MEASURING THE COSTS OF NOISE NUISANCE FROM AIRCRAFT

A Review Article

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The stimulative influence of the Roskill Commission during 1969-71 [1] led to many advances in the theory and measurement of the environmental effects of transport operations. The Commission was committed to the task of collecting and collating all the available evidence on the social effects of constructing and operating a Third London Airport. It wanted to do so, as its terms of reference requested, within a framework of a social cost-benefit analysis. Naturally one of the most important topics in the debate was noise nuisance to residents. The placing of money values on this and the many other environmental items had not been considered previously in United Kingdom practice. The Commission and its advisers and helpers, including the many expert witnesses who appeared before it, were faced with two main tasks in measurement. The first was to derive a conceptual model of residential noise nuisance to which data could be applied to give appropriate cost measures. The second was to find suitable data.

It would be fair to say there did exist a measure of agreement between Roskill participants about the broad approach. The nuisance itself had to be measured in appropriate physical terms. The various residential groups likely to be affected had to be identified and counted at each nuisance level. The principle of exact compensation should then be applied: that is, of the compensation necessary to make these people no worse off as a result of the injurious effects on their environment. It would also be fair to say that there was virtually no agreement between participants on the details of the measurements required, whether of the nuisance measures, of the appropriate "client" groups, or, more especially, of the compensation values. To some extent this reflected an inevitable desire for product differentiation. No expert witness at a public inquiry can afford to acknowledge the superiority of someone else's model.

But the differences went deeper than that. There were very real doubts about the appropriate principles to apply. And overshadowing the whole inquiry was the

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rather flimsy nature of much of the empirical evidence at that time. Some evidence of modest quality on measures of noise nuisance was available from the Wilson Committee [2], and the Commission readily adopted the NNI (Noise Number Index) in the absence of anything better. The community's social and economic reactions to the imposition of noise nuisances was a seriously underresearched topic. For behavioural responses, especially the rate of household movement about airports, there was nothing to go on.

Much the same could be said of the critical question of compensation values. The difficult economic problem here was, and remains, how to get people to reveal their relative preferences for different levels of nuisance. As there are no readily observable indicators, indirect approaches are necessary. There are various possibilities, all of them requiring careful execution and experimental control.

Some answers may be derived from social surveys which ask people, in appropriately guarded terms, what sums they think would be necessary. Indeed, some of the hastily produced evidence put to Roskill was of this kind. Weaknesses of this kind of approach are well known [3]. Another approach is by way of carefully constructed experiments in which people participate in simulations of the real world. One such attempt is the famous "noise machine" [4] experiment, in which subjects are exposed to nuisances for which they receive different levels of compensation. These experiments are usually expensive and time-consuming to set up. There are various behavioural responses to nuisances which can be observed and which may provide suitable evidence. But no substantive research in any of these methods had been undertaken when Roskill was deliberating.

Two books have recently appeared which have advanced our understanding of behavioural responses to aircraft noise. Both are analyses of aspects of housing markets in the vicinity of major airports. Both claim to have advanced the measurement of noise costs.

One is Noise and Prices, by a member of the Roskill Commission, A. A. Walters. His book builds directly upon the Commission's work. It contains no original empirical research. His contribution is to take the theoretical discussion of residential property markets much further than was possible in the hectic days of the Roskill proceedings. And he has assembled evidence taken from a wide variety of sources and locations about the ways these markets work near airports. The main focus of his attention is on household mobility between houses in various noise zones, including areas which are quiet. The main emphasis is on providing a justified analytical framework for market adjustments due to noise. It is therefore not his primary intention to present a noise cost model, or to improve on empirical specifications of noise costs. However, such a model and estimates are derived from his various discussions.

The other book is The Economic Value of Peace and Quiet by D. N. M. Starkie and D. M. Johnson. They devote less space and effort to theoretical analysis of residential property markets, although their focus, like that of Walters, is on residents near airports. It is their main intention to derive noise cost estimates for these residents. These estimates come from an account of a research project commissioned by the Department of the Environment: an investigation of the installation of soundproofing in houses in the vicinity of Heathrow Airport, London.

So, despite differences in intention, both books do make approaches to the
valuation of noise costs. The essential difference between them here is this. Walters bases his analysis of behaviour on household mobility between houses. Accordingly, when attempting to impute noise costs, he does so from the supposed willingness of some residents to be compensated for living in noisy conditions rather than in otherwise comparable but less noisy conditions in another location. House price differentials between relatively quiet and noisy areas stem from household mobility, which constitutes the way in which the market adjusts. Starkie and Johnson's analysis, on the other hand, is of the willingness of residents in different areas to exclude the noise nuisance in situ by installing soundproofing. Their estimates of noise costs are derived from this behavioural response to the nuisance.

Soundproofing is generally less costly than moving, especially for owner-occupiers. It is the minimum action a household can take, apart from taking no action at all. But at best it is only a partial excluder of noise, because it applies only to the inside of dwellings and not at all to their local environment. Walters analyses the maximum action a household can take. If the worst comes to the worst one can always move.

Starkie and Johnson obtained compensation estimates between £33 and £45 for their average household around Heathrow. Walters's estimates are between £500 and £770 per average household for the possible Roskill sites. This marked difference warrants further consideration. The two approaches are considered for each of the three stages of valuation: the physical index measure of nuisance used, the assessment of the appropriate incidence groups, and the evidence brought to derive estimates of noise cost.

MEASURES OF NUISANCE

Both books have chapters on the physical measures of noise nuisance. And both review and compare indices which have been adopted in different countries. For empirical estimation, Walters is restricted to the range of indices put forward by others. He finds a fair correspondence between these, despite difficulties in exactly converting any one index into any other. Their correspondence gives him confidence to press on with his analysis, using whichever is the most convenient index to hand; this is generally the NNI. This confidence in the NNI is supported by the seemingly broad association between NNI levels and certain data on depreciation in house prices around Heathrow Airport. Walters is very fair and open in his exposition of the various noise indices; nevertheless he is assuming away a lot of the difficulty encountered in deriving them. The Wilson Committee report is the only substantive exercise which relates subjective perceptions of nuisance to objective data on nuisance sources. It is dated and open to some criticism. Despite their similarities, the various indices of noise nuisance are built on poor empirical foundations, and Walters's account leaves one with rather an uneasy feeling about them.

Starkie and Johnson do not trust the indices. After fully discussing the NNI they are inclined to dismiss it as not sufficiently well based for their empirical work on behavioural responses to nuisance. This opinion is confirmed, in their view, by the "decidedly weak" statistical relationship which they found between the NNI levels and soundproofing take-up near Heathrow.
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Rejection of the NNI meant that some alternative had to be used if they were to proceed. In this search for another measure they conducted a curious approach. They pursued an inductive search among the basic characteristics of sound for those which were most highly correlated with household expenditure on sound insulation. In short, they assembled a variety of sound measures which were then used as explanatory variables (singly or in combination) in alternative regression models on soundproofing expenditure, with a view to fishing for the best catch. This was not the NNI.

This approach is curious because it implies a perfect correlation between subjects' perceptions of the nuisance and their market response to it. It does not allow for other influences on market response. The approach might be valid for comparing, say, total quiet on the one hand with "noise" on the other. But they have used it for gradations of noise where other conditions cannot possibly be equal. One relevant condition on the production side is the effectiveness of the product. Sound insulation may not be of the same effectiveness in different noise zones. It is probably a relatively poor excluder in really noisy areas, and this may account for their result. One requires an independently derived measure of nuisance before proceeding to the assessment of relative valuation. Without it one cannot be sure that the nuisance effects on behaviour have been isolated. Because the authors have blurred the effects, we cannot be sure how far the soundproofing expenditure attributed to noise is really due to it.

THE GROUPS AFFECTED

Turning now to the question of the groups, both studies are faced with serious practical difficulties. Starkie and Johnson's analysis was of an area with a relatively long history of aircraft nuisance. Over the years, and especially as the nuisance levels increased, the population around Heathrow would have turned over to a relatively unperturbable mix of people. By the time soundproofing became a popular option encouraged by Government grants, the expected rate of take-up would be much lower than for a group in the vicinity of a completely new airport.

A household's willingness to install soundproofing would depend, inter alia, on how long it expected to stay, and this in turn might well depend on the expected levels of noise. Starkie and Johnson do not venture into this difficult area of analysis; their discussion of the dynamics of the market processes is largely restricted to the process of diffusion of take-up in the population. In contrast, the dynamics of the housing market are central to Walters's model. In it, some people move out because of the nuisance. They are replaced by others who move in because of it, so as to take advantage of lower prices. The remainder either choose to stay put and suffer, or they are in the category of natural movers. Walters provides a useful theoretical discussion of the processes at work. Empirical evidence is called on from time to time to show that what one would expect from the theory is indeed consistent with known facts. He argues that there is a market in peace and quiet concealed within the property market; that he has demonstrated that it can be subjected to both theoretical and empirical investigation; and that the two approaches do not produce fundamental inconsistencies.
The main worry over this categorisation of groups within the population affected by noise is with the isolation of "movers due to noise". Mobility rates will be affected by noise, ceteris paribus. But any disturbance to equilibrium, including, for example, a decrease in noise levels, will also have the effect of increasing mobility. So "movers due to noise" is really a class of "movers due to changed conditions", which has no particular significance. However, in reality noise changes will occur in association with other things, one of which is changes in house prices. If we could conceptually isolate the price change in the same way as was done for the noise change, it would be clear that mobility rates would change as a consequence of price too. The net effect of changes in propensity to move caused by noise and by price, when both are considered together, remains uncertain. There need not be increased overall mobility.

Other factors will change when noises increase. No doubt enhanced accessibility to employment opportunities at the airport is relevant. And there will be changes to the social environment of the area consequent upon the population turnover, and so on. Accordingly, Walters seems on thin ice when he relies on semi-anecdotal evidence of higher mobility rates about airports than elsewhere and credits that mobility differential to noise alone. As a basis for attributing the causation to nuisance rather than to a multiplicity of other factors, the evidence just is not convincing. The conditions for identifying movers because of noise are very severe indeed. To be fair, Walters argues the case for more research into mobility about airports, recognising that comparison of rates alone is insufficient. But, as isolation of "movers due to noise" is an integral part of his approach to noise valuation, one is left wondering quite how this valuation will ever be achieved.

NOISE COSTS

Starkie and Johnson's approach to valuation is that the estimate of nuisance costs which is sought is the sums that existing residents would be willing to pay for peace and quiet. If these people were to receive these sums they could be said to be compensated for the loss of peace and quiet. If they so chose they could use the money to buy back what they had lost. (This assumes, of course, that the soundproofing is 100% effective.)

An obvious argument against this approach, and one which was much debated at the time of Roskill, is the problem of income effects. If noise costs are large relative to income, the exact compensation for noise will not be the same as the amount that might be paid to buy back peace and quiet, but will be larger.

Of course, noise nuisance spans a distribution from severe to zero, roughly as distance increases from the airport. Accordingly, when other things are equal, the numbers of households suffering severe noise nuisance are small compared with those at average nuisance levels. Starkie and Johnson's approach may be reasonable as a basis for low annoyance levels, but less appropriate for the (relatively small) groups of sufferers from severe nuisance.

It is almost a matter of judgement at what point the income effect becomes important. However, a fact which enters into the reckoning of Starkie and Johnson's estimates is that around Heathrow Airport substantial grants have been made
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available by the authorities to households who were willing to install double glazing. These offset the amount that households have to find to buy back quiet from income. The authors' empirical work is on the rate of take-up of these grants. Several daunting practical difficulties made this a lengthy task. There are, for example, other consequences of double glazing apart from soundproofing, and these cannot be ignored. Reduced ventilation is one that is not wanted, while improved heat retention is one that is. Problems arising from the choices of full and partial domestic double glazing systems were another source of concern. Perhaps the greatest set of problems arose over the dynamics of the process under study: for instance, the way a new commodity spreads through a population of potential consumers. Then, to complicate matters, the subsidy arrangements were altered by the authorities on two separate occasions during the study period.

Starkie and Johnson's painstaking and most interesting discussions of these difficulties were the appetite for the multivariate analyses which are expected to follow. But high expectations are not fulfilled. A variety of models are presented, but they do not reflect the richness of the theoretical discussions. In the final reckoning the authors opted for two models of conditional probabilities, one model for downstairs and the other for upstairs. A dichotomous dependent variable was used in each: whether or not insulation has been installed. Explanatory variables were cost and other possible influences on choice, such as noise levels. One of the most surprising aspects of the finding as presented was that in each case only two of the explanatory variables which were used to derive these models had significant coefficients at conventional levels. For downstairs installation these were cost and distance to the airport; for upstairs installation they were cost and a night-time sound measure. Installation cost to the consumer was interpreted as the price per unit of the product in the household demand function for soundproofing. The values of £45 and £33 were obtained by integrating each function with respect to price between the limiting values for the dependent quantity variable (that is, zero and unity).

Walters's estimates of noise costs are more general in their derivation. His main intention is to demonstrate the value of his conceptual model and to show how noise costs may be derived—given suitable data. Empirical evidence is called on only whenever it is currently to be found, in order to illustrate the orders of magnitude of costs and demonstrate otherwise how well the data fit together in the overall theoretical framework. On the whole they do fit together quite well. His model is based on the idea of a distribution of the population with respect to their valuation of noise. People move or stay put according to the relative costs of each option. (The soundproofing option is mentioned only in passing.) In order to predict what people would do, and hence what costs they would incur, certain information is necessary in order to calibrate the noise distribution. The two most critical items in this are the house price depreciation due to the noise and the number of movers due to it.

The distribution itself is not known. Some evidence of it for some samples of the population is available from social survey sources. And Walters outlines how it might be derived from other samples by the use of behavioural evidence. The number moving because of the noise is, as was previously indicated, a difficult concept to handle. And the available evidence on it is unsatisfactory. Evidence of house
price depreciation due to noise around major airports is generally more abundant—as is only to be expected—and Walters provides an extensive and very useful catalogue.

The noise distribution approach assumes away much with respect to the characteristics of population in the vicinity of any proposed airport development. It is not clear how variations in noise sensitivity (or, for that matter, residential mobility) could be identified ex ante. It is quite inappropriate to apply a distribution obtained elsewhere, or generally, to any particular locality. Populations are not evenly distributed with respect to noise sensitivity, if for no other reason than that noise itself is not evenly distributed. There are noisy and quiet areas before the introduction of specific aircraft noise; and the sensitive and the imperturbables, and all the people between, will have adjusted to them.

So the empirical side of Walters's model is rather patchy. All the usual caveats are stated, and so is the need for further research. But in the last analysis we are back to guestimates which, at best, one can say are not at variance with the facts at our disposal. For practical policy purposes we still need more dependable compensation values. For Walters' collation of empirical evidence, impressive as it is, still leaves substantial gaps on the valuation side. Indeed, he really does not take us further than Roskill in the production of estimates of noise cost.

Walters's use of house price differentials might be thought safer as a way into the problem than Starkie and Johnson's soundproofing. Whatever house price differentials represent in terms of values for particular groups, they clearly must involve an imputation of the total nuisance affecting the quality of the accommodation. (Incidentally, around Heathrow they will also reflect the availability of soundproofing grants.) Starkie and Johnson's evidence, useful as it is to have had it analysed and presented, is unconvincing as a valuation of peace and quiet. It covers only one out of the range of behavioural responses to the nuisance, and this one is only a partial exclusion of it. Both books demonstrate that private market processes do respond to the existence of public evils. Our understanding of the market processes is well advanced by them. But the empirical evidence remains unsatisfactory. In short, if, as suggested in the recent Airports Policy White Paper [5], the question of providing a new airport for the London area were to arise again, we should as a result of these books be in a better position to understand the problem than we were in 1971. But the quality of the estimates to go into the cost-benefit analysis under the heading of residential noise costs would, unfortunately, be no better.

REFERENCES