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Office Rent Premiums With Respect To Distance From Light Rail Transit Stations In Dallas And Denver

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Citation Details

Nelson, Arthur C.; Eskic, Dejan; Ganning, Joanna P.; Hamidi, Shima; Petheram, Susan J.; Liu, Jenny H.; and Ewing, Reid, "Office Rent Premiums With Respect To Distance From Light Rail Transit Stations In Dallas And Denver" (2015). *Urban Studies and Planning Faculty Publications and Presentations*. 128.
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1 **OFFICE RENT PREMIUMS WITH RESPECT TO DISTANCE FROM LIGHT RAIL**
2 **TRANSIT STATIONS IN DALLAS AND DENVER**

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43 Words: 3934
44 Tables: 3
45 Figures: 1

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Abstract

It seems an article-of-faith that real estate markets respond more favorably to location within one-half mile of transit stations. Planning and public decision-makers have thus drawn half-mile (or smaller) circles around rail transit stations assuming larger planning areas would not be supported by the evidence. Recent research, however, has shown market-responsiveness well beyond one-half mile. We contribute to this literature by evaluating the distance-decay function of office rents in metropolitan Dallas and Denver with respect to light rail transit (LRT) station distance. Using a quadratic transformation of distance we find office rent premiums extending in the range of two miles away from LRT stations with half the premium dissipating at about two-thirds on one mile and three quarters dissipating at about one mile. We offer planning and policy implications including the need to expand LRT station planning areas, perhaps considerably.

Introduction

Almost all forms of transportation have an economic development function as they connect people and/or goods from an origin to a destination usually in an economic exchange (1). Transportation systems can lead to agglomeration economies in certain industries by reducing the time and distance between them, their labor force, and markets (2, 3). Those economies can lead to higher population and employment densities that can increase overall economic activity (4, 5). Agglomeration economies combined with increasing population and employment density can tax highways, however, leading to congestion, reduced productivity, and ultimately diseconomies associated with agglomeration. A key role of transit is to mitigate transportation congestion effects of agglomeration. Voith (6) characterizes public transit as essentially “noncongestible” and is best suited to sustaining agglomeration economies in downtowns and secondary activity centers, and along the corridors that connect them. Nonetheless, not all economic sectors benefit from agglomeration economies and/or density.

There is a growing body of research showing that rail-based public transit enhances economic development (7, 8, 1). These economies are facilitated when they improve accessibility between people and their destinations by reducing travel time relative to alternatives. At the metropolitan scale, adding transit modes in built-up urban areas increases aggregate economic activity (9).

Economic development can be measured in many ways. A key way is by evaluating how the real estate market responds to the presence of transportation investments, such as rail systems. Higher property values closer to stations implies market capitalization of economic benefits. There are numerous studies assessing the market premium associated with residential property (10, 11, 12). As Ko and Cao (13) point out, however, there are fewer studies associating rail benefits with respect to nonresidential property values. We help close this gap in literature.

We begin with a literature review. We follow with a review of the role of hedonic analysis in uncovering important relationships transit accessibility and nonresidential property values. We identify two large metropolitan areas, Dallas and Denver, as reasonable candidates for hedonic analysis. Next, we present our research design, model, data, and variables. This is followed by results and implications.

93 **1. The role of hedonic analysis in estimating market responsiveness to transit**

94 Based on work by Iacono and Levinson (14) we are grateful to Ko and Cao (13) for observing
95 that previous studies into economic outcomes associated with rail transit used meta-analysis of
96 transit premiums, benefit-cost analysis, and production functions. We are also grateful to both
97 sets of authors for making the claim, which we accept, that hedonic pricing models are the most
98 appropriate for estimating the real estate market's willingness to pay for accessibility to rail
99 transit service. The reason is that the hedonic model decomposes goods (such as homes) that are
100 bundles of individual attributes (such as house size, lot size, bedrooms, bathrooms, neighborhood
101 location and so forth) into implicit prices for each of the attributes, pioneered by Rosen (15).
102 Therefore, the value of a property is the summation of implicit prices for the characteristics
103 associated with the property, such as location and structural attributes.

104
105 Hedonic real estate property analysis has thus emerged as a key way in which to assess market
106 responsiveness to public transit investments (16). A key reason hedonic modeling has gained in
107 popularity is the increasing availability of data that can be collected at a small scale, such as
108 specific properties, combined with the ability to measure distances from a parcel to discrete
109 places such as downtowns, suburban centers, and transportation facilities. Hedonic analysis is
110 also objective. Unlike contingent valuation and stated preference surveys wherein respondents
111 assign values to attributes under varying degrees of controls, hedonic analysis estimates the
112 revealed preferences of those attributes through marginal valuation techniques – mostly
113 multivariate regression analysis. We refer readers to Bartholomew and Ewing (16) for their
114 detailed review of literature on the role of hedonic analysis in estimating market responsiveness
115 to transit.

116
117 Bartholomew and Ewing also synthesize literature and key findings from dozens of studies
118 estimating the market's willingness to pay for transit accessibility. However, nearly all of the
119 studies they reviewed were of single family residential and occasionally multifamily rental
120 property sales. The reason is that to be statistically reliable and valid, a large number of cases are
121 needed for regression techniques to estimate the variation in the willingness of consumers to pay
122 more for specific property attributes (such as a larger home) even if at a declining rate (the next
123 square foot of a home is usually not as valuable as the last one). While local property assessor
124 data bases are large, many unfortunately do not provide reliable property valuation data. Many
125 researchers thus seek access to actual sales prices of properties and their attributes.

126
127 The data needs of hedonic analysis thus often work against applying this technique to
128 nonresidential properties. For one thing, there are far fewer nonresidential than residential
129 properties. For another, while the principal market purpose of residential properties is to house
130 people, nonresidential properties serve very different market purposes such as offices, retail,
131 hospitality, health, and industry among others. Moreover, acquiring sales data for a sufficient
132 number of nonresidential cases with which to conduct hedonic analysis is often difficult. It is for
133 these reasons and others that the number of hedonic studies of nonresidential properties with
134 respect to transit accessibility are far fewer than for residential property.

135
136 We are indebted to a recent review of the relevant nonresidential property hedonic literature by
137 Ko and Cao (13) both identifying these and other limitations, and reviewing results of the
138 relatively few studies applying hedonic regression analysis to nonresidential property.

139
140 For instance, while many studies find a negative relationship between rail transit distance and
141 sales prices of nonresidential properties, most studies show positive relationships (17, 18, 19,
142 20), about as many others find positive associations (21, 22, 23, 24, 25). Reasons for negative
143 outcomes may be unsafe surroundings at rail transit stations or poor accessibility to destinations
144 on-foot after disembarking. In their assessment of all studies reported to the middle 2000s,
145 Debrezion, Pels, and Rietveld (10) summarized a range of property value impacts from -62
146 percent to 145 percent within and beyond one-quarter mile of rail transit stations with an average
147 impact of about 16 percent.

148
149 One limitation of many of the earlier studies is using discrete distance bands around stations,
150 such as using binary variables to note whether a property was within one-half mile of a station or
151 not (1,0). In citing Weinberger's work (25), Ko and Cao argue that measuring continuous
152 distance from stations allows analysts to determine the slope of a distance gradient. Further, if a
153 nonlinear function is used, especially a quadratic transformation of the station-distance variable,
154 the outward extent to which station proximity confers value can be estimated (26, 27, 28).

155
156 For their part, Ko and Cao developed hedonic valuation models to assess the implicit value of
157 office and industrial properties within one-mile buffers of the Hiawatha LRT stations based on
158 sales data of such properties sold before and after the line was completed. They find that the LRT
159 line confers significant price premiums for office and industrial properties to about 0.9 miles
160 from LRT stations, or just about the full extent of their study area.

161
162 Our paper contributes to the literature in ways that both confirm and confound prior work.

163 164 **2. Metropolitan Dallas and Denver study areas**

165 We extend work of others including Ko and Cao by evaluating the office rent premium
166 associated with light rail transit station proximity in metropolitan Dallas and Denver. We chose
167 those systems for four reasons. First, they are among the oldest LRT systems in the US. The
168 Dallas Area Rapid Transit (DART) system began LRT service in 1996 while metropolitan
169 Denver's Regional Transportation District began operating its FasTracks LRT in 1994. Only
170 Portland's (1986), Sacramento's (1987) and San Diego's (1981) LRT systems are older.

171
172 Second, unlike Portland, Sacramento and San Diego, DART and FasTracks serve metropolitan
173 areas that are largely sprawling metropolises undeterred by terrain (the Rocky Mountains are
174 scores of miles away from downtown Denver) and policy (neither explicitly contains urban
175 development).

176
177 Third, they are among the nation's largest LRT systems. In 2012, DART had 60 stations and
178 nearly 100,000 daily passengers while FasTracks had 46 stations and nearly 90,000 daily
179 passengers.

180
181 Fourth, their sheer size allow for sufficient data on office rents to undertake hedonic analysis (as
182 we discuss below).

183
184

185 **3. Research design, model, data and variables**

186 Our study area is five miles within all LRT stations open or under construction in metropolitan
187 Dallas and Denver in fall 2012. It is thus the largest study area of any study of its kind. We
188 employ the following hedonic model in our analysis:

189
190 $R_i = f(B_i, S_i, C_i, L_i)$

191
192 where:

193
194 R is the market rent per square foot for property *i*;

195
196 B is the set of building attributes of property *i*;

197
198 S is the set of socioeconomic characteristics of the vicinity of property *i*;

199
200 C is a composite measure of urban form of the vicinity of property *i*; and

201
202 L is a set of location attributes of property *i*.

203
204 Our dependent variable, R or rent per square foot, and independent variables comprising B,
205 building attributes, come from CoStar, with permission. Through proprietary access during fall
206 2012, we were able to collect an inventory of all office buildings within the study area including
207 their address, square feet, occupied and vacant space, stories, effective age (by the later of the
208 construction or renovation year), building class (A, B and C), and weighted average contract rent
209 per square foot though we do not have lease terms for individual tenants. These variables
210 include:

- 211
212 Class A
213 Class B
214 Gross Leasable Square Feet
215 Floor Area Ratio (Gross Leasable Square Feet divided by land area)
216 Vacancy Rate
217 Effective Year Built
218 Stories

219
220 Socioeconomic data comes from either the 2010 census (for percent census tract population that
221 is not White non-Hispanic) or the 2012 5-year American Community Survey (for census tract
222 median household income).

223
224 C is a unique variable which measures urban form from most sprawled/diffused/disconnected to
225 most compact/integrated/connected at the level of the census tract. This index places urban
226 sprawl at one end of a continuous scale and compact development at the other. The original
227 index was developed in 2002 for metropolitan areas and counties (29, 30). In a recent study, the
228 compactness indices were refined and updated to 2010 for metropolitan areas, urbanized areas,
229 counties and census tracts and all are posted on a National Institutes of Health website (31).¹ For

¹ <http://gis.cancer.gov/tools/urban-sprawl> Accessed July 28, 2014.

230 census tract indices, Ewing and Hamidi used the same methodology and the same type of
231 variables as in larger area analyses. They extracted principal components from multiple
232 correlated variables using principal component analysis and transformed the first principal
233 component to an index with the mean of 100 and a standard deviation of 25. Because the number
234 of component variables is greater for street accessibility than land-use mix, and greater for land-
235 use mix than development density, the resulting index gives more weight to street accessibility
236 than mix, and to mix than density. This is not unintentional, since the built environment-travel
237 literature suggests that density is the least important of the three D variable types (32). Given that
238 retail land uses that depend especially on accessibility this is an appropriate composite variable
239 to include.

240
241 Finally, L, the set of location variables, measures the distance of the centroid of each parcel to
242 the center of central business district of Dallas or Denver, the nearest entrance onto a limited
243 access highway and its quadratic term, and distance to the nearest LRT station and its quadratic
244 term. Distances are measured in miles.

245
246 About three percent of all office properties in the CoStar data base do not have all data needed
247 for our analysis, mostly as unreported rent per square foot. The Dallas data base includes 812
248 properties comprising about 118 million gross leasable square feet of building while the Denver
249 data base includes 591 properties comprising about 67 million square feet. We believe this is the
250 largest market-based data base for office properties collected and evaluated in the literature for
251 our study purposes.

252 253 **4. Results**

254 Table 1 reports results of linear ordinary least squares regression separately for Dallas, Table 2
255 reports results for Denver, and Table 3 reports combined results. For all models, the coefficients
256 of determination are reasonable (all are above 0.50), the correlation matrices (not reported for
257 brevity) did not reveal problematic correlations, and autocorrelation was not detected.

258
259 INSERT TABLE 1 ABOUT HERE

260 INSERT TABLE 2 ABOUT HERE

261 INSERT TABLE 3 ABOUT HERE

262
263 In all regressions, the building structure variables performed reasonably. The difference in rents
264 per square foot between Class A and Class B buildings (with Class C buildings as the referent)
265 was substantial and expected. The incremental size of a building showed small increases in rent
266 suggesting bigger buildings confer slightly more value in the market's willingness to pay
267 (perhaps because they offer additional amenities that smaller building cannot). On the other
268 hand, the number of stories in a building did not change mean rents per square foot statistically
269 (Class A buildings by and large represent tall buildings) while increasing FAR (floor area ratio)
270 is associated with decreasing rent though this is offset with results for building class. Increasing
271 vacancy rates reduced mean rents while decreasing effective age increased rents at the margins.

272
273 The socioeconomic variables had expected results as increasing median household incomes were
274 associated with increasing while increasing shares of population that were not White Non-
275 Hispanic were associated with decreasing rents (although the coefficient in the Dallas regression

276 was not significant).

277

278 The Compactness Index was also positive in all regression equations. While this is a composite
279 variable, it suggests that on the whole the market is willing to pay more for locations that are
280 more densely occupied by jobs and people, more integrated in terms of land use mix, and have
281 well-connected streets compared to other locations.

282

283 The CBD distance location variables performed as expected but, while having the correct signs
284 the variables measuring distance to nearest limited access highways are not statistically
285 significant.

286

287 Of interest to us is the extent to which office rents are affected by proximity to LRT stations and
288 if so how far away. In all equations, the coefficients are significant and have the anticipated
289 signs; that is, as distance from an LRT station increases rents fall (negative coefficient on the
290 distance variable) but at a declining rate (positive sign on the quadratic transformation).

291 Differentiating the coefficients and then setting for zero, we solve for the distance threshold. In
292 the Dallas regression results, we estimate the LRT station effect extends about 1.85 miles; for
293 Denver we estimate the threshold extends about 3.30 miles; and in the regression for the pooled
294 case we estimate the threshold extends about 2.35 miles.

295

296 **5. Implications**

297 Our estimated distance thresholds are much larger than those reported by Ko and Cao. There
298 may be two reasons for this. First, our sample includes only offices while theirs includes
299 industrial properties. We know from prior research that industrial employment around rail transit
300 stations fall over time perhaps because other uses outbid such firms. We wonder what Ko and
301 Cao's results would be if only office properties are used. Second, Ko and Cao measured effects
302 only across the first mile from rail stations. This could have the effect of truncating the statistical
303 results of the quadratic terms to "fit" within this spatial constraint.

304

305 On the other hand, solving for the rent premium effect continuously from zero to the premium
306 threshold, we find that half the premium is lost by the first 0.50 mile, 0.75 mile, and 0.65 mile
307 respectively, and three quarters are lost by the first 0.90 mile, 1.20 mile, and 1.10 mile
308 respectively (see Figure 1). These thresholds are larger than conventional TOD planning practice
309 which is based on the one-half mile circle protocol.

310

311 INSERT FIGURE 1 ABOUT HERE

312

313 This is not to say that people will walk one to three miles to/from LRT stations; they will not.
314 But once disembarked from LRT, some may cycle to their trip end, connect with regularly
315 scheduled bus service with short headways, or use specially-provide intra and inter TOD
316 shuttles.

317

318 Planners and public officials may need to rethink assumptions underlying the half-mile circle.
319 This is consistent with Canepa (33) who argued that combined with good urban design and
320 multiple short-distance alternative modes (such as walking, biking, TOD-serving shuttles) there
321 should be every reason to expect the market premium for land uses near rail transit stations to

322 extend a mile and even well beyond a mile. That the office rent market capitalizes benefits of
323 LRT station proximity so much farther away than previously thought means there are
324 opportunities to maximize those benefits.

325

326 **Acknowledgements**

327 We gratefully acknowledge generous support for research reported in this paper from the
328 National Institute for Transportation and Communities, the Utah Transit Authority, the Wasatch
329 Front Regional Council, the Mountainland Association of Governments, and the University of
330 Arizona. We also give special acknowledgement to CoStar for allowing us to evaluate its
331 proprietary data on market rents for office buildings in the Dallas and Denver study areas. Our
332 views do not necessarily reflect those of our sponsors.

333

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443

444 **Table 1**445 **Hedonic Regression Results for Office Rent Premium with Respect to LRT Station**446 **Distance, Dallas**

Variable	Coefficient	Std Err of Coef.	t-score p
Constant	-56.137	18.623	-3.014 .01
Class A	7.329	0.528	13.869 .01
Class B	2.418	0.405	5.969 .01
Gross Leasable Square Feet	0.000	0.000	1.420 .10
Floor Area Ratio	-0.333	0.079	-4.237 .01
Stories	-0.018	0.041	-0.431
Vacancy Rate	-0.024	0.005	-4.674 .01
Effective Year Built	0.035	0.009	3.689 .01
Median Household Tract Income	0.046	0.005	9.767 .01
Percent Not White Non-Hispanic	0.000	0.010	-0.025
Compactness Index	1.095	0.366	2.995 .01
Distance from CBD, miles	-0.291	0.043	-6.777 .01
Distance from Interchange, miles	-0.133	0.633	-0.211
Square Distance from Interchange, miles	0.322	0.264	1.221
Distance Nearest LRT Station	-0.722	0.400	-1.803 .05
Squared Distance Nearest LRT Station	0.195	0.084	2.324 .01
R Square	0.542	0.533	3.52632
Adjusted R Square	0.533		
Std. Error of the Estimate	3.526		
F	62.779		
Sig. F	0.000		
Observations	811		
Degrees of Freedom	796		
Durbin-Watson	1.710		

447

448 **Table 2**
 449 **Hedonic Regression Results for Office Rent Premium with Respect to LRT Station**
 450 **Distance, Denver**

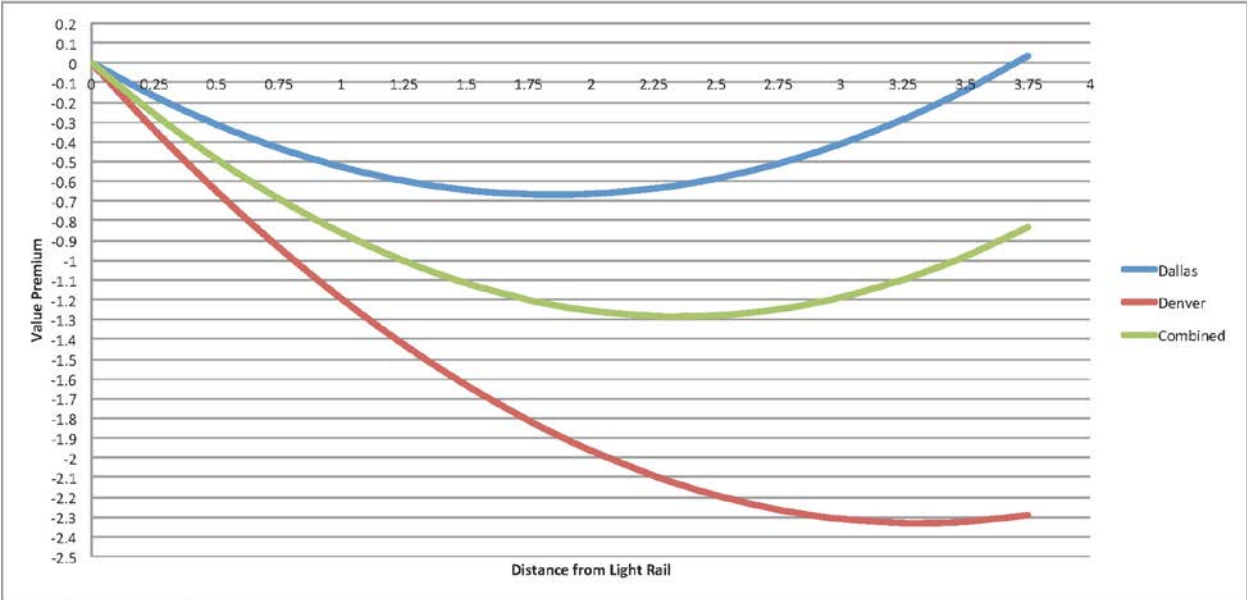
Variable	Coefficient	Std Err of Coef.	t-score p
Constant	7.789	4.194	1.857 .01
Class A	7.859	0.664	11.837 .01
Class B	3.711	0.519	7.153 .01
Gross Building Square Feet	0.000	0.000	1.339 .10
Floor Area Ratio	-0.129	0.071	-1.807 .05
Stories	-0.015	0.061	-0.246
Vacancy Rate	-0.023	0.007	-3.356 .01
Effective Year Built	0.006	0.002	2.712 .01
Median Household Block Group Income	0.023	0.007	3.123 .01
Percent Not White Non-Hispanic	-0.062	0.02	-3.089 .01
Compactness Index	0.146	0.442	0.331
Distance from CBD, miles	-0.453	0.067	-6.811 .01
Distance from Interchange, miles	-1.802	0.778	-2.318 .01
Square Distance from Interchange, miles	0.666	0.265	2.516 .01
Distance from Nearest LRT Station	-1.406	0.531	-2.65 .01
Squared Distance from Nearest LRT	0.212	0.112	1.898 .05
R Square	0.506		
Adjusted R Square	0.494		
Std. Error of the Estimate	3.620		
F	39.343		
sig. F	0.000		
Observations	591		
Degrees of Freedom	575		
Durbin-Watson	1.945		

452 **Table 3**
 453 **Hedonic Regression Results for Office Rent Premium with Respect to LRT Station**
 454 **Distance, Dallas and Denver**
 455

Variable	Coefficient	Std Err of Coef.	t-score p
Constant	0.400	3.971	0.101
Class A	7.929	0.409	19.381 .01
Class B	3.209	0.320	10.025 .01
Gross Building Square Feet	0.000	0.000	0.881
Floor Area Ratio	-0.164	0.051	-3.196 .01
Stories	-0.003	0.034	-0.092
Vacancy Rate	-0.026	0.004	-6.079 .01
Effective Year Built	0.007	0.002	3.372 .01
Median Household Block Group Income, 2010	0.040	0.004	10.091 .01
Percent Not White Non-Hispanic	-0.013	0.009	-1.470 .10
Compactness Index	1.054	0.263	4.008 .01
Distance from CBD, miles	-0.260	0.035	-7.492 .01
Distance from Interchange, miles	-0.148	0.475	-0.311
Square Distance from Interchange, miles	0.123	0.178	0.690
Distance from Nearest LRT Station	-1.092	0.318	-3.432 .01
Squared Distance from Nearest LRT Station	0.232	0.067	3.461 .01
Denver	0.780	0.280	2.789 .01
R Square	0.509		
Adjusted R Square	0.503		
Std. Error of the Estimate	3.643		
F	89.717		
sig. F	0.000		
Observations	1,403		
Degrees of Freedom	1,386		
Durbin-Watson	1.779		

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458
 459 **Figure 1**
 460 **Office Rents with Respect to Light Rail Transit Station Distance**