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Highway traffic noise effects on land price in an urban area

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Abstract

The study evaluates the monetary effect of traffic noise on property values in Seoul, Korea. Hedonic price models are estimated using the zone-based data that includes traffic noise levels, official land price, land use classification, distance to roadways, type of nearby roadway facilities, and traffic characteristics. It is found that a 1% increase in traffic noise associated with a 1.3% decline in land price. Based on this, the annual cost per kilometer due to traffic noise is about $347 thousand.

Keywords: Traffic noise; Property value; Land price; Hedonic price model

1. Introduction

Seoul, Korea covers 605 km^2 and has a population of 10.3 million (Seoul Metropolitan Government, 2006), many living near highways. While public concerns and complaints about the negative effects of traffic noise on property values have grown significantly, little scientific effort has been made to examine those effects in Korea; equally there are few studies on the effects of air pollution. This study examines whether there is a noticeable decline in property values due to traffic noise in Seoul. The 38.4 km Inner Circular highway is used as a case study and an hedonic price index of property values is developed.

The hedonic price model has been widely used in housing price studies but few have focused on the impact of traffic noise on housing values. For such example, Nijland et al. (2003) performed a cost-benefit analysis (CBA) looking at noise abatement treatments for roads and railways in the Netherlands, using hedonic price models to estimate implicit noise values and found significant declines in values due to traffic noise. Becker and Lavee (2003) also performed a CBA of introducing a stricter noise abatement program for road traffic in Israel. Using hedonic price indices, they found that reduced traffic noise due from the program were significant. Lim and Ko (2003) evaluated the impact of traffic noise on housing prices in Bucheon by applying

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quisi-hedonic price methods to data on 128 apartment units and found that on average a decibel increase in traffic noise is associated with a 0.3% decline in apartment with depreciation of larger apartments being more pronounced.

Nelson (2004) used meta-analysis based on 20 studies that had utilized hedonic price models and found that a one-decibel increase in airport noise reduces property values by between 0.5% and 0.6%. Morrell and Lu (2000) applied hedonic price models to compute the annual social cost of aircraft noise in Amsterdam, estimating the implicit value of noise during landings and take-offs They showed that the Dutch government charges are lower than the social cost of the noise.

2. Data

Zonal data were collected on strips along the Inner Circular highway in the central area of Seoul, from 2002 to 2004 and grouped by locational, neighborhood, and environmental characteristics. Locational characteristics include floor area ratio or floor space index, and land use type. Neighborhood characteristics include distances to the highway, nearby minor arterial and closest subway station, and subway travel time to the center of the city (city hall station). Environmental characteristics consist of traffic variables including average daily traffic volume (ADT) and average daily travel speed on a highway segment and environmental variables including the existence of a noise wall and a tunnel in a highway segment, and measured traffic noise levels. The dependent variable is the official land price determined on 1st January, 2003.

The study area encompasses the Inner Circular highway and its vicinity within 500 meters each side of the highway and is divided into 328 zones. This highway has 6 or 8 lanes, an average daily traffic volume of 177,456 vehicles and an average daily travel speed of 64.2 km/h in 2003. Heavy-duty trucks of 10 tons or over are prohibited. Most of the zones are either general-residential or semi-residential with mixed commercial land use, and a general residential land use type that is further categorized into type 1 (single family houses with maximum 3 floors), type 2a (row houses with maximum 10 floors), and type 3 (apartments with no maximum floor limit). Exclusive residential and commercial land use types are present, but negligible in quantity, so they are excluded. The highway was divided into eight segments that are used to define the locational, neighborhood, and environmental characteristics. For example, if a zone is located in a segment having a tunnel, a tunnel indicator for the zone is recorded as 1 (and 0 otherwise).

3. Results

Correlation analysis is performed to estimated links between land price and traffic noise level. Using all observations shows an unexpected positive sign implying an increase in land price as noise level increases. Separate correlation analyses are performed for each land use type (Table 1). A counter-intuitive negative correlation is still found for three land use types. The 114 observations belonging to the first two types are subjected to further analysis.

The hedonic price theory is based on economic equilibrium theory. If the market is analyzed as a single entity when it is in fact segmented into two or more sub-markets, the parameter estimates of the hedonic model are prone to be biased. In this regard, inclusion of only the two residential land use types mostly likely to be in the same market segmentation appears appropriate. The paired correlation coefficients of 13 variables are estimated using data belonging to either residential type 1 or type 2a (Table 2). The expected negative sign is found between land price and noise level but is not statistically significant at the 0.1 level. Some of the explanatory variables show significant correlations, for example, the existence of a tunnel is correlated with the distance to minor arterial. Traffic noise, though, is not highly correlated with any of them.

While most of the variables exhibited expected signs in their correlations with land price, a few variables showed signs that are the opposite to those expected. For example, a negative correlation was found between land price and a presence of a noise barrier. An area with noise barriers in its highway segment might still suffer high traffic noise than an area without barriers, and this suggests that the noise barriers performed poorly although they reduced noise level to some extent. Spatial correlation in the data might be behind these contradictory findings, and spatial effects could explain many of contradictory results from traditional hedonic models (Orford, 1999).

Table 1
Variable descriptions

Variables	Definition
	Dependent variable
Land price	Official land price (Korean won) per m^2 as of 1st January, 2003
	Independent variables
Locational characteristics	
Floor area ratio	Ratio of the total floor area of a building to the gross area of the plot
Residential type 1 indicator	General residential land use of single family housing with maximum 3 floors
Residential type 2a indicator	General residential land use of row houses with maximum 10 floors
Residential type 3 indicator	General residential land use of apartments with no maximum floor limit
Semi-residential indicator	Semi-residential land use of mixed with commercial land use
Neighborhood characteristics	
Distance to highway	Euclidean distance to the highway (meters)
Distance to arterial road	Euclidean distance to nearby arterial road (meters)
Distance to minor arterial	Euclidean distance to nearby minor arterial (meters)
Distance to subway	Euclidean distance to nearby subway station (metes)
Travel time to city center	Travel time from nearby subway station to city hall station (minutes)
Environmental characteristics	
Overpass indicator	1 if a highway segment is overpass, 0 otherwise
Noise barrier indicator	1 if noise proof barrier is installed along a highway segment, 0 otherwise
Tunnel indicator	1 if tunnel is present within a highway segment, 0 otherwise
ADT	Average daily traffic volume of the highway (veh/day)
Average speed	Average daily vehicle speed of the highway (km/h)
Traffic noise level	Measured traffic noise level in decibel (dBs)

Notes: The base unit of the data is an analysis zone, $1 is approximately equivalent to 1000 Korean won.

Four functional forms were formulated for a hedonic price model: linear, semi-log, inverse semi-log, and double log models. Finally, for each of the four functional forms was estimated and presented in Table 3. In addition to the correlation analysis, variance inflation factors (VIF) were also computed to discover potential collinear variables. The average speed variable and the tunnel indicator were thought to cause multicolliearity, and were excluded from the model specification. Thus, the final model specifications for the study include 10 explanatory variables. Variables that were not statistically significant at the 0.1 significance level still stay in the final model as control factors. Exclusion of those variables should not affect much the parameter estimates of the other variables because variables possibly posing multicollinearity were removed from the final model specification.

F statistics for the four models are highly statistically significant and R^2 values are similar among the models. The signs of the coefficients are generally consistent across the models. White's test (1980) is performed to see if heteroscedastic variance causes the ordinary least square estimates to be bias. Computed White's test statistics are translated so that the semi-log and double-log models do not suffer from heteroscedastic variance bias, while the linear and inverse semi-log models suffer at the 0.1 confidence level. Thus, the linear and inverse semi-log models are excluded from consideration. Of the remainder, the double-log model is selected over the semi-log model because of its higher R^2 and statistically strong evidence of homoscedasticity.

The interpretation of the coefficients for each model is different due to different functional forms. The β of the traffic noise variable in the double-log model is -1.33 while all other variables are fixed at their average levels. More specifically, if the traffic noise level decreases by 5.6 decibels (10% of the average noise level), the land price increases by $154.7 per m^2. For example, a housing unit with 100 m^2 would be lower in its land price by about $15.5 thousands than a housing unit with the same area but with 10% higher noise levels, all else being equal.

When considering the area within 300 m of the highway, a 48.6% of the area is classified as residential types 1 or 2a, which are predominantly composed of singly family houses or row houses. The cost due to the traffic noise in this area is estimated to be 266.4 million dollars using 55 decibels as a reference level. Based on this estimate, an average cost imposed by one vehicle per kilometer per day is computed as 0.536 cent/km/day. A

Table 2
Pearson's correlation coefficients

Variables	Land price	Noise level	Floor area ratio	Distance to highway	Distance to arterial	Distance to minor arterial	Distance to subway	Travel time to city center	Tunnel indicator	Overpass indicator	Noise barrier indicator	ADT	Average speed
Land price	1.00	−0.02	0.33	0.24^{**}	-0.18^{*}	−0.08	-0.16^{*}	0.20^{**}	−0.10	0.20^{**}	-0.26^{***}	-0.32^{***}	0.36^{***}
Noise level		1.00	0.34	−0.02	−0.06	0.19^{*}	0.05	0.35^{**}	0.10	0.45^{**}	-0.14^{***}	-0.59^{***}	0.59^{***}
Floor area ratio			1.00	−0.09	-0.22^{**}	-0.25^{***}	-0.29^{***}	-0.20^{**}	-0.17^{*}	−0.09	−0.11	0.01	0.22^{**}
Distance to highway				1.00	0.05	-0.20^{**}	-0.38^{***}	0.15	-0.38^{***}	0.32^{***}	-0.25^{***}	-0.22^{**}	0.35^{***}
Distance to arterial					1.00	-0.22^{**}	−0.03	0.15	-0.39^{***}	0.32^{***}	0.16^{*}	−0.01	0.09
Distance to minor arterial						1.00	0.81^{***}	0.33^{***}	0.88^{***}	−0.08	0.02	-0.22^{**}	-0.25^{***}
Distance to subway							1.00	0.24^{**}	0.83^{***}	−0.13	0.16^{*}	−0.07	-0.40^{***}
Travel time to city center								1.00	0.21^{**}	0.70^{***}	0.001	-0.76^{***}	0.49^{***}
Tunnel indicator									1.00	-0.31^{***}	0.08	−0.07	-0.40^{***}
Overpass indicator										1.00	0.15	-0.84^{***}	0.72^{***}
Noise barrier indicator											1.00	−0.12	-0.19^{**}
ADT												1.00	-0.77^{***}
Average speed													1.00

$^{*}p < 0.1$, $^{**}p < 0.05$, and $^{***}p < 0.0$.

Table 3
Estimated hedonic price models

Variables	Functional forms							
	Linear ($P = \alpha + \beta X$)		Inverse semi-log ($P = \alpha + \text{In}\ \beta X$)		Semi-log ($\text{In}\ P = \alpha + \beta X$)		Double-log ($\text{In}\ P = \alpha + \beta \text{In}\ X$)	
	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
Constant	3,298,316	6.30***	9,582,840	4.06***	15.73	38.7***	21.23	11.6***
Traffic noise level	−30,954	−6.20***	−1,639,949	−5.86***	−0.0250	−6.44***	−1.327	−6.09***
Total floor area ratio	6,376	5.79***	1,076,916	5.62***	0.00502	5.88***	0.843	5.65***
Distance to highway	153	0.68	19,694	0.53	0.00014	0.81	0.0198	0.78
Distance to arterial	−10.97	−1.76*	−32,452	−2.08**	0.00001	1.54	−0.0221	−1.94*
Distance to minor arterial	−298.5	−0.97	−16,723	−0.47	−0.00016	−0.68	−0.0115	−0.42
Distance to subway	44.16	1.03*	68,921	1.81*	0.00001	1.25	0.0352	1.19
Travel time to city center	−6,347	−1.69	−134,630	−2.06**	−0.00559	−1.79*	−0.110	−2.52**
Overpass indicator	−114,445	−1.07	−8,751	−1.40	−0.126	−1.51	−0.041	−2.55**
Noise barrier indicator	−590,563	−4.70***	−626,621	−4.65***	−0.453	−4.64***	−0.478	−4.55***
ADT	−5.25	−5.21***	−566,484	−4.56***	0.000001	−5.66***	−0.480	−4.96***
F	11.02***		10.74***		11.67***		12.11***	
R^2	0.52		0.51		0.53		0.54	
White's test statistics	20.27		17.38		12.46*		10.21***	

*$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$.

housing unit in a zone belonging to a highway segment having noise barrier is estimated to be valued less by about 5%. Increase in floor area ratio, which is proportional to the area of a housing unit, presence of overpass, travel time to city center, and traffic volume in a highway segment are associated with lower values in land price.

4. Conclusions

The study quantifies changes in property values due to traffic noise an area adjacent to the Inner Circular highway in Seoul. A hedonic price model estimates the implicit price of traffic noise and confirms that traffic noise has a negative impact on the values of the residential properties near the highway. However, this result is limited to the housing units classified to be residential land use type 1 or type 2a, which is largely consisted of single family houses or row houses. The effect of traffic noise is that a 1% increase in traffic noise level in decibel is associated with about 1.3% decrease in land price. This implies a cost on residents in the area of $0.536 for each kilometer driven.

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