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Managing the Cost of Noise Exposure in Transport Corridors, ICA 2010

Alex Marchuk, Frank Henry

Brisbane City Council, Brisbane, Australia

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ABSTRACT

In order to develop socially relevant noise policy it is necessary to understand the health effects of noise exposure and the corresponding cost of these effects. These social costs can then be considered against the economic costs of implementing noise mitigation measures. The study presented in this discussion illustrates a method of cost benefit analysis for noise mitigation. The response relationship between transport noise (road, rail and aircraft) and health effects (annoyance and sleep disturbance) are well documented. These health effects place a burden on society. Recent health studies have enabled quantitative analysis of the burden of disease on populations. The World Health Organization's 'Disability Adjusted Life Year' metric can be used for this purpose. In the case of transport noise, it is necessary to quantify the 'disability' caused by noise related annoyance and sleep disturbance. A basic economic analysis is considered in this study by attributing a 'human capital' value to Disability Adjusted Life Years. The benefits in terms of human capital can then be compared to the economic costs of providing noise mitigation measures. The techniques discussed above allow policy makers to consider a 'triple bottom line' where environmental, social and economic outcomes are taken into account. A case study of how this has been used in Brisbane for planning residential development near transport corridors will be presented.

1 BACKGROUND

The South East Queensland Regional Plan predicts that by 2026 a significant proportion of Brisbane's population will be living in or near transport (road and rail) corridors.

The health and well being of communities in these areas needs to be addressed in a way that minimises the intrusion of transport noise into dwellings in balance with achieving other desired outcomes, such as energy efficiency, access to public transport, visual amenity, public safety and affordable housing.

A new approach to managing transport noise impacts on new residential development is being investigated in Brisbane that uses planning and building law to specify acceptable solutions for noise reduction. The acceptable solutions specify construction materials (such as window thickness) capable of reducing noise transmission into dwellings in transport corridors. This approach aims to achieve a satisfactory indoor noise outcome for future residents while minimising development costs.

This approach is being developed to improve the current planning process for new residential development near transport corridors, which requires site specific acoustic report to be submitted for each individual development application in a transport corridor. This process increases development costs and creates development delays.

The proposed planning approach will remove the need for an individual site specific assessment of transport noise mitigation for each development application in a transport corridor, if the developer uses the acceptable solutions that have been specified for noise reduction.

Choice of acceptable building elements has been informed by considerable background research conducted in Brisbane, including noise contour mapping of transport corridors and an assessment of the noise attenuation performance of various building materials and configurations. This includes an assessment of the noise attenuation of existing residential buildings.

2 DEVELOPMENT OF TRANSPORT NOISE PLANNING POLICY

To develop appropriate environmental noise policy and strategy, it is important to understand the effects of noise on human health. There are clear correlations that have been established between transport noise (road, rail and aircraft) and human annoyance and sleep disturbance. Annoyance and sleep disturbance effects generally have a relatively low severity, however there is a significant combined 'disabling' effect when a large exposed population is considered. The World Health Organization (WHO) have developed a metric for expressing this effect. The metric is referred to as 'Disability Adjusted Life Years' or DALY. Further to this, a simple benefit to cost ratio can be considered by attributing a 'human capital' value to the DALY – in this case, we have considered the gross domestic product (GDP) per capita. This methodology is further discussed in section 4.

Economic benefits can be provided by identifying areas that are exposed to transport noise and providing noise mitigation solutions up front. This can provide savings in the form of reduced development costs. Savings are gained from reduced holding costs associated with preparing, submitting, reviewing and implementing these noise assessments.

3 OVERVIEW: 3 BEDROOM HOUSE EXAMPLE

This discussion will consider a hypothetical example of a single dwelling where there is a requirement to reduce internal noise levels by 10dB(A). The discussion considerers two scenarios:

- The Current Planning Approach – noise treatments within 150m of a transport corridor are specified by third party noise assessment.
- Proposed Planning Approach. – Acceptable noise treatments are provided by the planning authority for dwellings located in transport noise corridors.

The example considers holding costs, noise assessment costs, material costs of upgrades and then attempts to quantify benefits in terms of property, social and health value. Each of these concepts will be explained and applied to the example case in section 4 below.

4 BENEFITS AND COSTS

4.1 Holding Costs

Holding costs are the costs incurred in owning land prior to commencement of development (e.g. interest and rent). The longer the assessment and approval process the higher the holding costs.

Holding costs can impact housing affordability, they are typically passed on by the developer to the buyer. These costs place upward pressure on prices and therefore reduce housing affordability. The Local Government Association of Queensland has conducted benefits calculations and determined that significant savings can be obtained from the reduction of holding costs. These calculations have been referenced below[1]:

> The average holding time costs to the developer is $1000.00 per week (includes interest, rent). In many cases where there is a significant mortgage on the property, this will be greater - however, this is a conservative figure used to calculate the benefits.

Applying these costs to current situations where an acoustical report is required generally adds 12 to 16 weeks to the assessment process. In the case of a single dwelling this would indicate a cost of $12,000 to $16,000.

4.2 Noise Assessment Costs

Noise assessments are typically prepared by specialist acoustical engineers or scientists. The preparation of a noise assessment adds time and cost to the application process. The assessment consists of conducting a site visit, taking noise measurements and conducting noise monitoring, noise modelling, calculations, determining design solutions and finally the preparation of a report. Typically the minimum fee for this work is in the order of $5000. As a result of this work, the report may identify changes required in the design of the development – which can require rework of design, further adding to delays and cost.

4.3 Material Costs of Acoustical Upgrades

The weakest noise transmission path is generally the windows. Thus, often the only changes to a building design that are usually required as a result of a noise assessment report are window upgrades. Consider our example of a typical 3 bedroom house consisting of $27m^2$ of glazing. If we compare unsealed 4mm glazing to acoustically sealed 10.38mm laminated glazing, we can improve internal levels by approximately 10dB(A) at a cost of approximately $4,700. (Note that 10dB(A) is subjectively equivalent to halving the noise level.)

It is important to note that in Brisbane this cost is not a new cost imposed by the proposed planning approach. At present houses built within 150m of a transport corridor are required to implement design upgrades to comply with planning criteria.

4.4 Added Value of a Quieter Property

There have been a number of studies attempting to determine a cost or price of community noise annoyance. Studies relating to the socio-economic factors and sleep disturbance are discussed in 4.6 and 4.7 below. Some of the factors to be considered in determining the health cost of noise include the following:

- Psycho-physiological effects, stress, etc.
- Sleep disturbance and corresponding productivity loss
- Communication problems
- Possible hearing damage

It is likely that all factors combine and manifest as an effect on property values, whereby noise causes a reduced demand for the property and conversely, a quiet neighbourhood can be attractive to some people and drive up property value in quiet areas.

4.5 Property Values in Noise Affected Areas

The Victorian Transport Externalities Study indicates a relationship between property depreciation and road traffic noise. A discount range of between 0.5% per decibel and 1% per decibel was used [2]. Similarly, a European study identified a discount of 0.5% per dB [3]. As an example, when these factors are applied to a median value Brisbane home ($432,000) [4] with noise treatments applied to obtain a 10dB decrease in noise level (as discussed in 4.3). The result is a value improvement of between $21,000 and $42,000 depending on the discount of either 0.5% or 1% respectively.

4.6 Socio-Economic Impacts Of Noise Annoyance

The relationship between transport noise and community annoyance has been well established [5]. Dose response curves for road, rail and aircraft noise have been developed. As per our previous example a 10dB change in noise level is approximately equal to an 11% change in the number of 'highly annoyed' people, where the Day Night Average Level (DNL) changes from 68 to 58dB(A). An estimation of the community cost of annoyance has also been determined by the Norwegian Pollution Control Authority (approximately $1300 per highly annoyed person, per year [6]).

Considering again, the example of a 10dB change in noise, for an average Brisbane household (average household of 2.7 people per home) [7] the resulting value estimation over a 50-100 year building lifespan is between $19,000 to $39,000.

4.7 Disease Burden Due to Sleep Disturbance and Annoyance

The World Health Organization (WHO) uses a metric called the *disability-adjusted life year (DALY)* to measure overall disease burden. DALY can be calculated as follows:

DALY = Attributable Burden × Duration × Severity

In this section we will consider a single house exposed to transport noise and give an example calculation of the DALY over the lifespan of the building. Each of the terms used to calculate the DALY are discussed briefly below.

Attributable Burden: the number of people in a certain health state as a result of exposure to the factor that is being analysed.

In our example we consider sleep disturbance and annoyance. The amount of sleep disturbance for a single dwelling can be determined by the methodology used by the *European Working Group Position paper on dose-effect relationships for nigh-time noise (2004)*.

Note that there are other health effects, (e.g. cardiovascular effects) where the attributable burden due to noise is still under debate. Therefore in this example we consider only sleep disturbance and annoyance – it should be noted that the DALY may then increase as further attributable burdens are established.

Duration: Refers to the duration of the health state. In our example of a single dwelling, we can consider the duration to be equal to the life of the building (50-100 years).

Severity: Refers to the reduction in a persons health capacity due to the health condition is measured using severity weightings. A weight factor, varying from 0 (healthy) to 1 (death), is determined by experts (clinicians, researchers, etc).

In our example we use a figure of 0.02 for the severity weighting of annoyance and equally, a weighting of 0.02 for sleep disturbance – these factors were used in the Netherlands study *'Trends in the environmental burden of disease in the Netherlands (2005)'[8]*.

For comparison, some other disease severity weightings are shown below in **Table 1** from the Netherlands study.

Table 1 - Severity Weight of Disease

Weight	Disease stage
0.00 - 0.01	Gingivitis, caries
0.01 - 0.05	Mild asthma, mild vision loss, mild hearing loss
0.05 - 0.10	Low back pain, uncomplicated diabetes case, mild angina
0.10 - 0.15	Mild depression, osteoarthritis (grade 2), epilepsy
0.15 - 0.20	Mild/mod. panic disorder, spina bifida (sacral), HIV positive
0.20 - 0.30	Breast cancer (disease free), anorexia,
0.40 - 0.50	Blindness,
0.50 - 0.65	Paraplegia, AIDS (1st stage), Down syndrome
0.65 - 0.8	Cancer (diagnostic/treatment), severe depression, brain injury
0.8 - 1.0	severe dementia, severe schizophrenia, quadriplegia

(Source: *'Trends in the environmental burden of disease in the Netherlands (2005)')*

We can see that the noise related conditions are comparable with the low severity conditions at the low end of the scale.

There is also significant statistical uncertainty in the figure used for 'severity' in the DALY calculation for annoyance and sleep disturbance – it should be noted that a conservative rating from the Netherlands study was used in the example, so there is potential for the benefit/cost ratio to be significantly higher than indicated in this discussion.

Considering our example of a single dwelling, with a reduction of 10dB(A), 2.7 people and a building life of 50 to 100 years – we end up with a result of *an increase of between 0.5 to 1 disease adjusted life year for a home which has been upgraded to attenuate 10dB(A) of noise.*

The Report of the WHO Commission of Macroeconomics and Health [9] suggested that:

> "interventions with an annualised cost of less than three times the GDP (Gross Domestic Product) per capita are cost-effective interventions..".

So here we have the value of a DALY given as three times the GDP per capita, therefore in Australia a DALY has an equivalent value of $153,000 AUD.

Alternatively, one can use a more conservative 'human capital' approach which simply values a DALY as being equal to the GPD per capita, i.e. $51,000 AUD.

Even using this more conservative estimate, the example dwelling still provides a human capital benefit of between $25,500 and $51,000 AUD – this is comparable in magnitude to the other methodologies discussed in 4.5 and 4.6.

4.8 Summary of Benefits for Example 3 Bedroom Home

Table 2 compares the three different methods used to determine the added value of a 10 decibel noise reduction for a typical home located near a transport corridor.

Table 2 - Added value of a quieter property – single dwellings

Section	Methodology	Lower Value	Upper Value
4.5	Property Value	21,000	42,000
4.6	Socio-Economic Impacts	19,000	39,000
4.7	Disease Burden & Human Capital	25,500	51,000
Average of methods		$33,000 (Average)	

Comparing each of the methods gives an average added value of $33,000 for an acoustically upgraded property, i.e. a single dwelling with a 10dB improvement to its internal noise level. Taking an average value of the above is likely to be conservative as there may be some component of value that is independent in each case, e.g. it is likely that not all of the health/social value is reflected by the price of a property alone.

5 CONCLUSION: TOTAL BENEFIT/COST RATIO FOR A SINGLE DWELLING

All costs from sections 4.1 to 4.3 and benefits from 4.5 to 4.7 have been summarised below in **Table 3** below:

Table 3 – Summary of total costs and benefits for a single dwelling

Example: Single dwelling development	Existing Scenario: Building upgrades specified by site specific assessment	Proposed Scenario: building solutions provided by planning authority
Holding Costs (e.g. 14 weeks)	$14,000	N/A
Noise Assessment Fees	$5,000	N/A
Building Treatments	$4,700	$4,700
Total Costs:	$23,700	$4,700
Benefits		
Added Value of Quieter Dwelling	$33,000	$33,000
Benefit/Cost Ratio	**1.4**	**7.0**

Overall, we can see that under the existing scenario there is a marginal benefit, the total benefit/cost ratio is 1.4, i.e. the benefits marginally exceed the costs. There is a significant benefit to be gained by removing the need for a site specific noise assessment. This removes the associated holding costs during the application process and the ratio increases to 7.0.

This analysis should be taken into consideration when policy is driven by a need for faster development times and more affordable housing. In order to remove the need for site specific assessment, planning authorities should identify areas exposed to transport noise by conducting noise mapping, and providing solutions to building developers who propose to develop residential dwellings in those areas.

Further analysis should be considered as health effects become more established. In particular, the link between noise and cardiovascular disease will be an important future addition.

6 REFERENCES

1 Local Government Association of Queensland "Economic Development Australia initiatives benefits calculations" (2009)

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3 European Conference of Ministers of Transport. Efficient transport for Europe "Policies for internalization of external costs" Paris (1998)

4 Home Value Index, http://www.rpdata.com/ (July 2009)

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