The environmental impact of road investments: an economical analysis with an emphasis on by pass investments

S. Grudemo
Swedish Road Administration, Sweden

Abstract

When motoring was in its infancy in Sweden the main roads were located straight through towns – the first generation meeting between road and town. When traffic flows were growing, traffic problems along these roads were growing as well. The second generation meeting is when a by pass is built. Winners are heavy traffic, long distance travellers and inner city residents, getting less noise, exhaust fumes and vibrations. But by passes often cause encroachment on recreation areas for nearby residents. The third generation meeting occurs at substantial distances between built-up areas and continuous, broad roads passing towns. In southern Sweden, main roads often are built as such roads, but not in northern Sweden. There traffic flows are too low. "Environmental encroachment" is not yet valued monetarily in the Cost Benefit Analysis (CBA). The missing value includes physical encroachments in areas important for nature, recreation and/or culture, the barrier the road constitutes (towards an attractive area, river, lake etc.), and the impact on urban or rural landscape. Contingent Valuation Method (CVM) can be a suitable valuing encroachment, especially when winners and losers are different groups. Losers can state their willingness to pay (WTP) for getting environmental improvement (for example a road tunnel). Ex post studies are preferable. A road investment resulting in encroachment is usually controversial and respondents in ex ante studies tend to exaggerate their willingness to pay. In an ex post study they have no incentive for acting strategically. The development of a calculation model, from ex post studies with CVM, has been started. It shows that mean annual willingness to pay in a nearby area for getting a motorway that is a barrier between the dwelling and a lake in tunnel is about 4000 SEK (> 400 Euro).
Keywords: infrastructure investments, encroachment costs, Cost Benefit Analysis, Contingent Valuation Method, questionnaires, case study, referendums.

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1 Background

At the end of the second world war the conflicts between the environment and the roads where small in Sweden. The main roads linked towns together. But with more vehicles and higher speed, the need for improvement of the roads raised and also the need for new ones. This was especially needed in and in the surroundings of the towns, "where roads meet town". In most cases the old roads in the towns were kept but their function changed mainly to serve the local traffic. During the last fifty years a new road system for the road vehicles has been built.

2 Different generations of roads

When motoring was in its infancy Swedish main roads were located straight through towns – the first generation of meeting between road and town. When traffic flows were growing, traffic problems along these roads were growing as well.

Therefore roads were built passing the built up areas and traffic safety and speed raised. Such by passes can be called the second generation of roads. But then often another environmental problem occurs. In the area where the by pass is built there is often green areas used for recreational purposes for nearby living residents. Both these environmental effects, the relief in the built up area the by pass brings and the encroachment of the by pass, can by substantial.

The third generation of roads are those that are straight and broad passing the built up areas quite far from them. That is not always considered positive since some built up areas can be isolated.

Roads that are built today in Sweden often are by passes. Whether they are of the second generation of roads, as in northern of Sweden, or of the third generation, as in the southern of Sweden they often causes encroachment costs. These effects are not valued in monetary terms which are shortcoming. The different generation of roads often causes different kinds of encroachments which demand certain consideration.

3 Encroachment costs

Before making an investment in the infrastructure the Swedish Road Administration carry out a Cost Benefit Analysis (CBA) where as many effects as possible, both environmental and others, the investment is expected to result in are monetarized. One put the expected benefits towards the expected costs (where the investment cost is the largest part) and thereby does a social economic estimation of the planned investment.

The most important environmental effect that so far has been not possible to evaluate monetarily is the negative effect usually called "encroachment cost". This can include the physical encroachment an infrastructure construction causes in environment that is natural, recreational and/or cultural important or just in a built-up area where people are living. The environmental encroachment

also can be the barrier the road is towards an attractive area or a river or a lake. Furthermore it can be disturbances in form of noise, exhaust fumes, vibrations etc. from the traffic. Another sort of encroachment is the effect on the view of the town- or landscape that can occur due to an investment in the infrastructure. It is obvious that this term also includes some effects that actually are valued monetarily in the CBA, and the CBA must be adjusted for this if the encroachment costs are included.

3.1 The whole versus the parts

In the CBA the expected effects are split up in their parts as much as possible and then valued monetarily. But the encroachment cost instead probably ought to be valued as a whole to get a valid value. A big problem however is that a valuation of the whole in some parts also includes certain effects that have been given values of money in the CBA. The encroachment costs probably include more and as they are given no money values that means, especially in built up areas, that the investment decisions sometimes can be wrong.

3.2 Contingent Valuation Method

How shall this whole of the environmental cost be monetarized? We have found that the method called Contingent Valuation Method (CVM) and which has been developed in USA for the valuation of especially environmental assets can be a suitable method.

Figure 1: A view of Euro Way 4 passing Lake Vättern at the town of Huskvarna in southern Sweden.

CVM has been used to find out people's valuation of public goods that there are no markets for. Since public goods, for example environmental assets are not traded in any markets CVM is used as a surrogate to get a willingness to pay (WTP). That means that a hypothetical market for the actual good is created. A scenario is described to the respondent where it is described how the environmental benefit is to be designed and how the payment will be done. Photos like those in figures 1 and 2 can be used to show the change we want to evaluate.

Figure 2: The same view with the Euro Way in a tunnel (photo montage).

When it comes to the design of the question of the willingness to pay in CVM studies there are two main variants. The first one means that every respondent state his or her maximum willingness to pay. That can be done in three different ways; the respondent him- or herself (1) gives an amount, (2) choose an amount among a number of amounts given, or (3) react on a first amount that then is raised or lowered until you reach the amount that is the one that the respondent maximum is willing to pay for the good. The last variant only can be done in an interview but the two others also can be performed in questionnaires sent to the respondent.

The other main variant of CVM, and the one recommended nowadays and mainly used means that the respondent only has to consider if he or she thinks that the benefit is worth a certain price. The respondents are divided into a number of groups that have to consider different amounts but each respondent only has to consider one amount. In this way a cumulative frequency curve can

be constructed and from that the total WTP for the population can be calculated. The respondent can answer in two ways, yes or no, and because of that this variant usually is called binary CVM.

In USA CVM is frequently used, for example to value environmental damages (as the Exxon Valdes oil disaster in Alaska 1989) and to value different environmental assets as for example National Parks. But the method is not used, at least not much, within the infrastructure field, not in USA or elsewhere.

3.2.1 Ex post questionnaires

In the case where winners and losers are different groups, as in the case of a by pass, CVM is especially suitable as valuation method. By the creation of a scenario you can ask the losers for their willingness to pay for any environmental improvement (for example to build a tunnel that will save the green area) and in that way value the public good "environment".

A CVM study is preferably done ex post. If an ex ante study is carried out the risk is large that an overestimation will be done. This comes to the fact that when an infrastructure investment that means an encroachment of any kind is to be done it is often written about in newspapers etc. The debate is often so infected that people tend to be affected emotionally and therefore exaggerate their "real" willingness to pay.

In ex post studies it seems to be possible to get a clue of the size of the environmental losses caused by infrastructure investments. In an ex post study the respondent is not informed of the real costs and the way to finance an investment. He or she can be less emotionally affected than in an ex ante study and has therefore less incentive to act strategically. The disadvantage can instead be that the respondent is unmotivated to participate in the study since the investment is done and can not be changed. Also quite a large number of studies have to be carried out to get reliable values as input in a calculation model.

The fact that the study is done ex post means that the result can not be used in the actual case. But that is not the aim. Instead the aim is to use the result as input in a benefit transfer model to calculate values to use in the CBA in other cases. Using CVM studies one could hence be able to value encroachment monetarily and then get money values to negative environmental effects that today are not taken into account in the CBA.

One way to find out how large share of the population that thinks that a change is negative is to carry out a simulated referendum. In simulated referendums you ask the respondent if he or she wants the road or not. If a majority of the respondents think that the investment is not ought to be done, or says no in an actual referendum, you get the lowest cost of the encroachment since the expected benefits of the investment (due to the CBA) then is considered to be smaller than the encroachment costs of the investment.

3.2.2 Case studies with CVM

Table 1 shows the results from different CVM studies.

Table 1: Willingness to pay in some case studies to get a barrier in a tunnel (Price level 2000, *10 SEK at the time was approximately 1 Euro*).

	Annual WTP per person during 10 years (SEK)	**Total WTP per year during 10 years (million SEK)**	**Present value of total WTP during 10 years (4% rate) (million SEK)**
Euro way 4 at Huskvarna			
- nearby area	4 185	6,28	50,92
- town	324	19,76	160,27
Regional road 100 at Höllviken			
- nearby area	1 841	0,42	3,41
- town	273	1,56	12,65
National road 70 through Rättvik, town	179	0,55	4,46
Railway through Rättvik, town	194	0,60	4,87
National road and railway through Rättvik, town	252	0,78	6,33
National road 40 at Ulricehamn			
- nearby area	606	0,20	1,62
- town	473	3,07	24,90

Source: Grudemo [2].

Nearby areas at Euro way 4 at Huskvarna in the south of Sweden and at Regional road 100 at Höllviken in the very south of Sweden show high WTP which indicate that the roads is experienced negatively by many nearby living residents. The Euro way at Huskvarna also shows a high present value during a period of 10 years. This probably depends on the fact that the road, a motorway, is a large barrier and that the built up area is large as well and therefore there are many individuals that are willing to pay to get a tunnel. Perhaps in this case the encroachment costs would affect the whole social benefit of the road so it would not be profitable.

The WTP differs between the different case studies but that depends on that the different encroachments are of varying character. I some cases the impact on the environment is limited but in other cases the living environment has been changed dramatically.

3.3 Case studies with simulated referendums or analysis of real referendums

The road Vallaleden in the town of Linköping in Sweden was thought to be a part of a ring road and would have been situated through Vallaskogen (the Valla wood), a frequently visited recreational area just outside the central parts of the town. The politicians were not able to take a decision about Vallaleden and therefore decided to hold a local referendum about the issue.

Although the National Road Administration would finance the investment and although that substantial traffic economical benefits, mainly timesaving, would be the result of the investment, 75 % of the inhabitants in Linköping voted no to the road. In the table the social economical effects of the road are shown.

Table 2: Calculated benefits and costs, CBA, Vallaleden. (Annual million SEK, 1990.)

Traffic safety,	+ 1,5
Time saving	+ 13,9
Vehicle and operation costs	+ 3,9
Decrease of exhaust fumes and noise levels	+ 0,9
Sum	+20,2
Total benefits during 40 years, present value	+ 392,7
Investment costs	45,0
Net Social Benefit	+7,7

Source: Calculations in Grudemo [1].

The table shows that Vallaleden had been a very profitable investment according to the CBA. In spite of that a majority of the inhabitants in Linköping didn't want the road. This indicate that the encroachment costs Vallaleden would cause, and that are not valued in the CBA, would be higher than the total benefits expected.

3.4 Winners and losers in different groups

Often winners and losers of an infrastructure investment are different groups. A typical case is when a National Road which is situated right through the town is moved to a by pass outside the town. In this case a group of winners are the long distance travellers. They do not have the town as start or goal and the by pass means that they get a faster and safer road to travel on. Another group of winners are those that live and/or work in the inner city. They get a safer and nicer environment. The benefits of these groups are valued monetarily in the CBA. The losers when the road is moved are the people living in the nearby area of the new road. These people can get large disturbances when the road is built since the road can mean encroachment in recreational areas near the house and also the living environment can be worse. These negative effects are not valued monetarily in the CBA.

In a case like this it may be possible to create a calculation model that could do this valuation of the whole. A limited number of broad type cases can be defined and for each type case a model is created like the following:

$$WTP_j = f_j (X, Y, Z) \quad (1)$$

where WPT is Willingness To Pay to avoid the encroachment in a certain case within type case $_{j,}$ X is variables describing the exposure (for example the distance between the dwelling and the encroachment), Y is socio economical variables (age, salary etc.) and Z is variables describing the characteristics of the infrastructure object (number of vehicles, type of road etc.)

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