Transportation Research Part A 92 (2016) 195–205

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Does uncertainty make cost-benefit analyses pointless?

Disa Asplund [a,*,1], Jonas Eliasson [b]

[a] Division of Transport Economics, The Swedish National Road and Transport Research Institute (VTI) and Örebro University School of Business, Sweden
[b] Department of Transport Science, KTH Royal Institute of Technology, Sweden

ARTICLE INFO

Article history:
Received 1 March 2016
Received in revised form 23 June 2016
Accepted 2 August 2016
Available online 20 August 2016

Keywords:
Cost-benefit analysis
Infrastructure investments
Uncertainty
Robustness

JEL classification:
R42
R48

ABSTRACT

Cost-benefit analysis (CBA) is widely used in public decision making on infrastructure investments. However, the demand forecasts, cost estimates, benefit valuations and effect assessments that are conducted as part of CBAs are all subject to various degrees of uncertainty. The question is to what extent CBAs, given such uncertainties, are still useful as a way to prioritize between infrastructure investments, or put differently, how robust the policy conclusions of CBA are with respect to uncertainties. Using simulations based on real data on national infrastructure plans in Sweden and Norway, we study how investment selection and total realized benefits change when decisions are based on CBA assessments subject to several different types of uncertainty. Our results indicate that realized benefits and investment selection are surprisingly insensitive to all studied types of uncertainty, even for high levels of uncertainty. The two types of uncertainty that affect results the most are uncertainties about investment cost and transport demand. Provided that decisions are based on CBA outcomes, reducing uncertainty is still worthwhile, however, because of the huge sums at stake. Even moderate reductions of uncertainties about unit values, investment costs, future demand and project effects may increase the realized benefits infrastructure investment plans by tens or hundreds of million euros. We conclude that, despite the many types of uncertainties, CBA is able to fairly consistently separate the wheat from the chaff and hence contribute to substantially improved infrastructure decisions.

1. Introduction

In public decision making, for example regarding infrastructure investments, CBA is frequently used to systematically compare costs and benefits of various projects. Such analyses are based on forecasts of likely future scenarios, with and without the project in question. These forecasts are obviously subject to uncertainties, and so are the valuations of costs and benefits of the respective projects. Such fundamental uncertainties have led many researchers and policy makers to question the usefulness of CBA as a basis for public decision making (see e.g. Mouter et al., 2013). For example, Flyvbjerg (2009) criticizes CBA as a selection criterion based on the lack of precision in forecasts of investment costs and transport demand. He argues that the errors in forecasting are of such magnitude that CBAs will "with a high degree of certainty be strongly misleading," concluding with the words, "Garbage in, garbage out" (p. 348).

* Corresponding author.
E-mail address: disa.thureson@vti.se (D. Asplund).
[1] Maiden name: Thureson.

http://dx.doi.org/10.1016/j.tra.2016.08.002
0965-8564/

But will this intuitively persuasive argument hold up in reality? In the present study we aim to answer this question by investigating how robust the policy recommendations of CBAs of infrastructure investments are with respect to several kinds of uncertainty. We use a simulation-based approach based on real data to explore how uncertainties affect selection of investments under a given budget, and how they hence affect the total achieved net benefits of the resulting investment portfolio. This is compared with both the ideal selection (under no uncertainty) and a random selection of investments from the list of candidates. The latter comparison represents a choice situation where decisions are made without any consideration of CBA results. In fact, previous research has found that politicians' investment selections are virtually indistinguishable from random selection from the list of investment candidates, and that the transport administrations' compilations of investment candidates (which are done before CBAs are made) indicate that it is very difficult, even for professionals, to assess cost-efficiency of investments without CBA results (Eliasson et al., 2015; Eliasson and Lundberg, 2012).

We study the sensitivity of selection and realized total benefits with respect to uncertainties in forecasts of investment costs, transport demand, assessment of effects, and valuations of benefits (travel time savings, freight benefits, traffic safety, and CO_2 emissions). We study both systematic and random errors. Data on infrastructure investment CBAs from Sweden and Norway are used to perform the analyses.

Each investment candidate is assumed to have true values of benefits and costs, but the decision maker can only estimate benefits and costs subject to forecasting/measurement errors (which can be systematic or random). The decision maker selects the investments estimated to yield the highest total benefit subject to a budget constraint. This actual selection, based on the estimated costs and benefits, is then compared with the ideal selection, i.e., the one which would actually yield the highest net benefits and which the decision maker would have selected in the absence of the forecasting/measurement errors. We compare actual and ideal selections in terms of both the number of investments that are different and the difference in realized benefits, i.e., the loss in net benefits caused by the uncertainty in benefits and costs.

The analysis consists of two parts. In the first, we examine systematic uncertainty in benefit valuations, i.e., the true valuation of a specific benefit are over- or underestimated for all investments. In the second part, in addition to unit value uncertainty we examine random forecasting errors, i.e., when benefits and costs of each project are estimated subject to errors that differ across projects and that may be different for different types of benefits. We use Monte Carlo simulation for this task, with error distributions of investment costs and travel demand based on Flyvbjerg et al.'s studies (2002, 2005), in order to test whether Flyvbjerg's claim "garbage in, garbage out" holds in practice. We also study how fast the quality of CBA recommendations deteriorates as the level of total uncertainty increases. This is similar to an analysis by Eliasson and Fosgerau (2013), but in the present study the representation of uncertainty is more detailed.

Sensitivity of CBA ranking to uncertainty has previously been studied by Börjesson et al. (2014) and Holz-Rau and Scheiner (2011). In both cases it was concluded that CBA ranking is fairly robust against the examined uncertainties. These studies only looked at how the ranking was changed, not at the losses in terms of total net benefits that these changes resulted in, which we do in the present study. We show that this methodological difference is important, as the loss in total net benefits is typically significantly more robust against some types of uncertainty. The present study extends the results in Börjesson et al. (2014) and Eliasson and Fosgerau (2013) in several ways; three different datasets are used and compared; investments are selected under a given budget constraint, rather than selecting a fixed number of projects; uncertainty intervals and probability distributions are based on empirical findings; and more types of uncertainty are explored and compared.

The assumption of a fixed investment can of course be questioned. One could argue that the estimated net benefits of potential projects should influence the total size of the investment budget. This may be reasonable in theory, but there is little evidence that it is indeed the case. From this perspective, it seems most realistic to look at ranking and selection decisions under a given budget rather than decisions about the total investment budget.

It can also be noted that the CBA methodology is based on the notion of a social welfare function (SWF), which is inherently normative in nature, and hence open for debate.[2] Although we examine valuation uncertainty in this study, we do not examine changes of the SFW in terms of differentiating the weight placed on different groups of individuals.[3]

Of course, our conclusions are also conditional on the essential assumption that the CBA is an accurate representation of social welfare. As always, the choice of any particular social welfare function is a normative assumption open for debate. Moreover, we do not study the problems that arise if certain costs or benefits are completely left out of the CBA (damage on the natural environment may be an example).

[2] On the most fundamental level, the concept of Hicks-Kaldor efficiency provides the basic justification of CBA methodology. This means that society is willing to accept projects that make some citizens worse off if it in principle is possible to rearrange compensation so that no one is worse off than before, while some citizens are better off.

[3] In Swedish CBA practice the SWF is as following: life and health of are assumed equally worth across individuals, the benefit of travel time reductions is assumed equally worth across individuals and the value of cost reductions and changes of changes in monetary travel costs are valued equal across individuals. In economic theory it is well-known that relatively poorer individuals benefit more from cost decreases than rich individuals do, which seem to call for distributional weights for monetary transactions between individuals. However, Harberger (1978) argued not to use distributional weights in the CBA of a specific project if it is possible to find a more efficient redistribution mechanism outside the project, for example through the general taxation and redistribution system. One could of course still argue that it inconsistent that the same ratio between VoT and monetary transactions are assumed across individuals although this ratio probably differs between individuals in reality. That is, if one consistently follows Harberger's argument in order to ensure efficiency, one could indeed argue that VoT should be differentiated. The effect of this is not investigated in the present study. For a more thorough introduction to welfare calculations and CBA in general, see Boadway (2006).