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THE RENT-DISTANCE TRADEOFF FOR STUDENT HOUSING: AN EMPIRICAL ANALYSIS

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Introduction

The purpose of this paper is to estimate bid-rent or rent-offer functions for single-student apartments surrounding two major universities in Utah—Brigham Young University (BYU) in Provo and Utah State University (USU) in Logan. The statistical results provide an empirical test of the monocentric land-use model and have implications for evaluating proposed investments in student housing projects, for loan appraisals of apartment buildings, and for property tax assessments. The analysis also provides implied estimates of the value or opportunity cost that the average student assigns to time.

The Monocentric Model of Urban Structure and Land Rent

The conventional monocentric household location model, as articulated by Muth (1969 and 1985), Mills and Hamilton (1989), and Moses and Williamson (1967), analyzes the decision-making process of households and resulting pattern of land use and rents in an area characterized by one employment center where one or more members of the household commute to each work day. The model is based on a set of fairly restrictive assumptions:

- All households have identical utility functions and income levels;
- The households (or individuals forming these households) maximize the utility of consuming housing, nonhousing goods and services, and commuting to work (or school) subject to a budget constraint;
- All land surrounding the center is identical; and
- All employment (or education) opportunities and consumer services for the households are provided only at the center.

While these assumptions do not hold exactly in any real world setting, the model still has generated consistent and useful results in a myriad of applications. For example, the model's predictions of declining land rent and rent per unit of housing services with increasing distance from the center has been confirmed empirically by Muth (1984), Wiend and Muth (1972), and others. The prediction that suburban residents will

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consume greater amounts of housing and land per person has been tested by Clark (1951) and Kau and Lee (1977).[1]

With regard to the present application, the first two assumptions need little justification; they underlie many economic models in general use. In the two areas under study, the land is not identical in an economic sense because of zoning differences among areas surrounding the universities and the existing network of streets and roads that make some areas more or less accessible. Where zoning permits apartment construction, however, the distance variable still remains an important theoretical determinant of value. Therefore, the assumption that all land is identical is not overly restrictive.

Finally, the last assumption, concerning the location of all employment opportunities at the center, probably comes closer to holding in this study than in most others. The apartment units studied house only students who commute daily to the university. Some may have employment at other locations (although many work on the campus), but for virtually all students the daily trip to school is their primary activity. Thus, the location of their apartments relative to the university should be the primary concern.

In its most basic form, the model predicts a negative relationship between rent and distance. Given the family's budget constraint,

$$(1)\ Y = p_1(u)x_1(u) + p_2x_2(u) + tu$$

where:

- Y = Income;
- u = Distance from the center;[2]
- $p_1(u)$ = The price of land and housing services at a distance u from the center;
- p_2 = The price of a composite set of other goods and services which does not vary with distance;
- $x_1(u)$ = The quantity of land and housing services consumed at a distance u from the center;
- $x_2(u)$ = The quantity of other goods and services consumed at a distance u from the center; and
- t = Round-trip commuting cost per unit of distance.

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[1] In most cities, the development of employment centers and shopping malls throughout the urban complex has complicated the application of these rent-distance models. One of the features of this study is that it focuses on a true single center activity—the university.

[2] The *center* may refer to the primary site of employment or shopping facilities for area residents. In other applications, it may refer to a marketplace for output produced by firms.

Solving the budget constraint for the price of land yields

$$(2)\ p_1(u) = \frac{Y - p_2x_2(u) - tu}{x_1(u)}$$

If the price of other goods and the amounts of both goods consumed are held constant, the model predicts a linear relationship between rent and distance with a slope of -t. That is, the rent that can be bid at any distance u from the center must decline at the rate of the round-trip commuting cost per mile. That is,

$$(3)\ \frac{d[p_1(u)]}{du} = -t.$$

As the relative prices vary with distance, however, the utility maximizing household will vary the quantities of x_1 and x_2 consumed at different distances from the center (generally increasing the amount of land and housing consumed). It is easy to show that the theoretical bid-rent function will decrease, but at a decreasing rate. That is, the first derivative of the rent function is negative, but the second derivative is positive. In the following, this rent-distance relationship is tested using data on rental rates for student housing and distance from the university the students are attending.

Although the traditional land-use model is concerned with rent (or price) per unit of land, here the focus is the rental rate for a student apartment, not land *per se*. The real issue, however, is the value of location. In the statistical analysis below, the relationship between rent and distance is estimated holding constant the structural and aesthetic characteristics of the apartment unit and complex. Thus, the focus is the location value of the site of the apartment unit, which makes the analysis entirely consistent with the traditional monocentric land-use model.

The Study Area

The study is focused on students living in privately owned student apartments surrounding Brigham Young University in Provo and Utah State University in Logan. The nature of Brigham Young University and its students allows for a particularly unique test of the basic monocentric location model of urban structure and land rents. For example, almost all of the single students live in university dormitories or in private housing that have been approved by university officials. To be approved, an apartment complex must meet quality and living arrangement standards set by the university. Further, with few exceptions, the apartments are occupied only by BYU students. For all practical purposes, all of the residents of these housing complexes commute to the

same central location. In total, some 30,000 students will make one or more round-trips to the school each weekday for classes, many will go on Saturday for various university functions or to study, and most will go to a campus building on Sunday for various church meetings and activities (because more than 97 percent of the students belong to the Mormon Church). Thus, the average household member in this study will make significantly more trips to the central location per week than will individuals in more typical travel-to-work situations.

Further, the group is homogeneous. Most are between the ages of 18 and 25, virtually all are full-time students, and almost all belong to the same church that has high expectations that members are expected to meet with regard to personal living standards. With few exceptions, they are excellent students.[3] Obviously, this does not imply that they all have identical utility functions, but it is submitted that the variation in those functions probably is considerably less than for most populations.

The Utah State University situation is comparable. All of the apartment complexes included in the study rent almost exclusively to single students. About 75 percent of the students belong to the Mormon Church and attend church services at sites near the campus. While the group is not as homogeneous as the BYU students, it is more so than most populations. Students in both groups also may commute to other places for employment, but their primary commuting will be to the university campus.

Unfortunately, comparative data on the socioeconomic status of the two student groups are not available. Both campuses are primarily residential with a relatively small proportion of students commuting from their family homes. Our assessment is that the average BYU student is more affluent than his USU counterpart and that a higher percentage of USU students hold part- or full-time jobs, but we can offer no data in support of this assertion.

The Data

Two sets of data are developed for the empirical tests of the model. One is based on single-student apartment complexes surrounding the BYU campus for the 1991-1992 academic year. The other set is based on similar complexes near the campus of Utah State University for the 1992-1993 school year. After eliminating observations where the data were incomplete, there are 76 usable observations (i.e., apartment complexes) for the BYU set and 53 for USU.

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[3] For the 1991-1992 entering class, the average high school GPA was 3.65, and the average ACT score was 26. Of universities located west of the Mississippi River, only Stanford has more National Merit Scholars.

The two data sets are roughly comparable, although they are drawn on different years and not all variables are included in both. Also, the apartment complexes at BYU tend to be larger and have more amenities (e.g., swimming pools, tennis courts, hot tubs, shuttle buses to the campus, etc.). Such amenities may reflect the perceived greater affluence of the BYU students. Also, the complexes range up to 16 blocks away at BYU, whereas at USU the most distant units were only nine blocks from the campus.

The definitions of each variable used and their means are reported in Table 1. The structural or quality variables (e.g., persons per bedroom and per bathroom, air conditioning, covered parking, etc.) are included to standardize the analysis so that the net effect of distance or rent can be estimated.

The data on rent and characteristics of the apartment units are taken from summary data sheets for each complex that are maintained at the student housing office at each university. Rent reflects the average monthly payment due on a contract for the nine month school year. In virtually all cases, students are expected to buy a contract for the academic year that requires periodic payments (not necessarily monthly) that generally imply prepayment several months in advance. These contracts are transferable (i.e., they can be sold), and there is an active market with many transactions made to accommodate transfers at the end of the term.[4]

Distance is measured from the apartment unit to the library at BYU and to the student union building at USU.[5] These represent something of a focal point on each campus and are facilities of general interest to all students. The use of the library at USU as the center would increase the distance from almost all apartment complexes about 0.1 mile and would not have a significant effect on any of the statistical results. Certain campus buildings will be of differential interest to students; an attempt is made to identify the approximate economic or social center of student activity.

Using the OLS regression method, monthly rent is regressed on the set of structural variables and distance. Two variants of the distance measure are used:

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[4] Technically, the contract is a legally enforceable lease, although one apartment manager indicated the cost of enforcement is prohibitive. The strategy for the owner is to demand sufficient periodic prepayments that the cost of default is high for the student renter.

[5] The student union and library at BYU are adjacent and located approximately at the center of the campus.

$$\text{Equation 1: Rent} = \beta_0 + \sum_{j=1}^{k} \beta_j X_j + \alpha_1 \ln \text{Distance}$$

$$\text{Equation 2: Rent} = \beta_0 + \sum_{j=1}^{k} \beta_j X_j + \alpha_2 \text{ Distance} + \alpha_1 (1/\text{Distance})$$

where:

X_j = The structural variables; and
ln = The natural logarithm.

It is hypothesized that the coefficients on persons per bedroom and bedrooms per unit will be negative, reflecting the crowding and reduction of privacy that occur as these variables increase. The signs on the coefficients of the other structural variables should be positive. Based on the implications of the land-use model, the coefficient on distance and the logarithm of distance should be negative, and the coefficient on the reciprocal of distance is expected to be negative.

Statistical Results

The statistical results for the two equations for BYU are reported in Table 2, and the data for USU are outlined in Table 3. In all cases the single most important variable is persons per bedroom. The coefficient (negative $47 to $48 for the BYU data and negative $68 to $69 for the USU data) is highly significant, and the elasticity of -0.53 to -0.54 is the largest for any variable by at least a factor of two. Students will pay a premium for privacy and space.[6] In general, the coefficients on the other structural variables have the correct sign, although their significance levels are mixed. Also, for the BYU data, the coefficients on bedrooms per unit, bathrooms per unit, covered parking, and swimming pool are significant at the 0.05 probability level or lower. The coefficient on air conditioning is significant for the USU data, but not in the BYU case.

The effect of distance on rent is negative in all four equations, although the results for equation (2) (where distance and 1/distance are used) are mixed in terms of signs and statistical significance. The coefficient of distance is negative in both cases, but is significant only for the USU data. The coefficient on the reciprocal of distance is not significant in either case and has the wrong sign for the BYU data.

The specification for equation (1) using the logarithm of distance results in consistent and statistically significant results for both data sets. A negative relationship is indicated and the elasticities (-0.28 for

[6] As one student philosopher related, " ... the best roommate is no roommate at all."

BYU and -0.23 for USU) indicate this variable is second only to persons per bedroom in explaining changes in rent.

Evaluating these equations at the mean values of the structural variables yields the following bid-rent relationships:[7]

Equation (1):

BYU: Rent = 206.20 - 23.32 ln Distance

USU: Rent = 221.09 - 32.80 ln Distance

Equation (2):

BYU: Rent = 192.28 - 3.91 Distance - 20.33 (1/Distance)

USU: Rent = 212.45 - 8.70 Distance + 8.41 (1/Distance)

These equations have been plotted in Figures 1 and 2 and graphically depict the negative, nonlinear relationship between rent and distance. These students clearly will pay a premium to be located closer to the university.

Rent, Distance, and the Implicit Value of Time

The final question relates to the question of rational behavior. Specifically, what value of time is implied by the statistical results. Using equation (1) and evaluating the relationship between rent and distance at the mean levels of the other variables yields the following predicted rent-distance pairs for each university:

	Predicted Rent	
Distance (blocks)	BYU	USU
2	190.04	198.35
4	173.87	175.62
6	164.42	162.32
8	157.71	152.88
10	152.50	145.57
12	148.25	139.59

The difference in rent between living two blocks away and six blocks away (about 0.4 of a mile) is $25.62 per month for BYU students and $36.02 for USU students. Assuming that the student walks to school, that he or she can cover one mile in 15 minutes (or 0.4 miles in 6 minutes); and that the average student makes 30 round-trips to the university each month, the closer location saves about 12 minutes per day or about 6 hours per month in travel time. Relating the $25.62 per month

[7] The result of this is to hold constant the effect of the structural variables so that the net relationship between rent and distance is determined.

saving in rent for BYU students to the time saving suggests an implicit value of about $4.27 per hour for the student's time. For USU students, the rent saving of $36.02 per month implies an opportunity cost of time of $6.00 per hour. Given the typical wage rates earned by students in both of the local labor markets of $4.25 to $6.50 per hour, these statistical results seem plausible.

Summary

These tests of the standard conclusions about the relationship between rent and distance from the monocentric model of urban structure confirm the negative relationship between rent and distance. Because of the unique nature of the individuals studied, it is submitted that the test of the model is particularly strong. That is, each group is homogeneous (i.e., their utility functions probably are less dissimilar than for many other groups), and almost all commute daily (including most weekend days) to the central university location. Two alternative specifications of the bid-rent function are used; both confirm the negative slope of the bid-rent function results. Variant 1, using the logarithm of distance, appears to yield the best results. When the structural components of housing are held constant, this function yields a statistically significant, nonlinear negative relationship between rent and distance. Evaluating the differential rent for units between two and six blocks from the campus yields an estimate of the opportunity cost of time in the range of $4.27 to $6.00 per hour.

Finally, are the results sufficiently robust that they can be extended to other university settings? Only additional empirical studies at other sites will tell, but such studies are made easily. The data here suggest that college students are rational, at least when it comes to economizing on time.

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Table 1—Summary Characteristics of the Data Sets

Variable	Definition	Arithmetic Mean: Brigham Young University	Arithmetic Mean: Utah State University
Rent	Monthly rent during school year	161.158	180.325
Persons per Bedroom	Number of persons per bedroom	1.842	1.415
Persons per Bathroom	Number of persons per bathroom	NR	1.849
Bedrooms per Unit	Number of bedrooms per apartment unit	2.599	NR
Bathrooms per Unit	Number of bathrooms per apartment unit	1.579	NR
Air Conditioning	1 if complex was air-conditioned; 0 otherwise	0.684	0.665
New	1 if complex was less than seven years old; 0 otherwise	NR	0.188
Covered Parking	1 if covered parking was available; 0 otherwise	0.276	NR
Pool	1 if shuttle but to campus is provided; 0 if otherwise	0.368	NR
Distance	Distance in city blocks to the library at BYU and the Student Center (Union) at USU	7.174	4.174

NR = data not reported.

Table 2—Estimated Regression Equations for Brigham Young University Data (Provo, Utah) 1991-1992

	Equation 1			Equation 2		
	Coeffi-cient	t-value	Elasti-city[a]	Coeffi cient	t-value	Elasti-city[a]
Constant	294.91	---	---	278.16	---	---
Persons per Bedroom	-47.18**	-5.59	-0.54	-47.60**	-5.46	-0.54
Bedrooms per Unit	-13.93**	-2.78	-0.22	-13.84**	-2.75	-0.22
Bathrooms per Unit	12.38*	2.34	0.12	13.18*	2.38	0.13
Air Conditioning	7.41	1.27	0.03	6.89	1.16	0.03
Covered Parking	13.87*	2.30	0.02	13.47*	2.20	0.02
Pool	18.51**	3.68	0.04	19.25**	3.68	0.04
Bus	-3.21	-0.63	-0.00	-3.80	-0.66	-0.00
Distance	---	---	---	-3.91	-1.01	-0.17
1/Distance	---	---	---	-20.33	0.12	-0.02
Ln Distance	-23.32*	2.54	-0.28	---	---	---
Observations		76			76	
R^2		0.56			0.56	

[a]Estimated at the mean values of the variables

* and ** indicate statistical significance at the 0.05 and 0.01 probability levels, respectively

Table 3—Estimated Regression Equations for Utah State University Data (Logan, Utah) 1992-1993

	Equation 1			Equation 2		
	Coeffi-cient	t-value	Elasti-city[a]	Coeffi cient	t-value	Elasti-city[a]
Constant	294.14	---	---	282.25	---	---
Persons per Bedroom	-68.91**	-5.80	-0.50	-67.82**	-5.61	-0.53
Air Conditioning	29.25*	2.48	0.11	31.37*	2.59	0.11
New	25.80	1.84	0.03	27.33	1.91	0.03
Distance	---	---	---	-8.70*	-2.40	-0.20
1/Distance	---	---	---	8.41	0.421	0.02
Ln Distance	-32.80**	-3.60	-0.23	---	---	---
Observations		53			53	
R^2		0.58			0.57	

[a]Estimated at the mean values of the variables

* and ** indicate statistical significance at the 0.05 and 0.01 probability levels, respectively

Figure 1—Bid-Rent Function No. 1 for Single-Student Apartments at Brigham Young University, 1991-1992 and Utah State University, 1992-1993

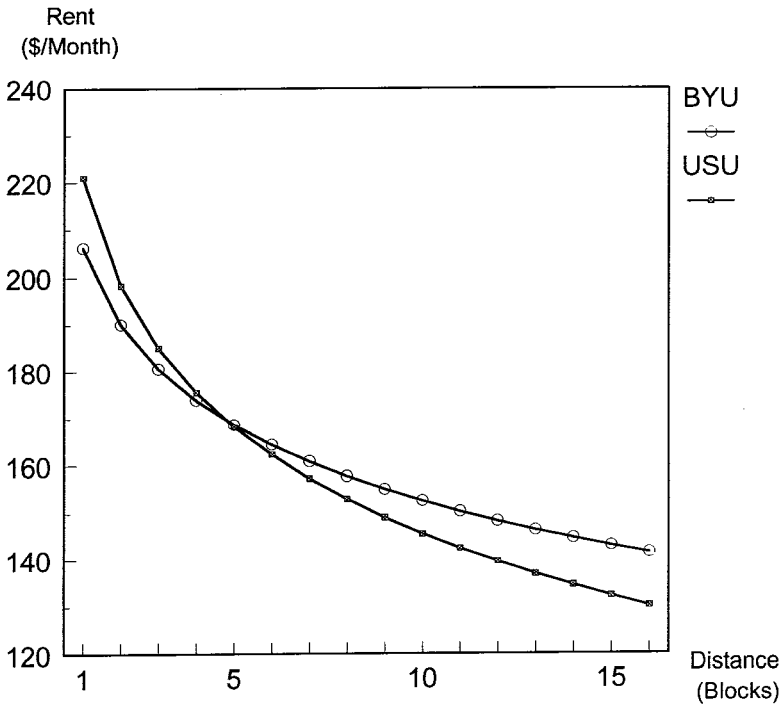

Figure 1. Bid-Rent Function No. 1 for Single-Student Apartments at Brigham Young University, 1991-92 and Utah State University, 1992-93.

Figure 2—Bid-Rent Function No. 2 for Single-Student Apartments at Brigham Young University, 1991-1992 and Utah State University, 1992-1993

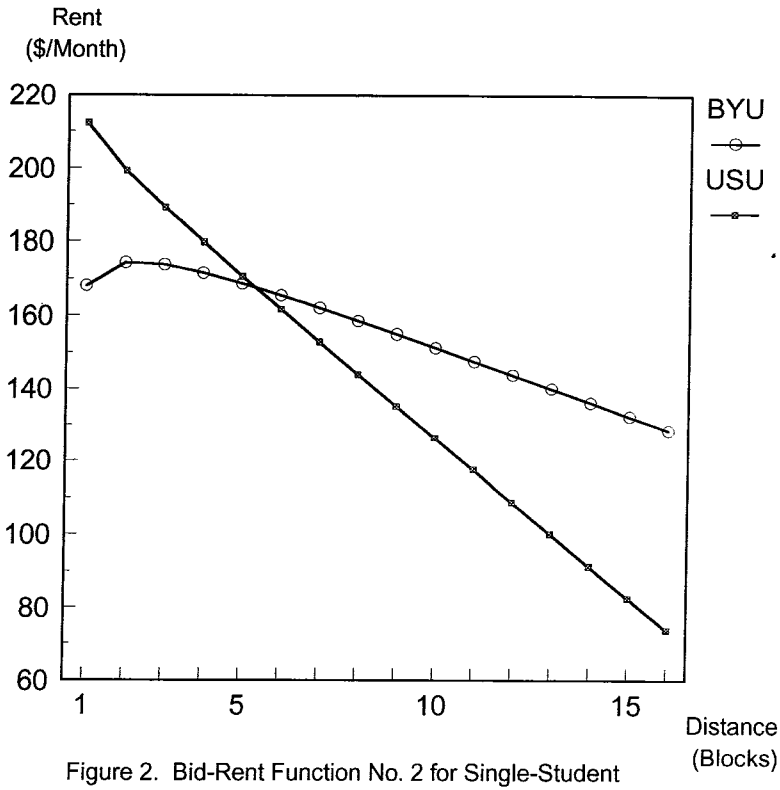

Figure 2. Bid-Rent Function No. 2 for Single-Student Apartments at Brigham Young University, 1991-92 and Utah State University, 1992-93.