Airport Noise and Apartment Rental Rates, Addison, Texas, 2002

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Problem Statement

The price a consumer is willing to pay for a home is affected, either positively or negatively, by external environmental factors. These factors influence the perceived value of a home. For example, a home shopper faced with two extremely similar comparatives, one next to a major airport and the other not, would pay less for the home near the airport, all other factors being the same. The reason for this behavior would seem relatively obvious; people would prefer not to be exposed to the noise associated with the airport. But to continue this line of reasoning, one would expect residential prices in general to reflect this preference. This study will investigate the relationship between rental rates and airport noise, specifically; to what degree does airport noise affect current (2002) apartment rental rates within 2 miles of Addison Airport (ADS)? The study will determine if exposure to airport noise is a significant predictor for apartment prices near ADS. Based on personal experience shopping for apartments in the area, it is hypothesized that airport noise is not a significant factor in apartment rental rates. It is theorized that renters view housing as an expense rather than an investment and so are not as concerned with long-term property value. In addition, renters view housing more as a short-term condition that can be easily changed, unlike buying a house. Finally, renters are usually more concerned with other amenities or characteristics of the apartment, like location or presence of a fitness center or pool than with other environmental factors.

Literature Review

The introduction and widespread adoption of large, multi-engine, turbojet powered aircraft along with the increasing number of operations of such aircraft at U.S. airports throughout the 1960's forced the issue of aircraft and airport noise to the top of the domestic political agenda. Congress enacted the Noise Control Act of 1972, recognizing noise as "a growing danger to the health and welfare of the Nation's population, particularly in urban areas." (Noise Control Act of 1972, sec. 4901) The Act acknowledges the role of state and local governments in controlling noise, but granted authority to the federal government to regulate major noise sources uniformly throughout the country. (Noise Control Act of 1972, sec. 4901) Noise, a complex acoustic phenomenon, can be measured in a number of ways, but federal agencies like the U.S. Department of Transportation, which includes the FAA, the U.S. Department of Housing and Urban Development (HUD), the U.S. Department of Defense (DOD) and the Veterans Administration (VA) have adopted the Day Night Level (DNL)[1], the measure set forth by the U.S. Environmental Protection Agency (EPA) for noise with respect to land use and development. (FAA Noise Division 2002)

To evaluate the issue of noise, the Federal Aviation Administration, in 1976, estimated the number of Americans for which aircraft noise was a significant annoyance at between 6 and 7 million. (U.S. Department of Transportation 1976, 1). Recognizing the impending noise problem, the FAA outlined its position and plan of action in the Noise Abatement Policy of 1976. (U.S. Department of Transportation

[1] Day Night Level is a long-term, average sound pressure level measurement that includes an additional 10db weighting between 10 p.m. and 7 a.m. to account for greater disturbance during these hours.

1976) The FAA shares responsibility for addressing the problem with airport proprietors, state and local governments and planning agencies, air carriers, travelers and shippers (consumers) and residents or potential residents of affected areas. (U.S. Department of Transportation 1976, 5) The regulations implemented by the FAA to address airport noise are codified in 14 CFR Part 150 and include both noise exposure measurement and forecast and noise compatibility planning. The goal of the program is to minimize incompatible land uses around airports thereby reducing the number of people exposed to airport noise. It must be noted that the FAA has no authority to control land use outside of the airport boundary and must rely on local planning authorities to implement compatibility planning, and local zoning standards vary widely. Other government agencies, like HUD (24CFR51), the Occupational Safety and Health Administration (OSHA) (29CFR1910) and the EPA, concerned with environmental noise, have established guidelines or regulations concerning noise exposure.

Perhaps the most obvious impact of noise exposure is hearing loss. Studies have shown that airport noise is a significant contributor to hearing loss (Chen, et. al. 1997), but there is also a growing body of research that indicates that airport noise causes other physiological effects, including hypertension and increased levels of stress (Meister and Donatelle 2001).

In addition to physiological effects, noise has an economic impact. A number of studies have examined the relationship between residential housing prices, and airport noise. (Espey and Lopez 2000);(Frankel 1991);(Gautrin 1975) Nearly all demonstrate a significant, negative relationship between airport noise and property value. The hedonic pricing method is one commonly used to evaluate the cost associated with noise, and this theme and procedure can be found duplicated in many Masters and PhD theses. In one study, a survey of real estate brokers and property appraisers detected perceived discount values for single-family as well as multi-family residential properties. (Frankel 1991) These findings generally indicate that housing consumers recognize a cost associated with living in a noisy environment, but does this concept extend to the rental market as well?

Apartment rental rates are established by market forces, but a number of descriptive determinants, like size or number of bedrooms or bathrooms, age, complex size (Smith and Islam 1998), amenities (Sirmans, Sirmans, and Benjamin 1989) like parking and pools are generally used as predictors with some variation in the precise method used. Jud, Benjamin and Sirmans provide a good overview of various works in the area. (Jud, Benjamin, and Sirmans 1996) Other models also include location oriented predictors, (Bible and Hsieh 1996) like distance to business centers, schools, or public transportation, services like property management quality, and even rental concessions or promotions, but few if any models explicitly address the cost of environmental noise exposure. This study examines the relationship between airport noise and apartment rents by extending the best-known models to include environmental airport noise.

Methodology

The study area is limited to apartments within 2 miles of ADS runway 15/33. Rental rates are current for the year 2002.

Data were collected at the apartment complex level and at the apartment unit level. Each observation represents a particular apartment unit at a specific apartment complex. For example, if a complex happened to have two 1-bedroom floor plans and two 2-bedroom floor plans, the complex would yield 4, co-located unit observations. Amenities at the complex level are duplicated in each unit observation. The following variables used in the analysis are displayed below in Figure 1.

Variable	Description
Location	Address (property name, street, zip) of the apartment complex.
Size	Size of apartment unit in square feet. Where square footage was provided as a range along with both low and high rents, the observation was split into two observations, one for smaller and lower rent and one for larger and higher rent.
Complex Size	Total number of apartment units in the complex.
Age	Computed as the current year (2002) minus the construction or latest renovation year. Where multiple years were provided, the latest date was used.
Covered Parking	Dummy variable (1 or 0) indicating covered parking. Covered parking includes simple covered parking, parking structures, attached garages and downstairs garages.
Access Gates	Dummy variable (1 or 0) indicating presence of access gates or other perimeter security.
Basketball Court	Dummy variable (1 or 0) indicating presence of a basketball court.
Tennis Court	Dummy variable (1 or 0) indicating presence of one or more tennis courts.
Clubhouse	Dummy variable (1 or 0) indicating presence of a clubhouse.
Laundry	Dummy variable (1 or 0) indicating presence of one or more laundry facilities.
Pool	Dummy variable (1 or 0) indicating presence of one or more pools.
Sauna	Dummy variable (1 or 0) indicating presence of a sauna.
Jacuzzi	Dummy variable (1 or 0) indicating presence of a Jacuzzi.
Playground	Dummy variable (1 or 0) indicating presence of a playground.
Volleyball	Dummy variable (1 or 0) indicating presence of a volleyball court.
BBQ Grills	Dummy variable (1 or 0) indicating presence of one or more barbeque grills.
All Bills Paid	Dummy variable (1 or 0) indicating all bills are included in the rental price.
Fitness Center	Dummy variable (1 or 0) indicating presence of a fitness center.
Courtesy Patrol	Dummy variable (1 or 0) indicating presence of on-site security officers or "Courtesy Patrol."
Water Volleyball	Dummy variable (1 or 0) indicating presence of water volleyball facilities.
Washer/Dryer	Dummy variable (1 or 0) indicating whether or not a washer and dryer are included in the rental price. When provided, no distinction is made between stackable or full size units. These data were provided at the complex level rather than the unit level.
Fireplace	Dummy variable (1 or 0) indicating presence of one or more fireplaces. No data were provided for fireplaces within efficiency apartments.
Rental Price	Monthly rental price for a twelve-month lease.
Within 65db Noise Exposure Contour	Dummy variable (1 or 0) indicating the apartment is within the 65db noise contour.
Within 70db Noise	Dummy variable (1 or 0) indicating the apartment is within the 70db noise

Exposure Contour	contour.
Within 75db Noise Exposure Contour	Dummy variable (1 or 0) indicating the apartment is within the 75db noise contour.

Figure 1 Analysis Variables

The data represents a sample of availability provided by an Internet apartment locator for the Dallas area. The original set included approximately 10,000 units in six counties in North Texas. This set was reduced to complexes having zip codes within 5 miles of the Addison, Texas zip code. Using a GIS, these addresses were address matched against street data provided by the 2000 Census. Complexes with an address matching score of less than 80 were rejected, ensuring that the remaining complexes are, in fact, where they are mapped. A printed FAA Part 150 Noise Exposure Map for ADS was scanned and the resulting image was georeferenced and rectified to the street data within the GIS. Each noise contour was digitized producing results with estimated error of ±30 meters. The shape of the noise contours, as shown in Figure 2, provides contextual information. The rather pointed ends of the contours reflect the altitude of the noise source. Approaching or departing aircraft are closer to the ground near the runway than at some distance from the runway. At a distance from the runway, the noise source is some number of feet above the ground, but closer to the ground above the flight path than areas away from the flight path. Perceived loudness of a noise source exhibits an inverse exponential relationship to distance. The lobe effect at the south end of the runway may be attributed to two factors, the prevailing wind, which defines the runway used, and the different power settings used for takeoff and landing operations. Airplanes typically land and takeoff into the wind. A landing operation requires a relatively low power setting whereas a takeoff operation employs a very high power setting. The relationship between power setting and noise is intuitive. From the map, it is relatively easy to see that runway 15 is typically in use and a south to south-east wind prevails in the area. The study area was selected such that more than 10% of the observations were within at least one noise contour. The adjusted sample included 285 observations, 17.5% of which fell within the 65db Noise Exposure Contour. During preliminary data screening for normality, apartment complexes with more than 600 units and apartments units with monthly rent greater than $1500.00 per month were excluded as outliers. The variable Age presented a bi-modal distribution, but was not modified. The variables Pool and All Bills Paid were removed as all apartments within the sample had pools and none offered the "all bills paid" incentive. Playground was removed as only 5.6% of the sample had playgrounds. The variables Within 75db Noise Exposure Contour and Within 70db Noise Exposure Contour were removed as none of the apartments lie within these areas.

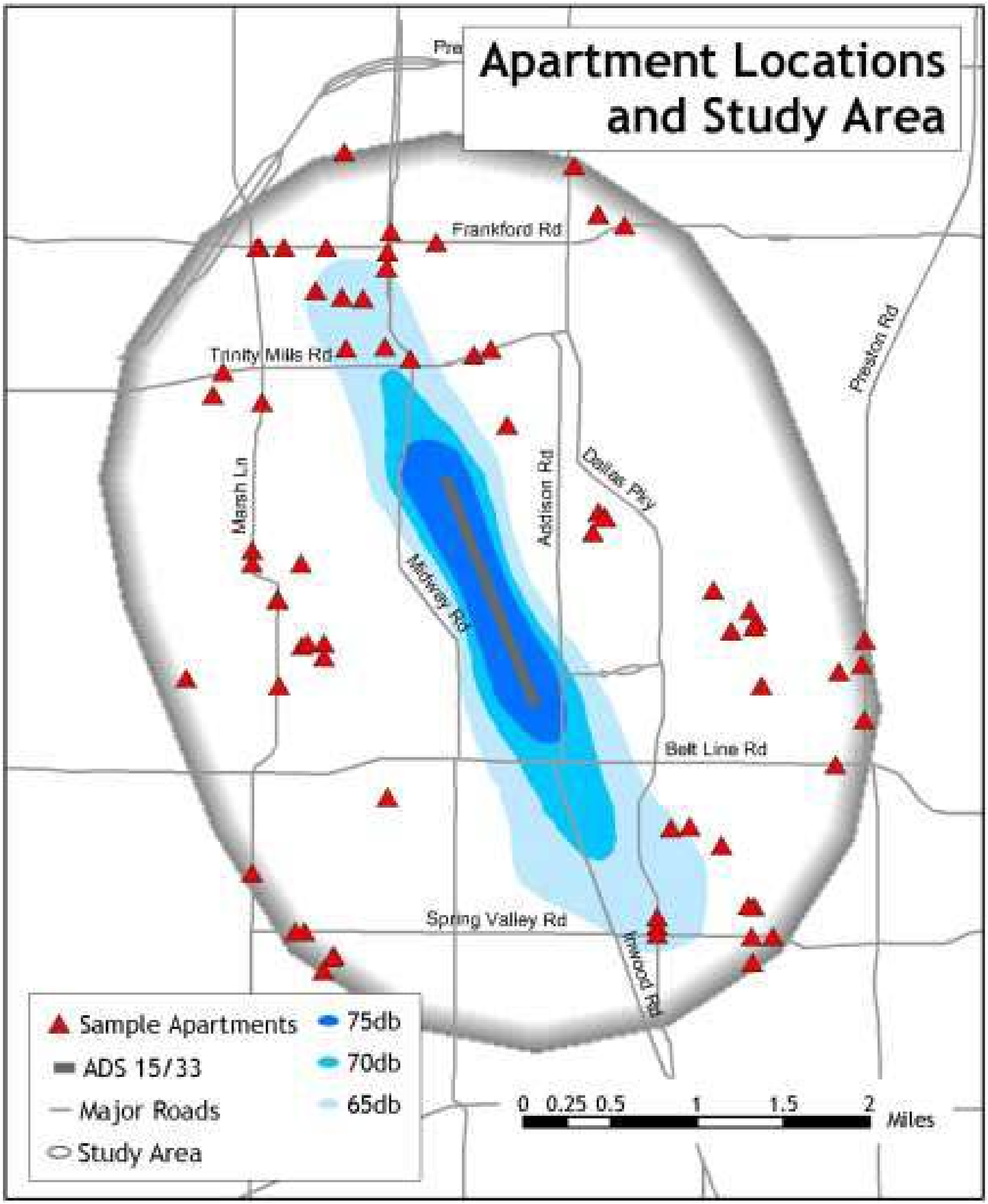

Figure 2 Map of Study Area

A backward, stepwise multiple regression was conducted to produce a sequence of regression equations to show the relationship between rent and the independent variables. Regression residuals were mapped and visually inspected for patterns and Moran's I and Geary's C were computed to provide an indication of spatial autocorrelation within the residuals. Next, a regression model was produced using the same variables as the original final model but without the noise variable. These residuals were mapped and visually inspected and Moran's I and Geary's C were calculated.

Results

The initial stepwise regression produced twelve models. The final model, model 12, has a relatively high multiple correlation of .851 and an adjusted multiple correlation of .847 indicating that this model accounts for nearly 85% of the variance of this combination of independent variables. The ANOVA results indicate that the model is linear and significantly predicts the value of the dependent variable from the collection of independent variables.

The coefficients table, Figure 3, shows the independent variables remaining in the model along with standardized coefficients and collinearity statistics. Tolerance for all of the independent variables is close to one, indicating that multicollinearity is low within this model.

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics
	B	Std. Error	Beta			Tolerance
(Constant)	338.093	28.765		11.754	.000	
NUM_UNITS	-.100	.045	-.054	-2.206	.028	.892
SQFT	.652	.020	.783	32.414	.000	.927
AGE	-8.992	.754	-.332	-11.927	.000	.697
WD_PROVIDE	-25.487	12.047	-.051	-2.116	.035	.941
FIREPLACE	42.618	16.133	.069	2.642	.009	.795
ACCESS_GAT	78.677	12.708	.178	6.191	.000	.656
JACUZZI	30.045	11.485	.067	2.616	.009	.817
I65DB	-53.132	14.809	-.091	-3.588	.000	.835

Dependent Variable: RENT

Figure 3 Model 1 Regression Coefficients

Figure 4 shows the model residuals mapped as an Inverse Distance Weighted surface. It is important to note that because there were potentially several residuals at each location, the average of the residuals for each location is used.

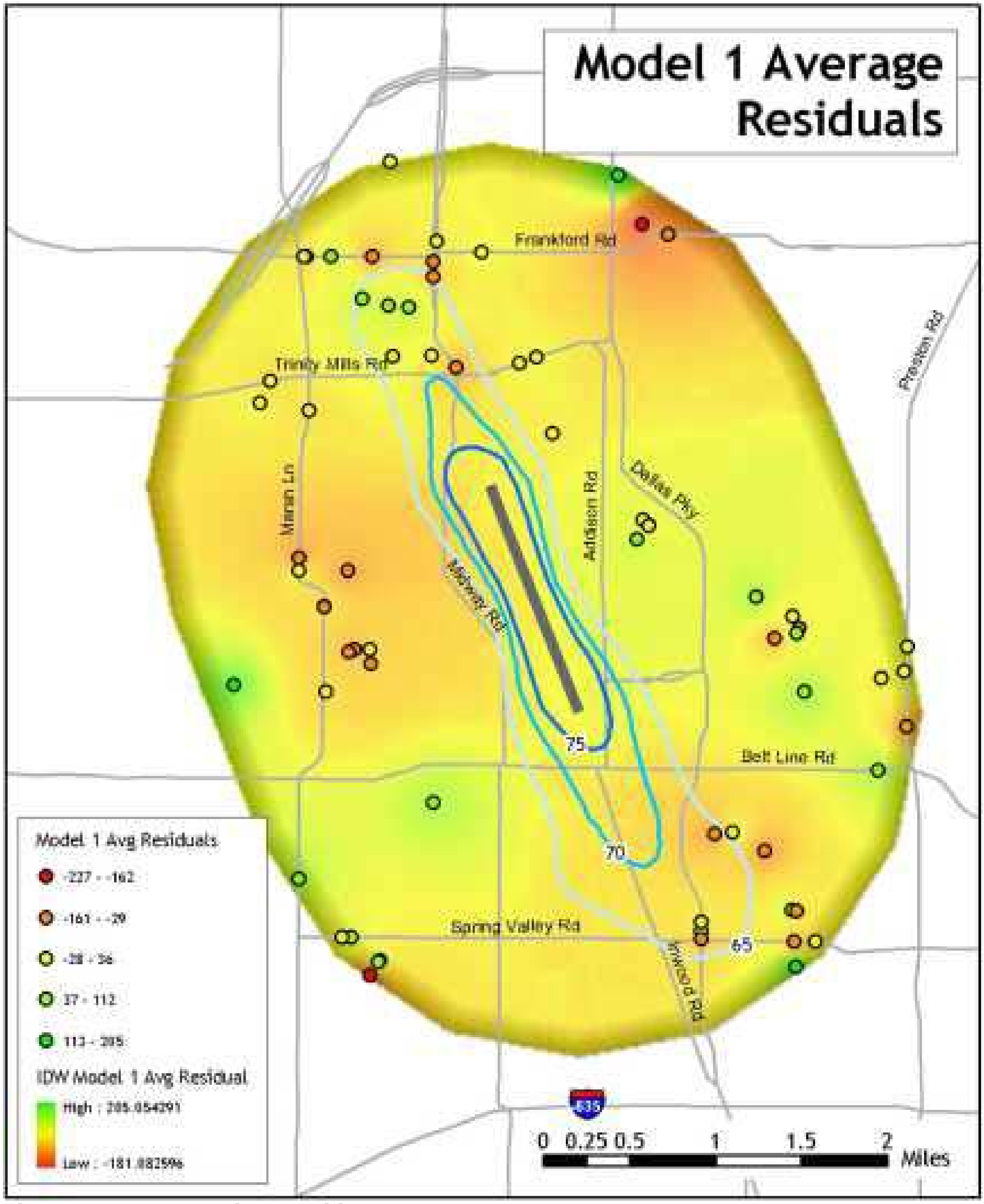

Figure 4 Average Model 1 Residuals

Moran's I and Geary's C results for the average residual at each location are shown in Figure 5. Moran's I shows no significant spatial autocorrelation among the average residuals but Geary's C, being slightly more sensitive to values at each location, shows slight, but significant positive spatial autocorrelation.

	Moran's I	Geary's C
Value	-0.020595	0.956198
Spatially Random Value	-0.014493	1.000000
Standard Deviation	0.017151	0.015303
Normality Significance (Z)	-0.355783	-2.862323
Randomization Significance (Z)	-0.356773	N/A

Figure 5 Moran's I and Geary's C for Average Model 1 Residuals

The second regression model is similar to the first but it excludes the noise variable. The results of the regression are shown below in Figure 6.

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics
	B	Std. Error	Beta			Tolerance
(Constant)	340.511	29.367		11.595	.000	
NUM_UNITS	-0.12	0.046	-0.065	-2.595	.010	.905
SQFT	0.65	0.021	0.78	31.657	.000	.928
AGE	-8.854	0.769	-0.327	-11.515	.000	.699
WD_PROVIDE	-25.999	12.302	-0.052	-2.114	.035	.942
FIREPLACE	40.68	16.465	0.066	2.471	.014	.796
ACCESS_GAT	64.918	12.372	0.147	5.247	.000	.722
JACUZZI	33.214	11.693	0.074	2.84	.005	.822

Dependent Variable: RENT

Figure 6 Model 2 Regression Coefficients

Once again, the model is linear and significantly predicts rent based on the remaining independent variables, but the adjusted multiple regression, .840, is very slightly less in this case, meaning Model 2 is not quite as accurate as Model 1 where noise is included. All coefficients are very similar to the first model and the relative importance of each variable is close to the original model.

Average residuals from Model 2 are mapped in Figure 7.

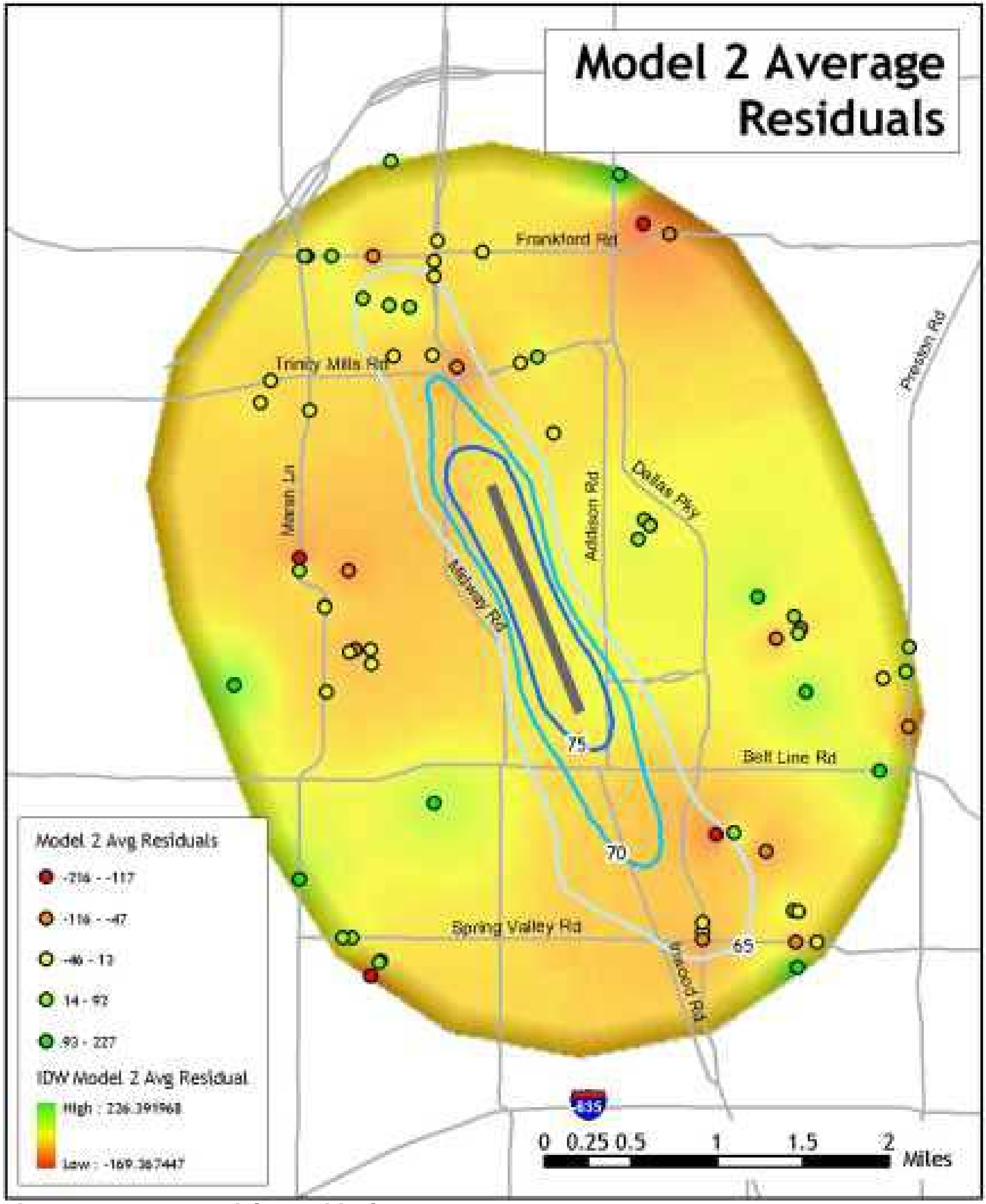

Figure 7 Average Model 2 Residuals

Spatial autocorrelation statistics for the second model are shown in Figure 8. In this case, Moran's I shows no significant spatial autocorrelation, but Geary's C shows stronger evidence of significant positive spatial autocorrelation.

	Moran's I	Geary's C
Value	-0.018648	0.953203
Spatially Random Value	-0.014493	1.000000
Standard Deviation	0.017151	0.015303
Normality Significance (Z)	-0.242293	-3.058072
Randomization Significance (Z)	-0.243003	N/A

Figure 8 Moran's I and Geary's C for Average Model 2 Residuals

The preceding results have been based on average residuals at each location. In order to more thoroughly investigate the arrangement of residuals, spatial autocorrelation statistics were also computed for "worst case" scenarios under both models. Under this configuration, the residual with the largest absolute value at each location was used in the computation. The results are shown in Figures 9 and 10, below.

	Moran's I	Geary's C
Value	-0.015106	0.974175
Spatially Random Value	-0.014493	1.000000
Standard Deviation	0.017151	0.015303
Normality Significance (Z)	-0.035728	-1.687560
Randomization Significance (Z)	-0.035671	N/A

Figure 9 Moran's I and Geary's C for Worst Case Model 1 Residuals

	Moran's I	Geary's C
Value	-0.013649	0.969458
Spatially Random Value	-0.014493	1.000000
Standard Deviation	0.017151	0.015303
Normality Significance (Z)	0.049190	-1.995855
Randomization Significance (Z)	0.049123	N/A

Figure 10 Moran's I and Geary's C for Worst Case Model 2 Residuals

Only Geary's C for Model 2 is significant detecting a slight amount of positive spatial autocorrelation.

Analysis

Based on standardized beta scores for each of the independent variables, Square Footage, Age, Access Gate and Within 65db Noise Exposure Contour are the most important factors and significant in Model 1. As one would expect, there is a positive relationship between Square Footage and Rent and a negative relationship between Age and Rent. Access Gate is also positively related to Rent, but its magnitude and importance in the equation suggest that it is working as a proxy for a number of other variables, perhaps describing the general "nice-ness" of the property. Surprisingly, Within 65db Noise Exposure Contour is negatively related to rent and significant, indicating that airport noise is indeed a factor in rental rates in the study area. The magnitude of the coefficient is surprising as well, equivalent to about a $53.13 per month discount for living within the 65db Noise Exposure Contour according to Model 1. The mapped average residuals show no obvious pattern and the Moran's I statistic is insignificant. Geary's C, perhaps a better measure in this case because it is more sensitive to the relationship between values at given locations, shows a small but significant amount of positive spatial autocorrelation indicating neighborhood or second-order clustering. From these statistics one can infer that the regression model is fairly reliable because of a relatively high adjusted r square value and the residuals, although not completely spatially random, exhibits no global and very little second-order spatial autocorrelation providing additional evidence that the regression assumption of independent observations has not been violated.

Model 2 shows very similar relationships between the independent variables and rent. The fact that the model accounts for slightly less (84%) variability in the dependent variable seems to support the notion that noise is indeed an important factor in apartment rents within the study area. Coefficients and standardized coefficients are similar between the models. Model 2 average residuals show no significant evidence of global spatial autocorrelation, but do show stronger evidence of second-order spatial autocorrelation. Although the location of neighborhood clustering has not been identified empirically, greater variation in the north and south ends of the 65 db noise contour can be seen in Figure 7. One can infer from the empirical evidence that Model 1 is better than Model 2 because it is marginally more predictive and appears to be less likely to violate the independent observations assumption for regression.

Several limitations of this study must be highlighted. First, the use of a binary variable for noise exposure theoretically weakens the regression model. It is likely that the ADS Noise Exposure Map was produced from a continuous surface but these data were unavailable for analysis. Producing a surface from the contour lines proved to be tedious and unreliable. The sample data included apartment units by floor plan but a single regression model was constructed to account for the complex relationship among the independent variables and rent. A residual for each unit at each location is produced from the model. Multiple residuals at a single location present a challenge for measuring spatial autocorrelation. In this study, the average residual for each location was considered the best means of resolving this issue, however, the worst case residuals were also examined. Evaluating the spatial distribution of residuals, particularly when dealing with spatial phenomena, is important when using regression because these techniques assume the distribution of error is random.

Conclusion

The results of this study suggest that there is a significant, negative relationship between airport noise and rental rates for apartments within two miles of Addison Airport. The magnitude of the discount within the study area is approximately $53.13 per month.

Further research on this topic might consider inclusion of other specific location variables, for example, distances to the nearest major road, employment center or to mass transportation. Inclusion of a variable to reflect the neighborhood in which the apartment is located might also increase the predictive power of a model. The same or a similar study could be performed around other airports in the Dallas area or in other cities across the country.

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