Apartment Rents and Locations in Portland, Oregon: 1992–2002

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Abstract This research examines changes in the apartment-rent gradient of Portland, Oregon from 1992 to 2002. The findings indicate that increased population growth has caused real increases in apartment rents across the metropolitan area. The largest increases have occurred closer to the city center and at the beltway. The fixed supply of land coupled with increasing population has resulted in a wealth transfer from renters to landlords. Major freeway intersections, which ten years before were just evolving into new urban sub-centers, now have a statistically significant impact on land values within a six-mile radius of the intersection.

This paper examines the evolution of Portland area rent gradients over the last ten years. The findings reveal that an essentially fixed supply of land, coupled with increasing population, has resulted in real increases in apartment rent levels. Estimating the rent-location gradient shows larger increases in rents near the city center and the city sub-centers, which have formed at intersections of major freeways.

These findings are consistent with a fairly extensive literature on the estimation of the various components of apartment rents. This literature was most recently summarized by Zietz (2003) in her nearly 60-page summary and additional references are contained in earlier works by Sirmans and Benjamin (1991) and Jud, Benjamin, and Sirmans (1996). For a summary of the urban economics literature, see Anas, Arnott, and Small (1998).

The articles summarized in these works estimate rents from a hedonic model, specified to include a set of physical characteristics of apartments (and often the complexes that they are a part of) and generally also include the distance to the city center or nearby university campus, etc. The vast majority of them find evidence that rents vary across space and are higher near transportation nodes, which are generally also economic centers or sub-centers (as suburbs or campuses grow and become more dense).

In addition to Frew and Wilson (2002), upon which this current study is based, two other studies are especially relevant because they focus more specifically on transportation routes and/or nodes. Using 1990 data, Hoch and Waddell (1993) determined that highway axes were related to apartment rents in Dallas, Texas. Asabere and Huffman (1996) found that for the 1980–1991 period, Philadelphia, Pennsylvania apartment rents declined with the distance from transportation arteries.

Several other studies of housing prices and rents have examined cross-sectional data between areas with different degrees of restriction caused by various regulations. These studies, nicely summarized by Malpezzi (1996), reach the same conclusion—that more land restrictions result in higher residential rents as population increases. This is consistent with the analysis in the current study, since Portland has maintained one of the most restrictive urban growth boundaries (UGBs) for the last thirty years, keeping the supply of developable land essentially fixed during the study period. However, a similar increase in rents might have resulted with a less restrictive UGB, if instead, other supply restrictions (such as restrictive multifamily zoning or further restrictions on apartment building permits) had been imposed.

Before considering the particular shape of the Portland rent gradients, a brief description of the area and its historical growth pattern is useful.

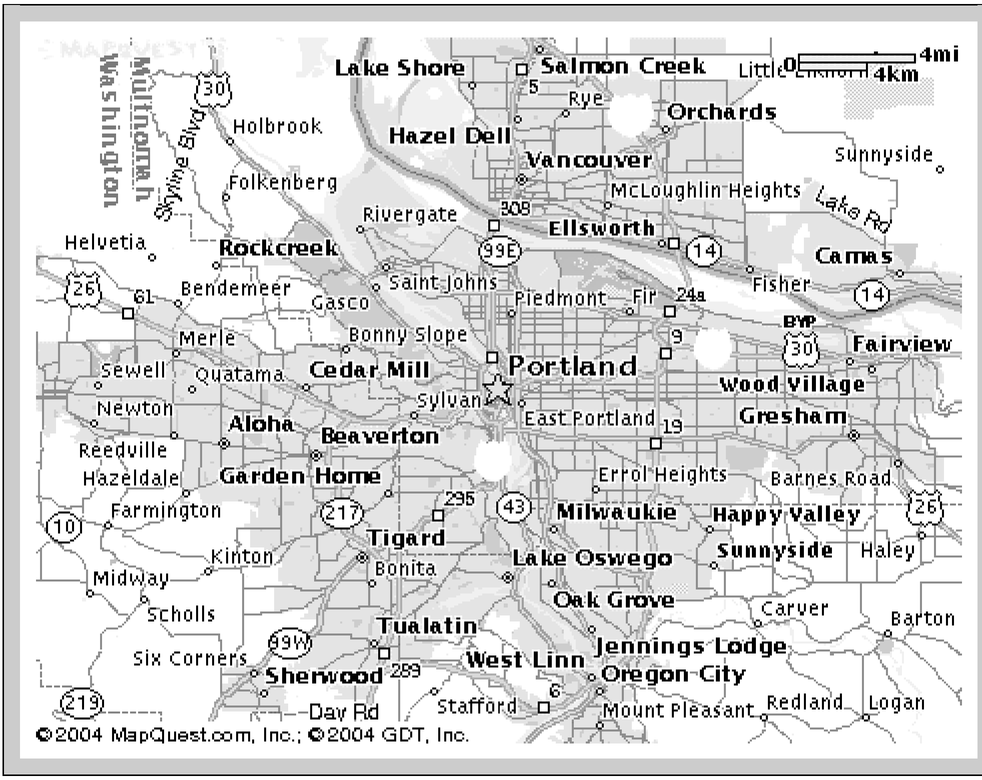
Details about Portland

Portland is located just south of the border with the State of Washington, at the intersection of two major rivers: the Willamette and the Columbia. The city of Portland has a population of about 600,000 and posts eight billion dollars of retail sales per year. The greater Portland/Vancouver (Washington) metropolitan statistical area (MSA) includes six counties and has just over 2 million residents. This MSA records annual retail sales of over 22 billion, which makes it the 25th largest commercial area in the country.[1]

As shown in Exhibit 1, greater Portland's main metro area lies along the (North-South) I-5 Freeway Corridor that connects the major cities on the West Coast. An ''urban beltway,'' the I-205 Bypass, runs along the city of Portland's east boundary. The beltway on the West Side begins with Highway 217, which connects with US 26 to return to the city center. Access to the city center from the East Side is achieved via the I-84 freeway (which comes in from the Columbia Gorge region to the east of the metro area).

The city grew outward from a central port, which provides deep-water access to the Pacific Ocean. Originally this port was used to receive imports and ship lumber down the western seaboard. Later, Portland became the location of a regional railhead that exported grain grown in the Willamette Valley and transshipped imported goods to inland destinations. More recently, as the land along the river became densely populated, many workers moved out to the greener suburbs, where lots were less expensive, and began to commute to work in the central city facilitated by a radial streetcar system, which was eventually replaced with

Exhibit 1 | Portland, Oregon



The greater Portland's main metro area lies along the (North-South) I-5 Freeway. US 26 comes into the city from the west and I-84 comes into the city from the east. The ''urban beltway'' consists of the I-205 Bypass, on the east side and Highway 217 on the west.

highways and ultimately urban freeways. Finally, ''beltways'' were built to circle the central city and provide transportation between points in the suburbs. (On average, these beltways lie approximately 15 miles from the city center.) Thus, Portland grew into a shape that resembles many other medium-sized cities that have expanded outward into the suburbs.

During the 1970s, Portland and its suburbs developed a unified restrictive urban growth boundary (UGB) to contain the growth of the metropolitan area and avoid the ''sprawl'' that was already occurring in the larger urban areas in California. (This boundary is located an average of about 20 miles from the city center.) The UGB prohibits residential building outside the boundary, except as necessary to support agricultural cultivation. More specifically, from that point on, any residential structures that are built outside the boundary were denied access to city services and utilities. In addition, minimum acreage requirements were imposed on the construction of new residential structures. A unified metropolitan government was created to enforce the restrictions and prevent urban expansion beyond the boundary.

During the ten-year sample period: 1992–2002, the population of the greater Portland area increased more than 30%, from 1.545 million to 2.013 million.[2] Although Portland is still primarily a medium-sized, mono-centric city, continued growth will soon transform the area into a multi-centric metroplex, as the city merges with Vancouver, Washington, immediately to the north, and grows south toward Salem, Oregon's state capital.

In terms of the general economy during the sample period, the data is drawn from periods before and after the peak in the high technology boom. These two periods are somewhat comparable in that the economy was in an economic slump on the verge of recovery in both periods. However, interest rates were much lower in 2002. Nevertheless, apartment vacancy rates were comparable in both periods.[3]

Model and Data

Apartment rent data is used to analyze the changes in the apartment rent gradient of Portland, Oregon from 1992 to 2002. The same model as Frew and Wilson (2002) is used and a comparison is conducted of the results from these two points in time. This is a ''snapshot'' analysis from periods before and after the technology boom. The empirical model is a typical hedonic rent equation augmented with distance controls.[4] Three distances were measured for each apartment observation in the sample: (1) the commuting distance to the freeway onramp; (2) the distance to the nearest freeway intersection; and (3) the distance to the city center. The model is as follows:

$$R_i = \beta' X_i + \gamma' D_i + \varepsilon_i$$
$$i = 1,\ldots,N. \tag{1}$$

Where: R_i is the monthly rent on the ith apartment, X_i is a kx1 vector of apartment attributes including a constant term, D_i is a jx1 vector of distance variables, including the distance from the city center (DCC) to the ith apartment, the distance from the nearest highway onramp (*DH*) to the ith apartment, and the distance from the nearest intersection of two highways (*DI*) to the ith apartment, and ε_i is a stochastic error term.

The data for Frew and Wilson (2002) were obtained from a 1992 apartment survey in the Portland metropolitan area. In 2002, the rent information was updated for as many apartments as possible (some no longer exist as rentals). This provides 533 observations. All apartments are between 2.1 and 19 miles outside the city center.[5] Therefore, all sample apartments are located inside the UGB, which is located about 20 miles outside the city center.

Exhibit 2 presents the descriptive statistics for the variables. There is a 30.5% increase in the mean value of apartment rents over this period. This is about the same as the 31% increase in the national average of housing prices in urban areas in the United States as reported by the BLS.[6] However, the BLS has CPI statistics on the Portland/Salem area that show a 34.8% increase in housing costs,

Exhibit 2 | Descriptive Statistics

Variable	Minimum	Maximum	Mean
Rent in 1992 (1992 $)	265	1400	529.96 (144.85)
Rent in 2002 (1992 $)	320	1678	527.30 (145.36)
Rent in 2002 (2002 $)	420	2200	691.43 (190.61)
# of Bedrooms	0.5	3	1.8 (0.77)
# of Bathrooms	1	3	1.40 (0.47)
Fireplace	0	1	0.44 (0.50)
Laundry Facility	0	1	0.70 (0.46)
Laundry Hookup/Unit	0	1	0.51 (0.50)
Exercise/Spa	0	1	0.75 (0.43)
Pool	0	1	0.88 (0.33)
Covered Parking	0	1	0.57 (0.50)
Cable Hookup	0	1	0.80 (0.40)
Air Conditioning	0	1	0.04 (0.20)
Distance to Highway (miles)	0.1	8	1.38 (1.11)
Distance to Intersection (miles)	0.5	12.7	5.10 (2.47)
Distance to City Center (miles)	2.1	19	10.82 (3.79)

Note: The number of observations is 533. Standard deviations appear in parentheses.

indicating that Portland has experienced growth in housing prices that is slightly faster than the national average. The rate of increase of average rental prices in the data set is slightly lower than the average rate of increase shown in the BLS series. This is due to the following: (1) the apartments at the city center were eliminated, which tend to have higher rates of increase on average;[7] (2) the sample does not include any newly constructed apartments;[8] and (3) the change in average rents in the data includes the effect of depreciation, while the BLS data holds property age constant.

Exhibit 3 shows the change in both nominal and real average rents as the distance from the city center increases. Apartments closer to the city center experience increases in real rents, while apartments further from the city center experience decreases in real rents. Therefore, although the overall average rent in the raw data has not increased in real terms, apartments within 8 miles of the city center have experienced real increases in rent. Once apartment size, other amenities, and distance to the city center and highways is accounted for, real rents in Portland increased for all apartments except those on the very edge of the city.

This pattern is consistent with urban theory, which predicts that as the costs and benefits of various locations change, utility-maximizing households continually compete for more ‘‘desirable’’ locations. Therefore, population growth with no expansion of the UGB will increase rents overall with the highest increases occurring in the city center. This is the result of increased congestion and higher commuting costs. Each step closer to the city center eliminates more commuting costs than it did in the earlier period. This savings is capitalized into the land values and hence (as will be illustrated in the next section), the rent gradient pivots to the steeper slope.[9]

Frew and Wilson (2002) compare a variety of functional forms (linear, log, quadratic, and cubic) for the distance to the city center (DCC) variable. They find

Exhibit 3 | Nominal and Real Changes in Average Rent by Distance to the City Center

Distance from City Center	%Δ Nominal Rent	%Δ Real Rent	# of Obs.
2–4 miles	47.5%	12.5%	35
4.1–6 miles	36.6%	4.2%	29
6.1–8 miles	33.7%	1.9%	56
8.1–10 miles	30.5%	−0.5%	93
10.1–12 miles	28.4%	−2.1%	92
12.1–14 miles	29.4%	−1.3%	116
14.1–16 miles	25.6%	−4.2%	86
16.1–19 miles	19.2%	−9.1%	26
Total (2–19 miles)	30.5%	−0.5%	533

that a cubic functional form best represented the rent gradient in 1992. This form allowed for the ‘‘rent gradient ridge’’ that was hypothesized to occur around the beltway. They find that rents decrease as one moves away from the city center, but moderately increase as one approaches the beltway, and finally decrease as one moves further from the beltway and the city center. Because the economic activity around the beltway is not as great as at the central hub, one would not expect rents to be as high as they are in the city center. Therefore, there is an overall downward trend in rent values as the distance from the city center increases. The results are qualitatively the same when the 1992 data is limited to only those apartments still available in 2002.

Heteroscedasticity is a common problem with cross-sectional data. For example, one might expect less variation in rents close to the city center, and more variation as one moves further from the city center. A scatter plot of residuals against predicted rents and a Goldfeld-Quandt test using ‘‘distance to the city center (DCC)’’ as the target variable, both indicate that heteroscedasticity is a problem. In addition, there could be other ‘‘problem’’ variables that are less obvious. If the disturbance terms are heteroscedastic, then ordinary least squares standard errors are biased. However, the exact nature of the heteroscedasticity is uncertain, and because of the large data set (over 500 observations), the White (1980) correction test is used to obtain a consistent estimate of the covariance matrix. However, for comparison purposes, the heteroscedasticity caused by the DCC variable is directly corrected by using weighted least squares (WLS). The results are qualitatively the same.[10]

Results

The first four columns of Exhibit 4 show the results from each period. In 2002, the cubic model is still preferred to the log model because it portrays a richer picture of the rent gradient. Exhibit 5 illustrates the regression results for both the cubic and the log models. A Chow test for both specifications indicates that the coefficients on the DCC variables are significantly higher in 2002 than in 1992 at the 1% level.[11] This is consistent with an increase in population density caused by population growth and a fixed urban growth boundary. However, these increases are not uniform throughout the area. In the cubic model, some variation in the rent increases since 1992 can be seen. The 2002 cubic model displays a sharper drop from the city center, a steeper increase at the beltway (15 miles out), and a sharper drop toward the urban growth boundary (20 miles out). As mentioned earlier, urban theory predicts that high rent areas in the city center (and along major transportation routes) will have the largest increases in rents.

A simulation model developed by Yinger (2001) is used to illustrate how closely the empirical results correspond to urban theory.[12] This simulation model is based on equations developed from a rigorous theoretical model.[13] This makes it an ideal model because the empirical results can be compared to those that flow directly from a model based on utility theory with clearly specified assumptions.

Exhibit 4 | Regression Results

	1992 Cubic	2002 Cubic	1992 Log	2002 Log	2002 Real[a]
Constant	528.47***	969.35***	408.51***	746.02***	739.24***
	(63.90)	(114.10)	(39.20)	(70.0)	(87.00)
Distance to City Center (DCC)	−77.64***	−153.58***	—	—	−117.13***
	(18.40)	(30.70)			(23.40)
DCC^2	6.42***	13.16***	—	—	10.04***
	(16.90)	(2.86)			(2.18)
DCC^3	−0.17***	−0.37***	—	—	−0.28***
	(0.05)	(0.08)			(0.06)
Ln(DCC)	—	—	−67.20***	−136.66***	—
			(13.50)	(21.10)	
Bedrooms	85.21***	99.61***	83.67***	97.38***	75.96***
	(5.94)	(8.80)	(6.04)	(9.05)	(6.71)
Bathrooms	79.04***	97.04***	81.66***	99.98***	74.00***
	(11.40)	(18.30)	(11.70)	(19.20)	(14.00)
Fireplace	34.60***	42.22***	33.87***	42.15***	32.20***
	(7.96)	(11.60)	(8.26)	(12.05)	(8.84)
Laundry Room	−43.77***	−43.11***	−48.38***	−52.07***	−32.88***
	(9.30)	(13.30)	(9.78)	(14.70)	(10.10)
Laundry Hookup / Unit	39.85***	43.08***	42.31***	46.14***	32.85***
	(9.10)	(12.40)	(9.39)	(13.10)	(9.49)
Exercise / Spa	15.88	30.70	20.80**	37.18*	23.41
	(10.30)	(20.30)	(10.20)	(21.30)	(15.50)
Pool	2.11	5.36	−7.23	−10.10	4.09
	(13.20)	(22.80)	(13.10)	(24.20)	(17.40)
Covered Parking	32.85***	16.73	35.87***	23.34	12.76
	(9.05)	(16.80)	(9.71)	(17.20)	(12.80)
Cable	7.56	−24.03	10.04	−21.43	−18.33
	(8.67)	(16.00)	(8.81)	(16.30)	(12.20)
Air Conditioning	18.04	86.53**	33.35	115.32***	65.99**
	(31.00)	(43.80)	(33.00)	(44.50)	(33.40)
Distance to Highway (DH)	1.53	9.67	−1.65	3.44	7.38
	(5.90)	(7.50)	(6.03)	(8.15)	(5.73)
DH^2	−0.13	−1.32	0.35	−0.40	−1.01
	(0.88)	(1.04)	(0.98)	(1.20)	(0.79)
Distance to Intersection (DI)	−9.36	−29.53***	−13.27**	−34.74***	−22.52***
	(6.27)	(7.48)	(6.21)	(8.00)	(5.71)

Exhibit 4 | (continued)

Regression Results

	1992 Cubic	2002 Cubic	1992 Log	2002 Log	2002 Real[a]
DI^2	0.79	2.31***	−1.18*	2.84***	1.76***
	(0.65)	(0.72)	(0.62)	(0.73)	(0.55)
Adj. R^2	0.678	0.611	0.666	0.589	0.611

Notes: Standard errors are in parentheses. Standard errors adjusted for heteroscedasticity using the White (1980) procedure. The number of observations is 533.

[a] Adjusted to 1992 dollars.

*Significant at the 10% level.

**Significant at the 5% level.

***Significant at the 1% level.

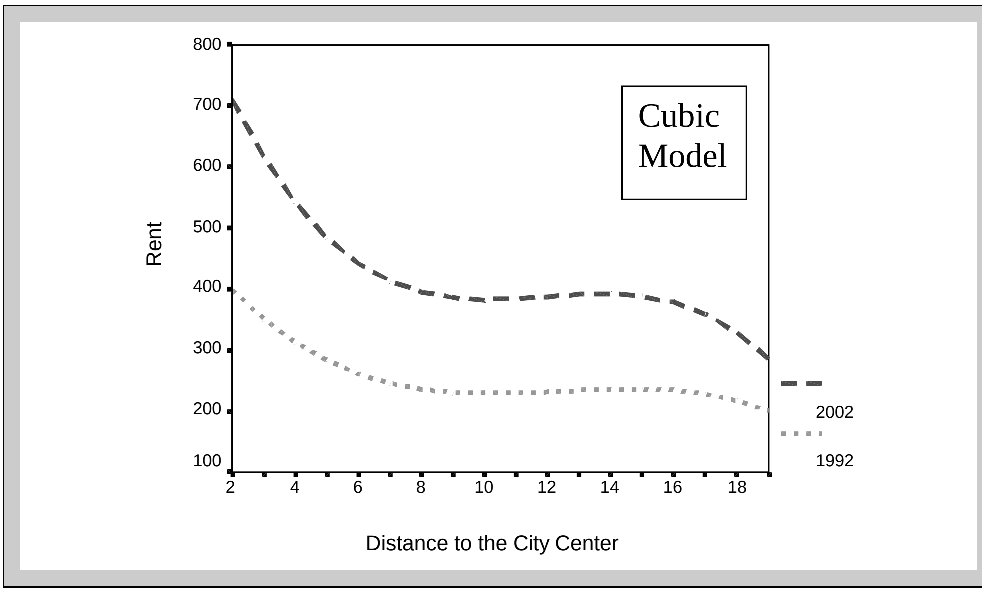
The simulation program accepts parameter values from the user and employs the mono-centric rent gradient model to produce a graph of the associated gradient. This user-defined gradient is also compared to a ''base case'' rent gradient, which illustrates an initial outcome from pre-set parameters. Exhibit 6 qualitatively reflects the changes observed in the data set over the 10-year time period. Both income and population have increased in the Portland metropolitan area since 1992. Because income has increased, the opportunity cost of commuting has increased. Higher population coupled with the restrictive UGB has increased congestion and decreased the commuting speed. These effects make the rent gradient steeper by increasing the cost of commuting from further from the city center.

Exhibit 7 shows the simulation results and the results of the current study.[14] The results of the current study have been altered by using annual rent values and re-scaling the data on both axes to match the units used in Yinger's (2005) model. The most interesting aspect of the comparison between the rent gradients is that the simulated rent values for land close to the city center closely mirror the model results. Both rent gradients increase at a steeper rate in the second period. This is the result of increased congestion and higher commuting costs. Because these costs are lower for apartments closer to the city center, this benefit is incorporated into land values and hence the rent gradient becomes steeper.

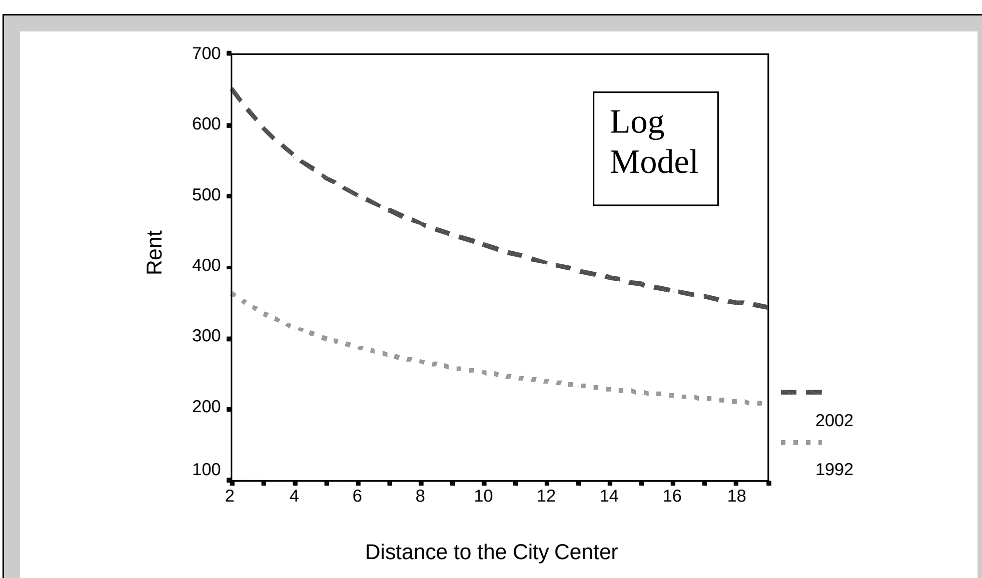
It is also clear that the rent gradient is deformed by the slight rise in rent values, which occurs about 15 miles from the city center, rather than continuing to decline at the exponential rate of the mono-centric model. As explained above, this is because of the formation of urban sub-centers in the Portland multi-centric, metropolitan area. It would be interesting to extend the simulation model of mono-centric city to include urban sub-centers.[15] Then, the richer model could be used

Exhibit 5 | Comparison of Cubic and Log Functional Forms

Panel A: Cubic Functional Form



Panel B: Log Functional Form



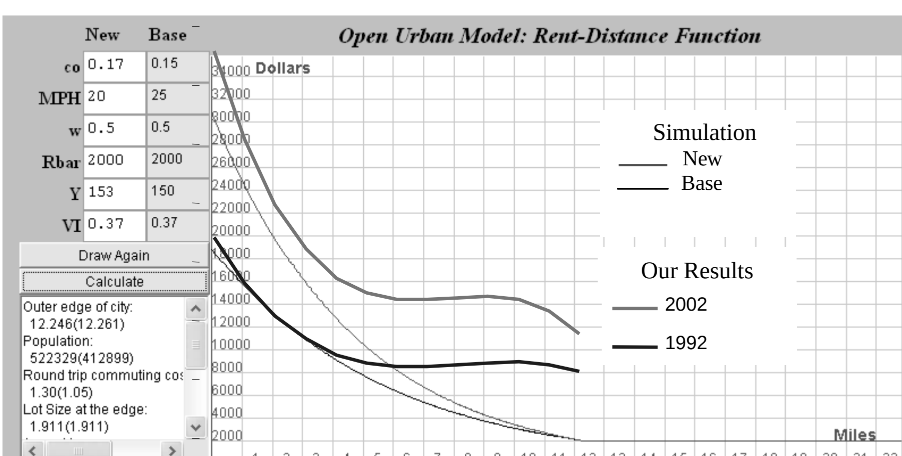
Notes: Both specifications show that rents are higher throughout the metropolitan area in 2002. However, the cubic model reveals some variation in the rent increases since 1992. The 2002 cubic form displays a sharper drop from the city center, a steeper increase at the beltway (15 miles out), and a sharper drop toward the end of the UGB (20 miles out).

Exhibit 6 | Changes in Simulation Parameters

	New	Base	Pct. Chg.
Input Values			
Commuting cost/mi.	0.17	0.15	0.13
Commuting speed	20	25	−0.20
Average daily income	153	150	0.02
Output Values			
Population	522,329	412,899	0.27
Round trip com. costs[a]	1.3	1.05	0.24
Annual income	38,250	37,500	0.02

Notes: The source is Yinger's Urban Economics Simulation Study (2001).
[a] Includes cost of time lost during commute, valued at half the wage rate.

Exhibit 7 | Simulation Results* Compared to Study Results



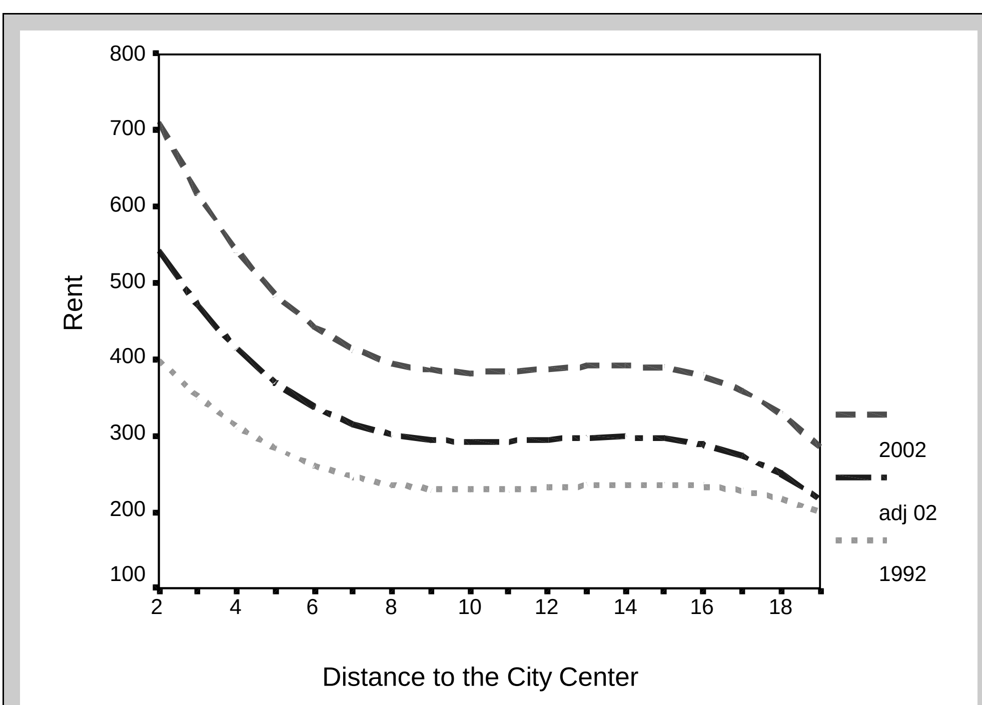
Notes: The simulated changes in Exhibit 6 are graphed above with rescaled results. The two mirror each other close to the city center. Both rent gradients increase at a steeper rate in the second period. This is the result of increased congestion and higher commuting costs. However, the rent gradient is deformed by the slight rise in rent values, which occurs about 15 miles from the city center, rather than continuing to decline at the exponential rate of the mono-centric model. This is because of the formation of urban sub-centers in our multi-centric, metropolitan area.
* From Yinger's Urban Economics Simulation Study (2001).

to simulate results for the data that are based on equations that are rigorously consistent with urban economic theory.

Real Changes in Rents

The results in Exhibit 5 provide the total increase in rents, but the average housing prices across the nation have increased by 31% since 1992. Therefore, the 2002 rent values are adjusted for inflation.[16] Again, a Chow test indicates that the coefficients on the DCC variables in 2002 are significantly different from those in 1992 at the 1% level.[17] The full regression results are presented in the last column of Exhibit 4. Exhibit 8 separates the distance from the city center variable into real and inflated components. About half of the increase in rent values is a real increase. As expected (see Exhibit 3), both the nominal increase and the real increase in rents become smaller as the distance increases from the city center. However, the real change in rents falls faster and is virtually zero at the edges of the urban growth boundary.

Exhibit 8 | Real and Inflationary Changes in Rents



Notes: The difference between "adj 02" and "1992" is the real change and the difference between "2002" and "adj 02" is the inflationary change. About half of the increase in rent values is a real increase. Both the nominal increase and the real increase in rents become smaller as we the distance from the city center increases. However, the real change in rents falls faster and is virtually zero at the edges of the urban growth boundary.

Interestingly, landlords were able to increase average rents at about the same rate as the population growth (i.e., the population-to-rent elasticity equals unity). The Bureau of Economic Analysis reports that the Portland area population has increased at an average compound rate of 3% from 1992 to 2002. The data shows the same rate of increase in the average apartment rent (30.5% over 10 years is about 3% per year). During the same period, however, the MSA average per capita income increased a little over 4%,[18] so this additional rent was probably often extracted from ''additional'' income available to the households.

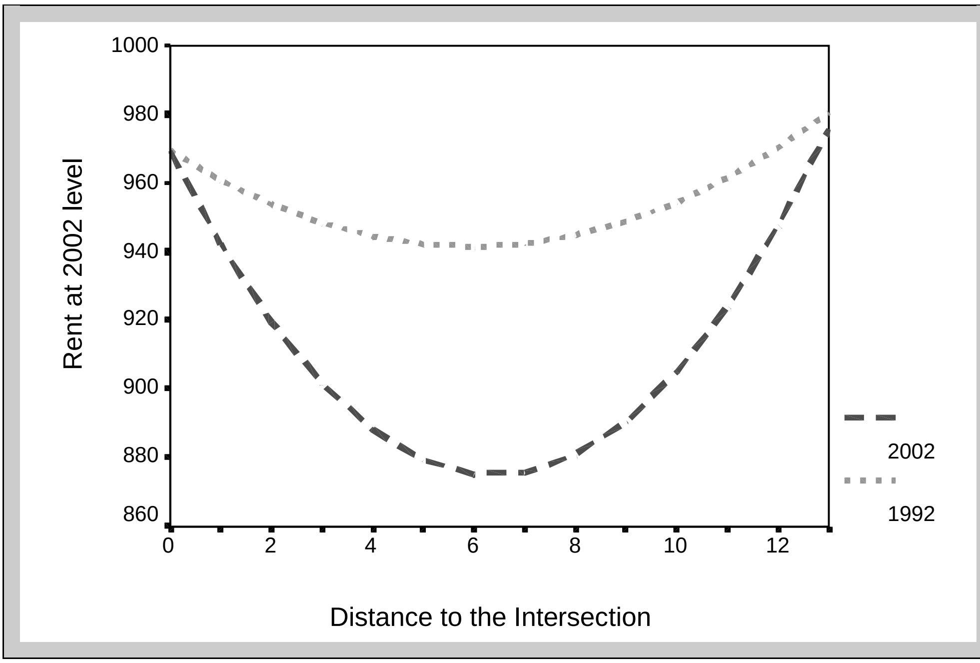
Distance to the Highway and Intersection

In addition to the inter-temporal changes in the relationship between rents and the distance to the city center, some changes are also seen in the relationship between rent and the other distance variables; distance to the highway onramp (*DH*) and distance to the intersection of two highways (*DI*). In general, lower rents on apartments located right next to the highway onramp or intersection are expected due to the noise and congestion. However, rents are also expected to be lower when access to the main arteries is less convenient. Therefore, rents are expected to rise, initially, as distance from the highway (or intersection) increases. They are then expected to fall the distance from the highway (or intersection) increases even further. Focusing on the preferred ''cubic'' model in Exhibit 4, the coefficients on the DH variables are not significantly different from zero in either period; however, the coefficients do have the expected signs. This result is not surprising since 75% of the apartments are within 2 miles of a highway onramp and 99% are within 4 miles. The highway system passes through the center of town, adjacent to both high and low value properties.

The more interesting result surrounds the relationship between rent and the distance to the intersection of two highways. The cubic model in Exhibit 4 shows that the coefficients on the *DI* variable are not significant in 1992, yet they are significant in 2002. A Chow test of the null hypothesis that the coefficients on the *DI* variables are the same in both periods is rejected at the 10% level.[19] However, the *DI* shape in both time periods appears to be the opposite of expectations. Exhibit 9 shows that, in both 1992 and 2002, rents fall as distance from the intersection increases, then rise again about 6 miles out (the effect is more pronounced in 2002).[20] Upon reflection, this result may not be surprising. It appears that the positive effect of having access to the intersection of two highways is more important than the negative effects of the noise and congestion. Rents drop for the first 6 miles as distance from a highway intersection increases and access to these urban centers and sub-centers is reduced. However, the question of why rents rise beyond 6 miles is less clear. One possible explanation is that 6 miles is so far from the intersection that other factors, including access to a highway onramp, become more important in determining rent values.

Furthermore, interpreting the statistical significance of these distance variables is clouded by the fact that a portion of their values may be due to positive

Exhibit 9 | Rent Changes with Distance to Intersection



For comparison purposes, the 1992 constant is set at the 2002 level. In both 1992 and 2002, rents *fall* as the distance from the intersection increases, then they rise again about 6 miles out. The effect is more pronounced in 2002 and the difference is statistically significant.

neighborhood effects in the sub-centers that develop around the highway intersections. As mentioned in Endnote 4, since data limitations prevent inclusion of these ''external'' neighborhood variables in the model, the intersection attribute may be less significant than the probability results indicate.

Conclusion

A hedonic rent equation supplemented with distance variables is used to estimate apartment rent gradients for Portland, Oregon in 1992 and 2002. The two paired-sample periods are compared to determine the change in the rent gradient. In 2002, a higher peak in rents exists at the city center, a higher secondary peak in rents exists at the beltway, and a steeper drop in rents occurs at the UGB. In addition, access to the intersection of two highways has become more important in 2002 than in 1992, but only for apartments within a 6-mile radius of the intersection. Moreover, real rents have increased across the vast majority of the metropolitan area, indicating that the increased population, coupled with an essentially fixed supply of land, has resulted in a wealth transfer from renters to landlords.

This study is largely descriptive in nature but contains a comparison to the simulated results from the theoretical, mono-centric model that provides the starting point for of many urban economic theories about rent gradients. Another interesting question is how the empirical results would compare to the simulation of a multi-centric theoretical model. Perhaps future research will produce a computer model to simulate the nucleation of urban sub-centers.

Endnotes

1 BEA regional economic accounts: Bearfacts 1992–2002 for Portland MSA.

2 Statistical Abstract of the U.S., Series #30: Large Metro Areas.

3 COMPS apartment appraisal data (various years).

4 In addition to the physical characteristics of the apartment (and its complex) and distance measures, several apartment rent studies add ''external'' variables. For examples, see Sirmans, Sirmans and Benjamin (1989), Bible and Hsieh (1996), Moudon and Hess (2000), Frew and Jud (2003), and Valente, Wu, Gelfand, and Sirmans. (2005). Unfortunately, data limitations prevent the inclusion of similar variables in the present study to measure neighborhood characteristics.

5 When comparing apartment attributes and the relationship between rent values and these apartment attributes, Frew and Wilson (2002) found substantial differences between the apartments in the heart of the city and the apartments in the surrounding areas. Thus, it was inappropriate to pool these data. Since the primary area of interest is the distance variables, the analysis is focused on apartments outside the city center.

6 BLS CPI series CUUR0000SAH: U.S. urban consumers, housing item (includes rent, fuel and utilities, household furnishing and operations).

7 The data show a 53% increase in average rents at the city center.

8 For comparison purposes, the observations are limited to apartments available in both 1992 and 2002. Therefore, newer apartment buildings that may command a higher price are not included.

9 As DiPasquale and Wheaton (1996; 36) put it: ''when rents [at central locations] exactly offset commuting costs, the market is said to be in equilibrium.''

10 Contact the authors for a copy of the WLS results.

11 For the cubic model, F-value = 11.09 and F-crit (3,515) for 1% = 3.82; for the log model, F-value = 25.72 and F-crit (1,517) for 1% = 6.68.

12 The rent-distance function in the Open Urban Model is used.

13 See Chapters 1–3 of Yinger's urban economics ''e-book'' at http://faculty.maxwell.syr.edu/jyinger/E-Books/Housing_And_Commuting/Housing_and_Commuting.htm.

14 The simulated results are based on the ''new'' values listed in Exhibit 6. These input values are shown in relation to the model's pre-set values for the comparative ''base case.'' The simulation output also lists several key values calculated from the simulation. These are listed in the table as ''output'' values.

15 Anas (1996) developed such a theoretical model, but the authors know of no associated simulation.

[16] The BLS series is used for the housing item of the CPI (series CUUR0000SAH) to put the 2002 rents into 1992 dollars.

[17] The F-value = 5.34 and the F-crit (3,515) for 1% = 3.82.

[18] BEA regional economic accounts: Bearfacts 1992–2002 for Portland MSA.

[19] The F-value = 2.86 and the F-crit (2,515) for 10% = 2.313.

[20] The apartments in the sample are located between 0.5 and 12.7 miles from an intersection of two highways.

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