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The Effects of Aircraft Noise at Williams Air Force Base Auxiliary Field on Residential Property Values

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The Effects of Aircraft Noise at Williams Air Force Base Auxiliary Field on Residential Property Values

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MASTER

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by

M.J. Morey

ABSTRACT

This report considers the environmental consequences of moving the flight training operations of the U.S. Air Force's 82nd Flying Training Wing from the auxiliary airfield, Coolidge-Florence Municipal Airport (CFMA), to a more remote location in Pinal County, Arizona. It examines how actual noise from touch-and-go flights of T-37 aircraft and perceived (anticipated) noise affect the market value of residential property near CFMA. Noise, measured by a noise index, is correlated with market values through a regression analysis applied to a hedonic price model of the Coolidge-Florence housing market. Prices and characteristics of 42 residential properties sold in 1987 and 1988 were used to estimate a perceived noise effect. The report finds that the coefficient on the measure of perceived noise, based on the noise exposure forecast (NEF) index, is statistically insignificant, even though the sign and value are consistent with those estimated in other studies. It concludes that current flights do not have a significant effect on residential property values, partially because there is no housing near CFMA. This and larger studies indicate that flight operations at a new auxiliary airfield would not affect property values if runways were at least 12,000 feet away from housing.

1 INTRODUCTION

1.1 PURPOSE OF STUDY

The U. S. Air Force (USAF) has proposed that the 82nd Flying Training Wing stationed at Williams Air Force Base (AFB) in Chandler, Arizona, use a new auxiliary airfield to train pilots. The new facilities would be used for the training activities that are now being conducted at the Coolidge-Florence Municipal Airport (CFMA), which is the current auxiliary airfield for Williams AFB. The use of a new auxiliary airfield is being proposed because (1) activities at the existing auxiliary airfield conflict with each other and (2) there is now a high density of air traffic at Williams AFB. This study addresses the possible effects on property values that could result from the construction and operation of this new auxiliary airfield and its associated facilities in one of three candidate areas southeast of Phoenix.

1.2 DETERMINING POTENTIAL SITE LOCATIONS

Approximately 600 acres would be needed for a new auxiliary airfield. The facilities that would be needed would include a runway, fire station, access roads, and two runway supervisory units. These are small buildings near the runway that contain meteorological and radio communications equipment and are used by USAF personnel to control military touch-and-go operations. Utilities, including electric transmission lines, telephone lines, and the domestic water and sewer system, would also be part of these facilities.

The USAF initially identified four large areas in Pinal County southeast of Williams AFB as possible locations for the airfield. They were from 12,160 to 44,000 acres in size. Three areas met all the USAF criteria for conducting training flights and operating jet aircraft. The fourth area was eliminated from further consideration because aircraft could possibly collide with birds from a nearby reservoir at this location. Major towns in the vicinity of the three areas investigated include Coolidge, Florence, Eloy, and Casa Grande, all of which are in Pinal County. Pinal County, with about 107,000 residents, accounts for about 32% of the total population of Arizona.

Although personnel from Williams AFB provided assurances that an airfield at any of these locations would not impinge on airspace needs of a proposed Municipal Regional Airport to be built nearby, the U.S. General Accounting Office had some concerns about the Federal Aviation Administration's (FAA's) management of "special-use airspace," i.e., airspace used for military training missions. Airspace in the Phoenix area, as well as in a large part of southern Arizona, is already committed to military operations; available airspace is limited. The analysis discussed in this report does not consider these concerns but rather assumes that sufficient airspace is available for both the new T-37 facility and the proposed Municipal Regional Airport. Conflicts that might arise from competing use of airspace are therefore not addressed, since it is assumed that Williams AFB has the time and resources to carefully plan for and minimize these impacts. Moreover, there would probably be no more sorties flown each day at the new facility than are flown now at the present facility. Therefore, T-37 operations have to be accommodated for, regardless of the location of the auxiliary field.

1.3 DETERMINING EFFECTS OF NOISE ON PROPERTY VALUES

Currently, CFMA has a 5-mile buffer between each runway and the nearest residential development. Williams AFB personnel have proposed moving T-37 operations to an even more remote location to minimize the impacts from these flights on the population. Nevertheless, the possibility that this move might have a negative effect on existing housing located near the new site was a major concern emphasized at public meetings. Thus, the focus of this report is on the effect that operations at the new auxiliary airfield could have on residential property values.

A number of studies indicate that relocating T-37 training operations from their present location at CFMA to a new auxiliary field could affect residential property values in Pinal County. The principal consideration in locating any airport next to residential property is the effect of the perceived noise level on the nearby property's market value. This report provides an empirical examination of the effects of relocation through the estimation of coefficients for a hedonic price equation to explain how prices of residential properties in Coolidge might vary because of T-37 aircraft flying training sorties on tracks around CFMA. This empirical study concludes (1) that the USAF's current use of CFMA does not have a significant effect on residential property values in Coolidge (or Florence) and (2) that relocating the auxiliary field elsewhere in Pinal County would probably not have a significant effect on residential property values unless the residences were within 12,000 feet (about 2.3 miles) of either of the runways at the facility.

2 GENERAL CONSIDERATIONS AND ECONOMIC MODELS OF NOISE AND PROPERTY VALUES

The notion that airport noise is a negative externality that very likely reduces the value of residential property and causes other environmental harm, all other factors held constant, has been a subject of some controversy over the last decade. There is considerable uncertainty about the extent of the environmental harm that occurs and how such harm should be measured. Although noise has been the focus of many communities that have opposed new airports, as an environmental issue, airport noise has been an extremely difficult topic to deal with. DeVany (1976) points out that "[p]sychological studies verify that intrusive noise, such as would be experienced by persons living under flight paths, interrupts sleep, decreases the effectiveness with which tasks are performed, and makes conversation difficult." Yet there is also evidence that people can adapt to noise and perform a variety of tasks even when noise is quite intensive. In summary, the evidence on the actual effects of noise, and on airport noise in particular, is mixed.

The hypothesis that airport noise has a negative effect on residential property values arises from the economic model of consumer behavior toward negative externalities, which indicates that individuals are willing to pay more for comparable housing that is located in relatively quieter residential areas. Many empirical studies tend to support this proposition. Yet DeVany (1976) argues that an airport has two effects on adjacent land values -- a depreciation effect because of aircraft noise and an appreciation effect because of increased opportunities for employment. In the instance discussed here, however, no new employment opportunities would occur except during a brief construction period. Hence, because employment accessibility might not be an important issue in this case, it is not allowed to unduly bias this analysis.

To understand the effect that the perceived noise associated with an airport has on property values, consider two residential properties that are identical in every respect, except that the first one is located under the flight path of an airport and the second one is not. The value of any residential property to the occupant can be viewed as the present discounted value of a stream of net benefits that accrue to the owner or occupant. These benefits are derived from a set of characteristics possessed by the property; some of these characteristics may be considered good, and others may be considered bad. Observations made by occupants or potential occupants of the two properties with regard to these characteristics would most likely lead to an implicit valuation that would place a lower value on the first (nearby) property than on the second. If the difference in the present discounted values of the two properties were to be divided by the difference in their noise levels, the result would be a measure of the discounted expected present value of relative quiet, expressed as an expense avoided through purchase of the second residence (in dollars per decibel). The prediction to be made from this behavioral model is that the market price of the residence closest to the airport would be lower than that of the residence in the quieter neighborhood.

This model of consumers' reactions to differences in noise levels across residences would be adequate if consumers had identical tastes and preferences, especially with respect to their tolerance for airport noise. However, differences in consumer tastes and preferences must be accounted for if markets, such as housing markets, are to operate efficiently. An understanding of these differences is the essence of an effective economic model of property valuation. In summary, in any examination of the effects of airport noise on property values, it is fundamental to develop an operational definition of noise that is consistent with an economic model of consumer choice, involving implicit valuation.

3 MEASURING NOISE

From the standpoint of the human auditory system, a "noise" (including airport noise) is the same thing as a "sound." However, noise can be defined as an unwanted sound. Noise in this sense is differentiated from other sounds only on the basis of human tastes or preferences. Most noise experienced by persons living near an airport is not intense enough to induce pain or other symptoms of physiological stress. According to Kryter (1970), noise is sound that interacts with activities, diminishing their value or impairing the ability of persons to enjoy or perform them. Noise perceived by an individual can be characterized in terms of its spectrum content and level, spectrum complexity, duration, and duration of increase. According to psychoacoustic research, these characteristics are the fundamental dimensions that people use to distinguish degrees of noisiness. Operationally, noisiness can be defined as a personal ranking of sound according to these characteristics.

In an effort to measure the noisiness of sounds, several noise indexes have been constructed. They combine sound characteristics to rank the noisiness of environments such as those found adjacent to airports. An appealing aspect of these indexes is that they are unique up to a linear transformation and have a concave contour, making them consistent with indexes that represent assumptions in economic theory about how consumers rank ordered bundles of goods.

There are two systems for measuring noise levels that are commonly used in airport noise studies. One is the noise exposure system, which gives rise to the noise exposure forecast (NEF). The NEF is a measure of the effective perceived noise level in decibels (dB). The second system is the graphically produced composite noise rating (CNR) system, which measures a house's aircraft-noise annoyance level on the basis of the number of flights, the time of day they occur, and the perceived loudness of the noise. For the purposes of this study, there was virtually no difference between the indexes, so the NEF was used because it was more convenient to do so.

Under the noise exposure system, the total noise exposure generated at a given point in space can be computed as the sum of noise levels produced by different aircraft flying different flight paths. The NEF is computed according to the algorithm in Eq. 1:

$$NEF = EPNL + 10 \log(ND + 16.7NN) - K \qquad (1)$$

where:

EPNL = the average effective perceived noise level at a given point in space (dB),

ND = the number of day-time (0700 to 2200 hour) flights,

NN = the number of night-time flights, and

K = a scale-adjusting constant with an assigned value of 88.

The noise exposure is therefore a function of the average perceived noise level, the time of day, and the number of operations. According to Nelson (1980), "NEF values range between 15 and 55 [decibels]. 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."

Sound-level measurements are based on a logarithmic scale, and loudness doubles every 10 dB. When plotted on a log scale, an annoyance index will be approximately linearly related to the perceived noise level in dB (Bishop and Horonjeff 1967). Hence, the annoyance level due to aircraft noise is assumed in most studies to be related to NEF according to Eq. 2:

$$A = a_1 + \exp\{a_2 \, NEF\} \tag{2}$$

where:

A = subjective annoyance due to aircraft noise,

a_1, a_2 = coefficients,

NEF = noise exposure forecast (dB), and

exp = the natural log base.

Specific estimates of noise exposure for the Coolidge market are discussed in the next section.

4 HEDONIC PRICE MODEL OF RESIDENTIAL PROPERTY VALUES

Originally developed by Griliches in 1971 (see Griliches 1979) and refined by Freeman in 1974 (see Freeman 1979), Rosen in 1974 (see Rosen 1974), and Walters in 1975 (see Walters 1975), the hedonic price model has been used extensively to explain variations in the market prices of residential and other types of property. The hedonic analysis of residential property values is based on the assumption that each house and its associated lot is viewed by both buyers and sellers as having a unique combination of characteristics or attributes. The price each buyer is willing to pay and the price each seller is willing to accept for each property is a function of these characteristics, such as location, quality of the neighborhood and the environment, taxes, public services (fire protection, police, etc.), and physical attributes of the structure and lot.

As are other goods, a house is a bundle of characteristics that cannot be sold separately. Therefore, it is difficult to infer from one or two sales what the incremental effect of a change in one characteristic will be on the value of the residence. However, the hedonic model assumes that buyers, by shopping around, can develop a sense of the values of various attributes and construct a value for the property in terms of the implicit prices they place on these attributes. If characteristics are bundled in various combinations, marketed as varieties or brands of goods, and sold in observable explicit markets, it becomes possible to estimate the parameters of an implicit or hedonic function that relates the price to the quantities of the various attributes possessed. Provided a measure of the relative noisiness of a property is included in the list of characteristics, the coefficient on noise in a hedonic price equation may reflect the marginal discounted value of a residential property given an incremental increase in perceived noise.

Most housing value studies assume, in a more formal way, that the vector of observed housing prices (V) is a function of a vector of structural characteristics (S), a vector of locational characteristics (L), a vector of neighborhood environmental-quality characteristics (Q), a vector of local taxes (T), and a vector of local public services (E). Equation 3 expresses this relationship mathematically:

$$V = f(S, L, Q, T, E) \quad (3)$$

where dV/dQ_i would represent the marginal implicit price, or the increase in expenditures (V) required to obtain one more unit of a particular environmental-quality attribute (Q_i). (Here i = an element of the vector Q.) If the Q_i element were the perceived noise level associated with an airport, the change in V would most likely be negative, all else being constant. If the model were properly specified, the incremental change in V resulting from a change in noise level could also be interpreted as a buyer's willingness to pay for an improvement in the noise exposure level.

The hedonic price model is a reasonable approximation of how a market for bundled commodities operates, provided certain restrictive but necessary assumptions are satisfied. Chief among these is the assumption that both explicit and implicit prices are the outcomes of equilibrium determined by the distribution of buyers' and sellers' tastes and costs. In the housing market, equilibrium may not, in practice, be satisfied for a number of reasons. (See Rosen 1974, Nelson 1980, and Freeman 1979 for discussions of problems that can arise.) The Coolidge real estate market, which provided the information for this study, is a small and relatively slow market that does appear to be in equilibrium except in the low-income-housing and rental submarkets. However, if the equilibrium assumptions made for the Coolidge housing market were incorrect, the estimated parameters of the hedonic function would be subject to bias.

An explicit econometric specification of the hedonic price equation is based on the assumption that there is a multiplicative relationship between a house's price and its property characteristics, including noise annoyance (A) related to NEF by Eq. 2. This can be expressed as:

$$\ln V = b0 + b1 \ln S + b2 \ln L + b3 \ln Q + b4\, NEF + u \qquad (4)$$

where:

lnV = the natural log of the vector of observed housing prices,

b0-4 = coefficients representing the marginal implicit prices of characteristics,

lnS = the natural log of the vector of structural characteristics,

lnL = the natural log of the vector of locational characteristics,

lnQ = the natural log of the vector of neighborhood environmental-quality characteristics (excluding NEF), and

u = a stochastic disturbance term assumed to be distributed independently of the characteristics, with a mean of zero and constant variance.

5 NOISE LEVELS AT WILLIAMS AIR FORCE BASE AUXILIARY FIELD

Measures of the effective noise levels associated with air traffic at CFMA (in decibels) were developed by Argonne National Laboratory (ANL). These measures reflect the flight tracks (paths) of the T-37 aircraft flying training sorties, primarily on closed-loop courses around the air facility. These patterns are expected to be repeated regardless of the location of the auxiliary field.

The maximum effective noise levels are reached within 12,000 to 16,000 feet (2.3 to 3.0 miles) of either of the two runways, 05 or 23. At points approximately 16,000 feet northwest and northeast of either Runway 23 or Runway 05, the NEF associated with the noise contour is approximately 45 dB. The noise contour at these points is approximately 12,000 feet (2.3 miles) from Florence and approximately 14,000 feet (2.6 miles) from Coolidge.

The majority of USAF flights use Runway 23, and the most frequently used flight tracks are 23 CH, 23 CG, and 23 DA. Both 23 CH and 23 CG are closed-loop tracks that would not be expected to cause any significant auditory annoyance unless a residence was within 12,000 feet of the field. Flight path 23 DA, the third most frequently taken track, passes by the easternmost edge of Coolidge. According to the flight profile, at this location, the T-37s have reached an altitude of approximately 3400 feet, and the NEF values for residential property in Coolidge are between 15 and 30 dB.

Because there are currently no flight paths of any significance from CFMA near the Florence market, the effects of noise exposure on residential property in Florence were assumed to be negligible. Consequently, this empirical analysis focused on the Coolidge real estate market.

6 PRICES AND CHARACTERISTICS OF HOUSING IN COOLIDGE

The data used in the hedonic price analysis were provided by real estate agents operating in the Coolidge market. Data on the sale prices and housing characteristics of 42 residential properties sold from January 1987 through October 1988 were obtained. Usually much larger data sets are desirable for analyses of this type, to ensure the fair representation of all combinations of attributes. However, additional data were difficult to acquire, because the agents in Coolidge, as well as most of the agents in Pinal County, did not become members of the Arizona Multiple Listing Service (MLS) Association until late 1987. (Some agents have still not joined.) Therefore, the MLS did not provide any listings obtained over this time period. Consequently, the interpretation of these estimated coefficients of the hedonic price equation are subject to all the caveats associated with the use of small data sets that may not represent a systematic random sample of the residential market.

Measures for variables expected to have a significant effect on residential prices were obtained for the following characteristics:

PRICE = current asking or offer price ($);

TAXES = property taxes, in some cases estimated ($);

ROOMS = total number of rooms;

SQFT = area, in some cases estimated (ft^2);

BATHS = number of bathrooms;

BEDRMS = number of bedrooms;

APPLIANC = 0-1 variable indicating the presence of appliances such as a stove or refrigerator (1 if present, 0 if not);

GARAGE = 0-1 variable indicating the presence of a garage or carport (1 if present, 0 if not);

AGE = age of the house (yr);

HEAT = 0-1 variable indicating the presence of central heating (1 if present, 0 if not);

COOL = 0-1 variable indicating the presence of central air conditioning (1 if present, 0 if not);

PROXIMTY = 0-1 variable indicating proximity to shopping (1 if within 3 blocks, 0 if not); and

NEF = noise exposure forecast (dB).

Data for other variables that could have significant effects on property values were missing for so many properties in the sample that the use of these variables would have severely restricted the size of the sample. It is recognized that the omission of these data, for whatever reason, may bias the estimated coefficients of the hedonic function.

Table 1 summarizes the statistics for the variables listed above. Natural log transformations were performed for measures of prices and all "continuous" characteristics in conformance with the specification presented in Eq. 4. However, statistics are not reported for the transformed variables.

Most of the variables for which there was a complete data set do not display wide variation. Moreover, several variables, for obvious reasons, are highly correlated, which created a problem of severe multicollinearity in the estimated regression model. This problem was addressed by reducing the number of regressors in the equation.

TABLE 1 Descriptive Statistics for the Variables Used in the Regression Analysis

Variable	Mean Value	Standard Deviation	Minimum Value	Maximum Value
PRICES ($)	53,409.09	17,722.61	27,000.00	79,500.00
TAXES ($)	529.09	142.00	250.00	792.00
ROOMS (no.)	7.91	1.64	5.00	10.00
SQFT (ft^2)	1,352.55	473.41	300.00	2,100.00
BATHS (no.)	1.66	0.34	1.00	2.00
BEDROOMS (no.)	3.00	0.63	2.00	4.00
APPLIANC (0-1)	0.82	0.40	0.00	1.00
GARAGE (0-1)	0.64	0.50	0.00	1.00
AGE (yr)	16.27	8.26	9.00	33.00
HEAT (0-1)	0.82	0.63	0.00	1.00
COOL (0-1)	0.82	0.63	0.00	1.00
PROXIMTY (0-1)	0.64	0.50	0.00	1.00
NEF (dB)	24.55	4.68	15.00	30.00

7 ESTIMATED HEDONIC PRICE EQUATION FOR COOLIDGE

The estimated coefficients of a hedonic price equation are presented in Table 2. Several versions of this equation were estimated; the coefficients for the "best" one of these is presented for interpretation. The best equation in this case was determined to be the one that represents a model that explains a high proportion of the variation in price and is consistent with the results obtained in other studies involving airport noise.

The estimated coefficients on NEF and ROOMS can be interpreted as elasticities. In other words, the coefficients represent the percentage change in the price of a residential property given a 1% change in the value of the variable when all else is held constant. The estimated coefficients on HEAT and PROXIMTY represent the percentage change in price given the fact that a residence has central heating or is close to a shopping area. The coefficient on NEF is consistent in both size and sign with those estimated in nearly all the U.S. and U.K. airport studies that had significantly larger data sets. The major difference in this instance is the fact that the coefficient is not statistically significant. A statistically significant coefficient could be obtained if other subsets of variables were included in the regression. However, the multicollinearity that would be created from the inclusion of these variables would be so severe that interpretations of results could not be considered trustworthy.

TABLE 2 Results of Estimating the Coefficients of the Best Hedonic Price Equation[a]

Variable	Estimated Coefficient	Standard Error	t Statistic	Probability Value
NEF	-0.0010	0.0159	-0.063	0.95148
ROOMS	0.4635	0.2390	1.940	0.10048
PROXIMTY	-0.3275	0.1297	-2.526	0.04494
HEAT	0.5872	0.1688	3.497	0.01316
CONSTANT	9.6373			

[a]Dependent variable = natural log of price; standard error of estimate = 0.1493; R squared = 0.9274; adjusted R squared = 0.9196; multiple R = 0.9630; F ratio = 11.826; and Prob(F) = 0.005.

[b]Degrees of freedom = 3%.

8 CONCLUSIONS

Results from the model estimated in this study are consistent with those from earlier studies on the effects of airport noise (Nelson 1979, 1980; DeVany 1976). These results, when considered along with the fact that the Coolidge real estate market is too far away to be affected by significant levels of aircraft noise, can lead one to conclude that the relocation of Williams AFB training operations to an auxiliary field elsewhere in Pinal County would not have any substantial effects on residential property values, unless these residences were located within 12,000 feet (2.3 miles) of either Runway 05 or Runway 23.

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