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The value of travel time, noise pollution, recreation and biodiversity: A social choice valuation perspective

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Abstract

Environmental effects of transport projects have a weak position in Cost-Benefit Analysis (CBA) which might be rooted in the valuation approach adopted in the dominant style of CBA. This conventional valuation approach has been criticized for not valuing positive and negative impacts of transport projects in relation to each other and for not valuing such impacts in a public context, but in the context of private decisions. These critiques might be circumvented through valuing transport projects in a social choice context in which overall burdens and benefits of proposed transport projects are considered together in a public – rather than private – context. In this study, we investigate the extent to which a social choice valuation approach produces different outcomes than a conventional valuation approach. We conducted four social choice valuation experiments in which respondents were asked to choose between alternatives for a new road, trading off travel time and three environmental impacts. Our findings suggest that, under social choice valuation, individuals assign substantially more value to environmental impacts than travel time as compared to conventional valuation studies. Moreover, in a social choice setting, respondents assigned monetary values to impacts that are not (or only qualitatively) considered in conventional CBAs of transport projects.

Keywords: Cost-Benefit Analysis; Social Choice Valuation; Transport Policy; Transport Appraisal; Environmental Valuation;

JEL Classification codes: R4; H50; Q50

1. Introduction

Cost-Benefit Analysis (CBA) is a widely applied tool for the appraisal of transport projects (e.g. Asplund and Eliasson, 2016; Mackie et al., 2014; Saraç-Lesavre, 2014; Sager, 2013; Welde and Odeck, 2011; Thomopoulos et al., 2009). Generally, the most dominant benefit in a CBA for road projects is travel time savings. Mackie et al. (2001) observe that, in the United Kingdom, travel time savings have accounted for around 80% of the benefits in CBAs for major road schemes, while Eliasson and Lundberg (2002) show that 90% of the benefits in the Swedish Transport Investment Plan 2010–2021 consist of reduced transport times and transport costs. On the other hand, although the environmental impacts of transport projects are recognized as items to be internalized in a CBA, their consideration has been hampered by difficulties in establishing the monetary value of a unit of environmental impact (Daniels and Hensher, 2000; Ivehammar, 2008, 2014).

One of the main criticisms of CBA is that, while it considers the non-monetized impacts of projects on objectives such as preserving landscapes and biodiversity, these effects are examined only in a qualitative manner (e.g. Lamari et al., 2014; Mackie et al., 2014; Mouter et al., 2015). Hence, they are not included in either of the indicators that are often decisive in the political process and the media: the benefit-cost ratio and the net present value (e.g. Annema and Koopmans, 2015). Based on an analysis of 67 CBAs performed in the Netherlands between 2000 and 2011, Annema and Koopmans (2015) conclude that in many cases relevant environmental effects are omitted or not monetized in the CBA. Moreover, they observe that non-monetized effects are often excluded from CBA conclusions. Mouter et al. (2015) establish that a result of the relatively weak position of effects that are difficult to monetize is that these can be underweighted in the decision-making process. Carson (2012) argues that, without knowing the monetary values of environmental externalities, infrastructure planners must make valuations arbitrarily. In some cases, this results in the assignment of infinitely high values, while in others it can produce a value of zero, possibly leading to the 'wrong' decisions being made. Nash et al. (1990) argue that the procedure of computing a net present value which includes a monetary valuation of time and accident savings but excludes all environmental effects is seriously misleading.

Ackerman and Heinzerling (2004) assert that the weak position of environmental impacts in CBA might be rooted in the valuation approach adopted in the dominant style of CBA. Their primary critique is that a CBA does not value positive and negative impacts of a government project in relation to each other as the CBA is built on the Kaldor-Hicks efficiency criteria (e.g. Boadway, 2006), which prescribe that the value winners attach to a project's benefits are evaluated separately from the value losers attach to their losses. More specifically, the Kaldor-Hicks efficiency criteria evaluate costs and benefits of a proposed project through measuring the monetary equivalent of a project's impact(s) on the individuals' welfare (either the individuals' compensating variation or equivalent variation). Subsequently, those projects where the sum of monetary gains outweigh the sum of monetary losses are recommended under the condition that the winners are still better off after compensating the losers. Importantly, winners and losers are not asked to judge whether the overall gains of a project legitimate its costs or to assess the entire impact of different alternatives of a project on society.

A second critique on the valuation approach adopted in conventional CBAs is that the impacts of government projects are evaluated in a non-representative context (e.g. Ackerman and Heinzerling, 2004; Sen, 1995, 2000). In a conventional CBA, the value individuals attach to a *government project's impact* is generally inferred from the value they attach to this impact

in the context of a private decision. For example, impacts of government projects on landscape, nature and noise pollution are evaluated through investigating the private decisions people make when buying a house (e.g. Allen et al., 2015; Seo et al., 2014). One reason why private choices may not reflect how individuals want public policies to change is that private preferences can be distorted through collective action problems (e.g. Hestermann et al., 2018; Lusk and Norwood, 2011; Sen, 1995, 2000). For instance, people may not be willing to contribute individually because the impact of their individual contribution is negligible, but people may be willing to contribute when the whole community is forced to contribute through a new law or a government project because the impact of this coordinated contribution can be substantial (Lusk and Norwood, 2011; Sen, 1995). For example, Californians voted overwhelmingly in support of a ballot prohibiting battery-produced eggs, which at the time of the vote were the most popular type of eggs purchased and consumed in California (Lusk and Norwood, 2011). Hestermann et al. (2018) argue that a first reason why individuals' voting decisions differed from their aggregate decisions in the grocery store is that individuals have the opportunity to coordinate their actions in a voting context. An alternative explanation is that individuals value the same impact, in this case animal welfare, differently in a private sphere (grocery store) and a public sphere (ballot box). The idea that individuals can entertain different kinds of valuations in different spheres is, amongst others, covered in the contributions of Sunstein (1993) and Anderson (1993). For instance, Sunstein (1993, p. 784) states: "distinctions among kinds of valuation are highly sensitive to the particular setting in which they operate. People do not value goods acontextually. In one setting – say, the workplace – the prevailing kinds of valuation might be quite different from what they are elsewhere – say, the home or the ballot box." Furthermore, Sunstein (1993) argues that because of the highly contextual nature of choice it is incorrect to assume that an individuals' private choices can be simply adaptable for policy use.

In sum, various scholars argue that crucial considerations might be lost in conventional CBAs, which results in recommendations that are not in line with the general public's actual preferences. These scholars argue that this critique can be circumvented through valuing government projects in a social choice context in which overall burdens and benefits of proposed government projects are considered together in a public – rather than private – context (e.g. Ackerman and Heinzerling, 2004). Essentially, a social choice approach (also coined by Ackerman and Heinzerling as 'holistic valuation') requires that individuals evaluate positive and negative impacts for the entire community in relation to each other in the context of a government decision. Scholars suggest that social choice-based valuation of positive and negative impacts of government projects will produce different outcomes than conventional valuation studies (also coined by Ackerman and Heinzerling as 'atomistic'). However, to our knowledge, this statement is primarily substantiated with thought experiments and anecdotal evidence; our field currently lacks empirical evidence comparing these two approaches.

This study aims to scrutinize this knowledge gap. To do so, we conducted four social choice valuation experiments in which respondents simultaneously evaluated the burdens and benefits of a transport project in the context of a decision of the Dutch government. To find out whether social choice valuation produce different outcomes than a conventional valuation approach, we compared the results inferred from our social choice experiments with the values enumerated in Dutch CBA guidelines (Rijkswaterstaat, 2018), as the studies on which these values are based (e.g. CE Delft, 2017; Kouwenhoven et al., 2014) meet the two criteria of a conventional valuation study: 1) positive and negative impacts of transport projects (such as

travel time savings and environmental attributes) are not valued in relation to each other; 2) impacts are not valued in a public context, but in the context of private decisions. For instance, the values for noise pollution are derived based on an international meta-analysis of stated preference studies in which respondents were asked to trade-off private income and transportation noise nuisance in a private context (Bristow et al., 2015) and the Dutch Value of Travel Time Savings is based on hypothetical route choice experiments in which respondents are asked to make a series of private choices between routes which differ in terms of travel time and travel costs (Kouwenhoven et al., 2014). A benefit of using the Dutch context is that several values prescribed in the CBA Guidelines (e.g. value of time and value of noise pollution) have been recently updated.

Because the arguments employed in the literature particularly focus on the evaluation of environmental impacts of transport projects, respondents participating in the choice experiments were asked to choose between different alternatives for a new public road connecting two municipalities which differed in terms of three environmental attributes: 1) Number of households experiencing noise pollution from traffic; 2) Remaining useable recreational area for 10,000 citizens; and 3) Number of hedgehogs living in a nature area in 2026. Furthermore, since scholars argue that social choice valuation might illuminate essential values that are lost in conventional studies, we asked respondents to provide qualitative motivations for their choices. This allowed us to identify considerations employed in social choice settings that respondents could not consider in conventional settings. Moreover, the qualitative data also enabled us to learn more about the perspective(s) individuals take when choosing between (impacts of) transport projects in a social choice setting.

The paper proceeds as follows: Section 2 provides a review of the literature that is relevant for this study. Section 3 discusses our methodology. Sections 4 and 5 describe the data collection and the results. Finally, Section 6 provides conclusions and a discussion.

2. Literature review

Section 2.1 covers literature on the distinction between conventional valuation and social choice valuation. Section 2.2 explores how this distinction relates to other academic debates regarding the valuation of impacts of (transport) projects.

2.1 Comparing social choice valuation with conventional valuation

The conventional empirical approach used to infer the value of travel time savings for government projects relies on (hypothetical) route choice experiments. In these, respondents are asked to make a series of private choices between routes which differ in terms of travel time and travel costs (e.g. Abrantes and Wardman, 2011; Armstrong et al., 2001 Batley et al., in press; Börjesson and Eliasson, 2014; Ehreke et al., 2015; Jara-Díaz, 2007; Kouwenhoven et al., 2014). Such studies deviate from social choice valuation in two respects. Firstly, value-of-time studies do not weigh the burdens and benefits of transport projects simultaneously. Travel time reductions are evaluated against a higher monetary cost for the individual, but not in relation to corresponding changes in noise pollution or environmental encroachment. Secondly, the impacts of government projects are evaluated in another context than the one in which the benefits and costs actually occur. The value individuals attach to travel time in the context of a government decision are inferred from the value they attach to this impact in the context of a (hypothetical) private route choice (Mouter and Chorus, 2016).

Hedonic pricing studies adopt a social choice context in one respect, as both amenities and disamenities of transport projects are evaluated simultaneously. Such studies are based on the notion that the value of a house is derived from its (observable) attributes, and therefore that regression analysis can be used to decompose observed house prices so as to provide an implicit price for each attribute (Allen et al., 2015). Hedonic pricing is thus well suited to estimating the market value of both a transport project's externalized costs, such as noise or pollution, and its externalized benefits, such as access to freeways or light rail (Seo et al. 2014). Various hedonic pricing studies have attempted to value accessibility premiums and noise/pollution discounts accruing from transport projects simultaneously (e.g. Allen et al., 2015; Bowes and Ihlanfeldt, 2001; Kilpatrick et al., 2007; Li and Saphores, 2012; Seo et al., 2014). Although hedonic pricing adopts a social choice perspective in one respect, in the sense that the burdens and benefits of transport projects are evaluated in relation to each other, it still exhibits the second dimension of conventional valuation studies. In particular, hedonic pricing still assumes that the value people derive from the impacts of a government project can be reliably inferred from their private choices in the real estate market.

There are a few studies which can be identified as employing a truly social choice perspective, in that they attempt to simultaneously evaluate the costs and benefits of transport projects in a public context. Daniels and Hensher (2000) carried out a study in which the benefits of a proposed urban road project (e.g. travel time savings) were mixed in a trade-off with various negative environmental impacts (e.g. noise pollution, bushland lost, open space lost). More specifically, respondents were asked whether they thought that the government should build the M5 East, a 13-kilometer extension of an existing tolled motorway. The study found that participants did not assign significant value to negative environmental impacts, but they also did not find a significant value for travel time savings. One potential explanation for this result might be that their models included 13 (or more) parameters based on 450 observations (150 participants made three choices). These choices might provide too little information to satisfactorily identify significant valuation for the environmental attributes. Ivehammar (2008, 2014) also conducted various contingent valuation studies (CVMs) in which Swedish citizens were asked whether they supported a road project resulting in both positive (travel time savings) and negative (environmental damage) impacts. She finds that respondents assign an important value to preventing environmental encroachment. For instance, in one study, Ivehammar (2008) finds that 48% of respondents rejected the road project even though the saved travel time was substantial (8 minutes per single trip). Indeed, she concludes that respondents were indifferent between saving 31 minutes of travel time per month and preventing the environmental encroachment. However, it is difficult to generalize the results of Ivehammar (2008, 2014) because the environmental encroachment is described in words and with a map showing the stretch of the road, but not quantitatively. We are of the view, that the issues of the studies of Daniels and Hensher (2000) and Ivehammar (2008, 2014) discussed above warrants conducting a series of new social choice valuation experiments for transport projects.

2.2 Related literature

The social choice valuation procedure as proposed by scholars such as Ackerman and Heinzerling (2004) shows close resemblance with accounts of (economic) philosophers such as Harsanyi (1976) and Rawls (1971) who investigate individuals' moral preferences. These scholars deduce moral guidelines from the so-called 'veil of ignorance' (VoI) postulate. The

VoI conceptualizes a person's moral preferences as the social state he would prefer when he is ignorant about the extent to which the costs and benefits that follow from his decision will affect him, or any other member(s) of society. Harsanyi (1975) translates the veil of ignorance notion into a utilitarian framework postulating that individuals would choose the social state with the highest expected utility in this context. On the other hand, Rawls (1971) champions the maximin principle, according to which the individual will choose for the social state which maximizes the interests of those for whom the outcome of the decision is the least advantageous.

A clear difference between these philosophical approaches and the social choice valuation approach is that the philosophical approaches concern the evaluation of social states from a specific normative perspective. For instance, the approaches of Harsanyi (1976) and Rawls (1971) require that an individual should assume that he has the same probability to be put in place of any one of the members of society to elicit his moral preferences (Chorus, 2015). Instead, the social choice approach that we adopt in the present study is non-paternalistic in the sense that individuals are not urged to take a certain perspective or standpoint when choosing between the social states. They are free to take a purely self-interested perspective, to identify themselves with each member of society, the members worst off in society, all individuals affected by the project or even with animals affected by the project when making their choice. Importantly, the social choice approach merely demands that an individual chooses between different social states while being both positive and negative impacts of a project in the context of a government decision.

Another related strand of literature investigates the extent to which individuals value effects of government projects differently in studies which use 'willingness to pay' (WTP) or 'willingness to allocate public budget context' (WTAPB) as a payment vehicle. Recent studies establish that the choice of WTP or WTAPB as a payment vehicle can substantially affect the way individuals trade-offs impacts of transport projects (e.g. Mouter et al., 2017a, 2018). The key difference between valuation experiments in these two types of contexts is that they investigate individuals' preferences in relation to different budget constraints (Mouter et al., 2017a). On the one hand, WTP experiments study the choices individuals make within their personal budget constraints (i.e., after-tax income). On the other hand, WTAPB experiments investigate choices individuals make when faced with effects accruing from alternative allocations of government budget (i.e., expected or previously-collected taxes). Importantly, WTAPB experiments do not directly impact the respondent's disposable income (Nunes and Travisi, 2009). One can use such experiments to measure the extent to which citizens support the allocation of taxes towards a government project from which the effects accrue that are object of the analysis (in the present study: travel time and environmental effects). Social choice valuation experiments can be conducted with both WTP and WTAPB as a payment vehicle as long as burdens and benefits of transport projects are evaluated in relation to each other in the context of a government decision. The payment vehicle in such experiments in a WTP setting is also called 'collective WTP', see Wiser (2007).

To summarize, Table 1 shows the dimensions on which social choice valuation differs from conventional valuation.

TABLE 1 Dimensions on which social choice valuation differs from conventional valuation

	Conventional valuation	Hedonic pricing studies	Social choice valuation
Are burdens and benefits of transport projects evaluated simultaneously?	No	Yes	Yes
Are burdens and benefits of transport projects evaluated in the context of a government decision?	No	No	Yes
What is the payment vehicle?	Private WTP	Private WTP	Collective WTP or WTAPB

3. Methodology

We decided to conduct social choice experiments in a WTP and a WTAPB context to increase the robustness of our conclusions regarding the extent to which social valuation and a conventional valuation produce different outcomes for transport projects. In the literature, a distinction can be made between two types of WTAPB experiments. Firstly, a range of studies investigate citizens' preferences concerning a tax reallocation towards a public good (e.g. Barak and Katz, 2015; Bergstrom et al., 2004; Dalrymple et al., 2012; Ivehammar, 2009; Kontoleon et al., 2007; Mouter and Chorus, 2016; Nunes and Travisi, 2009; Swallow and McGonagle, 2006). In such experiments, the financing of the public good under scrutiny is to be paid for by a decrease in the amount of a household's taxation money that was previously spent on other government-funded goods (Nunes and Travisi, 2009). A clear downside of a 'reallocation' context is that it is difficult to make an assumption regarding what will happen precisely in case of a tax reallocation. Ivehammar (2009) suggests that the re-allocation context does not work as good as a payment vehicle because respondents do not fully interpret it as a cost. Respondents might believe that the reallocation would be made from what they think is least valuable.

A second type of WTAPB studies, particularly applied in health economics, scrutinize citizens' preferences between two or more alternative tax allocations of the government (e.g. Anand and Wailoo, 2000; Dolan and Tsuchiya, 2005; Johannesson and Johansson, 1997; Johansson-Stenman and Martinsen, 2008). A feature of this approach is that the respondents only need to consider the effects of two or more alternative allocations of taxes. Both the respondent's disposable income and the provision of other public goods (other than those described in the choice experiment) will not be affected. This allows for a direct measurement of individuals' trade-offs between the effects of these alternative public investments: i.e. individuals' trade-offs between travel time and environmental effects. We selected this second type of WTAPB context our research, since we are only interested in how individuals trade-off travel time and environmental effects and not in how individuals trade-offs these effects against the effects accruing from other public goods.

We consulted various experts through bilateral meetings (including ecologists, economists and transport specialists) when designing the experiments. These experts were asked to reflect on our selection and operationalization of environmental attributes, with the aim of designing choice tasks that reflected the trade-offs that Dutch policy-makers typically face for road projects in proximity to a nature area. For instance, we asked them which environmental attributes they recommended to include in the experiments. To avoid excessive complexity (e.g. Swait and Adamowicz, 1996), we decided to include a maximum of three

environmental attributes. Moreover, we requested experts to reflect on the realism of attribute levels. Informed by these discussions, we drafted experiments in which respondents were asked to choose between different alternatives for a new road in proximity to a nature area connecting two municipalities. These alternatives differed in travel time and three environmental attributes: the number of households experiencing noise pollution from traffic; remaining useable recreational area for 10,000 citizens; and the number of hedgehogs living in the local nature area in 2026. We selected these three environmental variables as we concluded – informed by the discussions with the experts – that these are more important environmental variables in the political decision-making process regarding (specific) road projects close to a nature area compared to other candidate environmental variables (e.g. air pollution and CO_2 emissions). In such cases, noise pollution, the encroachment of a recreational area or negative impacts for animal populations can all be classified as common triggers for mass citizen protests, whilst traffic related air pollution and CO_2 emissions are relatively more important issues in urban areas (e.g. Orun et al., 2018; Perez-Prada and Monzon, 2017). The hedgehog was included in the experiment since the ecologists we consulted agreed that this was the only animal in the Dutch context which fulfilled three criteria: 1) it is unprotected (no red list species); 2) its populations are clearly affected by road traffic; and 3) the species is recognizable for respondents.

The draft experiments were tested in pilot surveys in which respondents were interviewed about their understanding and perception of the alternative experiments, and were explicitly asked if the experiments were realistic, intelligible and meaningful. Participants in the pilots included both laypeople and experts. For all experiments, we make respondents aware that it is unknown whether or not they would experience travel time savings and environmental effects themselves: a format in which respondents experienced only one of the effects would not allow for a fair comparison, while one in which respondents experienced all effects would be unrealistic. Furthermore, we made respondents aware that the government was interested in general trade-offs between the attributes included in the experiment (instead of trade-offs in a specific case), as the government considers to extrapolate the results of the experiments to public decisions concerning transport projects across the country. Hence, individuals are not urged to take a certain perspective or standpoint when recommending one of the alternatives for the new road, which aligns well with the non-paternalistic character of the our approach in this paper (see section 2). Another benefit of this framing is that the experiments are 'consequential' in the sense that the respondents perceive that their answers might have consequences for themselves, since their answers have the potential to influence the government's actions (e.g. Carson and Groves, 2007; Johnston et al., 2017). Consequentiality is currently regarded as being one of the key requirements for stated preference research (e.g. Johnston et al., 2017).

Based on the responses in the pilot surveys, we decided to conduct two experiments in a WTP context and two in a WTAPB context. Table 2 presents the most important differences between each of the four. Below, we discuss our motivations for selecting each experiment.

TABLE 2 Overview of the four stated choice experiments

Experiment	**1**	**2**	**3**	**4**
Willingness to pay or willingness to allocate context?	Willingness to allocate	Willingness to allocate	Willingness to pay	Willingness to pay
Information concerning Status quo	No	Yes	Yes	Yes
Is the status quo an alternative respondents can choose?	-	No	No	Yes
Number of alternatives between which respondents can choose	3	2	2	3

Experiment 1

In experiment 1, respondents were asked to choose between three possible routes of a new road in proximity to a nature area. The main reason for offering respondents three instead of two choice options is that the former offers more information about a respondent's preferences than the latter (Caussade et al., 2005). Importantly, respondents participating in the pilot surveys regarded it as plausible that there would be various options for building such a road (e.g., 1: a fast route through the nature area; 2: a slower route that prevents encroachment upon nature or recreation; 3: a route that prevents encroachment upon nature or recreation, but results in noise pollution due to its proximity to the built environment, such as residential areas). Figure 1 shows experiment 1 as it was presented to participants (the explanatory text that precedes the choice is the same across all tasks).

- The government decided to build a new road between two municipalities in the proximity of a nature area and the government asks you whether you would recommend Route A, Route B or Route C.
- All Routes will be 2x1-lane proviancial roads connecting two cities. The Roads will carry 10,000 trips per day (around 3.6 million trips per year). 10,000 trips per day corresponds with an average 2x1-lane provincial road in the Netherlands.
- The Routes only differ in terms of travel times, effect on the hedgehog population in the nature area, noise pollution and usable recreational area for citizens. Below we provide more information regarding these effects:
    - **Travel time between two cities for 10,000 trips per day:** some Routes provide a faster connection between the two cities than other Routes.
    - **The number of households experiencing noise pollution from traffic**: the Routes that are closely located to the built environment will result in noise pollution for more households than the Routes which are built further away from the built environment. It is difficult to directly compare noise pollution accruing from traffic with noise pollution accruing from an electronic device (since the sound of electronic devises is more monotonous). However, the volume of car traffic (on average, 63 Decibel on the façade) can be compared with the volume of an electronic device. The volume of car traffic equates the volume of a tumble dryer when the houses have their windows open and the volume of a refrigerator when the windows are closed.
    - **Remaining useable recreational area**: some Routes will form a clear barrier for citizens to access parts of the nature area and encroach recreational attractiveness in terms of noise pollution. These Routes will reduce the remaining useable recreational area for 10,000 citizens who live within 15 kilometer of the nature area. Routes that do not form a barrier for citizens to access the nature area will affect the remaining useable recreational area only marginally.
    - **The number of hedgehogs living in the nature area in 2026**: some Routes are located closely to an area in which many hedgehogs live. These Routes will result in more hedgehogs killed by traffic compared to the Routes that are located further away from the area in which many hedgehogs live.
- The government will use the results of the experiment for making decisions about Routes that only differ on the four aspects addressed above. Hence, we ask you to assume that the Routes do not differ in other aspects such as construction costs, maintenance costs, traffic safety and effects on population of other animals than hedgehogs.
- The government is interested in general preferences of Dutch citizens. The government considers to use the results of this experiment in public decisions concerning transport projects across the country. Hence, it is not made clear whether or not you would experience any effects (positive or negative) from either one of the Routes.

Please select the Route which you would recommend to the government.

	Route A	Route B	Route C
Travel time between two cities for 10,000 trips per day	46 minutes per trip	42 minutes per trip	32 minutes per trip
Number of households which experience 63 Decibel on their façade	150 households	660 households	990 households
Remaining useable recreational area for 10,000 citizens in hectares	600 hectares	750 hectares	850 hectares
Number of hedgehogs living in the nature area in 2026	800	400	160

FIGURE 1 Screenshot of experiment 1.

Experiment 2

Although experiment 1 received positive evaluations in the pilot surveys, several respondents indicated that it was difficult to evaluate the importance of the attributes because no 'baseline' reference levels were available. For this reason, we offered explicit information regarding the status quo in experiment 2. In order to adhere to the condition that the choice options presented in WTAPB experiments should not affect a respondent's disposable income (see above), it was not possible for respondents to choose the status quo. Figure 2 presents a summary of

experiment 2. For reasons of brevity, the information that does not differ between experiments 1 and 2 is excluded from the summary text provided in this figure.

- The government decided to build a new road between two municipalities in the proximity of a nature area and the government asks you whether you would recommend Route A or Route B.
- The Routes only differ in terms of travel times, effect on the hedgehog population in the nature area, noise pollution and usable recreational area for citizens. Below we provide more information regarding these four aspects of the two Routes.
- We also provide information about the Current Route between the two municipalities with respect to these four aspects.
- Both the Current Route and the new Routes are 2x1-lane proviancial roads carrying 10,000 trips per day (around 3.6 million trips per year). 10,000 trips per day corresponds with an average 2x1-lane provincial road in the Netherlands.

Please select the Route which you would recommend to the government.

	Route A	Route B	Current Route between the two municipalities
Travel time between two cities for 10,000 trips per day	42 minutes per trip	32 minutes per trip	50 minutes per trip
Number of households which experience 63 Decibel on their façade	660 households	990 households	30 households
Remaining useable recreational area for 10,000 citizens in hectares	750 hectares	850 hectares	1200 hectares
Number of hedgehogs living in the nature area in 2026	400	160	1000

FIGURE 2 Experiment 2.

Experiment 3

For reasons of comparability we decided to conduct, first, a (collective) WTP experiment that closely resembled experiment 2. The only difference was that one attribute was added: a one-time tax increase for all Dutch households in 2018. The respondents were told that this would be required to cover the construction and maintenance costs of the new road, which differed depending on the route chosen. This allows us to infer the trade-offs between travel time and environmental effects, but now in a context in which the individual's disposable income is also affected. As in experiment 2, respondents received information concerning – but were not permitted to choose – the status quo.

Experiment 4

One of the drawbacks of experiment 3 is that the extent to which it can be labelled as a (collective) WTP context can be contested; respondents always had to concede some portion of their after-tax income regardless of the option chosen. Hence, the choice faced by respondents concerned both free-to-spend after-tax income and after-tax income that would inevitably be delegated to the government. Experiment 4 was designed to address this. Unlike experiment 3, respondents in this experiment could not only choose between two variants of a new road – both involving a contribution from the individual's after tax income – but also for the status quo, a third option in which no new road would be built and the respondent's after tax income would be unaffected. Figure 3 presents a summary of experiment 4. Again, the information that does not differ between experiments 1 and 4 is excluded from the summary.

- The government considers to build a new road between two municipalities in the proximity of a nature area.
- The government considers a one-time tax increase to finance the new road because there is not enough regular budget to cover the construction and maintenance costs.
- The government asks you whether you would recommend to build a new road and if so, whether you would recommend the government to built Route A or Route B. Below you will find the characteristics of both routes.
- When you do not recommend a new road this implies that you recommend to maintain the status quo (current route).
- The tax increase will be implemented when a majority of Dutch households supports the tax increase. In that case, the route with the most votes will be implemented.

Would you recommend the government to maintain the status quo/current route or to build Route A or B?

	Route A	Route B	Current Route between the two municipalities
Travel time between two cities for 10,000 trips per day	42 minutes per trip	32 minutes per trip	50 minutes per trip
Number of households which experience 63 Decibel on their façade	660 households	990 households	30 households
Remaining useable recreational area for 10,000 citizens in hectares	750 hectares	850 hectares	1200 hectares
Number of hedgehogs living in the nature area in 2026	400	160	1000
One-time tax increase for Dutch households in 2018	19 euro	8 euro	N/A

FIGURE 3 Experiment 4.

We employed a heuristic design in creating the stated choice experiments. This was done for several reasons, the most important of which being that we were unable to generate an orthogonal or efficient design which consisted of realistic choice situations according to respondents participating in the pilot survey. Another reason for choosing a heuristic approach is that a relatively large share of respondents in the pilot surveys made choices consistent with non-trading on one of the attributes. Hence, we included choice situations in our experiments in which two alternatives scored almost equally well on one attribute (e.g. 'travel time'), but the second-best alternative on this attribute scored substantially better on the other attributes. Opting for this relatively complex design allowed us to maximize the possibility of observing trading behavior, even when respondents had a very high marginal utility for one particular attribute (Mouter et al., 2017b). We tested a wide array of choice tasks in the pilot surveys and selected those which respondents regarded as realistic trade-offs that the government might need to make.

We selected the final attribute levels based on discussions with experts, the model results of the pilot surveys and the feedback received from participants in the pilot surveys. We aimed to select attribute levels that were regarded as realistic by both experts and respondents. The reason for selecting realistic attribute levels is that 'realism' is regarded as a key characteristic of a high-quality stated preference experiment (e.g., Carson and Groves, 2007; Johnston et al., 2017). We selected six attribute levels each for travel time (30, 32, 36, 41, 42, or 46 minutes); the number of households experiencing noise pollution (30, 150, 390, 690, 750, or 990); remaining useable recreational area (500, 600, 750, 850, 1000, or 1200 hectares), number of hedgehogs living in the nature area in 2026 (20, 160, 400, 700, 800, or 1000); and

the one-time tax increase (5, 8, 13, 19, 21, or 26 euros). Note that the distance between the fourth and fifth levels of each attribute is relatively small (e.g. 41 and 42 minutes or 690 and 750 households experiencing noise pollution). This allowed us to mitigate the non-trading behavior mentioned previously by comparing small differences in one attribute to large differences in another.

4. Data collection

The questionnaire consisted of two major sections. Firstly, after reading through an introductory text, respondents were asked to complete the choice tasks. For reasons of attribute level balance, respondents participating in experiment 1 were asked to complete ten choice situations and respondents participating in the other three experiments were asked to complete twelve choice situations. These were presented in random order across respondents, to prevent ordering effects. Secondly, respondents were asked to reveal the most important criterion they had relied on in making their choices, along with the least important one. Additionally, they were asked to explain this choice. Finally, respondents evaluated the perceived ease and realism of the choice experiment.

A survey company (Kantar Public) was asked to draw four random samples from the population of Dutch citizens 18 years of age and older. The company was not explicitly requested to draw representative samples, but it was important that all relevant demographic segments – with respect to income, education, age and gender – were present and that the samples did not differ substantially in terms of these characteristics. In total, 673 respondents were recruited, each of which was assigned to one of the four experiments in such a way that differences in socio-demographic characteristics across experiments were minimized. Table 3 shows that neither these attributes nor the answers given by the respondents in the second part of the questionnaire differed substantially between the four experiments. As such, the sample selection process does not appear to have contributed to differences in the results obtained across choice settings.

TABLE 3 Socio-demographics and average scores criteria rated in the second part of questionnaire

	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Number of respondents	170	156	149	198
Gender				
Male	56%	54%	50%	55%
Female	44%	46%	50%	45%
Age				
18 to 29 yr.	10%	21%	20%	16%
30 to 39 yr.	12%	19%	13%	16%
40 to 49 yr.	21%	19%	22%	21%
50 to 59 yr.	17%	17%	23%	19%
60+ yr.	40%	24%	21%	28%
Completed education				
Lower education	27%	19%	20%	21%
Higher education	45%	41%	39%	35%
University education	28%	41%	40%	39%
Household gross income				
$I \leq I < 27\,000$	20%	17%	17%	20%
$27\,000 \leq I < 40\,000$	22%	19%	21%	13%
$40\,000 \leq I < 67\,000$	32%	32%	31%	30%
$I \geq 67\,000$	27%	32%	32%	32%
Voted previous election				
VVD (Liberal-rightwing)	21%	19%	19%	17%
PVV (Nationalists)	8%	9%	13%	7%
Christian parties	14%	12%	15%	9%
D66 (Social-Liberals)	11%	12%	8%	7%
Greenparties	8%	14%	11%	8%
SP (Socialists)	8%	14%	12%	13%
PVDA (Labor)	11%	5%	4%	12%

Experiment	**1**	**2**	**3**	**4**
I was confident of my choices (1 = strongly disagree, 5 = strongly agree)	3.9	3.9	3.8	3.9
I thought that the questionnaire was realistic (1 = strongly disagree, 5 = strongly agree)	3.5	3.4	3.3	3.2
This experiment provides the government with relevant information for making choices between routes of road projects (1 = strongly disagree, 5 = strongly agree)	3.5	3.6	3.4	3.2

5. Results

5.1. Descriptive results

Figure 4 presents, for each experiment, the percentage of respondents that mentioned a specific criterion as the most (least) important criterion for their choices. For instance, the fourth row (labelled 'Total sample') shows that 14% of the respondents participating in experiment 1 mentioned 'travel time' as the most important criterion in their choices, while 40% indicated 'number of households affected by noise' and 30% chose 'remaining useable land for recreation'. For each experiment, we highlighted the criterion that was mentioned most frequently in dark color. Figure 4 also shows the extent to which respondents with different income levels, education and voting behavior in the previous election answer the question which criterion was most/least important in their choices differently. Right-wing parties are indicated with (R), centrist parties with (C) and left-wing parties with (L).

	Most important criterion																Least important criterion													
	Time				Noise				Recr				Hedge				Costs				Time				Noise				Recr			
Experiment	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total sample	14	15	19	23	40	39	24	23	30	26	23	23	16	30	19	19	x	x	14	12	60	54	41	31	15	7	14	15	10	9	3	8
Voted previous election																																
VVD (R, Liberal-rightwing)	14	28	21	53	42	31	29	15	31	31	25	6	14	10	14	12	x	x	11	15	53	37	36	17	22	7	29	20	8	11	4	9
PVV (R, Nationalists)	21	21	16	7	43	36	16	14	29	29	21	21	7	14	11	29	x	x	37	29	50	40	53	57	29	0	16	7	14	20	0	7
D66 (C, Social-Liberals)	11	26	33	23	33	32	25	31	28	16	8	8	28	21	17	38	x	x	17	0	78	32	25	15	11	5	8	15	6	16	0	0
Christian parties (C)	9	11	9	28	61	32	27	28	22	42	14	33	9	16	27	0	x	x	5	11	65	53	23	33	9	5	9	11	9	11	5	17
Greenparties (L)	7	5	6	13	29	41	31	7	43	14	13	20	21	41	31	40	x	x	19	20	64	76	63	40	14	10	13	13	7	5	0	7
SP (L, Socialists)	0	10	11	8	36	52	22	36	36	19	39	24	29	19	17	28	x	x	11	4	71	71	50	44	0	10	11	12	14	0	0	12
PVDA (L, Labor)	16	0	0	13	26	38	50	38	42	38	50	33	16	25	0	8	x	x	0	8	63	63	50	38	16	25	0	8	16	0	0	0
Household gross income																																
12 900 ≤ I < 27 000	9	0	4	15	39	52	24	23	27	19	24	25	24	30	24	25	x	x	16	13	61	70	56	40	15	7	4	8	9	7	4	8
27 000 ≤ I < 40 000	8	14	19	24	49	38	16	16	32	31	16	28	11	17	23	12	x	x	26	20	73	71	52	40	8	4	26	20	11	7	0	12
40 000 ≤ I < 67 000	15	16	20	22	41	35	28	23	35	27	22	23	9	22	20	18	x	x	11	13	61	49	33	35	15	8	15	18	7	8	0	3
I ≥ 67 000	22	24	26	31	33	38	26	23	22	26	26	20	22	12	15	22	x	x	6	3	49	40	34	22	20	8	9	15	11	10	6	9
Education completed																																
Lower education	4	10	17	21	44	55	13	21	27	24	33	29	24	10	17	19	x	x	20	10	78	68	47	45	16	0	13	10	0	11	3	7
Higher education	12	17	22	20	38	34	21	29	36	25	14	20	15	23	24	17	x	x	19	14	58	52	40	33	9	11	21	15	13	10	3	10
University education	27	17	17	29	40	36	33	17	23	27	27	23	10	20	17	23	x	x	7	8	46	49	38	25	23	6	7	18	13	6	2	5

	Least important criterion										
	Hedge				Costs						
Experiment	1	2	3	4	1	2	3	4			
Total sample	15	30	13	16	x	x	28	31			
Voted previous election											
VVD (R, Liberal-rightwing)	17	44	7	26	x	x	29	29			
PVV (R, Nationalists)	7	40	21	21	x	x	11	7			
D66 (C, Social-Liberals)	6	47	17	8	x	x	42	62			
Christian parties (C)	17	32	23	11	x	x	45	28			
Greenparties (L)	14	19	0	0	x	x	25	40			
SP (L, Socialists)	14	19	11	8	x	x	28	24			
PVDA (L, Labor)	5	13	17	21	x	x	33	33			
Household gross income											
12 900 ≤ I < 27 000	15	15	8	10	x	x	28	34			
27 000 ≤ I < 40 000	8	18	10	8	x	x	13	20			
40 000 ≤ I < 67 000	17	35	15	18	x	x	37	25			
I ≥ 67 000	20	42	19	17	x	x	32	37			
Education completed											
Lower education	7	21	13	17	x	x	23	21			
Higher education	18	27	17	13	x	x	19	30			
University education	19	38	12	16	x	x	42	36			

Figure 4 Most important and least important criterion in respondents' choices

The result of Figure 4 that stands out is that respondents participating in the four experiments seem to answer the questions about the most (least) important criterion in their choices quite similarly. In all four experiments, the largest share of respondents regard 'noise' to be the most important criterion in their choices, with 'travel time' being the least important. The low importance of travel time is interesting, given that 'travel time savings' has been found to be the most decisive benefit in conventional CBAs for road projects (e.g. Mackie et al., 2001; Eliasson and Lundberg, 2012). Another interesting observation is that this result seems to be quite robust for different subsamples of respondents. For instance, for all segments of respondents participating in experiment 1, it holds true that the largest share of respondents regarded 'travel time' to be the least important criterion in their recommendations. Moreover, in none of the experiments do we find a subsample for which 'noise' or 'recreation' was mentioned most frequently as the least important choice factor. The fact that travel time savings dominates conventional CBAs while being indicated as the least important criterion in our

social choice experiments is a first indication that social choice and conventional analyses of costs and benefits can produce very different results.

5.2. Multinomial logit analysis

Next, we analyze our data using discrete choice models. Specifically, we estimate multinomial logit (MNL) random utility maximization (RUM) models. This type of choice model allows for the straightforward interpretation of results in terms of marginal rates of substitution (Train, 2009).[1] All models are estimated in a linear-additive specification – see equation (1) (with cost attribute) and equation (2) (without cost attribute) – where U_{ni} denotes the utility of individual n given alternative i. We represent utility as a (linear) function of the number of households affected by noise (NO), the remaining recreation area (RC), the number of hedgehogs living in the nature area (HH), the travel time between two municipalities (TT) and the monetary costs of building a road (C). Since the alternatives are unlabeled, no alternative-specific constants (ASCs) are estimated. Finally, the error terms are assumed to be independently and identically distributed and follow an extreme value type 1 distribution.

$U_{in} = \beta_{time} TT_{in} + \beta_{hedgehog} HH_{in} + \beta_{noise} NO_{in} + \beta_{recr} RC_{in} + \beta_{cost} C_{in} + \varepsilon_{in}$ with cost where $\varepsilon_{in} \sim$ i.i.d EV type1	Eq 1

$U_{in} = \beta_{time} TT_{in} + \beta_{hedgehog} HH_{in} + \beta_{noise} NO_{in} + \beta_{recr} RC_{in} + \varepsilon_{in}$ without cost where $\varepsilon_{in} \sim$ i.i.d EV type1	Eq 2

Table 4 presents the estimation results. Besides the parameter estimates, the marginal rates of substitution between travel time and environmental attributes are also reported.[2] Given our linear-additive RUM-MNL specification, the marginal rates of substitution (MRS) are given by the ratios of the parameters (Train, 2009). To illustrate, $\beta_{time}/\beta_{noise}$ is 25.33 in experiment 1; this means that respondents derive an equal level of utility from 1 minute of travel time savings for 10,000 travelers per day and preventing 25.33 households from being affected by 63 dB noise. The final column depicts which marginal rates of substitution are significantly different from one another at conventional levels of significance ($\alpha = 0.05$) using a two-sample t-test.

Table 4 Results MNL Experiments 1-4

[1] Latent class and mixed logit models were also tested. However, since the results from these did not alter the main findings of this study, for the purposes of this paper the parsimony of the MNL models is preferred.

[2] Standard errors are computed using the Delta method (see Daly et al., 2012).

	Experiment 1			Experiment 2			Experiment 3			Experiment 4			Sig. different
Context	Willingness to allocate			Willingness to allocate			Willingness to pay			Willingness to pay			
# Observations	1699			1872			1788			2376			
Null LL :	-1866.4			-1297			-1239.35			-2610.3			
Final LL:	-1538.8			1138			-1188.25			-1931.2			
Estimated parameters	4			4			5			5			
ρ^2 :	0.18			0.12			0.04			0.26			
Estimates	Est	SE	T	Est	SE	T	Est	SE	T	Est	SE	T	
B_time	-0.0499	0.0090	-5.61	-0.0310	0.0069	-4.36	-0.0427	0.0073	-5.38	-0.0407	0.0061	-6.67	
B_hedgehog	0.0003	0.0001	1.93	0.0007	0.0002	3.87	0.0012	0.0002	6.92	0.0004	0.0001	3.09	
B_noise	-0.0020	0.0001	-13.61	-0.0018	0.0002	-11.99	-0.0012	0.0001	-9.46	-0.0009	0.0001	-7.29	
B_recreation	0.0015	0.0002	9.86	0.0015	0.0002	7.18	0.0004	0.0002	2.38	0.0009	0.0001	6.58	
B_cost	N/A	N/A	N/A	N/A	N/A	N/A	-0.0341	0.0064	-5.32	-0.0373	0.0055	-6.77	
Marginal rate of substitution													
B_time/B_hedgehog	**176.33**	91.660	1.92	**41.12**	10.830	3.80	**34.72**	6.190	5.61	**105.71**	37.200	2.84	3&4
B_time/B_noise	**25.33**	4.280	5.92	**16.63**	3.771	4.41	**36.81**	6.540	5.63	**43.02**	7.723	5.57	1&4, 2&3, 2&4
B_time/B_recreation	**33.05**	5.785	5.71	**20.76**	5.042	4.12	**104.15**	46.06	2.26	**46.15**	9.443	4.89	2&4
B_time/B_cost	N/A	N/A	N/A	N/A	N/A	N/A	**1.25**	0.282	4.45	**1.09**	0.255	4.28	
B_hedgehog/B_cost	N/A	N/A	N/A	N/A	N/A	N/A	**0.036**	0.009	4.00	**0.010**	0.004	2.63	
B_noise/B_cost	N/A	N/A	N/A	N/A	N/A	N/A	**0.034**	0.006	5.41	**0.025**	0.005	4.80	
B_recreation/B_cost	N/A	N/A	N/A	N/A	N/A	N/A	**0.012**	0.005	2.45	**0.024**	0.005	4.41	3&4

B_time = marginal utility of one additional minute travel time savings for 10,000 travelers per day
B_hedgehog = marginal utility of one additional hedgehog in the nature area in 2026
B_noise = marginal utility of one additional household affected by 63 dB noise
B_recreation = marginal utility of one additional hectare available for recreation for 10,000 citizens
B_cost = marginal utility of a one-time, one euro tax increase for every Dutch household

A number of inferences can be made based on Table 4. Firstly, we can see that the signs for all of the parameter estimates conform with a priori expectations. Secondly, the estimates are significantly different from zero ($\beta_{hedgehog}$ in experiment 1 being the only exception). This implies that all attributes are considered relevant when making trade-offs. Thirdly, our results show that the MRSs between the environmental attributes and costs are highly significantly different from zero. For instance, $\beta_{recreation}/\beta_{cost}$ is 0.012 euros in experiment 3, which implies an average WTP of 0.012 euros (in the form of a one-time tax increase for Dutch households) for one additional hectare available for recreation for 10,000 citizens (in this way, 100 additional hectares would then be valued at 1.2 euros per household). Multiplying this by the number of households in the Netherlands in 2016 (7,720,787 households, CBS, 2016), the aggregated WTP becomes approximately 92,000 euros per hectare (i.e., 9.2 million euros for 100 hectares). Fourthly, the aggregate monetized travel time savings obtained from experiments 3 and 4 are close to the aggregate monetized travel time savings which can be derived from the most recent Dutch Value of Time Study (Kouwenhoven et al., 2014).[3] Finally, the rightmost column of Table 4 depicts that, in several cases, the marginal rates of substitution between travel time and environmental attributes differed significantly among the WTAPB experiments (1 and 2) and the WTP experiments (3 and 4) at conventional levels of significance

[3] The aggregate monetized travel time savings obtained from experiments 3 is 1.25 euro * 7,720,787 households = 9,650,983 euro. The aggregate monetized travel time savings which can be derived using the most recent Dutch Value of Time study is 10,000 travellers * 240 working days * (9.00 euro Value of Time * 1 minute / 60) = 360,000 euros per year. Time horizon of 100 years and 4.5% discount rate result in aggregate benefit of 8,261,947 euro.

($\alpha = 0.05$). For instance, participants in experiment 1 (2) derive an equal amount of utility from a policy that prevents noise pollution for 25.33 (16.63) households and a policy which results in one minute of travel time savings for 10,000 travelers per day. Conversely, individuals participating in experiment 4 would require the avoidance of noise pollution for 43.02 households to make them indifferent against a potential minute of travel time savings for 10,000 travelers per day. This implies that those asked to choose between alternative allocations of the public budget assign more value to mitigating noise pollution (at the cost of increased travel time) than they would be if asked about their willingness to pay from their private budget. However, it is noteworthy that in most cases, trade-offs made between environmental effects and travel time do not differ significantly across experiments. For instance, Table 4 shows that individuals do not trade-off 'travel time' and 'hedgehogs' differently in a WTP and a WTAPB context.

5.3. Differences in valuation using social choice approach and conventional approach

There is a stark deviation between the values assigned to the four attributes in our social choice experiments and those inferred from approaches that are currently applied in the Netherlands to monetize environmental externalities and travel time in a CBA (Rijkswaterstaat, 2018). For instance, based on the marginal rates of substitution we derived from the four experiments, we can infer that individuals prefer a project preventing 300 households from experiencing 63 dB of noise pollution over one which saves between 7 minutes (experiment 4) and 18 minutes (experiment 2) of travel time for 10,000 trips per day, all else being equal.[4] This drastically contrasts with the current Dutch practice in which a project saving 30 seconds of travel time for 10,000 trips per day performs better in a CBA than a project preventing 300 households from experiencing 63 dB of noise pollution.[5] Hence, we can conclude that a social choice approach to the analysis of a project resulting in travel time savings and noise pollution produces substantially different outcomes than an analysis of the same project using conventional valuation approaches. This conclusion holds for all the four social choice experiments. Apart from the fact that the valuation of noise pollution and travel time savings in a social choice valuation approach substantially differs from the values enumerated in Dutch CBA Guidelines, our results suggest that participants in social choice experiments also assign a substantial value to impacts that are not (or only qualitatively) considered in (Dutch) CBAs: in our case, these concerned recreational land and hedgehog populations. A substantial share of respondents even considered remaining useable recreational area to be the most important criterion in their choices between alternative road projects (see Figure 4). Moreover, because the marginal rates of substitution between environmental attributes and costs differ significantly from zero in experiments 3 and 4, we can conclude that the social choice approach enables analysts to attach monetary values to a broader range of effects which also impacts the results of a CBA in case these monetary values are adopted by CBA Guidelines and studies.

5.4 Explanations for differences between private WTP-based and social choice approach

[4] Experiments 2 and 4 represent the highest and lowest marginal rates of substitution, respectively, between 'travel time' and 'noise pollution' across the four experiments.

[5] Official Dutch guidelines prescribe 43 euros per dB per household for noise pollution higher than 55 dB (Rijkswaterstaat, 2018). Preventing noise pollution of 63 dB for 300 households result in a yearly benefit of 103,200 euro. Dutch Guideline prescribe a Value of Travel Time Savings of 9 euro per hour. 30 seconds of travel time savings for 10,000 travelers results in a yearly benefit of 180,000 euro (10,000 * 240 working days * 9.00 euro Value of Time * 30 seconds/ 60).

The results discussed in section 5.3 confirm that analyzing the impacts of a transport project from a social choice perspective can produce different recommendations than when the same impacts are analyzed based on valuations enumerated in Dutch CBA Guidelines. To identify possible explanations for this deviation, we asked respondents to provide a motivation for the criteria they mentioned as most (least) important for their choices. In the main text we only discuss the most illustrative categories of motivations (a comprehensive overview of motivations is listed in the Appendix).

A key characteristic of the experiments conducted in our study is the adoption of non-paternalism in the sense that individuals are not urged to take a certain perspective or standpoint when choosing between the social states. That is, respondents are free to take a purely self-interested perspective, to identify themselves with each member of society, the members worst off in society, all individuals affected by the project or even with animals affected by the project when making their choice. The qualitative motivations show that respondents indeed take different perspectives when making choices in a social choice setting. Some individuals clearly revealed a self-interested perspective ("I prefer to reduce my own travel time as much as possible"; "I personally enjoy recreation"), whereas other individuals clearly adopted a normative perspective when providing their recommendation to the government ("humans have a (high) responsibility to protect nature because nature cannot protect itself").

In the remainder of this section, we highlight justifications that can only be extracted from social choice settings. In section 5.4.1, we indicate considerations which can only be identified in choice settings in which individuals evaluate the negative and positive impacts of transport projects in relation to each other in the context of a government decision. Conversely, section 5.4.2 provides an example of a consideration that can only be obtained from choice settings in which individuals evaluate the impacts of transport projects in the context of a government decision.

5.4.1 Considerations people can only consider when evaluating impacts in relation to each other

Below, we discuss categories involving considerations that can only be extracted from social choice settings in which respondents value positive and negative attributes of transport projects in relation to each other and not from choice settings in which respondents evaluate impacts in isolation.

It is morally problematic to trade (small) benefits against (severe) negative impacts.

Firstly, we identified several categories which suggested (moral) aversion to trading off two or more effects of the proposed transport project. For instance, several respondents stated that it is morally intolerable to accept severe negative impacts (on recreational land, noise levels or animal lives) in order to provide 'luxuries' such as a small reduction in travel time. These considerations cannot be illuminated in a conventional setting, in which these effects are evaluated in isolation (e.g., if a minor time savings is only traded against an increase in the cost of fuel or travel fare). Below, we present four illustrative statements:

"I think it is important to respect nature, particularly when the benefits for humans are only *very minor."*

"In my view, respect for animal lives is more important than facilitating the hurried lives of human beings. I do not think it is right that humans always take and take and animals always *have to adapt."*

"I think it is important that animals do not have to suffer to solve the luxury problems of human *beings."*

"Nature does not have to capitulate for unimportant human 'problems'."

Several statements from these categories argued that sacrificing recreational land or increasing noise pollution in order to reduce travel time is unacceptable because the absence of noise pollution or the existence of sufficient recreational area is a primary good or a basic component of human well-being. On the other hand, these respondents did not seem to perceive a reduction of a few minutes of travel time as a basic need.[6] Below are two representative statements:

"Noise experienced in your residence directly affects your quality of life, which is a basic thing *of great importance. Noise pollution can negatively affect financial and mental health."*

"Recreation is very important for the well-being of people. It is by far more important than a *few minutes of travel time."*

Some respondents explicitly highlighted that, in their view, sacrificing the negative environmental impacts was only acceptable when the new road resulted in substantial travel time savings.

"It makes no sense to build a new road which only results in very small time savings and, at the same time, causes that many negative impacts. However, when the new road results in 20 *minutes of time savings it's a different story because thi*s will result in substantial benefits for *freight and business traffic."*

"It makes no sense to sacrifice nature to foster our own pleasure. When the new road results in 30 – *45 minutes of travel time savings I would be able to understand the decision."*

<u>Considerations that can only be identified when at least three attributes are evaluated in relation to each other</u>

A few respondents wrote that they tried to avoid negative impacts for animals because it was possible to trade 'human benefits' against 'human losses'. Importantly, such considerations can only be identified when individuals evaluate three attributes (human benefits, human losses and losses for animals) in relation to each other. Below we present three examples:

*"Roads are constructed to increa*se the well-being of humans. Hence, I think that humans should also face the negative consequences and not the hedgehogs who did not ask for this *road."*

[6] Primary social goods are a cornerstone in Rawls' theory of justice (Rawls, 1971). Rawls asserts that justice is reached if the people who are worst off have the highest level of primary social goods.

"The default should be that humans' wishes to travel faster should not be fulfilled at the cost of oth*er living creatures. Hence, I think we should accept the noise pollution."*

"Because humans want to build the road, it makes sense that they also have to face its negative impacts such as additional costs and noise pollution. Hedgehogs should not suffer because they do not experience any benefits from the new road. And what are the benefits for humans? They *reach their destination only a few minutes faster…Humans think that they own the whole* planet, but that is lunacy. The earth belongs to us all, and this also includes plants and *animals."*

Another observation that can be made concerning the three statements listed above is that respondents seem to treat 'benefits and costs for humans' and 'benefits and costs for animals' as two separate (mental) accounts (e.g. Thaler, 1999). According to the respondents the losses for humans hurt less than the losses for animals because the losses for humans can be combined with a gain (travel time savings).

<u>People are willing to accept longer travel times to prevent negative impacts for other people or nature</u>

Apart from those who argued that it is morally problematic to allow severely negative impacts for the purpose of reducing travel time by just a few minutes, various participants also claimed that they themselves were willing to accept longer travel times in order to limit such drawbacks. These considerations can only be inferred when respondents value attributes in relation to each other and not in isolation. Several examples are outlined below:

*"For me it is no problem to make a detour of 10 minu*tes if that results in the absence of noise *pollution for other people."*

"I would love to drive a bit longer in exchange for the preservation of nature."

"I would sacrifice these few minutes with pleasure if this preserves nature and avoids noise pollution."

<u>5.4.2 Considerations that can be considered in stated preference studies in a public context</u>

In this section, we provide one example of a consideration that can only be obtained from choice settings in which individuals evaluate the impacts of government projects in the context of a government decision. This stands in contrast to choices made in private contexts, such as choosing a travel route or purchasing a home. Unlike the considerations discussed in 5.4.1, the considerations addressed below could be retrieved in public choice settings in which the impacts of a government project are evaluated in isolation.

The illustrative example concerns respondents who argue that it is not necessarily the government's duty to reduce travel times. These respondents believe that car drivers have a relatively high own responsibility to reduce their travel time. For instance, drivers can try to avoid peak hours and they can start their trip earlier to ensure that they arrive on time, or they can take travel times into account when choosing where to live or work. These considerations could be incorporated into stated choice experiments in which respondents are asked about their

willingness to pay for a government project reducing travel times. However, these considerations will not be illuminated in (hypothetical) route choice experiments in which people are asked to make hypothetical route choices (e.g. Kouwenhoven et al., 2014). In such experiments, respondents abstract from a public context and only evaluate (small) impacts for themselves. Below, we present some illustrative statements:

"People can decide to live closer to their work if they think that the travel time is too long."

"Preservation of nature/recreation was the most important criterion in my choices. When people don't like their travel time, they have to relocate closer to their work."

"It is easy to plan travel time in your daily schedule. You can just decide to start your trip a bit *earlier. The other impacts are more difficult to cope with."*

6. Conclusions and discussion

Conventional valuation approaches adopted in CBA have been criticized for not valuing positive and negative impacts of transport projects in relation to each other and for not valuing such impacts in a public context, but in the context of private decisions. These critiques might be circumvented through valuing transport projects in a social choice context in which overall burdens and benefits of proposed transport projects are considered together in the context of a government decision. The key aim of this study was to gain empirical insight into the extent to which social valuation of burdens and benefits of transport projects produces different outcomes than a conventional valuation approach. To do this, we designed four social choice valuation experiments in which respondents were asked to choose between different alternatives for a new road connecting two municipalities. The alternatives among which the respondents could choose differed in terms of travel time, noise pollution, reduction in recreational lands and the number of hedgehogs living in the nature area. We find that there is a strong deviation between the values that respondents assign to the four attributes in the social choice valuation experiments administered in this study and the values that are currently applied in the Netherlands to monetize the same attributes which are inferred from conventional valuation studies (Rijkswaterstaat, 2018).

There are four main conclusions from our study. First, in all four experiments, the largest share of respondents mentioned 'noise' to be the most important criterion in their recommendations and 'travel time' to be the least important. The low importance of travel time stands in contrast to the fact that 'travel time savings' is the most decisive benefit in conventional CBAs for road projects (e.g., Eliasson and Lundberg, 2012; Mackie et al., 2001). Second, the decision to evaluate the impacts of a transport project using a conventional valuation approach or a social choice approach can substantially impact the outcome of an appraisal. Travel time savings are of relatively greater importance in a conventional CBA, while the same is true of the three environmental effects in a social choice setting. Third, in our social choice experiments, respondents assigned a statistically significant monetary value to impacts that are generally not (or only qualitatively) considered in conventional CBAs of transport projects: recreational area and hedgehogs. Hence, the social choice approach adopted in our study enables analysts to incorporate the impacts of a transport project on factors such as these in a monetary way. Fourth, social choice valuation enables analysts to include (moral) considerations regarding the way government should trade off the costs and benefits of

government projects that cannot be included in conventional valuation studies. An implication of this result is that analysts who stick to a conventional valuation approach have to be clear in their CBA report that such considerations are excluded from the appraisal.

We think that the reader should be cautious in drawing more far-reaching conclusions than the four listed above because our study has various limitations. A general limitation of our study is that the results are based on stated choice experiments. There is an abundant literature on non-negligible potential problems with stated preference studies that may cause a deviation between respondents' stated values and their true values for a non-market good (e.g., Hausman, 2012). One of the most well-known issues with stated preference research is its insufficient responsiveness to scope (e.g., Diamond and Hausman 1994; Blamey et al. 1999; Veisten et al. 2004; Heberlein et al. 2005), implying that respondents' choices may not be sufficiently sensitive to changes in quantity (e.g., Carson and Mitchell 1993; Heberlein et al. 2005). For instance, the choices of respondents may not be affected when the number of travelers on the provincial road or the number of hedgehogs in the nature area are multiplied with 10 (e.g. travel time for 100,000 trips per day instead of 10,000 trips per day). We believe that an implication of this limitation is that our study only provides reasonable values for a realistic road in proximity to a nature area in the Netherlands, but that it is unclear to which extent the results of our study are generalizable to other contexts. In consultation with experts we aimed to select attribute levels that were realistic for a road project in proximity to a nature area in the Netherlands. We think that our results are applicable in similar contexts but recommend caution when applying them to scenarios with substantially smaller or larger impacts.

Another well-known limitation of stated preference research is that results can be susceptible to 'framing effects'. For instance, Ajzen et al. (1996) indicate that invoking moral responsibility increases individuals' willingness to pay. In our study, we tested for some framing effects by conducting four different experiments. Most notably, we conducted social choice experiments in both a willingness-to-pay context (WTP) and a willingness-to-allocate public budget context (WTAPB). We can conclude that, to some extent, individuals made different trade-offs between environmental effects and travel time depending on which of the two they were responding to; participants in the WTAPB context assigned a comparatively higher value to preventing noise pollution (at the cost of travel time) than did those in the WTP settings. That being said, the general conclusions discussed in the beginning of this section hold for experiments conducted in both contexts, and the differences in the results found in each setting are less substantial than those between how individuals trade off travel time and safety in a WTP and a WTAPB context. Although the results of the four social choice experiments do not vary substantially, we do not claim that our study is immune to any other framing effects. For instance, it is possible that respondents are influenced by the introduction of the survey, which states that a new road connecting two municipalities is to be built in proximity to a nature area. Perhaps mentioning the words 'nature area' provides a signal to respondents that environmental impacts are important.

In sum, the most important implication of the (potential) limitations of our study is that the conclusions contain some amount of uncertainty and one should be very cautious in inferring exact values from it (e.g., one additional hectare available for recreation for 10,000 citizens is worth 92,000 euros). Further research is needed to determine the sensitivity of our results to scope effects, framing effects and other sources of uncertainty. One framing effect that might be interesting to investigate concerns the extent to which the results of our study change when we emphasize in the experiments that the number of people who experience travel

time savings as a result of the new road is 10 till 100 times higher than the number of people who experience noise pollution. We recommend that future studies test the generalizability of our results to other contexts, such as countries outside the Netherlands and other environmental impacts such as air pollution (e.g. Apparicio et al., 2018; Jandacka et al., 2017; Orun et al., 2018; Perez-Prada and Monzon, 2017) and CO_2 emissions (Broin and Guivarch, 2017; Lucas et al., 2014; Nocera and Cavallaro, 2016). Finally, it would be interesting to investigate the merits of valuing social and equity impacts of transport projects and policies (e.g. Lucas et al., 2014; Vanclay, 2014) such as 'social inclusion' (Lowe et al., 2018) using social choice valuation experiments.

In this paper we remain agnostic with respect to the question of whether government projects should be evaluated using a conventional and/or a social choice-based approach. The purpose of this study is to add empirical knowledge about the actual difference between these two approaches, a contribution which may help guide and shape future academic debate. That being said, we still believe that we can help provide a starting point for the discussion by considering arguments both for and against the social choice valuation approach. The first advantage of the social choice approach is that it strengthens the position of environmental effects in the appraisal of transport projects. Another advantage is that (moral) considerations regarding the way in which government should weigh the costs and benefits of government projects can be included in the appraisal. For instance, a large group of respondents thought it was morally unacceptabldelfe to allow severely negative environmental impacts in order to provide 'luxuries' such as a small reduction in travel time. This and other (moral) considerations cannot be illuminated in conventional valuation settings in which positive and negative impacts are evaluated in isolation.

However, a crucial issue of the social choice approach concerns the interpretation of the outcomes. These appraisals cannot be interpreted as an application of the Kaldor-Hicks efficiency criteria as individuals are asked to evaluate social states instead of impacts on their individual welfare. Another way to interpret the choices in the social choice settings is that they represent individual social welfare judgments which can be accumulated into an aggregate social welfare function (Arrow, 1951). However, from qualitative motivations we discussed in section 5.4. we can infer that it is difficult to defend that all individuals participating in the experiments aimed to maximize social welfare as some individuals clearly adopted a self-interested perspective (e.g. "I prefer to reduce my own travel time as much as possible"). Furthermore, apart from assuming that preferences in social choice settings represent individual social welfare judgments, we need to assume that utility is (at least) partially comparable between individuals to allow for a non-dictatorial social welfare function (e.g. Sen, 2017). The assumptions discussed above are obviously controversial. The question is whether this is problematic as the assumptions underlying classical CBA are controversial as well. For instance, authors such as Blamey et al. (1995) and Nyborg (2000) note that the postulation in classical CBA that individuals' willingness to pay for environmental impacts solely represents their personal interests is controversial as some individuals tend to report their social (or political) preferences in stated preference studies.[7] Moreover, scholars such as Nyborg (2014) and Sen (2017) criticize the potential compensation postulation of the Kaldor-Hicks efficiency criteria. When one is not willing to interpret individuals' choices in the social choice

[7] This can be circumvented through inferring values from revealed preference methods such as hedonic pricing and the travel cost method. However, as discussed in sections 1 and 2 stated preference is still the default approach in contemporary CBAs to elicit the value of environmental impacts and noise pollution.

experiments as individual social welfare functions it is possible to interpret the results as outcomes of 'surrogate referendums' with the purpose of assessing the relative appeal of competing proposals for public policy among citizens (e.g. Blamey et al., 1995; Hensher et al., 2015). Adopting this non-economic interpretation, the results of social choice experiments provide information on citizens' preferences regarding competing transport projects as well as their responsiveness to changes in attributes of such projects (Hensher et al., 2015). Hensher et al. (2015) argue that this information on citizens' preferences can complement the results of a CBA by a comparison of support for different planning options in a way that is not incorporated in the formal economic assessment but is strategically important in securing community buy-in and assistance in prioritizing projects.

7. References

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Appendix I

The final column presents the number of respondents mentioning each category.

	Most important criterion in respondents' choices	# resp.
Travel time savings		
1	I prefer to reduce my own travel time as much as possible	26
2	Travel time savings result in (large) economic benefits	17
3	Reduction of travel time results in reduction of kilometres travelled and lower emissions	13
4	Building a new road only makes sense when this results in substantial travel time savings	13
5	The negative impacts are only acceptable when travel time savings are substantial	24
Noise pollution		
6	In the status quo, there is already enough noise pollution	3
7	Personally I have negative experiences with noise pollution	13
8	Number of households facing noise pollution should be minimized because it's is a very severe impact	37
9	Noise pollution can result in health issues	21
10	Noise pollution is a daily recurring impact which also affects people continously during the day	18
11	Noise pollution impacts people's living environment	37
12	Preventing noise pollution is more important than the other criteria	24
13	It's hard to espace from noise pollution	4
14	Some people will not experience the noise pollution on a volontary basis	12
15	Noise pollution causes low public support which results in adjacent (judicial) costs	4
Recreation		
16	It is unacceptable to give up recreational area for small travel time savings	17
17	I personally enjoy recreation	3
18	Recreation and relaxation are important drivers for quality of life	29
19	Recreation was a more important criterion in my choices than the other criteria	15
20	Recreational opportunities should be maintained	15
21	More difficult to restore decrease in recreational area than noise pollution/decrease in hedgehogs	7
22	In the status quo, the availability of recreational areas is poor in the Netherlands	30
23	In the status quo, the quality and size of the Dutch road network is adequate	10
24	Recreational area should be maintained as people might have considered this when buying their house	1
Hedgehogs		
25	It is unacceptable that nature/animals have to suffer to solve the luxury problems of humans	33
26	The preservation of nature/animals was more important than the other criteria	23
27	More difficult to restore decrease in hedgehogs than noise pollution/recreational area	3
28	Humans have a (high) responsibility to protect nature because nature cannot protect itself	11
29	In the status quo, the quality/size of nature reserves is poor in the Netherlands	8
30	We should preserve nature	16
Costs		
31	I am not able to contribute because I have a low income	5
32	I already pay enough taxes	21
33	This road project should be financed from a reduction on spending on other government projects	6
34	Government should not ask people who have no interest in the project for an additional contribution	2

Appendix I: Motivations for most important criterion in choices

	Least important criterion in respondents' choices	# resp.
Travel time savings		
35	For me it is no problem if my travel time is a bit longer	16
36	Difference in travel time was very small and therefore relatively unimportant in my choice	93
37	Travel time was less important criterion in my choices than other criteria	78
38	Nature, recreation and/or quiet living environment should not be sacrificed for luxury problems of humans	18
39	I am willing to accept longer travel times to prevent negative impacts for other people/nature	9
40	The quality of the road network is already very high	3
41	Size of the travel time savings is relatively unimportant, because travellers always benefit from the new road	11
42	Car drivers have a (relatively high) own responsibility to reduce their own travel time	23
43	People are accustomed to current travel time	10
44	People should not rush and have to take things at a gentle pace	5
45	I am not a car driver and will not benefit from the road	6
46	I think that we should not encourage car use	2
Noise pollution		
47	The noise pollution is quite low and therefore not problematic	22
48	Noise pollution was less important criterion in my choices than the other criteria	4
49	There is already quite a lot of noise pollution. Hence some extra pollution does not matter that much	8
50	It's relatively easy to restore noise pollution through noise screens	13
51	One gets accustomed to noise pollution	6
52	Noise pollution is part of living adjacent to a road	7
53	Losses for animals should be avoided because it is possible to trade human benefits against human losses	2
54	It's likely that the people who experience noise pollution also experience benefits (time savings)	4
Recreation		
55	When people want to recreate they can travel to another (more remote) recreational area	5
56	Sufficient recreational area available when the road is build	18
57	It's relatively easy to restore recreational area	2
58	Recreational area was less important criterion in my choices than the other criteria	11
Hedgehogs		
59	Hedgehogs can find another place to stay	19
60	Humans can create a new living environment for the hedgehogs	20
61	Human interests are more important than animal lives	17
62	There are enough hedgehogs. It is not a protected species	25
63	The number of hedgehogs was less important criterion in my choices than the other criteria	22
Costs		
64	The amount of money was not that high	22
65	I can easily bear this amount of money	4
66	It's nice that one can influence government decisions through such an additional payment	2
67	It's not much of a problem because this is a one-time contribution	36
68	Cost was a less important criterion in my choices than the other criteria	10

Appendix I: Motivations for least important criterion in choices