

AN INVESTIGATION OF
PARKING PROBLEMS AND ALTERNATIVES
AT THE AMERICAN UNIVERSITY OF SHARJAH

By

Tahani Y. Al Hanaei

A final project submitted in partial
fulfillment of the requirements for the
degree of Master of Urban Planning

American University of Sharjah

2006-2007

Erik Ferguson
Jerry Kolo
Saeed Al Shamsi

Committee Chair
Reader I
Reader II

Wednesday, May 02, 2007

© 2007
TAHANI Y. AL HANAEI
ALL RIGHTS RESERVED

We approve the final project of

Date of signature

Tahani Yousuf Ebraheim Hamdan

Erik Ferguson

Assistant Professor of Urban Planning
Thesis Advisor

Jerry Kolo

Visiting Professor of Urban Planning
Graduate Committee

Saeed Al Shamsi

Director of Public Relations
Graduate Committee

Amer Moustafa

Director of Urban Planning

Fatih Rifki

Dean of Architecture and Design

Robert Cook

Dean of Graduate Studies and Research

AN INVESTIGATION OF
PARKING PROBLEMS AND ALTERNATIVES
AT THE AMERICAN UNIVERSITY OF SHARJAH

Tahani Y. Al Hanaei, Candidate for the Master of Urban Planning Degree

American University of Sharjah, 2007

ABSTRACT

This paper investigates parking and transportation challenges at the American University of Sharjah in response to regional and campus growth. A parking inventory was conducted in early 2007, including characteristics of the study area and sample population. A survey of all faculty, staff and students was conducted in February 2007. A methodology was developed for estimating a mode-choice model based on characteristics of the campus community and parking availability. The results of the survey, mode choice model and parking inventory are analyzed and compared. Finally, the research findings are summarized, and future research and programmatic needs are identified and explored.

Table of Contents

1. Introduction	1
2. Problem Statement.....	2
3. Methodology	3
4. Literature Review	4
5. AUS Parking Inventory	10
6. Methodology and Report Format.....	12
a. Survey Design	12
7. Discrete Choice Models	14
a. Purpose	14
b. Calibration/Validation Approach	16
c. Inputs/Data Needs.....	16
d. Computational Requirements	16
e. User Skill/Knowledge	16
f. Output Types	16
g. AUS Mode Choice: Disaggregate Behavioural Inferences.....	17
8. Parking utilization	28
9. Conclusions and Recommendations.....	31
10. References	35
11. Appendix A.....	37
12. Appendix B.....	90

List of tables

Table 1: The cost of different types of parking	6
Table 2: Typical parking ratios	6
Table 3: Total number of parking in AUS.....	11
Table 4: Total number of faculty-staff and students at AUS	11
Table 5: Some of the questions from the survey.....	13
Table 6: Statistics of mode choice for the faculty and staff at AUS.....	20
Table 7: Statistics of mode choice for the faculty and staff at AUS.....	22
Table 8: Models for drive alone, carpooling and taxi mode choices.....	26
Table 9 Model for walking, shuttle bus and bike mode choices.	26
Table10: AUS parking utilization in the center of the campus.	28
Table 11: AUS parking occupancy in the center of the campus.	29

List of figures

Figure 1: AUS campus with parking categories.	10
Figure 2: Discrete mode choice for faculty and staff at AUS.....	19
Figure 3: Discrete mode choice for all students at AUS	21
Figure 4: Driving alone model goodness-of-fit and serial autocorrelation	24
Figure 5: Walking model goodness-of-fit and serial autocorrelation.....	25
Figure 6: AUS parking utilization rates in the center of the campus.....	30

1. Introduction

The American University of Sharjah (AUS), like most colleges and universities, is a major traffic generator, with a tremendous impact on the traffic of its surroundings. Inside the campus, it means a high demand for parking. Campus parking needs depend on population characteristics that shape the demand for parking. The AUS administration reviewed the problem of increasing numbers of vehicles on campus, and considered a number of changes, from re-striping existing parking lots to proposing the construction of parking structures in one or more existing parking lots.

In this research study, three data collection efforts were undertaken. The first was to identify the total number of parking spaces available on campus. The second was to measure the average parking occupancy rate during the peak hour. The third was an electronic survey of the entire campus population to identify variables that affect mode choice decisions.

2. Problem Statement

The unique situation of university campuses makes them excellent environments in which to examine the transportation-land use relationship, specifically, how to optimally occupy and manage space while maintaining maximum mobility and accessibility. For the purposes of this study, the definition of land use is the function of space, for example, the campus land used for parking, vehicular access roads, the pedestrian network, academic and administrative buildings, athletic facilities, boarding facilities, etc. One example of the transportation-land use relationship on a campus is the effect that the function of space may have on transportation and vice versa, as land used for a parking lot provides campus access to motor vehicles and, if convenient, may encourage campus users to drive to campus rather than consider a transportation alternative (e.g., transit) that consumes less land thereby leaving space available for preferred functions such as an auditorium or a stadium.

The American University of Sharjah (AUS) now is facing a parking problem due to the increasing number of student and staff vehicles on a campus with limited land. A lot of policies and alternatives were offered to address the problem in the short term. Mr. Al Shamsi (Public Relations Director, with responsibility for managing parking operations at AUS) was kind enough to grant an interview where he explained many of the complex aspects of this problem, including parking pricing, demand and supply characteristics. Mr. Al Shamsi noted that new undergraduate students often are just reaching the legal driving age, and will then become interested in acquiring parking spaces for their cars on campus.

3 Research Methodology

A technique resulting in a reasonable forecast of traffic and parking demands shall be used, including:

1. Collection of inventory data;
2. Forecasts of traffic and parking demands;
3. Determining relative preferences for different types of mode choice;
4. Preparation and analysis of alternate mode choice models;
5. Conclusion and recommendation.

The use of a questionnaire survey in data collection, the illustration of consequences of alternate policy choices will be also presented. The need for involvement of all persons and the need for adequate communications shall be considered. Major benefits of such planning will be an adequate and safe traffic access and parking scheme for all campus users with minimum disruption of the campus, minimum conflicts among land uses, and maximization of savings in financing.

The literature (as shown in Chapter 4) suggests that data and a thorough discussion of campus land use and transportation are lacking; moreover, as available land on campus disappears planners are urgently in need of effective approaches to manage transportation and land use relationships. This research will examine parking, residential demographics, campus-community coordination, and transit operations.

“The more parking spaces you provide, the more cars will come to fill them. It is like feeding pigeons.”
HUGH CASSON¹

4 Literature Review

Hindman and Sanchez 2004

Many local governments, universities, and colleges experience parking problems because of the rapid expansion of population and need for car parking spaces. Anyone who drives a car appreciates the difficulties of finding a parking space in areas such as intense academic, administrative, student residential, and recreational activities. The average personal car is only driven for approximately 5-10% of the time, while for the remainder it is parked.

Hindman and Sanchez outline the root of the parking problem. They argue that it began when the number of vehicles per household increased in the early twentieth century. At the same time, developers were building homes to maximize profits by allocating the least amount of land to parking. Prior to 1950, most municipalities had no requirements regarding the provision of private parking in new residential or commercial developments (Ferguson 2003). The gradually worsening of this problem led to adoption of zoning for parking as the primary public policy solution to parking problems (Ferguson 2004).

Hindman and Sanchez offer seven ways to increase available parking:

1. Re-stripe the existing parking lot to accommodate more vehicles; this will not work if users drive oversized vehicles like SUVs.
2. Lease or purchase more land for parking, adjacent to the existing parking facility.
3. Rent or lease additional off site parking; cheaper in the short term, may be more expensive in the longer term.

¹ <http://www.happenstance-music.com/quotes-all.asp>

4. Build a parking garage to replace surface lots; this is highly efficient spatially, but constructing a parking garage can be expensive and time consuming.
5. Employ a mechanical parking system. This system uses mechanical conveyers to stack cars in a highly compressed vertical structure; requires the least area and volume for vehicle storage, also the most expensive solution.
6. Convert common areas or open space to parking areas. This is economically inexpensive, but may deter from the campus environment.
7. Charging parking fees to reduce parking demand; a very common solution on most large urban campuses, an effective solution, popular with administrators, but rarely appreciated by most students, staff or faculty.

Barnett (2003)

Barnett is an urban designer who describes the five essentials of urban design as:

1. Fostering a sense of community.
2. Creating livable neighborhoods and workplaces.
3. Reducing traffic congestion and providing parking that complements rather than undermines urban living.
4. Encouraging social equity.
5. Achieving sustainability.

Barnett argues that the development around the typical highway interchange is the result of designing the highway as an isolated artifact, without any recognition that it will induce development. Typical interchange designs minimize the amount of land needed, and permits cars to maintain speed as they leave the highway. But nobody thinks about how to fit the interchange into the buildings that will go up around it. Barnett says that highway interchanges fragment development into quadrants; the development within the quadrant is fragmented even further by large quantities of at-grade parking.

Barnett suggests that the amount of land required for a typical parking space is about 350 square feet, 200 square feet for the car parking space itself, and 150 square feet for aisles, ingress and egress points, and other traffic circulation needs. Table 1 describes the cost of different types of parking.

Cost of an At-Grade Parking Space :	\$1000 + land (good landscaping is extra) (UAE costs are usually much less)
Cost of Garage Parking Space :	\$ 10,000 to \$ 12,000 + pro rata share land as garage is multi story
Cost of Sub-Grade Parking Space :	\$ 20,000 to \$ 30,000

Table 1: The relative cost of different types of parking (Source: Barnett 2003, pg. 51)

Barnett indicates that providing adequate parking is a necessity for developers. He mentions some typical parking indices, which represents the minimum number of parking spaces required for each type of building in local zoning codes. Table 2 shows some typical parking requirements under zoning.

Retail:	5 cars per 1,000 square feet
Office in suburb:	4 cars per 1,000 square feet
Office in city with rapid transit :	2.5 cars per 1,000 square feet
Office in a big city with a metropolitan transit system:	0 - 1.5 cars per 1,000 square feet
Hotel:	1.5 cars per room
Apartments:	1.5 to 2 cars per apartment
Industry:	1 car per employee

Table 2: Typical parking requirements (Source: Barrnet 2003, pg. 51)

Barnett discusses the effect of parking on office location, where the economics of parking influence the dispersal of development from city centers to accessible highway locations, like Tysons Corner in northern Virginia, a suburb of Washington, DC.

Barnett suggests that a good way to gain a price advantage for office development is to buy cheap land with good access and get it rezoned for offices. Then the developer has enough room to build at-grade parking, which provides a big price advantage over a developer who has to build a garage. He thinks that it is difficult to create urbanity while accommodating today's standard suburban parking requirements. He cites the example of the continuous frontages of Parisian boulevards in the Ile de France, which most people would agree is one of the most beautiful and livable cities in the world.

Daggett and Gutkowski (2003)

Daggett and Gutkowski (2003) conducted a survey of universities and concluded that the master plan provides an excellent opportunity for both universities and surrounding communities to address transportation issues and to establish working relationships with one another as a framework for accomplishing goals. The survey results indicate that demand for parking is greater than the supply, thereby creating substantial opportunities for Transportation Demand Management (TDM) programs and transit, bicycle and pedestrian facility improvements.

Local land use codes, regulations and Adequate Public Facilities (APF) ordinances do not apply to most of the universities surveyed, allowing campuses to develop according to their own needs, regardless of the impact on surrounding communities and their transportation systems. Transit often is a significant part of a university transportation system. Campus transit operations may provide regional accessibility, access to remote parking lots, or internal campus circulation, serving the campus population, the general public, or both. Most campus transit systems provide good access to the central campus. Many now utilize unlimited access programs, and are offered free of charge to ride, with operational costs covered by student fees. Most serve mainly students who reside within one mile of campus.

Several studies have examined the transportation systems of individual universities; for example, Boyd et al. (2003) found that mode split is a function of the student's distance from campus. They showed that UCLA's unlimited transit access program increased transit ridership

significantly while decreasing automobile trips. Meyer and Beimborn (1996) drew similar conclusions from their study of the University of Washington's U-PASS program, and further found that "the U-PASS program has the potential to have a major impact in attracting and retaining students at the University." The U-PASS system is a comprehensive TDM program that involves increased transit service, shuttle service, car and van pools, ride-matching, bicycles, reimbursed rides home, commuter tickets, and merchant discounts.

As described by Williams and Petrait (1993), U-PASS's predecessor turned out to be unsustainable, and the need for a new transportation program arose when 1) a new university development plan called for the construction of four parking garages and 2) projections for the University of Washington Medical Center indicated more faculty, staff, and patient vehicle trips would be arriving. The implementation of the U-PASS program resulted in a considerable mode shift: before U-PASS, 21% of commuters used transit and 33% drove alone; after U-PASS, 33% used transit and 23% drove alone.

Williams and Petrait go on to cite five lessons learned from the U-PASS program:

1. Include both incentives and disincentives to balance a TDM program.
2. Create flexible commuting options.
3. Use parking fees as a disincentive for driving alone as well as a means for funding other TDM strategies.
4. Run a comprehensive education program to increase the likelihood of acceptance.
5. As demand may be greater than expected, be prepared to meet the excess so that first-time users don't get a poor impression of service and revert to driving alone.

While it appears that most universities are beginning to establish truly multimodal transportation systems on their campuses and reduce congestion, a glimpse of what may lie ahead is in order. Markowitz and Estrella (1998) suggest that distance learning may eventually become the dominant form of higher education. They cite California State University at Monterey Bay's Master Plan, which in 1998 predicted that of a future enrollment of 25,000 full-time students; only 8,300 would physically be on campus. The land use implications of such concepts may be

positive for transportation both on the university campus and in the surrounding communities. Moreover, car-sharing has come to several campuses including the San Jose State University campus (Business Wire 2002), and although it is still too early to determine whether the program is successful, the potential of the concept is quite encouraging.

5 AUS Parking Inventory

In early fall 2006; a parking inventory was completed. The inventory identified the number of parking spaces for three different categories of parking.

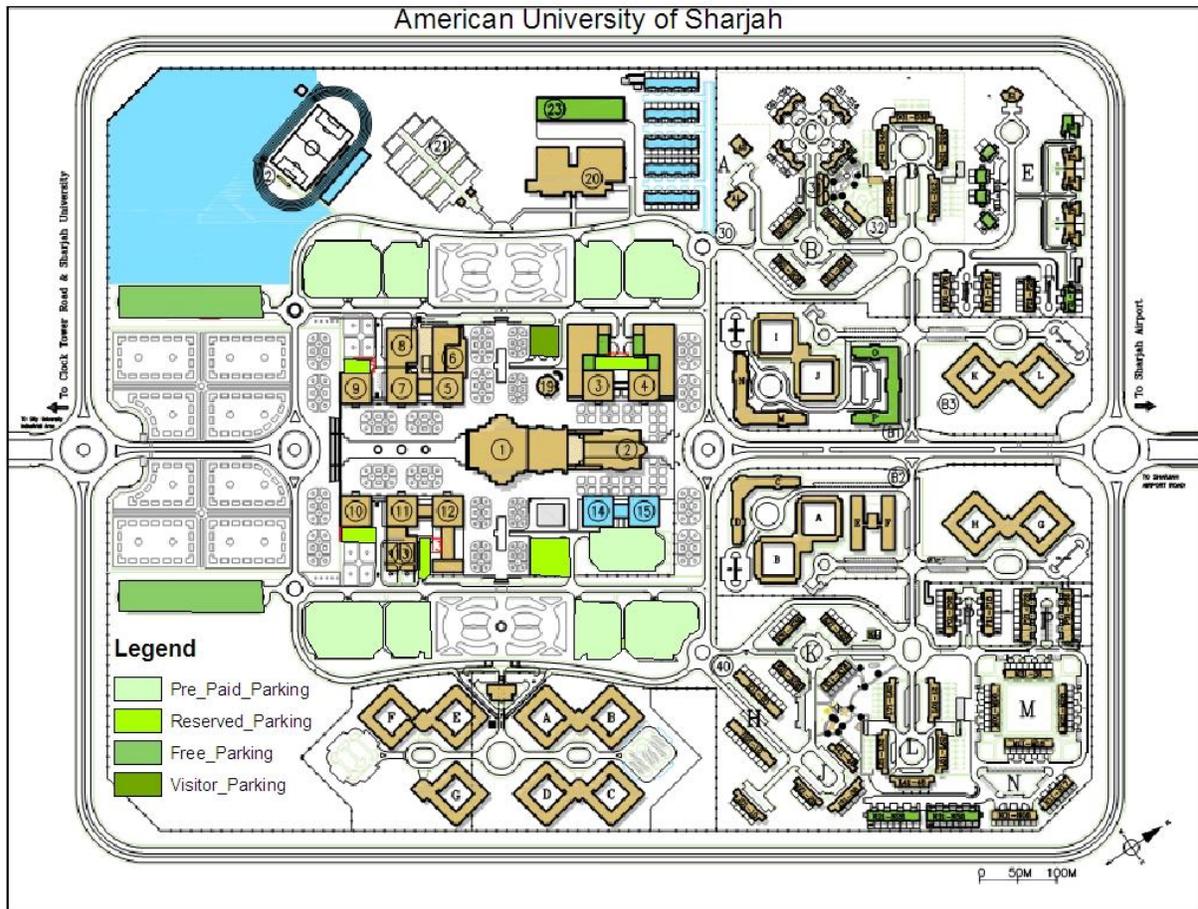


Figure 1: AUS campus with parking categories.

The following Table 3 shows the total number of all parking spaces at AUS:

Location	Covered	Uncovered	Disabled	Total
Central Campus	976	818	33	1,827
Faculty Housing – East	229	318	0	547
Faculty Housing – West	142	45	0	187
Men's Dorms	181	244	0	425
Women's Dorms	82	73	0	155
Total	1,610	1,498	33	3,141

Table 3: Total number of parking spaces at AUS
(Source: author's inventory)

As we see, 58.2% of AUS parking serves the central campus, the remainder being allocated to surrounding residential areas. For more demographic information about AUS, the following table will demonstrate the number of people living on and off campus.

	Faculty & Staff	Students	Total
ON Campus	338	1927	2265
OFF Campus	396	2728	3124
Total	734	4655	5389

Table 4: Total number of faculty-staff and students at AUS
(Source: Human Resources department of AUS and the registrar's office, 2007).

6 Survey Methodology

An Internet survey was used in this study. Perhaps the three most common reasons for choosing an electronic survey over traditional paper and pencil approaches are:

- Decreased cost
- Faster response
- Increased response rates

Most business communications between people, even on the same campus or in the same building, these days is via email.

a. Survey Design

A survey research design based on self-administered questionnaires was used in this study (see Appendix A and B for the survey instruments and complete survey results). The survey was created on SurveyMonkey.com, and sent to two separate groups. The first group was faculty and staff, who received their survey link via email from Dr. Robert Cook, Dean of Graduate Programs and Studies at AUS. The second group was graduate and undergraduate students, who received their survey link via email from Dr. Moza Shehhi, Vice Chancellor for Student Affairs.

The questions were divided into general information questions and work travel questions as follows:

General information questions	Work Travel questions
<ul style="list-style-type: none"> • Where do you live? 	<ul style="list-style-type: none"> • What is your primary mode of transportation?
<ul style="list-style-type: none"> • In which building do you work? (faculty) • What is your program of study? (students) 	<ul style="list-style-type: none"> • Do you have a driver's license? • Do you have a car available?
<ul style="list-style-type: none"> • Do you work...? 	<ul style="list-style-type: none"> • Is your car registered at AUS?
<ul style="list-style-type: none"> • Are you male or female? 	<ul style="list-style-type: none"> • What kind of parking sticker do you have?
<ul style="list-style-type: none"> • What is your age, in years? 	<ul style="list-style-type: none"> • Where do you usually park your vehicle?
	<ul style="list-style-type: none"> • How much are you willing to pay to park?

Table 5: Some of the questions from the survey

The faculty and staff survey was conducted in spring 2007. Of 734 people working at AUS, 327 responded, for a quite reasonable 45% response rate. Of the 4,700 graduate and undergraduate students at AUS, 1,141 responded to their survey for an adequate 25% response rate. Most of the data in the survey were found to be usable, but required some cleaning prior to use.

The focus of this analysis will be on the two dominant modes of travel serving the majority of campus residents, namely driving alone and walking. Other modes briefly considered include carpooling, taxi, and the campus shuttle bus system. Bicycle and motorcycle usage were too low to provide reliable statistical information, and will not be discussed in any detail.

7 Discrete Choice Models

a. Purpose

A discrete choice model predicts a decision made by an individual (choice of mode, choice of route, etc.) as a function of any number of variables, including factors that describe a bicycle or pedestrian facility improvement or policy change. The model can be used to estimate the total number of people who change their behavior in response to an action. As a result, the change in both non-motorized and motorized trips and distance of travel can be estimated.

A discrete choice model is a mathematical function which predicts an individual's choice based on the utility or relative attractiveness of competing alternatives (for example, bike or drive). The logit function is a common mathematical form used in discrete choice modeling.

The model generally includes characteristics of the individual (e.g., age, gender, and car ownership) and relative attributes of competing choices (e.g., cost and time of auto vs. bike travel). It also might include environmental factors, personal attitudes, or other factors which are thought to influence the choice in question. The model is developed from a data set containing individual trip decisions, characteristics of alternative choices for the trip, geographical characteristics, and characteristics of the individual.

A simple discrete choice model, for example, might be used to predict the probability of taking a trip by bicycle vs. by car, based on two factors:

1. Time difference between the two modes for the trip.
2. Whether the respondent is male or female.

The estimated coefficients (or weights for each factor) can be used to derive elasticities. Elasticities indicate the percent change in the variable being predicted (i.e., probability of choosing a mode) for a given change in one of the independent variables, holding the other variables constant. While transferring elasticities to real world situations involves a number of assumptions, the elasticities may be used to estimate the change in users as a function of a given change in a facility or policy variable.

Ideally, instead of simply using elasticities, the model is applied to the entire affected population to estimate the total number of people who will change their behavior as a result of an improvement. There are three alternative methods for aggregating results for the population (Horowitz, Koppelman, and Lerman, 1986):

1. The "naive" method. Average values are assumed for each variable except the one of interest. An average trip time difference and an average gender value (such as 50 percent M/ 50 percent F) are used, and the probability of choosing the bicycle mode is compared with and without bike lanes. Significant errors may be introduced, however, by using single aggregate values for population variables.
2. The "market segmentation" method. The population is divided into groups (i.e., male vs. female and with different travel distances). For each group, a mode choice probability is estimated, multiplied by the total population of the groups, and summed across all groups. This is repeated with and without bicycle lanes, and the total numbers of bicycle trips for the two alternatives are then compared. This reduces, but does not eliminate, aggregation errors. The method is widely used in practice (see Wilbur Smith Associates, 1996).
3. The "sample enumeration" method. This method takes a random sample of the total population, estimates a mode choice probability for each person in the sample, and averages the sample probabilities to estimate a mode share for the entire population. This method is the most accurate of the three but is also the most difficult to apply.

b. Calibration/Validation Approach

Discrete choice models developed from stated-preference surveys can be calibrated/validated using models developed from data on actual (revealed) behavior.

c. Inputs/Data Needs

Discrete choice models are developed from data sets containing individual trip decisions, including characteristics of the individual and of alternative choices for the trip. Two types of data, revealed-preference and stated-preference, may be used, as described below:

1. "Revealed-preference" data or data on actual behavior. This was collected from a work travel question in the survey, which determines characteristics of a trip (origin and destination, mode, etc.) as well as characteristics of the individual and other influencing factors.

d. Computational Requirements

Discrete choice models can be estimated using a desktop microcomputer with specialized software such as ALOGIT.

e. User Skill/Knowledge

Knowledge of statistical analysis and discrete choice modeling techniques is required, in addition to familiarity with sources and methods of collecting survey data.

f. Output Types

Possible outputs include the probability of an individual making a particular choice given particular levels of variable, such as availability of car parking, presence of a sidewalk, etc. Elasticities indicating the percent change in the variable being predicted (i.e., probability of choosing a mode) for a given change in one of the independent variables, holding the other

variables constant. Total number/percent of people expected to change behavior, if results of the model are aggregated over a population.

g. AUS Mode Choice: Disaggregate Behavioural Inferences

To demonstrate the mode choice for AUS, a weighted least squares logit regression model of the following form was used:

$$P_m = \frac{\exp^{b_n * V_n + err}}{1 + \exp^{b_n * V_n + err}}$$

Where,

P_m	the percentage of employees choosing travel mode m
b_n	A vector of parameters to be estimated,
V_n	a vector of independent variables which are given
Exp	the natural exponent
Err	A random error term.

In disaggregate models, P_m cannot be measured, but rather must be interpolated or inferred. This can be accomplished through the use of indirect estimation techniques, a based on random utility theory, or through directed speculation on the part of the traveler.

Equations for drive alone and walking mode choices can be estimated directly using linear regression techniques, with the following set of independent variables which has been chosen:

- Employee
- 1=yes, 0=no

- Living on campus
- 1=yes, 0=no

- Gender
- 1=female, 0=male

- Age (in years)
- Category midpoint

- No license
- 1=yes, 0=no

- Car availability
- 1=never or sometimes, 0=always

- Free sticker
- 1=yes, 0=no

- No sticker
- 1=yes, 0=no

Sample variations can be corrected in regression analysis by proportionately "weighting" squared error terms used in obtaining best linear unbiased parameter estimates. Specifically, the following weight could be used:

$$W = \ln \left(\frac{N_t * P}{1 - P} \right)$$

Where N_t in this project will be:

- 750 day for faculty and staff
- 300 day for undergraduate students
- 150 day for the graduate students.

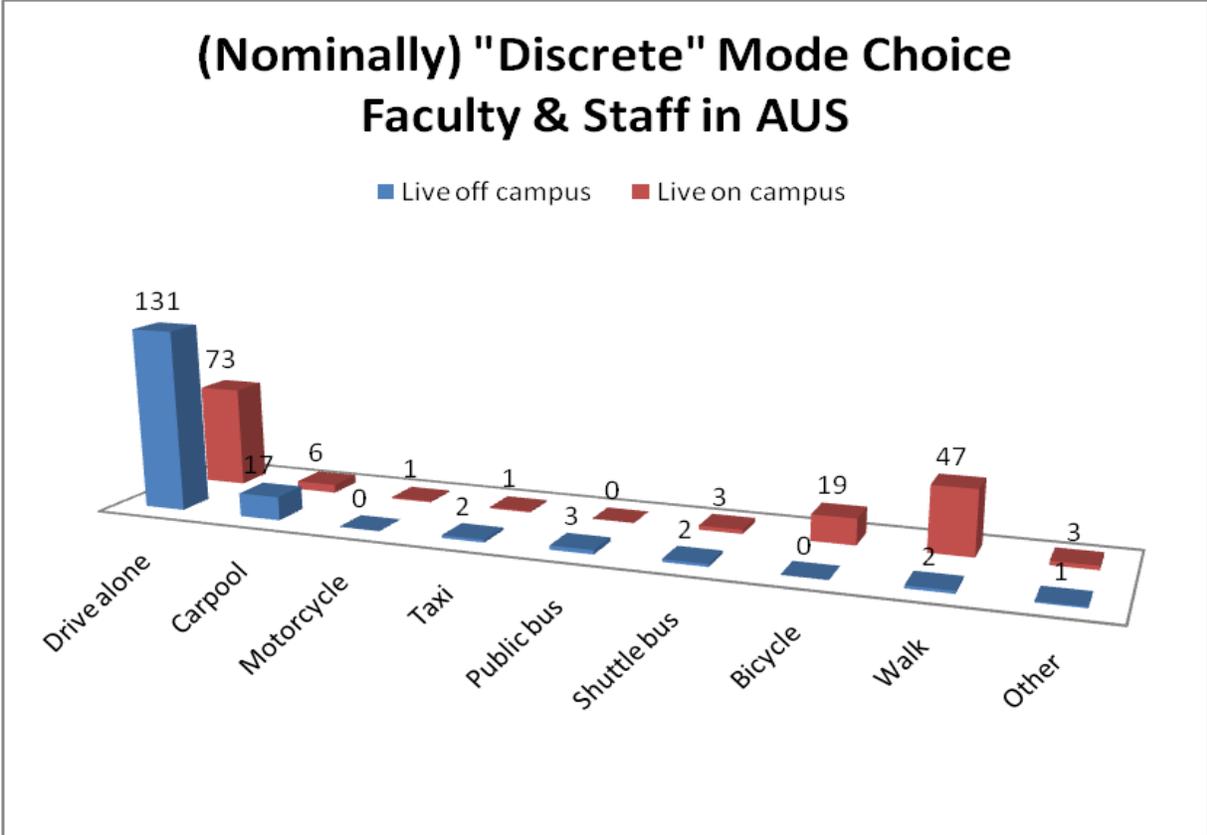


Figure 2: Discrete mode choice for faculty and staff at AUS

For faculty and staff in AUS as illustrated in Figure 2, driving alone mode has the highest share mode compared to different mode choices. And for people who live on campus walking and bicycle is the second mode choice. But note that the survey was conducted in spring of 2007. So maybe the walking and bicycle mode choice will be affected by the weather, since we have a hot and dry weather in summer.

Faculty & Staff survey results	Drive alone	Carpool	Motorcycle	Taxi	Public bus	Shuttle bus	Bicycle	Walk	Other
For all respondents									
Min	0	0	0	0	0	0	0	0	0
Median	0.94	0	0	0	0	0	0	0	0
Mean	0.65	0.08	0	0.01	0.01	0.02	0.06	0.16	0.01
Maximum	1	1	0.42	0.75	0.99	0.99	1	1	0.95
Count	296	296	296	296	296	296	295	296	296
For on campus respondents									
Min	0	0	0	0	0	0	0	0	0
Median	0.75	0	0	0	0	0	0	0.05	0
Mean	0.55	0.06	0	0.01	0	0.03	0.08	0.25	0.02
Maximum	1	0.99	0.42	0.75	0.05	0.79	1	1	0.95
Count	139	139	139	139	139	139	138	139	139
For off campus respondents									
min	0	0	0	0	0	0	0	0	0
median	0.99	0	0	0	0	0	0	0	0
mean	0.74	0.1	0	0.01	0.02	0.02	0.03	0.08	0
maximum	1	1	0.23	0.5	0.99	0.99	0.99	1	0.2
count	157	157	157	157	157	157	157	157	157

Table 6: Statistics of mode choice for the faculty and staff at AUS

Table 6 shows that 55% of faculty and staff who live on campus prefer to drive alone to the center of the campus and 25% of them walk. For faculty and staff who live off campus, 74% drive alone.

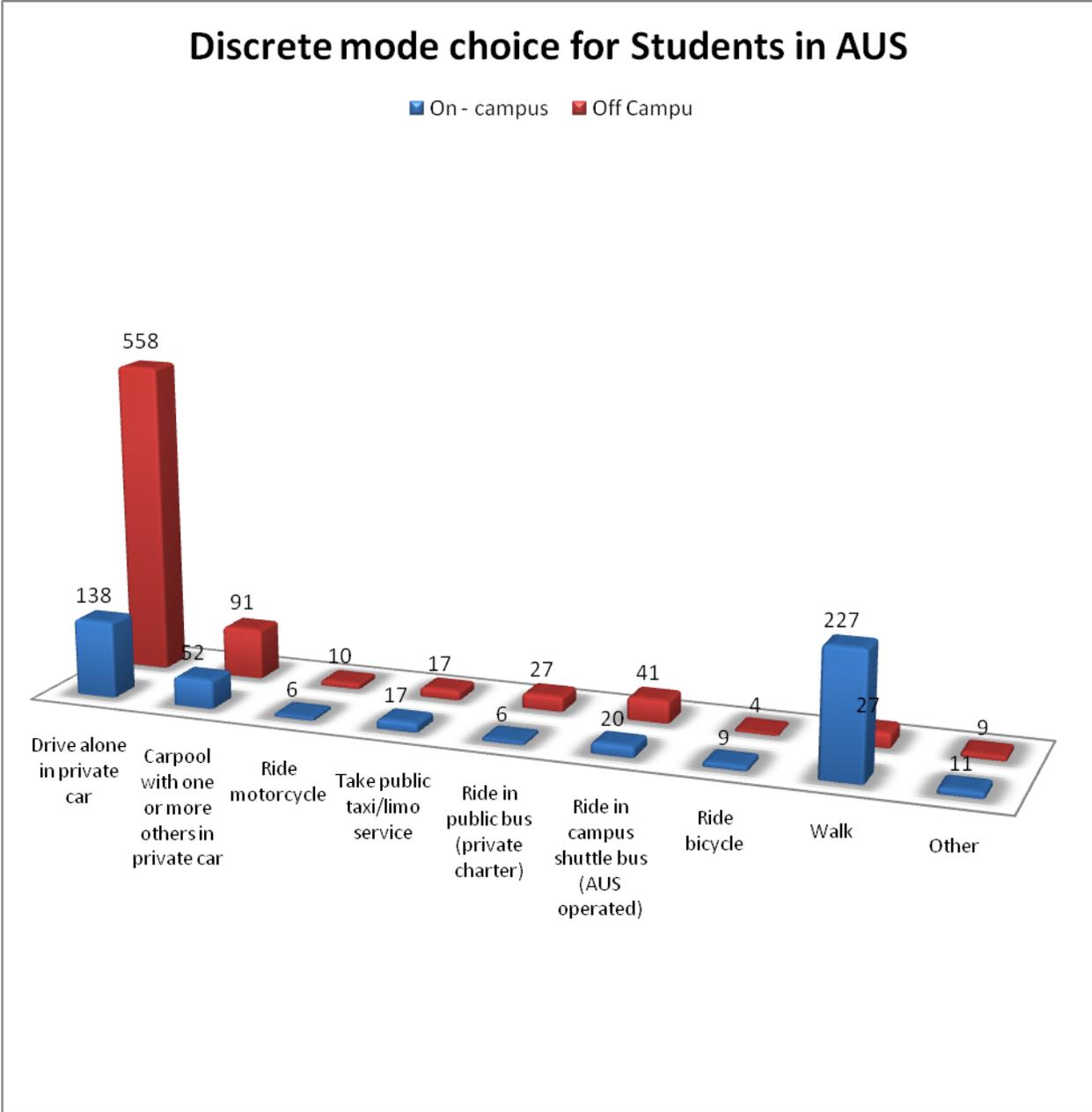


Figure 3: Discrete mode choice for all students at AUS

Figure 3 shows that on campus, walking is the main mode choice, and there are some which are using their private cars to move to the center of the campus, which contradicts the policy of AUS. And it is normally that off campus students are choosing to reach the campus either driving alone or carpooling.

Graduate & Undergraduate Students in AUS	Drive alone	Carpool	Motorcycle	Taxi	Public bus	Shuttle bus	Bicycle	Walk	Other
Total respondents									
min	0	0	0	0	0	0	0	0	0
median	0.8	0.01	0	0	0	0	0	0	0
mean	0.61	0.1	0.01	0.02	0.02	0.05	0.01	0.17	0.01
maximum	3	2	0.92	1	1	1	0.8	2	1
count	998	997	998	997	998	998	998	997	998
On campus respondents									
min	0	0	0	0	0	0	0	0	0
median	0.2	0.01	0	0	0	0	0	0.47	0
mean	0.32	0.11	0	0.03	0.01	0.04	0.01	0.49	0.02
maximum	3	2	0.41	0.48	0.48	0.8	0.8	2	1
count	321	321	321	321	321	321	321	321	321
Off campus respondents									
min	0	0	0	0	0	0	0	0	0
median	0.97	0	0	0	0	0	0	0	0
mean	0.75	0.1	0.01	0.02	0.03	0.05	0	0.02	0.01
maximum	1	1	0.92	1	1	1	0.34	0.5	0.97
count	677	676	677	676	677	677	677	676	677

Table 7: Statistics of mode choice for the faculty and staff at AUS

As shown in Table 7, 32% of students who live on campus use their car to reach the center of campus and 49% walk.

Weighted Least Squares Analysis

WLS reduces the variance of the coefficient estimates without sacrificing consistency, subject to a mean independence assumption. The following figures illustrate the effects of WLS estimation on regression models for driving alone and walking at AUS.

Interestingly, the measure (R^2) used to evaluate OLS goodness of fit and the power function used to maximize the likelihood that the WLS model is optimized operated in opposition to each other for both driving alone and walking (Figures 4 and 5). What this means is that one must be chosen over the other in selecting a model, since the two do not work in tandem with each other (Ferguson 1992). In this case, I chose R^2 rather than log likelihood in selecting the best fitting model for each mode.

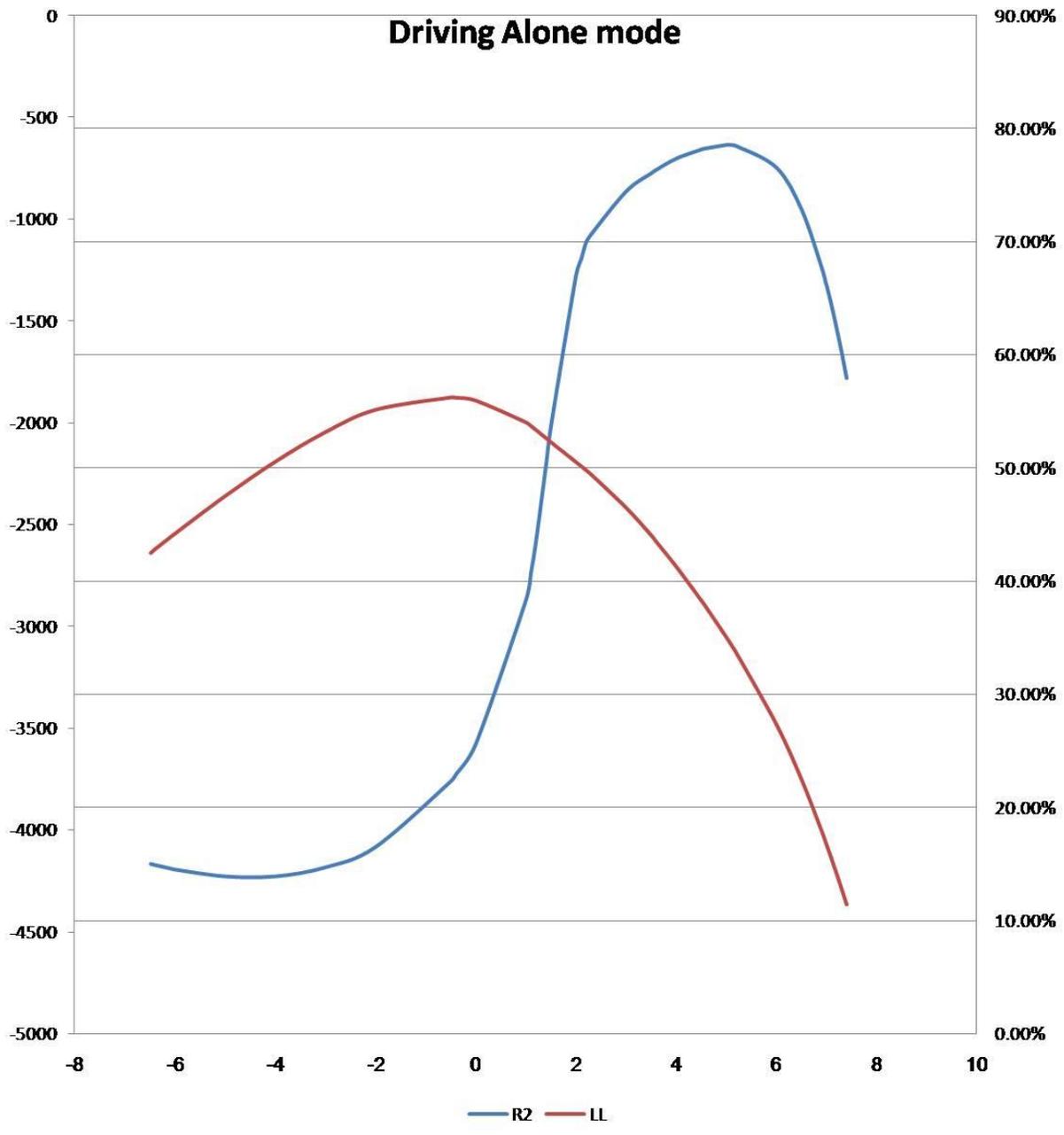


Figure 4: Driving alone model goodness-of-fit and serial autocorrelation

Walking mode

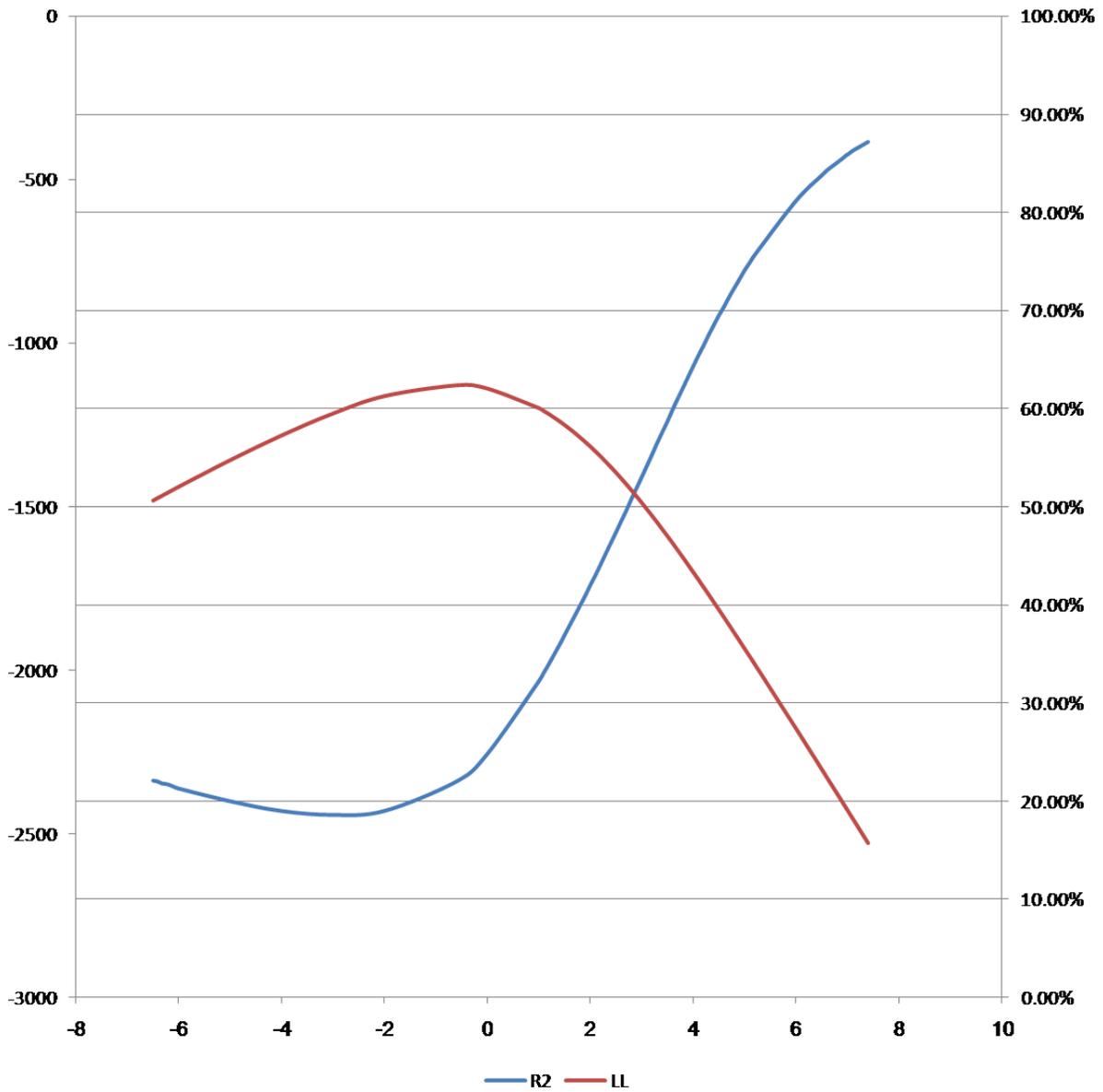


Figure 5: Walking model goodness-of-fit and serial autocorrelation

	Driving alone		Carpooling		Taxi	
	B	t	B	t	B	t
Constant	4.633	9.968	-2.026	-5.164	-2.724	-6.770
Employee	0.109	0.256	-4.525	-14.358	-2.241	-6.082
On campus	-4.322	-15.352	-0.587	-2.678	-0.192	-1.042
Female	-1.686	-8.221	0.754	3.612	-0.014	-0.075
Age	0.046	2.191	0.041	2.823	0.027	1.616
No_license	-0.422	-0.924	0.408	1.061	0.336	1.295
Not_always	-4.387	-14.505	0.312	1.205	1.022	4.498
Free	-1.226	-4.662	0.618	1.964	0.103	0.362
No_sticker	-2.112	-6.973	0.211	0.738	-0.097	-0.352
	Power Value	LL	Power Value	LL	Power Value	LL
Log-likelihood Values	5.000	-3,053.110	-6.400	-2,141.070	-3.500	-890.078
R-square	0.886		0.433		0.282	

Table 8: Models for drive alone, carpooling and taxi mode choices.

Drive alone model which is illustrated on Table 8 suggests that people (faculty-staff-student) who live on campus are less likely to drive alone. Also, people who do not have a car or parking sticker available are less likely to drive alone.

	Walk		Shuttle Bus		Bike	
	B	t	B	t	B	t
Constant	-3.904	-8.928	-3.000	-6.164	-1.434	-0.843
Employee	0.006	0.017	-3.095	-7.801	-2.078	-1.345
Live on campus	4.083	14.470	-1.477	-5.521	0.941	0.562
Female	-0.106	-0.360	-0.312	-1.332	-1.216	-1.491
Age (years)	-0.042	-2.370	0.078	4.622	0.002	0.043
No driving license	4.705	5.676	0.897	2.827	1.323	0.609
Car not always available	2.334	2.933	-0.464	-1.777	-3.046	-4.042
Free parking sticker	-1.956	-5.583	1.976	5.950	2.227	2.249
No parking sticker	-1.392	-3.954	1.658	5.283	2.656	3.358
	Power Value	LL	Power Value	LL	Power Value	LL
Log-likelihood Values	7.000	-2,452.430	-6.400	-1,329.175	-6.400	-454.463
R-square	0.929		0.409		0.210	

Table 9: Model for walking, shuttle bus and bike mode choices.

In Table 9, the walking model suggests that people (faculty-staff-student) who live on campus plus those who do not have a driving license are more likely to walk. Also, people who do not have a car or parking sticker available are more likely to walk.

8 Parking Utilization

On 19 April 2007, a parking count was conducted to check the occupied parking lots at 11:00 am (peak hour). Table 10 shows the total parking spaces in each parking lot in the central part of the campus and the total occupied spaces.

Lot Number	Total available	Total occupied
P1	191	180
P2	96	85
P3	93	80
P4	191	145
P5	258	123
P6	259	114
P7	185	166
P8	99	79
P9	96	82
P10	147	63
P11	46	31
P12	58	42
P13	8	8
P14	21	18
P15	26	26
P16	24	22
Total	1798	1264

Table10: AUS parking utilization in the center of the campus.

Exactly 70% of the parking spaces were occupied. Two lots were completely full, P13 and P15, both reserved for faculty and staff only. Among lots where students were allowed to park, P01 had the highest utilization at 94%.

Lot Number	Ratio of occupation
P1	94%
P2	89%
P3	86%
P4	76%
P5	48%
P6	44%
P7	90%
P8	80%
P9	85%
P10	43%
P11	67%
P12	72%
P13	100%
P14	86%
P15	100%
P16	92%
Total	70%

Table 11: AUS parking occupancy in the center of the campus.

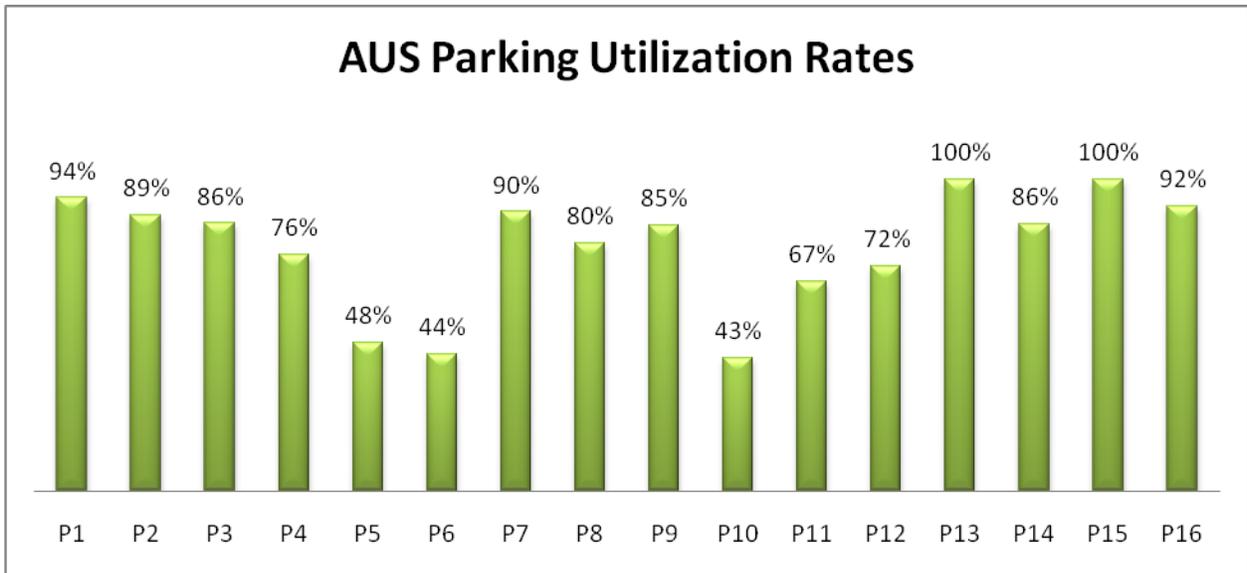


Figure 6: AUS parking utilization rates in the center of the campus.

Out of 734 faculty and staff there are 396 who live off campus and 57% drives alone and carpools. And from 4655 students, 2728 that live off campus with 80% that choose to drive alone or carpool with others. So the total people who need to park their car inside the campus are 3280, and we have only 1827 parking space available on the center of the campus. It is obvious that we have leakage in supply. The demand for the parking lot is increasing, so to cover the need for it, a construction of multi layer parking building is needed. From the parking occupancy table, the priority for building such a construction would be for the P1 and P15 which are located in the west of the campus.

9 Conclusions and Recommendations

There is no formula that inputs community size, transportation resources, and economic activity and outputs the appropriate amount of parking. The amount of parking to be supplied must be informed by community transportation plans, community growth, community goals and existing levels of supply and demand. To help accommodate this growth, this report has, through a comprehensive data collection effort, identified areas where existing conditions warrant improvement and has set the stage to evaluate future projects, in particular through the collection of necessary data on parking supply and demand characteristics.

Mr. Al Shamsi, Director of Public Relations, identified some of the solutions that AUS had already implemented to address parking issues, including:

1. Making the traffic circulation in parking lots one way to get better use out of each lot.
2. Reducing the number of parking spaces for the disabled, most of which are unused.
3. Introducing the practice of paid parking, so that faculty and staff pay 360 Dirham and students pay 300 Dirham per year for annual parking permits.
4. Changing the design of parking stickers to separate students who live on campus from those who live off campus.
5. Not allowing students who live on campus to park in any central campus lot, other than the two remote lots (P5 and P6).
6. Offering a special reserved parking lot for visitors only near the mosque.
7. Encouraging people to use a recently implemented shuttle bus system.

According to Mr. Saeed Al-Shamsi (2007), some of the future proposals AUS may consider include:

1. Changing the orientation of parking stalls from perpendicular (90 degrees) to angled (45-60 degrees).
2. Increasing the number of sheltered corridors for the residents to encourage them to walk instead of using their cars.
3. Considering constructing parking structures to accommodate the increasing number of automobiles.

Building multi-level parking structures is not always the easiest way to solve parking problems. Parking structures impact both adjacent land uses and the surrounding local environment. These impacts can be divided into short-term construction related impacts and long-term unavoidable impacts. The short-term impacts include construction traffic and noise, increased sediment transport from the site, dust, disruption of vehicle and pedestrian traffic, loss of parking, loss of vegetative cover, and construction waste generation. The long-term impacts include increased waste generation, and increased traffic.

A reliable and comprehensive transportation system can reduce parking demand and improve campus vitality. The existing shuttle system lacks both qualities. As the campus expands its borders and population, a viable transportation system will be even more important. The time to start such a system is now. Establish a formal transportation program adequately staffed: the goal is to start early in planning for future growth and new parking facilities and to gain more experience in the field.

In the following paragraphs, some of recommendations are being offered as alternatives to address the parking problems.

Making better use of public transport

One of the reasons that people are unwilling to take public transport is the uncertainty associated with bus arrival times. The shuttle is not convenient. The problem is that it takes such a circuitous route (going through every other housing unit before finally arriving to the

university), that you actually get to campus much faster walking than by taking the shuttle. So the campus bus system must be reviewed.

One way to do it is by providing smart and fast bus system. Smart bus system will provide advance and attractive feeder and distributor service that operate reliably and relatively rapidly, and are part of the passenger door to door chain with smooth and synchronized transfer. Public transport can reduce parking demand and as a result will reduce political pressure to expand the parking supply.

Increase opportunities for non-motorized transport

“The cost of walking is low, consisting of the time involved minus any inconveniences. In many places, the inconvenience of battling a car-oriented world is a greater problem than the lost time. Perceived costs (or dis-benefits) go up when the walk is unsafe or unpleasant” (Untermann, 1984). Walking is the default mode for most human beings. Regardless of whether people drive, ride a bicycle or take a bus, they *always* end their trip by walking.

At its most fundamental, this means that routes for pedestrians and cyclists are direct, attractive, safe and with high permeability. As you walk on campus, you will see that the available shade is unused because it is away from pedestrian paths. Improved landscaping could be one of the solutions to attract more people to walk. A competition to redesign the landscape architecture of pedestrian facilities at AUS between the students in the School of Architecture and Design would be one way to do that. Weather will be the big challenge.

What is of concern, beyond this seemingly obvious statement is to define what makes walking attractive and so incorporate those elements into the built environment. According to Jacobs (1961), three basic needs of the pedestrian are:

1. **Safety:** passive, natural observation of human presence is recognised as the single most successful way of ensuring security in public places.

2. **Convenience:** When walking, everyone tends to take "short cuts", that is, use the most direct path to their destination. This is a strong instinct difficult to deny, and will induce many pedestrians to take risks.
3. **Pleasure:** The pedestrian that is entertained and comfortable is more likely to walk further and repeat the experience. Also, the slow speed of walkers (5 Km/h rather than 40 Km/h) means that they become aware of every detail, and will quickly lose interest if not stimulated by vibrant and varied surroundings

Outreach and educational programs

Introduce awareness and educational programs about all mode choices and their implication on the environment. Also, encourage public participation in transportation planning by conducting numerous public meetings, creating and distributing quarterly newsletters and other publications. The aims of public outreach programs may include some or all of the following:

- Identify all stakeholder issues and interests
- Determine shared community values and desired outcomes
- Develop performance measures for evaluating strategies based on community values
- Involve stakeholders in evaluating strategies
- Develop a plan with the support of a broad range of stakeholders

Incorporating students' suggestions, concerns, and needs into the planning process and outcomes will result in better decisions with greater support. Their comments and involvement in the study will help shape the study's priorities and decisions.

10 References

Al-Shamsi, S. 2007. Personal interview. American University of Sharjah, Public Relations Department, Sharjah, UAE, January 7.

Barnett, J. 2003. *Redesigning Cities: Principles, Practice, and Implementation*. Chicago: Planners Press.

Boyd, B., M. Chow, R. Johnson, and A. Smith. 2003. An analysis of the effects of UCLA's fare-free transit program (BRUINGO) on student commuting mode shares. Presented at the 82nd Annual Meeting of the Transportation Research Board, Washington, D.C., January.

Business Wire. 2002. Flexcar Brings Car-Sharing to San Jose; Adobe and San Jose State University Among First Customers. Nov. 20.

Available online at:

http://findarticles.com/p/articles/mi_m0EIN/is_2002_Nov_20/ai_94449294

Daggett, J. and R. Gutkowski. 2003. University transportation survey. Presented at the 82nd Annual Meeting of the Transportation Research Board, Washington, D.C., January.

Ferguson, E. 1992. Transit ridership, incident effects, and public policy. *Transportation Research, Part A* 26(5): 393-407.

Ferguson, E. 2003. Zoning for parking as policy innovation. *Transportation Quarterly* 57(2): 47-55.

Ferguson, E. 2004. Zoning for parking as policy process: a historical review. *Transport Reviews* 24(2): 177-194.

Hindman, T. & L.K. Sanchez. 2004. *The Pursuit of Parking: a Guide for Community Associations*. Alexandria, VA: Community Associations Press.

Horowitz, J.L., F.S. Koppelman and S.R. Lerman (1986) *A Self-Instructing Course in Disaggregate Mode Choice Modeling*. Final report. Washington, DC: U.S. Department of Transportation, December.

Jacobs, Jane. 1961. *The Death and Life of Great American Cities*. New York: Vintage.

Markowitz, F. and A. Estrella. 1998. Campus moves: lively experiments in transportation technology are crossing the line between town and gown. *Planning* 64(7): 14-16.

Meyer, J. and E. Beimborn. 1996. *Evaluation of an Innovative Transit Pass Program: the U-Pass Program*. Executive Summary.

Available online at: <http://www.uwm.edu/Dept/CUTS//upassum.htm>

Untermann, R. 1984. *Accommodating the Pedestrian: Adapting Towns and Neighborhoods for Walking and Bicycling*. Van Nostrand Reinhold Company.

Weant, R.A. and H.S. Levinson. 1990. *Parking*. Westport, CT: Eno Foundation.

Whitlock, E.M. 1982. *Parking for Institutions and Special Events*. Westport, CT: Eno Foundation.

Wilbur Smith Associates, 1996. *Non-Motorized Access to Transit*. Final Report. Chicago, IL: Regional Transportation Authority, July.

Williams, M.E. and K.L. Petrait. 1993. U-Pass: a model transportation program that works. *Transportation Research Record* 1404. pp. 73-81.