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Participatory value evaluation for the evaluation of flood protection schemes

Niek Mouter [a,*], Paul Koster [b,c], Thijs Dekker [d]

[a] Delft University of Technology, Faculty of Technology, Policy and Management, Transport and Logistics Group, the Netherlands
[b] Vrije Universiteit Amsterdam, School of Business and Economics, Department of Spatial Economics, the Netherlands
[c] Vrije Universiteit Amsterdam, John Stuart Mill College, the Netherlands
[d] Institute for Transport Studies Leeds and Choice Modelling Centre, University of Leeds, UK

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ABSTRACT

Participatory Value Evaluation (PVE) is a new survey method which elicits citizens' preferences over the allocation of public budgets as well as their private income. In a PVE, citizens are asked to choose the best portfolio of projects given a governmental and a private budget constraint. First, this paper aligns PVE with the traditional Kaldor-Hicks welfare economics framework underlying many Cost-Benefit Analyses. Second, this paper positions PVE against other valuation methods. Third, this paper applies the PVE method to evaluate the impacts of projects mitigating flood risks in the Netherlands. This empirical application reveals that Dutch citizens indicate a preference for projects that combine strengthening dikes and give space to the river to flood safely, particularly when such projects positively influence biodiversity and recreational opportunities.

1. Introduction

In virtually all western countries, Cost-Benefit Analysis (CBA) is nowadays considered the gold standard for supporting public decision-making [1]. In various countries, such as the United Kingdom, the Netherlands and Sweden, CBA is mandatory when national funding is required for large transport projects [2]. CBA is also widely applied to governmental decisions on environmental policies, safety regulation and water management [3–5]. For instance, CBA has been used to inform policies regarding flood protection, marine protection, water quality management, biodiversity and environmental conservation in the United Kingdom [5]. The theoretical foundations of CBA are rooted in welfare economics, which is a branch of economics that investigates the social desirability of alternative economic outcomes [6]. A CBA is built on the Kaldor-Hicks efficiency criterion [7], which recommends projects where the sum of monetary gains outweigh the sum of monetary losses such that winners can potentially compensate the losers and still be better off. The conversion of positive and negative social impacts of government projects into monetary units relies on willingness to pay (WTP) and willingness to accept (WTA) estimates.

Several scholars criticize the WTP/WTA valuation methods by arguing that they take a too narrow perspective when evaluating government projects because choices individuals make with their private income might not accurately reflect their preferences towards public policy [8–10]. To resolve this issue, scholars developed so-called willingness to allocate public budget experiments (WTAPB) in which individuals make choices when faced with effects accruing from alternative allocations of *government budget*

* Corresponding author.
E-mail addresses: n.mouter@tudelft.nl (N. Mouter), p.r.koster@vu.nl (P. Koster), t.dekker@leeds.ac.uk (T. Dekker).

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[11–13]. The WTAPB approach aims to infer welfare effects of government projects from individuals' preferences regarding the expenditure of public euros.

Participatory Value Evaluation (PVE) is a survey method which interconnects the WTP/WTA and the WTAPB valuation paradigm. The similarity between WTAPB experiments and PVE experiments is that participants are asked to express which public projects should be financed from a limited amount of public budget. The most important difference between these two approaches is that participants in a PVE have the option to advise the government against allocating the budget to any (or some) of the projects that are considered in the PVE and shift the remaining budget to the next year (or to other government departments). In addition to this 'fixed budget PVE' format, the 'flexible budget PVE' format allows participants to adjust the size of the public budget (and thereby their private after-tax income) by changing taxes.

The contribution of the flexible budget PVE format is that the WTP valuation paradigm and the WTAPB valuation paradigm are integrated in a single valuation framework. That is, the desirability of government projects is established simultaneously through the elicitation of individuals' preferences over the allocation of (an earmarked) public budget as well as their private income. Dekker et al. [14] present the econometric and microeconomic framework which allows for a social welfare analysis of government projects included in fixed and flexible budget PVE experiments. Although the social welfare approach is our preferred way of interpreting the results from a PVE study, a key connection that needs to be made is the extent to which any derived measure of consumer surplus from a PVE study can be aligned with the Kaldor-Hicks efficiency framework.

To this end, and this is the first aim of this paper, we develop a stylised model in Section 2 extending the work of Bergstrom et al. [13]. Section 3 continues with a qualitative discussion positioning PVE relative to other valuation methods. As a second contribution this paper presents a case study focusing on the policy evaluation features of PVE (Section 4). The case study concerns flood protection schemes of the Dutch Ministry of Infrastructure and Water Management. The main aim of the case study is to provide a tangible example of the PVE method. Section 4 also discusses the experiences of participants and policy makers. Section 5 provides a discussion.

This paper does not aim to draw the conclusion that PVE is a better or worse method compared to other methods. We also do not aim to compare policy recommendations produced by a PVE and standard CBA as this particular question is investigated in Mouter et al. [15].

2. Participatory Value Evaluation and the connection with welfare economics

In this subsection, we introduce two alternative versions of Participatory Value Evaluation (PVE) and build upon the framework presented by Bergstrom et al. [13] allowing us to align PVE to the Kaldor-Hicks welfare economics framework. Respondents in a PVE are requested to select their optimal bundle of public goods Q, where spending public budget on the bundle Q implies that less budget can be spend on other public goods Z. The fixed budget PVE requires respondents to allocate a fixed public budget across alternative public goods. The flexible budget PVE provides respondents the additional opportunity to increase (or decrease) the public budget by recommending the government to levy a collective tax increase (reduction).

We define Z as the spending of the remainder of the public budget on future public projects. Alternative formulations are possible where Z is the remainder of the public budget that is available for spending in other departments of the (local) government. Since the exact spending of Z is not defined, it is treated as a numeraire (or composite) public good which satisfies the public budget constraint. In the flexible budget PVE setting, an additional numeraire (or composite) private good X is introduced alongside a tax increase (or a reduction) which results in an increase of the public budget. Given our focus on evaluating public investments in public goods, the exact spending of the private budget is irrelevant and the introduction of a numeraire private good is sufficient. The introduction of a public and private numeraire good enables to firmly root PVE in the context of welfare economics and related measures of consumer surplus.

2.1. Behavioral model: fixed budget PVE

Following Bergstrom et al. [13], we define the direct utility function U_n for individual n in a fixed budget PVE as:[1]

$$U_n = u_n(Q, Z) \tag{1}$$

The public budget constraint B for the fixed PVE experiment is defined by:

$$B = Q^{'} \cdot P + Z \tag{2}$$

where Q is a vector of binary variables indicating which projects have been included in the policy portfolio and P is the corresponding price vector. Z is the numeraire public good that completes the public budget constraint. Assuming the individual is utility maximising, we can summarise the fixed PVE decision problem as follows:

$$\max_{Q,Z} U_n = u_n(Q, Z) \text{subject to } B = Q^{'} \cdot P + Z \tag{3}$$

[1] It is assumed that the private budget decisions do not influence the available public budget in the fixed budget PVE, and therefore X is disregarded in the present subsection.

The solution to the above maximisation problem provides a set of conditional Marshallian demand functions *Q*(P,B)* and *Z*(P,B)*, which when plugged into the direct utility function provides the conditional indirect or optimal utility function V_n:

$$V_n = v_n(P, B) \tag{4}$$

The corresponding conditional public expenditure function E can, under the assumption that the public budget is exhausted, be obtained by inverting the conditional indirect utility function for a given optimal utility level V_n:

$$E = e(P, V_n) \tag{5}$$

Following the definition of Bergstrom et al. [13], we can define the impact of a price (or quality change) of the public goods in Q as a *compensating tax reallocation* (CTR):

$$CTR = E\left(P^0, V_n^0\right) - E\left(P^1, V_n^0\right) \tag{6}$$

In terms of the Hicksian measures of welfare change the CTR measure is comparable with the compensating surplus given that we are contrasting against the original level of utility ($V_n{}^0$) and are generally considered with quality changes rather than price changes. Relative to Bergstrom et al. (2004), the fixed budget PVE explicitly incorporates the notion of the numeraire public good into the data elicitation process. The benefits of doing so are discussed in more detail in Section 3.3.

2.2. Behavioral model: flexible budget PVE

In flexible budget PVE experiments, the respondent can adjust the size of the public budget through the tax system and hence private consumption X_n and the private budget constraint become relevant. We can reformulate the utility maximisation problem to:

$$\max_{Q,\ X_n, Z, \tau_n} U_n = u_n(Q, X_n, Z) \text{subject to } B + \sum_n \tau_n = Q' \cdot P + Z\ ;\ M_n = X_n + \tau_n, \tag{7}$$

where X_n is demand for the composite private good with unit price, τ_n is a tax (or tax rebate) which can be imposed to increase (decrease) the public budget, and M_n is income for individual n. For simplicity, the design of the tax system is assumed to be exogenous. The two budget constraints can be combined to reflect the total (public and private) budget E^T available in the economy:

$$E^T = B + \sum_n M_n = Q' \cdot P + Z + \sum_n X_n \tag{8}$$

Solving the utility maximisation problem provides the Marshallian demand functions *Q*(P,B,M), Z*(P,B,M)* and X_n*(P,B,M)*, where M is the vector of disposable income for all individuals in the population. These demand functions can again be used to arrive at the conditional indirect or optimal utility function:

$$V_n = v_n(P, B, M) \tag{9}$$

In the absence of non-paternalistic altruistic preferences, it can be assumed that $\frac{\partial V_n}{\partial M_j} = 0\ \forall j \neq n$. The private budget available to other individuals in the population for consumption does not influence the value obtained by individual n from consuming the public goods Q and Z and neither do changes in the income of individual j allow individual n to consume more of good X_n and thereby derive a higher level of utility. Given these assumptions, the indirect utility function then only depends on the income level of individual n and reduces to:

$$V_n = v_n(P, B, M_n) \tag{10}$$

The corresponding expenditure function for individual n, representing the total budget, clearly shows this separation and can be defined as:[2]

$$E_n^* = \sum_{j \neq n} M_j + e_n(P, V_n) \tag{11}$$

The total budget (expenditure) formulation above highlights that private and public money are completely fungible (i.e. a euro is a euro). The tax system allows converting private budget into public budget and vice versa. The flexible budget PVE format thus allows to adjust changes in the public budget (B) and the private budget (M_n) to reach a given level of utility under the assumption that there are no deadweight losses associated with the collection of public funds via taxation. This respectively corresponds to the referred *CTR* welfare measure and the traditional consumer surplus (*CS*) measure. The fungibility of money in the flexible budget PVE framework ensures *CTR* is equivalent to *CS*.

Bergstrom et al. [13] relates the traditional *CS* measure to the case of financing a public good (or its change in price, quantity etc.) entirely from private budgets (i.e. by means of a special tax). The *CTR* welfare measure relates to financing a public good (or its change in price, quantity etc.) entirely from public budgets (i.e. by means of a tax reallocation between Q and Z, and (or) amongst the different policies in Q). Differences in the marginal utility of the private (X) and public (Z) numeraire goods, i.e. the shadow prices of private and

[2] Note that E_n^* does consider the individuals optimal decision from the collective tax which increases the public budget.

public spending, thus potentially introduce differences between *CTR* and *CS*. Flexible PVE experiments, however, allow to derive both *CTR* and *CS* welfare measures from the *same* experiment. That is, we learn the extent to which individuals are willing to trade-off the allocation of public budget across public goods and the extent to which they are willing to trade-off their private consumption (i.e. their disposable income) against public spending. The flexible conversion of either form of budget through the tax system, ensures that the two welfare measures are equivalent whilst accounting for potential differences between the marginal utilities of private and public numeraire goods.[3]

The benefit of the flexible budget PVE format is thus that public expenditure on public goods can directly be related to the traditional Hicksian welfare measures through its connection with private income. Working in the context of the relevant (public) decision problem potentially enables to overcome some of the shortcomings of other valuation approaches, as argued in Section 3.

In practice, deriving the referred welfare measure in fixed and flexible budget PVE experiments requires the evaluation of a large number of corner solutions. The reason is that individuals choose bundles of discrete projects and also make continuous choices on the numeraire goods [16]. Dekker et al. [14] show that the PVE framework allows the use of social welfare functions to provide policy makers with direct advice on the optimal policy portfolio in the application of interest. The latter approach is applied in the PVE case study in Section 4 and we leave an empirical comparison of PVE based WTP measures against more conventional (CS based) WTP measures to future studies as the presented application does not allow for such a comparisons.

3. Comparing participatory value evaluation with other valuation methods

In this section, we compare PVE with other valuation methods. In this discussion we focus on the quantification of consumer surplus measures and primarily Willingness-to-Pay (WTP) which is considered to form the theoretical underpinning of most CBA studies [17]. A CBA expresses the social costs and benefits of government projects in monetary terms. There are many ways in which costs and benefits can be expressed in monetary terms, including the use of market prices. Analysts usually derive WTP estimates directly from market behaviour (e.g. market prices). Impacts of government projects are, amongst other things, often evaluated through investigating the private decisions people make when buying a house [18] or recreation decisions (e.g. [19,20]). A shortcoming of studying behaviour in real-world markets is that the derived welfare measures, including market prices, can be incomplete due to only accounting for user benefits instead of the *Total Economic Value (TEV)* [17]. Similarly, suitable (surrogate) markets may be absent. This is particularly relevant in the context of studying the impact of public policies. It is in this context that (hypothetical) choices, studied through stated preference (SP) surveys become useful (e.g. [21,22]). PVE can be operationalised using SP surveys.

3.1. Private willingness to pay as the primary measure of value in CBA

In the private WTP approach, including the study of real-world markets, changes in *personal* income are explicitly linked to changes in individuals' consumption of private and (or) public goods (e.g. quality improvements). A critique on the private WTP approach is that individuals' consumption choices may not reflect how they want public policies to change [8,10,23–25]. For instance, people may not be willing to contribute individually to the public good because, in their view, the impact of their individual contribution is negligible. People may, however, be willing to contribute when the whole community contributes because the impacts of coordinated efforts can be substantial [10,24,26,27]. Scholars also argue that individuals' private consumer choices might not reflect their preferences towards public policy because moral considerations might be more salient in the latter context [9]. [9, p. 48] asserts that:

> "*many of us are concerned, for example, that the workplace be safe and free of carcinogens; we may share this conviction, even if we are not workers. And so, we might favour laws that require very high air-quality standards in petrochemical plants. But as consumers, we may find no way to support the cause of workplace safety. Indeed, if we buy the cheapest products, we may defeat it. We may be concerned as citizens, or as members of a moral and political community, with all sorts of values – sentimental, historical, ideological, cultural, aesthetic, and ethical – that conflict with the interests we reveal as consumers, buying shoes and choosing tomatoes. The conflict within individuals, rather than between them, may be a very common conflict.*"

3.2. Public willingness to pay

To ameliorate this issue, impacts of government projects have been evaluated through public WTP experiments. These experiments express the impacts of government projects for the entire community and are financed by a uniform tax increase or alternative but comparable payment vehicle [28–31]. In such experiments, respondents are told how much each would have to pay if the measure passed and are then asked to cast a simple "yes" or "no" vote. Since everyone is asked to contribute, the coordination problem associated with private WTP studies is resolved. Public WTP still makes the connection between policy impacts and private income but formulate the decision problem in the context of the actual public decision in which an individual has to decide whether the overall positive and negative impacts of a government project warrant a (often uniform) tax increase. Hence, individuals express their preferences toward a collective choice of the government that potentially affects their private income and that of others. The distinction between private WTP experiments and public WTP experiments differs from the distinction that is made in the literature

[3] Separate *CTR* and *CS* measures can be derived by limiting the use of either budget source for sole use in the public or private domain. Again, the differences in the marginal utilities of Z and X determine the relative sizes.

between the elicitation of people's personal interests ('consumer preferences') and the elicitation of people's perceptions of 'the common good' ('citizen preferences') [9,31,32]. Both private WTP experiments and public WTP experiments enable respondents to express personal interests and (paternalistic) altruistic considerations. The main difference is that public WTP experiments allow respondents to express these considerations in the context of a government decision where a trade-off needs to be made between social impacts of a project and a tax. In private WTP experiments and public WTP experiments, participants make their choices individually, which differs from the study of Alvarez-Farizo et al. [32] in which participants collectively expressed their preferences for water quality improvements in a group setting.

3.3. Willingness to allocate public budget

The shift from private WTP to public WTP does not solve all criticisms regarding WTP-based valuation. A remaining critique concerns the implicit assumption within private and public WTP-based valuation that private euros and public euros cannot have a different purpose [12,33,34]. Thaler [34], for example, shows that euros contained within a given budget can indeed have a specific goal or purpose. From this point of view, individuals might view their private income and government funds as constituting two separate budgets or use different utility functions depending on the funding source. When it makes a difference how public projects are paid for, it is compelling to infer the welfare effects of government projects that are financed from public revenues through investigating individuals' preferences regarding the expenditure of public euros. In so-called willingness to allocate public budget experiments (WTAPB) participants make choices over alternative allocations of government budget across different government projects [11,12,35–37]. For instance, in the experiment of [11] respondents were asked to choose between two safety-enhancing road investment projects that target different age groups and road user types. Both options required the same level of public investment. WTAPB experiments therefore do not directly impact the respondent's disposable income and the provision of other public goods (other than those considered in the choice experiment).[4] It is in this context that Bergstrom et al. [13] developed the CTR welfare measure as discussed in Section 2.1.

One clear downside of the WTAPB approach is that respondents are forced to make a choice between two or three alternative allocations of public budgets [11,35]. When respondents believe that it is better to do nothing instead of allocating public budget to the proposed projects, they do not have the opportunity to express this preference. [41] argue that any WTP estimate based on an experimental design in which the baseline is not present will yield inaccurate estimates of consumer welfare. Such biases will particularly arise when for some respondents, the most preferred option is the current baseline (i.e. 'do nothing') situation. The fact that respondents can express this preference in a fixed budget PVE is an important feature compared to existing WTAPB experiments.

3.4. Extending the fixed budget PVE to a flexible budget PVE

The limitation of WTAPB and fixed budget PVE experiments is that no connection exists between the spending of public money and the private budget (See Section 2.1). As a result, only the *CTR* welfare measure can be derived. This limits the interpretation of the *CTR* measure relative to the standard *CS* measure, unless a survey is run with two alternative payment vehicles [13]. The tax system can be used to connect the two welfare measures, as proposed by our flexible budget PVE design in Section 2. The conceptual innovation of the introduction of flexible budget PVEs is that the public WTP valuation paradigm and the WTAPB valuation paradigm are integrated in one valuation framework. That is, the desirability of government projects are established through the elicitation of individuals' preferences over the allocation of public budgets, including the trade-off between the public budget and their private income. As shown in Section 2, the *CTR* and *CS* measures are equivalent whilst recognising the two separate sources of budget and associated opportunity costs central to the WTAPB argument.

4. A PVE for a flood protection scheme of the Dutch Ministry of Infrastructure and Water Management

In this section we present a PVE case study to provide a tangible example of the method and its policy evaluation features. The case study concerns the first application of PVE and was developed to empirically test the conceptual idea of PVE. The Dutch Ministry of Infrastructure and Water Management was willing to facilitate and finance a case study regarding flood protection schemes in the Netherlands. The flood protection schemes focused on a trade-off between two types of solutions to mitigate flood risks at locations along the Dutch river 'de Waal' which do not meet the prescribed safety standards. The first type of project (solution) is simply strengthening the dikes (henceforth: 'classical project'). The second type of project involves strengthening the dikes to some extent combined with measures to give the river space to flood safely (henceforth: 'combination project'). The two types of projects have an equal impact on mitigating flood risks but differ on costs and social impacts (e.g. impact on biodiversity, impact on recreation and number of households that need to relocate). Combination projects increase recreation opportunities and biodiversity but are more expensive. A demo version of this PVE can be found online via www.populytics.nl www.participatie-begroting.nlhttp://burgerbegroting.tbm.tudelft.nl/pve-flood-protection

[4] There is a subtle difference between WTAPB experiments (in which the provision of other public goods than those respondents could choose in the choice experiment is not affected) and 'willingness to re-allocate tax experiments' in which 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 public goods that are not considered in the choice experiment [38–40].

4.1. Experimental set-up

The main tasks of participants in the PVE concerns recommending the Dutch government on the budget allocation of 700 million euros. On four locations alongside the river 'de Waal' citizens must choose between a 'classical project' and a 'combination project' (Fig. 1 depicts these four locations).

Respondents receive information about the costs and impacts of choosing for a 'classical project' or a 'combination project' at each location (e.g. impact on recreation, impact on biodiversity and number of households that experience nuisance due to the project as they potentially need to relocate). The governmental budget can also be spend on six other projects that fall within the remit of the Dutch Ministry of Infrastructure and Water Management (two road projects, two projects mitigating damage from heavy rainfall, and two projects reducing flood risks beyond current safety standards). Respondents receive similar information regarding the impacts of these projects (e.g. travel time savings and reduction in the number of severe traffic accidents). In essence, respondents need to decide about the extent to which they want to sacrifice these 'other projects' in order to enable the selection of the more expensive 'combination project' on the locations alongside 'de Waal'.

The four locations alongside the river 'de Waal' were selected in close collaboration with policy makers from the Ministry who were preparing these decisions. We selected locations for which a strategic choice between a 'classical project' and a 'combination project' needed to be made in the short run (after this strategic choice various more detailed decisions needed to be made). The six other projects were selected together with policy makers from other departments within the Ministry who were asked to suggest projects that were also up for a decision. To disentangle the impact of the policy features (i.e. policy attributes) from the overall policy, we asked policy makers of the Ministry to provide bandwidths within which the policy features could vary. As with the design of standard choice experiments, we used these bandwidths to generate an experimental design (see the supplementary material for more information). The features of the policies thus vary slightly across respondents. In contrast with most choice experiments respondents only define a single optimal portfolio (choice task) in the PVE. Table 1 describes the bandwidths for the features associated with each project.

The most important differences between the four locations in terms of the impact of choosing for either the 'classical project' or the 'combination project' were: 1) the difference in costs between the two options was much lower at the location "Gendtse Waard" relative to the other locations, but at the other three locations choosing for the combination project had a stronger positive impact on biodiversity; 2) only at the location "Oosterhout" a number of households would experience nuisance from the choice for the combination project.

Two PVE experiments were conducted: a fixed budget PVE and a flexible budget PVE. In the fixed budget PVE respondents were asked to recommend a portfolio of projects given a governmental budget constraint of 700 million euros. Respondents were obliged to choose a classical project or a combination project at each of the four locations. The other six projects were optional. Any remaining budget was shifted forward to the next year. In the flexible budget PVE respondents could adjust the governmental budget by increasing the tax per household or by selecting a rebate. A tax increase (decrease) of 8 million euro of the budget in the PVE resulted in an increase (decrease) of taxes of 1 euro per Dutch household in 2019. As such, individuals participating in the flexible budget PVE can influence their after-tax income. Participants of the fixed budget PVE do not have this opportunity.

Both the fixed and the flexible PVE were conducted in a web-based environment. First respondents received information about the goals of the experiment. To ensure that respondents feel that their responses might influence decisions, we communicated to the respondents that the research project was commissioned by The Ministry of Infrastructure and Water Management in order to seek advice from a large group of citizens with regard to a policy dilemma [42]. Next, they were asked to give informed consent.[5]

Fig. 2 presents a screenshot of the page where respondents could select projects. Fig. 3 presents a screenshot of a page where respondents could find more information about a project.

Respondents in the experiment could make the choice to delegate their decision to an expert (two civil servants and one academic). This delegation option recognises that some of the respondents might find the experiment to complicated or burdensome or find it more rational to put their trust in the expertise of experts in the context of this decision problem. These experts also made their choices in the experiment. When participants delegated, their choice was replaced by the choice of the selected delegate in the empirical analysis. It is possible to redo this analysis without these delegated choices in order to see whether the results differ. Furthermore, the option is useful as it might reduce protest responses in the survey.

After respondents selected their preferred portfolio, they were asked to motivate their choices for each project they selected. These motivations provide valuable insights into the qualitative reasons why some of the projects were chosen. At the end of the survey, respondents were asked to evaluate several aspects of the PVE.

[5] Respondents who gave informed consent for participating in the experiment received the following instruction: *"The Ministry of Infrastructure and Water Management decided to consult a large number of citizens to provide an advice for this choice situation. You are one of the citizens that we selected. We ask you to choose between a classical project and a combination project at four locations. You can allocate a budget of 700 million euros. You are obliged to choose on the four locations alongside the river 'de Waal' between a 'classical project' and a 'combination project'. In case there is governmental budget left, you can spend it on six other projects that fall within the responsibility of the Dutch Ministry of Infrastructure and Water Management (two road projects, two projects mitigating damage from heavy rainfall, and two projects reducing flood risks beyond the new safety standards). More specifically, we ask you to select the projects you advise to the government through clicking on the 'selection button'. Please note that any remaining budget will be shifted forward to the next year. This implies that the Ministry of Transport and Water Management will be able to spend more money on projects that fall within their responsibility in the next year. In the instruction video we further explain how you can sort the projects, compare the projects by one of the impacts, and find out more about the (impacts of) projects through clicking on an information button.*

Fig. 1. The four locations on which respondents have to choose between a 'classical project' and a 'combination project'.

Table 1
Description of the projects and project impacts.

	Costs	Protection against flooding	Number of hectares nature affected)	Improvement biodiversity	Improvement recreational opportunities	Number of households experiencing nuisance
1) Gendtse Waard classical project ensures that the safety standards are met through broadening and increasing the height of the dikes.	35/90	In line with standards	0	No improvement	No improvement	0
2) Gendtse Waard combination project ensures that the safety standards are met through: (1) Broadening and elevating the dikes; (2) Giving the river more space which ensures that the river can discharge more water. The fact that the floodplains will be filled with water on a more frequent basis ensure that certain types of biodiversity will develop.	40/97	In line with standards	30/70	Small improvement/large improvement	No improvement/very large improvement	0
3) Oosterhout: this project ensures that the safety standards are met through broadening and increasing the height of the dikes.	20/35	In line with standards	0	No improvement	No improvement	0
4) Oosterhout combination project ensures that the safety standards are met through: (1) Broadening and elevating the dikes; (2) Giving the river more space which ensures that the river can discharge more water. The dike will be relocated. Possibly some households and a campsite should be relocated. The quality of a nature reserve will improve.	55/90	In line with standards	80/120	Small improvement/large improvement	No improvement/very large improvement	1/30
5) Sleeuwijk classical project ensures that the safety standards are met through broadening and increasing the height of the dikes. At some locations the dikes will be elevated with 10 cm and at other locations with 100 cm.	70/115	In line with standards	0	No improvement	No improvement	0
6) Sleeuwijk combination project ensures that the safety standards are met through: (1) Broadening and elevating the dikes. At some locations the dikes will be elevated with 10 cm and at other locations with 100 cm; (2) an additional trench will be made which can be filled with water in case of high water circumstances. The dike elevation can decrease with 25 cm at several locations. A wide ecological connection emerges. Animals can travel more easily.	145/280	In line with standards	120/180	Small improvement/Very large improvement	Small improvement/very large improvement	0
7) Werkendam: this project ensures that the safety standards are met through broadening and increasing the height of the dikes. At some locations the dikes will be elevated with 10 cm and at other locations with 100 cm.	70/110	In line with standards	0	No improvement	No improvement	0
8) Werkendam: this project ensures that the safety standards are met through: (1) Broadening and elevating the dikes. At some locations the dikes will be elevated with 10 cm and at other locations with 85 cm; (2) an addtional trench will be made which can be filled with water in case of high water circumstances. The dike elevation can decrease with 15 cm at several locations. A wide ecological connection emerges. Animals can travel more easily.	105/255	In line with standards	140/200	Small improvement/Very large improvement	No improvement/very large improvement	0
	Costs		Number of households	Number of times damage caused		

(*continued on next page*)

Table 1 (*continued*)

	Costs	Protection against flooding	Number of households experiencing nuisance	Number of times damage caused by heavy rainfall prevented	Travelers affected (thousands)	Minutes time savings	Decrease severe injuries
		Protection against flooding	experiencing nuisance	by heavy rainfall prevented	Travelers affected (thousands)	Minutes time savings	Decrease severe injuries
9) De Hooge Boezem can be transformed into a large-scale water storage. New dikes will be built which can be unlocked in case of heavy rainfall. De Hooge Boezem can store around 30 swimming pools of water which can prevent damages caused by heavy rainfall for the surrounding villages because the superfluous water can be stored. The variety of biodiversity will increase as a result of the project. Various meadow birds and water birds such as the stork, the crane and the moorhen will settle in the area.	1/10	In line with standards	0	Once every 2.5 years/once every 25 years	0	0	0
10) Mitigation heavy rainfall Driemanspolder: new dikes will be built which can be unlocked in case of heavy rainfall. De Nieuwe Driemanspolder can store around 300 swimming pools of water which can prevent damages caused by heavy rainfall for the city of Zoetermeer because the superfluous water can be stored. The project also has a positive impact on the quality of biodiversity. Different kinds of birds, amphibians, butterflies and dragonflies will settle. In the long run, relatively rare specifies such as the grass snake and the Eurasian water shrew will populate the area.	60/100	In line with standards	0	Once every year/once every 5 years	0	0	0
11) The A6/A7 junction at Joure is the last motorway in the Netherlands with a roundabout. The roundabout will be replaced by an overpass which will separate the A6 motorway from the A7 motorway. This results in travel time savings and an increasing traffic safety.	55/95	0	0	0	30,000/45,000	1/8	1/7
12) Road expansion A2 motorway: The project concerns replacing the hard shoulder with an extra lane. The new lane will be particularly beneficial in case of accidents and heavy weather. In normal circumstances the new lane results a few minutes of travel time savings. However, in case of accidents and heavy weather the travel time savings resulting from the replacement of the hard shoulder with a new lane are much larger.	205/305	0	1/27	0	10,000/22/000	1/6	0/7
13) Additional flood reduction Moerwijk: an area can be protected beyond the obligatory safety standards when a flooding would result in societal disruption (e.g. lots of human casualties or great economic damage). One of the places considered by the government is Moerwijk. In that case the additional flood protection	8/20	Above standards/highest protection	0	0	0	0	0

(*continued on next page*)

Table 1 (*continued*)

	Costs	Protection against flooding	Number of households experiencing nuisance	Number of times damage caused by heavy rainfall prevented	Travelers affected (thousands)	Minutes time savings	Decrease severe injuries
will be realized through broadening and elevating the existing dikes.							
14) Additional flood reduction Venlo: an area can be protected beyond the obligatory safety standards when a flooding would result in societal disruption (e.g. lots of human casualties or great economic damage). One of the places considered by the government is Venlo. In that case the additional flood protection will be realized through broadening and elevating the existing dikes	2/10	Above standards/ highest protection	0	0	0	0	0

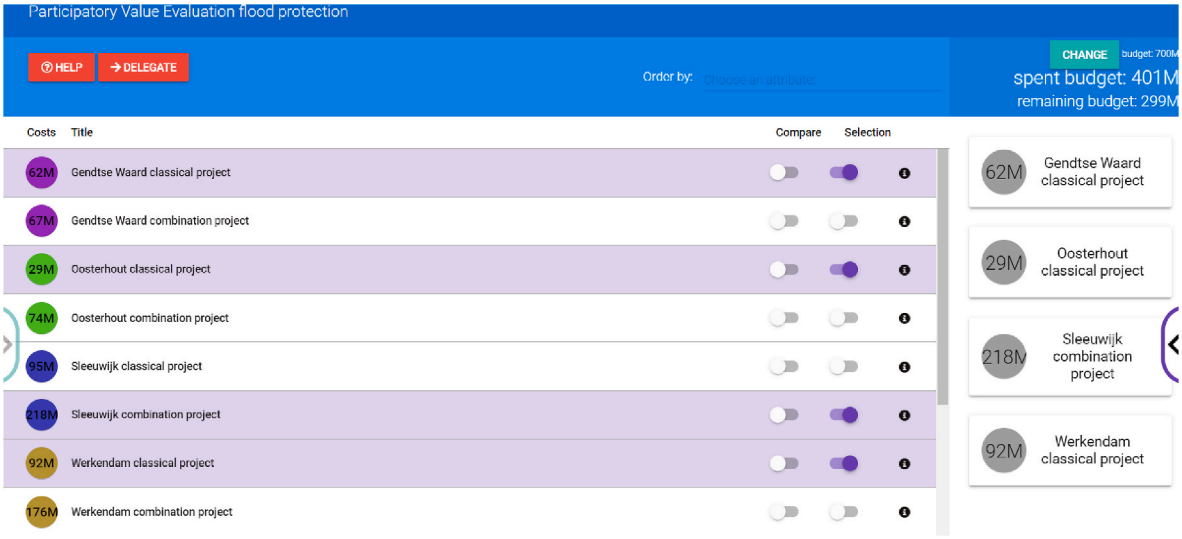

Fig. 2. Screenshot of a part of the page of the flexible budget PVE on which respondents could select projects.

The survey company Kantar Public was asked to provide two random samples of Dutch citizens of 18 years and older and we used a between-subjects design for our study. 2900 respondents participated in the experiments out of which 937 respondents were specifically recruited in the areas adjacent to the river 'de Waal'. All respondents who finished the experiment received a financial compensation from the survey company. In case respondents delegated their choice, they received a lower financial compensation (around 1 euro). The use of different incentives for providing an advice or delegating might muddle the preference elicitation process. At the margin, if getting extra euros from the survey company is more important for respondents than making the "right" choice, then they might go ahead and click through just to get the extra euro, even if, absent the monetary incentive, they think it is better if an expert makes the call. Notwithstanding this drawback, we decided to provide respondents who delegated with a lower financial compensation because we were concerned that many respondents would choose for 'delegation' when we would give them the same financial compensation. The underlying reason for this decision is that this was the first time that we applied the PVE method and we wanted to learn as much as possible from the responses of the participants. Overall, we found ample room for improvements while conducting this PVE study. We recommended the policy makers who commissioned the study to keep this in mind when interpreting the results of the study. The next subsection discusses the results from the case study.

4.2. Results

In the fixed budget PVE 266 out of 1855 respondents delegated their choice to an expert (14%) and in the flexible budget PVE 223 out of 1045 respondents delegated (21%). The fact that more individuals delegated in the flexible budget PVE may be the result of the increased complexity of the choice task in this experimental setting. On the other hand, it is surprising that a relatively large number of

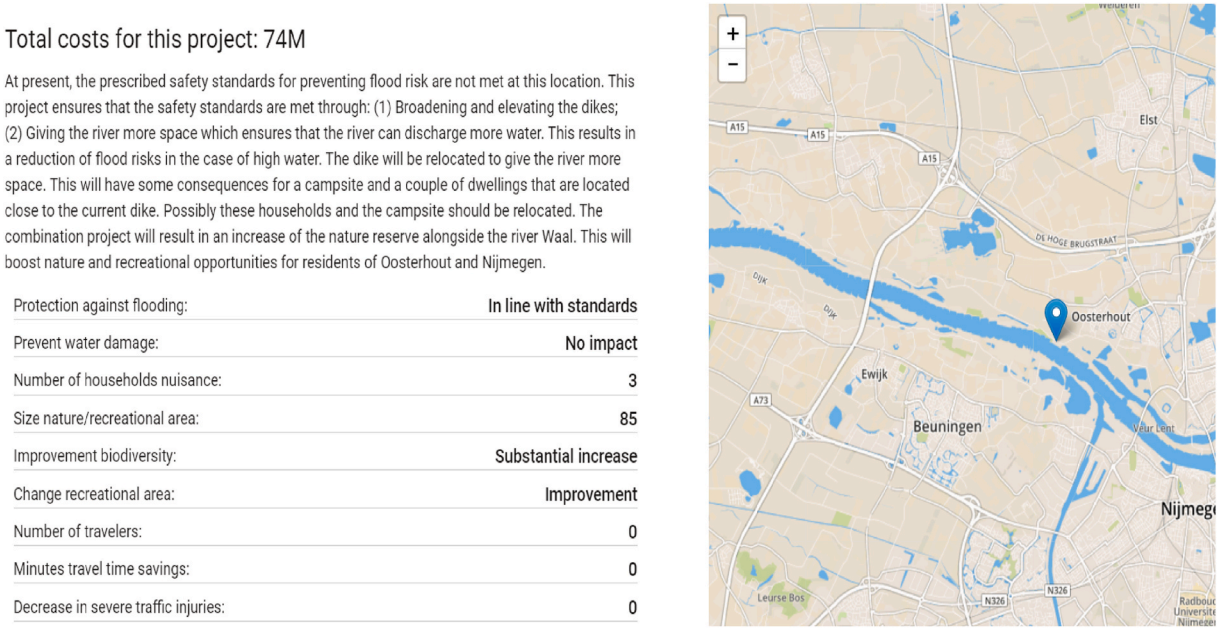

Fig. 3. Screenshot of a page on which respondents could find more information about a project.

respondents delegated a choice to an expert that might affect their private income. In the fixed budget PVE 2.1% of the respondents fully exhausted the budget, which is partly a result of the limited number of project portfolios available that would exhaust the public budget. In the flexible budget PVE the percentage of the respondents who fully exhausted the budget was a bit higher (6.8%). Fig. 4 provides more detailed information with regard to the size of the budget that was shifted forward in the two experimental settings.

620 respondents participating in the flexible budget PVE did not change the budget, 122 respondents decreased the budget and 82 respondents increased the budget (see Fig. 5 for more detailed information on the extent to which respondents changed the budget). We did not find a significant correlation between the income of the respondent and their decision to change the budget. However, the single respondent who selected the null portfolio (choosing for the classical project at each location and a maximal reduction in budget) was an individual with a very low income.

After participants of the flexible budget PVE completed the experiment, we asked them why they decided (not) to change the budget. Most respondents who increased the budget stressed the importance of biodiversity and said that the relatively low tax increase that was needed to improve biodiversity urged them to increase the budget. Many respondents who decreased the budget referred to low importance of the projects among which they could choose. Moreover, a group of participants argued that they reduced the budget because they had a negative stance towards government spending in general. For instance, one respondent argued: *"I think that taxes*

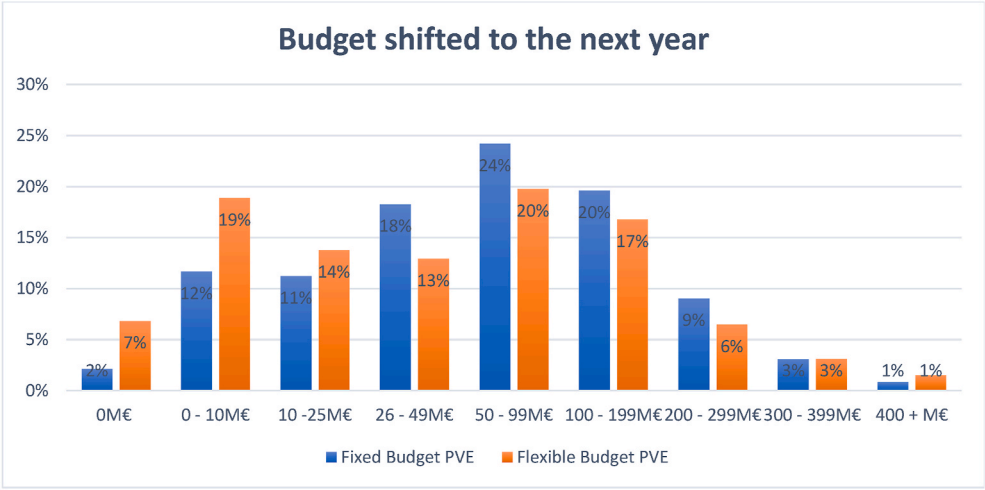

Fig. 4. Budget shifted forward to the next year in the Fixed Budget PVE and Flexible Budget PVE.

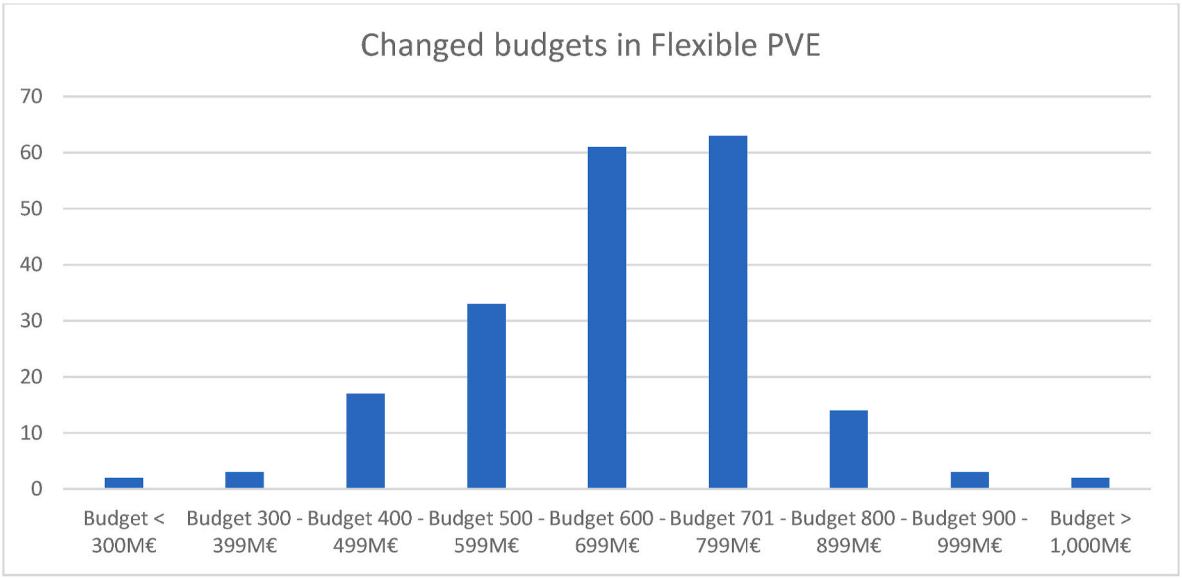

Fig. 5. Changes in budget in the Flexible PVE.

should be as low as possible. Only the most essential tasks should be conducted and financed by the government." Many of the respondents who did not change the budget argued that the government would have a good reason for setting the budget at this level and they found it risky to overrule such a decision. Another group of respondents stated that they did not decrease the budget because they thought that it would be good if the government had some financial reserves in case of a setback. For instance, one respondent argued: *"I didn't decrease the budget because such projects always face cost overruns."* Various respondents argued that they did not increase the budget because they thought that the government should respect its budget.

Fig. 6 presents the market shares of the different projects for the respondents who did not delegate their decision to an expert. To check for spatial differentiation in project choices, both the market shares for the full sample (The Netherlands), and for the respondents recruited in the Waal area are reported. For each project the average costs presented to the sample are also displayed.

In all four locations the majority of respondents selected the 'combination project'. In the fixed budget PVE and the flexible budget

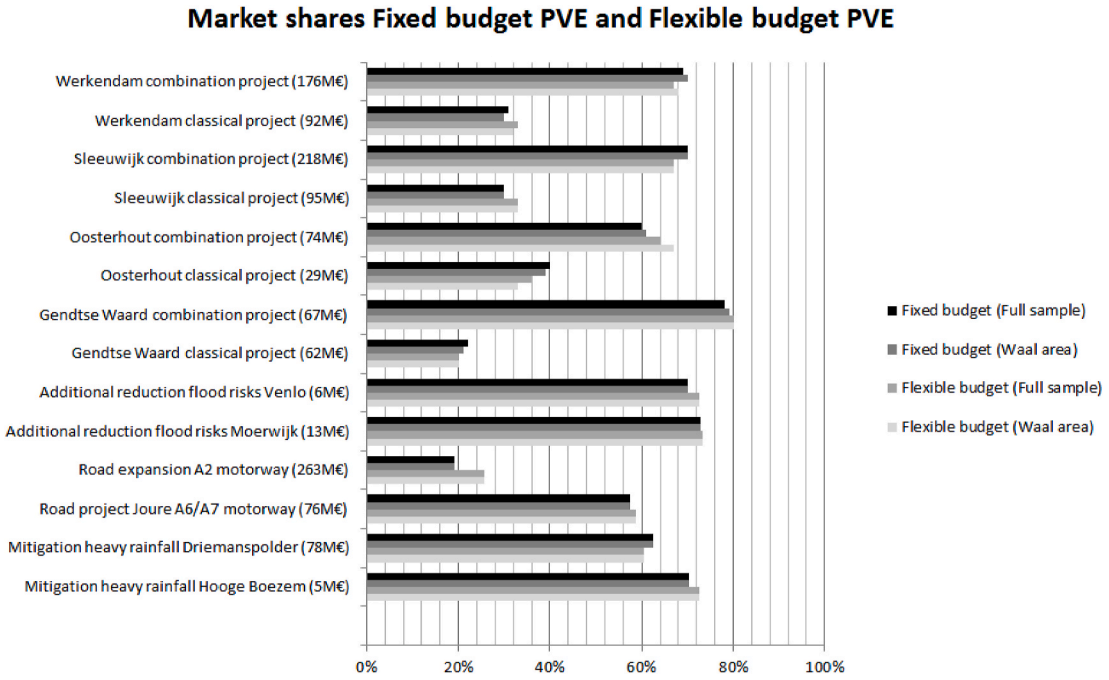

Fig. 6. Percentage of respondents which selects the classical projects, the combination projects and the six other projects.

PVE respectively 39.1% and 40.9% of the respondents selected the combination project at all four locations. The classical project was selected at all four locations by 7.0% of the respondents (fixed budget PVE) and 7.6% of the respondents (flexible budget PVE). Strikingly, the results did not differ very much between the respondents living close to the river 'Waal' and random sample of Dutch citizens. A proportions test revealed that, at the 5% significance level, only for the road project Joure A6/A7 motorway and the project mitigating heavy rainfall at Hooge Boezem were selected more often by respondents from the random sample of the Dutch population than respondents living in the Waal area. Overall, the results of the fixed and flexible budget PVE are quite similar. A proportions test across the fixed and flexible budget PVE reveals that only for the Road Expansion A2 motorway we observe a significant difference in proportions between the fixed and flexible PVE samples at the 5% significance level. Although the comparisons between the two samples is not entirely fair (e.g. in the flexible budget PVE respondents were allowed to change the budget and respondents in the fixed budget PVE did not have this option). We take this as evidence that the two samples are largely comparable.

The chosen policy portfolios are quantitatively analysed using advanced discrete-continuous choice models (more details on the modelling can be found in the supplementary material). We estimate taste parameters in order to derive the relevance of social impacts associated with the projects (comparable to attributes in stated preference surveys). This analysis revealed that participants particularly preferred the combination projects over the classical projects when the former projects would positively influence biodiversity and recreational opportunities (see the supplementary material for more detailed information). Respondents' answers to the question why they selected the combination projects also show that improved recreational opportunities and variety in biodiversity are the main reasons for choosing these projects. However, we also inferred from these qualitative motivations that participants mentioned reasons that were not linked to the impacts for which they received explicit information in the PVE. For instance, respondents argued that they selected combination projects because they believe that this solution to mitigate flood risk is aesthetically superior and is more 'future proof'. Moreover, various respondents stated that they selected the road project Joure A6/A7 motorway which is located in the North of the Netherlands for reasons of spatial fairness. These respondents believe that issues in the urban areas in the Western part of the country receive too much attention compared to issues in the periphery. See for instance the following statement of a respondent: "The North and the South of the Netherlands are always forgotten by the West. Politicians have no problem with spending millions of euros on congestion issues in the Western part of the country, but they should also have an eye for issues in other parts of the country". Hence, we estimate so-called project specific parameters for each project which captures the utility individuals derive from a project irrespective of the level of the impacts included explicitly in the PVE (comparable to alternative specific constants in stated preference surveys).

The obtained results can be used to inform policy makers about the desirability of the various policies and projects (see the supplementary material for the technical details and [14] for the generic microeconomic framework of Participatory Value Evaluation). A first useful output of the analysis is the probability that an individual project improves social welfare compared to shifting the required budget to the next period. In other words, it reveals the probability that the project provides value for money.

Fig. 7 shows that all the combination projects provide value for money. For instance, choosing the combination project at Gendtse Waard has an 86% probability to improve social welfare compared to choosing for the classical project at this location and shifting the difference in costs (in this case 5 million euro) to the next year.[6] The project desirability of the road expansion of the A2 motorway is only 31%. Its low probability to provide value for money over shifting the required public budget to the next year implies the project should not be implemented, irrespective of the available budget.

A second useful output of the analysis is the ranking of portfolios of projects in terms of expected social welfare. When the public budget is unlimited, policy makers could opt for all projects with a desirability probability of higher than 50%: the combination projects at all four locations and the projects Moerwijk, Venlo, Hooge Boezem, Driemanspolder and Joure. However, in reality policy makers are faced with limited budgets and PVE also allows for the identification of the optimal selection of projects (i.e. the optimal portfolio) for a given budget. Fig. 8 shows the top 10 of portfolios within a budget constraint of 688 million euros. We used the average budget recommended in the flexible budget PVE (688 million euros) as the budget constraint. This implies a tax decrease of 1.5 euro per household in 2019.

Based on these results we can draw three main conclusions: 1) the large road project (road expansion A2 motorway) is not included in all the top 10 portfolio's; 2) at the locations Sleeuwijk and Werkendam the combination project is included in all the top 10 portfolio's; 3) the optimal portfolio opts for the combination project in all four locations. In order to see whether these conclusions are robust to changes in assumptions concerning the level of the social impacts included in the experiment (e.g. costs and impact on biodiversity) we performed various sensitivity analyses (see the supplementary material). These sensitivity analyses reveal that the first two conclusions are highly robust to changes in assumptions. However, when we assume a very low impact of the combination projects on biodiversity and recreational opportunities, the combination project is not included in the optimal portfolio at the location 'Oosterhout'.

4.3. Experiences of participants and policy makers

Policy makers who commissioned the PVE case study presented the results of the study (both within and outside the Ministry). In the presentations they stated that a useful insight for them was that both the quantitative and qualitative information from the PVE

[6] If all the participants in the PVE would have selected the null portfolio, they would have recommended to implement the classical project at each of the four locations and shift the remaining public budget to the next year. In that case, the probability that one of the combination projects improves social welfare would have approached 0%.

Combination project versus classical project	Project desirability	
Gendtse Waard combination project (67M€)	86%	✓
Gendtse Waard classical project (62M€)	--	X
Sleeuwijk combination project (218M€)	75%	✓
Sleeuwijk classical project (95M€)	--	X
Werkendam combination project (176M€)	75%	✓
Werkendam classical project (92M€)	--	X
Oosterhout combination project (74M€)	67%	✓
Oosterhout classical project (29M€)	--	X
Other projects		
Additional reduction flood risks Moerwijk (13M€)	75%	✓
Additional reduction flood risks Venlo (6M€)	74%	✓
Mitigation heavy rainfall Hooge Boezem (5M€)	74%	✓
Mitigation heavy rainfall Driemanspolder (78M€)	70%	✓
Road project Joure A6/A7 (76M€)	61%	✓
Road expansion A2 motorway (263M€)	36%	X

Fig. 7. Probability that a project improves societal welfare.

	Top 10 portfolio's									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gendtse Waard classical project (62M€)	0	0	0	0	0	0	0	1	0	0
Gendtse Waard combination project (67M€)	1	1	1	1	1	1	1	0	1	1
Oosterhout classical project (29M€)	0	1	0	0	1	1	0	0	1	0
Oosterhout combination project (74M€)	1	0	1	1	0	0	1	1	0	1
Sleeuwijk classical project (95M€)	0	0	0	0	0	0	0	0	0	0
Sleeuwijk combination project (218M€)	1	1	1	1	1	1	1	1	1	1
Werkendam classical project (92M€)	0	0	0	0	0	0	0	0	0	0
Werkendam combination project (176M€)	1	1	1	1	1	1	1	1	1	1
Mitigation heavy rainfall Hooge Boezem (5M€)	1	1	1	0	1	0	0	1	0	1
Mitigation heavy rainfall Driemanspolder (78M€)	1	1	1	1	1	1	1	1	1	1
Road project Joure A6/A7 (76M€)	0	1	0	0	1	1	0	0	1	0
Road expansion A2 motorway (263M€)	0	0	0	0	0	0	0	0	0	0
Additional reduction flood risks Moerwijk (13M€)	1	1	1	1	1	1	1	1	1	0
Additional reduction flood risks Venlo (6M€)	1	1	0	1	0	1	0	1	0	0
Costs (in millions of euros)	**641**	**671**	**635**	**635**	**665**	**665**	**629**	**636**	**659**	**627**

Fig. 8. 10 portfolio's which result in the highest expected social utility.

indicate that citizens particularly prefer the combination projects over the classical projects when the former projects positively influence biodiversity and recreational opportunities. Moreover, policy makers found it interesting to learn which type of projects citizens are willing to sacrifice to enable them to choose the more expensive combination project instead of the cheaper classical project. For instance, citizens are willing to sacrifice the large road project (road expansion A2 motorway) to make way for more expensive combination projects which foster biodiversity and recreation.

Policy makers also argued that a strength of PVE concerns the facilitation of mass participation of citizens in the evaluation of public policies. A key benefit of PVE compared to existing approaches for citizen participation (e.g. public hearings and citizen juries) is that the entry barriers for participating are relatively low. Participants generally spend 20–30 min before submitting their choice(s), and the respondents can choose themselves when and where they conduct the PVE. As a result of the low entry barriers not only the passionate proponents and opponents, but also the so-called 'silent majority' can participate in the evaluation of public policies. The socio-demographics of the respondents (see the supplementary materials) reveal that all relevant segments of the population are represented.

In the final part of the PVE experiment, participants were asked about the extent to which they agreed with four propositions. All four propositions were evaluated in a positive way: 1) *"I was convinced of my choices"* (24% strongly agree; 55% agree; 18% neutral; 2% disagree; 1% strongly disagree); *"I thought that the experiment was realistic"* (16% strongly agree; 45% agree; 27% neutral; 10% disagree; 2% strongly disagree); 3) *"I think it is good that the government aims to involve citizens in making choices between projects in the experiment"* (41% strongly agree; 42% agree; 12% neutral; 5% disagree; 1% strongly disagree); 4) *"This experiment provides the government with relevant information for making choices between projects"* (19% strongly agree; 46% agree; 26% neutral; 7% disagree; 1% strongly disagree). The fact that more than 80% of the participants in the case study agreed that it is good that the Ministry of Transport and Water Management involved citizens in the evaluation of policy options indicates that there is a clear demand for public participation among Dutch citizens. Possibly, PVE can be a response to this demand.

Besides responding to the four statements mentioned above, participants in the PVE were asked to provide qualitative feedback with regard to the PVE-experiment in which they participated. Various citizens argued that they thought that participating in a PVE is a nice way to get involved into policymaking and to ensure that their voices are heard. They liked the fact that they are invited to make a strategic choice that is close to the dilemma policy makers face. Moreover, citizens who participated in the PVEs argued that it raised their awareness concerning the dilemmas policy makers are faced with in making complex decisions, because they have to make – consequential – choices themselves. For instance, citizens learned about scarcity of public resources (not everything is possible) and the cons and pros of the alternative policy options.

Apart from the respondents who were positive about PVE we saw that 1% of the respondents strongly disagreed with the statement "*This experiment provides the government with relevant information for making choices between projects"*. When analysing the experiences of these respondents we saw that some of them thought that the experiment was too simplistic to provide policy makers with solid information to underpin political decisions, whereas other respondents struggled with the complexity of the experiment. Apart from the respondents that questioned their own ability to complete the experiments, another group of respondents questioned the extent to which respondents with low levels of education were able to complete the choice tasks. Some negative respondents thought that complex decisions regarding flood protection should be left to experts instead of the general public. Finally, various respondents criticised the lack of transparency with regard to the selection of the projects that were part of the experiment and some even stated that they wanted to be involved in this selection process.

5. Discussion

This paper started out by extending the welfare framework for the evaluation of public expenditure as presented by Bergstrom et al. [13] with the purpose of aligning the Participatory Value Evaluation (PVE) survey method with the Kaldor-Hicks efficiency criteria underlying the Cost-Benefit Analysis (CBA) framework. The fixed budget PVE survey format – which concerns the optimal allocation of public budget – allows deriving the Compensating Tax Reallocation (CTR) measures as obtained from Bergstrom et al. [13]'s Willingeness-To-Allocate Public Budget (WTAPB) experiments. The fixed budget PVE survey format makes the shadow price of public budget directly insightful to respondents, improving the validity of the CTR welfare measure relative to WTAPB. A further contribution is made through the flexible budget PVE survey format, which allows connecting, and under the assumption of perfect fungibility of the private and public budget equating, the CTR welfare measure to the traditional Consumer Surplus (CS) measure. This is achieved by allowing respondents to adjust the size of public budget through the tax system and thereby connecting the private and public budget.

Several arguments have been provided in Section 3 as to why fixed and flexible PVE surveys are considered relevant alternatives to traditional private Willingness-To-Pay (WTP) studies. These include the need to elicit preferences for public policies and corresponding trade-offs in the context of the actual policy context as opposed to the use of private markets, the opportunity to solve coordination problems (alike public WTP studies), and that public policies are typically financed from public budgets as opposed to private budgets (alike WTAPB). Bergstrom et al. [13] do recognise that such context specific welfare measures pose challenges for the transfer of such values to other policy contexts and these reflections translate to the PVE framework. On the other hand, it can be argued that decisions on the allocation of vast amounts of public budget (700 million euro in the context of this case study) warrant a context specific welfare analysis.

To illustrate the PVE framework, we presented a case study regarding projects mitigating flood risks in the Netherlands. The main result of this PVE case study is that citizens prefer projects that combine strengthening dikes and give space to the river to flood safely, particularly when such projects positively influence biodiversity and recreational opportunities. This application was positively evaluated by policy makers who commissioned the case study and by citizens who participated in this case study. However, we also

found that there is ample room for further improvement of which some directions are given below.

A key limitation of our study is that it was not possible to investigate how the welfare measures from PVE studies compare to those from private WTP studies. This requires specifically designed experimental setups which were not possible to conduct with the PVE case study presented here.

A second limitation is that PVE experiments are complex when compared to conventional private WTP studies. We dealt with this issue through offering respondents who find the experiment to complicated or burdensome the option to delegate their choice to an expert. Moreover, it is quite comforting that 89% of the respondents agreed with the statement: "I was convinced of my choices" which indicates that most of the respondents understood the experiment even though the choice tasks in a PVE are relatively complex. Of course, the concern remains that participants structurally overestimate their own competence to make a rational choice. We recommend further research which investigates whether participants applied simplified heuristics (like the attribute non-attendance in CE) due to the complexity of the choice task, and what the effects would be from potential cognitive overload (and if there are certain groups of respondents that have).

A third limitation is that we saw that some respondents criticised PVE because they thought that complex government decisions should be left to experts. We think it is interesting to give participants in further research projects the option to communicate their opinion regarding the extent to which outcomes of the experiment and expert advice should influence decision-making. Perhaps these critical respondents are more satisfied when they are explicitly asked in a PVE to answer this question.

Moreover, we think that it is interesting to investigate the merits of new delegation options (e.g. providing participants who delegate with the same financial compensation and also provide participants with the option to delegate to politicians) and to analyse whether respondents who adopt different choice strategies make different choices through tracking the behaviour of participants during the experiment (how many respondents watch the whole instruction video and how many respondents used the attribute sorting function?).

We wish to emphasize that the purpose of this study is not to claim that PVE is superior or inferior to other valuation approaches. Arguably, the appropriateness of using PVE or other valuation methods depends on the policy-related economic question. Moreover, the normative question about whether PVE is (not) a more appropriate method for the valuation of public goods compared to other approaches also requires more consideration. A practical approach to further investigate this question is to evaluate the welfare effects of (a set of) government projects through both a PVE and alternative valuation techniques such as private WTP and evaluate the performance of these two studies on various criteria such as hypothetical bias, protest votes, confidence of respondents in their choices and the extent to which respondents believe that the study provides the government with relevant information for making choices between projects.

Author contributions

Niek Mouter: development of the Participatory Value Evaluation, literature review, analysis of qualitative data and project management, Paul Koster: development and design of Participatory Value Evaluation, behavioural model formulation and policy analysis, Thijs Dekker: behavioural model formulation, econometric programming and estimation, policy analysis. All authors discussed the results and contributed to the final manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.wre.2021.100188.

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