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

Arthur C. Nelson  
*University of Utah*

Dejan Eskic  
*University of Utah*

Joanna P. Ganning  
*University of Utah*


Shima Hamidi  
*University of Utah*

Susan J. Petheram  
*University of Utah*

*See next page for additional authors*

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**Authors**

Arthur C. Nelson, Dejan Eskic, Joanna P. Ganning, Shima Hamidi, Susan J. Petheram, Jenny H. Liu, and Reid Ewing

1 **OFFICE RENT PREMIUMS WITH RESPECT TO DISTANCE FROM LIGHT RAIL**  
2 **TRANSIT STATIONS IN DALLAS AND DENVER**

3  
4 Arthur C. Nelson (corresponding author)  
5 Professor of Planning and Real Estate Development  
6 College of Architecture, Planning and Landscape Architecture  
7 University of Arizona  
8 Tucson, Arizona 85719  
9 520.621.4004  
10 acnelson@email.arizona.edu

11  
12 Dejan Eskic  
13 Research Analyst, Metropolitan Research Center  
14 University of Utah  
15 Salt Lake City, Utah 84112

16  
17 Joanna P. Ganning  
18 Executive Director, Metropolitan Research Center  
19 University of Utah  
20 Salt Lake City, Utah 84112

21  
22 Shima Hamidi  
23 Doctoral Student and Research Associate, Metropolitan Research Center  
24 University of Utah  
25 Salt Lake City, Utah 84112

26  
27 Susan J. Petheram  
28 Doctoral Student and Research Associate, Metropolitan Research Center  
29 University of Utah  
30 Salt Lake City, Utah 84112

31  
32 Jenny H. Liu  
33 Assistant Professor  
34 School of Urban Studies and Planning  
35 Portland State University  
36 Portland, Oregon 97201

37  
38 Reid Ewing  
39 Director, Metropolitan Research Center  
40 University of Utah  
41 Salt Lake City, Utah 84112

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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).<sup>1</sup> For

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<sup>1</sup> <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

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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**

<b>Variable</b>	<b>Coefficient</b>	<b>Std Err of Coef.</b>	<b>t-score p</b>
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

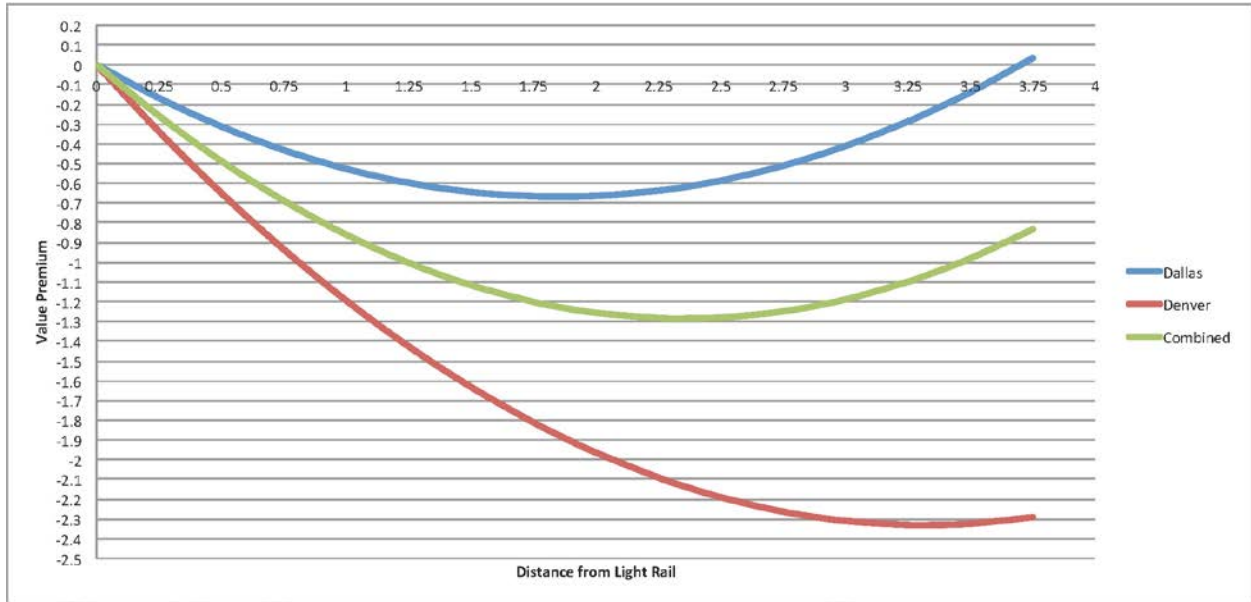
448 **Table 2**  
 449 **Hedonic Regression Results for Office Rent Premium with Respect to LRT Station**  
 450 **Distance, Denver**

<b>Variable</b>	<b>Coefficient</b>	<b>Std Err of Coef.</b>	<b>t-score p</b>
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

<b>Variable</b>	<b>Coefficient</b>	<b>Std Err of Coef.</b>	<b>t-score</b>	<b>p</b>
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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**Figure 1**  
**Office Rents with Respect to Light Rail Transit Station Distance**