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THE BENEFITS AND COSTS OF NOISE REDUCTION: A COST BENEFIT CASE STUDY IN ISRAEL

Submitted by the Resource and Environmental Research Center, University of Haifa, Israel[1]
and Economic Consultants and Investment LTD[2]

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1 Prepared by Nir Becker and
2 by Doron Lavee.

I. Introduction

The benefit from noise reduction becomes an increasing area of interest in developed countries. While benefits in the working place are mainly negotiable between the employer and the employees, that is not the case in noise pollution from roads airports etc. Transaction costs are to high to solve the problem by negotiations so a social Cost-Benefit-Analysis (CBA) should be performed. Here the costs are those of reaching a less noisier standard while the benefits are those associated due to better life quality.

Research on noise pollution was mainly carried in the 70’s and early 80’s. However, since then, there are major changes in terms of technological solutions to reduce road noise and also a probable increase in the Willingness to pay (WTP) for environmental resources which noise is one of them.

This study performs such kind of a social CBA with respect to two propose alternative noise standards. 64 Decibels and 59 where the current standard is only 67 decibels. The analysis was performed on urban and rural areas in Israel. It should be noted that rural areas in Israel means more suburb then rural. This effects, of course, the WTP and hence the results. The cost of the project were estimated through engineering data regarding the cost effectiveness solution to reach a specified target. The benefits were estimated according to differences in property values in the same neighborhood with different noise level.

The results of the study do not provide a clear cut solution but rather serves as a crystal ball to decision makers with respect to the impact of their future decisions on taxpayers (through higher cost of insulation) and residents in effected areas (through an increase in their property value).

The paper continues as follow: Next section deals with the theoretical foundations of measuring the benefits from noise reduction. Section 3 summarizes past research effort with respect to estimating the benefits from noise reduction. Section 4 summarizes the cost of the given target. Section 5 introduces the case study of two different alternative cost standards in Israel. Section 6 summarizes the paper.

II. The Benefit from Noise Reduction

The economics of noise abatement is characterized by two main features. It does not accumulate and it varies from person to person. With regards to the first point, the important difference between this kind of pollution and other types of pollution is that road noise almost not associated with health damages. On the other hand, it causes stress, discomfort and some degree of dysfunction both within the working environment as well as in the privacy of ones own house. With regards to the second point, there is an importance policy problem of the liability of abatement measures that should be taken if at all. As recognized, abatement can take place both by the individual effected (home insulation) and the public (National or regional noise standard).

Leaving aside the legal and distribution aspect of the liability issue, if one wishes to decide about the desirability of the given noise standard or a proposed one should be judged on the basis of its benefits and costs to whomever they accrue.

There are four major techniques to measure the economic benefit of noise reduction

1. Cost of Abatement (COA) – Here we assume that the cost of abatement is a minimal estimate of the noise damage. This is based on revealed behavior. If the individual was willing to pay $100 for the insulation process, then it must be the case that the benefit from this action is at least $100. The problem with this approach is that it ignores the true value of the benefit which is probably higher then the cost involved.
2. Cost of Illness (COI) – In this approach one uses the health expenditures as a proxy market for the noise damage. Here we take hearing capacity of two types of population. One that was subjected to noise and the other that did not and we measure the economic cost associated with hearing loss. The problem with this approach is that, as mentioned earlier, there are no specific evidence that correlates hearing losses to road transportation. Besides, it is quite difficult to assign a specific value to the noise and its contribution to the hearing loss since the person might work in a noisy place and leave in a quite one or vice versa, or he can move from one place to another with different noise levels. Therefore, it will be quite difficult to get reliable estimates by this method.
3. Contingent Valuation Method (CVM) – This method is based on stated preferences of a representative sample of the public, which is going to be effected by the new noise standard. By asking people how much they are willing to pay (WTP) for a given amount of noise reduction we can get an estimate on the benefit of noise reduction. For example Soguel (1994) evaluated the WTP in Switzerland for cutting the noise level by half. Results ranged between 56 and 67 SF per month. The problem with this approach is the high

non-familiarity of residence with what the researcher calls, x% reduction. Other issues of CVM that contributes to the "noise" in the results could be found in Mitchell and Carson (1989).

4. Hedonic Prices Method (HPM) – This seems to be the best approach to estimate the true value noise reduction. Here we use the real estate market as a proxy for the WTP for a less noisy apartment. If we assume that the price of a product is determined by the vector of its attributes, then noise is one attribute which we are looking for its unique effect on the real estate price. We are looking for the following relationship:

$$V = v(N, Z)$$

Where V is the real estate value and it is determined by:

N – The noise level, and

Z – All the other characteristics which might effect the real estate price.

If we can distinguish between N and Z regarding its effect on V, then the coefficient of N represents the value of 1 Decibel in terms of how much people are willing to pay, in terms of property value, in order to eliminate it. That is :

$$V/ N = NV \text{ (= Noise value).}$$

This is the approach taken in this study. The drawback of this approach is that people do not have perfect information when buying a new apartment or a new house and that the real estate market is not a perfectly competitive one, thus it introduces some noise. We, however, think that in the case of Israel, the apartment value is high enough to attract people to look for all the information they could get regarding the true value of the apartment. With respect to the second objection, since the government stepped out of the mortgage market, the real estate market became quite competitive. In addition, we tried to estimate the difference in real estate value only in neighborhoods where there is a free demand and supply forces.

III. Relevant Literature – Property Value

There is a major gap between the presence and the timing when all the relevant research with respect to noise from road transportation was done. Clearly if one compares studies done in the seventies and eighties to the nineties, then one should take into account that the awareness to environmental aspects of the quality of life have changed dramatically especially with respect to the developed countries. Hence, substantial differences should come at no surprise in comparing different decades.

Anderson and Wise (1977) studied differences in property values in four suburbs in the US which are located nearby a highway. Their results show difference of $42-129 on a $30,000 house (about 0.3%). Baily (1977) study also suggest a 0.3% change for any decibel above 55. A discrete analysis of a house close to the highway compared to another in a1000 feet distance (critical value for noise) was found to be 7.5%.

Other studies have found similar results (Allen, 1980; Gamble et. al., 1974; Hall et. al., 1978; Langley, 1976; Nelson, 1978; Oosterhuis and Van der Pligt, 1985; Palmquist, 1980, 1981 and Vaughan and Huckins, 1975). The correlation between a given increase in the noise level and reduction in the property value was determined by what is called NDSI (Noise Depreciation Sensitivity Index), which is the percent reduction in the property value. Alternatively, a dollar amount was attached to each decibel. The ranges in the NDSI was between 0.08% and 1.05% with an average estimate of 0.4%. Hence, an apartment which is subjected to a 75 decibel noise level would sell for 8% less then an apartment with the same characteristics except for the noise level which is 55 decibel for the later. When trying to compare a house which is located in a "noisy" area relative to a house in a "quite" one, the difference is 20-25 decibels. There is a hidden assumption, therefore, of all the relevant studies that the NDSI is linear. However, for our purposes, the noise standard change is probably too small to worry about linearity.

Other studies, done in the 80's found higher NDSI then the previous ones (Ariel and Barde, 1985; Nelson, 1982 and Pearce et. al. 1987). This fact backs up our previous claim that over time the WTP for improvements in the quality of the environment increases with time as GDP per capita increases.

IV. The Application of Benefit Assessment to Israel

4.1. The noise components effect

Noise reduction in this study is approximated by the location of the property relative to the nearest main road. Different regions in Israel in three main cities: Tel-Aviv, Haifa and Beer-Sheva were compared in terms of price differences. In each region, a street which is adjacent to a main road was chosen and price difference between apartment facing the road and not facing the road has been found out.

In comparing price differences, one should take into account three major factors:

1. What was the price difference between an apartment facing the front and one facing the back **without** the presence of the main road.
2. What is the price difference **today.**
3. Is there a **neighborhood effect**. That is, is there some general price effect on the prices in the neighborhood because of its location.
4. The existence of an insulating wall.

The difference in the prices was found out from two main sources. The first one is the Itzhak Levy price guide (1997), which lists the prices of different apartment in different streets of cities in Israel with the marginal effect of different characteristics, among them is the apartment facing the main road or not. The second source is the real estate agencies in the areas of study. We used two sources because the price guide tries sometimes to set prices rather then to follow them. That is, there are differences between the listed price and the real price which is the reason to take into account individuals with real experience in the study areas. For a full list of the real estate agencies and the study areas in the different cities see Lavee (1998).

Table 1 gives the results for the Tel-Aviv area. As can be seen, there is a price reduction of 3-5% due to noise in apartments on the same block. When the block is not facing a main road, there is a price difference of 5% in favor of apartment facing the front. [3]

Table 1

The changes in the prices of houses (in percent) approximated by the location of the property to the source of noise.

Neighborhood	an apartment facing the front in a noisy street	an apartment facing the front in a silent street
Bavly	+5%	-5%
Even Gvirol	+5%	-5%
Naot Afeca bet	+3%	-5%
University district	+5%	-5%
Ramat Aviv Gimal	+3%	-5%
Hahalacha Bridge	+3%	-5%
Cicar Hamdina	+5%	-10%

Source: Levy I. (1997)

The neighborhood effect should be taken into account as well. As explained before, it is the indirect effect of the entire price level in a noisier neighborhood relative to a quite one. Obviously, this effect is smaller then the direct effect. This is due to the fact that even in these neighborhoods there are quite streets (The price level here is a neighborhood average), and also because being adjacent to a main road partly eliminates the necessity to lose time in traffic jams etc.

Comparing adjacent neighborhoods with and without main road effect shows that there is a general price decrease of 1% for apartment in neighborhoods by main roads.

Summing the relevant averages, we get a total direct effect in the 0.375%-1.25% range. Comparing price differences in neighborhoods with and without an insulating wall yields a 50% reduction in the difference to neighborhoods with a wall. That is, adding the effect of an insulating wall reduces the overall effect by half which brings the price difference to the 0.1875-0.625% range.

All that is left now is to add the price difference **without** the noise effect. This was shown earlier to be in the 5-10% range in favor of the front looking apartment. This difference includes as well the neighborhood effect.

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[3] It should be noted that nosier apartment have another disadvantage which is reflected by the time they have to stand up on the market. According to some real estate agents, it doubles the time. We ignored this point by assuming that this factor is reflected in the final transaction price.

In other words, if one takes a noisy street and turns it into a quite one, then, the average value of apartments in this street would rise: This is the neighborhood effect. In addition, the value of a front looking apartment would rise by more because of the other characteristics other then noise.

Summing up all the relevant effects brings us to a total effect in the 0.8%-1.9% range and an average effect of 1.4% per decibel.

4.2. The density effect

An accurate measure of damage can not be found without looking at the population at risk in the effected area. In the case of noise it is the apartment's density which is the relevant factor. The density in Israel can be split to rural and urban areas. Within the rural areas the density is 5 units per 100 meters road. In the urban areas the density depends on the height of the building: For a four floor building the density is 8 units per floor per 100 meters road while for an eight or more floors it is 6 units/floor/100 meters road. All numbers are for apartments facing one side (the front). That is, the back looking apartments should be added by the same ratio. The average unit price in Israel is 534.4k NIS (Annual statistics, 1998). Therefore, an NDSI of 1.4% implies:

- Four floors or less – 42.8k NIS /meter/floor[4]
- Eight floors or more – 32.1k NIS/meter/floor.

We are now in a position to calculate the total benefit in a given urban area. This is done by the following:

PVC = 1.4*(Dec.0 – Dec.1)*Ci*(NF-1)

Where:

PVC = Property value change (In thousands NIS/meter road).
Dec.0 = Old noise standard (In decibels)
Dec.1 = New noise standard (In decibels)
Ci = Change in total property value/floor/meter (In thousands NIS).
C1 = 42.8K NIS
C2 = 32.1K NIS
NF = Number of floors.

The results are shown in table 2. As can be seen, insulation reduces the noise by 10 decibels so we have added that case as well.

Table 2

The growth in benefit for urban areas in Israel, for a change of 1.4% for 1 Dba
(in thousands of shekels for one meter of road)

Change in the standard dba	**density of housing**				
	2 floor (1 apartment)	4 floor (3 apartment)	8 floor (7 apartment)	12 floor (11 apartment)	Average
67-64	1.8	5.4	9.4	14.8	7.9
67-59	4.8	14.4	25.1	39.5	20.9
[5]10	6.0	18	31.4	49.4	26.2

[4] Besides the 1st floor which are the house foundations.
[5] In some cases, in order to reduce the noise to the right level, the road has to be roofed. In this case there will be a leap in the reduction of noice (10 Dba instead of 3 Dba).

4.3. Adding the rural sector

Prices in the rural area are higher then in the urban. One of the reasons people are moving to the suburbs is the quest for quite. Same Hedonic price analysis adds another 1% to the benefit. That is 2.4% NDSI index. The density in the rural-Suburb areas is a unit for every 20 meters. Therefore we can use the following formula:

$$PVC = (1000/20)*V*0.024*(Dec.0 – Dec.1)$$

Where V is the initial property value and all the other variables were previously determined.

The results are shown in table 3. As can be seen from the table, there is a large price difference in rural – suburb houses so a different benefit estimate is derived for each property price.

Table 3

The growth in benefit for rural areas in Israel, for a change of 2.4% for 1 Dba
(in thousands of shekels for one meter of road)

Value of the house (in thousands of shekels)								**Change in the standard of dba**
1,800	**1,620**	**1,440**	**1,260**	**1,080**	**900**	**720**	**540**	
6.5	5.8	5.2	4.5	3.9	3.2	2.6	1.9	67-64
17.3	15.6	13.8	12.1	10.4	8.6	6.9	5.2	67-59
21.6	19.4	17.3	15.1	13.0	10.8	8.6	6.5	[6]10

V. Analyzing the acoustic costs

5.1. Definitions

The cost of reaching a new noise standard is the cost difference in moving from one level of noise to another. The analysis was made for the transition from the level of 67 Dba to the level of 64 Dba, and for the transition from the level of 64 Dba to the level of 59 Dba.

The analysis show the marginal cost necessary for reduction of noise from one level to another. The mythology is based on concluding from deduction. The analysis was done for several theoretical schematic types of roads, and buildings. The types differ in the parameters: pattern of the roads, number of floors, the distance of the buildings from the road. For each type a cost effective analysis was performed. The numbers were normalized for one meter of road.[7]

5.2. Technical Data

The analysis is based on the relevant parameters of Israel and of normative technical data. Here are the main relevant parameters:

The volume of traffic was determined as level of service “C” in both tracks of an 80 Kph road.
The analyzes was based on the TNCAD model.
The maximum height of an acoustic barrier is 6 miters.
The minimum affect of a barrier is 5 Dba and the maximum is 15 Dba.
Quit asphalt decreases the noise by 3 Dba.
The boundary of deviation is up to 0.5 Dba.

The results are shown in tables 4 and 5 with respect to the 64 and 59 noise standard respectively.

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[6] In some cases, in order to reduce the noise to the right level, the road has to be roofed. In this case there will be a leap in the reduction of noice (10 Dba instead of 3 Dba).

[7] In addition, in order to calibrate the model, we analyzed several existing representing projects.

Table 4

The grows in costs in the transition from 67 Dba to 64 Dba
(in thousands of shekels for one meter of road)

road												
intersection			**Upper road**			**road sunk**			**road flat**			
loop	**sunk diamond**	**Upper diamond**	100	50	25	100	50	25	100	50	25	distance of the Building frontier[8] from the road
8	8	Im[9]	5.5	8	8	5.5	8	8	5.5	0	8	Floors 2
Im	Im	Im	5.5	8	8	5.5	8	10	5.5	8	0	Floors 4
Im	Im	Im	8	8	10	5.5	10	0	5.5	10	10	Floors 8
Im	Im	Im	10	10	0	6	10	0	10	10	0	Floors 12

Table 5

The grows in costs in the transition from 67 Dba to 59 Dba
(in thousands of shekels for one meter of road)

road												
intersection			**Upper road**			**road sunk**			**road flat**			
loop	**sunk diamond**	**Upper diamond**	100	50	25	100	50	25	100	50	25	distance of the Building frontier from the road
6.7	9.9	5.7	0.7	1.4	2.2	0	4.9	5.3	0.7	3.3	10	Floors 2
6.7	11.3	Im	1.4	3.6	10	NR	5.5	93.5	NR	6.6	NR[10]	Floors 4
Im	Im	Im	1	23.9	NR	NR	16.1	NR	6	25.8	47.8	Floors 8
Im	Im	Im	0.6	47.8	NR	4.6	93.5	NR	2.9	NR	NR	Floors 12

VI. Results

6.1 Description

As in the cost section, we divide the net benefit estimates into the two proposed noise standards, namely, from 67 Dba to the level of 64 Dba, and to the 59 Dba standard.

The results are shown in tables 6 and 7 for the urban and rural-suburb respectively. In the tables we show both the marginal cost necessary for reduction of noise from one level to another, and the benefit from the reduction. The analysis was done for several types of roads, and buildings. The types differ in the parameters: pattern of the

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[8] Building frontier – the distance of the buildings from the center of the road.

[9] In some cases it is impossible to reduce the noise to the right level (it's not possible to roof an intersection). The marking for these cases is **– IM** (impossible).

[10] In some cases the solution for both standards (example: 67 Dba and 64 Dba) is the same. This means there is no marginal cost in the transition between the standards. The marking for these cases is **– NR** (not relevant).

roads, number of floors, the distance of the buildings from the road, overflow of traffic and the type of acoustic treatment.

The net benefit was calculated first for a meter road. In order to analyze the value of a specific project one has to characterize the parameters above and then to multiply the value from the tables in the length of the specific road.

Tables 6

The net benefit in the transition from 67 Dba to 64 Dba-in urban areas
(in thousands of shekels for one meter of road)

road												distance of the Building frontier from the road
intersection			**Upper road**			**road sunk**			**road flat**			
loop	**sunk diamond**	**Upper diamond**	100	50	25	100	50	25	100	50	25	
-4.9	-8.1	-3.9	-0.4	0.4	-0.4	NR	-3.1	-3.5	-0.4	-1.5	-8.2	Floors 2
-1.3	-5.9	IM	1.8	1.8	-4.6	1.7	-0.1	-75.5	1.1	-1.2	NR	Floors 4
IM	IM	IM	1.8	-14.5	NR	-1.1	-6.7	NR	3.4	-16.4	-16.4	Floors 8
IM	IM	IM	1.9	1.6	NR	-2.0	-44.1	NR	4.5	NR	NR	Floors 12

The net benefit in the transition from 67 Dba to 59 Dba -in urban areas
(in thousands of shekels for one meter of road)

road												distance of the Building frontier from the road
intersection			**Upper road**			**road sunk**			**road flat**			
loop	**sunk diamond**	**Upper diamond**	100	50	25	100	50	25	100	50	25	
-4.9	-8.1	-.39	0.1	-8.3	-35.8	-0.7	-3.1	-22.4	-10.3	-10.3	-30.1	Floors 2
-1.3	-5.9	IM	4.6	4.4	-19.8	6.9	-3.0	-75.5	-20.5	-20.5	NR	Floors 4
IM	IM	IM	14.3	1.0	-16.4	15.6	-68.9	NR	-27.2	-27.2	-16.4	Floors 8
IM	IM	IM	-10.9	1.6	NR	24.5	-44.1	NR	1.6	1.6	NR	Floors 12

Tables 7

The net benefit in the transition from 67 Dba to 64 Dba-in rural areas (in thousands of shekels for one meter of road)

decrease in the value of property for one Dba	**road**						intersection		
	Upper road		**road sunk**		**road flat**		**Upper diamond**	**sunk diamond**	**loop**
	50	100	50	100	50	100			
1.8%	-0.6	-0.3	-2.2	NR	1.3	-0.2	-3.0	-7.2	-4.0
2.4%	0.3	-0.0	-1.3	NR	2.2	0.7	-2.1	-6.3	-3.1
2.9%	1.1	0.8	-2.2	NR	3.0	1.5	-1.4	-5.6	-2.4

The net benefit in the transition from 67 Dba to 59 Dba -in rural areas (in thousands of shekels for one meter of road)

decrease in the value of property for one Dba	**road**						intersection		
	Upper road		**road sunk**		**road flat**		**Upper diamond**	**sunk diamond**	**loop**
	50	100	50	100	50	100			
1.8%	-7.9	0.1	-0.7	1.7	-5.9	2.5	NR	-22.0	-19.3
2.4%	-5.5	2.0	1.7	4.1	-3.5	4.9	NR	-19.6	-16.9
2.9%	-3.5	4.0	3.7	6.1	-1.5	6.9	NR	-17.6	-14.9

6.2. Analysis of the results

In a “Nut shell” it can be seen that there is not a clear cut in the optimal level. The result depends on several parameters: pattern of the roads, number of floors, the distance of the buildings from the road, overflow of traffic, density of housing, prices of housing and the type of acoustic treatment. Some of the parameters have a clear direction of influence, but most of them have two components with opposite influences.

Number of floors- the higher the number of floors in the buildings near the road, the higher the acoustic barriers needed to protect them. But the number of flats is higher also, so the benefit from noise reduction is higher.

The distance of the buildings from the road- The higher the distance between the road and the buildings, the lower the acoustic barriers needed to protect them, but also as the effect of the acoustic barriers decline, so does the benefits from them.

Overflow of traffic- The higher the traffic volume, the higher the number of sources of noise. But the speed of the cars is reduced, so each source makes less noise (in this paper, the test was made for level of traffic – C, which means the highest combination of noise).

Prices of housing – The higher the prices of the houses, the higher the benefit from noise reduction.

Type of acoustic treatment – there are several different types of acoustic means that could be in use in order to achieve the reduction of noise. Here, we used the cost affective tool.

In order to show a clearer result, we divided the different types of roads in to a two by two metrics: rural areas verses urban areas, roads verses intersection. For each combination we looked for the optimal level of noise, that will give us, in most cases a net benefit result. The results are shown in table 8.

Table 8

Type of road / Type of area	roads	intersection
Rural areas	64 Dba	67 Dba
Urban areas	67 Dba	67 Dba

Another important result was: As long as the acoustic means were “regular” means (e.g., acoustic barriers, quite asphalt), the optimal level of noise is lower – 64 Dba and even 59 Dba. In the cases were the acoustic means were “expensive” means (e.g., roofed roads or triple barriers), the optimal level of noise is higher – 67 Dba.

VII. Summary

A social CBA was performed with respect to noise standards in Israel. Two proposed new standards were proposed and analyzed. The analysis was divided into the urban and rural suburb area. The costs were taken from engineering data. The hedonic price method was utilized in order to find out price differences between less and more noisy apartments.

It was found out, by the NDSI measure that there is a 1.4% and 2.4% reduction in the property value for the urban and rural-suburb areas respectively. On the other hand, in urban areas the population density is higher then in rural areas so it balances off the lower WTP in the urban areas.

A noise standard of 59 Decibels clearly fails on the ground of a social CBA. It simply does not worth the cost involved. With regards to the 64 decibels standard, it depends on the type of area and type of acoustic solution for the noise reduction.

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