Journal of Air Transport Management 57 (2016) 138–142

Contents lists available at ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman

Note

The cost of aircraft noise — Does it differ from road noise? A meta-analysis☆

Fredrik Kopsch [a, b]

[a] The Swedish National Road and Transport Research Institute, VTI, Sweden
[b] Centre for Transport Studies, CTS, Sweden

ARTICLE INFO

Article history:
Received 13 November 2015
Received in revised form
8 April 2016
Accepted 29 May 2016

JEL-classifications:
Q51
R41
R48

Keywords:
Noise
Property value
Meta-analysis
Hedonic model

ABSTRACT

This paper aims at studying the difference in cost between aircraft noise and road noise using meta-analysis. 90 *NDI* estimates have been gathered from the literature (a total of 53 studies), out of which 44 are estimates for aircraft noise and 46 are for road noise. The results of the meta-regression suggest that aircraft noise costs somewhere in the range of 0.40 and 0.60 percent more per increased dB than road noise. Knowing the associations between these costs of noise pollution can be a convenient tool for planners and policy makers, offering an opportunity to make predictions of aircraft noise when only estimates of road noise are available, and vice versa.

1. Introduction

There is a large literature on how noise (or conversely; peace and quiet) is capitalised into housing values. This literature is important as to understand the social cost of noise pollution from different transport modes, which in turn, is important to determine what investments in noise abatements should be prioritised. However, within the body of literature one can find a large spread of estimates of the costs associated with noise pollution. This paper aims at partially explaining these differences by looking at potential differences in transport modes (road and air) in relation to costs associated with noise pollution. One large benefit directly resulting from this approach is that when establishing the relation between transport modes, planners can predict the cost of aircraft noise pollution when only estimates for road noise pollution are available, and vice versa. The findings suggest that the cost of aircraft noise is larger, all else equal, than the cost of road noise. To which there may be several reasons, one being the difference in intensity and unpredictability between the two transport modes. Road noise is normally an ongoing event (when you live in proximity to a road) while aircraft noise is attributed to the landing and take-off cycle. Differences in exposure to noise stemming from different transport modes have been examined in the medicinal field. For example, Stansfeld et al. (2005) argue that aircraft noise has a greater impact on children's reading capabilities than road noise. Basner et al. (2011) found differences in sleep patterns related to the source of noise pollution.

Peace and quiet are goods that cannot be purchased on the open market, yet they are in high demand. This results in a lack of available observable prices for these goods. The common denominator of the included studies of this paper is that they all have approached the valuation of the social cost of noise in the same way, namely though estimation of the *Noise Depreciation Index* (NDI) using the hedonic modelling framework, where noise levels are associated to property values (rents or prices). The approach is not without its problems but it gives good estimates of the social cost of noise pollution. The included studies do of course differ in a number of ways. Early studies of aircraft noise used *Noise Exposure Forecast* (NEF) as the measurement of noise (Abelson, 1979; Maser et al., 1977; Nelson, 1979; O'byrne et al., 1985) while estimations of

☆ This paper has benefited substantially by the comments of two anonymous referees and help from Kyle Farrell. Any remaining errors are due to the author alone.

E-mail address: Fredrik.kopsch@vti.se.

http://dx.doi.org/10.1016/j.jairtraman.2016.05.011
0969-6997/© 2016 Published by Elsevier Ltd.

Table 1
Summary of included studies.

Study	NDI	Noise measure	Transport mode	Country	Time period of data	Study	NDI	Noise measure	Transport mode	Country	Time period of data
Abelson (1979)	0,4	NEF	Air	Austrailia	1972–1973	Maser et al. (1977)	0,61	NEF	Air	USA	1971
Abelson (1979)	0,5	NEF	Air	Austrailia	1972–1973	McMillan et al. (1980)	0,51	NEF	Air	USA	1975–1976
Allen (1980)	0,15	L10	Road	USA	1977–1979	Mieszkowski and Saper (1978)	0,52	CNR	Air	Canada	1969–1973
Allen (1980)	0,14	L10	Road	USA	1977–1979	Myles (1997)	0,37		Air	USA	1991
Anderson and Wise (1977)	0,43	NPL	Road	USA	1969–1971	Nelson (1978)	1,06	NEF	Air	USA	1970
Anderson and Wise (1977)	0,14	NPL	Road	USA	1969–1971	Nelson (1978)	0,87	Ldn	Road	USA	1970
Andersson et al. (2010)	1,68	Laeq	Road	Sweden	1996–2006	Nelson (1979)	0,58	NEF	Air	USA	1970
Bailey (1977)	0,3	Distance	Road	USA	1968–1976	Nelson (1979)	0,51	NEF	Air	USA	1970
Baranzini et al. (2010)	0,226	Ldn	Road	Switzerland	2003	Nelson (1979)	0,29	NEF	Air	USA	1970
Baranzini et al. (2010)	0,197	Ldn	Road	Switzerland	2003	Nelson (1979)	0,4	NEF	Air	USA	1970
Bateman et al. (2001)	0,202	Leq	Road	UK	1987	Nelson (1979)	0,75	NEF	Air	USA	1970
Bateman et al. (2004)	−0,5	Leq	Road	UK	1997	Nelson (1979)	0,52	NEF	Air	USA	1970
Bateman et al. (2004)	0,53	Leq	Road	UK	1997	Nelson (1979)	0,55	NEF	Air	USA	1970–1971
Bateman et al. (2004)	0,28	Leq	Road	UK	1997	O'Byrne et al. (1985)	0,69	Ldn	Air	USA	1980
Bateman et al. (2004)	0,55	Leq	Road	UK	1997	O'Byrne et al. (1985)	0,64	NEF	Air	USA	1970
Bateman et al. (2004)	0,18	Leq	Road	UK	1997	Paik (1972)	1,9	NEF	Air	USA	1960
Bateman et al. (2004)	0,25	Leq	Road	UK	1997	Paik (1972)	1,8	NEF	Air	USA	1960
Bateman et al. (2004)	1,6	Leq	Air	UK	1997	Paik (1972)	2,3	NEF	Air	USA	1960
Blanco and Flindell (2011)	0,45	Laeq	Road	Great Britain	2005	Palmquist (1982)	0,48	L10	Road	USA	1962–1976
Blaylock (1977)	0,99		Air	USA	1970	Palmquist (1982)	0,3	L10	Road	USA	1958–1976
Brandt and Maennig (2011)	0,233	Lden	Road	Germany	2002–2008	Palmquist (1982)	0,08	L10	Road	USA	1950–1978
Brandt and Maennig (2011)	0,13	Lden	Air	Germany	2002–2008	Pennington et al. (1990)	0,47	NNI	Air	UK	1985
Chalermpong (2010)	2,12	NEF	Air	Thailand	2002–2008	Pommerehne, 1988	1,26	Leq	Road	Switzerland	1986
De Vany (1976)	0,8	NEF	Air	USA	1970	Price (1974)	0,81	NEF	Air	USA	1970
Dekkers and van der Straaten (2009)	0,77	Lden	Air	Netherlands	1999–2003	Püschel and Evangelinos (2012)	1,04	Lden	Air	Germany	2009
Dygert (1973)	0,5	NEF	Air	USA	1970	Renew (1996)	1	Leq	Road	Austrailia	
Dygert (1973)	0,7		Air	USA	1970	Rich and Nielsen (2004)	0,54	Laeq	Road	Denmark	2002
Emerson (1972)	0,58	CNR	Air	USA	1967	Rich and Nielsen (2004)	0,47	Laeq	Road	Denmark	2002
Fromme (1978)	1,49		Air	USA	1970	Salvi (2007)	0,93	Leq	Air	Switzerland	1995–2007
Gamble et al. (1974)	2,22	NPL	Road	USA	1969–1971	Soguel (1991)	0,91	Leq	Road	Switzerland	1990
Gamble et al. (1974)	0,24	NPL	Road	USA	1969–1971	Swoboda et al. (2015)	0,2	Leq	Road	USA	2006
Gamble et al. (1974)	0,21	NPL	Road	USA	1969–1971	Swoboda et al. (2015)	0,3	Leq	Road	USA	2008
Gamble et al. (1974)	0,26	NPL	Road	USA	1969–1971	Swoboda et al. (2015)	0,4	Leq	Road	USA	2010
Gautrin (1975)	0,62	NNI	Air	UK	1968–1969	Swoboda et al. (2015)	0,27	Leq	Road	USA	2006–2010
Grue et al. (1997)	0,24	Leq	Road	Norway	1995	Tarassoff (1993)	0,65		Air	Canada	1989–1990
Grue et al. (1997)	0,48	Leq	Road	Norway	1988–1995	Taylor et al. (1982)	0,42	Leq	Road	Canada	1972–1978
Grue et al. (1997)	0,54	Leq	Road	Norway	1988–1995	Taylor et al. (1982)	0,52	Leq	Road	Canada	1972–1978
Hall et al. (1978)	1,05	Leq	Road	Canada	1975–1977	Uyeno et al. (1993)	0,65	NEF	Air	Canada	1987–1988
Hidano et al. (1992)	0,7	Leq	Road	Japan	0	Uyeno et al. (1993)	0,9	NEF	Air	Canada	1987–1988
Iten and Maggi (1988)	0,9		Road	Switzerland	0	Uyeno et al. (1993)	1,66	NEF	Air	Canada	1987–1988
Kaufman et al. (1996)	0,28		Air	USA	1991–1995	Vainio (1995)	0,36	Leq	Road	Finland	
Langley (1976)	0,22	NPL	Road	USA	1962–1972	Vaughan and Huckins, 1975	0,65	Leq	Road	USA	1971–1972
Levesque (1994)	1,3	EPNL	Air	USA	1985–1986	Wilhelmsson (2000)	0,6	Leq	Road	Sweden	1990–1995
Mark (1980)	0,56	NEF	Air	USA	1969–1970	Yamaguchi (1996)	1,51		Air	UK	1996
Maser et al. (1977)	0,88	NEF	Air	USA	1971	Yamaguchi (1996)	2,3		Air	UK	1996

road noise have traditionally used different types of equivalent levels (L_{eq}, LA_{eq}) or noise levels throughout the day (L_{dn}, L_{den}) as measurement (e.g. Bateman et al., 2001; Grue et al., 1997; Renew, 1996). Later, studies of aircraft noise adopted the same measures as road noise studies. Studies also differ in terms of data availability. Some rely on aggregate prices at, for example, the census tract (e.g. Nelson, 1979; Price, 1974; De Vany, 1976). With better data availability, later studies have access to more disaggregated data and focus on individual sales (e.g. Brandt and Maennig, 2011; Blanco and Flindell, 2011; Levesque, 1994) or rents (e.g. Baranzini et al., 2010; Püschel and Evangelinos, 2012). Furthermore, studies may differ in terms of model specification where most use a semi-logarithmic approach, with a few exceptions. These differences, aside from the mode of transport under study, may all be causes of the differences in estimated costs of noise pollution.

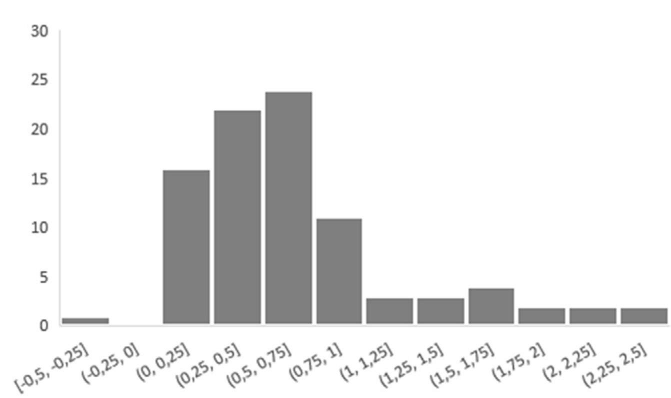

Fig. 1. Distribution of estimates of *NDI*.

Table 2
Regression output - Dependent variable *NDI*.

Variable	Model I		Model II		Model III	
	Coeff	t-value	*Coeff*	t-value	*Coeff*	t-value
Aircraft	0,4085*	3,86	0,4272*	3,42	0,6053*	4,09
Noise measure, $L_{eq} = 1$	–		−0,0201	−0,13	0,0420	0,28
Country, USA = 1	–		−0,1413	−1,21	−0,1135	−0,93
Year published	–		–		0,0158*	2,73
Published	–		–		0,0953	0,8415
Type of data, individual transactions = 1	–		–		0,1273	0,93
Control for accessibility = 1	–		–		0,2230***	1,84
Model specification, Log-Linear = 1	–		–		−0,3606**	−2,32
Ln(sample size)	–		–		−0,3117*	−3,39
Constant	0,4810*	6,50	0,5499*	4,29	−30,37**	−2,65
R2	0,1448		0,1603		0,395791	
Nobs	90		90		64	

Note: *, ** and *** significant at the 1%, 5% and 10 level respectively.

The remainder of the paper is structured as follows. In Section 2 the most common approach to estimating the cost of noise pollution will be described. In section 3 the meta-analysis performed here is discussed, with the results presented in section 4. Section 5 concludes.

2. Estimating the cost of noise pollution

Since Rosen (1974) presented the framework, the concept of hedonic pricing models has come to play a large role in numerous studies estimating the price (or cost) of non-market goods (or bads), such as noise pollution, or accessibility. Hedonic price models use the known price (P_i) and composition (Z_i) of a heterogeneous market good (often property). Drawing upon the fact the properties are differently exposed to, e.g. noise, one can estimate the implicit price of noise (β_1) from (1).

$$lnP_i = \beta_0 + \beta_1 Noise + \beta_3 lnZ_i + u_i \quad (1)$$

Where the natural log of price is regressed on the property characteristics (such as size, age and accessibility) and the noise level. The benefit of estimating the log-linear model is that the implicit price of noise (β_1) can be directly interpreted as the quasi elasticity called the *Noise Depreciation Index (NDI)*. That is, a 1 dB change in the noise level yields a β_1 percent change in price. Formally, the *NDI* is given by:

$$NDI = \frac{\partial P}{\partial Noise} \frac{(-100)}{P} \quad (2)$$

The *NDI* is defined negatively as the effect of noise on price is normally thought be negative. *P* is the price, for example the sample mean. The *NDI* provides means of comparing estimates between studies.

For this paper a total of 90 *NDI* estimates from 53 studies have been gathered. Out of these, 44 are estimates of aircraft noise and 46 regarding road noise. The included studies are summarised in Table 1. A histogram of the distribution of *NDI* estimates is presented in Fig. 1 with intervals of *NDI* estimates on the x-axis and number of studies on the y-axis.

The sample mean of the *NDI* is 0.68 with a standard deviation of 0.53, which tells us the variation is large. The sample mean differs between the two transport modes with aircraft seeing a mean *NDI* of 0.88 while road noise estimates has a mean of 0.48.

There is not a single approach to measuring noise pollution. Measures of noise pollution have differed over time, across countries and between transport modes. This is a potential source of the differences in estimates of the noise depreciation index. This suspicion is supported by e.g. Wilhelmsson (2000) who states, when comparing results, that "… and that L_{eq} dBA is less than L_{10} under the same condition" pp. 810.

3. Meta-analysis

Since the point of the *NDI* is to provide a comparable (between studies) estimate of the cost of noise, it is also a good candidate for meta-analysis. Nelson (2004) performs a meta-analysis on airport noise in order to provide a useful sample mean, based on the assumption that all included estimates are unbiased estimates of a true population discount. Schipper et al. (1998) also perform a meta-analysis on aircraft noise with the aim to describe what may cause differences in estimates and find that relative house values can explain a lot of the variation (aircraft noise is a larger problem in wealthier neighbourhoods). Instead of explaining aircraft noise alone, the present paper will aim to explain and estimate the size of the difference between the cost of aircraft and road noise. Additionally, this will provide an estimate of a "multiplier" that can be used when only road noise estimates are available but not aircraft noise, or vice versa.

The meta-regression that will be estimated is given by (3):

$$NDI_i = \beta_0 + \beta_1 aircraft_i + \beta_2 X_i + \varepsilon_i \quad (3)$$

Where the *NDI* of study *i* is regressed on study specific characteristics (X_i), such as country, time of publication, number of observations and so on. These are important to add as control variables as there may be systematic differences in these underlying variables that cause differences in *NDI* estimates between the two transport modes. Also included is a binary variable describing if the *NDI* is estimated on aircraft noise or not. Thus, β_1 is of specific interest. ε_i is a random disturbance.

4. Results

As previously mentioned, 90 *NDI* estimates have been gathered from 53 different studies. In addition, information regarding the study has been gathered. Other than describing whether the *NDI* estimate regards aircraft or not, the following information has been gathered.

The type of noise measure
Country
Year of publication
Peer-reviewed journal
Type of data (individual sales or census)
Accessibility measure
Specification, log-linear or linear
Sample size

The information regarding a few studies has been gathered from Bateman et al., 2004[‡], hence not all information is available for these studies. Which results in a reduced sample size when all variables are included, that is in Model III presented in Table 2.

Table 2, column 1 illustrates the results of model I, where the NDI is regressed on the aircraft noise dummy alone. The estimate of 0.40 is significant and tells us that, on average, aircraft noise costs 0.40 percent more than road noise. This estimate varies between 0.40 and 0.60 over the three models; it is always significantly different from 0. In model III the whole range of variables is added to the regression. These results give us some additional interesting insights into the cost of noise. The estimate controlling for inclusion of some sort of accessibility measure is positive and significant (although weakly at the 10% level). This is reasonable. If a study fails to control for accessibility this effect will more than likely be picked up by the noise measure. As accessibility tends to have a positive effect on house prices, studies disregarding this effect will underestimate the cost of noise pollution. The sample size shows a significant, and negative, effect on the *NDI* estimate, which are in line with the coefficient estimates of Nelson (2004). The year published has a positive effect. This may be resulting from the fact that over time, estimation techniques and the availability of better data becomes available. Interestingly, whether or not a study is published in a peer review journal does not seem to have an effect on the estimates of *NDI*, thus it seems this strand of literature does not suffer strongly from a publication bias, although this might still be a possibility.

5. Conclusions

This paper set out to study the difference in costs between aircraft noise and road noise. When applying a meta-regression to the 90 *NDI* estimates of 53 studies the results indicate that there is a difference in the range 0.40–0.60 in terms of *NDI*, which means that aircraft noise costs an additional 0.40 and 0.60 percent more per increased dB than road noise. Noise valuations are resource intensive, they take time and require costly data gathering. In light of this, valuations are not always available for both road noise and aircraft noise. Knowing the cost of noise is important. Policy makers need this knowledge when implementing noise reduction schemes and planners when determining where to construct new roads or expand airports. The knowledge of a relation between road noise and aircraft noise can serve as a rough conversion “multiplier” when aircraft noise estimates are not available, but road noise estimates are, or vice versa. Thus it may be a convenient tool for planners and policy makers when it comes to noise regulation and traffic planning.

The question of why there is a difference in cost of noise between the two transport modes is still left unexplained in this paper. New research might be warranted in this area. An attempt to answering the question can however be found in the field of medicinal research. For example, Stansfeld et al. (2005) argue that aircraft noise affects health differently than road noise due to the differences in predictability and intensity. That is, road noise is continuous while aircraft noise is more dispersed and often louder.

References

Abelson, P.W., 1979. Property prices and the value of amenities. J. Environ. Econ. Manag. 6 (1), 11–28.

Allen, G.R., 1980. Relationship between Highway Noise, Noise Mitigation and Resident Property Values, FHWA/VA-81/1. Virginia Highways and Transportation Research Council, Charlottesville, VA.

Anderson, R.J., Wise, D.E., 1977. The Effects of Highway Noise and Accessibility on Residential Property Values, DOT-FH-11–8841. National Technical Information Service, Springfield, Va.

Andersson, H., Jonsson, L., Ögren, M., 2010. Property prices and exposure to multiple noise sources: hedonic regression with road and railway noise. Environ. Resour. Econ. 45 (1), 73–89.

Bailey, M.J., 1977. Report on Pilot Study: Highway Noise and Property Values. unpublished paper. University of Maryland.

Baranzini, A., Schaerer, C., Thalmann, P., 2010. Using measured instead of perceived noise in hedonic models. Transp. Res. Part D Transp. Environ. 15 (8), 473–482.

Basner, M., Müller, U., Elmenhorst, E., 2011. Single and combined effects of air, road, and rail traffic noise on sleep and recuperation. Sleep 34, 11–23.

Bateman, I., Day, B., Lake, I., Lovett, A., 2001. The Effect of Road Traffic on Residential Property Values: a Literature Review and Hedonic Pricing Stucy. Report to the Scottish Executive Development Department. School of Environmental Sciences, University of East Anglua, Norwich.

Bateman, I., Day, B., Lake, I., 2004. The Valuation of Transport-related Noise in Birmingham. University of East Anglia: School of Environmental Sciences.

Blanco, J.C., Flindell, I., 2011. Property prices in urban areas affected by road traffic noise. Appl. Acoust. 72 (4), 133–141.

Blaylock, J.E., 1977. Airport Noise and Housing Values: an Investigation into the Hedonic Theory of Housing and the Value of Quiet. Blaylock.

Brandt, S., Maennig, W., 2011. Road noise exposure and residential property prices: evidence from Hamburg. Transp. Res. Part D Transp. Environ. 16 (1), 23–30.

Chalermpong, S., 2010. Impact of airport noise on property values: case of Suvarnabhumi International Airport, Bankgkok, Thailand. J. Transp. Res. Board 2177, 8–16.

Dekkers, J., van der Straaten, W., 2009. Monetary valuation of aircraft noise: a hedonic analysisa round Amsterdam airport. Ecol. Econ. 68 (11), 2850–2858.

De Vany, A.S., 1976. An economic model of airport noise pollution in an urban environment. In: Lin, S.A.Y. (Ed.), Theory and Measurement of Economic Externalities. Academic Press, New York, pp. 205–214.

Dygert, P.K., 1973. Estimation of the Cost of Aircraft Noise to Residential Activities. Unpublished Ph.D dissertation. Univrsity of Michigan.

Emerson, F.C., 1972. Valuation of residential amenities: an econometric approach. Apprais. J. 40, 268–278.

Fromme, W.R., 1978. Conceptual Framework for Trade_off Analysis of Multiple Airport Operation: Case Study of the Metropolitan Washington Airports. unpublished Ph.D. dissertation. University of Maryland.

Gamble, H.B., Sauerlender, O.H., Langley, C.J., 1974. Adverse and beneficial effects of highways on residential property values. Transp. Res. Rec. 508, 37–48.

Gautrin, J.F., 1975. An evaluation of the impact of aircraft noise on property values with a simple model of urban land rent. Land Econ. 51 (1), 80–86.

Grue, B., Langeland, J.L., Larsen, O.I., 1997. Housing Prices – Impacts of Exposure to Road Traffic and Location. TØI report 351/1997, Oslo.

Hall, F.L., Breston, B.E., Taylor, S.M., 1978. Effects of Highway Noise on Residential Property Values (No. HS-026 811).

Hidano, N., Hayashiyama, Y., Inoue, M., 1992. Measuring the external effects of noise and vibration of urban transportation by the hedonic approach. Environ. Sci. 9 (3), 401–409.

Iten, R., Maggi, R., 1988. The economic value of traffic noise abatement in an urban area: empirical evidence from a hedonic and discrete choice approach. In: 5th Conference on Transportation Research (Yokohama).

Kaufman, H.F., Espey, M., Englin, J.E., 1996. No Plane, Big Gain: Airport Noise and Residential Property Values in the Reno-Sparks Area. Master's thesis. University of Nevada, Reno.

Langley, C.J., 1976. Adverse impacts of the Washington beltway on residential property values. Land Econ. 52 (1), 54–65.

Levesque, T.J., 1994. Modelling the effects of airport noise on residential housing markets: a case study of Winnipeg International Airport. J. Transp. Econ. policy 28 (2), 199–210.

Mark, J.H., 1980. A preference approach to measuring the impact of environmental externalities. Land Econ. 56 (1), 103–116.

Maser, S.M., Riker, W.H., Rosett, R.N., 1977. The effects of zoning and externalities on the price of land: an empirical analysis of Monroe County, New York. J. Law Econ. 20 (1), 111–132.

McMillan, M.L., Reid, B.G., Gillen, D.W., 1980. An extension of the hedonic approach for estimating the value of quiet. Land Econ. 56 (3), 315–328.

Mieszkowski, P., Saper, A.M., 1978. An estimate of the effects of airport noise on property values. J. Urban Econ. 5 (4), 425–440.

Myles, C.L., 1997. Sound Effects: Measuring the Impact of Aircraft Noise on Residential Property Values Around McCarran International Airport. Unpublished M.A. Thesis. University of Nevada, Las Vegas.

Nelson, J.P., 1978. Economic Analysis of Transportation Noise Abatement. Ballinger, Cambridge, MA.

Nelson, J.P., 1979. Airport noise, location rent, and the market for residential amenities. J. Environ. Econ. Manag. 6 (4), 320–331.

Nelson, J.P., 2004. Meta-analysis of airport noise and hedonic property values. J. Transp. Econ. Policy (JTEP) 38 (1), 1–27.

O'Byrne, P.H., Nelson, J.P., Seneca, J.J., 1985. Housing values, census estimates, disequilibrium, and the environmental cost of airport noise: a case study of Atlanta. J. Environ. Econ. Manag. 12 (2), 169–178.

Paik, I.K., 1972. Measurement of Environmental Externality in Particular Reference to Noise. unpublished Ph.D. dissertation. Georgetown University.

Palmquist, R.B., 1982. Impact of Highway Improvements on Property Values in Washington State (No. 887).

Pennington, G., Topham, N., Ward, R., 1990. Aircraft noise and residential property values adjacent to Manchester International Airport. J. Transp. Econ. Policy 24 (1), 49–59.

Price, I., 1974. The Social Cost of Airport Noise as Measured by Rental Changes; the Case of Logan Airport. Unpublished Ph.D. dissertation. Boston University.
Pommerehne, W.W., 1988. Measuring environmental benefits: a comparison of hedonic technique and contingent valuation. In: Welfare and Efficiency in Public Economics. Springer, Berlin Heidelberg, pp. 363–400.
Püschel, R., Evangelinos, C., 2012. Evaluating noise annoyance recovery at Düsseldorf International Airport. Transp. Res. Part D 17 (2012), 598–604.
Renew, W.D., 1996. The relationship between traffic noise and house price. In: Conference of the Australian Acoustical Society, Brisbane, 13-15th November, 1996.
Rich, J.H., Nielsen, O.A., 2004. Assessment of traffic noise impacts. Int. J. Environ. Stud. 61 (1), 19–29.
Rosen, S., 1974. Hedonic prices and implicit markets: product differentiation in pure competition. J. Political Econ. 34–55.
Salvi, M., 2007. Spatial Estimation of the Impact of Airport Noise on Residential Housing Prices. Working Paper. Zürcher Kantonalbank.
Schipper, Y., Nijkamp, P., Rietveld, P., 1998. Why do aircraft noise value estimates differ? A meta-analysis. J. Air Transp. Manag. 4 (2), 117–124.
Soguel, N., 1991. Evaluation du coût social du bruit généré par le trafic routier en ville de Neuchâtel. Université, IRER, Institut de recherches économiques et régionales.
Stansfeld, S., Berglund, B., Clark, C., Lopez-Barrio, I., Fischer, P., Öhrström, E., Haines, M., Head, J., Hygge, S., van Kamp, I., Berry, B., 2005. Aircraft and road traffic noise and children's cognition and health: a cross-national study. Lancet 365 (9475), 1942–1949.
Swoboda, A., Nega, T., Timm, M., 2015. Hedonic analysis over time and space: the case of house prices and traffic noise. J. Regional Sci. 55 (4), 644–670.
Tarassoff, P.S., 1993. A Hedonic Model of the Impact of Localized Aircraft Noise on Housing Values. Unpublished M.S. thesis. McGill University.
Taylor, S.M., Breston, B.E., Hall, F.L., 1982. The effect of road traffic noise on house prices. J. Sound Vib. 80 (4), 523–541.
Uyeno, D., Hamilton, S.W., Biggs, A.J., 1993. Density of residential land use and the impact of airport noise. J. Transp. Econ. Policy 27 (1), 3–18.
Vainio, M., 1995. Traffic Noise and Air Pollution: Valuation of Externalities with Hedonic Price and Contingent Valuation Methods. Helsingin Kauppakorkeakoulu.
Vaughan, R.J., Huckins, L., 1975. The Economics of Expressway Noise Pollution Abatement.
Wilhelmsson, M., 2000. The impact of traffic noise on the values of single-family houses. J. Environ. Plan. Manag. 43 (6), 799–815.
Yamaguchi, Y., 1996. Estimating the Cost of Aircraft Noise Around Airports in London. unpublished M.Sc. thesis. University College London.