HOW CRITICAL IS A GOOD LOCATION TO A REGIONAL SHOPPING CENTER?

★ AMERICAN REAL ESTATE SOCIETY (ARES)

1996 ICSC Research Best Paper Award

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Overview

The goal of this paper is to measure empirically the consumer utility trade-off between store location (i.e. distance to a shopping center) and retail agglomeration in regional shopping centers. Using the Lakshmanan and Hansen retail expenditure model, our findings reveal that the distance specification is of surprisingly little importance in explaining retail sales. Conversely, agglomeration economies were of significant importance in explaining consumer patronage at regional shopping centers. The implication of these results is that smaller regional shopping centers may be dominated by large super-regional shopping centers with the smaller one or two anchor regional shopping centers unable to compete with the larger, many-anchored super-regional shopping centers.

■ Introduction

This paper uses the Lakshmanan and Hansen (1965) retail gravity model to estimate sales for a sample of regional shopping centers located throughout the United States. Then we proceed to use these estimates as an explanatory variable in a least-squares regression to predict actual sales for each center. The explained variance of this equation tells how important center size and proximity to competition are to the overall success of a regional shopping center. A high explained variance would indicate that center size and proximity to the competition are key determinants of the overall success of these centers, while a low explained variance would indicate that other factors like store mix, retailer pricing policies and merchandise quality are relatively more important in explaining aggregate retail sales in regional shopping centers.

The theoretical literature in this area has gone in two directions.[1] The first, pioneered by Losch (1954), focuses directly on proximity to the competition. The notion is that unless a retailer is selling to customers door-to-door it behooves the retailer to be the first door the customer comes upon when making a purchase (on the theory that consumers shop at the nearest center that carries the desired good). This notion, when combined with the premise that there is a minimum demand necessary for a store to be viable economically, is at the heart of central place theory. The second approach focuses on retail agglomeration and consumer search costs (e.g., Eaton and Lipsey [1979 and 1982]). West, Von Hohenbalken and Kroner (1985) develop a model of consumer search behavior that combines the insights of Eaton and Lipsey (1979 and 1982) with the idea that similar retailer clustering creates a critical mass of retail space for comparison shopping.[2] In particular, West et al. predict that for certain high-order goods, such as apparel items, agglomeration of similar retailers is both desirable and a necessary condition of market equilibrium.

This paper uses actual retail sales to test the importance of retail agglomeration and proximity to competition to the overall success of a regional shopping center using a retail gravity model. Many applications of the traditional gravity model can be found in the literature,[3] however none of the extant gravity model research uses actual retail sales to test the importance of retail agglomeration and proximity to competition. Thus, these empirical studies of the importance of center size and proximity to competition are limited.

The findings in this paper suggest that actual retail sales at regional shopping centers are largely determined (as measured by R^2) by center size, and to a lesser extent by proximity to competition. These findings are consistent with Gautschi (1981). By measuring the effects of gravity model estimates on actual retail sales, the findings in this paper address an area of the literature that has not been fully developed.

■ Modeling Retail Sales in Regional Shopping Centers

Lakshmanan and Hansen's Retail Gravity Model

To examine the extent to which movement in actual retail sales at each shopping center are related to center size and proximity to competition, first we employ Lakshmanan and Hansen's (1965) retail gravity model to estimate the retail sales potential of regional shopping centers. Then we proceed to use least-squares regression analysis to test the model's "goodness-of-fit."

The theoretical formulation in Lakshmanan and Hansen (1965) differs somewhat from earlier models. Reilly (1931) was among the first to use retail gravity models to predict consumer patronage. Reilly's model suggests that greater shopping center mass (size) increases consumer utility, thus increasing the gravitational pull of a center; and that distance to the center decreases consumer utility, which exponentially decreases the gravitational pull of a center.

Reilly's model has two major limitations: an exponentially increasing distance-decay parameter, which overemphasize travel distance, and a two shopping center specification, which limits store location analysis to two locations. A more flexible model that allows for a less steep distance-decay function and multiple competing shopping centers was proposed by Huff in 1964. Huff's model suggests that the market capture rate of a shopping center is directly related to its mass and inversely related to distance (from the consumer to the center). Additionally, Huff's model includes the possibility of having an unlimited number of competing centers in the market as well as allowing for a varying distance–decay parameter.

Using Huff's model to determine store patronage, Lakshmanan and Hansen (1965) constructed a retail expenditure model to estimate aggregate sales in shopping centers. Lakshmanan and Hansen also broadened the Huff model by allowing for the size of a retail center to vary in importance. Historically, retail gravity models constrained the retail size parameter to one while the distance parameter was allowed to vary. By allowing the shopping center size parameter to be nonlinear, Lakshmanan and Hansen permit researchers greater flexibility in assessing the consumer utility trade-off between distance and size when selecting which shopping center to patronize. The simplicity of the Lakshmanan and Hansen model has been succeeded by more complex mathematical spatial interaction models that are difficult, if not impossible to test empirically.

Specifically, the Lakshmanan and Hansen model estimates aggregate retail sales (R_{ij}) in retail market i for shopping center j as

$$R_{i,j} = Y_i * \frac{\left(\frac{M_j^{\alpha}}{D_{i,j}^{\gamma}}\right)}{\left(\sum_{k=1}^{m} \frac{M_k^{\alpha}}{D_{i,k}^{\beta}}\right)} \tag{1}$$

where M_j is the size (in square feet) of the j^{th} shopping center, D_{ij} is the distance from the i^{th} consumer to the j^{th} shopping center, M_k is the size of the k^{th} shopping center, D_{ik} is the distance between the i^{th} consumer and the k^{th} competing center, Y_i is total retail expenditures in the trade area, and α, β and γ are friction parameters (a low value for α indicates that shopping center size is of little importance and low values for β and γ means that distance is not inhibiting when selecting a shopping center).[4] Equation (1) assumes that consumer patronage, and thus retail expenditures generally, depends on the destination's attractiveness (measured in shopping center square footage) and distance between origin and destination. Equation (1) is simulated using reasonable values for α and β. In equation (1) the γ parameter is constrained to zero. Additionally, consumers are assumed to be equally distributed across the market area, allowing D_{ik} to be defined as the distance between shopping center j and the k^{th} competing center.[5]

Retail Sales Forecasting Model

The most obvious choice to test Lakshmanan and Hansen's (1965) retail gravity model is

$$S_{i,j} = a + bR_{i,j} + \epsilon_{i,j}. \tag{2}$$

where S_{ij} are actual sales in the i^{th} area spent at shopping center j and R_{ij} is from equation (1). The estimation of equation (2) is straightforward using ordinary least-squares. Values of R^2 are then used to measure the variation in S_{ij} explained by the movement in R_{ij}. A high value of R^2 would indicate that shopping center size and location factors are important in explaining the success of regional shopping centers. Likewise, a low value of R^2 would indicate the reverse. Moreover, if Lakshmanan and Hansen's model is unbiased, the null hypothesis, that $a = 0$ and $b = 1$, will not be rejected.

A caveat with the above specification involves the fact that R_{ij} is known to be measured with some error. This means that ordinary least-squares estimates of a and b will be inconsistent; in particular, the least-squares estimate of b will be biased downward.[6] However, this problem is remedied by focusing on the calculation of R^2 (rather than hypothesizing and testing for the existence of an economic relationship between S_{ij} and R_{ij}).

■ Regional Shopping Center Data

To estimate equation (1), we use privately collected data from 38 shopping centers and data from the National Decision System's *Demographic Trend Report*.[7] The competitive centers analyzed were those that fell within a 10-mile radius ring around each regional shopping center in the sample. With the exception of two small regional shopping centers located in non-metropolitan areas, the minimum competitive shopping center size minimum was 400,000 square feet. Exhibit 1 presents a summary of the competitive shopping center data and some socioeconomic

EXHIBIT 1
MEANS, STANDARD DEVIATIONS, MINIMUMS, AND MAXIMUMS FOR COMPETING SHOPPING CENTERS IN A TEN-MILE RADIUS RING OF THE *j* SHOPPING CENTER

	Range			
	Mean	Standard Deviation	Minimum	Maximum
Shopping Center Size (in 000 s.f.)	888	302	234	1,539
Aggregate s.f. Space in 10-Mile Radius Ring (in 000 s.f.)	5,045	2,828	834	11,241
Number of Competing Shopping Centers	5.18	3.22	1	14
Distance to Nearest Competitor (in miles)	2.84	1.98	0.2	6.6
Distance to Furthest Competitor (in miles)	7.67	2.52	2.0	9.9
Aggregate Household Income (in billions)	$10.10	$6.73	$0.99	$29.56

characteristics. A review of the data reveals that: 1) the average competitive regional shopping center size was 888,000 square feet; 2) there were 5.18 competing regional shopping centers within each trade area, with over 5 million square feet of aggregate retail space; 3) the average distance to the nearest regional shopping center was 2.84 miles, with a range from 0.2 to 6.6 miles; and 4) the average aggregate household income in the trade area was $10.1 billion.

To estimate equation (2), we used cross-sectional data on 38 regional shopping centers located throughout the U.S.[8] Exhibit 2 presents some summary statistics for this sample of regional shopping centers. As can be seen, the average non-anchor tenant sales per square foot across these 38 regional shopping centers was $253 in 1990. As importantly, average aggregate shopping center sales were $193,000,000, and average rentable area was 844,000 square feet. [9] Other descriptive data includes an average shopping center age of 19.3 years, an average of

EXHIBIT 2
SAMPLE MEANS, STANDARD DEVIATIONS, MINIMUMS, AND MAXIMUMS FOR *j* SHOPPING CENTER (i.e. the dependent variable)

			Range	
	Mean	Standard Deviation	Minimum	Maximum
Number of Shopping Centers	38	n/a	n/a	n/a
Non-Anchor Tenant Sales per Square Foot	253	72	137	469
Aggregate Shopping Center Sales (in 000,000 of dollars)	193	103	56	520
Total Shopping Center Square Feet (in 000 rentable area)	844	285	337	1,551
Shopping Center Age (years since construction)	19.3	6.4	5	33
Regional Chain Retailers (percent of total non-anchor tenants)	20.6	5.8	7.8	33.0
National Chain Retailers (percent of total non-anchor tenants)	53.9	7.7	39.7	76.0
Average Non-Anchor Space Occupied (square feet in 000)	2.73	0.50	1.96	3.95

74.5% of the center's non-anchor tenants are regional chain stores (10–99 retail outlets) or national chain stores (greater than 99 retail outlets), and the average non-anchor tenant occupies 2,730 square feet of space.

■ Empirical Results

Exhibit 3 presents the results of estimating equation (2). Of primary interest is the explanatory power of the individual equations. In general, the "explained" variation is quite high: the R^2 ranges from 0.59 to 0.73 for a combination of parameter estimates of α between 1.2 and 4.0, and for estimates of β between 0.2 and 0.8. These results are consistent with Gautschi (1981), who used a Huff model to estimate mall-type sales potential and found the distance specification to be small in absolute value. However, the small parameter estimates of β are contrary to the original specifications of Reilly, who used a distance parameter of 2.0. Using a

EXHIBIT 3
EXPLANATORY POWER FOR A RANGE OF DISTANCE AND SIZE SPECIFICATIONS (as measured by R^2)

Size Parameter (α)	Distance Parameter (β)							
	0.0	0.2	0.4	0.6	0.8	1.0	2.0	4.0
0.4	0.422	0.486	0.491	0.468	0.430	0.388	0.253	0.189
0.8	0.585	0.625	0.617	0.577	0.520	0.462	0.281	0.196
1.2	0.644	0.691	0.690	0.651	0.591	0.526	0.311	0.206
1.6	0.653	0.709	0.722	0.696	0.642	0.579	0.342	0.217
2.0	0.644	0.705	0.730	0.718	0.677	0.620	0.372	0.229
2.4	0.629	0.693	0.727	0.727	0.699	0.650	0.402	0.243
2.8	0.615	0.678	0.717	0.727	0.710	0.672	0.429	0.257
3.2	0.601	0.663	0.705	0.722	0.715	0.687	0.456	0.271
3.6	0.588	0.648	0.690	0.713	0.715	0.696	0.480	0.284
4.0	0.580	0.632	0.675	0.702	0.710	0.700	0.504	0.296
5.0	0.546	0.594	0.635	0.666	0.685	0.692	0.559	0.323
10.0	0.450	0.476	0.497	0.516	0.533	0.550	0.623	0.476
20.0	0.405	0.415	0.422	0.427	0.431	0.435	0.476	0.547

Note: If the distance parameter is reduced to 0.0, β becomes 1.0 for all competing centers, which allows us to assess the effects of size without the effect of distance.

2.0 distance parameter estimate, the predictive power of the model is below 50% using reasonable estimates of α (i.e. less than 4.0).

Additionally, the more flexible model presented by Lakshmanan and Hansen that allows α to vary returns some interesting insights. First, the predictive power of the model is consistently strong for values of α between 1.2 and 4.0. Second, the model with the strongest predictive power (73%), maintains an α of 2.0 and a β of 0.4, revealing that consumer patronage decisions are affected more strongly by agglomeration economies than travel distance.

The least-squares parameter estimates along with their standard errors and other relevant data are provided in exhibit 4 for a range of distance specifications. When holding the shopping center size specification to 2.0, we find that the highest predictive power is for distance specifications of less than 1.0 and that the predictive power drops significantly for specifications of β greater than 1.0. For all specifications in exhibits 3 and 4, the Huff variable coefficients are significant at the 95% level.

Next we looked to see whether these results hold when controlling for a variety of shopping center specific characteristics. The list of covariates include shopping center age, retail tenant type, non-anchor tenant average size and shopping center design.[10] Shopping center age is the difference between 1990 (the year of the sales data) and the year the shopping center was built and originally placed in service. Also included in the regression are two variables measuring type of non-anchor tenants in the center: one for the percent of non-anchor tenants that maintain a regional chain of stores, and one for the percent of national chain non-anchor tenants. Non-anchor tenant average size is the average size in square feet of the non-anchor tenants in the shopping center. Finally, three binary variables are included in the regression to control for center design: one each for "I" shaped, "T" shaped and "X" shaped designs. The missing design variable was the "L" shape. Additionally, R_{ij} was estimated using $\alpha = 2.0$ and $\beta = 0.4$, the parameter estimates for shopping center size and distance parameters.

The results of the fully-specified model (see exhibit 5) are similar to those reported in exhibit 3, except for the increased fit. The predictive power of fully-specified model increased to 86.4% from 73.0% with several variables maintaining significant t-ratios. Of most importance to this study is R_{ij} which maintained a positive sign and statistical significance at the 95% level. Additionally, the coefficient estimate for R_{ij} was stable at 34.73 for the fully specified model relative to the 36.80 reported in exhibit 4, indicating robustness of statistical estimation. Shopping center age was negative indicating that older centers have lower aggregate sales; however, the variable was highly insignificant. The regional chain store

EXHIBIT 4
LEAST-SQUARES ESTIMATION RESULTS FOR A RANGE OF DISTANCE SPECIFICATIONS[a]
(Standard Errors in Parentheses)

	$\beta = 0.0$	$\beta = 0.2$	$\beta = 0.4$	$\beta = 0.6$	$\beta = 0.8$	$\beta = 1.0$	$\beta = 2.0$	$\beta = 4.0$
Constant	98.1	87.7	81.8	80.78	84.0	90.0	112.0	140.0
	(62.9)	(58.2)	(54.7)	(55.9)	(59.9)	(65.0)	(83.5)	(92.5)
R_{ij}	46.8	42.1	36.8	31.3	26.3	22.0	11.1	7.3
	(5.8)	(4.5)	(3.7)	(3.3)	(3.0)	(2.9)	(2.4)	(2.2)
R-Squared	64.4%	70.5%	73.0%	71.8%	67.7%	62.0%	37.2%	22.9%
Number of Observations	38	38	38	38	38	38	38	38

[a] The shopping center size parameter, α, remained constant at 2.0.

EXHIBIT 5
ORDINARY LEAST-SQUARES ESTIMATE RESULTS FOR THE FULLY-SPECIFIED MODEL

Variable	Coefficient	t-Ratio
Constant	253.04	2.90
R_{ij}	34.73	10.30
Shopping Center Age	−0.082	−0.06
Regional Chain Tenancy	221.5	1.49
National Chain Tenancy	−237.4	−2.21
Average Non-Anchor Tenant S.F.	−40.41	−2.33
"I" Shape	28.92	1.22
"T" Shape	41.57	1.61
"X" Shape	35.55	1.51
R^2		86.4%

variable was positive and insignificant at the 95% level, while national chain store variable was negative and significant. The negative coefficient sign on the national chain store variable was not expected. The negative sign of the national chain store variable may be attributable to national chain stores occupying more square feet than their local and regional counterparts. Average square feet per non-anchor tenant, as expected, was negative and significant. Finally, shopping center design variables were positive and insignificant.

While the findings reported in Exhibits 3–5 give us some sense of the predictive power and robustness of R_{ij}, these results reveal little of the magnitude of R_{ij}. The effect of changes in competitive shopping center size and distance to competitors on estimated shopping center sales is reported in Exhibit 6. Sensitivity analysis results use the least-squares model that yielded the highest predictive power, which maintained an $\alpha = 2.0$ and a $\beta = 0.4$. To measure the effects of a change in the size of competitive shopping centers, distance to competitive shopping centers, and aggregate household income on sales per square foot at center *j*, we use a series of assumptions that are reflective of the average shopping center.

Overall, it is interesting that the effect of changes in competitive shopping center size is the only parameter that maintained a significant effect on shopping center *j*. Additionally, because $\alpha > 1$ and $\beta < 1$, a 20% change in the size of competitive shopping centers is asymmetric. The impact of a change in competitive shopping center size can be seen in exhibit 6. A decrease in competitive shopping center size of 20% increases center *j* sales by 30% to 40% depending on the size of shopping

EXHIBIT 6
ESTIMATED SHOPPING CENTER SALES PER SQUARE FOOT BASED ON A CHANGING SET OF COMPETITIVE AND SOCIOECONOMIC VARIABLES
(percentage change in sales per square foot in parenthesis)

Shopping Center *j* Size (000 s.f.)	Base Case[a]	Competitive Shopping Centers Decrease 20% in Size	Competitive Shopping Centers Increase 20% in Size	Distance to Competitive Shopping Centers Increase 20%	Distance to Competitive Shopping Centers Decreases 20%	Aggregate Household Income Increases 20%	Aggregate Household Income Decreases 20%
800	212	275	178	221	202	235	190
		(30%)	(−16%)	(4%)	(−5%)	(11%)	(−10%)
1,000	220	297	178	231	206	247	192
		(35%)	(−19%)	(5%)	(−6%)	(12%)	(−13%)
1,200	233	327	183	248	217	267	201
		(40%)	(−21%)	(6%)	(−7%)	(15%)	(−14%)

[a] The base case analysis uses $\alpha = 2$ and $\beta = 0.4$ which maintained the best R-squared, 0.730. Parameter estimates for this model were a = 81,764 and b = 0.036791. Approximations for variable averages or actual averages were used to estimate expected sales per square foot. As the average 10-mile radius ring around a shopping center includes 5.18 regional shopping centers with 887,684 square feet per center, each of five competing shopping centers were assumed to have 1,000,000 square feet. Finally, the average minimum (maximum) distance between shopping center *j* and closest the competing shopping center was 2.84 (7.67) miles, therefore, the distance between the center *j* and the competing shopping centers was assumed to be 3.0, 4.0, 5.0, 6.0, and 7.0 miles for the estimates above.

center *j* (i.e. 800,000, 1,000,000, or 1,200,000 square feet). Conversely, a 20% increase in size of competitive shopping centers reduces center *j* sales by 16% to 21%. Since $\beta < 1$, the effect of a 20% change in the distance to competitive shopping centers is asymmetric in the opposite direction of α. A 20% increase in the distance to competing shopping centers increases center *j* sales less than a 20% decline in the distance to competing centers. In contrast, changing aggregate household income by 20% has a greater effect on larger shopping centers than smaller shopping centers. In summary, it is clear from Exhibit 6 that distance to competing shopping centers maintains a surprisingly small effect on shopping center *j* sales, while the effect of changing mass of competing centers has a large impact on shopping center *j* sales.

■ Implications

Our results generally suggest that retail gravity models are able to explain approximately 70% of the variation in actual retail sales at regional shopping centers. While these results are based on a relatively small sample of regional shopping centers located throughout the United States, we find these results important for the following reasons.

First, in Reilly's original gravity model, he suggests that the drawing power of a shopping center varied directly with size of the center and inversely with the square of the distance traveled. By squaring the distance parameter, Reilly believed that distance to a shopping center was of greater significance than shopping center size in determining store patronage. Our findings suggest the contrary. We find little relationship between actual retail sales at center *j* and the distance between the center *j* and its competition. In fact, the explanatory power of our model is highest for values of β that are less than 1.0, indicating that the distance parameter for most gravity models may be significantly overstated. Therefore it follows that size of the center (relative to its competition) may be a much better determinant of the overall success of the center than the center's relative location to competing centers in the trade area.

Second, given the importance of center size, our findings would imply that the dominant shopping center in a market area should be able to draw a disproportionate market share, significantly reducing the sales at smaller surrounding centers. The sensitivity to center size is borne out by the analysis presented in Exhibit 6. If competitive centers are decreased by 20% in size, center *j* can expect a 30% to 40% increase in retail sales. Meanwhile, adjusting either the distance to the competition or aggregate household income has a much more muted effect.

■ Notes

1. For a review of the central place literature see Craig, Ghosh and McLafferty (1984) and Eppli and Bejamin (1994); for a review of the retail agglomeration literature see Brown (1989).

2. The notion of similar retailer agglomeration is built on the theoretical explanations forwarded by Hotelling in his classic 1929 article. Hotelling's model shows that two competing firms selling a similar product will tend to agglomerate at the center of the market. Detractors at that time argued that the clustering of homogeneous retailers was socially wasteful and economically unstable for retailers since there is a doubling of economic effort.

3. See LaLonde (1962), Dent (1978), Ellwood (1954), Lakshmanan and Hansen (1965), Pankhurst and Roe (1978), Turner and Cole (1980) and Okoruwa, Nourse and Terza (1996).

4. The measurement of Y_i requires that we have data on total retail expenditures within the trade area. Unfortunately, we do not have this data. Aggregate household income is used as a proxy of total retail expenditures.

5. Constraining γ to zero and assuming that customers are evenly distributed across the market area are based on limitations of the data. Ideally, data that allow for the testing of consumer patronage decisions at location *i* to shopping center j and to competing centers at k locations would be preferable. Unfortunately, we do not have access to such data at the current time.

6. Maddala (1988) describes the nature and direction of this bias.

7. Detailed data are maintained on 54 regional shopping centers, however, data from National Decision Systems on 16 of these centers were not available.

8. For a complete discussion of the data, see Eppli and Shilling (1996).

9. Anchor tenant sales were not available for many shopping centers, while non-anchor sales were available for all centers. Anchor tenant sales were estimated to be 77% of non-anchor tenant sales based on the comparative sales data presented by the Urban Land Institute (1990).

10. We are thankful to the anonymous reviewer who suggested that we control for several shopping center specific factors to allow for a more accurate assessment of the effects of R_{ij}.

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Acknowledgment

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