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Spatial Variation in Office Rents within the Atlanta Region

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Summary. Hedonic office rent models are estimated using data for Atlanta that span the years 1990–96. Controlling for typical building characteristics and lease terms, we find that variables measuring locational differences in wage rates, transport rates and proximity to concentrations of support services and office workers play an important role in explaining spatial variation in office rents. No evidence is found in support of the hypothesis that technological advances in telecommunications have diminished the role played by face-to-face agglomeration economies in determining the intra-metropolitan location of office firms.

1. Introduction

Studies on the determinants of housing prices and rents abound in the literature. In contrast, little evidence exists on the determinants of office rents. The studies that have been done generally focus on the influence of building characteristics, architectural design or leasing provisions on rents, with little, if any, attention paid to locational factors. Among these factors, there is considerable interest by both scholars and practitioners in the roles that transportation infrastructure, labour accessibility and face-to-face agglomeration economies play in explaining the considerable spatial variation in office rents that characterise urban areas.[1]

In recent years, this interest has been heightened by the proposition that the relative importance of the factors that explain locational rents has changed over time as the result of advances in telecommunications technologies. The consensus opinion appears to be that faxes, e-mail, video conferencing and the like have decreased the importance of face-to-face contact, which has allowed cost-minimising firms to take better advantage of the potential wage savings that come from more decentralised locations.

If the new technologies are good substitutes for face-to-face contact, there is concern that this will jeopardise the chief remaining *raison d'être* for the central city. Hence, this issue has played a prominent role in the recent debate over whether cities and suburbs are independent or interdependent with regard to their economic fortunes (Ihlanfeldt, 1995).

The purpose of this paper is to provide evidence on the locational determinants of office rents in the Atlanta region at different points in time. In addition to the use of

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multi-period data, our study is unique in that data from the 1990 Census Transportation Planning Package and variables constructed using a geographical information system have been merged with our sample of office buildings, allowing us to construct direct measures of transport access (i.e. to rail and freeway), proximity to the residential locations of office workers and convenience for face-to-face interaction.

2. Literature Review

We were able to find eight hedonic office rent studies that provide evidence on location as a determinant of office rent. However, four of these studies (Glascock *et al.*, 1990; Mills, 1992a; McDonald, 1993; Wheaton and Torto, 1994) include only a set of dummy variables for sub-market location in the estimated model. Hence, while they all document that location matters to office rents, they provide no evidence on the factors that actually cause the observed variation among places. Our review will focus on the remaining four studies, which do include variables that attempt to explain spatial variation in office rents.

Clapp (1980) used a sample of 105 office buildings located in Los Angeles to regress the quoted annual rental rate per square foot of office space on building characteristics and three locational variables: distance to the CBD, average commute time of the building's workers and square footage of office space within a two-block radius. These variables are all statistically significant at conventional levels with the expected signs. Beta coefficients indicate that the importance of CBD distance is substantially greater than the other two effects. Clapp took his results as supportive of the ideas that office firms are willing to pay a premium for access to face-to-face contacts, especially those within the CBD, and to the residences of employees.

The primary focus of Wheaton's (1984) study was to determine whether inter-jurisdictional differences in property taxes are reflected in office rents. Using Boston data, he regressed rent per square foot on taxes, building characteristics and the following location variables: the number of transit lines within a mile of the building, the number of distinct highways leading in and out of the town in which the building is located, the percentage of households with a college education living in the six closest towns encompassing or surrounding each office building, and the ratio of the complex's square feet to the building's square feet. His results indicate that property tax differentials are not borne by office tenants and that access to workers (as measured by proximity to rail, highways and college-educated people) is an important determinant of office rents. Being part of a larger complex of buildings also has a positive effect on the building's rent. Wheaton suggests that the latter effect may be due to such complexes offering a greater scale of space and better services. Although not mentioned, the complex effect may also be the results of access to face-to-face contacts.

Cannaday and Kang (1984) estimated their hedonic rent equation using 19 office buildings located in Champaign-Urbana, Illinois. Their model included two locational factors: air-line distance in miles between the office building and the nearest shopping centre and air-line distance in miles between the office building and the quadrangle on the University of Illinois campus. Only the latter variable, which the authors suggest defines the focal point of the urban area, is found to have a statistically significant effect on office rents.

The most recent and most comprehensive study of the locational determinants of office rents is by Sivitanidou (1995). By adopting a general equilibrium modelling framework allowing for interactions among the commercial services, land and labour markets, Sivitanidou demonstrates that, in the absence of data on wages (or commuting costs), a completely specified office rent equation must contain three sets of variables: firm amenities that induce productivity effects; utility-bearing worker amenities; and zoning constraints on commercial development. The latter two sets of variables capture the omitted wage effects, since wages are hypothesised to be lower where worker amenities are better and where zoning is more restrictive. Zoning affects wages because smaller commercial centres enable workers to live closer to their jobs. As a result, employers need not pay as much of a compensating differential for commuting costs.

Sitivanidou's empirical model is based on data for 1462 office buildings located in Greater Los Angeles. Firm amenity variables included distance from downtown Los Angeles, the number of interstate freeways passing through the commercial district containing the building, and distance from the closest major airport. The worker amenity variables included the district's crime rate, distance of the centroid of the district from the ocean, retail employment per resident population within the district, and educational expenditure per student by school district. Zoning constraints are represented by a set of proxies for commercial zoning, density limits and growth moratoria. *All* of the above variables are found to be statistically significant at conventional levels with the expected sign.

Our research is distinguished from the above studies by the use of multi-period data and more direct measures of access to face-to-face contacts and the residential locations of office workers. In the next section, the theoretical model which underlies our estimated equations is presented.

3. A Model of Office Rents

Before presenting our model of office rents, it is useful to review the standard theory of office location (Heilbrun, 1987, p. 118). This theory hypothesises that each office firm is heavily dependent on daily face-to-face contact between its own executives and their counterparts in firms with which it deals. These face-to-face meetings are assumed to occur exclusively within the CBD. Hence, a location closer to the CBD centre reduces the travel cost associated with maintaining contact with other firms. Office firms, therefore, are willing to pay a higher rent per unit of floor space closer to the CBD centre. To the extent that advances in telecommunications technology reduce the need for face-to-face meetings, the willingness of firms to pay a premium to be closer to the CBD centre will decline, causing the office rent gradient to be less steeply sloped.

Our model drops the assumption that face-to-face meetings occur exclusively within the CBD. The basic assumption underlying the model is that office firms search the metropolitan area for the location that maximises profit, given the locations of all other activities and households. Location affects profits because input prices are assumed to vary spatially.

All office firms are assumed to be the same and have the following production function:

$$Q = f(OS, K, N, MS, MC), \tag{1}$$

where, Q = output of office services; OS = office space;[2] K = services of depreciable capital assets (for example, office equipment and furniture); N = labour input measured in efficiency units; MS = face-to-face meetings with suppliers; and MC = face-to-face meetings with customers.

Clapp (1980) was the first to include face-to-face meetings as a necessary input in the production of office services. He assumed that these meetings would occur in both the CBD and a suburban office node. As noted above, our model places no restrictions on where these meetings can occur within the urban area.

The justification for including face-to-face meetings with suppliers as an input is that office firms generally rely heavily on outside suppliers for support services (such as, consulting advice, accounting and bookkeeping needs and legal services), and these services typically must be tailored to meet the diverse needs of each individual client. Face-to-face interaction is assumed to facilitate customisation. Similarly, since many office services are unique to individual buyers, face-to-face meetings with customers may be required throughout the production process to obtain pertinent information that only the customer can provide.

The labour input which enters the production function of office firms is measured in efficiency units. The number of efficiency units per worker is assumed to increase as the distance between the office firm and the locations of office workers employed by other firms decreases, i.e.

$$N = a(\bar{x})L, \tag{2}$$

where, L is the number of man-hours; $(\bar{x})$ is average distance to other firms' workers; and a is the efficiency parameter.

This formulation of the labour input is designed to capture the exchange of ideas, augmentation of human capital, knowledge spillovers and diffusion of technology that come from face-to-face interactions, both formal and informal (i.e. chance encounters), among workers from different firms. The idea that physical proximity affects labour productivity was first emphasised by Jacobs (1969) and has recently resurfaced in the 'new regional economics' literature (Glaeser, 1994). Empirical support for this hypothesis is provided by Ciccone and Hall (1996).[3]

Given equation (1), the cost and profit functions for office services can be expressed as:

$$C = sOS + c(1 + g/r)K + eN + tuMS + tvMC; \tag{3}$$

$$\pi = PQ - C; \tag{4}$$

where, s, c, and P are the prices of office space, capital services and office services respectively; g = property tax rate; r = discount rate that converts capital services into a capital stock; e = cost per efficiency unit of labour; t = rate for transporting employees to external meetings; u = distance between the office location and suppliers of support services; and v = distance between the office location and customers.

Given spatial variation in input prices and demand, the maximisation of profit with respect to office space, labour, capital services and face-to-face meetings yields demand equations for each of these inputs. The demand function for office space at location i can be expressed as:

$$OS_i = f(s_i, g_i, w_i, t_i, u_i, v_i, x_i, R_i) \tag{5}$$

where, R_i represents expected revenue; w_i is the wage rate; and the other variables are as previously defined.

Assuming constant returns to scale and a perfectly competitive market for office services, the inversion of equation (5) yields the equilibrium bid-rent function:

$$s_i = f(g_i, w_i, t_i, u_i, v_i, x_i) \tag{6}$$

An inverse relationship is expected to exist between s_i and each of its hypothesised determinants.

4. Empirical Methodology

Our data came from Jamison Research, Inc., the major firm in Atlanta that tracks the office market. Quoted annual rental rates per square foot of office space for a sample of buildings located in the Atlanta region were provided for three periods: the fourth quarter of 1990, the third quarter of 1994 and the first quarter of 1996.[4] The sample of buildings for each year ranges from 658 to 907. The pooled sample represents an unbalanced panel, since most, but not all, of the same buildings appear in all three quarterly samples. The data provide a complete physical description of each building and its address. A geographical information system (ARC-INFO) was used to assign each building to a census tract and the traffic analysis zone. This system was also employed to compute the linear distances between each building and the nearest MARTA train station, the nearest freeway interchange and Five Points. Five Points is an intersection in downtown Atlanta that represents the centre of the central business district.

The determinants of office rents are investigated by regressing the quoted annual rate per square foot of office space in an individual building on sets of explanatory variables that describe the location, typical leasing provisions and physical characteristics of the building.[5] Our theoretical model suggests that property tax rates, wage rates and physical accessibility to suppliers, customers and other office workers should enter the empirical model as locational determinants. The choice of which building characteristics to include is based on the findings of previous studies. Each explanatory variable is described below. Table 1 lists our data sources and provides a definition of each independent variable. Mean and standard deviation for all variables are reported in the Appendix.

Property tax rates. Within the study area there are 79 local government jurisdictions (69 municipalities and 10 counties serving unincorporated areas). TAXRATE was constructed by assigning a property tax rate to each building in accordance with its location within a jurisdiction. The property tax in Atlanta is levied on land and improvements, and on depreciable capital assets. Nominal tax rates vary across jurisdictions but the same rate is applied to the value of all taxable property within each jurisdiction. In this study, only nominal property tax rate information was available for all jurisdictions. However, Georgia law mandates that taxable property be assessed at 40 per cent of market value throughout the state. Once a year, the state conducts an assessment ratio study of each local jurisdiction to assure compliance with the law. Hence, nominal tax rates and effective tax rates should be closely aligned.

Wage rates. Labour costs comprise the largest single component of operating costs for office firms (Hamer, 1974). Consequently, intra-metropolitan variation in wage rates should be a significant determinant of office rents. While information on wage rates by location was not available, both theory and existing empirical evidence indicate that within metro areas wage rates are directly related to workers' commuting costs (Zax, 1991; Ihlanfeldt, 1992) and inversely related to utility-enhancing attributes of the work location (Rees and Schultz, 1970).

To estimate the commuting costs of workers employed within a particular office building, the proximity of sites within the building's tract to the residential locations of office workers was measured using a gravity variable:

$$PROCOM_i = PRES_i/d_i^2 + \sum PRES_j/d_{ij}^2$$

where, $PRES_i$ = number of workers employed in executive, and professional specialty occupations living in tracts i, j; d_{ij} = linear distance between the centres of tracts i, j; and d_i = average distance between centre of tract i and all points in tract i. A separate gravity variable (CLERCOM) is used to measure the building's proximity to clerical workers.[6]

Four variables are included to measure attributes of the work location that enter worker's utility functions (and therefore affect the wages that firms must pay): whether the building is near a shopping mall (MALL); the concentration of blue-collar workers employed in the tract (BLUE); the percentage of the tract's population that is black (PCTBLACK); and the median household income of the tract (TRACTINC). MALL is a measure of the availability of shopping amenities to the building's workers. BLUE is included because industrial areas are expected to provide less-desirable work environments due to pollution, noise and negative sight externalities. Boehm and Ihlanfeldt (1991) have shown that PCT-BLACK and TRACTINC are correlated with perceptions of neighbourhood quality and therefore may capture other dimensions of the neighbourhood environment (for example, perceived personal security) not reflected by the other variables.

Distances to suppliers, customers and other office workers. Our theoretical model suggests that the office building's distances to suppliers of support services, customers of office services and the office workers of other firms should affect the rent that office space users are willing to pay, because shorter distances enable face-to-face exchanges to occur at lower cost, holding transport rates constant. We could not separately measure each of these distances; and even if

Table 1. Variable definitions and data sources

Variable	Definition	Data source
TOTSQFT	Total building square feet	Jamison
FLOORS	Number of floors	Jamison
FLRSQFT	Average square feet per floor	Jamison
MTLF	Multiple tenant loss factor	Jamison
COMPLEX	Building part of complex, yes = 1	Jamison
PARK	Building has parking, yes = 1	Jamison
PARKDECK	Covered/deck parking, yes = 1	Jamison
AGE	Building age in years	Jamison
CLASSA	Class A building, yes = 1	Jamison
NET	Offered lease is net, yes = 1	Jamison
EXPSTOP	Lease contains a stop clause, yes = 1	Jamison
ESCAL	Escalation factor in asking rent, yes = 1	Jamison
BANK	Building contains a bank, yes = 1	Jamison
CONFER	Building has a conference room, yes = 1	Jamison
EAT	Building has a restaurant, yes = 1	Jamison
CLUB	Building has a health club, yes = 1	Jamison
YR90	Year is 1990, yes = 1	Computed
YR96	Year is 1996, yes = 1	Computed
DIST5PTS	Linear distance to Five Points	Geographical information system
NDIST	DIST5PTS if building is north, otherwise = 0	Geographical information system

SDIST	DIST5PTS if building is south, otherwise = 0	Geographical information system
HWY1MI	Highway interchange within 1 mile of building, yes = 1	Geographical information system
MARTAQTR	Building within a quarter-mile of MARTA, yes = 1	Geographical information system
TAXRATE	Millage rate on property	Georgia Department of Revenue
TRACTINC	Median household income of census tract	Census Tape STF3A
PCTBLACK	Percentage of tract population black	Census Tape STF3A
MALL	Building near a shopping mall, yes = 1	Jamison
BLUE1	Blue-collar jobs in tract/Total blue-collar jobs in tract	Census Transportation Planning Package
BLUE2	Blue-collar jobs in tract/Total blue-collar jobs in region	Census Transportation Planning Package
SERVICE1	Tract employment in FIRE, business and repair services, and other professional services/Total tract employment	Census Transportation Planning Package
SERVICE2	Tract employment in FIRE business and repair services, and other professional services/Regional employment in these industries	Census Transportation Planning Package
CLER1	Clerical jobs in tract/Total jobs in tract	Census Transportation Planning Package
CLER2	Clerical jobs in tract/Clerical jobs in region	Census Transportation Planning Package
PRO1	Executive, managerial, professional jobs in tract/Total jobs in tract	Census Transportation Planning Package
PRO2	Executive, managerial, professional jobs in tract/Regional employment in these occupations	Census Transportation Planning Package
HHIND	Herfendahl–Hirschman index of industry concentration in tract	Census Transportation Planning Package
CLERCOM	Gravity variable measuring building proximity to residential locations of clerical workers	Census Transportation Planning Package
PROCOM	Gravity variable measuring building proximity to residential locations of executive, managerial and professional workers	Census Transportation Planning Package

this was possible, these distances would probably be too collinear to separate out their individual effects. However, in general, all of these distances are expected to be highly correlated with the concentration of office workers within the tract. Separate variables are included measuring the concentration of executive, managerial and professional jobs (PRO) and clerical jobs (CLER) in the tract. To measure separately proximity to office support services, we also included the concentration of employment in office service industries within the tract (SERVICE).

In addition to the concentration of office employment in the tract, the industrial diversity of the firms located in the tract may influence labour productivity. One view, which Glaeser *et al.* (1992) attribute to the *Marshall–Arrow–Romer externality*, suggests that knowledge spillovers among nearby firms are facilitated if these firms are members of the same or related industry. Another view is embodied in Jacob's (1969) theory of urban growth. She emphasises that greater variety of industries within a geographical area promotes knowledge externalities, innovative activity and creativity. As a measure of industrial diversity, we employed an index based on the Herfindahl–Hirschman concentration index (HHIND). The percentage of employment within a census tract of each of 18 industries was squared and summed to arrive at the index.

Transport rates. In addition to distances, transport rates affect the cost of conducting face-to-face meetings. To measure differences across locations in transport rates, two variables are used: MARTAQTR is a dummy variable indicating whether the office building is within one quarter of a mile of a MARTA train station and HWY1MI is a dummy variable indicating whether the building is within a mile of a highway interchange.[7]

A number of the explanatory variables described above measure concentration within the census tract. Concentration is a relative concept that can be measured using alternative benchmarks. For example, the concentration of professional and managerial employment in the tract can be measured either as the proportion of total tract employment represented by these workers or as the proportion of total regional employment in these occupations falling within the tract. We argue that the measures of manufacturing concentration and service concentration should be relative to the base of employment within the census tract, while professional and clerical concentrations should be relative to the employment within the entire region. The manufacturing variable (BLUE) represents a disamenity of the census tract. If manufacturing is a large portion of the employment within the tract, the tract is an undesirable office location, even if the manufacturing employment is small relative to the region. Similarly, regardless of how much of the region's employment is located within the tract, if the tract's industry mix favours firms in office-serving industries, the location should be desirable to office firms. PRO and CLER, on the other hand, attempt to capture the building's physical proximity to the work locations of other office workers. These variables, therefore, should be measured relative to regional totals. However, while we believe these arguments are reasonable, we do not find them compelling. Therefore, each of the tract concentration measures (BLUE, SERVICE, PRO, CLER) was alternatively constructed using total tract employment and total regional employment (appropriately defined) as the benchmark.

Since the data span a six-year time-interval, an effort was made to update 1990 variable values for 1994 and 1996. Since millage rates were available for each year, TAXRATE is the nominal tax rate of the jurisdiction that contained the building in the year that asking rent was observed. BLUE, SERVICE, CLER, PRO, CLERCOM and PROCOM were updated using the annual census tract population and employment (by one-digit industry) estimates of the Atlanta Regional Commission[8]. Variables that could not be updated include TRACTINC, PCTBLACK and HHIND.

Building characteristics and lease provisions. An extensive set of building characteristics was available. Our chosen variables (see Table 1) represent a composite of those included in previously estimated hedonic office rent models. Leasing provisions include whether the offered lease is net (NET), whether the lease contains a stop clause (EXPSTOP) and whether there is an escalation factor in asking rent (ESCAL).[9]

5. Results

Three sets of regression models were estimated:

(1) simple rental gradient models that included building characteristics, leasing provisions and distance to the centre of the CBD as explanatory variables but none of the other locational variables;
(2) fully specified models including the entire set of locational variables that restricted the estimated location coefficients to be the same over time; and
(3) fully specified models that allowed the estimated coefficients on selected location variables to vary over time.

We employed generalised least-squares estimation to efficiently estimate models using the imbalanced panel of buildings.[10] The variance of the residual was allowed to vary over each of the three years, as were the three combinations of co-variances between years. Both linear and log-linear models were estimated. Because results were highly similar between the two functional forms, only the coefficients obtained from the linear models are reported below.[11]

Simple Models

As noted above, the standard theory of office location hypothesises a negatively sloped gradient between office rent per square foot of floor space and distance from the CBD centre. The implication can also be drawn that this gradient has flattened over time in response to technological changes that have reduced the necessity for face-to-face meetings and transport costs. Previously estimated hedonic office rent models have consistently found support for the first hypothesis (Clapp, 1980; Hough and Kratz, 1983; Sivitanidou, 1995), but absence of data has precluded an investigation of whether office rent gradients have flattened over time.

Table 2 reports the results obtained from estimating office rent gradients for the Atlanta region using 'simple' models (i.e. models including distance to the CBD centre but none of the other locational variables). Consider first column A, which reports the results obtained from regressing asking rent per square foot of office space on building characteristics, lease provisions and distance to the CBD centre. With few exceptions, the estimated coefficients on the building characteristics have the correct sign and are statistically significant. Rents are higher for buildings with greater total square footage, more floors, higher average square feet per floor, a greater multi-tenant loss factor, a parking deck, a conference room and a health club. Newer buildings and those designated as Class A office space also command higher rents. Only COMPLEX behaves contrary to expectations. Space in buildings that are part of a complex rents for less, which is opposite to the findings of Wheaton (1984). The estimated coefficients on the variables specifying leasing provisions (NET, EXPSTOP and ESCAL) are all highly significant with the anticipated signs.

The large *t*-statistic for the estimated coefficient on DIST5PTS indicates that an office rent gradient exists within the region, but its slope is *positive* not negative as predicted by the standard theory of office location. However, the gradient is quite flat. Rent per square foot of office space rises by only 3.5 cents with each additional mile from the CBD centre.

Column B presents the results from estimating a model that allows the rent gradient to differ between the north and south sides of the region. These two areas are markedly different. In comparison to the south side, the north side of the city and the northern suburbs are much more affluent and contain far

Table 2. Simple model results (standard errors in parentheses)

Variable name	Model A	Model B	Model C	Model D
CONSTANT	11.069102**	10.905620**	11.097816**	10.909757**
	(0.313703)	(0.312565)	(0.330681)	(0.329711)
TOTSQFT	0.000002**	0.000002**	0.000002**	0.000002**
	(0.000001)	(0.000001)	(0.000001)	(0.000001)
FLOORS	0.060150**	0.060307**	0.059395**	0.059306**
	(0.019385)	(0.019198)	(0.019353)	(0.019154)
FLRSQFT	0.000015**	0.000014**	0.000015**	0.000014**
	(0.000005)	(0.000005)	(0.000005)	(0.000005)
FLRMIS†	−0.286782	−0.258701	−0.271750	−0.255175
	(0.292080)	(0.290114)	(0.292317)	(0.290439)
MTLF	0.137126**	0.131595**	0.136225**	0.130284**
	(0.011325)	(0.011270)	(0.011322)	(0.011266)
MTLFMIS†	2.130899**	2.234561**	2.129446**	2.222053**
	(0.512709)	(0.511381)	(0.512985)	(0.511589)
COMPLEX	−0.690472**	−0.769520**	−0.681431**	−0.763997**
	(0.242934)	(0.240664)	(0.242954)	(0.240473)
PARK	−0.038062	−0.013586	−0.036818	−0.005329
	(0.159939)	(0.158719)	(0.159776)	(0.158576)
PARKDECK	1.189216**	1.209552**	1.180551**	1.202865**
	(0.209262)	(0.207125)	(0.209469)	(0.207150)
AGE	−0.030701**	−0.029107**	−0.031398**	−0.029647**
	(0.004867)	(0.004836)	(0.004862)	(0.004828)
AGEMIS†	−0.447549	−0.399770	−0.452201	−0.403772
	(0.344789)	(0.343458)	(0.344000)	(0.342421)
CLASSA	3.106492**	3.152989**	3.129653**	3.181199**
	(0.218855)	(0.216691)	(0.219091)	(0.216818)
NET	−1.489527**	−1.503705**	−1.498166**	−1.519202**
	(0.195821)	(0.194521)	(0.195701)	(0.194351)
EXPSTOP	1.393267**	1.468278**	1.394036**	1.478447**
	(0.206443)	(0.205469)	(0.206262)	(0.205211)
ESCAL	0.294395**	0.321480**	0.293236**	0.325317**
	(0.144289)	(0.143200)	(0.144237)	(0.143074)
BANK	−0.081226	−0.044917	−0.097561	−0.053389
	(0.236571)	(0.234046)	(0.236394)	(0.233745)

CONFER	0.229252	0.255631	0.245403	0.276909
	(0.181592)	(0.179595)	(0.181693)	(0.179651)
EAT	−0.010448	0.017276	−0.030486	0.004626
	(0.244030)	(0.241371)	(0.243920)	(0.241140)
CLUB	0.755176**	0.620527**	0.755399**	0.603557**
	(0.230919)	(0.229437)	(0.230856)	(0.229583)
YR90	0.720509**	0.707699**	1.159903**	1.178755**
	(0.104160)	(0.103831)	(0.214133)	(0.213681)
YR96	0.669005**	0.662718**	0.295477	0.276882
	(0.098170)	(0.097865)	(0.201705)	(0.201208)
DIST5PTS	0.034589**	—	—	—
	(0.012702)			
NDIST	—	0.054122**	—	—
		(0.013018)		
SDIST	—	−0.028985*	—	—
		(0.016524)		
DIST90	—	—	−0.007038	—
			(0.016025)	
DIST94	—	—	0.033625**	—
			(0.016027)	
DIST96	—	—	0.068891**	—
			(0.015233)	
NDIST90	—	—	—	0.011330
				(0.016277)
NDIST94	—	—	—	0.053625**
				(0.016390)
NDIST96	—	—	—	0.092185**
				(0.015668)
SDIST90	—	—	—	−0.077971**
				(0.024990)
SDIST94	—	—	—	−0.020985
				(0.022344)
SDIST96	—	—	—	−0.006789
				(0.021747)
Total R^2	0.626318	0.632998	0.627680	0.634688

** = significant at the 5 per cent level.
* = significant at the 10 per cent level.
† = These variables are indicators representing missing values for the corresponding variables: FLOORS, MTLF and AGE.

fewer black residents (Hartshorn and Ihlanfeldt, 1993). Moreover, employment suburbanisation has been strongly biased in favour of the northside. The share of the region's jobs located in the northern suburbs grew from 40 per cent in 1980 to 52 per cent in 1990. The southern suburb's share of the region's jobs declined over the decade from 20 to 19 per cent. This disparate growth suggests that the office rental gradient may vary with direction from the CBD centre. The estimated coefficient on SDIST is negative and statistically significant (at the 5 per cent level by a one-tailed-test), while the coefficient on NDIST is positive and highly significant. The difference in the gradients is statistically significant at the 1 per cent level. Once again, the size of the coefficients indicates that both of these gradients are very flat.

Columns C and D allow the slopes of rental gradients to differ across the three time-periods included in our data. The single gradient results (column C) reveal that there was no gradient in 1990 and an increasingly positive gradient from then on. The north–south gradient results (column D) show that the northside gradient was positive at all three points in time and became steeper over the six-year period. Intertemporal differences are all significant at the 5 per cent level. The southside gradient, on the other hand, was negative throughout the period, but became flatter over time. The 1990 gradient is statistically different from the 1994 and 1996 gradients, but the latter two gradients are not statistically different from one another. The magnitudes of the changes in the northside and southside gradients are non-trivial. The gradient going north increased from 1.1 cents per mile in 1990 to 9.2 cents per mile in 1996. The south gradient changed from −7.8 cents per mile in 1990 to −0.7 cents per mile in 1996.

The dramatic changes that have occurred in Atlanta's office rent gradients over the relatively short span of time represented by our data indicate that there have been strong locational shifts in the demand for office space within the region. Office space demand within the CBD and the rest of the central city has declined relative to the demand within the inner suburbs. These results are consistent with the notion that advances in telecommunications have reduced the office firm's dependance on access to face-to-face meetings within the CBD. There are, however, other factors that may account for the observed changes in Atlanta's office rent gradients. Many of these factors are included in our fully specified models, to which we now turn.

Full Model

Results obtained from estimating models which include the full set of locational variables are reported in Table 3.[12] The three columns of this table differ in the benchmarks used to construct the census tract concentration measures. Column A measures blue-collar (BLUE1) and support services (SERVICE1) concentration relative to total tract employment, while the concentration of office workers in the tract (CLER2, PRO2) is measured relative to total regional employment. In addition to being our preferred specification for the reasons outlined in section 4, using a combination of benchmarks has the advantage of reducing some of the collinearity among our census tract variables. In column B, concentration is measured for all four variables relative to regional totals (BLUE2, SERVICE2, CLER2, PRO2), while in column C the benchmark is the tract total (BLUE1, SERVICE1, CLER1, PRO1).

In addition to the estimated GLS coefficients and their standard errors, the beta coefficient is reported for each explanatory variable. The beta coefficients measure the change in office rent in standard deviation units for a unit change in the explanatory variable in standard deviation units. As such, they facilitate comparisons in the relative effects of our independent variables, which are measured in widely different units.

Consider first the results in column A. We expected that adding the full set of locational variables to the estimated hedonic equation

Table 3. Full model results (standard errors in parentheses, with beta coefficients beneath)

Variable	Model A	Model B	Model C
CONSTANT	5.992385** (0.784291) 0.000000	6.793746** (0.785335) 0.000000	5.454412** (0.827365) 0.000000
TOTSQFT	0.000003** (0.000001) 0.100972	0.000003** (0.000001) 0.105770	0.000002** (0.000001) 0.076827
FLOORS	0.063881** (0.019214) 0.108957	0.058893** (0.019210) 0.100449	0.081200** (0.018794) 0.138497
FLRSQFT	0.000014** (0.000005) 0.041711	0.000015** (0.000005) 0.044479	0.000013** (0.000005) 0.040298
FLRMIS	− 0.445803 (0.277325) − 0.022190	− 0.417820 (0.276503) − 0.020797	− 0.405665 (0.277222) − 0.020192
MTLF	0.102171** (0.011025) 0.159887	0.099358** (0.011047) 0.155484	0.106354** (0.010883) 0.166432
MTLFMIS	2.032350** (0.494083) 0.048027	2.076260** (0.490649) 0.049065	1.944312** (0.495388) 0.045947
COMPLEX	− 0.878927** (0.227007) − 0.062548	− 0.814644** (0.227147) − 0.057974	− 0.843858** (0.226550) − 0.060053
PARK	− 0.000790 (0.153508) − 0.000069	− 0.015457 (0.153072) − 0.001341	− 0.022505 (0.152785) − 0.001953
PARKDECK	0.848338** (0.199856) 0.081875	0.915664** (0.200141) 0.088372	0.882230** (0.198859) 0.085146
AGE	− 0.025164** (0.004947) − 0.088800	− 0.027861** (0.004933) − 0.098317	− 0.022314** (0.004832) − 0.078743
AGEMIS	− 0.119942 (0.332187) − 0.004234	− 0.124240 (0.330431) − 0.004386	− 0.277359 (0.332077) − 0.009791
CLASSA	3.243118** (0.205876) 0.308688	3.191298** (0.205890) 0.303756	3.160308** (0.205004) 0.300806
NET	− 1.388645** (0.188128) − 0.162815	− 1.444106** (0.187124) − 0.169318	− 1.268451** (0.188800) − 0.148723
EXPSTOP	1.397052** (0.197691) 0.161674	1.430915** (0.196905) 0.165593	1.329168** (0.198239) 0.153818
ESCAL	0.252032* (0.137202) (0.024663	0.318992** (0.136508) 0.031215	0.246543* (0.137175) 0.024126
BANK	− 0.109801 (0.222863) − 0.009044	− 0.202666 (0.223335) − 0.016693	0.010392 (0.223240) 0.000856
CONFER	0.174214 (0.169852) 0.017143	0.210123 (0.169607) 0.020677	0.169129 (0.170041) 0.016643

Table 3. *Continued.*

Variable	Model A	Model B	Model C
EAT	0.009886	−0.022796	−0.008267
	(0.226753)	(0.227210)	(0.226396)
	0.000770	−0.001776	−0.000644
CLUB	0.486908**	0.468724**	0.481053**
	(0.218835)	(0.218990)	(0.218409)
	0.041063	0.039529	0.040569
YR90	0.835543**	0.708572**	0.792243**
	(0.105616)	(0.101757)	(0.106226)
	0.089261	0.075697	0.084635
YR96	0.558038**	0.643163**	0.567132**
	(0.097950)	(0.095248)	(0.097691)
	0.060207	0.069391	0.061188
NDIST	0.120051**	0.114488**	0.112002**
	(0.019442)	(0.019483)	(0.019197)
	0.174363	0.166284	0.162673
SDIST	0.080874**	0.072760**	0.070718**
	(0.022354)	(0.022160)	(0.022646)
	0.074077	0.066645	0.064775
HWY1MI	0.335675**	0.281657*	0.337441**
	(0.154843)	(0.155536)	(0.153049)
	0.037293	0.031292	0.037489
MARTAQTR	−0.954539**	−0.986678**	−0.805227**
	(0.247891)	(0.247745)	(0.242947)
	−0.071081	−0.073474	−0.059962
TAXRATE	0.022501**	0.016227	0.020280*
	(0.010934)	(0.010957)	(0.010770)
	0.038300	0.027620	0.034519
TRACTINC	0.000019**	0.000020**	0.000008
	(0.000005)	(0.000005)	(0.000005)
	0.081346	0.085345	0.031457
PCTBLACK	0.157478	0.146542	−0.062047
	(0.428604)	(0.424869)	(0.420888)
	0.008011	0.007454	−0.003156
MALL	0.564783**	0.525944**	0.591846**
	(0.185818)	(0.186006)	(0.183950)
	0.049229	0.045844	0.051588
BLUE1	−0.896931**	—	−0.750850*
	(0.408016)		(0.413046)
	−0.026369		−0.022075
SERVICE1	3.684840**	—	3.101020**
	(0.608367)		(0.616967)
	0.086339		0.072659
BLUE2	—	−38.378621**	—
		(12.476057)	
		−0.039250	
SERVICE2	—	114.956621**	—
		(14.560886)	
		0.339539	
HHIND	4.046841**	5.600434**	4.328007**
	(1.236873)	(1.211736)	(1.243438)
	0.044385	0.061424	0.047469
CLRCOM	−0.000237**	−0.000249**	−0.000307**
	(0.000078)	(0.000077)	(0.000077)
	−0.120306	−0.126444	−0.155584

Table 3. *Continued.*

Variable	Model A	Model B	Model C
CLER2	− 93.295293**	− 140.618434**	—
	(0.000078)	(39.45034)	
	− 0.120306	− 0.362454	
CLER1	—	—	2.342651
			(1.520758)
			0.024687
PROCOM	0.000180**	0.000197**	0.000175**
	(0.000034)	(0.000034)	(0.000034)
	0.219003	0.239236	0.213112
PRO2	123.676177**	62.638623*	—
	(37.892229)	(37.406448)	
	0.320873	0.162513	
PRO1	—	—	3.875013**
			(0.903801)
			0.068506
TOTAL R^2	0.675163	0.677382	0.674612

** = significant at the 5 per cent level.
* = significant at the 10 per cent level.

would cause the estimated gradients to flatten substantially, if not completely disappear. Instead, both the northside and southside gradient become more steeply positively sloped. This suggests that there are locational variables that are correlated with distance from the CBD centre that are missing from our model. Judging from media accounts and the concerns raised by public officials and business managers in hearing and other forums, these variables may well be the personal security perceptions of office workers and their harassment by street people. In recent years, both crime and panhandling have become rampant within the City of Atlanta, especially within the CBD.[13]

The variables we were able to include that measure the attractiveness of the work location all behave much as expected. TRACTINC, MALL and BLUE1 all have the right signs and are highly significant. The effect of PCTBLACK, however, is insignificant.

In addition to the work milieu, the commutes of office workers are expected to affect the wages that office firms must pay their workers. As expected, the estimated coefficient on PROCOM is positive and highly significant and the beta coefficients indicate that PROCOM is one of the strongest predictors of office rent. However, the estimated coefficient on CLERCOM is negative and also highly significant. A possible explanation for the contrary results for CLERCOM starts with the recognition that professional and clerical labour generally reside in different neighbourhoods. This fact, combined with the higher cost executives and professionals place on their commuting time, suggests that office firms may be attracted to upper-income neighbourhoods and away from neighbourhoods where clerical workers reside in order to minimise total labour costs. It is interesting to note that both Ihlanfeldt and Raper (1990) and Long (1984) found that new office firms tend to locate near the homes of professional workers and away from neighbourhoods with high concentrations of clerical workers. There are therefore precedents for our results.

Perhaps of greatest interest are the results obtained with the variables that measure convenience for face-to-face meetings. Concentrations of professional workers (PRO2) and workers employed in industries that provide services (SERVICE1) to office firms have strong positive effects on office rents. The beta coefficients indicate that these variables are among the strongest predictors of office rents. In fact, PRO2 has the largest beta coefficient of all of the variables included in the model, including the building characteristics.[14] Higher concentrations of clerical workers, on the other hand, are found to reduce rents. A possible explanation for this result is that while having more people in the tract facilitates face-to-face meetings, it also creates congestion. In the case of professional workers, the first effect is likely to be dominant, while for clerical workers the second effect may dominate.

Our measure of the industrial diversity of the tract (HHIND) has a positive and highly significant effect on office rents. Since higher values of HHIND are associated with less diversity, the results suggest that office firms prefer tracts with high levels of employment in just a few industries. Such an environment may be more conducive to knowledge spillovers among firms as suggested by Glaeser *et al.* (1992). Alteratively, there may simply be localisation economies that reduce the costs of intermediate inputs that are specific to the firms in particular or related industries.

The final location variables are those that measure transport rates (HWY1MI, MARTAQTR) and differences in the rate of property taxation across buildings (TAXRATE). Proximity to a highway interchange has a positive effect on office rents, while being within walking distance of a MARTA train station reduces rents. Both effects are statistically significant at the 5 per cent level. The failure of MARTA to increase rents is consistent with the recent findings of Bollinger and Ihlanfeldt (forthcoming) and Kain (1997). Bollinger and Ihlanfeldt find that MARTA has had no discernible effect on total employment or population in station areas, while Kain has documented that MARTA has had a negligible impact on transit ridership.[15] The negative relationship between MARTA proximity and office rents may stem from the perception that station areas are relatively unsafe (Morehouse Research Institute, 1995). Currently, the rail system lies entirely within only 2 (Fulton and Dekalb) of the 10 counties that constitute the Atlanta region. The failure of other counties to join MARTA (in particular, Cobb and Gwinnett) is commonly attributed to the perceived link between crime and rapid transit (Poister, 1996).

The estimated coefficient on TAXRATE is statistically significant with an unexpected positive sign. Our theoretical model suggests that where property tax rates are high, office users would be willing to pay less rent, because they must pay more tax on their depreciable capital assets. However, interjurisdictional tax differentials on structural capital may positively affect office rents if higher taxes are correlated with valued public services or if office firms are less than perfectly mobile[16].

The results from the equations that exclusively utilise either regional totals (column B) or tract totals (column C) in the construction of the tract concentration variables are qualitatively highly similar to those reported in column A. The story we have told based on column A would change very little if we had focused instead on either column B or column C. The results are therefore robust with respect to alternative measurement of the concentration variables.

Trends in Effects

To investigate whether certain effects have changed over the six-year time-span covered by our data, we allowed the estimated coefficients on SERVICE1, PRO2, PROCOM, NDIST and SDIST to vary over time in our preferred model (Table 4). Our interest in SERVICE and PRO stems from one of the primary questions motivating our research; namely, have advances in telecommunications weakened the importance of convenience for face-to-face meetings as a determinant of office rents. Intertemporal changes in the estimated effects of PROCOM are of interest, since the growth of telecommuting may have lessened compensations for commuting costs. The distance gradients are allowed to vary to determine whether the intertemporal shifts observed in

Table 4. Full model with time effects

Variable name	Coefficient	Standard error	Beta coefficient
CONSTANT	5.547056**	0.853278	—
TOTSQFT	0.000003**	0.000001	0.095671
FLOORS	0.063594**	0.019073	0.108468
FLRSQFT	0.000014**	0.000005	0.042928
FLRMIS	− 0.445839	0.274898	− 0.022192
MTLF	0.101867**	0.010973	0.15941
MTLFMIS	2.027038**	0.488939	0.047902
COMPLEX	− 0.847831**	0.225602	− 0.060335
PARK	− 0.008196	0.152116	− 0.000711
PARKDECK	0.86547**	0.199158	0.083528
AGE	− 0.025422**	0.004911	− 0.08971
AGEMIS	− 0.122472	0.328353	− 0.004323
CLASSA	3.241438**	0.204503	0.308528
NET	− 1.41288**	0.186534	− 0.165656
EXPSTOP	1.419441**	0.195921	0.164265
ESCAL	0.272575**	0.136058	0.026673
BANK	− 0.080981	0.221332	− 0.00667
CONFER	0.198208	0.168762	0.019505
EAT	0.011651	0.225125	0.000908
CLUB	0.484221**	0.217548	0.040836
YR90	2.051918**	0.66633	0.219206
YR96	1.339948**	0.595787	0.144568
NDIST90	0.058839**	0.024137	0.076933
NDIST94	0.154949**	0.023589	0.229636
NDIST96	0.127897**	0.022239	0.167798
SDIST90	0.015193	0.034291	0.006697
SDIST94	0.129065**	0.031076	0.085205
SDIST96	0.064406**	0.028917	0.031907
HWY1MI	0.234163	0.154672	0.026015
MARTAQTR	− 0.964457**	0.246426	− 0.07182
TAXRATE	0.019193*	0.010917	0.032668
TRACTINC	0.000021**	0.000005	0.086386
PCTBLACK	0.23968	0.42613	0.012192
MALL	0.556789**	0.184623	0.048532
BLUE1	− 1.449614**	0.422079	− 0.042618
SERVICE1–90	4.433349**	1.1286	0.104653
SERVICE1–94	1.254236	0.857657	0.03735
SERVICE1–96	3.817474**	0.712821	0.120825
HHIND	4.95955**	1.268581	0.054395
CLRCOM	− 0.000227**	0.000078	− 0.115235
CLER2	− 82.085236**	37.501234	− 0.21158
PROCOM90	0.000162**	0.000038	0.206337
PROCOM94	0.000218**	0.000036	0.319743
PROCOM96	0.00016**	0.000037	0.223544
PRO2–90	107.70109**	37.914181	0.202786
PRO2–94	134.250883**	38.264565	0.26023
PRO2–96	98.535**	38.217241	0.188509
R-squared	0.68		

** = significant at the 5 per cent level.
* = significant at the 10 per cent level.

the simple models also apply to the full model.

Taking up the latter issue first, both the northside and the southside gradients became more positively sloped between 1990 and 1994. These differences are significant at the 1 per cent level. Between 1994 and 1996, both gradients flattened somewhat, but neither of these changes is statistically significant. These results are therefore consistent with those obtained from the simple models and reinforce the conclusion that some unobserved factor (or factors) has increased the demand for office space in buildings farther out from the centre relative to space located closer in.

The estimated coefficient on SERVICE1 falls between 1990 and 1994, and then rises between 1994 and 1996. The estimated coefficient on PRO2 rises between 1990 and 1994, and then comes back down between 1994 and 1996. While these patterns are somewhat puzzling, the estimated coefficients for 1990 and 1996 are similar in magnitude for both variables and the differences between these years do not come close to being statistically significant. The evidence therefore is not supportive of the idea that telecommunications have diminished the role played by convenience for face-to-face interaction in determining office rents.

Finally, the estimated coefficients on PROCOM are similar across years and have not significantly differed between 1990 and 1996. There is, therefore, also no evidence that telecommunications have diminished the importance of commuting costs as a determinant of office rents.[17]

6. Conclusions

This study has provided considerable evidence on the factors that influence spatial variation in office rents. Controlling for typical building characteristics and lease terms, we find that variables measuring locational differences in wage rates, transport rates and proximity to concentrations of support services and office workers all affect rents in a reasonable fashion. These results provide strong confirmation of our theoretical model.

Of particular significance are the findings that relate to agglomeration economies. In the case of office activities, face-to-face contact between the firm's employees and its customers, suppliers and the professional and managerial employees of other offices is believed to be a fundamental element of agglomeration economies, especially among geographers and planners (Clapp, 1993). Our results provide the first hard evidence that convenience for face-to-face meetings is an important determinant of office rent. In fact, we find that this factor is among the most important predictors of locational differences in office rent.

In recent years, rapid technological advances in telecommunications have caused some scholars to argue that convenience for face-to-face interaction is becoming less important to office activities (Pascal, 1987; Webber, 1968). Other scholars (Clapp, 1993; Mills, 1992b; Downs, 1994) have been critical of this argument and have made various counter-arguments suggesting that faxes, e-mail and even video-conferencing are poor substitutes for the face-to-face transmission of information. Both our cross-sectional and intertemporal evidence provide no support for the idea that telecommunications have diminished the importance that office firms place on face-to-face agglomeration economies. Of course, it may be the case that our data cover too short a time-span or it may simply be too early to capture the full impact of changing technology. Nevertheless, the years represented were a time when considerable evolution occurred in office communications.

Our results also have a bearing on the debate over whether central cities and suburbs are independent or inter-dependent with regard to their economic fortunes (Ihlanfeldt, 1995). As part of this debate, a number of scholars have argued that central cities pay a unique and important role in the regional economy because face-to-face agglomeration economies stimulate economic growth and these economies are maximised within central cities (Persky *et al.* 1991). Our data indicate that the mean values of PRO2 in 1990 were 0.041, 0.010 and 0.009 for office firms located in the CBD, the rest of the central city and the suburbs, respectively. The values for 1996 show little change (0.038, 0.010, 0.009). The evidence, therefore, is consistent with the idea that agglomeration economies are maximised within the CBD. However, we did not find that office rents were higher in the CBD in comparison to the rest of the region. In fact, just the opposite was found. In Atlanta, it appears to be the case that the advantage the city has in providing convenience for face-to-face exchange is more than offset by negative attributes of the work locations that force employers to pay higher wages. Unfortunately, we were not able to document this fully because the alleged disamenities (perceptions of crime and harassment) are difficult to measure. Nevertheless, we are in the process of gathering data that will allow us to investigate the relationship between crime rates and office rents in the next phase of our research.

Notes

1. Wheaton and Torto (1994) estimated hedonic office rent equations for 36 metropolitan areas. For San Francisco they found a 38 per cent range in rents across sub-market locations, after controlling for building type and lease terms. Regarding the results for the other MSAs, they concluded that "The locational variation is noticeably larger in Washington and in several other large, older markets. In larger, but newer markets (such as Denver and Houston), the locational variation is less and tends to be around 25–30 per cent" (Wheaton and Torto, 1994, p. 130, fn 1).
2. Since the focus is on locational variation in office rents, office space is treated as an undifferentiated input. In our empirical model, office space is standardised by including an extensive set of building characteristics among the independent variables.
3. Ciccone and Hall (1996) use data on gross state output and find that a doubling of employment density increases average labour productivity by around 6 per cent. Their results suggest that more than half of the variance of output per worker across states can be explained by differences in the density of economic activity.
4. The Atlanta Region includes the central city and the counties comprising the inner suburbs of the Atlanta MSA. The region represents the planning area of the Atlanta Regional Commission. The region accounted for 83 per cent and 90 per cent of the MSA's population and employment in 1990, respectively.
5. As Mills (1992a) has noted, theoretically the dependent variable in hedonic office rent equations should be an estimate of the present value of all of the payments under the lease, rather than base rent. However, operationally he found that asking rents as the dependent variable produced similar and equally plausible coefficients to use of the present value of the lease as the dependent variable.
6. These variables give equal weight to workers living a given distance away from tract centres regardless of whether or not they are located inside or outside the tract. The distance exponent (2) is based on the experimentation with alternative exponents conducted by Ihlanfeldt and Raper (1990), who used variables analogous to PROCOM and CLERCOM to explain the locational choices of new office firms in Atlanta.
7. A quarter mile (2.5 blocks) is used as the radius of the MARTA impact area because this is commonly defined as a reasonable walking distance (Bernick and Carroll, 1991; Cervero, 1994; Untermann, 1984).
8. A complete description of ARC's methodology can be found in any of their annual employment and population reports (for example, *Employment 1995, Population 1995*, Atlanta Regional Commission, 1996).
9. A net lease requires that the tenant pays some costs that are paid by the landlord under a gross lease, generally real estate taxes, insurance and operating costs. A stop clause specifies the maximum amount of costs the landlord will pay.
10. The GLS estimates used the residuals from a first-stage regression to estimate the variance-co-variance matrix for observations in time on each building. There are potentially six unique elements to this matrix if a building is observed in all three time-periods: the variance for each time-period (three unique terms) and the co-variance between each time-period. This allows for time-varying heteroskedasticity and time-varying autocorrelation for each building.

11. The signs and significance levels of the explanatory variables were almost identical between the two functional forms as were their explanatory power.
12. Tests for spatial autocorrelation were performed for these models. The Cliff–Ord test was utilised (Cliff and Ord, 1981; Anselin, 1980). The test statistic is constructed as an asymptotic standard normal deviate (Burridge, 1980; Cressie, 1993). All test statistics are below the usual 1.96 rejection value, which suggests that spatial correlation has not biased our estimated standard errors.
13. In recognition of these problems, business improvement districts have recently been established within the city that are patrolled by 'ambassadors' who possess direct communication with the police. In addition, anti-begging and 'urban-capping' ordinances were recently approved by the Atlanta City Council.
14. It is possible that we have overestimated the true effects of PRO2 and SERVICE1 on office rents. For example, a locational characteristic may be missing from our estimated equations that office users find attractive, which would both increase rent and cause greater concentration of office workers within the tract. While this *caveat* deserves mention, it is by no means clear what variable we might have overlooked that is positively correlated with both rent and worker concentration. We believe that the relative homogeneity of Atlanta's landscape (for example, no major *rivers, lakes, mountains or parks* exist within the city) mitigates this concern.
15. According to Kain (1997), transit ridership, as measured by linked trips, was only 2.5 per cent higher in 1993 in comparison to 1979, the year before Atlanta initiated rail service.
16. Due to data limitations, measures of local public services are excluded from our estimated models. In Georgia, there is no state office that collects data on municipal expenditures. While these data are available from the Census of Governments, this Census is conducted only every five years. Moreover, expenditures per capita are generally unreliable measures of services directly produced and the latter may be unrelated to the output of primary interest to the citizen-consumer (Bradford *et al.*, 1969).
17. We also estimated separate equations by year and equations that permitted all of the variables other than the building characteristics to have different effects by year. While the reductions in sample size/degrees of freedom cause fewer of our variables to be statistically significant, none of our conclusions is altered by these results.

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Appendix

Table A1. Means and standard deviations of variables: pooled sample ($N = 2246$)

Variable	Sample mean	Sample standard deviation
RENT	14.050	4.260
TOTSQFT	108714.000	161229.000
FLOORS	5.450	7.270
FLRSQFT	15806.000	12868.000
MTLF	7.270	6.670
COMPLEX	0.102	0.303
PARK	0.837	0.370
PARKDECK	0.215	0.411
AGE	19.140	15.030
CLASSA	0.207	0.406
NET	0.522	0.500
EXPSTOP	0.417	0.493
ESCAL	0.776	0.417
BANK	0.144	0.351
CONFER	0.228	0.419
EAT	0.126	0.332
CLUB	0.152	0.359
YR90	0.293	0.455
YR96	0.303	0.460
DIST5PTS	10.870	5.760
NDIST	9.841	6.189
SDIST	1.034	3.903
HWY1MI	0.661	0.473
MARTAQTR	0.114	0.317
TAXRATE	41.200	7.250
TRACTINC	40566.000	17823.000
PCTBLACK	0.179	0.217
MALL	0.165	0.371
BLUE1	0.104	0.125
BLUE2	0.004	0.004
SERVICE1	0.229	0.100
SERVICE2	0.012	0.013
CLER1	0.200	0.045
CLER2	0.011	0.011
PRO1	0.370	0.075
PRO2	0.011	0.011
HHIND	0.122	0.047
CLERCOM	4661.000	2162.000
PROCOM	10794.000	5185.000