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Safety and travel time in cost-benefit analysis: A sensitivity analysis for North Rhine-Westphalia

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ABSTRACT

Decisions on large-scale infrastructure concepts are frequently based on cost benefit analysis (CBA). Using 431 road projects evaluated in the integrated transport planning process in North Rhine-Westphalia, Germany (IGVP NRW) this paper examines the evaluation dimensions traffic safety (fatalities) and travel time in private passenger transport. The unit values of traffic fatalities and travel time are varied, and the effects of the variations on the rank order of the projects are examined. Target conflicts between safety and travel time are studied as well as the contribution of these two dimensions to the total benefit values. The sensitivity analysis shows that the evaluation results are fairly stable against variations in unit values of travel time and fatalities. The relevance of traffic safety in terms of its contribution to total benefit as well as in terms of the unit value appears to be relatively minor. The unit value of travel time is higher than that of lifetime. Some projects turn out as feasible in the evaluation even though they are likely to increase the number of fatalities. The paper therefore suggests the higher weighting of traffic safety in CBA.

1. Introduction

Cost-benefit analysis (CBA) is a crucial component of transport planning when the allocation of scarce means for investment has to be justified. The bulk of benefit commonly arises from travel time savings that are achieved by network expansions (Metz, 2004, p. 338). On the other hand, increasingly high thresholds with respect to traffic safety are set as goals to be achieved. Among the most prominent examples is the 'Vision Zero' in Sweden that states as a long-term goal "that nobody should be killed or seriously injured in the transport system" (Rosencrantz et al., 2007).

Although the two goals of increasing speed and more safety do not necessarily conflict with each other, there may well be a trade off in some cases. Hauer (1994) illustrates this with respect to a study that gives guidance to replacing 'stop' signs at intersections with 'yield' (give way) signs. The main benefit of yield signs is to save time for vehicle occupants, while "the main drawback is that it degrades safety" (Hauer, 1994 p. 109).

This paper contributes to discussion of the valuation of safety and travel time with a secondary analysis of CBA results for 431 road projects in the federal state of North Rhine-Westphalia (NRW), Germany. CBA plays a key role in the allocation of financial means for infrastructure upgrade and expansion in Germany. This is true for federal transport infrastructure planning (Bundesverkehrswegeplanung, BVWP) as well as for integrated transport planning in NRW (Integrierte Gesamtverkehrsplanung Nordrhein-Westfalen, IGVP NRW). Although the IGVP NRW includes cost efficiency analyses as well, political decisions in the transport ministry are mainly based on the CBA results. The methodology is reported in detail by the project group (Projektgruppe IGVP, 2005).

In this paper we present findings from a sensitivity analysis that aims to examine the sensitivity of the rank order of road projects against variations in the values of traffic fatalities and travel time in private (non-business) passenger transport.

The next section presents a short description of the relevant elements of CBA with a particular focus on the problem of uncertainty. Our research approach is subsequently described, followed by an overview of our data and methodology. Sections 4 and 5 present the results. The paper finishes with some policy recommendations and an outlook.

2. Background

2.1. Methodology of cost-benefit analysis

CBA is a widely acknowledged and widely used methodology for the economic appraisal of infrastructure projects (Nas, 1996; Vickerman, 2007) including transport projects (Bristow and Nellthorp, 2000; Mackie and Nellthorp, 2001). The effects of an investment are assessed as benefits and monetised. Over and above

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their economic impact, this may include social or environmental effects that have to be transformed into monetary units. Negative effects such as additional emissions are treated as negative benefits. The benefits are compared with the project costs, which include construction and maintenance. Benefits as well as costs are discounted over an assumed project lifespan and they may be annualised. If the benefit sum exceeds the costs the project yields a positive economic benefit (i.e. if the benefit cost ratio $BCR > 1$). The BCR of various projects can be used to compare and rank the projects.

In transport planning practice, not all projects with $BCR > 1$ are completed. For instance, in earlier federal transport plans in Germany a threshold of $BCR > 3$ was set for 'urgent need' that then implied that the project had at least a chance of realisation. The recent BVWP no longer uses such a fixed threshold. In the IGVP NRW a 'rough threshold' for orientation of $BCR > 2$ is used.[2]

2.2. Uncertainty in cost-benefit analysis

A large proportion of the benefit of transport infrastructure projects is often due to travel time savings. In fact, in CBA ensuring and improving accessibility, the key goal of transport planning, is implicitly often operationalised as increasing travel speed and thereby reducing the generalised cost of travel, although there is consensus in transport science that "there's more to it (i.e. to accessibility) than just summing up travel cost reductions" (Zondag et al., 2007).

Besides such conceptual shortcomings, there are a number of other problems in CBA, including mathematical problems, monetisation problems, the assumption of mutual substitutability of positive and negative effects, and the problem of recognising target conflicts. What is more, ex ante appraisals in planning processes always involve uncertainties. In CBA these mainly relate to three elements: transport forecast, the estimation of effects, and monetisation.

2.2.1. Transport forecast

Assessing a project by CBA requires transport forecasting. Besides travel time changes, the transport effects of a project may include changes in the origin-destination matrix, travel mode choice and route choice. All these effects may result in further travel time changes. In the IGVP NRW the transport effects of the projects were estimated using a transport model for the affected partial networks. The forecast is uncertain even though the approach used was highly ambitious.

In a review of experience from mega transport projects Flyvbjerg et al. (2003, p. 22ff) conclude that travel demand has been systematically overestimated. Van Wee (2007), in a comprehensive review of demand and cost forecasts for which ex-post evaluations were available, finds that the quality of the forecasts is often very poor, and "overestimation of demand is more common than underestimation" (Van Wee, 2007, 614). He also notes having found "only a few references in which a systematic comparison between forecasts and actual demand is made. This in itself is striking" (Van Wee, 2007, p. 613).

De Jong et al. (2007) study uncertainty in input variables as well as in model coefficients for traffic forecasts in the Dutch context. In a similar vein to Van Wee they note that "the literature on quantifying uncertainty in traffic forecasts is fairly limited" (De Jong et al., 2007, p. 391). In their own study they find "substantial, but not very large uncertainty margins" (De Jong et al., 2007, p. 392) for the whole study area of Rotterdam as well as for selected links.

2.2.2. Estimation of effects

The estimation of traffic effects, e.g. on safety and the environment, involves uncertainties as well. The estimation of safety effects in the IGVP NRW may serve as an example. Safety effects are estimated here by using generalised accident parameters for different road types (Projektgruppe IGVP, 2005, p. 58). The relevant network links are classified (e.g. single-lane extra-urban road) and the traffic volumes on a link are multiplied by the mean accident rate of the respective road type. Changes in safety result from changes in transport demand, from shifts in transport demand towards links of a different type, and from the planned project (e.g. upgrade from a single-lane to a two-lane road). The actual accident situation in the planning area is not considered and may considerably differ from the parameters used. As a consequence, the future accident situation may also markedly differ from the expected situation. To the best of our knowledge there is no study for Germany that includes comparisons of accident rates before and after the realisation of projects, or comparisons between forecast and actual accident rates. In the UK this is carried out in the POPE (Post Opening Project Evaluation) scheme. Results show close correlation between accident predictions and outcome within five years after implementation. However, this conclusion is based on the very limited data referring to nine projects that is available to date (Highways Agency, 2009, p. 20ff).

The estimation of project costs is another example of uncertainty. Nijkamp and Ubbels (1999) find that generally cost estimates are fairly reliable in the Netherlands and Finland. By contrast, Flyvbjerg et al. (2003) find substantial cost escalation for a large sample covering 258 rail, road, tunnel and bridge projects in 20 countries all over the world. According to their results, the tendency to overrun cost is common for different project types and different geographic regions, and has not improved over the past 70 years. Flyvbjerg et al. (2003, p. 11ff) find a systematic underestimation of costs in transport projects. Lee (2008) finds cost overruns of an average of 27.9% for a sample of 161 Korean road, rail, airport and port projects. Odeck (2004) finds an average cost overrun of 'only' 7.9% for road projects in Norway, with a substantial variation of misestimates. Van Wee (2007) concludes from his literature review that "all the studies show that cost overruns are common" (Van Wee, 2007, p. 617). In Switzerland, CBA includes a buffer of 20% of estimated costs for schemes unless they include an additional risk analysis. For tunnels and bridges the buffer is even 40% (VSS, 2006, p. 32).

2.2.3. Monetisation

All non-monetary effects of a project have to be monetised in CBA. For instance, in the IGVP NRW a traffic fatality is valued by 1.2 million €. One hour of travel time in non-business workday passenger transport is valued by 6.52 € (Projektgruppe IGVP, 2005, p. 30).

Both the value of travel time savings and the value of life are subject to debate in transport studies. Methodologies of measurement include two basic approaches. First, human capital theory claims that lost time is lost productivity. Empirically this leads to the estimation of future earnings lost by accidents (or by time spent travelling). Second, willingness-to-pay approaches measure the value of time either by revealed preferences, i.e. by some measure of observed behaviour, or (more often) by stated preferences, i.e. by what people say about what they would do in a hypothetical situation. Initial research on the value of travel time was

[2] The IGVP NRW considers projects with $BCR > 2.2$ as being feasible. This threshold is derived from the available budget rather than from methodological considerations, and it was reduced in a political adjustment process to $BCR > 2.0$. In reality, however, considerable deviations from this threshold are evident due to 'urgently required projects' with lower BCR values. As a threshold for comparison, we regard projects with a $BCR > 2.0$ as feasible in this paper.