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The Vacancy Rate and Rent Levels in the Commercial Office Market

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Abstract. **This paper develops and estimates a cross-sectional model of the commercial office market in which the building vacancy rate is a key factor in the determination of rents. Individual buildings in Greensboro, North Carolina are used as the unit of analysis and simultaneous equation procedures are employed to produce estimates of rent per square foot. The estimates confirm that the vacancy rate must be included when estimating the price of commercial office space.**

Introduction

Although numerous studies have examined the market for residential real estate, only a handful have looked at the commercial office market. Three past studies have sought to quantify the relationship between building attributes and rent per square foot using hedonic regression models [Clapp 1980; Hough and Kratz 1983; and Brennan, Cannaday and Colwell 1984]. Each of these studies employed attributes such as distance to the center of the central business district, distance to a major highway or commuter train station, building age, number of floors, and the amount of common space, for example, lobbies, lounges, etc.

One of the studies [Brennan, Cannaday and Colwell 1984] examined the relationship of the building vacancy rate to the level of rents, but the vacancy rate was discarded as insignificant. No empirical results were reported and no theory concerning the expected sign of the coefficient was developed.

A recent study by Shilling, Sirmans and Corgel [1987] discusses the price adjustment process for rental office space as a price–inventory adjustment process. The authors develop an expression for the dynamic rate of change in rents, assuming that the relationship between rent adjustments and vacancies is uncertain. They hypothesize that an increased vacancy rate slows the rate of change in rents whenever the actual vacancy rate exceeds the desired (natural) rate. They mention (p. 93) that theory suggests a joint determination of rents and vacancies but do not use simultaneous–equation procedures to produce their estimates of rent changes for seventeen cities during the 1960–75 period.

The lack of attention generally given the vacancy rate variable in past studies of the commercial market is surprising given the high degree of both theoretical and empirical attention this issue has received in the residential real estate literature (see, for example, Rosen and Smith

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1983). In the residential market, the vacancy rate has been viewed as pivotal to explaining the price of housing services. This relationship has been described by Black and Winnick [1953], and empirical evidence of the relationship has been uncovered in studies by Smith [1974] and Rosen and Smith [1983]. Contrary evidence has been reported by de Leeuw and Ekanem [1971] and Eubank and Sirmans [1979].

This paper develops and estimates a cross–sectional model of the commercial office market in which the building vacancy rate is a key factor in the determination of rents. The discussion proceeds as follows: The first section develops the model of the commercial market, extending Smith's [1974] past work in the residential sector. The next section presents estimates of the model, based on a survey of the commercial rental market in Greensboro, North Carolina. The final section summarizes relevant findings.

A Model of the Commercial Office Market

In the commercial market at any given time there is a stock of office units, and a demand for the services of these units. The supply of office units in a period is fixed, being identically equal to the supply the previous period plus newly completed or converted units added during the period, less the units lost by depreciation, demolition, or removal. The demand for commercial office space depends on the level of rents, the characteristics of available buildings and sites, and a number of other economic and demographic variables that also influence business locational choice. These demand and supply functions interact to determine simultaneously the level of rents and the stock of vacant units, or the vacancy rate.

The level of rents and the vacancy rate determined in the market tend to adjust slowly, so that the vacancy rate can be above or below its competitively optimal level for extended periods. The lags in market adjustment are the result of numerous frictions in the adjustment of office rents, the long gestation period for new construction, and the slow depreciation of existing units.

In mathematical terms, the demand for commercial office space, D, is assumed to be a function of rent per unit of office services, R; the characteristics of available buildings and sites, X; and other economic and demographic factors, Z.

$$D = d(R,X,Z) \tag{1}$$

Because the supply of office services, S, is fixed in short run, excess demand or supply is measured by the vacancy level, VL.

$$VL = S - D \tag{2}$$

The vacancy rate, V, is found by dividing the vacancy level, VL, by available supply, S:

$$V = VL/S = 1-(D/S) = 1-(1/S)^{*}d(R,X,Z) \tag{3}$$

Since the law of demand requires that $\partial D/\partial R$ be negative, it follows from 3 that the level of rents is positively related to the vacancy rate and is determined by:

$$R = r(V,X,Z) \tag{4}$$

Using cross–sectional data, equation 4 can be estimated with information on individual office buildings as the basic unit of observation. When data are drawn from a particular area for a single period, Z reasonably can be assumed constant, and therefore need not be considered in any cross-sectional analysis of a single area.

Equation 4 is similar to a standard hedonic price function. In the residential housing market, a great deal of attention has been devoted to the analysis of hedonic equations (see, for example, Rosen 1974) and it generally is agreed that a hedonic function is not an inverse demand equation. The reason is that a hedonic function contains no measure of quantity demanded, because it is not possible to construct a single measure of quantity for such a complex commodity as residential housing. Indeed, some researchers have argued that the predicted values from a hedonic equation can substitute as a measure of the quantity of housing demanded in studies of housing demand [Barnett 1979].

Equation 4 differs from the traditional hedonic equation because it contains the vacancy rate variable (V), which is by definition inversely related to quantity demanded through equation 3. By including the vacancy rate in 4, we have implicitly included a measure of quantity demanded. Thus, we interpret 4 as an inverse demand function. Accordingly, estimates of 4 can be used to determine $\partial R/\partial V$, and $\partial R/\partial V$ plus equation 3 are sufficient to estimate the elasticity of demand for rental office space.

In the model estimated by Rosen and Smith and in the model outlined in equations 1–3, the system is recursive. At any point in time, there is a one–way flow of causation from rents to vacancy levels, given the fixed supply of office space. Equation 4 in this system is simply a tautology; it provides no additional information.

Yet if we attempt to estimate equation 4 from cross–sectional data, we must recognize another facet of the rental market. At any one time, a vector of sample rents is likely to contain observations which are off the estimated equilibrium hedonic "production–frontier." These residuals are positively correlated with vacancy rates. As explained by Rosen and Smith (p. 783)," the price structure of competing landlords and set of reservation prices for tenants are not known with precision, landlords often adjust rents on units as they become vacant, and only raise the rents of existing tenants once the new rent levels have become pretested." Landlords who are willing to accept higher average vacancy rates, thus, will tend to have higher average rents at any point in time. Vacancies are in effect partially the result of an "experiment" by the landlord designed to yield market information.[1]

Including the vacancy rate in the rent equation 4 creates a proxy for the effect of the unobserved rent adjustment mechanism and helps eliminate specification bias in the other estimated coefficients. But since the vacancy and the rent level are simultaneously determined, the interpretation of the vacancy rate coefficient is clouded by the correlation between the vacancy rate and the residuals of the rent equation that results from simultaneous equation bias when the OLS method is used. Consistent estimates of 4 require the use of the TSLS estimation technique or other methods of simultaneous equation estimation.

Estimates of the Commercial Office Model

Equation 4 was estimated using office market data for Greensboro, North Carolina, a medium–size sunbelt city located roughly midway between Washington, DC and Atlanta. Greensboro is the largest city in the seven–county Greensboro/High Point/Winston–Salem metropolitan area. Originally, a classic southern textile "mill town," Greensboro has undergone substantial structural change since the 1960s. Post–war advances in communication and transportation have made the area attractive to a number of new industries and firms ranging from distribution to financial services. In 1984, the population of Guilford County was estimated at 325,300 and that of the entire MSA to be 886,100.

Greensboro's office market is quite homogeneous. Although there is some variation between the various areas of the city, no distinct "office nodes" exist, so our data avoid the problem of different "classes" of office space sometimes encountered in larger urban areas where "central city" is sharply distinguished from "suburban" office space.

Greensboro is a disbursed city, and it provides an opportunity to study the pattern of commercial office rents that result when firms locate in an area where the traditionally defined central business district (CBD) is no longer the dominant center of economic activity. In recent years, commercial development has shifted to the west out along I–40, which connects Greensboro and Winston–Salem, and to the south along I–85, which runs from Durham to Greensboro and on southwest to Charlotte. The regional airport that serves the entire MSA is located off I–40, about halfway between Greensboro and Winston–Salem. This area increasingly has become a focal point for commercial development.

Data for this study were collected by the Greensboro Planning Department in its 1984 survey of the office market.[2] The Planning Department surveyed every commercial office building in Guilford County, outside the city limits of High Point, that had at least 10,000 square feet of space. The survey obtained usable responses from 66 commercial buildings. The average vacancy rate in these structures was 16.6%.

Using data from the survey, equation 4 was estimated as follows:

$$R_i = f(V_i, D_i, A_i, F_i, C_i, H_i) \tag{5}$$

where

R_i = office rent per square foot in the ith building. This is the approximate rate at which *additional* space can be obtained in the ith building;
V_i = vacancy rate;
D_i = distance from the CBD;
A_i = building age;
F_i = number of floors;
C_i = % of total space devoted to common area;
H_i = location adjacent to major thoroughfare or interstate highway (1 = yes, zero otherwise).

Exhibit 1 shows OLS estimates of the office rent model, using four different functional forms and estimated using the White adjustment for consistent standard errors in the presence of unknown heteroskedasticity [White 1980]. The vacancy rate coefficient is positive, and statistically significant in three of the four equations at the .05 level or better. The positive sign on this coefficient supports the office market model set out in equations 1–4 above.

The age variable is negative and significant, as expected. And the floors variable is positive and significant. The percentage of building space devoted to common areas (a measure of office–park amenities) is not statistically significant in any of the estimated regressions, and indeed has a negative sign consistently.

Distance from the CBD does not appear in Exhibit 1 to exert a significant influence on the pattern of commercial office rents in Greensboro. This is as might be expected given the disbursed nature of Greensboro development (see above). It demonstrates that other considerations beyond agglomeration and transportation economics affect business choices

Exhibit 1
OLS Estimates of Office Rent Model
(*t*-values in parenthesis)

Functional Form	Linear	Semi–Log	Square Root	Log–Linear
Dependent Variable	*R*	*ln*(*R*)	$R^{0.5}$	*ln*(*R*)
Vacancy Rate (*V*)	*2.319	*0.222	*0.553	0.076
	(2.41)	(2.55)	(1.97)	(0.71)
Distance (*D*)	0.011	0.001	0.01	0.013
	(1.75)	(1.57)	(1.35)	(0.85)
Age (*A*)	*−0.086	*−0.008	*−0.140	−*0.164
	(3.66)	(3.65)	(4.86)	(6.33)
Floors (*F*)	*0.456	*0.044	*0.346	*0.218
	(4.26)	(4.29)	(6.55)	(5.68)
% Common Area (*C*)	−3.360	−0.407	−1.194	−0.426
	(1.76)	(1.99)	(1.81)	(1.80)
Highway (*H*)	*−1.309	*−0.144	−*0.184	*−0.117
	(2.02)	(2.06)	(2.01)	(2.04)
Constant	*11.14	*2.489	*3.71	*2.476
	(4.81)	(10.47)	(5.30)	(20.53)
$\bar{R}^2$	0.50	0.54	0.58	0.58
N	66	66	66	66

*Significant at the .05 level (one–tailed test)

of office locations, and, thus, the slope of office rent gradients within any disbursed metropolitan area may be largely an empirical issue.

The shape of the rent gradient estimated here is consistent with the findings for manufacturing rents reported by Schmenner [1981]. He found that the rent gradient for manufacturing in the Cincinnati MSA was essentially flat.

Location adjacent to a major thoroughfare or interstate highway appears to exert a substantial negative effect on office rents. This suggests that noise and congestion effects associated with highway locations override access time considerations.

Although the adjusted R^2 statistics show that over 50% of the variations in the dependent variables are explained by the models—which seems quite descriptive for cross–sectional data on individual buildings—some of the residual variation could no doubt be explained by additional data that unfortunately were not available.

We also posit the following market, vacancy rate equation:

$$V_i = g(R_i, A_i, S_i) \tag{6}$$

where S_i is total space in the building and V_i, R_i, A_i are as defined above.

We expect managers of newer buildings to know less about the relationship between market rents and feasible rental rates for their buildings. Landlords with newer buildings, therefore, may be willing to accept higher vacancy rates in an effort to gather more market information. Accordingly, building age is expected to be negatively associated with the rate of vacancy. Size of the building also is likely to have an effect on the attitude of landlords toward temporary vacancy losses and the trade–off between such losses and more accurate market information. The sign of the size effect, however, is difficult to specify a priori.

Exhibit 2
TSLS Estimates of Office Rent Model
(t-values in parenthesis)

Functional Form	Linear	Semi-Log	Square Root	Log-Linear
Dependent Variable	*R*	*ln*(*R*)	$R^{0.5}$	*ln*(*R*)
Vacancy Rate (*V*)	*2.698	*0.239	0.49	0.099
	(2.85)	(2.77)	(1.45)	(0.46)
Distance (*D*)	0.012	0.001	0.017	0.014
	(1.62)	(1.50)	(1.36)	(0.88)
Age (*A*)	* −0.085	* −0.008	* −0.141	* −0.163
	(3.65)	(3.64)	(4.79)	(5.49)
Floors (*F*)	*0.452	*0.044	*0.347	*0.219
	(4.26)	(4.24)	(6.50)	(5.75)
% Common Area (*C*)	−3.296	−0.404	−1.210	−0.419
	(1.75)	(1.99)	(1.84)	(1.75)
Highway (*H*)	* −1.301	* −0.144	* −0.183	* −0.118
	(2.02)	(2.06)	(2.00)	(2.03)
Constant	*10.634	*2.467	*3.793	*2.465
	(4.80)	(10.64)	(5.33)	(17.67)
$\bar{R}^2$	0.50	0.49	0.58	0.58
N	66	66	66	66

*Significant at the .05 level (one-tailed test).

Estimates of equation 6 were obtained using both OLS and TSLS. As expected, the level of rents was a positive and significant ($p=.05$, two-tailed test) determinant of building vacancy rates. Building age (A) and size (S) were negatively associated with the rate of vacancy. Size was significant statistically in the TSLS estimates at the .05 level (two-tailed test).

Exhibit 2 presents TSLS estimates of the office rent model that are produced for our system (equations 5 and 6) using total space (S_t) as the instrumental variable. Again the estimates are calculated using the White adjustment for standard error consistency. The coefficient on vacancy rate is positive and significant in two of the four equations at the .05 level. The vacancy coefficient generally is larger in the equations estimated by TSLS than it is in the corresponding OLS equations.

The size and statistical significance of the other variable coefficients are very similar to the OLS results. Building age, number of floors, and highway location are statistically significant determinants of office rents, while distance from the CBD and percent common space are again insignificant.

Calculation of the elasticity of demand for rental office space requires a determination of the proper functional specification of the rent equation. We employed the Box–Cox [1964] analysis of functional form in order to gain some insight into this question (Exhibit 3).

In our application of the Box–Cox analysis, we have limited the range of application of the lambda transformation in order to ease the computation burden of the analysis and also to make the results more understandable. Our approach follows the suggestions of Cassel and Mendelsohn [1985] who recommend that in applying the Box–Cox analysis there may be some reasons to prefer simple elasticity estimates. Cassel and Mendelsohn (p. 135) point out that "...the formal hypothesis testing advantage of the Box–Cox functional form is purchased

Exhibit 3
Box–Cox Test of Functional Form

	Lambda Transformation Applied To:			
	Dependent Variable Only		All Variables	
	Likelihood Function	Accept H_0	Likelihood Function	Accept H_0
$L_{max}(\lambda)$	−125.59	—	−120.64	—
λ	1.4		0.3	
$H_0 : \lambda = 0$ (log):				
$L(\lambda = 0)$	−128.88	reject	−122.52	reject
χ^2	6.58		3.76	
$H_0 : \lambda = 1$ (linear):				
$L(\lambda = 1)$	−125.82	accept	−125.82	reject
χ^2	0.46		10.36	
$H_0 : \lambda = 0.5$ (square root):				
$L(\lambda = 0.5)$	—	—	−120.97	accept
χ^2	—		0.66	

Critical value of χ^2 is 2.71 for a .10 level test.

at the expense of other important goals . . . . In fact, the larger number of coefficients estimated with the Box–Cox functional form reduces the accuracy of any single coefficient."

In Exhibit 3, when the Box–Cox lambda transformation is applied only to the dependent variable (see column 1), we are able to reject the null hypothesis that lambda equals zero, or that the correct functional specification is semi–logarithmic. We are not able to reject the null hypothesis that lambda equals one, that is that the functional specification is linear.

When the lambda transformation is applied simultaneously to all variables in the rent equation (see column 2), we are able to reject the null hypothesis that lambda is zero, leading us to conclude that the correct specification is not double–logarithmic. We also are able to reject the null hypothesis that lambda is one, suggesting similarly that the functional form is not linear. We are unable to reject the null hypotheses that lambda is 0.5. A lambda value of 0.5 suggests a square root specification of the rent equation.

Using the TSLS results shown in Exhibit 2 for the square root specification, the rental demand elasticity calculated at the point of means is −5.3. The corresponding linear specification suggests an elasticity of −4.6.

To properly interpret the elasticity results, we emphasize that the unit of analysis in this study is the actual building, not cities or regions as has been used by other authors. Thus we expect the price elasticity of demand to be very high: other buildings in the same area presumably serve as very close substitutes. Moreover, alternatives to leasing space in the existing buildings included in this study exist. Potential renters may decide to purchase or build their own buildings or locate outside the Greensboro area in another nearby community. The wide availability of vacant sites, the disbursed nature of Greensboro development, and the lack of strong zoning controls on office construction make it rather easy for businesses to build new office structures as alternatives to existing rental space. At the same time, the keen competition among cities all over the nation to attract more office development to their communities assures that any business not tied exclusively to a particular area has abundant alternative location opportunities.

Summary and Conclusion

This paper develops and estimates a cross-sectional model of the market for rental offices in Greensboro, North Carolina using individual office buildings as the unit of analysis and employing appropriate simultaneous equation techniques. Estimates of the model confirm that the simultaneously determined vacancy rate must be included when estimating the rental price of commercial office space.

Estimates of the model further reveal that the demand for office space in a given building is highly elastic due to the presence of close substitutes. This means landlords must be cautious when setting higher rent levels. If they raise the rent and others do not, they may experience a large increase in vacancies. This will place them off their "intended equilibrium," until others raise rents correspondingly, because vacancies will exceed the intended or "natural" rate.

Notes

[1]For a more extensive discussion of the relevant aspects of micro economic theory, including landlord behavior in setting rents and holding inventories, see Shilling, Sirmans and Corgel [1987].

[2]See, City of Greensboro, Department of Planning and Community Development [1985].

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