AIRPORTS AND PROPERTY VALUES

A Survey of Recent Evidence

By Jon P. Nelson*  

In recent years, many public officials and concerned groups have attempted to place constraints on noise emissions of major transport modes, especially commercial jet aircraft.¹ From an economic perspective, debates over noise regulation largely reduce to a comparison of the costs and benefits of possible measures. While abatement costs have been extensively documented, valuation of benefits remains controversial and underdeveloped. As on so many issues involving non-market or public goods and services, decisions must frequently be made with only the vaguest notion about the magnitude of beneficial effects of noise abatement regulations. Given only cost information, the decision to adopt a regulation determines a revealed-preference value for increments of quiet, rather than value determining the choice. The continuing policy debate thus reflects a lack of any standard or criterion for determining benefits that is outside the realm of political processes.

The purpose of this paper is to suggest that a fairly extensive body of evidence exists on at least one aspect of the benefit question and that this evidence, when properly interpreted, is consistent. Freeman (1979), on page 4, has characterised the problem of benefit measurement as involving a kind of detective work—wherein one pieces together clues about values people place on public goods that are left behind in the process of responding to other market signals. While this process is somewhat more than elementary, the market signals in question here are property values (or rentals) in residential areas adjacent to large commercial airports in Australia, Canada, Great Britain, and the United States. Evidence is reviewed from thirteen empirical studies covering eighteen different airports. The empirical results are summarised in the form of a noise depreciation sensitivity index, which is the ratio of the price of quiet to the price of an average or basic house and lot. The range of values for this index provides a means of evaluating the consistency of the studies and their results.

We do not propose to provide a definitive measure of benefits from abatement of aircraft noise. Rather, we attempt to clarify the technique of benefit measurement that underlies property value studies and to survey the results from these studies systematically. With these objectives in mind, the remainder of the paper is divided into four parts. First, we review the theoretical model that has been the basis for most recent

* Professor of Economics, The Pennsylvania State University. Research leading to this paper was supported in part by a grant from the Office of University Research, U.S. Department of Transportation. Views expressed are those of the author.

¹ Policy issues are discussed in recent reports by the National Academy of Sciences (1977) and OECD (1978); see also Nelson (1978).
empirical studies—the hedonic price model. Second, we discuss some major issues associated with specification and estimation of this model, and present a survey of evidence from twelve earlier studies covering fifteen airports. Third, we present some results from a recent property value study conducted by the author for six major U.S. airports: San Francisco, St. Louis, Cleveland, New Orleans, San Diego, and Buffalo. Fourth, we summarise the main conclusions obtained in this survey.

THE HEDONIC PRICE MODEL OF PROPERTY VALUES

Consider two residences that are identical in all respects, except that one is located under the flight path of an airport and the other is not. Since the value of a residence is the sum of present discounted streams of benefits and costs derivable from it, observations on these present values should reveal that the first house sells for a lower price than the second house. Dividing the difference in present value by the difference in noise exposure results in an estimate of the expected discounted present value of quiet, expressed in dollars per decibel avoided. Thus, individuals can choose consumption levels of a local public good through their choice of a residential location; and, as they do so, information on public good demand is embodied in the prices and quantities of private goods (Freeman, 1979, p. 78). The measurement problems are: first, to model this process explicitly; second, to apply econometric techniques that extract information suitable for welfare measures of abatement benefits.

Each house and lot, in fact, represents a unique combination of characteristics, so the decision to purchase a given property is complex. The price a potential buyer is willing to pay depends on location, attributes of the neighbourhood and community, local taxes, and locally provided services (schools, police, etc.), as well as on physical characteristics of the structure and lot. Since these characteristics are sold as a package, it is difficult to infer from one or two sales the incremental effect of one characteristic or attribute on the final selling price of a dwelling. However, if characteristics are provided in various combinations as varieties or brands of goods, it is possible to estimate an implicit or hedonic price relationship which gives the price of any brand as a function of quantities of various characteristics. For example, if the locational characteristic in question is time required to commute to places of employment, then the coefficient on a variable for commuting time embodies an estimate of the marginal implicit value of time (see Nelson, 1977, for empirical evidence).

More formally, let $V$ be a vector of observations on housing prices, $S$ a vector of structural characteristics, $L$ a vector of locational characteristics, $Q$ a vector of

---

2 This example treats noise as an attribute of housing, rather than as a characteristic. In reality, noise levels are continuous and, in areas near major airports, vary by as much as 30 decibels. Thus, individuals have an opportunity to vary their degrees of noise exposure in an important manner. It is possible for one family to choose a really quiet house, while another family prefers to buy only a moderately quiet one. For additional discussion, see Walters (1975), chapter 4.

3 The hedonic price model was originally developed by Griliches (1971); received significant elaboration in works by Freeman (1974), Rosen (1974), and Walters (1975); and has been applied frequently to durable goods such as automobiles and farm tractors. The notion of an implicit price for product characteristics is also developed in Quandt and Baumol’s work (1966) on the demand for abstract modes of transport and Lancaster’s model of consumer choice.
neighbourhood environmental-quality characteristics, $T$ a vector of local taxes, and $E$ a vector of local public services.\(^4\) We can express $V$ as a function of all relevant characteristics, or
\[
V = V(S, L, Q, T, E)
\] (1)
where $\partial V / \partial Q_j$ is the marginal implicit price, or increase in expenditures on $V$ required to obtain one more unit of the $j$th environmental-quality characteristic, other things being equal. The implicit price function may be linear or non-linear; that is, the value of $\partial V / \partial Q_j$ may or may not depend on quantities of characteristics being purchased. Owing to tie-ins and indivisibilities, non-linear relationships would appear to be the norm for residential housing, especially for non-structural characteristics (see Rosen, 1974, pp. 37–38).

Residential housing values of course reflect both supply and demand, and the same should be true also of implicit prices of characteristics. It is important to recognise that estimates of equation (1) do not directly represent the underlying structural equations; rather, observed marginal implicit prices are determined by the distribution of consumer tastes and producer costs, and are therefore outcomes of equilibrium. Figure 1 illustrates the demand for a characteristic, where $w_i$ is the implicit marginal valuation or willingness-to-pay function of the $i$th consumer, and where $\partial V / \partial Q_i$ is assumed to be decreasing in $Q_i$.\(^2\) Consumers increase their consumption of $Q_i$ as embodied in various brands so long as $w_i > \partial V / \partial Q_i$. Thus, an implicit or hedonic price function is a locus of equilibrium willingness to pay, and individuals locate themselves in characteristics space so that price differences between brands are equalising only at the margin (Nelson, Measuring Benefits . . ., p. 44; Freeman, 1974, p. 77).

The usefulness of this information for policy decisions depends in part on the circumstances in question. First, consumers must be sufficiently mobile for all potential consumer surpluses to be fully captured in the form of higher land rents. Second, for equation (1) to be directly applied to benefit questions, it must be possible to treat improvements in environmental quality as marginal improvements. The circumstances under which the first assumption holds have been debated extensively, and a summary is given in Freeman (1979). Empirical evidence consistent with mobility is presented below for six U.S. cities as well as for the period 1960 to 1970. The second assumption is also appropriate for current noise emission regulations (see Nelson, Economic Analysis . . ., chapter 8).\(^5\) We turn now to a discussion of some issues associated with specification and estimation of equation (1) and a survey of twelve earlier empirical studies.

\(^4\) The hedonic price model explains the price or value of a product in terms of characteristics that determine its quality. Characteristics of the consumers of the product—such as their income or occupation—are not included, except where these variables are taken as proxies for broad socio-economic aspects of neighbourhood quality; see Rosen (1974), p. 50.


\(^5\) When partial equilibrium assumptions do not hold, two alternatives are available. One is to approximate the marginal value function as described by Freeman (1979), pp. 143–147. The other is to use estimated implicit marginal prices as the dependent variable in a second-stage estimation of a demand function for a given characteristic (see Rosen, 1974, p. 50). For attempts to apply this latter approach, see Harrison and Rubinfeld (1978) and Nelson (July 1978).
SURVEY OF AIRPORT NOISE—PROPERTY VALUE STUDIES

There have been at least twelve earlier studies of the relationship between airport noise and property value that are either consistent with or rely explicitly on the hedonic price model. Most of these studies employ a cross-section of property value data along with information on characteristics of housing and some measure of aircraft noise exposure. The most commonly used noise measure in the United States is the Noise Exposure Forecast (NEF). The total noise exposure produced at a given point may be viewed as the sum of noise levels produced by different aircraft flying different flight paths. For the $i$th aircraft on the $j$th runway, the NEF algorithm is

$$\text{NEF}_{ij} = \text{EPNL}_{ij} + 10 \log (N_{dij} + 16.7 N_{nj}) - k$$  \hspace{1cm} (2)$$

where EPNL is the average effective perceived noise level in decibels at a given point in space, $N_d$ is the number of day-time flights (0700 to 2200 hours), $N_n$ is the number of night-time flights, and $k$ is a scale-adjusting constant with an assigned value of 88. When summed on an energy basis over all aircraft types and flight paths, noise exposure is a function of the average perceived noise level, time of day, and number of

---

7 For a study that employs longitudinal data on airport noise and property values, see Crowley (1973).
8 Aircraft noise exposure indexes are described in Nelson (Economic Analysis . . ., 1978, chapter 2) and Schultz (1972).
airports and property values

JON P. NELSON

Operations. Observed NEF values range between 15 and 55. Case histories in residential areas suggest that there is little or no individual or community annoyance between 15 and 25, some to much annoyance from 25 to 40, and considerable annoyance above NEF 40. Since the effective origin of this index is usually NEF 20—which equals 55-60 dBA—assigning a value of zero to control areas creates measurement errors. That is, the empirical question should be one of differential noise levels, and not whether aircraft noise is either present or absent in an area. At least four earlier studies fail to recognise this potential source of error.

Sound level measurements are based on a logarithmic scale, and loudness doubles every 10 decibels. A subjective annoyance rating plotted on a log scale will approximate a linear relationship with the perceived noise level in decibels (see Bishop, 1966). To capture this relationship, suppose the hedonic price equation is represented by the following multiplicative relationship:

\[ V = b_0 Z^{b_1} A^{b_2} u_1 \]

where \( V \) is the property value, \( Z \) is a set of physical and locational housing characteristics, \( A \) is subjective annoyance due to aircraft noise, and \( u_1 \) is a stochastic error term. Annoyance, in turn, is expressed by

\[ A = c_0 e^{e_{\text{NEF}}} u_2 \]

where NEF is measured in decibels, \( e \) is the natural log base, and \( u_2 \) is a stochastic error term.

Taking logs and substituting for \( \ln A \), we obtain

\[ \ln V = d_0 + d_1 \ln Z + d_2 \text{NEF} + u_1 \]

where \( d_2 = b_2 e^{c_0} \), etc. Coefficient \( d_2 \cdot 100 \) represents the percentage change in a given property value associated with a decibel change in noise exposure. The implicit marginal price of noise is given by \( \partial V/\partial \text{NEF} = d_2 V \), and the noise elasticity is \( d_2/\text{NEF} \). These relationships suggest that investigators should exercise some care in specifying economic relationships that are consistent with psychoacoustical indexes. Several earlier studies employ a logarithmic transformation for a noise index which converts the index into its sound intensity or energy-equivalence level. The economic meaning of this transformation is not clear.

A third specification issue is the importance of major airports as employment centres. If an airport were nonpolluting, land rentals would be expected to decline with increased distance from the airport, reflecting capitalised values of increased commuting costs. The actual trade-off faced by individuals is to balance increased noise exposure against reductions in commuting costs. Empirical studies which ignore airport accessibility may result in noise exposure coefficients that are biased toward zero, because of positive correlations between noise exposure and airport accessibility. Only two earlier studies make a concerted effort to avoid this bias.

The key features and main findings of twelve studies of airports and noise-property values are summarised in the Appendix. One study (Paik) covers three cities for the year 1960. The other studies cover cities and suburbs for years between 1967 and 1976. Most studies examine only single-family, owner-occupied property values. In one case (Price), the dependent variable is the change in apartment rents between 1960 and 1970, while in a second case (McDougall) results are reported for both
owner-occupied housing values and apartment rents for 1970. Mean property values in 1970 for U.S. cities range from about $15,200 to $27,600. Five studies use contemporaneous NEF data as a measure of aircraft noise exposure, but Paik employs NEF data for 1965 and census data for 1960. Two studies (Dyger; Mieszkowski and Saper) employ both NEF and Composite Noise Rating (CNR) data, while Emerson uses CNR data and Gautrin employs the Noise Number Index (NNI). Two studies (McDougall; Maser et al.) use data for only one or two noise contours (90 and 100 dB). In six instances the noise exposure range is 20-25 decibels (NEF 20-45, for example), while the other studies have a range of 10-17 decibels. Four studies (Emerson; Paik; McDougall; McMillan et al.) use a logarithmic transformation of the noise variable.

Four studies use census tract data from the U.S. Census of Population and Housing, while two studies employ census block data from the same source. Six studies use sales price data as the dependent variable. While the sales data should be more accurate, Nelson (Economic Analysis . . ., 1978, p. 81) was able to compare census owner-estimated median property values with professional assessments of individual parcels aggregated to the tract level. He found a high correlation (0.9 or better) between the two estimates, although owner estimates were systematically higher by about 3-6%. There appears to be little reason to suspect that owner estimates are grossly inaccurate when averaged over a large number of households.

Sample sizes in the Appendix vary from 35 observations to 1,270 observations. In most cases, final samples include 90 to 400 observations. In addition to aircraft noise exposure, explanatory variables include measures of house and lot size and several neighbourhood characteristics such as the condition of adjacent structures and racial composition. At least six studies include one or more public sector characteristics such as property tax rates, school quality, and crime rates. The main shortcoming of studies employing census data is the limited amount of information about structural characteristics of housing. Regressions based on individual sales data include a large number of structural variables.

Accessibility has been handled differently in almost all cases. Emerson includes variables for proximity to commercial centres and schools in linear feet, proximity to bus lines in number of blocks, and freeway proximity in a dummy variable form (1 for real estate within two lots of a freeway, and 0 otherwise). Dyger includes six accessibility variables including distance to community shopping centres, regional shopping centres, industrial sites, airport terminals, central business districts (CBD), and public elementary schools. All these variables are based on road distances in miles. McDougall uses the relative quality and convenience of bus service as determined by a weighted average of time spent walking and waiting. Studies by Price, Dyger, and McMillan et al. use direct distance in miles to the CBD, while Nelson uses a time-weighted measure of employment accessibility. Accessibility measures in Maser et al. include average driving time to the CBD, a set of interaction variables between zoning categories and driving time, and several dummy variables for access to commercial establishments and industrial plants. Abelion includes accessibility measures for block access, public transport, and proximity to the ocean. Gautrin computes a measure of the capitalised value of accessibility to both the airport and the CBD, while De Vany uses dummy variables to capture the net impact of an airport on land values. Two studies (Paik; Mieszkowski and Saper) exclude accessibility
measures, but in Paik this may be justified by the small study areas based on census blocks.

The main findings of these studies can be summarised, with some adjustments, by means of a noise depreciation sensitivity index (Walters, 1975, pp. 102–105). For two residential properties that differ only in their level of noise exposure, the absolute amount of housing depreciation per decibel (price of quiet) can be defined as

$$D = \frac{\text{difference in total noise discount}}{\text{difference in noise exposure}}$$  \hfill (6)

Dividing $D$ by the price of a basic house, the percentage rate of depreciation, or noise depreciation sensitivity index (NDSI), is defined as

$$\text{NDSI} = \frac{D}{\text{property value}} \cdot 100 = \frac{\text{difference in total percentage depreciation}}{\text{difference in noise exposure}}$$  \hfill (7)

where we assume that differences in absolute price levels are fully accounted for when deflated by the average property value.

The range of NDSIs in the Appendix is about 0.40 to 1.10% per decibel for those regressions using data for 1967–76. Taking a simple average of twelve estimates yields a mean NDSI of 0.62%, as shown in Table 1.9

---

9 The average NDSI is based on what, in the author's opinion, are the best coefficient estimates obtained in each study. Using the highest reported values would result in an average NDSI of about 0.9% per decibel.
The one study (Paik) that uses 1960 census data obtained an NDSI of about 2.0% per decibel. Since 1960 is the beginning of commercial jet travel in the United States, this result may be explained by short-run disequilibrium in residential housing markets.

SUMMARY OF A SIX-CITY PROPERTY VALUE STUDY\textsuperscript{10}

Sampling procedures in the six-city study attempt to render constant many of the characteristics of residential housing, especially airport access and characteristics of the local public sector. Each study area is about two miles in radius and contains NEF values from 20 or 25 to 45. This procedure attempts to ensure constant accessibility to airport terminals, CBDs, and other major focal points. In addition, the amount of variation in local public sector variables (property tax rate, quality of schools, etc.) should be quite small. The study areas include 300 to 400 contiguous census blocks; these blocks are screened in various ways, so that final samples average about 140 blocks. By the use of aerial photographs and other information on each area, the samples exclude blocks if they are near local environmental features (parks, cemeteries, golf courses), major transport facilities (freeways, main streets, railroad tracks), commercial developments (shopping centres, apartment complexes), or other special neighbourhood features (sewage treatment plants, canals, naval bases, etc.).

Blocks are also excluded if they are adjacent to actual NEF 25 or 30 contour lines, or within NEF 30 but adjacent to NEF 35. This procedure is adopted for three reasons. First, NEF data are for the year 1972 and census data are for 1970. While noise contours (isopleths) may have shifted during this interval, this is less likely to have affected blocks situated between two contours. Second, since NEF data are in 5-decibel increments, using all available blocks will tend to introduce measurement errors where two blocks border on each side of a noise contour. Third, by excluding these blocks we obtained samples containing a relatively large proportion of residences exposed to high NEF levels.

Remaining data were obtained from the 1970 Third Count census tapes, printed census block reports, and printed census tract reports for each urban area. Explanatory variables specified at the block level include the mean property value for reporting units, mean number of rooms per unit, percentage of total housing units that are owner-occupied, percentage of population which is black, percentage of owner-occupied houses with substandard plumbing, and NEF levels. Variables specified at the tract level include percentage of housing units built before 1939 and percentage of housing units that have central air conditioning.

Regression results for the six cities are summarised in Table 2. In addition to various exclusions noted above, final samples reflect the following constraints: (1) blocks are excluded if less than 50% of housing units were single-family, owner-occupied; (2) blocks are excluded if they contained fewer than ten single-family, owner-occupied units; and (3) blocks are excluded if less than 80% of the residential units reported values to the Census in 1970. In percentage terms, NEF coefficients range from $-0.29\%$ for Cleveland to $-0.74\%$ for San Diego, with a simple average of

\textsuperscript{10} Results summarised in this section are described more extensively in Nelson (forthcoming).
AIRPORTS AND PROPERTY VALUES

Jon P. Nelson

Table 2

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Sample Size</th>
<th>Mean 1970 Property Value</th>
<th>Mean NEF Level</th>
<th>Percentage of Observations NEF ≥ 40</th>
<th>NEF Coefficienta (t-value)</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>153</td>
<td>$29,686</td>
<td>31.8</td>
<td>12.4</td>
<td>-0.0058 (3.1549)</td>
<td>0.713</td>
</tr>
<tr>
<td>St. Louis</td>
<td>113</td>
<td>16,411</td>
<td>30.2</td>
<td>17.7</td>
<td>-0.0051 (1.9136)</td>
<td>0.742</td>
</tr>
<tr>
<td>Cleveland</td>
<td>185</td>
<td>20,898</td>
<td>33.9</td>
<td>17.8</td>
<td>-0.0029 (2.2695)</td>
<td>0.690</td>
</tr>
<tr>
<td>New Orleans</td>
<td>143</td>
<td>21,975</td>
<td>27.7</td>
<td>8.4</td>
<td>-0.0040 (2.0523)</td>
<td>0.751</td>
</tr>
<tr>
<td>San Diego</td>
<td>125</td>
<td>32,241</td>
<td>32.3</td>
<td>23.2</td>
<td>-0.0074 (3.1795)</td>
<td>0.762</td>
</tr>
<tr>
<td>Buffalo</td>
<td>126</td>
<td>20,656</td>
<td>29.3</td>
<td>13.5</td>
<td>-0.0052 (2.6000)</td>
<td>0.611</td>
</tr>
<tr>
<td>Pooled Sample</td>
<td>845</td>
<td>23,713</td>
<td>31.0</td>
<td>15.4</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

a NEF coefficient from a regression of the mean block property value on variables for house size, housing density, housing quality, racial composition, deteriorated housing, age of housing, and aircraft noise exposure (NEF). For additional details, see Nelson (two forthcoming articles).

-0.51%. These estimates are statistically stable about a weighted-mean value of -0.50, using an $F$-test for individual regression coefficients.11

Table 3 presents results for a pooled sample consisting of 845 observations. A Chow test indicated nonhomogenous samples, so five dummy variables are included in these regressions. The NEF coefficients are -0.0040 and -0.0048, the latter value reflecting inclusion of a control variable for access to the airport in each area. Accessibility is defined as straight-line distance to the airport terminal in miles, rounded down to the nearest mile.12 The empirical results from six U.S. cities, on both individual and pooled bases, suggest an average NDSI of about 0.50 to 0.55% per decibel.

CONCLUSIONS

To date, some thirteen empirical studies of airport noise and property values have been conducted using cross-sectional housing data. These studies are consistent with or based on the hedonic price model. The estimated coefficient for noise exposure is the marginal implicit damage per decibel of noise or the marginal implicit price per decibel of noise avoided. Households can be assumed to locate themselves in space so that differences in values of residential properties are equalising only at the margin.

11 The individual samples were partitioned to include observations within one to four miles of the airport terminals. NEF coefficients ranged from -0.0039 to -0.0074, and were stable about a weighted mean of -0.0053.

12 The pooled sample was partitioned into several two-mile intervals. NEF coefficients ranged from -0.0030 to -0.0061, and were stable about weighted means of -0.0046 and -0.0055.
TABLE 3
Regression Results—Pooled Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>7.5614</td>
<td>7.6016</td>
</tr>
<tr>
<td></td>
<td>(49.3988)</td>
<td>(49.2221)</td>
</tr>
<tr>
<td>NEF</td>
<td>-0.0040</td>
<td>-0.0048</td>
</tr>
<tr>
<td></td>
<td>(5.3979)</td>
<td>(5.5740)</td>
</tr>
<tr>
<td>Ln Mean rooms per unit</td>
<td>1.3365</td>
<td>1.3370</td>
</tr>
<tr>
<td></td>
<td>(28.5900)</td>
<td>(28.6410)</td>
</tr>
<tr>
<td>Ln Percentage owner-occupied</td>
<td>0.1191</td>
<td>0.1229</td>
</tr>
<tr>
<td></td>
<td>(3.5750)</td>
<td>(3.6876)</td>
</tr>
<tr>
<td>Percentage black population</td>
<td>-0.0027</td>
<td>-0.0029</td>
</tr>
<tr>
<td></td>
<td>(4.4968)</td>
<td>(4.6980)</td>
</tr>
<tr>
<td>Percentage substandard plumbing</td>
<td>-0.0005</td>
<td>-0.0004</td>
</tr>
<tr>
<td></td>
<td>(0.1981)</td>
<td>(0.1383)</td>
</tr>
<tr>
<td>Percentage built before 1939</td>
<td>-0.0005</td>
<td>-0.0004</td>
</tr>
<tr>
<td></td>
<td>(1.3474)</td>
<td>(1.0390)</td>
</tr>
<tr>
<td>Percentage central air conditioning</td>
<td>0.0017</td>
<td>0.0018</td>
</tr>
<tr>
<td></td>
<td>(3.3349)</td>
<td>(3.4145)</td>
</tr>
<tr>
<td>Distance to airport</td>
<td>—</td>
<td>-0.0110</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>(1.8260)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.8383</td>
<td>0.8387</td>
</tr>
</tbody>
</table>

* Dummy coefficients for regression (2) are −0.5844 for St. Louis; −0.2876, Cleveland; −0.4303, New Orleans; 0.0084, San Diego; and −0.4264, Buffalo. All, except San Diego, are significant at the 95% level or better. For additional details, see Nelson (forthcoming articles).

That is, if two houses have different noise environments and are otherwise identical, the difference in value is the expected discounted present value of noise annoyance. Evaluation of the marginal implicit price function over the range of noise exposures and property values produces a locus of equilibrium outcomes that reflect both demand and supply forces. While this locus of values is not a marginal valuation function, benefit estimation can be conducted if the change in noise exposure levels is small and if partial equilibrium assumptions can be assumed to hold.¹³

A survey of evidence from thirteen studies suggests noise discounts in the range 0.4 to 1.1% per decibel. Noisy and quiet properties will differ by at least 20 decibels of noise exposure. Thus, a $40,000 house would sell for $32–36,000 if located in a noisy zone, or at a total discount of 10–20%. The evidence reviewed further suggests that the noise discount is commonly 0.5–0.6%, though a higher value may occur in some high-income areas (Boston, Washington, D.C., London, for example). While none of the studies reviewed are completely free of error or bias, the weight of the evidence is consistent with the orthodox economic theory of land rents. For broad policy decisions on noise abatement alternatives, order-of-magnitude or lower bound estimates based on property value data may be quite valuable to decision makers.

¹³ For an overall discussion of noise externalities in the context of airport planning and investment, see Walters (1978).
AIRPORTS AND PROPERTY VALUES

APPENDIX

Survey of Twelve Property Value Studies

Abelson (1979)

*Area(s) studied and year.* Sydney, 1972–73. Mean property values are $21,000 for Marrickville and $24,000 for Rockdale, in Australian dollars.

*Noise Pollution Measure.* NEF 20 to 45 for 1973. Noise variable specified as NEF — 25, so that all NEF scores of 25 or less receive a value of zero. The background noise level is therefore 25 NEF.

*Type of Data.* Individual housing data, actual sales for January 1972 through September 1973, deflated using a time variable. Sample sizes are 592 for the inner city of Marrickville and 822 for the suburb of Rockdale. Dependent variable is either linear or log of sales price, with the latter preferred because of lower heteroskedasticity.

*Model Characteristics.* Explanatory variables include no. of rooms, frontage and depth of land in feet, month of contract (inflation), construction (brick or not), property type (detached or not), date of construction, type of roof, improvements such as modernized windows, no. of stories, external condition, and type of garage. Accessibility variables also included for block access, block level, access to shops, closeness to sea, quality of public transportation, and road width. Other variables included are road blight, road traffic, zoning, social status, closeness to railway, and view.

*Main Findings.* Abelson (1979, p. 23) concludes that, within the 25 NEF contour, the price of aircraft noise is 0.4% per NEF for Marrickville. For higher-priced homes in Rockdale, the price difference between very noisy and quiet houses was 10%, or about 0.5% per NEF. The R²’s are about 0.62 to 0.66. Abelson also concludes that noise depreciation is a non-linear function of NEF.

De Vany (1976)

*Area(s) studied and year.* Dallas, 1970. Mean property value is about $22,000.

*Noise Pollution Measure.* NEF 20 to 50 represented by four qualitative (dummy) variables for 1970.

*Type of Data.* Census block data for 1,270 observations in the vicinity of Love Field. The model is linear and the dependent variable is the mean property value for each block.

*Model Characteristics.* Explanatory variables include no. of rooms, percentage of homes that are owner-occupied, age of housing, average length of occupancy, percentage of homes with air conditioning, and distance to the CBD. The R² is about 0.82. The total noise discount for a property bordering on the airport is about $5,300, or $177 per NEF. Using the mean value of housing of $22,000 yields a noise depreciation index of about 0.8% per NEF.

*Main Findings.* The dummy variables capture the net effect of an airport on property values. Within one mile of the airport (NEF 50) there is a sizeable net reduction in value; for one to two miles the net effect is inconsequential; for two to three miles the net effect is positive; and beyond three miles there is no net effect on value. NAS (1977, p. 139) estimates that the noise depreciation index is 0.58% within two to three miles (NEF 20–45) from the airport.

Dygert (1973)

*Area(s) studied and year.* San Francisco, 1970. San Jose, 1970. Mean property values are about $27,600 and $21,000, respectively.

*Noise Pollution Measure.* NEF 25 to 45 for 1970. Some estimates for CNR also employed. No adjustment for noise thresholds in full sample regressions.

*Type of Data.* Census tract data and assessed land values aggregated to the tract level. Sample size of 128 observations for San Mateo County in the vicinity of San Francisco International Airport and 198 observations for Santa Clara County near San Jose Municipal Airport and Moffett Field, a naval air station. Dependent variable is log of mean assessed site value per square foot.

*Model Characteristics.* Explanatory variables include accessibility (shopping centres, industrial sites, airport terminals, public schools, and the central business districts), median no. of people per unit, percentage nonwhite units, characteristics of the terrain, dwelling units per acre, and the property tax.
rate. Regressions presented for full sample and partitioned samples based on noise levels, proportion of single-family dwellings, and total property value.

**Main Findings.** Significant (90% level) San Mateo County noise coefficients tend to cluster around \(-0.005\), but range from \(-0.004\) to \(-0.034\). Santa Clara County coefficients range from \(-0.007\) to \(-0.015\), but do not cluster around a central value. Suggested noise depreciation indexes are 0.3 and 0.7%, respectively, but could be greater. Typical $R^2$ is in range 0.60 to 0.70.

**Emerson (1969, 1972)**

**Area(s) studied and year.** Minneapolis, 1967. Mean property value is $19,683.

**Noise Pollution Measure.** Composite Noise Rating (CNR) from 90 to 125 (NEF 25–45) for summer 1967; threshold CNR of 90 or 100 units is used.

**Type of Data.** Individual housing data, actual sales prices from Multiple Listing Service sheets for 15 July to 30 September 1967. Sample size is 222. Dependent variable is log of sales price. The noise variable is the log of (126 – CNR).

**Model Characteristics.** Significant explanatory variables include square feet in house, square feet in lot, age, garage space, no. of baths, no. of floors, stucco or stone exterior, no. of ranges, etc., no. of fireplaces, distance to school, location within two lots of freeway, location near parks or open green space, percentage nonwhite population in elementary schools, and freedom from aircraft noise nuisance. The noise variable is significant at 90% level, one-tailed test; $R^2 = 0.798$.

**Main Findings.** Emerson (1972, p. 275) concludes that the reduction in price for residences exposed to a CNR of 125 was 9.8%, or $1,929 for a mean $19,683 residence. The implied marginal damage is about $115 per NEF, or a noise depreciation index of 0.58% per NEF. The CNR–NEF relationship is approximately CNR = 53 + 1.5 NEF (see Dygert, 1973, p. 19). Final regressions use a threshold CNR of 100 (NEF 30).

**Gautrin (1975)**

**Area(s) studied and year.** London Heathrow, 1968–69. Mean property value is £5,100 for Cranford and Hayes–Harpington.

**Noise Pollution Measure.** NNI 35 for Hayes–Harlington and NNI 55 for Cranford. A “modified Mohring model” of land rents is used, where Cranford is located closer to the CBD and airport employment.

**Type of Data.** Individual housing sales for January 1968 to April 1969. Sample size is 67. The data suggest that typical houses in Cranford either sell for the same or a premium of £50 per lot relative to Hayes–Harlington.

**Model Characteristics.** Cranford is located nearer to the airport by one-half mile, so that lots bear an estimated premium of £269 per lot due to airport accessibility. Cranford lots also bear a premium of £30 due to superior accessibility to the CBD.

**Main Findings.** It is assumed that the accessibility premium and noise discount are exactly offsetting or result in a £50 premium for Cranford. This implies a noise discount of £249–299 per lot in Cranford, or a noise discount of about 0.25–0.30% per NNI, or about 0.56–0.68% per NEF (see Walters, 1975).

**McDougall (two papers, 1976)**

**Area(s) studied and year.** Los Angeles, 1970. Mean property value is approximately $26,700.

**Noise Pollution Measure.** Relative noise intensity is measured by a weighted figure of the percentage of each planning area subject to 90 decibels or more for 1970 and 1990. Those areas with noise levels above 100 decibels are given twice as much weight.

**Type of Data.** The data consist of approximately 35 census tracts within the 35 planning areas of the city of Los Angeles. All variables, including the noise level measurement, are in natural logs.

**Model Characteristics.** Explanatory variables include mean no. of rooms per unit, accessibility to bus service, neighbourhood quality and land use, and school quality. The $R^2$ is 0.83 and the noise variable is significant at the 90% level.
AIRPORTS AND PROPERTY VALUES

Jon P. Nelson

Main Findings. McDougall (winter 1976, p. 63) concludes that a residence of average value will decline in value by $24 if the weighted area subjected to 90 decibels or more increases by 1%. A noise depreciation index cannot be calculated from this information.

McMillan et al. (1978)

Area(s) studied and year. Edmonton, 1975–76. Mean property value is $51,933, in Canadian dollars.

Noise Pollution Measure. NEF 20 to 37 for 1975. The noise measure is specified as the log of 38 – NEF. The mean is about 23 NEF. Background noise level of 20 NEF.

Type of Data. Individual housing data, multiple listing price for September 1975 to September 1976. No adjustment for inflation. Sample size is 352 observations and the dependent variable is the log of the sales price.

Model Characteristics. Explanatory variables include floor area in square feet, date of construction, no. of bathrooms, no. of bedrooms, lot size in square feet, and dummy variables for no. of storeys, duplexes, finished basement, brick exterior, and garages. Other variables include distance to CBD, zoning dummies for duplexes and apartments, and the effective property tax rate.

Main Findings. The difference in value between a house located at NEF 35 and a house located at NEF 20 is $3,709 (McMillan et al., 1978, p. 7), so the noise depreciation index is about 0.5%. The $R^2$ is 0.66.

Maser et al. (1977)

Area(s) studied and year. Rochester, 1971. Mean property values are about $15,200 and $22,000 for city and suburban samples, respectively.

Noise Pollution Measure. 100 PNdB contour (NEF 30) for 1967. There is a large discrepancy between the FAA 100 PNdB contour and the estimates used. The actual noise levels might be greater than 100 PNdB.

Type of Data. Individual housing sales and census tract data. For 1971, city and suburban observations were analysed separately for samples of 398 and 990 observations, respectively. The model is linear and the dependent variable is the sales price per acre of land plus structure for each individual parcel. The noise variable is in dummy form.

Model Characteristics. Significant variables include no. of rooms, percentage nonwhite population, property crime rate, condition of property, adjacent or visible land use characteristics such as apartments, industrial sites and public buildings, type of street, access to central business district, and access to bodies of water or parks. The $R^2$ is about 0.60 for the city sample and 0.80 for the suburban sample.

Main Findings. The reported results plus communication with the authors suggest that city properties within NEF 30 are discounted by $2,500–2,900, or a noise depreciation of about 0.82 to 0.95% per NEF on an average $15,200 property. The suburban discount is $2,400–3,000 on an average $22,000 property, or a noise depreciation index of about 0.55 to 0.68% per NEF.

Mieszkowski and Saper (1978)

Area(s) studied and year. Toronto, 1969–73. Mean property values are about $30,000 and $35,000 for Mississauga and Etobicoke, respectively, in Canadian dollars.

Noise Pollution Measure. NEF 25 to 35 for 1971 and CNR 95 to 115 forecasts for 1975–76. No adjustment for thresholds in full sample regressions, but noise-free regressions can be used to calculate implied discounts in noisy areas.

Type of Data. Individual housing data, actual sales for January 1969 through June 1973. Data are deflated to 1969 using a time variable. Sample sizes vary depending on control group, but 621 observations are available for the borough of Mississauga and 509 observations for Etobicoke. Dependent variable is either linear or log of sales price.

Model Characteristics. Explanatory variables include square feet in lot, average room size, lot size, square of both room size and lot size, no. of bedrooms, no. of utility rooms, no. of bathrooms, and
dummy variables for 25 additional characteristics such as number of stories, garage size, fireplaces, type of siding, etc. No accessibility measures are included.

**Main Findings.** Final results are difficult to interpret due to use of control groups and the authors indicate several problems for the Mississsauga regressions. For Etobicoke, the total noise discount relative to the control group (NEF 20) is $-6.4\%$ for NEF 25, $-4.6\%$ for NEF 30, and $-7.8\%$ for NEF 35. This implies noise depreciation rates of $1.3\%$, $0.5\%$, and $0.5\%$ per NEF, respectively. The $R^2$ is about 0.90 when all observations are used.

**Nelson (Economic Analysis . . ., 1978)**

*Area(s) studied and year.* Washington, D.C., 1970. Mean property value is $27,455.$

*Noise Pollution Measure.* NEF 20 to 35 for 1970. Background noise level of NEF 20 is assigned to tracts in vicinity of Washington National Airport.

*Type of Data.* Census tract data are screened to exclude tracts with less than 110 single-family, owner-occupied units (sample size is 52). Dependent variable is log of median property value for each tract.

*Model Characteristics.* Explanatory variables include no. of rooms, lot size in square feet, age of housing, central air conditioning, dummy for riverside locations, and accessibility to employment. Tests are conducted for 18 other variables that proved to be insignificant, including the property tax rate and school expenditures.

*Main Findings.* The noise depreciation index is about 1.1%. The $R^2$ is 0.863. Noise coefficient is significant at the 90% level, one-tailed test.

**Paik (1972)**

*Area(s) studied and year.* New York, 1960, Los Angeles, 1960, Dallas Love Field, 1960. Mean property values are $16,656,$ $19,772,$ and $18,011,$ respectively.

*Noise Pollution Measure.* NEF 20, 30, and 40 for 1965. Background noise level of NEF 20. Census blocks eliminated near the boundaries of the NEF contours.

*Type of Data.* Census block data screened so that at least 50% of residences are single-family and owner-occupied. Sample sizes are 106, 92, and 94 observations, respectively. Dependent variable is log of median property value for each block. The log of NEF is used as an explanatory variable.

*Model Characteristics.* Explanatory variables include the mean no. of people per household, absolute no. of single-family homes, the percentage of deteriorated houses, the absolute no. of nonwhite homes, and the median no. of rooms per house. Only the room and noise variables are significant. The corrected $R^2$ is about 0.77 for each city regression.

*Main Findings.* Paik (1972, p. 143) concludes that a 1% increase in NEF would result in a $130$, marginal capitalised damage on a $20,000$ property. Assuming that NEF increases from 31 to 32 (3.22%), this implies a marginal depreciation rate of 2.09%. Nelson (Economic Analysis . . ., 1978, pp. 103–105) reran the regressions and obtained a noise depreciation index of 2.20%.

**Price (1974)**

*Area(s) studied and year.* Boston, 1960 to 1970. Mean apartment rental is about $100$ per month for 1970.

*Noise Pollution Measure.* NEF 25 to 45 for 1970. NEF values for each tract are interpolated to the nearest NEF unit. No adjustment for threshold noise levels.

*Type of Data.* Census tract data screened so that at least 25% of the total housing units are rental units (sample size is 270). Dependent variable is the percentage change in median contract rent from 1960 to 1970 for each tract.

*Model Characteristics.* Explanatory variables include the change in the percentage of nonwhite population from 1960 to 1970, percentage of nonwhites in 1960, percentage of people over 65 in 1960, log of median contract rent in 1960, distance to the Boston central business district, percentage increase in property tax rate, percentage of housing units built before 1930, percentage of housing units built since 1960, and the percentage of housing units that are public housing units.
AIRPORTS AND PROPERTY VALUES

Jon P. Nelson

Main Findings. Price (1974, p. 59) concludes that, for 1970, the differences in rents between a quiet residence (NEF 25) and a comparatively noisy one (NEF 35) would be about $8.33 per month. The average monthly rent is about $100 per month in 1970. This implies a noise depreciation index of about 0.83%, or slightly less for more costly rental properties. Corrected $R^2$ is 0.50 or less, and the noise coefficient is significant at 95% or better.

REFERENCES


