Noise and property values

Maintenance of property values is one of our common concerns. An unwelcome local development might knock thousands off the value and be fiercely resisted in the planning stages. Noise is often one of the most prominent factors in the objectors' armoury, so that it is clearly relevant to have a quantification of the effects of noise on property values. The main noises which affect property values follow from developments in transportation. Other, more localised, noisy developments may also occur, such as entertainment and industrial complexes, but these are not yet assessed as devaluers. However, air, road and rail have been studied in some detail, particularly air and road transport.

THE CONCEPT OF DEVALUATION

An economic assessment of noise follows from a *willingness to pay (WTP)* in order to reduce noise, or to be removed from it. Alternatively, the *willingness to accept compensation (WTAC)* to remain in the noise is also considered as a cost of noise. There are two main methods of assessment.

THE HEDONIC PRICE METHOD

This is based on study of consumer preferences, revealed through their behaviour. It is assumed that willingness to pay for the preferred noise environment around one's home is revealed in the market price for house purchase or rental. That is, houses in noisy areas will cost less than the exact equivalent houses in quiet areas. There are assumptions in this method: for example, the property market is in free equilibrium, the noise must be noticeably different in the two areas, purchasers understand the long term effects of noise etc. There is a tendency to either underestimate long term effects of noise through ignorance of its potential or to overestimate it, because of its high correlation with other environmental effects (visual intrusion, dust, congestion).

THE CONTINGENT VALUATION METHOD

This is based on surveys of respondents willingness to pay for quiet or willingness to accept compensation for noise. For example, the questions in the table above might be used.[1]

Aircraft noise. A recent review by Nelson[2] considered the results of 20 hedonic property value studies, covering 33 estimates of noise effects for 23 civilian airports in the USA and Canada. Airports provide local employment and access to travel, so that both positive and negative effects might be expected. However, day-night average noise levels (LDN) of 75dB or greater are classed as incompatible with residential use, levels of 65–74dB are normally incompatible with this use, whilst DNL's lower than 65dB are compatible. A house under a flight path will have a lower market value than one which is not and, in this way, purchasers show their valuation of quietness.

It is very unlikely that two properties will be identical in all respects other than noise exposure and it is necessary to separate these out from noise. Variables include:

- Structure (S), related to size, number of rooms etc.
- Location (L)
- Local taxes (T)
- Local services (G)
- Local environment (E).

Then the value (V) of the property is a function of these variable and

$$V = V(S, L, T, G, E)$$

The effect of each of the variables on value is given by the increased expenditure required to obtain one more "unit" of that variable, whilst all others are held constant, and is given by the partial differentiation of V with

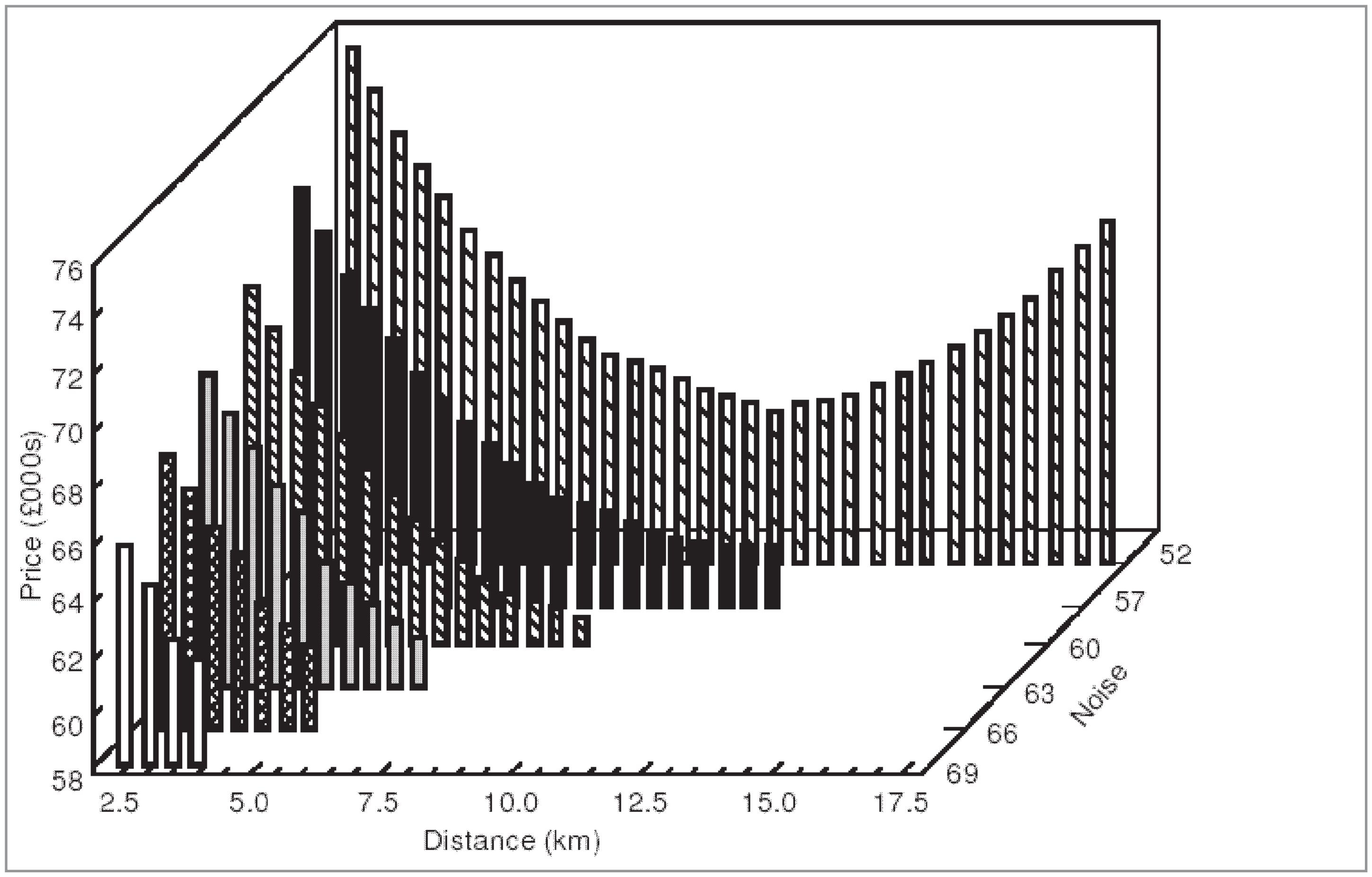

Figure 1. Distance (km) from Manchester Airport and Noise (LAeq) in relation to house prices in the mid-1990s (from Tomkins[3])

respect to the characteristic, for example, ∂V/∂E for the local environment.

Nelson also uses the following relations:

> Hedonic function for properties near an airport is $V=b_0Z^{b1}A^{b2}u_1$, in which V is the property value, Z is all other influences except noise, A is annoyance due to aircraft noise, u_1 is a stochastic error term and b_0, b_1, b_2 are parameters

> Annoyance due to aircraft noise is approximated by an exponential function, $A=c_0e^{c1(\mathrm{DNL})}u_2$, where DNL is the Day-Night-Level in decibels, u_2 is a stochastic error term and c_0, c_1 are parameters

From combining these two relations it can be shown that a Noise Depreciation Index (NDI), which is the percentage decrease in a given property value per decibel of exposure, is[2]

WTP for improvement

1. How much would you be willing to pay each month for living in a quiet environment?
2. How much extra rent per month would you be willing to pay to make sure half the traffic noise was removed from this road?
3. How much would you be willing to pay each month to make sure you will no longer be annoyed by traffic noise?

WTAC for a deterioration

1. How much would you accept to continue living in this noisy environment?
2. How much money would you need each month to just make up for doubling of traffic noise.
3. Suppose the local authority were to offer you XXX per month as compensation for the disturbance you think you may suffer from traffic noise. Do you think this offer will be adequate or inadequate?

$$NDI = \frac{1}{V} \cdot \frac{\partial V}{\partial (DNL)} \; x \; 100\%$$

Then, if NDI is 1%, a property exposed to 70dB is worth 10% less than one exposed to 60dB. Of course, there is cut off at low noise levels, around 55dB, which do not affect property values.

Nelson re-evaluated studies which had NDI values from less than 0.5% to over 1% and concluded that, in the USA and Canada, aircraft noise led to a weighted mean noise discount of 0.58% per decibel. However, the discount is greater in Canada than in the USA.

A UK study by Tomkins et al.[3] in the proximity of Manchester airport evaluated the advantages and disadvantages of proximity to an airport. It was concluded that houses near to the airport benefited positively from location, but negatively from noise, as shown in Fig 1. A fall in prices with distance from the airport is apparent at all noise levels, but at the lowest levels, where airport noise is not intrusive, there is a rise in values at distances greater than 12.5 km, presumably as a result of some other factor, such as increasing desirability of the neighbourhood. Separating out the noise effects indicates an NDI value of about 0.75%, which is consistent with other investigations.

It is possible that devaluation due to aircraft noise varies with cultural differences between nations. Where flying, for both internal and external travel, is more entrenched in their communities, the devaluation may be lower.

To be capitulate, loss of value is assessed by several methods:

- A study of property prices
- Willingness to pay (WTP) to reduce noise
- Willingness to accept compensation (WTAC) to remain in the noise.

Quantification is by methods such as a study of consumer preferences, shown in market prices for equivalent properties exposed to different noise levels, thus giving a direct figure for devaluation. Surveys of willingness to pay for quiet, or to accept compensation for noise, give another method of assessment in an attempt to derive the appropriate levels for WTP or WTAC.

ROAD TRAFFIC NOISE

Exposure to road traffic noise is recognised as the big problem in noise exposure, affecting more individuals

noise notes

AGGRAVATED VIOLATION

The keg you put in your conveniently undersized kitchen could cost you more than $60. The live music in your living room might cost you $20 or $30 – and don't forget to add a few dollars for ice to keep the brew chilled. But the combined cost of your party could be as much as $1,000 if a proposal from by Robert Sarachan, Ithaca assistant city attorney, is passed by the Ithaca Common Council. At the end of January, Sarachan detailed a proposal at City Hall that would increase possible noise violation fines to a minimum of $250 or 50 hours of community service and a maximum of $1,000 or 200 hours of community service and/or up to 15 days in jail. While it is considered unconstitutional to force a defendant to submit to community service, many law violators who cannot afford expensive fines choose community service. Sarachan's proposal is based on similar legislation currently in place in East Lansing, Mich. An aggravated noise violation could incur the maximum penalty, depending on the severity of the violation. The presence of a keg, DJ, amplified sound faced toward windows, a cover charge, public urination, more than 25 people or the presence of underage drinkers coupled with a noise violation could place a hefty financial burden upon party hosts in Collegetown. "If any two of these are present with a noise violation, then a noise violation becomes aggravated," Sarachan said.

than any other noise source. Back in 1996 the EU Green paper on Future Noise Policy, looked at a number of studies and estimated that between 17 and 22% (close on 80 million people) of the EU-15 population are exposed to continuous day-time outdoor noise levels caused by transport above what are generally considered to be acceptable levels – more than 65 dB(A)[2]. An additional 170 million citizens are exposed to noise levels between 55–65 dB(A), which is the level at which people become seriously annoyed during the daytime. The main cause of these exposures was road transport, accounting for nine tenths of the proportion of the EU's total population exposed to levels of noise over 65 dB(A). For comparison, similar levels of noise from rail transport affect 1.7% of the population and air transport a further 1%. Exposures to road traffic noise has increased over the past 10 years

The high percentage of affected people might, on the one hand, lead to an acceptance of traffic noise as an unavoidable part of the living environment, but on the other hand, properties in areas of very low traffic noise could become very attractive to a purchaser.

In some countries, recognition of the effect of traffic noise has led to statutory compensation for increased levels of the noise, and other environmental degradations, following developments of new roads. The amount of compensation is based on an independent assessment followed by negotiation with the property owner. The compensation is intended to reflect the reduction in sale price, consequent upon the increased noise, if the property were sold on the open market.[6]

It would clearly be advantageous if an objective method of assessment could be added to those already in use, in order to expedite what is a rather slow and expensive process of determining depreciation. Bateman et al.[7] have conducted a study of the effect of road traffic noise on property values. A large number of variables were included in the estimations, including floor area, garden area, type of house, distances to amenities, and noise. Some of the results on traffic noise, using different models which were developed for the work, are as follows:

Model 1 contained only structural details of the property and noise variables
Model 2 was Model 1 with the addition of neighbourhood effects
Model 3 was Model 2 with the addition of accessibility
Model 4 was Model 3 with the addition of visual amenity

It was found that the structural variable were significant across all four models. This is to expected, since the value of a property with a greater floor area, larger garden and distinctive design will be higher than others. About 63% of the variation in price can be explained solely through the structural characteristics of the property.

When neighbourhood variables were included, it was found that areas of low socio-economic standing led to reduction in the price of the property.

Accessibility variables were very significant. Properties particularly close to shopping centres, city centres and railway stations had relatively low prices, reflecting the increased congestion and pollution caused by these areas. The values increased on moving further away, rising to a maximum before decreasing as the distances became inconvenient. Peak price was at around 500m walking distance to shops, but was an increase of only 0.1%

Visual amenity variables were such that pleasant views of parkland and open spaces increased values, whilst views dominated by roads or industry led to a reduction.

Noise is included in all models, but its effect was not the same for all.

Model 1 gave a noise coefficient of 0.84% reduction per 1dB increase in noise level
Model 2 gave a noise coefficient of 0.57% reduction per 1dB of increase in noise level
Model 3 gave a noise coefficient of 0.42% reduction per 1dB increase in noise level
Model 4 gave a noise coefficient of 0.20% reduction per 1dB increase in noise level

It is to be expected that the effect of noise reduces as more variables are included, since these each have their effect on property values and the variation between models shows the importance of structure, neighbourhood, accessibility and visual amenity, in addition to noise. It was concluded that Model 4 gave the most complete account of the effects of noise, within the overall representation of a property, and it was concluded that that each decibel increase in traffic noise decreases property price by 0.20%, with a standard error of 0.08%.

Therefore the loss of property value, equivalent to the compensation appropriate for the increased noise exposure, is given by:

$$COMP = CP\left[1-\left(\frac{100}{100=[0.20\text{x}D db]}\right)\right]$$

in which *COMP* is the compensation
CP is the price before the increase in noise exposure
DdB is the increase in noise.

As an example of the use of this method, a property of initial price of £150,000 subject to an increase in noise of 6dB, will receive a compensation of £1779, which is a measure of the reduction in value due to noise.

Other work on road traffic noise in different countries has led to the following percentage loss in values.[7]

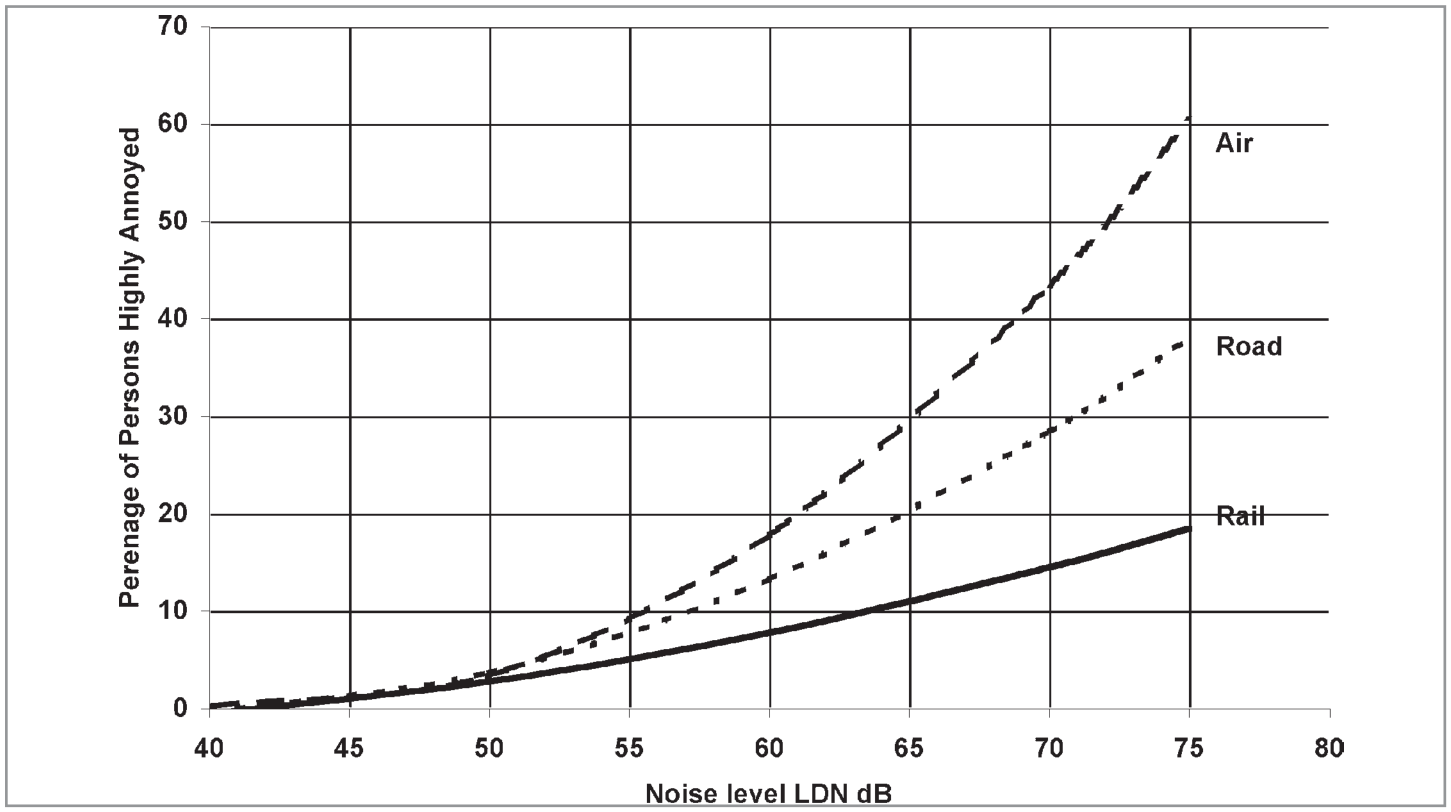

Figure 2 *Comparison of annoyance of air, road and rail noise*

USA	between 0.08% and 2.22% (14 studies)
Canada	between 0.42% and 1.05% (3 studies)
Norway	between 0.21% and 0.54% (3 studies)
Japan	0.7% (1 study)
Switzerland	0.91% and 0.90% (2 studies)
Australia	1.0% (1 study)
Finland	0.36% (1 study)

There is clearly a national, and perhaps local, variation of the percentage loss in property value due to road traffic noise, although the magnitude is likely to be between about 0.2% and 1% per dB increase in noise level.

TRAIN NOISE

The majority of work on loss in value due to trains has been for new light rail lines, where the convenience of a location near, but not too near, to a station may be more positively rated than negative effects of noise. In general, a property very close to a commuter train station has lower value than one a short distance away, due to congestion and other unattractive features close to the station, in addition to noise. As the distance from the station increases, the property value rises and then begins to fall when the distance exceeds about 500m. Here, convenience and accessibility are the main factors.

The worst case, which occurs along main train lines, is when the property is close to the track, but derives little benefit from it. As there have been few new-build main lines since noise came to prominence as an environmental problem, there is little information in this area. However, two studies will be considered.

Expansion of Sydney suburban railways in the late 1970s included an Eastern Suburbs extension. It was considered that the accessibility

SHANGHAI SUBWAY

One of Shanghai's top seismology experts is pushing the local government to take immediate action to reduce the amount of noise generated by Shanghai's subway lines. "When a subway train races by at high speed, it will cause neighbouring constructions, including their floors, walls and pillars, to quiver and produce noise," Zhu Yuanqing, deputy director of the Shanghai Seismological Bureau, said yesterday. In January, Zhu submitted a proposal to the city government during the annual plenary session of the Shanghai People's Congress. Zhu noted in his proposal that a noise test conducted by the bureau in an underground area close to the People's Square metro station on November 10 measured vibration level as high as 94 decibels – China's environmental policies recommend a ceiling of 65 decibels for noises in urban areas. "Normally, the subway noise can affect an area of some 30-50 meters around the subway facilities," he said. "Those noises will disturb people and cause them to feel uncomfortable." Zhu has suggested the city take steps to reduce the amount of vibration caused by passing trains, especially near preserved buildings. He noted the cities of Shenzhen and Guangzhou in Guangdong Province have both been successful in curbing subway noise. In Shenzhen, subway constructors installed vibration-separating springs and rubber boards inside subway tunnels to reduce noise. In a telephone interview, Wu Yi, general manager of Shanghai Metro Construction Corporation, said: "Our company has already decided to use various noise-reduction facilities in future metro construction." He said the company is considering installing vibration-reducing boards below subway tracks to cut down on noise. According to the company, the city will have built nine subway lines stretching 250 kilometres by the end of next year. By that time, the city's subway system will be capable of handling 3.2 million passengers every day. The city has announced plans to build 12 new metro lines by 2020 to augment its current five lines.

benefits of the railway compensated for noise, although noise measurements were not taken. However, in one region, where there were minimum accessibility benefits, there was an indication of up to 10% reduction in property prices near to the track.[8]

A study was carried out in Norway following plans to build a new 40 km long main line, eastward and then northwards from Oslo to the new main airport, at Gardermoen, cutting through a heavily populated area.[9] The line was to be of intercity express standard. Two methods of assessment were used.

- A hedonic price study based on inspection of a registry of house sales, giving 2152 sets of data, 83% of which were apartments.
- A survey of the opinions of 15 experienced real estate agents on the values of hypothetical apartments of a number of types, located close to the rail line.

The hedonic study resulted in a logarithmic variation of value with distance of *0.29log(d)*, for distances from 20m to 100m from the line, leading to a reduction of about 20% at 20m compared with 100m. As it is known that train noise changes by 3dB per doubling of distance, there is a 7dB change between 100m and 20m and about 3% change in property value per decibel. This is higher than the values obtained for air and road transport noise and has been obtained by comparisons at different distances from the track. It should *not* be interpreted to mean that at a fixed distance, say, 100m from the track, the same percentage figure applies to changes in noise levels.

The estate agents' valuations led to a linear decrease in value between 100m and 20m from the track, of about 2300 NOK per meter, where the average apartment value at 100m was 640,000 NOK. From this, a property at 100m from the track will have a value about

LEARNING QUIETLY

Noise has become a major barrier to learning in the classroom. Now, a researcher at the University of British Columbia has designed a software program that will help design out noise. The software, called ClassTalk, is the first of its kind in the world. It helps architects, engineers and acoustical consultants to build classrooms that help students learn and protect teachers from unnecessary voice strain. Prof. Murray Hodgson, the acoustics expert at UBC's Centre for Health and Environment Research who created the program, said that very little attention is being paid to the acoustics of classroom design, and that "designing the noise out of classrooms benefits both students and teachers." Classroom noise has become widely recognized as a learning barrier for all children, whether they have hearing difficulties or not. Prof. Hodgson cited specialists who found that children with normal hearing could miss one in four words spoken by the teacher simply due to poor classroom design. The recommended level for classroom noise is 35 decibels. Traditionally designed classrooms frequently have levels ranging between 40 and 60 decibels. ClassTalk allows designers to predict and assess how the teacher's voice can be heard in different parts of the room. The program takes into account the physical characteristics of a classroom, such as building materials, the number of windows, the texture of surfaces, lighting fixtures and fittings, all of which influence how a teacher's voice carries through the room and is heard by students. The program also calculates how teachers can be heard above the noise of heating and ventilation systems, student activity in the classroom and neighbouring classes, and outside noises such as traffic. "ClassTalk can be easily used during the design of schools, where there is currently little consideration for classroom acoustics," said Clair Wakefield, president of Wakefield Acoustics in Victoria, B.C. "Also, there are many existing classrooms with poor acoustics, so this software should be an effective tool for easily modelling existing classrooms and determining the optimum acoustical treatment for retrofits."

180,000 NOK higher than one at 20m, all other characteristics being equal. This gives a higher percentage than the hedonic study, where the variation in value between 100m and 20m was about 120,000 NOK, but the two are similar.

CONCLUSIONS

There are considerable variations in the results of different studies for loss in property value from transportation noise sources. Most work has been on aircraft noise, with least work on train noise. An indication of the effects is as follows, for percentage loss in property value per decibel increase in noise level.

Aircraft noise: about 0.6% per decibel
Road traffic noise: about 0.2% per decibel
Train noise: about 3% per decibel from 20m to 100 from the track, but probably lower at a fixed distance.

As it is known that, at a given level, train noise annoys fewer people than traffic or aircraft noise of the same level, as shown in Figure 2,10 there are likely to be additional, unresolved factors in the effect of train noise on property value, probably related to closeness to the source.

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noise notes

BUSH INTERCONTINENTAL

The city of Houston plans to hire a consultant to conduct a noise study in an effort to address complaints of residents near the new runway at Bush Intercontinental Airport. Kent McLemore, assistant director of the aviation management planning division with the Airport System, said the department is recommending that City Council hire a firm to conduct a $250,000 study. He said it's the first step to determine if any homes near the airport are eligible for noise mitigation, including sound-proofing or buyout.