MONETARY VALUATIONS OF RIDE QUALITY AND PAVEMENT CONDITION

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ABSTRACT

According to the Swedish government, cost benefit analysis will be used in the transport sector not only for investment but also in the operations and maintenance area. The aim with this project was to find out how motorists' monetary ride quality scores vary according to different maintenance standards. The general public perception of a good road is one that provides a smooth ride. Consequently, it is desirable to determine the ride quality of the pavement deriving from roughness characteristics. The car users' perception of ride quality must be expressed in monetary terms in order to make cost benefit calculations. The valuations should also relate to the International Roughness Index (IRI).

A number of willingness to pay (WTP) studies about ride quality has already been carried out since the 1980s with varying results and methods. One reason for the willingness to pay varies between different studies may be differences in how bids are presented to respondents. One way to get around the problem with bid levels could be to measure value of time (VOT) quotes on roads with different IRI values. The theory was that motorists have higher VOT quotes on rougher roads than smoother roads. The differences between the quotes interpretation is the willingness to pay for travelling on smoother roads. The pilot studies showed that this way of obtaining monetary valuations of ride quality did not work well.

The VOT scores for roads with different IRI were not significantly separated from each other.

Therefore, ride quality in this project has been captured by making a more traditional Stated Preference (or Stated Choice) approach where the factors of ride quality, travel time and journey length was varied or ride quality, travel time and travel cost. The survey design allowed the ride quality valuation to be expressed in monetary terms. Alternatively, the valuation was measured as the detour, in time or length, as the motorist is willing to drive to go on a comfortable way instead of a path of damage.

The main survey included 1451 people in a web survey. The respondents had to consider roads with different IRI measures that are typical for low-, medium-and high-traffic roads. The obtained estimates have been used to calculate respondents' willingness to pay to avoid

each type of road damage based on fundamental assumptions about value of travel time and variable car cost. The analysis shows that WTP to avoid driving on roads with some cracks and patch repairs is 2.3 SEK per 10 kilometres, WTP to avoid some cracks and occasional rut is 1.9 SEK per 10 kilometres and the willingness to pay to avoid roads with ruts is 1.5 SEK per 10 kilometres.

The calculated valuation could be used for cost benefit analysis in the maintenance sector or as indicators on when it is necessary for new pavement coating according to the road users.

1 INTRODUCTION

The need for a scientifically based method for cost-benefit calculation methodology for operations and maintenance in the road and rail sector has grown considerably. In Sweden, cost benefit analysis (CBA) should be used for economic analysis in the field of transport policy according to the government. The uses of economic assessments have been limited in operations and maintenance area in comparison with analysis of investment in the infrastructure sector. One reason is that there is no reliable confirmed connection between measures and effects for maintenance actions. In this project the aim was to analyse the car users' benefit from pavement maintenance management. If the benefit for new coating could be expressed in monetary terms cost benefit calculation could be made in the maintenance area.

CBA in the maintenance management area is a bit different than CBA in for investment decisions. Usually in the investment field there has been a benchmark option (if nothing is done) as compared to new investment alternatives. Operating and maintenance works are procured in large part with the functional requirements of the finished work. The contractor could often decide and select the type of action that should be used to meet these functional requirements. This is the reason why the operation and effect manual for maintenance primarily describes the effects of various conditions in the road and not the effects of various measures.

Review of literature reveals a number of previous studies that tries to capture the utility of maintenance management. Despite the number of newer studies he comfort score used today in the Swedish maintenance estimates are from a older Finnish revealed preference (RP) study (Mäkele and Lampinen, 1985). The study was based on 30 test drivers who had to choose between a shorter rough road or a long smooth way.

The first Swedish stated preference study (SP) with the aim to investigate WTP for road comfort was carried out in 1991 (Rückert, Forsström). In the study, respondents watch a video that showed three levels of road surface in three road types. It resulted in WTP 0.7 SEK / litre petrol to go on a wide road with a semi-smooth road surface compared to an uneven. On the narrow road WTP was 0.8 SEK / litre of petrol.

In 2000, a SP-study in a doctoral project at the Royal Institute of Technology was carried out (Olsson, 2002). The SP survey was based on pictures and descriptions of various roads and surface conditions. The result, expressed in WTP was 0.9 SEK / km to avoid tracks, 0.6 SEK / km to avoid cracks and was 1.7 SEK / km to avoid bumps. WTP for offering good comfort compared to the poor was 1.2 SEK / km and offering good comfort compared to average was 0.4 SEK / km.

The Swedish National Road and Transport Research Institute (VTI) carried out a study of motorists' monetary valuation of comfort in 2004. The method of SP was compared to the Contingent Valuation Method (CVM). Fifty volunteers compared nine 500-meter stretches of roads with different road surface. The mean of the measured IRI value of the distances vary from 0.8 mm / m at the most equal distance to 10.5 mm / m at the roughest road surface. They respondents answered both SP and CVM questionnaires based on their driving experience. The monetary values from the CVM was significantly lower than from the SP, 1.1 SEK per

10 kilometres for roads with IRI 0.8 compared to the road with IRI 3.5 in comparison with 6.1 SEK. The explanations why the WTP can differ so much when the same people answered questions on the same roads at the same time depends on the bids are formulated. In the CVM study the bids differed 0.50 SEK per 10 kilometres and the SP bids 2 to 9 SEK. That difference in bid anchoring explains the difference in outcome between the two studies.The contradictions is also a key reason why the old valuation from the small limited study has not yet been replaced with more recent results from the newer more comprehensive studies.

2 METHOD

2.1 CBA and maintenance management

Normally, in CBA there are separate valuations between different types of effects. In the case of car users WTP, the vehicle travel time savings are separated from car costs, which also could be divided into a number of different components, fuel, repair, etc. Other effects related to coating operation affects other than road users and are so called externalities such as road safety and noise.

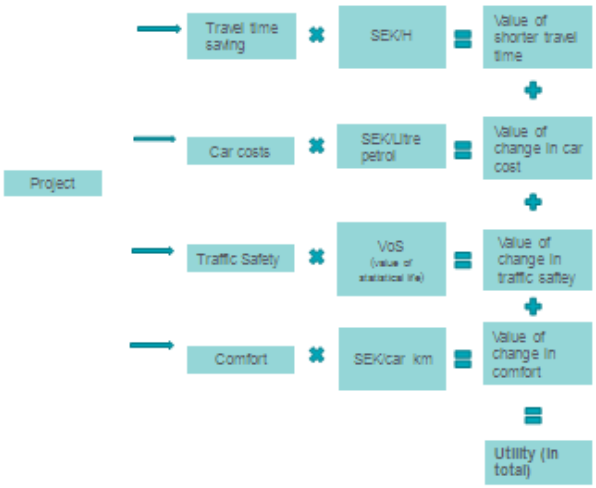


Figure 1: Principle of CBA methodology in the field of maintenance management.

The figure above shows how the socio-economic calculations normally are separate between different types of effects and finally added up to the value of all the effects. It would theoretically be possible to make such measurements directly, with a major study of the collective willingness to pay for better road maintenance. Why it is common to do a detour over the grouping of different effects is of course that measured values like travel time savings could be reused.

This approach does involve methodological problems if different types of effects are strongly intertwined. Then it may be impossible to separate them from each other when the calculation values should be determined, or when the size of the effects should be quantified. Since the respondent is not expected to know the different kinds of effects the Swedish calculation methodology separates from it is probable that she makes a complete picture, which includes all the factors that she expects will be different between the presented the road surface standards in the questions.

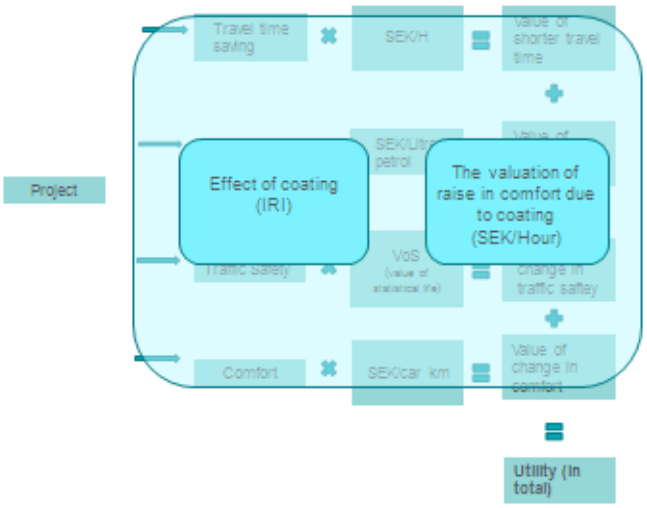


Figure 2. Suggestions for handling the context of valuation of road comfort.

The proposal of this project is to manage comfort evaluation as an overall score consisting of comfort. This means that in some situations, such as poor coat, the car users must reduce their speeds and will that their travel time, vehicle costs, traffic, noise, etc will be affected. The result in this study is an additive model in which the individual effects are calculated and summed up cannot be used.

2.2 Survey design

The study is mainly based on the Stated Preferences survey technique. The SP experiment was aimed at assessing motorists' choice of coating standard. The car users answered stated choice questions on web questionnaires. The Stated Choice set was based on a factorial fractional design (Ben-Akiva and Lerman, 1985; Louviere et al., 2000). The collected data was analysed by using a multinomial logit model.

Motorists' willingness to pay for maintenance coatings has been estimated for three different road categories, which represent different types of coating injuries that could occur on the specific road category.

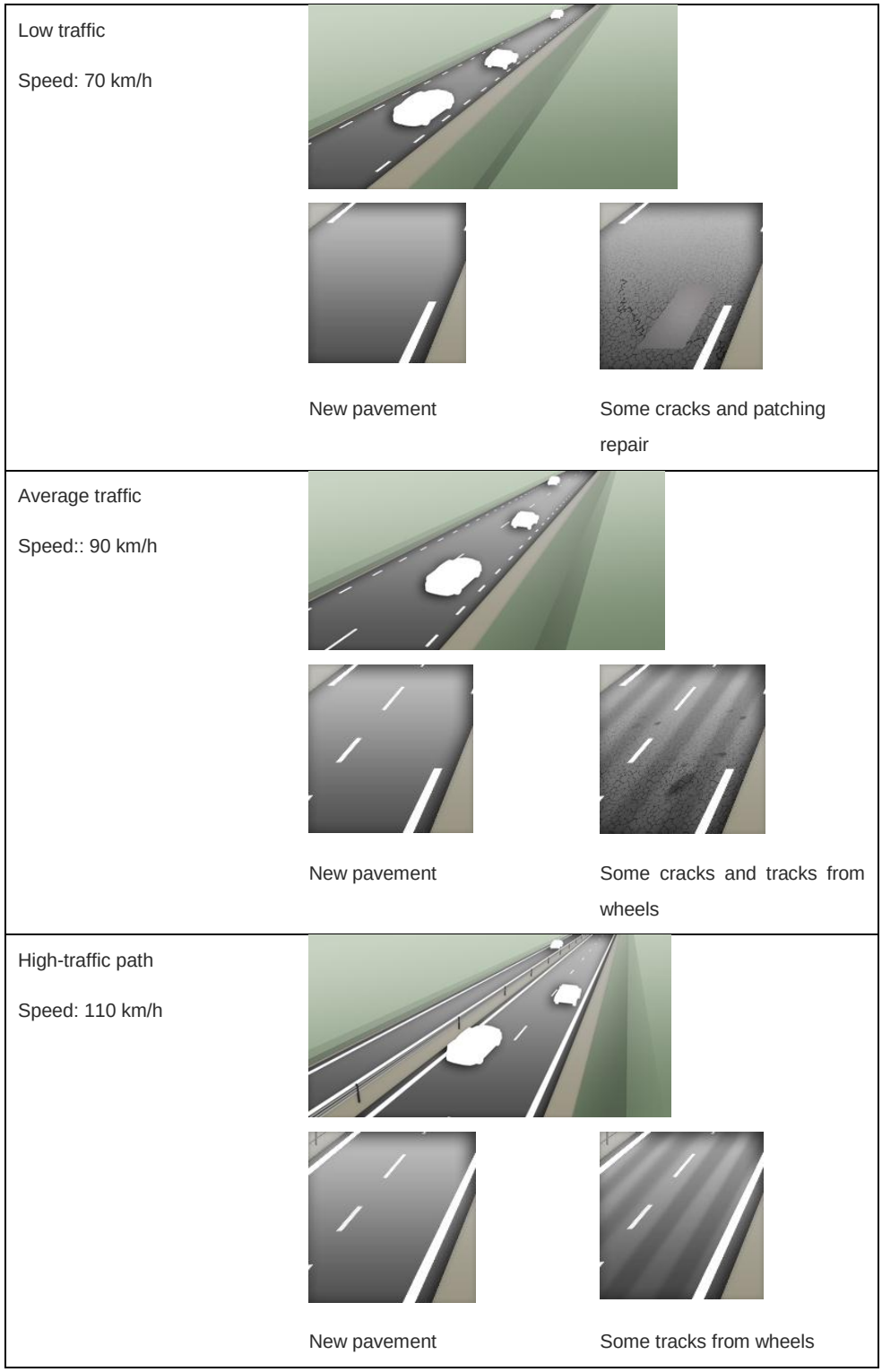


Figure 3. Valuated coating damage on different road categories.

In the Stated Choice survey; 4 factors were analysed; road surface damages, travel time and length of travel or travel cost. The factors were separately valuated from each category of road.

1. Your choice?

	
Some wheel tracks Travel time: 70 minutes Length of travel: 105 km	New pavement Travel time: 77 minutes Length of travel: 95 km
☑	☐

Figure 4. An example of a pairwise choice for the respondent. Travel length trade off

2. Your choice?

	
Some wheel tracks Travel time: 70 minutes Parking cost at destination: 15 SEK	New pavement Travel time: 77 minutes Parking cost at destination: 15 SEK
☑	☐

Figure 5. An example of a pairwise choice for the respondent. Travel cost trade trade off.

Each interviewee had to answer three different Stated Choice sets, one per category of road. Two of the sets considered the balance between comfort, travel time and path length, and one was about trade-offs between comfort, travel time and travel cost. The scenario given for the respondents was that they were going between two places and that there were two routes to choose from.

The collected data was then analysed by using logit analysis which is a well-known statistical method for analysis of discrete choices in the transport sector (Ben-Akiva & Lerman, 1985 and Louviere et al 2000). The method is based on that individuals will maximize their advantage in elections. Individuals' utility is calculated by setting up benefit functions between different choices.

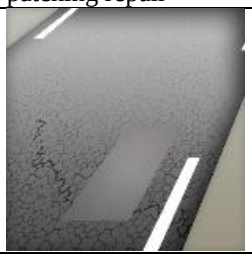
3 RESULT

3.1 Motorists valuation

A total of 1451 interviews were carried out. The respondents were stratified into three regions, south, middle and north of Sweden. The reason to stratify the sample was to be able to reveal differences in comfort rating.

Since the valuation of comfort is calculated as a ratio between the logit models comfort parameters and the parameters of travel time, travel length and travel cost, it means that comfort values can be expressed in both, time, length and cost.

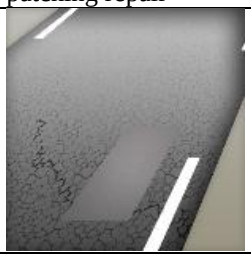
Table 1. Value of new pavement in comparison with roads with higher IRI.

	Some cracks and patching repair	Some cracks and tracks from wheels	Some tracks from wheels
			
Travel time (1)	17 minutes	14 minutes	11 minutes
Travel length (2)	1,7 km/10 km	1,7 km/10 km	1,1 km/10 km
Travel cost (3)	1,7 SEK/10 km	2,0 SEK/10 km	0,95 SEK/10 km

[(1) Minute detour one is prepared to drive to drive on the newly paved road per 10 mil]
[(2) Number of km detour one is prepared to drive to drive on the newly paved road]
[(3) Money one is prepared to pay to drive on the newly paved road]

The comfort values calculated from the logit models indicate that motorists have higher values in order to avoid the more extensive damage that may be on sparsely trafficked roads than the less prevalent injuries that may occur on roads with more traffic. It becomes particularly evident as regards the valuation of time corresponding to the detour the car users are willing to drive for driving on a road with a good standard. Those valuation differences disappears when consider that the speeds of the different types of road where the different types of damages can occur is different because the signposted speed is lower on the more damaged the road than the less rough roads.

Table 2. The values of avoiding rough roads recalculated into share of total travel time, travel length and travel cost.

	Some cracks and patching repair	Some cracks and tracks from wheels	Some tracks from wheels
			
Travel time	20%	21%	20%
Travel length	17%	17%	11%
Travel cost	9%	10%	5%

Example travel time: (17/60*(100/70))*100=20%
Example travel length: (2,5/10 km)*100=25%
Example travel cost: (1,7/18.50 kr)*100=1,7/18,5=9%

A recalculation of how motorists' prefers newly sealed roads compared to older with some damage shows that in both travel time and distance car users can think of about 10 to 20 percent longer trips, depending on the type of road damage. Cost-wise, car users could consider a cost increase of 5 to 10 percent.

3.2 Example of a cost benefit calculation

Suppose a region has a budget of 6 million for performing coating operations within an operating area. There are three items that the budget can be used, a distance of 31 km on a road with a flow of 300 vehicles / day, 13 km of a primary county road with 2000 vehicles per day and for a distance of nearly 7 km highway with 4500 vehicles per day.

Table 3. Conditions for the calculations.

	Road 1		Road 2		Road 3	
Width	6,5	m	9	m	13	M
Traffic volume	300	vehicle/d	2000	vehicle/d	4500	vehicle/d
Posted speed limits	70	km/h	90	km/h	100	km/h
IRI	4		3		2,5	
Cost for repavement	30	kr/m2	50	kr/m2	70	kr/m2
Length	30,8	km	13,3	km	6,6	Km
Total cost	6	Mkr	6	Mkr	6	Mkr
Benefit valuation (from table 1)	0,17	SEK/km	0,20	SEK/km	0,095	SEK/km

It should be emphasized that the road surface defects is different for the three different roads. In this example, the IRI be the indicator for the amount of the damage. It might as well have been a covering index.

Table 4. Costs and benefits.

	Road 1	Road 2	Road 1	
Benefit, year 1	0,7	2,0	2,2	MSEK
Life cycle	15	12	10	YEAR
Total cost for repavement	6	6	6	MSEK
Net value	4,6	9,2	5,1	MSEK
Net present value NPV	-0,3	0,6	0,5	

The benefit value of addressing a distance of 30.8 kilometers with 300 vehicle is 0.57 million SEK for the first year. (300 vehicles * 365 days * 30.8 km * 0.17 SEK / km). The benefits will gradually decline each year until it is 0 which occurs when the road has reached the same damaged condition once again that it had before the action. The sum of the present value of benefits under the measure life is 2.7 million (4 percent discount rate).The estimated value of benefits from the two other roads in a similar way.

The net present value ratios (NPV) is calculated for the three roads and indicate which of the alternatives that is most economically efficient. In this example it is Road 2.

4 CONCLUSIONS

This study shows that the Stated Choice methodology allows us to find out the motorists comfort values and monetary valuations for avoiding different kind of road damage. Comfort valuation of a larger standard raise is higher than a smaller one.

Comfort is a vague term which may complicate interpretation of studies such as this, both for the respondent and the analysis of the results. One conclusion from this project is that the comfort valuation reflects an overall benefit of higher road standard to road users. The monetary valuation of road comfort includes travel time, vehicle costs, security, noise, road safety and more. When the coating is poor road user compensates the increased discomfort by lowering the speed, which affects all the effects.

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