population.
- General Service Administration (GSA): The cost of living while attending a university is approximated by the GSA's per diem rate (hotel and meals) (GSA, 2021).
- Weather.com: The website weather.com provided the number of days with precipitation and the average fall temperature.

Table 6 Variable dictionary.

Variable	Name and unit	Description	Data source
Y	Annual median permit fee ($/year)	The median fee among the different types of faculty/staff parking permits available for purchase by faculty/staff, in Fall 2019.	University's parking website
X_1	Type of university	0 if public, 1 if private	CDS
X_2	Campus setting	1 if rural, 2 if suburban, 3 if urban	CDS
X_3	Log (City population)	Log (city's population in 2019)	U.S. Census Bureau (Census, 2021)
X_4	Campus area (acres)	Land area occupied by the campus	CDS
X_5	Number of rainy days (days/year)	Average number of days in a year with precipitation	CDS
X_6	Average fall temp (F)	Average temperature in September, October, and November.	Weather.com
X_7	Cost of living ($/day)	Average daily per diem rate (hotel and meals) in the city or county over 12 months from Oct. 2018 to Sept. 2019 (FY2019).	GSA (GSA, 2021)
X_8	In-state tuition fee ($/year)	Average in-state tuition fee paid by a full-time undergraduate student in the Fall 2018 and Spring 2019 semesters or Fall 2018, Winter 2019 and Spring 2019 quarters	CDS
X_9	Enrollment	Total number of students (undergraduate and graduate) on October 15, 2019.	CDS
X_{10}	Student-faculty ratio	Number of full-time equivalent students divided by the number of full-time equivalent faculty	CDS
X_{11}	Number of employees	Total number of equivalent faculty and staff in Fall 2019.	CDS and university's website
X_{12}	Campus population density (persons/acre)	Number of students and employees per acre = $(X_9 + X_{11})/X_4$	Calculated

After the university data had been collected, descriptive statistics were compiled and analyzed. Seven universities offered free parking to their faculty and staff. Free-parking is a policy decision and cannot be predicted by the potential independent variables. Therefore, after removing these seven universities, the data set was left with 213 universities. Table 7 shows the descriptive statistics of the attributes computed from these 213 universities. Figure 7 shows the distribution of these 213 universities in the different states.

Table 7 Descriptive statistics.

Variable	Name and unit	Sample size	Mean	Median	Minimum	Maximum	Standard deviation
Y	Annual median permit fee ($/year)	213	460	313	25	2352	419
X_1	Type of university	213	0.16	0.00	0.00	1.00	0.37
X_2	Campus setting	213	2.49	3.00	1.00	3.00	0.70
X_3	Log(City population)	213	5.19	5.16	3.79	6.59	0.65
X_4	Campus area (acres)	213	832	521	49	7958	954
X_5	Number of rainy days (days)	213	109	115	27	171	29
X_6	Average fall temp (F)	213	58	57	39	79	8
X_7	Cost of living ($/day)	213	195	182	149	374	48
X_8	In-state tuition fee ($/year)	213	17,396	10,780	4,535	60,862	16,274
X_9	Enrollment	213	23,988	21,705	7,624	69,525	11,967
X_{10}	Student-Faculty ratio	213	16.5	16.5	7.1	29.7	4.0
X_{11}	Number of employees	213	4032	2888	814	24372	3332
X_{12}	Campus population density (persons/acre)	213	71.8	44.1	5.5	585.2	75.4

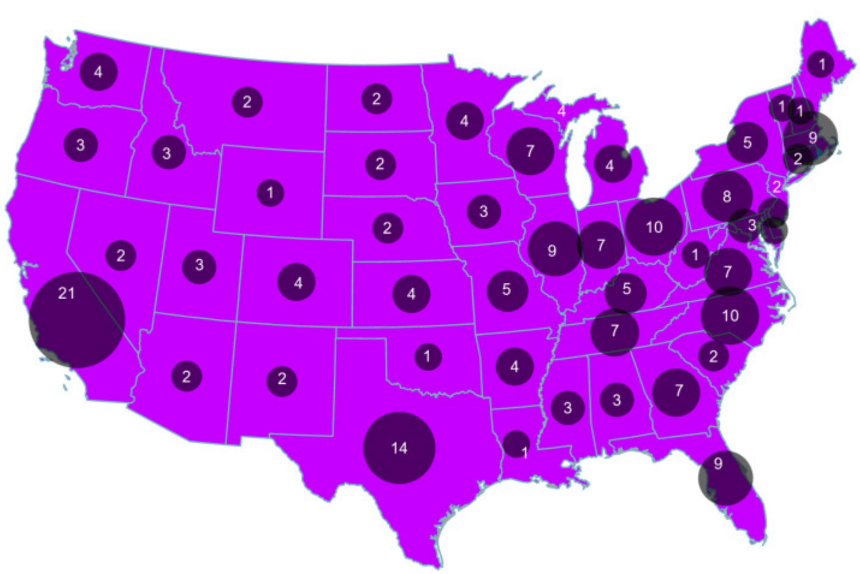

Figure 7 Distribution of 213 university campuses by states.

During the data collection, the research team encountered several challenges. They are discussed here:

- None of the universities did not publish the number of parking spaces, the number of permits available or sold in each zone. Because of this the research team did not know the supply of parking spaces on a campus.
- Because of the lack of data on the capacity of each zone or the number of available permits put up for sale, the research team could not compute the exact median fee of all the faculty and staff parking permits in each university. The researchers resorted to estimating the median fees by picking the median fee category after eliminating the outliers such as special permits for the President, Provost, and Deans.
- The researchers noted that in several universities, the faculty and staff parking permits fees were kept extremely low because they were negotiated by their faculty and/or staff union. The research team could not add a variable to denote the union's involvement as most of the universities did not declare the role of the union (if any) in the fee-setting process.
- The university calendar operates in either the semester system or the quarter system. For a fairer comparison, the research team has opted to use the permit fee for 12 months. Some universities' websites were not very clear in stating if the advertised fees included or excluded the summer months. The answers were inferred from information on other websites at the same university.
- Some of the advertised fees included applicable tax. By default, if no information about tax was mentioned, the advertised fees were regarded as the fees before applicable taxes.
- The city population for universities in a large metropolitan area was difficult to estimate. For these universities, the populations in the metropolitan area were used instead of the city where the campus is located.
- Some universities included the undeveloped land areas in the CDS which made the land area very large. For these universities, the developed areas of the campus were used if the statistics were found.
- The number of employees is the sum of faculty and staff. The researchers decided not to distinguish part-time or full-time status as both contribute to parking demand, i.e., part-time faculty and staff still need to purchase permits at regular fees.

4.2. Model Development Process

This section describes the development of the Faculty And Staff Base Price (FSBP) model. The dependent variable is the annual median permit fee (Y). The independent variables considered were X_1 to X_{12} as listed in Table 6. The model was developed in three stages:

Stage 1: Correlation analysis.

First, a correlation analysis was performed between all possible pairs of variables drawn from the dependent and possible independent variables. The purpose of this stage was to acquire ideas on the significant independent variables and check the dependency of any two variables in the data set which may influence the selection of independent variables in the subsequent stages.

Stage 2: Fitting of a single model.

The data set of 213 universities were randomly assigned to two data sets:

- The training data set (Dataset T) consisted of 171 universities.
- The validation data set (Dataset V) consisted of 42 universities .

The Tobit regression was applied to fit a model to Dataset T. The fitted model was then tested with Dataset V.

Stage 3: Fitting of dual models.

The purpose of Stage 3 was to see if the estimation of the annual median permit fee may be improved by segregating Dataset T into two subsets of an equal number of data points, using the significant independent variables found in Stage 2 as the division points. A separate Tobit regression model was fitted to the subset of data.

4.3. Correlation Analysis

Table 8 lists the correlation coefficients (r^2) of the dependent variable and the 12 independent variables initially considered. Figure 8 shows the scatter plots of all the possible pairs of variables.

Table 8 Correlation coefficients.

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	0.382											
X_2	0.275	0.070										
X_3	0.373	0.279	0.581									
X_4	-0.064	-0.138	-0.127	-0.247								
X_5	0.084	0.177	-0.139	-0.357	-0.059							
X_6	-0.071	0.017	0.065	0.322	0.008	-0.394						
X_7	0.333	0.446	0.208	**0.508**	-0.231	-0.111	0.135					
X_8	0.447	**0.908**	0.069	0.278	-0.158	0.224	-0.058	0.483				
X_9	0.174	-0.207	0.269	0.310	0.355	-0.206	0.330	0.079	-0.237			
X_{10}	-0.255	**-0.564**	-0.031	-0.132	0.170	-0.318	0.277	-0.288	**-0.618**	0.339		
X_{11}	0.447	0.217	0.226	0.340	0.265	-0.007	0.086	0.253	0.275	**0.582**	-0.171	
X_{12}	0.339	0.203	0.356	0.443	-0.443	0.024	0.058	0.491	0.226	0.117	-0.167	0067

The correlation coefficients between Y and all the 12 independent variables were first analyzed. As can be observed in the second column in Table 8, none of the independent variables correlated strongly with Y. The highest r^2 value was 0.447, between Y and X_8 (in-state tuition fee/year) and between Y and X_{11} (number of employees).

Among the possible pairs of variables, the highest r^2 value was 0.908, between X_1 (type of university: public/private) and X_8 (in-state tuition fee/year). This high r^2 value was expected because public universities ($X_1 = 0$) charge lower in-state tuition fees; on the other hand, private universities ($X_1 = 1$) charge higher tuition fees. The second-highest r^2 value was -0.618. This was the r^2 value between X_8 (in-state tuition fee/year) and X_{10} (student-faculty ratio). This was not surprising because higher tuition fees often lead to lower student-faculty ratios. The third highest r^2 value is 0.582, which was calculated between X_9 (enrollment) and X_{11} (number of employees). This reflected that more faculty and staff were necessary to serve more students. The next highest r^2 value was -0.564, between X_1 (type of university) and X_{10} (student-faculty ratio). Private universities ($X_1 = 1$) tend to have lower student-faculty ratios. X_3 (log of city's population) and X_7 (cost of living at per diem rate/day) were correlated with $r^2 = 0.508$. The remaining r^2 values were all below 0.5.

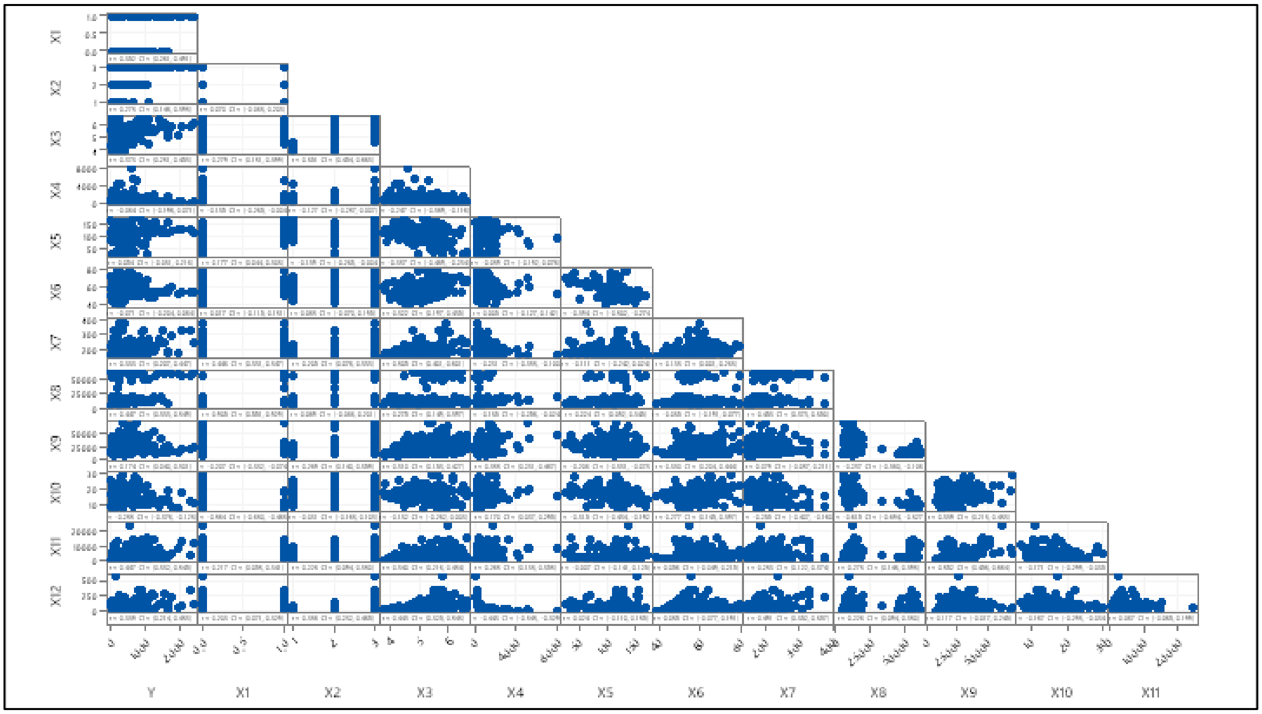

Figure 8 Scatter plots of pairs of variables (from Minitab (2021)).

The significance of an r^2 value may be judged by performing a hypothesis test with $H_0: r = 0$ against $H_1: r \neq 0$. The test statistic is

$$T_0 = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \tag{1}$$

The H_0 is rejected if $|T_0| > t_{\alpha/2,n-2}$. With $n = 213$, $\alpha/2 = 0.01$, $t_{\alpha/2,n-2} = 2.33$. Table 9 lists the calculated T_0 values. The values with $|T_0| > 2.33$ are highlighted in bold.

Table 9 T-statistics of hypothesis tests for correlation coefficients.

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	**6.00**											
X_2	**4.15**	1.02										
X_3	**5.84**	**4.22**	**10.37**									
X_4	-0.93	-2.02	-1.86	**-3.70**								
X_5	1.22	**2.61**	-2.04	**-5.55**	-0.86							
X_6	-1.03	0.25	0.95	**4.94**	0.12	**-6.23**						
X_7	**5.13**	**7.24**	**3.09**	**8.57**	**-3.45**	-1.62	1.98					
X_8	**7.26**	**31.48**	1.00	**4.20**	-2.32	**3.34**	-0.84	**8.01**				
X_9	**2.57**	**-3.07**	**4.06**	**4.74**	**5.52**	**-3.06**	**5.08**	1.15	**-3.54**			
X_{10}	**-3.83**	**-9.92**	-0.45	-1.93	**2.51**	**-4.87**	**4.19**	**-4.37**	**-11.42**	**5.23**		
X_{11}	**7.26**	**3.23**	**3.37**	**5.25**	**3.99**	-0.10	1.25	**3.80**	**4.15**	**10.40**	**-2.52**	
X_{12}	**5.23**	**3.01**	**5.53**	**7.18**	**-7.18**	0.35	0.84	**8.19**	**3.37**	1.71	**-2.46**	0.98

4.4. Single Model

This step of model building applied the Tobit regression to Dataset T to fit a single FSBP model. Two variants of the models were developed: the FSBP-0 which is without a constant term; and FSBP-1 which has a constant term. The Tobit regression model with a lower limit of 0 was used because the annual median parking permit fee should not be negative. The STRATA Special Edition 17 (STATA, 2021) was used to fit the model. The stepwise regression and backward elimination approaches (with $\alpha/2 = 0.05$) were deployed independently to select the significant variables and to check that both approaches converged to the same fitted model. Figure 9 summarizes the results of the fitted FSBP-0 and FSBP-1 models.

Between the FSBP-0 and FSBP-1 models, the FSBP-1 has a slightly better fit to Dataset T as it has a slightly larger log-likelihood value. Both models have the same significant variables. Their coefficients for the same variable have very similar numerical values in the two models (with and without a constant term). All the selected variables have $|t| > 1.96$. The FSBP-1 model is preferred over the FSBP-0 model.

The significant variables in the FSBP-1 model may be explained with the following reasons. The city's population (X_3), in-state tuition (X_8), number of employees (X_{11}) and campus population density (X_{12}) reflect the land-use density, cost of living, and/or traffic congestion levels. Therefore, it is reasonable to expect that they have positive impacts on the parking fees. The negative coefficient of average fall temperature (X_6) is also expected. Lower average fall temperature may cause more faculty and staff who travel by public transportation modes to driving cars and therefore generate more parking demand and an increase in parking permit fees.

Gurbuz et al. (2000) fitted a Tobit regression model to a different data set for an annual student base price model. The significant variables in predicting the base price were campus setting, cost of living, the proportion of undergraduate students, faculty/student ratio, and proportion of students who purchased permits. None of the significant variables appears in the FSBP-1 model.

Tobit regression

Number of obs = 171
Uncensored = 171
Left-censored = 0
Right-censored = 0

Limits: lower = 0
upper = +inf

Wald chi2(5) = 525.51
Prob > chi2 = 0.0000

Log likelihood = -1219.1664

(1) [y]_cons = 0

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x3logpop	108.4092	34.59457	3.13	0.002	51.5062	165.3122
x6temp	-8.235252	2.808593	-2.93	0.003	-12.85498	-3.615528
x8tuition	.0048866	.0016017	3.05	0.002	.0022521	.0075211
x11employ	.0475237	.0086671	5.48	0.000	.0332676	.0617797
x12density	1.460828	.3292171	4.44	0.000	.9193146	2.002342
_cons	0	(omitted)				
var(e.y)	91251.86	9868.671			76381.18	109017.7

(a) FSBP-0 model

Tobit regression

Number of obs = 171
Uncensored = 171
Left-censored = 0
Right-censored = 0

Limits: lower = 0
upper = +inf

Wald chi2(5) = 135.88
Prob > chi2 = 0.0000

Log likelihood = -1219.1656

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x3logpop	107.358	44.33006	2.42	0.015	34.44158	180.2745
x6temp	-8.292097	3.183586	-2.60	0.009	-13.52863	-3.055564
x8tuition	.0048844	.0016027	3.05	0.002	.0022481	.0075207
x11employ	.0475825	.0088049	5.40	0.000	.0330998	.0620653
x12density	1.463852	.3387328	4.32	0.000	.9066861	2.021018
_cons	8.440607	222.5829	0.04	0.970	-357.6757	374.5569
var(e.y)	91251.09	9868.588			76380.54	109016.8

(b) FSBP-1 model

Figure 9 Results of Tobit regression for FSBP-0 and FSBP-1 models (from STRATA (2021)).

The FSBP-1 model was then applied to Dataset V which has 42 data points. Figure 10 plots the annual median permit fees predicted by the FSBP-0 model versus the observed values. If the FSBP-1 model predicted the observed values correctly, the data points should fall in a 45-degree straight line with $r^2 = 1$. The plotted data showed that the fitted FSBP-1 model achieves $r^2 = 0.7191$. The gradient of the fitted straight line that passes the origin has a slope of 0.7784. The FSBP-1 model under-estimated the annual median permit fees in the Dataset V by 22%.

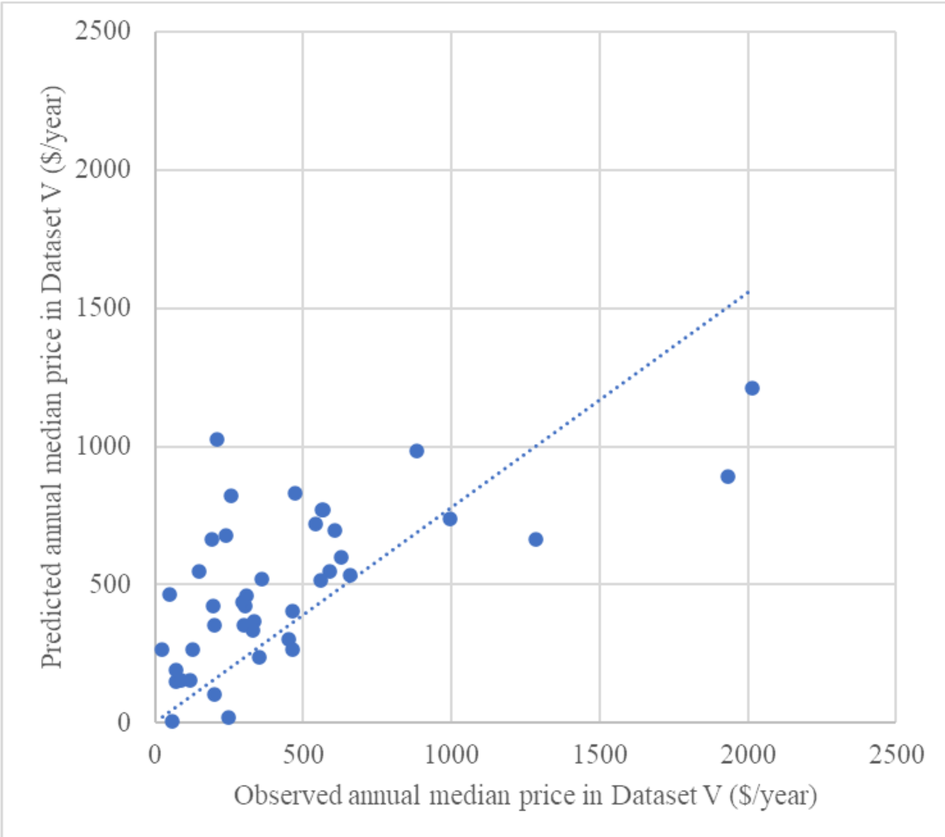

Figure 10 FSBP-1 predicted versus observed annual median permit fees.

4.5. Dual Models

The fitted FSBP-1 model identified city's population (X_3), average Fall temperature (X_6), tuition (X_8), number of employees (X_{11}) and campus population density (X_{12}) as significant variables. This section describes the attempts to improve the FSBP model by dividing the 171 data points in Dataset T into two equal halves and fitting a Tobit regression model to each half of the data. That is, the Dataset T were separated into two halves, using a significant variable (X_i). One half of the new data set contained smaller X_i values while the other half of the new data set contained larger X_i values. Each "half" data set was used to fit its regression model. Since the "half" data sets had been filtered by X_i, it was expected that X_i would not appear in the fitted model. Each of the "dual models" were labeled FSBP-DMi, where DM denotes Dual Model. The steps carried out to fit the "dual models" were:

For FSBP-DMi, $i = 3, 6, 8, 11, 12$:
- The 171 data points in the Dataset T were sorted in increasing order of X_i.
- The median value $X_{i,median}$ was identify.
- The 171 data points in the Dataset T were divided into two data sets:
  - The 85 data points with $X_i < X_{i,median}$ formed Dataset T1.
  - The 86 data points with $X_i \geq X_{i,median}$ formed Dataset T2.
- The 42 data points in the Dataset V were divided into two data sets:
  - The data points with $X_i < X_{i,median}$ formed Dataset V1.
  - The data points with $X_i \geq X_{i,median}$ formed Dataset V2.
- Fit Tobit regression models to Dataset T1.
  - Two models, with and without a constant, were fitted.
  - The better model, with the higher log-likelihood value was selected.
  - The selected model was applied to Dataset V1 to evaluate the sum-of-squared error.
- Fit Tobit regression models to Dataset T2.
  - Two models, with and without a constant, were fitted.
  - The better model, with the higher log-likelihood value was selected.
  - The selected model was applied to Dataset V2 to evaluate the sum-of-squared error.
- The two sum-of-squared errors from Dataset V1 and V2 were added and used as the performance measure for FSBP-DMi.

Repeat for X_3, X_6, X_8, X_{11}, X_{12}.

The fitted Tobit regression models with Dataset T2 (with larger X_i values) were checked against the results of the fitted models obtained by multiple linear regression. It was found that, for all the models tested, both Tobit regression and multiple linear regression produced the same statistical outcomes. This was because none of the data points in Dataset T2 had a Y value that was <0.

Table 10 Summary of the dual models.

	FSBP-DM3	FSBP-DM6	FSBP-DM8	FSBP-DM11	FSBP-DM12
Dataset T1					
Without constant					
Significant variables	X_1, X_8, X_{11}, X_{12}	X_3, X_4, X_{11}, X_{12}	X_3, X_6, X_{11}	X_7, X_{10}, X_{12}	X_4, X_7, X_{11}
Log-likelihood	-561.0164	-613.3435	-571.8721	-582.6010	-579.1478
With constant					
Significant variables	X_1, X_8, X_9	X_3, X_{11}, X_{12}	X_1, X_6, X_{11}	X_7	X_4, X_7, X_9, X_{11}
Log-likelihood	-561.7839	-612.5770	-571.8657	-585.3557	-576.7024
Selected model	Without constant	With constant	With constant	Without constant	Without constant
Dataset T2					
Without constant					
Significant variables	$X_2, X_6, X_8, X_{11}, X_{12}$	X_8, X_{11}, X_{12}	X_3, X_6, X_{11}, X_{12}	$X_3, X_6, X_8, X_9, X_{11}, X_{12}$	X_1, X_3, X_6, X_{11}
Log-likelihood	-632.5066	-598.9535	-624.8039	-625.0856	-625.6597
With constant					
Significant variables	X_6, X_8, X_{11}, X_{12}	X_{11}, X_{12}	X_3, X_6, X_{11}, X_{12}	$X_3, X_6, X_8, X_9, X_{12}$	X_3, X_5, X_6, X_{11}
Log-likelihood	-632.8717	-599.6175	-624.8037	-625.0245	-625.9919
Selected model	Without constant	Without constant	With constant	With constant	With constant
SSE from Dataset V1	658,438	680,161	292,039	1,470,869	1,309,673
SSE from Dataset V2	3,531,913	4,180,024	5,250,795	4,097,747	3,752,998
Total SSE	**4,190,351**	**4,860,185**	**5,542,814**	**5,568,616**	**5,062,671**

The SSE of FSBP-1 was 4,619,149. The lowest SSE of all the dual models was 4,190,351, given by FSBP-DM3. However, this model has X_1 (type of university) and X_8 (in-state tuition fee) as significant variables. These two variables are highly corelated with a $r^2 = 0.908$. Therefore FSBP-DM3 is not desirable. The model recommended was FSBP-1 which has the second lowest log-likelihood.

$$Y = 8.441 + 107.358X_3 - 8.292X_6 + 0.00488X_8 + 0.04758X_{11} + 1.4639X_{12} \quad (2)$$

where

Y = annual median permit fee for a faculty and staff parking permit ($/year)
X_3 = log of city's population
X_6 = average fall temperature (F)
X_8 = in-state tuition fee ($/year)
X_{11} = number of employees (faculty and staff, sum of part-time and full-time employees)
X_{12} = campus population density (persons/acre) = (number of students, faculty and staff)/area

4.6. Case Study

This section applied the FSBP-1 model to predict the faculty and staff annual median permit fees at Cornell University, UCD, USF and UTEP. The input data to the models are listed in Table 11. The results are also listed in Table 11.

Table 11 Case study using the FSBP-1 model.

University	Cornell	UCD	USF	UTEP
X_3, Log(city population)	4.485	4.841	5.541	5.828
X_6, average fall temperature (F)	50	65	76	65
X_8, in-state tuition fee ($/year)	55,188	14,463	6,410	7,651
X_{11}, number of employees (persons)	7,430	8,826	5,757	2,489
X_{12}, campus pop. density (persons/acre)	42.2	9.0	32.6	65.8
Y from FSBP-1 ($/year)	760	534	326	347
Actual annual median permit fee ($/year)	697	660	270	525
% difference	+9%	-19%	+21%	-34%
Actual permit fees ($/year)	333, 532, 697, 747	420, 660, 780	262, 270, 450	400, 500, 525, 575, 600

The FSBP-1 model estimated the annual median permit fee with a +9% difference for Cornell University, -19% difference for UCD, +21% difference for USF, and -34% difference for UTEP. Note that the differences are not errors in the model's estimations. A positive difference means the model's prediction is higher than the actual permit fee. A fairer comparison is to see how the Y obtained from the FSBP-1 model falls within the different levels of faculty and staff parking permit fees in each university. The permit fees in Tables 1 to 4 are summarized in the last row of Table 11. Here, we observed that the FSBP-1 model over-estimated even the highest permit fee at Cornell University. This was because Cornell University, being a private university, has a higher tuition fee (X_8). The FSBP-1 model also under-estimated the lowest parking permit fee at UTEP. The most probable reason is because UTEP has fewer employees (X_{11}). Although the campus has the highest population density and the city has the largest population among the four universities in the case studies, the increase in the Y value was not enough to offset the small number of employees. The median price estimates for UCD and USF are near the mid-level fee of the respective university.

5. CONCLUSIONS

5.1. Recommendations

The first part of this project reviewed the faculty and staff parking management practices at four university campuses: Cornell University, UCD, USF and UTEP. The following trends were observed from the practices of managing faculty and staff parking at the four university campuses:

- The spatial distributions of parking lots follow two patterns: rings and clusters. For university campuses that are designed with a center core, the road network likely to follow the spoke-and-ring layout. Parking lots may be zoned in several rings, each with different walking distances to the campus core. The types of permits and the permit fees depend on the distance to the campus core. Parking zones for faculty and staff are closest to the campus core (inner rings) and are sold at higher fees. Students pay lower permit fees to park at the lots in the outer rings. For university campuses that are spread out with several clusters of buildings in different areas, each cluster of buildings has its parking lots. Since the walking distances between a cluster's parking zones to the cluster center have smaller differences, fewer types of parking zones and the types of permits are used.
- Many universities are moving towards License Plate Recognition (LPR) systems which use vehicle license plates as virtual parking permits. The LPR systems also semi-automate the enforcement of a parking lot's usage without entry and exit control.
- Cross parking is allowed in many universities all the time. This is especially convenient for faculty and staff whose original permitted lot is 100% occupied.
- Most of the universities sell faculty and staff parking permits for a lot at one price. Only the University of South Florida offers a discount for staff members whose salaries are below $25,000/year. This salary-based permit pricing may be considered by other universities.
- Another attractive option is to allow faculty and staff who occasionally drive to campus to purchase single-day permits via a smartphone application and park in faculty and staff lots, instead of paying visitor rates and park at visitor's lots.

The second part of this project used the campus demographic, setting, and economic data of 213 universities to develop the FSBP model that predicts the annual median permit fee for faculty and staff parking at a university campus. Among the different Tobit regression models fitted to the data, the FSBP-1 model was found to be the best fit. The FSBP-1 model may be expressed as:

$$Y = 8.441 + 107.358X_3 - 8.292X_6 + 0.00488X_8 + 0.04758X_{11} + 1.4639X_{12} \quad (3)$$

where

Y = annual median permit fee for a faculty and staff parking permit ($/year)

X_3 = log of city's population

X_6 = average fall temperature (F)

X_8 = in-state tuition fee ($/year)

X_{11} = number of employees (faculty and staff, sum of part-time and full-time employees)

X_{12} = campus population density (persons/acre)

5.2. Outputs, Outcomes, Impacts

The research efforts have produced the following tangible outputs:

1. A summary of management practices of faculty and staff parking on university campuses.
2. Date sets (Dataset T and Dataset V) in which the attributes include campus land-use, demographics, economic and climate data.
3. The FSBP-1 model that predicts the annual median permit fee ($/year) for faculty and staff parking at a university.

The products of this research may change the practice of parking management at universities. Campus planners and university parking offices now have guidelines on faculty and staff parking management. These guidelines provide information on how to zone parking lots, set the types of parking permits and the annual median permit fee for faculty and staff parking on a campus.

The above outcome may potentially impact faculty and staff in at least 300 universities. Our conservative estimates, using data from 213 universities placed the total number of faculty and staff at 844,511. If the annual median permit fees at the universities are adjusted, the economic effects will be extended to the institutions and the communities.

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APPENDIX – STRATA OUTPUTS OF DUAL MODELS

FSBP-DM3

$X_3 < X_{3,median}$, without a constant

```
Tobit regression                                Number of obs     =         85
                                                   Uncensored     =         85
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(4)      =     274.42
Log likelihood = -561.01644                     Prob > chi2       =     0.0000
 ( 1)  [y]_cons = 0
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x1type	-359.1827	125.1192	-2.87	0.004	-564.9854	-153.38
x8tuition	.0135875	.0029311	4.64	0.000	.0087663	.0184088
x11employ	.0291834	.0086558	3.37	0.001	.014946	.0434209
x12density	1.363445	.5706423	2.39	0.017	.4248219	2.302068
_cons	0	(omitted)				
var(e.y)	31650.43	4854.942			24592.55	40733.88

$X_3 < X_{3,median}$, with a constant

```
Tobit regression                                Number of obs     =         85
                                                   Uncensored     =         85
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(3)      =      27.85
Log likelihood = -561.78392                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x1type	-313.6764	153.0279	-2.05	0.040	-565.3849	-61.96785
x8tuition	.0141001	.0037496	3.76	0.000	.0079326	.0202677
x9enroll	.0062662	.002137	2.93	0.003	.0027511	.0097812
_cons	6.559695	63.18118	0.10	0.917	-97.3641	110.4835
var(e.y)	32227.27	4943.437			25040.73	41476.29

$X_3 \geq X_{3,median}$, without a constant

```
Tobit regression                                Number of obs     =         86
                                                   Uncensored     =         86
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(5)      =     278.55
Log likelihood =  -632.5066                     Prob > chi2       =     0.0000
 ( 1)  [y]_cons = 0
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x2setting	207.6212	79.91372	2.60	0.009	76.17483	339.0676
x6temp	-8.117241	3.409028	-2.38	0.017	-13.72459	-2.509889
x8tuition	.0060573	.002165	2.80	0.005	.0024962	.0096185
x11employ	.0542391	.0132081	4.11	0.000	.0325137	.0759646
x12density	1.269948	.4685765	2.71	0.007	.4992085	2.040688
_cons	0	(omitted)				
var(e.y)	143140.1	21828.65			111384.2	183949.5

$X_3 \geq X_{3,median}$, with a constant

```
Tobit regression                                Number of obs     =         86
                                                   Uncensored     =         86
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(4)      =      54.93
Log likelihood =  -632.8717                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x6temp	-12.65406	5.36141	-2.36	0.018	-21.4728	-3.835326
x8tuition	.0046147	.0022445	2.06	0.040	.0009227	.0083066
x11employ	.0565271	.0131284	4.31	0.000	.0349329	.0781214
x12density	1.489578	.4454918	3.34	0.001	.7568097	2.222347
_cons	858.4615	351.4689	2.44	0.015	280.3467	1436.576
var(e.y)	144360.6	22014.78			112334	185518

FSBP-DM6

$X_6 < X_{6,median}$, without a constant

```
Tobit regression                                Number of obs     =         84
                                                   Uncensored     =         84
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(4)      =     248.28
Log likelihood = -613.34348                     Prob > chi2       =     0.0000
 ( 1)  [y]_cons = 0
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x3logpop	53.66807	17.39319	3.09	0.002	25.05881	82.27732
x4area	-.1428383	.05783	-2.47	0.014	-.2379601	-.0477165
x11employ	.071403	.0143877	4.96	0.000	.0477373	.0950688
x12density	1.389048	.5246763	2.65	0.008	.5260321	2.252063
_cons	0	(omitted)				
var(e.y)	128738.5	19864.78			99880.77	165934

$X_6 < X_{6,median}$, with a constant

```
Tobit regression                                Number of obs     =         84
                                                   Uncensored     =         84
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(3)      =      72.01
Log likelihood = -612.57698                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x3logpop	247.8595	79.28012	3.13	0.002	117.4553	378.2637
x11employ	.0486312	.0140897	3.45	0.001	.0254557	.0718068
x12density	1.38156	.5071673	2.72	0.006	.5473439	2.215776
_cons	-1016.791	365.0023	-2.79	0.005	-1617.167	-416.4161
var(e.y)	126410.4	19505.55			98074.49	162933.2

$X_6 \geq X_{6,median}$, without a constant

```
Tobit regression                                Number of obs     =         87
                                                   Uncensored     =         87
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(3)      =     284.81
Log likelihood = -598.95347                     Prob > chi2       =     0.0000
 ( 1)  [y]_cons = 0
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x8tuition	.0041176	.0018822	2.19	0.029	.0010217	.0072135
x11employ	.0547702	.008505	6.44	0.000	.0407808	.0687597
x12density	1.464465	.3841289	3.81	0.000	.8326292	2.096301
_cons	0	(omitted)				
var(e.y)	55891.54	8474.253			43554.84	71722.54

$X_6 \geq X_{6,median}$, with a constant

```
Tobit regression                                Number of obs     =         87
                                                   Uncensored     =         87
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(2)      =      45.51
Log likelihood = -599.61749                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x11employ	.0545626	.0091898	5.94	0.000	.0394468	.0696784
x12density	1.22573	.4432739	2.77	0.006	.4966091	1.95485
_cons	95.21867	51.67309	1.84	0.065	10.224	180.2133
var(e.y)	56751.26	8604.603			44224.8	72825.77

FSBP-DM8

$X_8 < X_{8,median}$, without a constant

```
Tobit regression                                Number of obs     =         87
                                                   Uncensored     =         87
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(2)      =      45.51
Log likelihood = -599.61749                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x11employ	.0545626	.0091898	5.94	0.000	.0394468	.0696784
x12density	1.22573	.4432739	2.77	0.006	.4966091	1.95485
_cons	95.21867	51.67309	1.84	0.065	10.224	180.2133
var(e.y)	56751.26	8604.603			44224.8	72825.77

$X_8 < X_{8,median}$, with a constant

```
Tobit regression                                Number of obs     =         85
                                                   Uncensored     =         85
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(3)      =      32.77
Log likelihood = -571.86572                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x3logpop	92.80158	36.46924	2.54	0.011	32.81503	152.7881
x6temp	-5.51677	2.755837	-2.00	0.045	-10.04972	-.9838218
x11employ	.049187	.0106654	4.61	0.000	.0316439	.06673
_cons	20.83519	185.1122	0.11	0.910	-283.6473	325.3177
var(e.y)	40855.1	6266.886			31744.6	52580.25

$X_8 \geq X_{8,median}$, without a constant

```
Tobit regression                                Number of obs     =         86
                                                   Uncensored     =         86
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(4)      =     333.03
Log likelihood = -624.80392                     Prob > chi2       =     0.0000
 ( 1)  [y]_cons = 0
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x3logpop	155.6386	58.32634	2.67	0.008	59.70029	251.5769
x6temp	-11.39842	4.797081	-2.38	0.017	-19.28891	-3.50792
x11employ	.044406	.0121819	3.65	0.000	.0243686	.0644435
x12density	2.724587	.5348669	5.09	0.000	1.844809	3.604364
_cons	0	(omitted)				
var(e.y)	119664.4	18248.65			93116.69	153780.9

$X_8 \geq X_{8,median}$, with a constant

```
Tobit regression                                Number of obs     =         86
                                                   Uncensored     =         86
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(4)      =      80.97
Log likelihood = -624.80374                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x3logpop	154.6951	77.22475	2.00	0.045	27.67167	281.7185
x6temp	-11.45665	5.724441	-2.00	0.045	-20.87251	-2.040779
x11employ	.04447	.012656	3.51	0.000	.0236528	.0652872
x12density	2.727514	.5574391	4.89	0.000	1.810608	3.64442
_cons	7.824564	419.7435	0.02	0.985	-682.5921	698.2412
var(e.y)	119663.9	18248.58			93116.32	153780.3

FSBP-DM11

$X_{11} < X_{11,median}$, without a constant

```
Tobit regression                                Number of obs     =         85
                                                   Uncensored     =         85
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(3)      =     183.95
Log likelihood =   -582.601                     Prob > chi2       =     0.0000
 ( 1)  [y]_cons = 0
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x7cost	2.489557	.5339869	4.66	0.000	1.611227	3.367888
x10sf	-11.11185	5.428267	-2.05	0.041	-20.04055	-2.183141
x12density	.7835678	.3494191	2.24	0.025	.2088245	1.358311
_cons	0	(omitted)				
var(e.y)	52595.29	8067.749			40866.78	67689.8

$X_{11} < X_{11,median}$, with a constant

```
Tobit regression                                Number of obs     =         85
                                                   Uncensored     =         85
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(1)      =      20.81
Log likelihood =  -585.3357                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x7cost	3.653739	.8009973	4.56	0.000	2.336216	4.971262
_cons	-347.045	146.4872	-2.37	0.018	-587.995	-106.095
var(e.y)	56090.83	8603.94			43582.83	72188.54

$X_{11} \geq X_{11,median}$, without a constant

```
Tobit regression                                Number of obs     =         86
                                                   Uncensored     =         86
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(5)      =     324.23
Log likelihood = -625.08564                     Prob > chi2       =     0.0000
 ( 1)  [y]_cons = 0
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x3logpop	222.2329	58.90821	3.77	0.000	125.3375	319.1283
x6temp	-19.67118	4.712401	-4.17	0.000	-27.42239	-11.91997
x8tuition	.0088749	.0026208	3.39	0.001	.0045641	.0131857
x9enroll	.0092965	.0044293	2.10	0.036	.002011	.016582
x12density	1.357562	.5585671	2.43	0.015	.4388012	2.276323
_cons	0	(omitted)				
var(e.y)	120451	18368.61			93728.78	154791.8

$X_{11} \geq X_{11,median}$, with a constant

```
Tobit regression                                Number of obs     =         86
                                                   Uncensored     =         86
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(5)      =      67.72
Log likelihood = -625.06245                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x3logpop	212.7972	73.3994	2.90	0.004	92.06595	333.5285
x6temp	-20.28424	5.504206	-3.69	0.000	-29.33785	-11.23063
x8tuition	.0087631	.0026711	3.28	0.001	.0043695	.0131566
x9enroll	.009197	.0044521	2.07	0.039	.001874	.0165201
x12density	1.390544	.5790313	2.40	0.016	.4381222	2.342966
_cons	91.24727	423.6449	0.22	0.829	-605.5865	788.081
var(e.y)	120386.1	18358.7			93678.24	154708.3

FSBP-DM12

$X_{12} < X_{12,median}$, without a constant

```
Tobit regression                                Number of obs     =         86
                                                   Uncensored     =         86
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(3)      =     312.30
Log likelihood = -579.14775                     Prob > chi2       =     0.0000
 ( 1)  [y]_cons = 0
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x4area	-.0420514	.0265075	-1.59	0.113	-.0856523	.0015496
x7cost	1.368278	.2413495	5.67	0.000	.9712939	1.765263
x11employ	.047633	.008527	5.59	0.000	.0336073	.0616588
_cons	0	(omitted)				
var(e.y)	41385.06	6311.162			32203.73	53184.01

$X_{12} < X_{12,median}$, with a constant

```
Tobit regression                                Number of obs     =         86
                                                   Uncensored     =         86
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(4)      =      60.82
Log likelihood = -576.78238                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x4area	-.0646177	.0307998	-2.10	0.036	-.1152789	-.0139566
x7cost	2.614115	1.018675	2.57	0.010	.9385434	4.289686
x9enroll	.0059993	.0029593	2.03	0.043	.0011316	.010867
x11employ	.0326685	.0108746	3.00	0.003	.0147814	.0505556
_cons	-267.1733	177.502	-1.51	0.132	-559.1382	24.79149
var(e.y)	39170.01	5973.37			30480.09	50337.44

$X_{12} \geq X_{12,median}$, without a constant

```
Tobit regression                                Number of obs     =         85
                                                   Uncensored     =         85
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(4)      =     232.41
Log likelihood = -626.65967                     Prob > chi2       =     0.0000
 ( 1)  [y]_cons = 0
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x1type	240.3745	107.1211	2.24	0.025	64.17589	416.5731
x3logpop	238.2552	57.61725	4.14	0.000	143.4832	333.0271
x6temp	-17.35534	4.985531	-3.48	0.000	-25.55581	-9.154873
x11employ	.0575243	.0160864	3.58	0.000	.0310645	.0839841
_cons	0	(omitted)				
var(e.y)	148309.5	22749.63			115237.1	190873.4

$X_{12} \geq X_{12,median}$, with a constant

```
Tobit regression                                Number of obs     =         85
                                                   Uncensored     =         85
Limits: lower = 0                                  Left-censored  =          0
        upper = +inf                               Right-censored =          0

                                                Wald chi2(4)      =      54.91
Log likelihood = -625.99187                     Prob > chi2       =     0.0000
```

y	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
x3logpop	300.7688	76.82637	3.91	0.000	174.4007	427.137
x5rain	3.937719	1.599019	2.46	0.014	1.307566	6.567871
x6temp	-15.30037	6.396739	-2.39	0.017	-25.82207	-4.77867
x11employ	.0598407	.0159233	3.76	0.000	.0336492	.0860321
_cons	-841.6609	641.6663	-1.31	0.190	-1897.108	213.7863
var(e.y)	145997.3	22394.96			113440.6	187897.6